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A snapshot of the first encounters of visually disabled users with the Web

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Abstract

Navigating the Web is particularly challenging for disabled users who are not familiar with the idiosyncrasies of the Web and have to rely on assistive technologies. We provide insights on the adaptation process of novice visually disabled users through a snapshot that depicts their first encounters with the Web during a period of 2 months. We discover that, as the sessions go on, last resort tactics are replaced by more sophisticated exploration tactics, which suggests that users not only become more skilled, but also more independent and autonomous. We observe that at later stages, tasks are more effectively accomplished at the expenses of reduced efficiency. We propose 2 explanations for this phenomenon: at later stages users may be more prone to misuse tactics from a larger repertoire or alternatively, they may feel more confident and less thoughtful. Design implications suggest that, initially, users should be provided with mechanisms to recover from failure, while interventions at later stages should not interfere with the learning process.

Keywords: Behavioural sciences, Web, adaptive behaviour, learning, skill acquisition, coping tactics, visually disabled, blind users, visually impaired users

1. Introduction

Adaptive behaviour is a ubiquitous trait in the animal kingdom. It enables individuals to adjust their behavioural responses to the stimuli received from the environment. As a result, the relationship with the environment

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becomes more beneficial in terms of energy, time or resources expenditure. Adaptive behaviour is thus one of the factors that increase survival expectancies. Humans are not an exception as we constantly try to increase our fitness to the environment we live in.

The World Wide Web is an environment where users consume and produce information, communicate and socialise. The interface to perform such activities is not always straightforward to operate though. It is especially cumbersome for those whose interaction is constrained by their abilities (e.g. visually disabled users) or devices (e.g. mobile phones) and those who are not familiar with it. The interaction problems encountered by visually disabled users in the Web environment are primarily triggered by poorly designed websites in terms of information architecture (Hochheiser and Lazar, 2010), usability (Leporini and Patern, 2004) and accessibility (Caldwell et al., 2008).

Since the Web is eminently a visual environment visually disabled users employ assistive technologies to be able to interact with web content. Visually disabled users can be roughly classified in 2 groups: visually impaired and blind users. Visually impaired users, who are typically users with low vision, use screen magnifiers that augment content, while blind users employ screen readers that talk out loud the content of websites. If the visual impairment is severe some users employ screen readers jointly with screen magnifiers. In addition to being constrained by their abilities and design flaws, if visually disabled individuals are not familiar with the Web and its idiosyncrasies, the problems that emerge can severely hinder the interaction and consequently bring about frustration on users (Lazar et al., 2007). Our goal is to explore how visually disabled users address these problematic situations in order to suggest interventions that help their adaptation to the Web environment.

Several efforts have been devoted to address the accessibility barriers encountered by people with disabilities on the Web. International legislation¹ mostly draws from the guidelines proposed by standardisation bodies such as the W3C, see for example the Web Content Accessibility Guidelines 2.0 (Caldwell et al., 2008). However, research suggests that users still find a number of accessibility related problems even if guidelines are satisfied (Power et al., 2012). As a reaction to such difficulties, users try to better adjust to the Web environment by getting familiar with procedures that enable them

¹Policies Relating to Web Accessibility. Available at <http://www.w3.org/WAI/Policy/>

to overcome the encountered obstacles. This process may be understood as *learning*² since users gain factual and especially procedural knowledge to cope with challenges.

The traditional view on skill gaining supports this perspective in that novice users employ problem-solving strategies, whereas skilled users show automated strategies (Card et al., 1983). According to Newell and Simon (1972) the evolution from the novice to the skilled dimension materialises by gaining search control knowledge in the problem space. However, this sort of automated behaviour only happens in restrictive situations: simple tasks with a low level of variability that require small cognitive effort (and require thus more perceptual-motor effort). Under these constraints, the evolution of the users' performance is regular and thus predictable by the Power Law of Practice (Snoody, 1926).

Adaptive behaviour, and especially coping are tools to overcome challenging situations. When users tackle such situations, their internal conditions tend to be exceeded and can result in anxiety. Therefore, the goal of the actions taken by users is to alleviate stressful situations while at the same time addressing the event that causes disruption (Lazarus and Folkman, 1984). Our perspective on user adaptation to Web environments posits that users learn from and adapt to every action they take on the Web. Adaptive human behaviour occurs in complex and highly variable tasks such as the ones that take place on the World Wide Web. These actions are purposeful (Newell, 1990), goal-oriented and are carried out either consciously or unconsciously.

The goal of this study is to explore how novice visually disabled users adapt to the Web environment and learn to cope with encountered challenges in this process. To do so, we identify how adaptive behaviour mechanisms evolve over time and analyse the relationship of this evolution with navigation and performance metrics. Specifically, we provide insights about the following aspects:

- We analyse the skill acquisition process of visually disabled users who are not familiar with the Web.
- We describe how users acquire skills by coping with difficulties and overcoming the problems encountered on the Web.

²All the instances of 'learning' refer to 'procedural learning' throughout the paper.

- We identify the mechanisms by which novice users acquire confidence and become competent users.
- We discuss how interventions could be applied in order to smooth out the adaptation and learning process.

2. Background

According to standardisation bodies learnability is a quality of the product that falls under usability (ISO/IEC 9126-1, 2001; ISO/IEC 25010, 2011) and is defined as *the degree to which a product or system can be used by specified users to achieve specified goals of learning to use the product or system with effectiveness, efficiency, freedom from risk and satisfaction in a specified context of use*. Even if it is included in standard quality models, there is no unified way of measuring learnability (Grossman et al., 2009). The literature about the learnability of applications and systems is scarce and in the past it was mainly focused on word processor use (Mack et al., 1983; Rieman, 1996).

In this section we describe the axes that inform our analysis on the adaptation of visually disabled users to Web environments: section 2.1 highlights the role of expertise in learning how to interact with software applications; the consideration of *time* as a key dimension to analyse user adaptation is emphasised in section 2.2; finally, section 2.3 describes the influence that the aforementioned axis have with the interaction of those who are visually disabled.

