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Coping Tactics Employed by Visually Disabled Users on the Web

Markel Vigo*, Simon Harper
School of Computer Science, University of Manchester, Manchester, UK

Abstract
Interaction on the Web is often problematic for visually disabled users. In order to analyse how visually disabled users deal with problematic situations we carried out a secondary analysis of 2 independent datasets containing the interaction of 24 users. As a result, we determine the situations in which coping occurs including uncertainty, reduced mobility, confusion and overload, and identify 17 tactics employed to overcome these situations, being impulsive clicking, exploration tactics and re-doing some of the most noteworthy. These tactics are novel in that they are contextualised and complete: their presence denotes the presence of specific problems. Therefore these tactics are behavioural markers of cognitive processes that indicate problematic situations. We highlight the importance of these behavioural markers for designers and tools in order to remove the need to cope, evaluate accessibility-in-use and inform navigation models.

Keywords: Behavioural sciences, web tactics, behavioural strategies, coping tactics, blind users, low vision, screen readers, screen magnifiers.

1. Introduction
The World Wide Web is an eminently visual media and as such, web pages are normally designed with visual metaphors in mind. However, there are a plethora of users who have access restrictions to the Web through the visual channel. Users employing devices such as smartphones while on the move and users of bicycle or in-car interfaces not only have to experience the

*Corresponding author
Email address: markel.vigo@manchester.ac.uk (Markel Vigo)

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limitations of constrained screens and keyboards, but also they have to split their attention. While these users are considered to be situationally impaired, visually disabled users face these situations constantly; consequently they tend to rely on the auditory channel to interact with the Web.

According to the World Health Organisation\(^1\), based on individuals’ visual acuity, visual disabilities are classified as mild, moderate or severe visual impairment and blindness. Individuals who are visually disabled (low vision users and blind users) employ assistive technologies to overcome the access problems to visual media. Assistive technologies are the devices that augment and transform content across interaction modalities. For instance, screen magnifiers, which are normally employed by low vision users, augment the visual channel by zooming into the content. Screen magnifiers also have colour inversion and cursor enhancement features, amongst others. The shortcomings of using screen magnifiers are that users only have a partial view of the page they are interacting with and therefore the interaction context is lost. Screen readers, which are employed by blind and low vision users, transform content across modalities: the content which is intended to be visually displayed is conveyed through the auditory channel. To do so, screen readers extract content from the web page and read it out loud in a serial fashion by reading it from the top-left to the bottom-right area of the page, by jumping between blocks of paragraphs or between sections denoted by headings. Advanced features such as “auto web spot” by VoiceOver screen reader are able to detect areas of pages that are visually and structurally meaningful such as the mast header, navigation links, main content or the footer, and provide users with navigation mechanisms to jump to them.

Actually, users explore web pages by passively listening to the output of the screen reader, which is a strategy adopted by 5.4% of skilled users and 18.4% of novices \(\text{[WebAIM]}\ 2012\); this strategy tends to be employed when users get to a page for the first time. This is an inefficient yet effective way to navigate through a web page. A vast majority of users (accounting for more than 75%) report that they employ scanning strategies such as navigating through links and through headings as their main strategy \(\text{[WebAIM]}\ 2012\). As these quasi-sequential navigation techniques are often suboptimal, users employ their own navigation strategies in order to more efficiently navigate

\(^1\)International Classification of Functioning, Disability and Health (ICF). Available at \url{http://apps.who.int/classifications/icd10/browse/2010/en/#H53-H54}
through web pages (see an analysis of these strategies in §3).

In addition to the accessibility problems that may be encountered and are covered by accessibility guidelines (Caldwell et al., 2008), the navigation mechanisms employed by screen reader users hinder their performance when compared to that of their sighted counterparts. While the problems visually disabled users face are well covered by the literature (Theofanos and Redish, 2003; Lazar et al., 2007; Power et al., 2012), the situations provoked by these problems are less known. Using coping theory as a framework of reference (see §2), we classify the problematic encounters into problems caused by uncertainty, reduced mobility, confusion and overload in §5.1. In order to explore the specific cases of the general case we provide a mapping between a Web technology driven classification and general coping situations in §5.2. Then we analyse how users react and what are the solutions and workarounds employed (namely tactics) in order to overcome or bypass such problematic situations in §6. We compare the problematic situations and tactics identified with previous work in §7; we also contextualise tactics in light of coping theory and we finally discuss how matching tactics to coping situations paves the way to programmatically detect problematic situations. The implications for evaluating accessibility-in-use and modeling navigational behaviour are also discussed.

2. Adaptive Behaviour and Coping

Adaptive behaviourists establish that skills are learned through experience and when these skills are automatically exhibited, the relationship between individuals and the environment is more effective. At early stages of skill acquisition, an enormous effort and concentration is required, while at the later stages skills become gradually automated. Adaptive behaviour is the behaviour by which individuals adjust to the environment. Coping is defined as “the constantly changing cognitive and behavioural efforts to manage specific external or internal demands that are appraised as taxing or exceeding the resources of a person” (Lazarus and Folkman, 1984) and as such it can be considered an extreme adaptation. Even if the boundary between adaptive behaviour and coping is fuzzy, these are normally distinguishable efforts. Coping is often required when new situations are faced and such events cannot trigger automatic responses. Cognitive control mechanisms deal with automatic behaviours, whereas coping takes place if the response is purpose-
ful and requires effort. Both of them are adaptational activities yet coping requires effort and consciousness. One of the misconceptions about coping is relating it to successful outcomes. Coping strategies can be good or bad depending on the individuals and their environment. Therefore, its effectiveness is determined by the long-term effects of employing a given strategy in a specific situation. Another common misunderstanding is to consider coping as gaining mastery over the environment. Coping does not only entail applying problem-solving strategies but also managing one’s emotions, which is considered equally important for adaptational purposes. Coping tactics tend to be exhibited in the following situations:

- **Uncertainty.** In the context of coping theory uncertainty is defined as “the sense of doubt that blocks or delays the action” (Lipshitz and Strauss, 1997). There are 3 situations that generate uncertainty: inadequate understanding, incomplete information and undifferentiated alternatives. The strategies adopted for coping with uncertainty in real life are assumption based reasoning, weighting pros and cons of competing alternatives and forestalling. Decision making under uncertainty is typically biased by the use of stereotypes in the judgements (representativeness), the familiarity with the stimuli (availability) and the initial assessment, which determines subsequent ones (anchoring) (Tversky and Kahneman, 1974).

- **Reduced mobility.** Case studies describing the way in which concentration camp prisoners, prisoners of war or people who have suffered natural catastrophes behave give some hints about the coping strategies that are adopted in analogous situations where freedom and autonomy are reduced or non-existent (Moos, 1976). The tactics adopted in such situations, amongst many others are: null coping, surrendering to coping, taking advantage of smallest portion of autonomy or focusing on small gratifications.

- **Confusion.** Confusion is a category built on the appraisal factors of novelty, unfamiliarity and ambiguity of the setting (Lazarus and Folkman, 1984). Therefore, the initial expectations of the user play a central role. When any of these factors is present confusion is likely to happen.

- **Overload.** Selective attention allows individuals to discriminate between many sources of information (through the visual and auditory
channel) and select just the one it is targeted. It is a mechanism to overcome information overload by tracking some stimuli at the expense of others. This way, one can attend to what is important in a given environment and to adaptively cope with changed circumstances. When it comes to coping, filtering and withdrawal emerge as the strategies employed by individuals (Savolainen 2007).

In circumstances of uncertainty, reduced mobility, confusion and overload, coping involves the simultaneous management of the following variables that can be operationalised through coping tactics (White 1974).

- Individuals have to keep the right amount of information about the environment. Cognition requires the right amount of information as a guide to action: depending on the situation, adaptation may require seeking for more information or just removing the exceeding one.

- Individuals have to maintain satisfactory internal conditions in terms of alert and information processing in order to be ready for any event that may happen.

- Individuals have to maintain autonomy or freedom on the environment. This requires a constant monitoring of the available ways of escaping from any potentially threatening situation.