2.1. Factors that influence the learning process of software

Carroll and Rosson (1987) describe how the eagerness to action and prior experience determine the learning process of software. While poor interface design can be blamed for problematic computer use, eagerness to action and prior experience constitute a paradox on interface operation rather than a design problem, namely *the active user paradox*. There are two paradoxes that constitute the active user paradox: *the production paradox* and the *assimilation paradox*.

The production paradox establishes that users stick to their operating procedures even if more efficient techniques are available: in the case of novice users, they prefer to adopt exploratory trial and error strategies instead of being provided with guidance, while skilled users prefer to stick to the methods they already use. In both cases, users strike a balance between

the time taken to learn new procedures and the hypothetical increase of performance that these procedures bring about. In order to encourage users to learn and use new software procedures and functionalities that may improve their performance some design guidelines have been proposed:

- Reinforce users with rewards such as achievement, satisfying curiosity or providing sense of control over the environment.
- Remove the sense of risk when operating the interface by providing simulations of the effect of certain actions.
- Disclosing complex and error-prone functionalities as the expertise level increases.

The assimilation paradox posits that individuals apply what they already know in order to interpret new situations, which is a useful strategy when the new situations resemble to previously experienced ones. Nevertheless, wrong assessments of isomorphic situations can lead users to erroneous procedures and prevent them from using available functionalities they have at hand. Therefore, novice users are inclined to interact with an interface rather than learning it. As a result, their little knowledge leads them to erroneous inferences about the effects of the interaction with the interface. Similarly, prior knowledge inhibits skilled users from learning. Design guidelines to overcome assimilation propose arguable solutions like developing interfaces that mimic exactly the functionalities of the metaphors used (e.g. a word processor should look like a notebook).

Fu and Gray (2004) found that the reduction of the required cognitive effort is what leads users to adopt generic procedures to interact, which is in line with the active user paradox. This entails that, in the long run, users will require more adaptive efforts as the available functionalities — which boost efficiency — are not used. This phenomenon occurs even when users are aware of the existence of optimal procedures, which casts some doubt on the rationality principle (Card et al., 1983). However, it was found that this strategy leads to a suboptimal yet stable performance, which indicates that users prefer to avoid disruptive situations at the expenses of being less efficient.

2.2. The time factor

Adaptation is a process that inherently occurs and evolves over time. It is not possible to observe it as a punctual event but as a series of events across

time. Among the disciplines that study evolutionary human behaviour, those concerned with the shortest temporal scale of observation (e.g. behavioural ecology) view adaptations from a phenotype perspective (Smith, 2000). The time spans under this viewpoint can range from a few hours to months and actions are never observed in isolation, but in relationship with past and subsequent events.

We emphasise that the time factor is crucial in order to observe adaptive behaviour on the Web and to explore how users learn to use the Web. The fact that increased intervals of time enable the consolidation of declarative knowledge in the long-term memory, where consolidation does not happen automatically and it is not determined at the time it has been learned (Squire, 1986), calls for analysing user interaction over time and across multiple sessions. By doing this, we can analyse the evolution of the coping tactics as well as the skill acquisition process.

If it was not for ethnography studies of computer use, little attention has been paid to time as a factor that can determine human-computer interactions — except for those interactions constrained by time such as decision-making under pressure or interruptions. Nonetheless, the time variable should be taken into account to get a broader picture of user interactions with interactive systems (Hassenzahl and Tractinsky, 2006) and some efforts are being directed to address the effects of time on user experience (Karapanos et al., 2009). Exceptionally, research has been conducted to investigate the evolution of usability in terms of user frustration (Mendoza and Novick, 2005), and to keep track of user performance over time (Vaughan and Courage, 2007).

Retrospective reporting of experiences (Kujala et al., 2011) and, especially, diaries have been used to capture human interaction over time as opposed to traditional studies in the laboratory, which force users to interact with established stimuli in order to accomplish specific tasks. Additionally, the controlled nature of laboratory experiments does not allow adaptive behaviours to emerge in a natural way. By using diaries, users report frustrating episodes (Ceaparu et al., 2004) as well as the tasks (Sellen et al., 2002) and activities (Lindley et al., 2012) they carry out. Since the use of diaries to report events does not impose tasks or stimuli to users it is a more naturalistic approach to observe human adaptation to the Web. Diaries have at least 2 drawbacks: firstly, it is an intrusive way of collecting data from users; secondly, data are inherently subjective as they are based on self-reporting. In order to counterbalance the inherent subjectivity of self-reporting, diaries tend to be complemented with focus groups, user observation and log

analysis. In section 3 we propose *in situ* observations aiming to minimise intrusiveness and subjectivity when observing adaptive behaviour on the Web.

2.3. Visually disabled users learning to navigate the Web

Kurniawan et al. (2003) analysed how experienced blind users approach to unfamiliar screen readers. They found that expert users employ a three stage strategy to get familiarised with new software: in the *exploration* stage users discover and try the new features of software; then, in the *task-action* stage users plan and execute actions asking for help or employing trial and error strategies when failing to accomplish what they initially had planned; finally, users customise applications when feeling under control at the *configuration* stage. In line with what it is mentioned in section 2.1 with regard to the active user paradox, prior exposure to other screen readers shapes users' mental models in that they expect similar functionalities to those provided by the screen reader they normally used. The usability problems encountered at the outset will diminish the longer it is the exposure to the new screen reader. The authors suggest that users should given training in order to smooth out the learning process.

When navigating the Web visually disabled users come across diverse barriers, which are mainly shaped as accessibility and usability problems. These problems do not only make users underperform, but also generate frustration (Lazar et al., 2007). In such situations users employ coping strategies in order to overcome the problems encountered. Lunn et al. (2011) identified the coping strategies employed by low visions users: candidate chunk discovery, masthead avoidance, clustered element, probing, backtracking and withdrawal. Previous work (Vigo and Harper, 2013a) isolated 8 tactics and 17 different implementations (i.e. different ways of executing tactics) that visually disabled users employ on the Web: asking for assistance, impulsive clicking, exploration tactics, narrowing down search, gaining orientation, re-doing, not operating and giving up. The situations in which these coping tactics were exhibited were also identified: situations of uncertainty, reduced mobility, confusion and overload. In section 4 we report how these tactics evolve over time and how they compare to metrics such as performance or number of visited websites.

3. Design of the study

The herein presented study is based on *in-situ* observations of visually disabled users interacting with Web technology. These observations took place during a course where people with visual disabilities were taught to use information and communication technology and were helped to develop skills to interact with the Web. Participants were supervised by visually disabled tutors, who gave them a crash course on basic commands before they were started. Since participants learned all the basics about computers, Internet, browsers, screen readers and screen magnifiers, it can be understood as a course to acquire computer literacy.

Two observers, who played the role of classroom assistants, offered their assistance to participants during the course. Adopting a peripheral membership role (Adler and Adler, 1987) observers sat next to the participants and jotted down their observations while participants surfed the Web. The observers focused on those events in which participants found difficulties, paying a special attention to the problems encountered and the steps taken to overcome them. 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. The observations took place during a period of two months. After each session, the notes taken during the observations were transformed into formal reports that can be found in Lunn and Michailidou (2007, 2008).

3.1. Type of data analysed

The formal reports contain detailed descriptions of the actions taken by participants, the way in which the browser and assistive technologies were employed and the problems encountered. For example, the following excerpt shows how user interaction is described in these datasets: “... *As P1 became confused by the page, he pressed the ‘back button’ to go back to Google to ensure he had selected the correct link. Satisfied that it was the correct page to be reading, P1 navigated to it again and then looked around the page. He then tentatively clicked on ...*”.

3.2. Participants

Table 1 shows the profile of the participants: *P1* is visually impaired and makes use of the Zoomtext screen magnifier. He had used the Internet

Table 1: Participants observed in the study

id	sessions	disability	assistive technology (AT)	specific AT
<i>P1</i>	5	visually impaired	screen magnifier	Zoomtext
<i>P2</i>	5	visually impaired	screen reader or screen magnifier	JAWS or Zoomtext
<i>P3</i>	4	blind	screen reader	JAWS
<i>P4</i>	2	visually impaired	screen reader	JAWS
<i>P5</i>	2	visually impaired	screen magnifier	Zoomtext

before but when the course started he had already forgotten how to use it. *P2* is visually impaired although his vision is variable. Some days he can see better than others and on these occasions he makes use of the Zoomtext screen magnifier. On a bad day he uses the Jaws screen reader. He had basic knowledge on computers although he was inexperienced on the Web. *P3* is profoundly blind; he is a competent Braille user who normally accesses the Web using the JAWS screen reader. He never used a computer prior to the course. *P4* 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 he able to start browsing using the Jaws screen reader. *P5* was slightly more experienced than his peers and uses the Zoomtext screen magnifier. His goal in the course was to acquire further browsing skills.

3.3. Tasks

Participants did not have to accomplish any particular task when they navigated the Web. Since the main goal of the course was to increase employability prospects participants were encouraged to navigate through pages that would lead them to achieve such objective. Participants navigated mostly on those sites that were going to be of some use for them in the near future: they emulated the booking of a flight, the purchase of an item in an e-commerce site and they also read the news. Often they just browsed for fun: they searched for some old friends names or football teams websites, which led them often to serendipitous findings. Participants often talked among themselves in order to recommend a certain website or to give some assistance when help was needed. The only time constraint participants had was the length of the class, which was 1 hour long.

4. Results

Previous work identified 8 coping tactics and 17 implementations that visually disabled participants employ when encountering difficulties and problems on the Web (Vigo and Harper, 2013a). The situations that trigger coping tactics were classified in four main groups: situations of uncertainty, reduced mobility, overload and confusion. In this section we analyse how these coping tactics and the situations that trigger them vary across time on this particular group of users. The objective is twofold: firstly, it allows us to explore the dynamics of coping situations and the tactics employed. Secondly, it enables us to analyse the relationship between exhibited coping tactics and performance metrics.

4.1. Coping situations

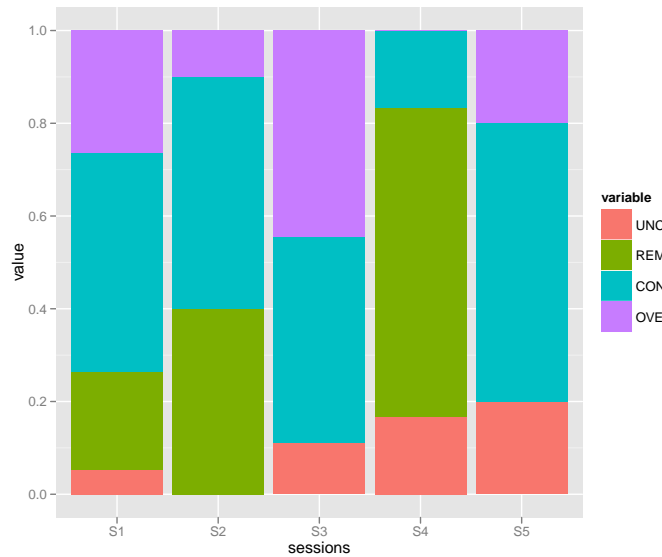


Figure 1: Relative number of problematic situations encountered across sessions. UNC = uncertainty; REM = reduced mobility; CON = confusion; OVE = information overload.

In the context of coping theory *uncertainty* (UNC) is defined as “*the sense of doubt that blocks or delays the action*” (Lipshitz and Strauss, 1997). We found that uncertainty was not only triggered by accessibility barriers (e.g. lack of alternative text for pictures) or usability problems (e.g. bumping into

unexpected banners), but also by the accumulation of negative experiences in the previous navigation tasks.

Reduced mobility on the Web (REM) draws from case studies about the behaviour of concentration camp prisoners, prisoners of war or individuals who have suffered natural catastrophes. These situations provide insights about the coping strategies that are adopted in analogous situations on the Web, where mobility and autonomy are limited (Moos, 1976). In Web environments these situations are illustrated by users who loop on a sequence of pages and are not able to find the way out, users who find themselves in a dead-end web page or users who get stuck due to compatibility problems of screen readers and browsers.