3. Related Work

Goble et al. (2000) employed the travel metaphor to define the Web mobility of visually disabled users, where blind users employed several mobility instruments in their journeys: in-journey guidance is the implementation of asking for directions in the physical world by means of bookmarks and browser history; previewing and probing are employed to get a glimpse of the page by traversing it in a sequential fashion or by jumping between headings. This allows the identification of obstacles and areas of interest for later exploration. Clicking on a link, followed by a quick exploration of the page beyond the link and returning to the linking page is another implementation of probing corroborated by Bigham et al. (2007). In this study it was found that when coming across accessibility barriers, some blind users make use of cursor keys, which is the functionality that simulates the use of the mouse by reading out loud the area of the page which is hovered.
In exploring navigability of e-commerce sites for blind users, Takagi et al. (2007) discovered the importance of landmarks for orientation purposes; additionally it was observed that users stick to their methods even if accessibility bridges such as headings or skip-links are provided. Alternatively, users employ the exhaustive scanning tactic by listening to content in a sequential fashion; also, users exhibit the gambling scanning tactic by jumping forward and skipping a determined amount of lines until bumping into content that draws their attention, normally because of its strong information scent; thereafter users navigate sequentially. The memorisation of the amount of links users have to skip in order to get to the main content was also observed in pages users were familiar with (Yesilada et al., 2007). When it comes to information retrieval tasks, it was observed that screen reader users try to write accurate queries in search engines in order to minimise the overall search time (Sahib et al., 2012). If results are not satisfactory, instead of refining the initial query – as sighted users do – screen reader users submit a different one.

Users make the most of screen readers by increasing their speech rate or by using them jointly with another assistive technology such as Braille displays (Borodin et al., 2010). Additionally, the role that previous experience and familiarity with pages plays is also highlighted in that it shapes how users are able to guess the labels in non-accessible forms. Another example of how familiarity determines interaction is related to the dynamic nature of Web 2.0: if users have previously experienced frequent updates in a given web page, this leads them to learn how to manually refresh the page and then navigate right to the area that is updated (e.g., a ticker).

The coping strategies employed by low vision users have been used to inform behaviour based transcoding of web pages (Lunn et al. 2011). The interesting contribution regarding tactics relies on the fact that this work confirms the similarity of the tactics employed by blind users and low vision users employing screen readers, screen magnifiers or both: candidate chunk discovery is equivalent to gambling scanning (Takagi et al., 2007), masthead avoidance is observed elsewhere (Yesilada et al., 2007) when referring to the memorisation of the number of links to skip in order to get to the main content, probing (Goble et al., 2000) is identified again, clustered element strategy extends the usage of cursor keys (Borodin et al., 2010) by describing how it is used in a concentric fashion; finally, the backtracking strategy describes how users, when facing difficulties, click back until reaching a familiar web page.
Most works above describe adaptive behaviour tactics in that they do not report whether users have undergone extreme adaptations, which suggests that the tactics above are regularly employed procedures. As we are interested in the tactics employed by visually disabled users when encountering problems, the most closely related work about coping tactics deals with the frustration of blind users on the Web (Lazar et al., 2007). Under frustration, users often employ asking for help, re-trying, giving up and restarting tactics. However, the most frequent actions taken by users (accounting for the 78% of the reported tactics) were inconclusive about how users tackled frustrating situations: “I was unable to solve it”, “I knew how to solve it because it has happened before”, “I found an alternative solution”, “I figured out how to fix it myself” and “I rebooted”. Our work expands on this by analysing the coping tactics employed by visually disabled users in problematic situations.

4. Observational Setting and Data Acquisition

In order to expand on the hints provided by previous work, we conducted a secondary analysis of two heterogeneous datasets belonging to two independent in-situ studies: the first is a think-aloud exercise where visually disabled users had to accomplish a number of tasks, while the second study reports the observations carried out by two investigators during a course where users learnt how to develop their Internet skills.

When analysing data to identify coping situations and behaviours, in-situ observations have a number of benefits compared to other data collection methods: in-situ observations allow to recognise emergent behaviours, identify the sources of user frustration and enable a better understanding of when, why and how users employ determined tactics. On the other hand, in-situ observations have some limitations as they are resource intensive; moreover, observers may introduce subjectivity or may miss relevant events.

Visually disabled users are heterogeneous and the tactics they employ to overcome problematic situations may vary based on their abilities or expertise. That is why we categorise the participants of both studies in terms of experience, disability and assistive technology used. Experience is measured in terms of exposure to the Web so we group participants as experienced if they have been exposed to the Web for more than one year and we group them as novices otherwise. Regarding disability, users are categorised as blind or visually impaired, and the assistive technologies they employ are screen readers, screen magnifiers, a combination of them or none of them.
The heterogeneity of datasets jointly with the fact that datasets were collected by different researchers who employed different collection methods allows us to triangulate the data and remove the possible bias introduced in each study.

4.1. Study 1

The goal of this study was to analyse the interaction of blind and visually impaired users on the Web. A think-aloud method was employed so that the observer could record what users verbalised jointly with interaction data\textsuperscript{2}.

4.1.1. Type of Data Analysed

As mentioned, the dataset not only contains the verbalisations of the user that correspond to the think-aloud protocol, but includes also additional explanatory comments made by the observer that help to clarify the situations; the interaction with the keyboard and the mouse, and the commands executed are also recorded. An excerpt of the interaction of \textit{U12} in this dataset looks as follows\textsuperscript{3}: 

- \textbf{Arrow Down} to select Africa [by mistake]
- [Page brings up Telegraph Travel window but JAWS does read it out]
- (It’s gone, the information refuses to come up)
- \textbf{Click on} back (I’ll start again)
- \textbf{Read out} top of the page [user is in the travel page, not in the weather page but he does not realise]
- \textbf{Tab down} through links
- \textbf{Tab up} page (where is the weather?)

4.1.2. Users

Table \[\textbf{1}\] shows the profile of the 19 participants that took part in the study: 13 blind (68\%) and 6 visually impaired users (32\%). 16 participants (84\%) employed screen readers in the study (2 of them used them jointly with a Braille display) distributed as 11 JAWS users (69\%), 3 SuperNova users (19\%) and the remaining 2 (13\%) used another screen reader. Finally, 2 visually impaired users did not use any assistive technology at all but just

\textsuperscript{2}Dataset from study 1 cannot be published due to the ethical arrangements made by its author.

\textsuperscript{3}The square brackets are the comments made by the observer and the round brackets is the verbalisation of the user.
looked closer to the screen and only 1 visually impaired user relied on a screen magnifier alone. All participants had more than 1 year of experience in the Web so we classified them as experienced users. It can be observed that the group was not homogeneous and the usage of assistive technologies varied across users and disabilities. Unsurprisingly, some visually impaired users employed screen readers, while some other did not use any assistive technology. The last column in table 1 refers to the onset in which the disability was acquired\textsuperscript{4}.

4.1.3. Tasks

Each participant had to accomplish 4 tasks without any time limitation; they had to find (1) the weather forecast for a specific location, (2) specific information about a journal in a digital library, (3) information about Solomon Islands in a large catalogue of resources, and (4) purchase a suit in a large department store.

4.2. Study 2

The study presented in this report is based on in-situ observations of visually impaired users interacting with Web technology. These observations took place in a course where people with visual disabilities learn to use technology and they are especially helped to develop Web access skills. Participants are taught all the basics about computers, Internet, browsers, screen readers and screen magnifiers. Thus it can be understood as a course to acquire computer literacy. Users often talked among themselves in order to recommend a certain website or to give some assistance when they needed help. They were supervised by visually disabled tutors who gave them a crash course on basic commands before they were started. Sometimes, the tutors would also suggest some websites for job seeking purposes.

The two observers that reported observational data played the role of classroom assistants, offering their assistance to users during the course. Participants were informed that two observers were in the class ready to help. Adopting a peripheral membership role (Adler and Adler [1987]), observers

\textsuperscript{4}Due to the neuroplasticity of the brain, the visual cortex of those who have an early onset of blindness gets adjusted for other purposes; e.g., the part that was originally devoted to vision is repurposed for touch or hearing. Even if there is not an agreement upon the age in which the cortex loses its plasticity, it is suggested that it occurs around the age of 16 (Sadato et al. [2002]).
Table 1: Users taking part in study 1.