Confusion (CON) is a situation generated by the interplay of novelty, lack of familiarity and ambiguity of the setting, which are the appraisal factors documented in coping theory (Lazarus and Folkman, 1984). In a Web environment unmet expectations typically lead to confusing situations. A plethora of confusing situations were mainly triggered by usability problems including lack of search results, coming across unfamiliar search options or landing on pages whose content was not anticipated by the text in the clicked link. Accessibility problems such as small font sizes and misuse of assistive technologies did also generate confusion on users.

Selective attention is a mechanism to overcome information overload (OVE) by tracking some stimuli at the expense of others. Being able to discriminate between many sources of information, individuals can attend to what it is considered important. Screen readers provide linear navigation mechanisms by which users access to content. Provided that the web page is well structured users can navigate through headings or sections that the screen reader detects. In the worst case scenario users have to listen all content from top to bottom of the page. Consequently, there is no chance to discriminate at first sight between different chunks or components by relying on visual cues or information scent. Some of the situations that illustrate situations of information overload in Web environments are long lists of search engine results, long navigation menus and filling out forms in a series of distinct pages in order to conduct a transaction.

Figure 1 shows the relative number of problems encountered across sessions. Considering that users were not required to carry out specific tasks and the stimuli were chosen on a personal basis Figure 1 provides a picture of the situations undergone by these particular users in their first 5 sessions. It can be observed that uncertainty does not account for more than 20% of

the problems, while 40% of the problems are consistently caused by confusing situations. Information overload and reduced mobility are more variable and range between 10-40% and 20-70% respectively. As a result, the problems related to information overload and reduced mobility, which are more dependent on the design conventions implemented in the stimuli, are more variable. On the other hand, uncertainty and confusion, which are subjective and are more tied to personal experiences, keep stable across sessions.

4.2. Coping tactics

Novice visually disabled users *ask for help* (ASK) as a mechanism to get feedback, especially when they are not confident about the consequences of their actions and do not know what step to take next. Asking for help is often the way to learn the procedures of browsing, familiarise with the idiosyncrasies of the Web and get to know the functionalities of user agents — in this case, the interplay of the browser, the screen reader and Web content. When participants were helped by their peers or the tutors of the course they did not only expect guidance or further instructions, but also to be reassured and acquire confidence. We found that when this tactic is articulated through rhetorical questions it is considered an emotion-focused coping tactic and no help is expected as a result.

When users come across pages containing a large amount of information that does not meet their information needs, they tab down or scroll down very fast without paying much attention to what they see or what the screen reader says. This *exploration* mechanism (EXP) is employed to get a quick overview of the page: when users get to the bottom of the web page indicates that they have not found what they were looking for at first sight; then, screen magnifier users tend to move the viewer horizontally in case they miss anything; finally, screen reader and screen magnifier users get back to the top of the page to start over, focusing more on the content this time.

When users get disoriented while navigating within a web page, they regain their spatial awareness by going to the top of the current page. If users lose their orientation while traversing a number of different web pages, they *orientate* themselves (ORI) by backtracking to a page they are familiar with. When they have a clear goal, users *narrow down* (NDO) their search by clicking only on those links that have not been selected yet.

Sometimes users revisit web pages by checking at least twice whether the link they have clicked does actually meet their information needs. When facing some difficulty, some users backtrack or go directly to a web page they

know well and start over their task. Then, they retrace their steps until the turning point that has caused the initial problem is reached again. Retracing and revisiting are considered *redoing* tactics (RED) that work as reassurance mechanisms whereby users review by themselves the consequences of the actions made.

It was also found that sometimes users activate advanced screen reader functionalities, swap assistive technologies or just wait and *do nothing* when encountering problems (NOP). *Giving up* (GUP) is the tactic by which users surrender to coping and move onto a new task. Typically, this was not only observed when encountering extreme difficulties, but also after users had overcome a series of problems of a similar nature and coming across a problem that was completely different to the ones experienced previously.

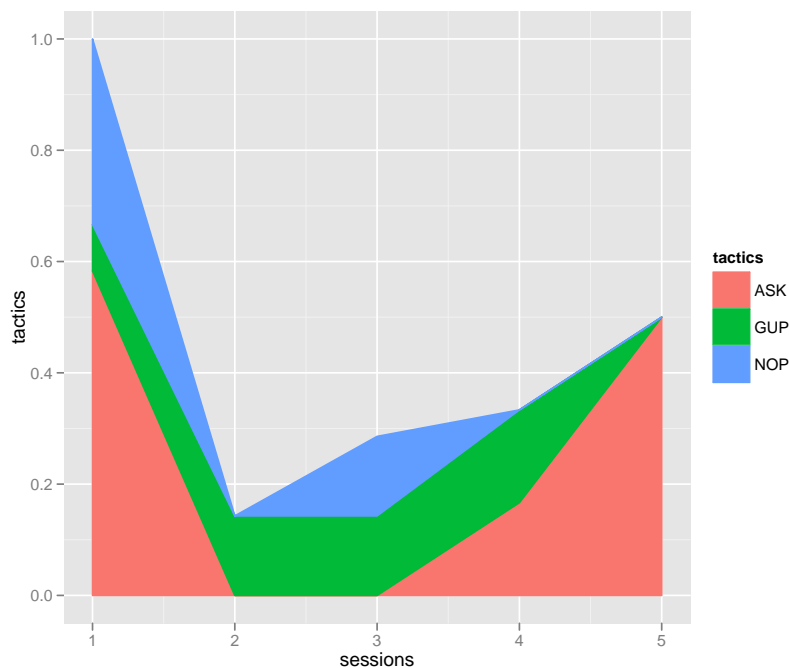


Figure 2: Aggregation of last resort tactics employed per task. ASK: asking for help; NOP: not operating; GUP: giving up.

We group the above-mentioned tactics in two main groups: last resort tactics and exploration tactics. The former group comprises the most disruptive and less effective tasks including asking for help, giving up and not

operating. These tactics, which are employed when users get stuck, require little interaction from users, who tend to delegate on tutors, peers or assistive technology to accomplish their tasks. Alternatively they withdraw and give up. Note that if our participants were not supervised by somebody else when asking for help, they would have been forced to give up as they lacked the resources to proceed with their tasks. Figure 2 shows the evolution of the exhibition of these tactics, whose use decreases sharply after the first session, where asking for help was understandably more frequently exhibited. After the second session a gradual increase is observed although last resort tactics are not employed as frequently as in the outset. It can be observed that in the last session, on average, these tactics are exhibited once every two tasks (i.e. 0.5 tactics per task).

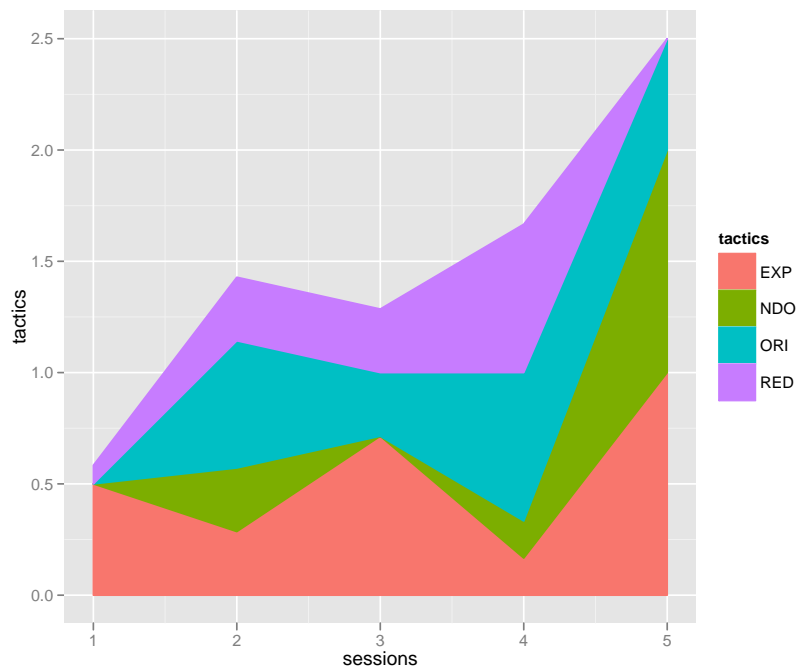


Figure 3: Aggregation of exploration tactics employed per task. EXP: exploration; NDO: narrowing down; ORI: gaining orientation; RED: redoing.

Another group of tactics are those that require active problem solving through exploration. The exhibition of exploration tactics indicates that users are able to autonomously address the problems they encounter on the

Web by employing sophisticated techniques. Figure 3 suggests that there is a substantial increase of exploration tactics across sessions: at the first session 1 exploration tactic is employed every 2 tasks, while at the last session 2.5 exploration tactics are employed per task. The grow on the frequency of exploration tactics and the parallel reduction of last resort tactics is indicative of users gaining mastery over the Web environment and suggests the transformation of novice users into independent users.

4.3. Performance metrics

The previous section indicates that users become more autonomous and independent across sessions. Users also learn to develop sophisticated tactics in order to address the problems they encounter. In this section we analyse the evolution of users' performance in terms of how successfully accomplish the tasks they set to themselves and how effectively coping tactics allow users to overcome problems.

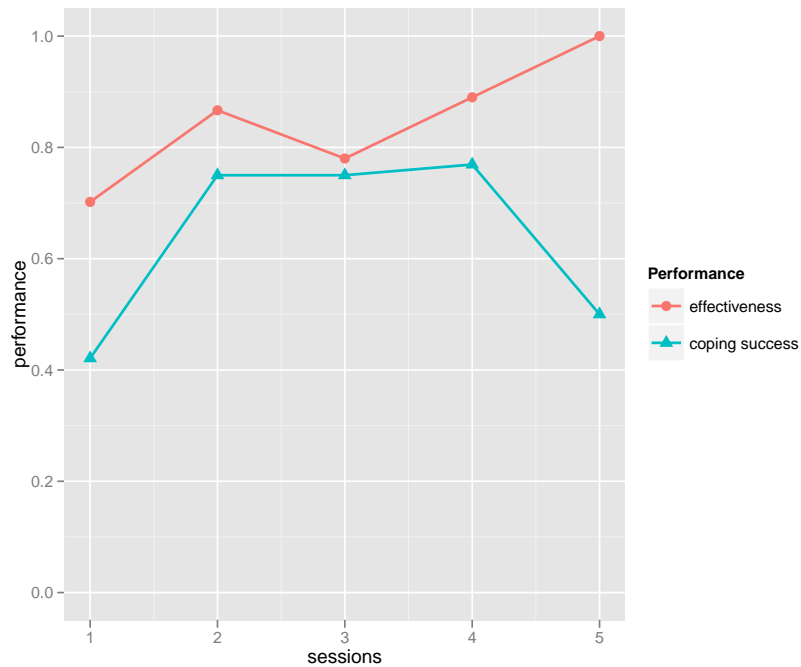


Figure 4: Performance metrics: effectiveness and coping success.

Effectiveness is computed as a binary metric (0: failure; 1: success) that measures whether users are able to accomplish each task, no matter how

long it takes them to complete it. Figure 4 shows that effectiveness is high — always above 0.7 — from the very beginning, increasing steadily until reaching full effectiveness (i.e. 1). The performance in later stages suggests that, as the sessions go on, users become more effective. Coping success is also a binary metric which measures whether a given tactic allows the user to overcome a determined problem. If after employing the tactic the problem still persists it is considered a failure and a success otherwise. Figure 4 indicates that coping situations are overcome at a rate of 0.4 in the first session increasing until 0.75 in the second session. A plateau is observed from session 2 to 4, whereas in the last session coping tactics success decreases until 0.5, which means that out of 2 tactics employed only 1 overcomes the problem. Considering that, on average, users are fully effective in the last session this decrease in coping success may indicate that users are less successful in coping because, as the sessions go on, they add new tactics to their repertoire. Consequently they have more tactics to choose from and are more prone to failure as they might employ tactics that are not suited to address the problems faced.