<table>
<thead>
<tr>
<th>id</th>
<th>disability</th>
<th>assistive technology</th>
<th>specific AT</th>
<th>experience</th>
<th>onset</th>
</tr>
</thead>
<tbody>
<tr>
<td>U1</td>
<td>blind</td>
<td>screen reader</td>
<td>SuperNova</td>
<td>experienced</td>
<td>before 16</td>
</tr>
<tr>
<td>U2</td>
<td>blind</td>
<td>screen reader</td>
<td>JAWS</td>
<td>experienced</td>
<td>N/A</td>
</tr>
<tr>
<td>U3</td>
<td>blind</td>
<td>screen reader</td>
<td>SuperNova</td>
<td>experienced</td>
<td>congenital</td>
</tr>
<tr>
<td>U4</td>
<td>visually impaired</td>
<td>none</td>
<td>User looks closer to the screen</td>
<td>experienced</td>
<td>N/A</td>
</tr>
<tr>
<td>U5</td>
<td>blind</td>
<td>screen reader</td>
<td>JAWS</td>
<td>experienced</td>
<td>congenital</td>
</tr>
<tr>
<td>U6</td>
<td>blind</td>
<td>screen reader</td>
<td>JAWS</td>
<td>experienced</td>
<td>before 16</td>
</tr>
<tr>
<td>U7</td>
<td>blind</td>
<td>screen reader</td>
<td>JAWS and Braille display</td>
<td>experienced</td>
<td>after 16</td>
</tr>
<tr>
<td>U8</td>
<td>visually impaired</td>
<td>screen reader</td>
<td>PW Webspeak</td>
<td>experienced</td>
<td>N/A</td>
</tr>
<tr>
<td>U9</td>
<td>blind</td>
<td>screen reader</td>
<td>JAWS</td>
<td>experienced</td>
<td>N/A</td>
</tr>
<tr>
<td>U10</td>
<td>visually impaired</td>
<td>screen reader</td>
<td>SuperNova</td>
<td>experienced</td>
<td>N/A</td>
</tr>
<tr>
<td>U11</td>
<td>visually impaired</td>
<td>none</td>
<td>User looks closer to the screen</td>
<td>experienced</td>
<td>N/A</td>
</tr>
<tr>
<td>U12</td>
<td>blind</td>
<td>screen reader</td>
<td>JAWS</td>
<td>experienced</td>
<td>before 16</td>
</tr>
<tr>
<td>U13</td>
<td>blind</td>
<td>screen reader</td>
<td>JAWS</td>
<td>experienced</td>
<td>before 16</td>
</tr>
<tr>
<td>U14</td>
<td>visually impaired</td>
<td>screen magnifier</td>
<td>Zoomtext</td>
<td>experienced</td>
<td>N/A</td>
</tr>
<tr>
<td>U15</td>
<td>blind</td>
<td>screen reader</td>
<td>HAL</td>
<td>experienced</td>
<td>N/A</td>
</tr>
<tr>
<td>U16</td>
<td>blind</td>
<td>screen reader</td>
<td>JAWS</td>
<td>experienced</td>
<td>congenital</td>
</tr>
<tr>
<td>U17</td>
<td>visually impaired</td>
<td>screen reader and screen magnifier</td>
<td>JAWS and Zoomtext</td>
<td>experienced</td>
<td>before 16</td>
</tr>
<tr>
<td>U18</td>
<td>blind</td>
<td>screen reader</td>
<td>JAWS</td>
<td>experienced</td>
<td>N/A</td>
</tr>
<tr>
<td>U19</td>
<td>blind</td>
<td>screen reader</td>
<td>JAWS and Braille display</td>
<td>experienced</td>
<td>after 16</td>
</tr>
</tbody>
</table>
sat next to the participants on a one-to-one basis. Participants were observed while interacting with the Web so that the difficulties encountered, problems faced and steps taken could be identified and jotted down by observers. When participants faced difficulties, help was not provided if it was not explicitly requested. In such situations, participants were encouraged to overcome the problem by themselves. Assistance was provided as a last resort when all remaining options had been exhausted and it was clear that participants would be unable to accomplish their goals. The notes taken during the observations were transformed into formal observation reports after each session (available at Lunn and Michailidou, 2007; 2008).

4.2.1. Type of Data Analysed

The dataset contains a detailed description of the actions taken by users, the way in which assistive technology is employed and the problems encountered. For example, the following excerpt shows how user interaction is described in these datasets: “... the button was not within U20’s field of view due to screen magnification. Also, the background colour and button colour did not have a high contrast and U20 found it difficult to identify the button and click on it. It only when the mouse pointer changed from a pointer icon to a hand icon that ...”.

4.2.2. Users

5 users were observed in periods of time comprising a maximum of 2 months. The small amount of number of users can be counterbalanced with multi-session observations ranging from 2 to 5 sessions, where a wide variety of behaviours can be exhibited. Table 2 shows the profile of the participants: U20 is visually impaired and makes use of Zoomtext. He had used the Internet before but when the course started he had already forgotten how to use it. U21 is visually impaired although his vision is variable. Some days he can see better than others and on these occasions he will make use of the Zoomtext screen magnifier. On a bad day the Jaws screen reader will be used. He has basic knowledge on computers although he is inexperienced on the Web. U22 is profoundly blind, has a guide dog and is a Braille competent user; his interaction method is the Jaws screen reader. He never used a computer prior to the course. U23 is visually impaired but not profoundly blind; he never used a computer before and spent most of his time learning basic computer functionalities. Only at the end of the course was able to start browsing using the Jaws screen reader. U24 is a experienced user who
Table 2: Users taking part in study 2.

<table>
<thead>
<tr>
<th>id</th>
<th># of sessions</th>
<th>disability</th>
<th>assistive technology (AT)</th>
<th>specific AT</th>
<th>experience</th>
<th>onset</th>
</tr>
</thead>
<tbody>
<tr>
<td>U20</td>
<td>5</td>
<td>visually impaired</td>
<td>screen magnifier</td>
<td>Zoomtext</td>
<td>novice</td>
<td>N/A</td>
</tr>
<tr>
<td>U21</td>
<td>5</td>
<td>visually impaired</td>
<td>screen reader or screen magnifier</td>
<td>JAWS or Zoomtext</td>
<td>novice</td>
<td>N/A</td>
</tr>
<tr>
<td>U22</td>
<td>4</td>
<td>blind</td>
<td>screen reader</td>
<td>JAWS</td>
<td>novice</td>
<td>N/A</td>
</tr>
<tr>
<td>U23</td>
<td>2</td>
<td>visually impaired</td>
<td>screen reader</td>
<td>JAWS</td>
<td>novice</td>
<td>N/A</td>
</tr>
<tr>
<td>U24</td>
<td>2</td>
<td>visually impaired</td>
<td>screen magnifier</td>
<td>Zoomtext</td>
<td>experienced</td>
<td>N/A</td>
</tr>
</tbody>
</table>

is visually impaired and uses the Zoomtext screen magnifier. His goal in the course was to acquire further browsing skills. Based on their skills and knowledge on accessing the Web, all the subjects that took part in study 2 but U24 were considered novice users.

4.2.3. Tasks

There were no structured tasks to accomplish as users were free to browse the Web. Users tended to browse on sites that were going to be useful for them in the near future. For instance, they emulated the booking of a flight or the purchase of an item in an e-commerce site. Users also tried to browse on nationwide and local media; they also browsed for fun and this sometimes led them to serendipitous findings. However, they were encouraged by tutors to navigate through pages that would allow them to get a job as one of the goals of this course was to increase their employability prospects. Users were not constrained by time in any of their tasks.

4.3. Data Analysis Method

We analysed the datasets of study 1 and study 2 in two main stages: discovery and coding (Taylor and Bogdan, 1984). In the discovery stage we got familiar with the data and identified the main themes and concepts. To do so, we paid attention to those events that were especially problematic for users. Datasets contained three main indicators pointing to these problematic situations: problems reported by the observers (e.g., “user is confused over which resource to use”), utterances of users that denoted problems (e.g., “I’ve no idea what these links are”) and a combination of observer and user reports.
The actions taken by users as a reaction to problems, namely tactics, were also collected. Specific key or mouse events are of a too low granularity level, making it difficult to find a manageable set of tactics. Therefore, a medium granularity level – a concatenation of low level events – allowed us to find tactic patterns across users. In the coding stage we refined the discovered concepts and found relationships between them in order to categorise them. To do the categorisation we followed as follows:

- Initially, in order to identify coping situations we did a first pass using categorical coding by classifying encountered problems and tactics according to the situations described in §2: uncertainty, reduced mobility, confusion and overload. We proceeded similarly to categorise the tactics employed. One of the advantages of using coping theory to categorise problematic situations and the tactics employed to overcome them is that it allows to identify and describe the problems faced by users on the Web independently of how the underlying technology is deployed (see §5.1).

One of the weaknesses of current literature is that tactics employed by users are dependent on the implementation and design of web pages. For instance, one of the tactics found by Yesilada et al. (2007) was that users counted the number of tabs in order to skip content at the top of the Google results page. If the mentioned web page updates or if the design patterns of websites evolve or if assistive technology provides the mechanisms to bypass such problems, the coping tactic becomes obsolete. By employing categorical coding, we aim at having generalisable outcomes that are applicable in the future regardless the evolution of design patterns, Web technology or user agents.

- In a second pass we coded the data in a open or emergent fashion. In this way, the categories describing problematic situations emerged without any intentional prejudice. As a result we came up with the following categories that determine problematic situations on the Web: accessibility issues, unmet expectations, navigation strategy, exploration strategy, information architecture, assistive technology and emotional issues (see §5.2 for further information).

- Finally, we mapped the general categories found as a result of employing categorical coding into the categories encountered by employing
emergent coding. While the former categories are independent of the underlying Web technology, the latter are dependent on it. By proceeding in this way, we were able to identify the emergent specific cases of the general case.

The categorisation of the problematic interactions faced by users was carried out with dataset 1 (the dataset from study 1) at each pass of the data analysis (categorical coding and open coding). At each pass, we employed dataset 2 to confirm and validate the categorisation built using dataset 1. We found that our initial categorisation was able to accommodate the problematic situations found in dataset 2. This confirms the flexibility of the categorisation and the lack of possible bias that might have been introduced when building it. As a result, except those categories containing a small number of reported problematic situations, there are not categories that belong to a specific dataset and the problematic situations of each dataset appear at least once in each category, as table 4 and table 5 illustrate.

When it comes to the categorisation of the tactics employed to overcome the problematic situations, the two datasets contain all the identified tactics although some of the implementations of tactics are particular to a dataset. The last column in table 6 sheds more light on the particular user group that employs a determined tactic. This can be justified in that the stereotypical user of dataset 1 is an experienced screen reader user, while dataset 2 mainly contains visually impaired novices. This indicates that the strength of our categorisation resides on being able to accommodate heterogeneous datasets containing heterogeneous user profiles.

5. Inventory of Problems Faced

The analysis revealed 129 problematic situations in which the 24 users faced problems of a different nature. Table 3 outlines the number of situations categorised by disability and employed assistive technology.

5.1. General Coping Situations

By considering coping theory discussed in §2, we categorise coping in the Web with regard to situations of uncertainty, reduced mobility, confusion and overload. The boundaries of such categories were not always clear as sometimes we could find situations fitting in more than one category. For instance,
Table 3: Number of problematic situations analysed

<table>
<thead>
<tr>
<th>Category</th>
<th>Study 1 situations</th>
<th>Study 1 users</th>
<th>Study 2 situations</th>
<th>Study 2 users</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visually impaired</td>
<td>31</td>
<td>7</td>
<td>34</td>
<td>4</td>
</tr>
<tr>
<td>Blind</td>
<td>50</td>
<td>12</td>
<td>14</td>
<td>1</td>
</tr>
<tr>
<td>Screen reader users</td>
<td>71</td>
<td>15</td>
<td>16</td>
<td>2</td>
</tr>
<tr>
<td>Screen magnifier users</td>
<td>0</td>
<td>1</td>
<td>21</td>
<td>2</td>
</tr>
<tr>
<td>Screen reader and screen magnifier users</td>
<td>5</td>
<td>1</td>
<td>11</td>
<td>1</td>
</tr>
<tr>
<td>None</td>
<td>5</td>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

it was common to find confusing and overloading situations where each category appeared at a different degree. We decided to classify such situation based on its most prominent characteristic – especially if it was indicated by the user –, for instance: if confusion prevailed over being overwhelmed the situations was classified as “confusing”.

5.1.1. Uncertainty

Unexpected banners, previous negative experiences in navigating through similar content or lack of alternative text for pictures are some of the problems that cause uncertain situations. U10 expressed uncertainty as “I can’t read this but I will give a try, I am assuming it is what I want so let’s see where it takes me”; also while U18 was exploring a page and was not able to find what he was looking for, commented “I’m not confident this is what I want”, when coming across some pictures that did not have any alternative text.

5.1.2. Reduced Mobility

Looping on a sequence of pages and not being able to escape, finding oneself in a dead-end web page or software compatibility problems depict some of these situations. These situations are illustrated by U10 when realising he had unintentionally looped “I’ve got back to shorts again ... shorts again!” or U21, when he was not able to get out of the navigation bar; the observer comments “JAWS seemed to read the links many times, as though in an infinite loop”. Some expressions illustrate how users got disoriented: “Oh, I’ve got lost, I don’t know where I am now” as a consequence of U17 clicking in the wrong link or “Not sure where I am ... if in doubt go back to the beginning”, after U2 read all the results provided by a search engine.
5.1.3. Confusion

There is a broad scope of situations that generate confusion to users: problems with text size, the lack of search results, encountering unfamiliar content and functionalities, or misuse of assistive technology, to name a few. An example of a confusing situation is the one faced by U16 when a search engine provided 0 results: “Where have the results gone?”; U19 was unable to distinguish between a link and text, “It’s not there ... it’s annoying me now ... it’s not a link!”.

5.1.4. Overload

Some of the situations that illustrate overwhelming situations are a large amount of search results, too many steps to complete a transaction and a large number of items in navigation menus. Overload can be illustrated by the following examples: when the prospect of a large amount of links deterred U7 from carrying on: “900 links ... OK that’s enough”; U6 was aware that the page contained what he was looking for but the goal was buried somewhere in between all the information provided: “This is a problem sometimes, you can have 30 or 230 links that you have to sit and listen to!”.

5.2. Specific Emergent Coping Situations
5.2.1. Accessibility (A)

As expected there are a number of accessibility barriers that cause problems in accessing the content and hinder the interaction of visually disabled users. While this category encompasses those problems that are covered by accessibility guidelines (Caldwell et al., 2008), it can be argued that the remaining categories contain also accessibility issues if one has a more ample definition that goes beyond the traditional understanding of accessibility. For instance when encountering pictures without alternative content U12 described “[screen reader] keeps reading out part of weather page: ‘min’, ‘min’, ‘min’”; in the case of U2, when a number of links were similarly labelled: “everything seems to say ‘suit pieces’, will probably have to click on every link to find out what happens”.

5.2.2. Unmet Expectations (UM)

Our analysis found that user expectations tend not to be met due to a number of reasons: coming across unfamiliar layouts and functionalities, bumping into banners and advertisements and lack of results when querying
search engines, to name a few. For instance, \textit{U10} got surprised when finding a banner about mortgages while searching for the weather forecast: “\textit{Mortgages? What’s that got to do with the weather?”}; similarly when no results were provided by a search engine \textit{U1} expressed “\textit{Don’t understand what all this is about}”.

5.2.3. \textit{Inter-page Navigation Problems (N)}

Inter-page navigation refers to the steps taken by users to reach to the page that contains their goal. Therefore, we focus on the hyperlink assessment made by users and the sequence of hyperlinks scanned and clicked. Navigation problems can be illustrated as when \textit{U17} realised he had looped while searching for information “\textit{Damn, I’m just going round in circles}”; when \textit{U12} had wrongly implemented the backtracking technique (as he unintentionally skipped the page he was looking for) and got to another different one: “\textit{Where is the weather? ... I have come to the conclusion that I am on the wrong page}”.

5.2.4. \textit{Intra-page Exploration Problems (E)}

Intra-page exploration refers to the navigation of the user within a web page, it is all about reading and listening to content, scanning through links in order to find the goal or the link which will lead to the goal. Exploration problems can be described as the situation faced by \textit{U18} when arrowing around (using the virtual cursor) deviated him from the goal, which was actually very close to him. Another example of exploration problems is depicted when \textit{U10} got to a page containing his goal but it was missed as the user just gave a quick overview to the page without traversing it.

5.2.5. \textit{Information Architecture (IA)}

This category refers to those elements of the interface that regardless their (lack-of) accessibility cause problems to users. They can be considered design problems as they are closely related to current website conventions in terms of layout and content arrangement (mast header, lateral navigation links menu, banner, content, footer, etc.) and the amount of information in each component. Such problems can be described as follows: \textit{U23} found too much textual information between the top and the main content of the page, “\textit{This is doing my head in this}”. Similarly, a number of links sat in between the location of \textit{U2} and his desired content: “\textit{There are lots of links between the search box and results}”.

18
Table 4: Mapping general situations to emerging coping situations: number of users experiencing problems in study 1 (s1) and study 2 (s2)

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>UM</th>
<th>N</th>
<th>E</th>
<th>A</th>
<th>AT</th>
<th>EM</th>
<th>unique users</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>s1</td>
<td>s2</td>
<td>s1</td>
<td>s2</td>
<td>s1</td>
<td>s2</td>
<td>s1</td>
<td>s2</td>
</tr>
<tr>
<td>uncertainty</td>
<td>5</td>
<td>1</td>
<td>3</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>reduced mobility</td>
<td>2</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>4</td>
<td>3</td>
<td>1</td>
<td>3</td>
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<tr>
<td>confusion</td>
<td>1</td>
<td>1</td>
<td>9</td>
<td>3</td>
<td>10</td>
<td>2</td>
<td>9</td>
<td>3</td>
</tr>
<tr>
<td>overload</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0</td>
<td>1</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

5.2.6. Assistive Technology Issues (AT)

There are some interaction problems that are caused by the lack of knowledge about specific features of screen readers, misuse of their functionalities of because users forget to activate a specific interaction mode (i.e., forms mode in JAWS). For instance, a software compatibility problem frustrated U15: “this is a waste of time ... it just will not read it ... don’t want this ... can’t go on this ... can’t understand it”; the lack of synchronisation between the screen magnifier and the screen reader lead U17 to an unwanted location: “I meant to click on search [link]”.