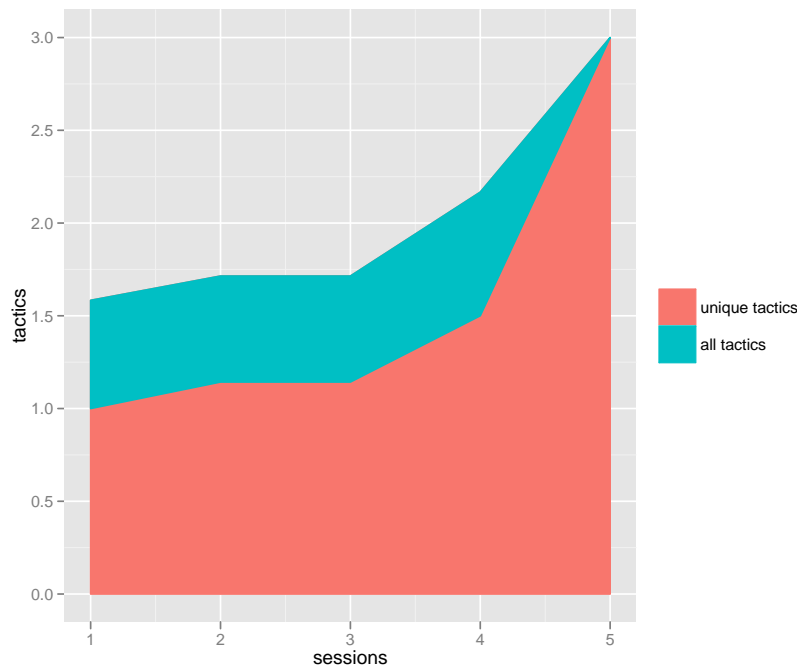


Figure 5: Rate of unique tactics and all tactics employed per task.

The reduced efficiency because of a larger repertoire of tactics is reinforced by figure 5, which shows that all the tactics employed in the fifth session are exhibited once per task, while in the previous sessions some tactics are repeatedly used in the same task.

4.4. Other metrics: number of exhibited tactics, visited websites and problems encountered

Figure 6 shows the number of websites visited per task, which increases from 1 to 1.5 website visited per each task. Since we found that users employ more exploration tactics at later stages (see figure 3), the increased number of visited websites may be one of the consequences of employing these sort of tactics.

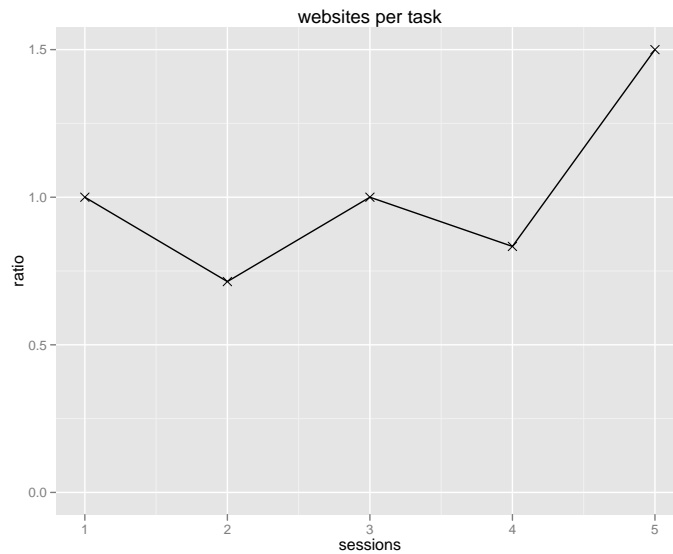


Figure 6: Websites visited per task across sessions.

Figure 7 shows an increase in the number of tactics employed per task. The figure duplicates from the first to the last session: from 1.5 to 3 tactics per task. The fact that users visit more pages may be the cause why users encounter more coping situations (as suggested by figure 8) and exhibit more coping tactics as a consequence (see figure 7). That is, as sessions go on users get more confident and gain independence; they are more adventurous and explore a higher number of pages where they are more likely to come across

more problems. Alternatively, another explanation on the increase of coping tactics can be explained in that the web pages navigated in later sessions pose more problems than at the outset. However, this explanation is refuted by figure 9, which does not display any particular trend and shows that the ratio of problems encountered per website stays normally around 1.5 problems per site.

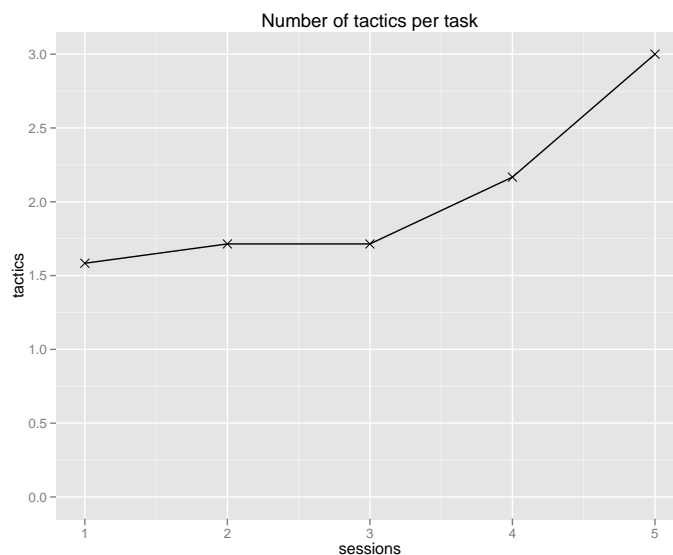


Figure 7: Tactics per task across sessions.

5. Discussion

In section 5.1 we analyse the implications of the above discussed results in order to understand the learning process of visually disabled users on Web environments. In light of this understanding we also discuss how interventions could support users during this process (see section 5.2).