5.2.7. Emotional Coping (EM)

The current mood and the confidence on what users are doing plays a key role in determining subsequent interactions on the Web. This category refers to the situations that are constrained by a previous negative experience in a similar page or in the previous task. As an example of emotional coping, U20 was disheartened because of a previous bad experience, which negatively influenced his subsequent experience. Similarly, after unsatisfactorily exploring the page, U18 clicked on a link not being sure of what he was doing “I’m not confident this is what I want”.

A mapping between the problematic situations categorised through categorical (see §5.1) and open coding (see §5.2) allows to identify the emergent specific cases of the general case. Table 4 shows the number of users who experienced problematic situations in each mapped category, whereas table 5 depicts the number of problematic situations analysed.
Table 5: Mapping general situations to emerging coping situations: number of problematic situations in study 1 (s1) and study 2 (s2)

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>UM</th>
<th>N</th>
<th>E</th>
<th>A</th>
<th>AT</th>
<th>EM</th>
<th>total</th>
</tr>
</thead>
<tbody>
<tr>
<td>uncertainty</td>
<td>13</td>
<td>1</td>
<td>3</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>5</td>
</tr>
<tr>
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<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>25</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(19%)</td>
</tr>
<tr>
<td>reduced mobility</td>
<td>2</td>
<td>2</td>
<td>-</td>
<td>-</td>
<td>6</td>
<td>3</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2</td>
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<td></td>
<td></td>
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<td></td>
<td></td>
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<td></td>
<td></td>
<td>23</td>
</tr>
<tr>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(18%)</td>
</tr>
<tr>
<td>confusion</td>
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<td>4</td>
<td>11</td>
<td>9</td>
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<td>59</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(46%)</td>
</tr>
<tr>
<td>overload</td>
<td>-</td>
<td>-</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>-</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>10</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(21%)</td>
</tr>
</tbody>
</table>

6. Compendium of Tactics Employed

Users employ different tactics when tackling problematic situations. Generally, there is not a unique way of implementing each tactic but there are several ways in which users articulate them. Next, we discuss the categorisation of tactics and the different implementations we found; table 6 shows the details about the frequency and number of users who employed each tactic, its implementations, the coping situation in which the tactic occurs and whether a given implementation was specific to a particular groups of users (rightmost column).

6.1. Tactic 1: Asking for Assistance

Users asked for assistance for many different purposes and in diverse contexts of use. Our analysis discovered that novice users employed this tactic when encountering problems. We provide further details on the main purposes of this tactic:

**I11. Get reassurance.** Under a situation of uncertainty some users ask for help to be reassured. The lack of confidence of U5 confused her about whether she could type the keywords in a textbox “Shall I just type in the search terms?” A previous disheartening negative experience U20 had undergone led him to ask for help to be reassured: “is this is where I click? [his confidence was slightly knocked from not being able to complete the previous task]”.

**I12. Get confirmation.** In a situation of confusion, some screen reader users request a description of what is displayed on screen. U22 also wanted to be confirmed whether a navigation menu was being repeated at every page in all the pages of a site. In order to perform a search U10 expected to find a
textbox to submit a query although he encountered a link that would lead him to it “is there a search facility?”.

I13. Get further instructions. Some novice users requested further instructions under a variety of situations: e.g., while traversing confusing layouts or when looking for buttons that were located out of their field of view. For example, U24 was confused on how to proceed next in filling out a form “[U24 became confused as he was unsure what to do next...became visibly frustrated]”. Issues related to screen reader functionalities were also mentioned: users asked about how to activate/deactivate features, they also asked for more efficient reading modes when the ones used were not considered effective any more (such as exhaustive scanning techniques) or asked about basic functionalities (U22 did not know how to tab backwards). Users also requested more instructions when the screen reader behaved unexpectedly.

6.2. T2: Impulsive Clicking

Users click on links without much forethought in order to escape from the problematic situation they are undergoing. In our analysis, we found that users clicked on links with low information scent, which indicates that pages beyond these links were not likely to lead users to their goals. Impulsive clicking was employed mainly by expert users, implemented in several ways:

I21. Deliberately clicking on low scented links. Users click on a link that will not lead them to their goal but will alleviate the problem they are facing. This behaviour was found in situations of uncertainty caused by accessibility issues, especially when pictures lack alternative text or links are poorly labelled. U1 clicked on a bitmap without knowing what it was: “I’m just going to click on one of these things, I don’t know what it is for”. U2 encountered a high number of poorly labelled links “everything seems to say ‘suit pieces’, will probably have to click on every link to find out what happens...tried any one to see what you get”. U7 got confused because the screen reader combined the content of cells of a table containing links, “it reads The British Journal of PERIODICAL Visual Impairment, this does not make sense!” but the user still clicked on the link. U7 had to undergo the uncertainty caused by a large number of links, “when I was listening I heard that one of the links was weather [the target link] - this is a problem sometimes, you can have 30 or 230 links that you have to sit and listen to!” but instead of looking for that precise link the user clicked on another link he knew would
not lead him to the goal. In these situations of uncertainty users clicked on links that would help them escape from the page that was causing them problems even if this entailed to change the navigation course.

I22. **Clicking on any link after coming across unexpected functionalities or content.** Users click on any reachable link in a situation of confusion produced by a previous unsuccessful exploration, by an unfamiliar functionality or by mistakenly clicking on a link. The following are some of the situations that provoke such behaviour: unconventional features in the form of a unexpected search functionality made U1 click on a linked keyword even if U1 was expecting a search box, “*does not tell me where to do this*”. Even if U2 did not get what he was looking for in a search engine results page, “*found a few links, none directly what I want*” he still clicked on the results. U19 was unable to distinguish between links and content as he was expecting a piece of text to be a link “*nothing happens...I’m going to have to click on another link*” and then clicked on the next available link.

I23. **Clicking on any link as long as it is accessible.** U10 clicked on any link that was accessible (in terms of being properly labelled) due to the uncertainty caused by surrounding inaccessible content “*the links are hard to read, I’m trying to find a link I can read*”. As a consequence, not following a highly scented but accessible link leads U10 to a page that does not contain his goal.

6.3. **T3: Exploration Tactics**

Exploration tactics refer to the actions taken by users to acquire more information about the current web patch in order to accomplish their tasks. Exploration tactics are implemented in several ways:

I31. **Persevering.** Some novice users repeated the same actions time and again, mostly under situations of confusion. These situations can be illustrated as when U20 was not able to distinguish between advertisements and search results; also, when clicking on a link did not apparently work for U21 (as he was clicking on a link that was leading him to the current page). Perseverance was exhibited by U20, who kept looking around, while U21 clicked time and again on the same link.
I32. Escaping from non-useful, non-usable or inaccessible content by tabbing down or scrolling down. This behaviour was observed when U20 came across a highly scented text and mistakenly tried to click on it thinking it was a link “It’s not there... it’s annoying me now... it’s not a link!”. U17 proceeded similarly when instead of finding the results produced by a search engine, he encountered a number of links that sat between the search box and results: “where have the results gone?”.

I33. Fast tab/scroll/arrow down the page without completely listening to content. Users employ this tactic on familiar pages “I know you can get weather forecasts from this site” (U3) and tab down the page very quickly without reading the content of links in a complete way. On unfamiliar pages some users also employ this technique if content is arranged according to some criterion (alphabetically, yearly, etc.); this tactic has some risk in that users may miss the content they are looking for: while tabbing down very quickly, U5 and U14 skipped the links they were looking for and had to backtrack.

I34. Moving around. Screen magnifier users explored areas of interest in a circular and outwards fashion with their screen magnifiers. Moving around is mainly employed under situations of confusion caused by unexpected banners, navigation menus with a unclear purpose or when a misleading link was clicked, to name a few. Moving around was employed when the screen magnifier and the cursor were not focusing at the same content: before moving around U17 unintentionally clicked on a link because the screen reader and screen magnifier were focusing on different content; similarly, U12 clicked twice on a link thinking it was the text he was currently reading.

6.4. T4: Narrowing down search

This tactic is similar to exploration tactics (T3) although it is applied in a sequence of pages instead of applying it in a single page. Users narrow down the selection of links in their navigation towards their goal by not visiting those links that lead to unsatisfactory pages. Therefore users just click on those links that had not been selected yet. Narrowing down search was mostly employed under situations of confusion caused by clicking on links with low information scent and when users clicked on highly scented links that did not lead them towards the goal (also called high-quality distractors by Brumby and Howes (2008)). It was observed that after retracing (see I63
below) and reaching the turning point of the previous failed trial, some users employed this tactic.

6.5. T5: Gaining Orientation

We observed that users sometimes lost their orientation within a web page (local orientation problem) and when they traversed through different web pages (global orientation problem). In the former case users are not able to locate themselves within a page, whereas in the latter users lose their spatial location in the sequence of pages they have traversed. Users employ this tactic not only to overcome mobility problems caused by disorientation as one could expect, but also to overcome confusing situations.

I51. Gaining local orientation by going to the top of the current page. Some expert users get to the top of the page after reaching the bottom of the page when they have not found what they are looking for. U2 was feeling disoriented at the bottom of the page after reading the list of results provided by a search engine: “not sure where I am...if in doubt go back to the beginning”. After scanning through all the results provided by a search engine and not finding expected results U14’s cursor was located at the bottom of the page; U14 believed results must be in that page, “I’m convinced I have here the results...can’t find any actual result” so U14 got to the top of the page, started the navigation over and traversed the page more slowly this time.

I52. Gaining global orientation by backtracking to a shelter. A shelter is a web page users are familiar with and does not challenge them. The tactic is implemented in such a way that users tend to backtrack to it from the page that is causing problems. For instance, U19 had to backtrack to a shelter after reaching a dead-end page as a consequence of clicking on a highly scented link that did not lead him to the goal: “I seem to have come to a dead end here, it’s so frustrating - it’s not logically where I would have expected to be”. Similarly some users backtracked to a shelter after clicking on low scented links that made them lose their orientation for several reasons: U13 gets to a dead-end page “it’s gone, the information refuses to come up”; on the other hand, it is the lack of accessible content that made U17 backtrack “it’s not doing what it is supposed to do, just reading ‘link’, ‘link’, ‘link’ ”. Backtracking was also employed when U11 realised she was looping time and again and was unable to get out of the loop “I’ve got back to shorts again...shorts again!”.
6.6. T6: Re-doing: Re-check, Re-type, Re-trace and Re-start

We found a number of situations in which users repeat their actions for several reasons: to check the consistency of the outcomes in the case of re-checking, to write a more accurate keyword after getting unsatisfactory results from search search engines, to retrace their previous unsuccessful traversal path in order to reach a turning point and to start over.

I61. Re-checking. This tactic is observed on individuals who check at least twice whether the link they have clicked is actually a good choice. It works as a reassurance mechanism. The lack of support for global orientation in a site and accessibility problems make U1 lose his global location with respect to the homepage and keeps on clicking on a link that leads to the current page: "this is quite hard to understand". Same action is carried out by U23 after reading a web page and not finding what he was looking for; he kept on intentionally landing on the same page after backtracking and refining his search.

I62. Re-typing queries. A number of users rewrote their search keywords in search engines and digital libraries. We found that re-typing is not only employed as a technique to refine a query and get better results, but also after unsuccessfully exploring search engine results that actually point users to their goals: after exploring on a particular result provided by the search engine and not getting what he was looking for, U20 typed another query instead of exploring remaining results, "[he believed that search terms must have been incorrect]". Search keywords were also re-typed after exploring a page that contained U12’s goal, which was conveyed by inaccessible pictures, therefore missing this key information. Similar behaviour was observed in U2, as he was not able to get the piece on information he was looking for “I can’t read it, I can’t understand why when you type in the title, it does not give you all the details on one page”, he then tried new keywords.

I63. Re-tracing. When facing some difficulty, users retrace their steps until they reach again the turning point that has caused the initial problem. In these situations users often go to a shelter (I52) directly or backtracking, and then retrace. For instance, the large number of links that appeared to U23 via drop-down menus made him get lost. The lack of results provided by a search functionality ("nothing found...I’ll do that search again") made U17 retrace and try a new search query instead of going directly to the search box located in the current page.
Some other users start over their tasks when finding themselves in a situation of reduced mobility: \( U_{21} \) was not able to get out of the navigational area (PH2) “[JAWS seemed to read the links many times, as though in an infinite loop]” so he decided to restart the task.

### 6.7. T7: Not Operating or Delegating on Assistive Technologies

We found that some users employ tactics related to the usage (or misuse) of assistive technologies. The following tactic implementations (but I73) are mainly used under circumstances of information overload.

**I71. Activating advanced screen reader functionalities.** Using the link list dialogue provided by JAWS when coming across a vast number of links – “this is a problem sometimes, you can have thirty or two hundred and thirty links that you have to sit and listen to!”, \( U_7 \) – and employing functionalities that remove clutter or bypass groups of links – “it has found a hell of a lot of pages, there are lots of links between the search box and results”, \( U_2 \) – are some of the features activated by users when too much content (textual content and links) was found.

**I72. Swapping assistive technology.** Depending on how well \( U_{21} \) could see in a given day he would employ the screen reader or the screen magnifier. However, on one occasion it was observed that due to the tiredness caused by the amount of content read out loud by the screen reader, \( U_{21} \) decided to stop using it and launched the screen magnifier instead.

**I73. Waiting.** Some users do not operate during a determined amount of time until some events happen on the web page. For instance, \( U_5 \) stopped operating the computer when it took too long for pages to load; \( U_{20} \) was frustrated as the updates in a news carousel did not let him read the news – “[it caused frustration because he is a slow reader and did not finish reading]” – so he had to wait until the desired news appeared again.

### 6.8. T8: Giving Up

Giving up is the tactic by which users surrenders to coping. In our analysis, it is employed due to a broad variety of causes and under different circumstances in a quite balanced way: lack of mobility accounted for 7 cases, confusion for 6, and uncertainty and overload for 4 each. Most of the problems that provoked to give up were common to other problematic situations. We found that the type of problem users encountered is not the
principal factor to employ this tactic, but a sequence of failures and unsuccessful interactions. Therefore, giving up often occurs after navigating with difficulties through a number of pages and coming across a problem that is completely different to the ones experienced previously. For instance, when $U2$ and $U3$ managed to escape from a loop of pages, if the next visited page contained any sort of problem, especially if it was an accessibility problem (e.g., linking pictures without alternative text or poorly labelled links), they gave up their task.

7. Discussion

7.1. On the Problems and Coping Situations Discovered

Previous research that systematically analysed guidelines coverage of problems encountered by blind users found that WCAG 2.0 covered 50% of the problems (Power et al., 2012). Our analysis confirms that most of the problems encountered by visually impaired users are not caused by accessibility problems. The categories found in §5.2 are consistent with those found in the literature although our categories can be considered of a higher granularity. For instance, the categorisation by Power et al. (2012): “Content found in pages was not expected by users”, “Expected functionality not present” or “Functionality does not work as expected” is included in our more general “Unmet expectations”.

Even if the goal of this paper is not to exhaustively analyse the extent of the problems covered by existing guidelines, we found that at least those that could be considered traditional accessibility issues accounted for 19% of the problems analysed. Therefore, our findings suggest that the situation could be even worse as the 50% found by Power et al. (2012) would be the upper-bound of accessibility problems encountered by visually disabled users that are covered by WCAG guidelines. However, we are cautious about this statement because it is also the case that this 19% accounts for the most problematic situations, leaving out expected and more frequent accessibility problems.