5.1. On the skill acquisition process

The effectiveness metric, measured in terms of task completion rate, indicates that there is an increase in user performance during the 5 sessions in which participants were observed. This suggests that observed novice participants, who had very little knowledge about computer use and the Web,

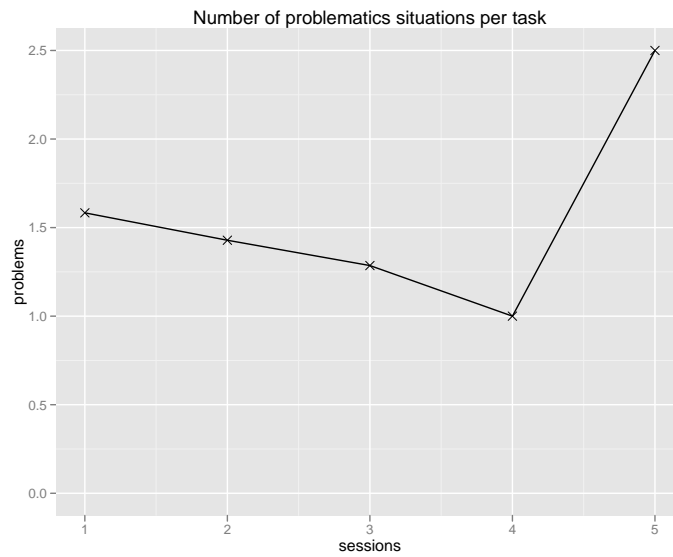


Figure 8: Problems encountered across sessions.

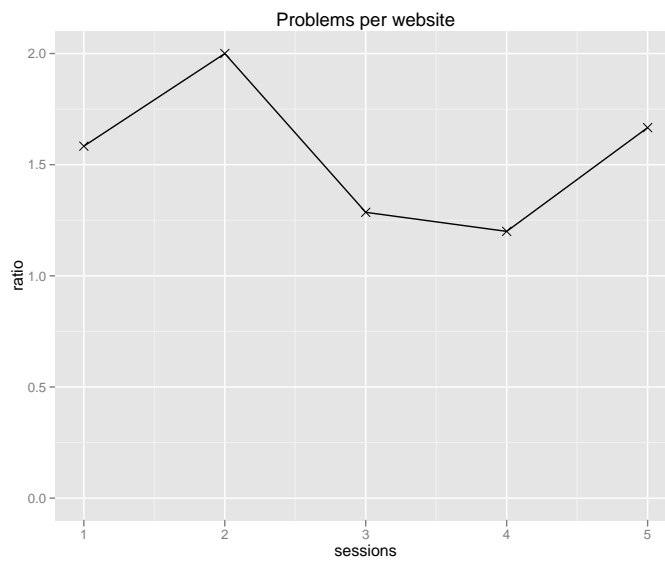


Figure 9: Problems encountered per website visited.

developed a number of skills and acquired competences across a period of time that comprises 2 months. We ignore whether these users practised at

home or elsewhere in between the observations we report in this paper. However, we provide 5 snapshots that depict the learning process of 5 users who were novices at the time they joined the course. This picture shows that, over this period of time, users became more effective accomplishing their tasks.

If we observe the skill acquisition or learning process from a coping tactics perspective some interesting phenomena emerge: in the initial sessions, understandably, users fundamentally exhibit last resort tactics when they encounter problematic situations: asking for help, not operating and giving up. This behaviour is justified by the manifest lack of skills and scarce competences that users have at the outset. Last resort tactics such as asking for help are indicative of individuals not being independent users as they have to rely on somebody else to get further instructions or to be reassured about the actions taken. In the majority of cases asking for help was an effective tactic provided that the tutor or a peer was available. In a more realistic setting this might not be the case if users were on their own and relatives may not know how to support them. In such a situation, we hypothesise that users would employ other last resort tactics such as not operating or giving up.

The fact that users do not actively seek to overcome a problem when employing not operating and giving up tactics may suggest that they lack the autonomy to creatively tackle problems. However, it should be noted that not employing sophisticated tactics does not always entail failure in overcoming problems. One paradigmatic case of this can be described with the not operating tactic: an item looping in a carousel widget drew the attention of *P1*. When *P1* decided to click on the item, the carousel updated and it was replaced by new content. At that moment, *P1* got stuck and decided not to do anything. The carousel updated its content by looping its items from time to time and unexpectedly — *P1* was not aware of the looping functionality — the item appeared again. Therefore, not doing anything was in this case, even if not a very efficient, an effective tactic.

We discover that, as the sessions go on, last resort tactics are gradually replaced by exploration tactics: exploration, narrowing down, gaining orientation and redoing. These tactics are more sophisticated than last resort tactics in that they imply the exhibition of problem-solving strategies to overcome problematic situations. Even if the increased use of exploration tactics is an indicator of skill acquisition, at this stage users are still considered novices as suggested by the problem-solving strategies they employ (Card et al., 1983). However, progress towards the expert/skilled end of

the continuum is observed as some automated behaviours are also exhibited: moving down quickly in order to get an overview of the page (exploration) and backtracking to a familiar web page (gaining orientation).

As a result of employing exploration tactics users rely less on other individuals and progressively achieve independence and autonomy in the Web environment. As opposed to last resort tactics, which are employed on a single web page, the implementation of some exploration tactics such as narrowing down, gaining orientation and redoing entails link traversal. Consequently employing exploration tactics, in addition to gaining autonomy, leads users to visit more websites, allowing them to experience new grounds.