By categorising encountered problems from a perspective of coping situations we are able to identify and classify coping tactics as a consequence of these problematic situations. For instance, should web design patterns evolve, we would expect that users who asked for help to be reassured (I11) would still be undergoing situations of uncertainty; similarly, we would expect persevering users (I31) to be subjected to confusing situations.
<table>
<thead>
<tr>
<th>Tactic</th>
<th>Implementation</th>
<th>Coping situations</th>
<th># users</th>
<th># situations</th>
<th>Particular user group</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1. Asking for assistance</td>
<td>1. Get reassurance</td>
<td>Uncertainty</td>
<td>3</td>
<td>6</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>2. Get confirmation</td>
<td>Confusion</td>
<td>3</td>
<td>4</td>
<td>Screen reader users</td>
</tr>
<tr>
<td></td>
<td>3. Get further instructions</td>
<td>Uncertainty, Reduced mobility</td>
<td>6</td>
<td>9</td>
<td>Experienced</td>
</tr>
<tr>
<td>T2. Impulsively clicking</td>
<td>1. Deliberately clicking on low-scoped links</td>
<td>Confusion</td>
<td>5</td>
<td>4</td>
<td>Screen reader users</td>
</tr>
<tr>
<td></td>
<td>2. Clicking on any link after finding unexpected functionalities or content</td>
<td>Confusion</td>
<td>5</td>
<td>6</td>
<td>Experienced</td>
</tr>
<tr>
<td></td>
<td>3. Clicking on any link as long as it is accessible</td>
<td>Uncertainty</td>
<td>1</td>
<td>1</td>
<td>Experienced screen reader users</td>
</tr>
<tr>
<td>T3. Exploration tactics</td>
<td>1. Persevering</td>
<td>Confusion</td>
<td>2</td>
<td>5</td>
<td>Novices</td>
</tr>
<tr>
<td></td>
<td>2. Escaping from useless, non-useable or inaccessible content by tabbing down or scrolling down</td>
<td>Confusion, Overload, Uncertainty</td>
<td>6</td>
<td>8</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>3. Fast tab/scroll/arrow down the page without listening to content completely</td>
<td>Overload</td>
<td>8</td>
<td>9</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>4. Moving around</td>
<td>Confusion</td>
<td>3</td>
<td>8</td>
<td>Screen magnifier users</td>
</tr>
<tr>
<td>T4. Narrowing down search</td>
<td>1. Local orientation by going to the top of the current page</td>
<td>Confusion, Reduced mobility</td>
<td>5</td>
<td>6</td>
<td>N/A</td>
</tr>
<tr>
<td>T5. Gaining orientation</td>
<td>1. Global orientation by backtracking the page</td>
<td>Confusion, Reduced mobility</td>
<td>11</td>
<td>20</td>
<td>N/A</td>
</tr>
<tr>
<td>T6. Re-doing: re-check, re-type, re-trace and re-start</td>
<td>1. Re-checking</td>
<td>Confusion, Reduced mobility</td>
<td>5</td>
<td>6</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>2. Re-typing queries</td>
<td>All</td>
<td>6</td>
<td>12</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>3. Re-tracing</td>
<td>Confusion, Reduced mobility</td>
<td>5</td>
<td>6</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>4. Re-starting</td>
<td>Reduced mobility</td>
<td>2</td>
<td>2</td>
<td>N/A</td>
</tr>
<tr>
<td>T7. Not operating or delegating on AT</td>
<td>1. Activating advanced screen reader functionalities</td>
<td>Overload</td>
<td>5</td>
<td>10</td>
<td>Experienced</td>
</tr>
<tr>
<td></td>
<td>2. Re-checking</td>
<td>All</td>
<td>1</td>
<td>1</td>
<td>Novices</td>
</tr>
<tr>
<td></td>
<td>3. Waiting</td>
<td>Uncertainty, Confusion</td>
<td>2</td>
<td>2</td>
<td>N/A</td>
</tr>
<tr>
<td>T8. Giving up</td>
<td>All</td>
<td>All</td>
<td>13</td>
<td>21</td>
<td>N/A</td>
</tr>
</tbody>
</table>
7.2. On the Tactics Employed

7.2.1. How Discovered Tactics Compare to Previous Work

Previous work on the tactics employed by visually disabled users is scattered. In our study, we come up with 8 tactics and 17 ways in which users implement them. Even if the goal of this work was to identify the tactics employed under extraordinary conditions such as confusion, reduced mobility, uncertainty and overload our work provides evidence to confirm and bring together previous works. Persevering (I31) was identified as re-trying by Lazar et al. (2007) as a tactic employed to tackle frustrating situations. Moving down without listening to content (I33) is consistent with the so-called gambling scanning strategy discussed by Takagi et al. (2007) and also by the memorisation of the number of links to skip in order to get to a determined location in a web page (Yesilada et al., 2007). Moving around (I34), which was first observed by Borodin et al. (2010) on screen reader users employing cursor keys, was later identified on screen magnifier users as the clustered element strategy (Lunn et al., 2011). Our analysis could only confirm the latter case. Giving up (T8) was also found elsewhere in the context of coping by visually impaired users (identified as withdrawal by Lunn et al. (2011)) and the frustration of blind users on the Web (Lazar et al., 2007). Sheltering (I52) was discussed as a stage of the backtracking strategy identified by Lunn et al. (2011), where users backtracked to a familiar location. Re-checking (I61) is similar to the probing strategy, by which users catch a glimpse of a web page to get an overview, backtrack and come back to the page (Goble et al., 2000). Re-starting (I64) is also identified by Lazar et al. (2007). Using the advanced functionalities offered by screen readers (I71) is something one would expect from visually disabled users and it was previously identified by Borodin et al. (2010) and Lunn et al. (2011).

T1 and I62 were identified elsewhere but we discovered different implementations. T1 was discussed in Borodin et al. (2010) as falling back to external help, while we have extended its definition by identifying three different purposes for asking assistance: for reassurance (I11), to get a confirmation of what is on screen or what has been done (I12) and to get extra instructions (I13). When it comes to re-typing queries (I62), we have found that re-typing was not only employed as a technique to refine a query and get better results (as discussed by Sahib et al., 2012), but also as a tactic when accessibility problems prevented users from achieving their goals.

To the knowledge of the authors, the remaining tactics – I21, I22, I23, I32,
I51, I63, I72 and I73 – are not identified in previous work. We argue that these tactics are especially exhibited under extraordinary situations and previous works have not focused on coping, but on strategies employed in ordinary situations. The above explained overlap suggests that some of the tactics are employed under ordinary and extraordinary situations; some tactics are implemented in a different way when problems are found and remaining tactics – those that do not overlap – are particular to coping situations.

7.2.2. How Tactics Are Seen in Light of Coping

As the tactics we discovered are identified under extraordinary situations they can be explained in light of coping theory. In this way, we corroborate that these are coping tactics instead of routinely employed tactics. To do so, we match the discovered tactics with the strategies that indicate coping behaviours (see in §2):

*Exploration tactics to keep adequate information about the environment.* The active exploration of issues and search for information is one of the most common coping mechanisms in real life (Caplan 1964). We discovered exploration (T3) and narrowing down search (T4) are the most sophisticated tactics as they lead users to actively innovate and be more effective. In other words, T3 and T4 bring about epiphanies that provide users with new insights and skilled behaviours. On novice users T3 and T4 are only applied when users already have the basic knowledge or the confidence to operate on the Web. Since knowledge and skills are acquired through practice, if users are not sufficiently skilled, reassurance tactics (see below) provide users with the required confidence to employ T3 and T4. Being confident seems necessary because using exploration tactics implies taking risks such as going through unexplored areas (see I33).

*Tactics to gain reassurance in order to maintain satisfactory internal conditions.* We found that the lack of confidence on what one is doing is a major problem for visually disabled users. Asking for assistance (T1) is employed by users to reassure themselves by asking for confirmation about what they are doing or what is happening and by getting feedback from their peers. Actually, *active invoke for help* was described as one of the main coping mechanism employed by individuals in real life (Caplan 1964). Re-doing (T6) was employed to double-check the effect of previous actions. It is a way of reassuring oneself by confirming the steps taken so far.
As a result of employing these tactics users feel more confident and gain spatial awareness about what surrounds them. Exploration tactics (see above) are often employed only if users feel in control; this situation is only reached if users have sufficient skills or if they feel confident. Therefore, it can be understood that in order to gain a certain level of autonomy users first employ reassurance tactics (T1 and T6) prior to exploration tactics.

*Tactics to gain more freedom and autonomy.* Impulsive clicking (T2) can be understood as one of the coping mechanisms employed by individuals in real life when freedom and autonomy are reduced, making individuals to focus on small gratifications [Moos 1976]. Jointly with gaining orientation (T5) these tactics are employed under situations of reduced mobility, uncertainty and confusion. The usage of both tactics entails the move to a safer place and enables users to browse without any obstacle and retake their objectives. Giving up (T8), which is a last resort tactic, is employed when remaining tactics have been exhausted. In real life, surrendering to coping is a way to give up in order to lessen the perception of stress [Moos 1976]. Therefore giving up is also considered as a tactic to gain more freedom.

Tactics are not always used in isolation but are operationalised in conjunction with other tactics as a way to form strategies. For instance, in a number of occasions we observed how users went to a shelter (I52), then retraced (I63) and finally employed a narrowing down search tactic (T4). We therefore conceive tactics as fundamental behavioural constructs that can be composed and dovetailed to form complex strategies.

7.3. On the Relationship between Problematic Situations and Tactics Employed

We understand coping tactics as behavioural markers of cognitive processes. If we establish a relationship between the tactics employed and the situations being experienced we can programmatically infer problematic situations. Table 6 highlights this relationship by providing a mapping between coping situations and tactics. For instance, the table conveys that if users decide to quickly scroll down until they reach the bottom of the page (I33) it is likely they are subjected to a situation of overload. For some other tactics the coping situation will not be that clear: when deliberately clicking on a low scented link (I21) users may be experiencing uncertainty or may be undergoing a situation of reduced mobility.
Interventions to pre-empt and bypass coping situations will help to attenuate these situations. While problematic situations categorised in light of coping are generalisable and independent of the underlying web technology and idiosyncrasy, some of the solutions are dependent on the current mark-up and web design practices. We suggest tackling problematic situations in two complementary ways: a tightly coupled approach catches (and subsequently allows to repair) problems based on established design guidelines that correspond to each of the categories identified in §5.2; a loosely coupled approach provides the means to remove uncertainty, reduced mobility, confusion and overload in order to attenuate the encountered problems (see §7.4). In this sense, Leuthold et al. (2008) have proposed enhanced text interfaces to avoid narrowing down search (T4) and re-checking (I61) tactics, which would indirectly avoid confusing situations according to our findings.

Detecting problematic situations in this way opens several research avenues: if we loosely define accessibility problems as those deterrents that prevent optimal user interaction, we conceive that all the identified problematic situations are caused by accessibility problems. In §7.5 we suggest that behaviour-driven accessibility evaluations pave the path to innovative and effective methods that go beyond traditional guidelines conformance methods.

7.4. Practical Implications I: Removing the Need to Cope

In order to remove the problems that arise from the emerging situations we have uncovered, these problems could be addressed from an accessibility, usability or information architecture perspective. It is less clear how to address navigation and exploration issues, and even less clear how to deal with unmet expectations, assistive technology problems or emotional coping. One possible strategy to avoid the distress caused by coping situations is to smooth out those factors that can potentially harm the interaction from a coping perspective: uncertainty, reduced mobility, confusion and overload.

We propose a set of techniques that can help to diminish the risk of coping.

Uncertainty. In order to avoid the uncertainty generated by web content, designing for familiarity or at least for learnability will lessen the unavoidable process of traversing through unfamiliar grounds. Designing for learnability mitigates the lack of skill showed by inexpert users; familiarity (i.e., being consistent with established practices) facilitates the use of automated interaction routines to users of a higher expertise. To do so, it is essential to promote users’ understanding of the task flow, to make them aware of the
functionalities of the interface and to provide help to locate and understand the goal of such functionalities (Grossman et al., 2009).

*Reduced mobility.* Ineffective navigation strategies adopted by users lead them to getting stuck in dead-end pages and looping through pages. Some of these situations are caused by orientation problems that can be ameliorated by spatial hypermedia techniques. These techniques take advantage of the visual and spatial affordances to organise and interpret information (see the VIKI framework by Marshall and Shipman [1995]. Similarly, Walden Paths (Furuta et al., 1997) aim at addressing the temporal and linearly incremental way in which users browse by providing directed linear paths while allowing users to explore off-path nodes.

*Confusion.* Clicking on high-quality distractors (i.e., links with strong information scent that do not lead to the goal (see Brumby and Howes, 2008)) and clicking on low scented links generates confusion on the user. When users click on such links, they get a confusing impression as they realise that the page they land on will not lead them to the goal. Addressing such problem from a guidelines perspective (see success criteria 2.4.4 *Link Purpose* and 3.2.4 *Consistent Identification* in WCAG (Caldwell et al., 2008) leads to providing meaningful texts (avoiding texts such as ‘click here’, ‘more’ and similar) and to making sure link texts are consistent: e.g., links with the same text should not link to different locations. Removing ambiguity and being consistent with link texts is crucial; however, it is a preliminary step because it does not prevent users from the problems caused by information scent or the bad execution of the re-checking technique (I61). Ideally, links should not only clearly describe the purpose of the web page they point to, but they also have to provide some hints on the content users will come across. The literature suggests link augmentation techniques such as Gist summaries (Harper and Patel, 2005) that provide a summary of the page beyond a link and numeric scores of the accessibility level of the linked page (Vigo et al., 2009).

*Overload.* There are several factors on the Web that cause overload: high information density, the arrangement of information and the semi-serialised fashion in which content is rendered by screen readers. In order to remove information density some have suggested providing relevant summaries (Berger and Mittal, 2000); applying adaptive hypermedia techniques such as highlighting important content, hiding non-relevant content and removing clutter
is another way of alleviating information overload. Some other interventions should go in line with including advanced navigation techniques in screen readers.

We emphasise that the tactics we have identified are behavioural markers of cognitive processes that indicate problematic situations (see table 6). Therefore, if we automatically detect the employed tactics we are able to infer the situations users are undergoing and provide the means to overcome them. Currently, we are running user studies by injecting scripts to detect such behaviours on web pages. For instance, the script detecting fast movements downwards (I33) checks whether the user moves abruptly down (through scrolling or tabbing); to detected local orientation (I51), scripts check whether users reach the bottom of the page and then move up until they get to the top. The retracing algorithm (I63) detects the longest traversed path which has been repeated at least two times. For instance, in the following sequence of web pages: \( wp_i \rightarrow wp_j \rightarrow wp_k \rightarrow wp_l \rightarrow wp_m \rightarrow wp_l \rightarrow wp_k \rightarrow wp_j \rightarrow wp_k \rightarrow wp_l \rightarrow wp_m \rightarrow wp_i \), the algorithm detects \( \{wp_k, wp_l, wp_m\} \) as the longest pattern and \( wp_m \) as the turning point page.

The techniques to relieve coping situations discussed above could be applied when tactics are automatically detected through these algorithms.

7.5. Practical Implications II: Evaluating Accessibility-in-Use

Accessibility-in-use is defined as “the effects that real accessibility problems will have on the quality of interaction as perceived by real users when interacting with real pages for achieving real goals” (Vigo and Brajnik, 2011). As discussed in §7.1, the findings by Power et al. (2012) support that in addition to the problems covered by accessibility guidelines there are some real problems that may only be encountered during the interaction with pages and cannot be caught by analysing the underlying code and structure of pages, let alone specified through guidelines. We emphasise that coping tactics employed by users are behavioural markers of cognitive processes. As such, the presence of coping tactics indicates problematic situations not only caused by accessibility problems. Therefore, coding the proposed tactics into detection algorithms and injecting them into web pages – as illustrated in §7.4 – allows to detect such problems. A tool that shows the feasibility of this approach has been proposed elsewhere (Vigo and Harper, 2013b). We pose that evaluating accessibility-in-use is complementary to traditional accessibility testing in that it enables to broaden the detection of barriers that
prevent users from optimal interaction.


Web navigation models for sighted and screen reader users do not consider the role that problematic situations play in navigation and link selection strategies. The proposals for modeling the interaction of users with disabilities on the Web focus on adapting existing low level interaction modeling methods to the interaction modalities of screen reader users. [Schrepp (2010)] adapts goals, operators, methods and selection rules (GOMS) to those users who rely on keyboard navigation and employ an exhaustive scanning strategy. [Trewin et al. (2010)] accommodation the motor, perceptual and cognitive actions of one blind user to the low level behaviours modeled by keystroke modeling level (KLM). They found that KLM had to be adapted to cater for the fast speech rates set and the particular way of using keyboard commands. The observed parallelisation of hearing, cognitive processing and motor operations was also included in the updated KLM model.

Navigation models assume that information overload, situations of reduced mobility, and confusing or uncertain situations have no influence on the interaction of the user. For instance, they assume that users will follow the same link selection strategy no matter if a web page has 20 or 250 links. Our findings suggest that in the latter case, information overload may influence users’ behaviours. Considering these situations in navigation models is especially important for people with disabilities and visually disabled users in particular as they face more severe navigation problems than sighted users. We discuss the inclusion of coping tactics in Web navigation models in [Vigo and Harper (2013a)].

8. Conclusions

We have identified 17 tactics employed by visually disabled users when they experience problems on the Web. In addition to isolating the tactics we have uncovered the situations where these tactics are exhibited. Consequently, not only do we add a substantial amount of behavioural tactics to the existing corpus, but we also provide contextual and situational information about tactics. Relating tactics to technical problems and coping situations allows us to understand what users do when they are undergoing problematic situations. This has at least two important implications when
it comes to the removal of the need to cope: on the one hand, we make designers aware of the problems that bring about such situations; on the other hand, the incorporation of algorithms to detect tactics in tools will allow to infer such problematic situations in real time and provide automatic help so that users do not have to undergo extreme adaptations. These are invaluable insights for researchers and user agent developers as new research avenues on transformation, evaluation and modeling are opened.

9. Acknowledgements

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