However, drawbacks are also observed as the sessions progress: while users become more effective accomplishing tasks, they are not that successful overcoming problematic situations that arise when carrying out these tasks. We see that problem overcoming rate does not only remain stagnant across sessions, but it even decreases in the last session. The fact that in this final session users employ more unique tactics per task — meaning that tactics are not repeatedly employed, but they are used just once in each task — and problem overcoming rate decreases, suggests that a wide variety of tactics was unsuccessfully employed in each task. Considering that over the sessions new tactics are added to a coping tactics repertoire that becomes larger, coping failure can be described through 2 explanations: the first explanation indicates that the wider choice of tactics in later sessions makes the selection of the most appropriate tactic more challenging; the second explanation suggests that in later sessions users have acquired enough confidence not to employ their tactics in an thoughtful way, which is a negative consequence of exhibiting the above-mentioned automated behaviours. Moreover, this may also be indicative of users being sufficiently skilled to recover from failure at this point. In any case, our analysis shows that, even if users fail to cope in later sessions, they are more effective accomplishing their tasks. This means that in later sessions users have emotional and procedural mechanisms to recover from failure, insist on overcoming encountered problems and are more determined to achieve their goals.

The evolution of the herein reported behaviours — compared to initial sessions, users explore more web pages, are more effective and are less successful employing tactics at later sessions — reminds of the distinct behaviours exhibited by younger and older adults on the Web. Literature suggests that, compared to their younger counterparts, elderly users make fewer mistakes and it takes them more time to accomplish their tasks; however, they are

as effective as younger adults (Fairweather, 2008; Lunn and Harper, 2011). Older adults are less prone to error, are more cautious and prefer to proceed safely when trying to accomplish their tasks, whereas younger adults are less thoughtful and more prone to make mistakes, which suggests they use error recovery mechanisms. The behaviour of younger adults resembles to that exhibited by our participants in later sessions. This may be indicative of a pattern on the behaviour of individuals who are constrained either by their perceptual and cognitive abilities (elderly users) or by their lack of skills and perceptual abilities (novice visually disabled users, our participants). This suggests that the constraints imposed by abilities and experience may influence the behaviour of different populations.

5.2. Removing the need to cope: adaptive interfaces for adaptive behaviour?

The active user paradox (Carroll and Rosson, 1987) suggests that individuals consciously ignore the procedures that make them more efficient (i.e. production paradox) and their reliance on previous knowledge makes them underperform (i.e. assimilation paradox). Adaptive systems that automatically adjust their interface by disclosing and rearranging new functionalities or content are often proposed to overcome these situations and smooth out the learning process. However, by doing so, there might be unforeseen negative consequences as users may feel unsettling in unfamiliar ground. What is more, learned habits become useless as the adjustments made to the interface disrupt the learning process. On top of that, the notion of adaptive interfaces collides with the idea of embedding into the interface features that bring about habituation (Raskin, 2000), which leads users to automate their behaviour and routines.

The outcomes discussed in section 5.1 indicate that even if users fail to cope, eventually they are able to accomplish their tasks effectively. Our 5-session-snapshot suggests that failure to cope in later stages is caused by the difficulty in appropriately selecting a tactic that better addresses the encountered problem from an increasingly larger repertoire. The fact that users may recover from failure better at later sessions and the larger number of disruptive tactics employed at the outset manifests that what are needed at the initial sessions are mechanisms to assist users in recovering from failure.

In light of our outcomes interventions should be devoted to recovering from failure at the initial stages and allow visually disabled users to develop automatic behaviours through habituation at subsequent stages. Failure is avoidable if users are provided with assistance that explains how to interact

with unknown features: Lunn and Harper (2011) address this problem by providing elderly users with an assistance tool containing videos and explanations about how to interact with Web widgets. It should be noted that for *absolute beginners* this interventions should preferably be complementary to training sessions as users may need help to operate the assistance tool. Future research should explore how to provide users with mechanisms not only for preventing failure, but also for failure recovery. In this regard, coping tactics are useful to recognise situations of failure as they are behavioural markers of cognitive processes that indicate problematic situations. Therefore, we argue that automatic detection of coping tactics is key to intervene in those situations in which support to recover from failure is needed (Vigo and Harper, 2013b).

Mechanisms that foster the development of habits can be implemented through modeless interfaces according to Raskin (2000). Modelessness happens spontaneously when users stick to one method and ignore other alternatives. In addition, modelessness can also be implemented deliberately by implementing on the interface gestures or operations that have only one result, which is called *monotony* of design. As a consequence of not having competing alternatives to accomplish the same atomic task users would develop habits and automated behaviours. Incidentally, when describing habituation features for sighted users, Raskin states that habituation features are those features that would make blind users interact successfully.

5.3. *Limitations of the study and future work*

In-situ observations are invaluable as they allow observers to contextualise the problems faced by users and identify the cause of these problems. However, they also have their downsides in that the presence of observers, which eventually interacted with participants on demand, may lead to the Hawthorne effect (Payne and Payne, 2004). In any case, if this bias was introduced it would have been introduced consistently, increasing the performance indicators equally across sessions. Since we focus on the evolution of user behaviour instead of focusing on absolute performance values, there would not be any significant impact on the analysis of user adaptation.

Our findings indicate that more research is needed to explore human adaptation to Web environments. We provide an initial study that explores how novice visually disabled users cope with difficulties on the Web. Longer studies, especially longitudinal ones, may shed some light on user adaptation

in the medium term. There are a number of questions that remain unanswered: do individuals eventually stabilise their behaviour? If so, at which point does this happen? Do individuals learn to make better selections from their tactics repertoire? Finally, it would be desirable the involvement of a higher number of participants in future studies.

6. Conclusion

The Web is a hostile habitat for novice visually disabled users, who are constrained by their abilities, their lack of expertise and a large number of websites that contain accessibility barriers. This environment is an invaluable setting to explore adaptive behaviour and observe how this particular group of users manages to cope with difficulties. To do so, we not only analyse how their coping tactics evolve over 5 sessions in a period of 2 months, but also examine the relationship of this evolution with navigation and performance metrics. We discover that, as sessions go on, users achieve higher task completion rates, exhibit more exploration tactics at the expense of employing fewer last resort tactics and acquire the confidence that enables them to visit more websites. These metrics can be considered learnability indicators that could be exploited in order to appropriately intervene on the interface. In this way beginners would be provided with failure recovery mechanisms, whereas more advanced users would be supported through interventions that would facilitate habituation.

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