

5 Discussion

The main question of this research, as pointed out in section 4, was: “How does WNH help or not help functionally illiterate and blind users in navigating the web?”. This study started with an initial conception of the system architecture, its main functions and how the interaction with the users would take place. At that point, the main purpose was to test if this pre-conceived system would work for these users or not. The experiments nevertheless were quite revealing, since they evidenced misconceptions in the initial proposal, and this promoted a new progressive approach, aiming at knowing how WNH can be improved to suit these two (functionally illiterate and blind) different classes of users with special needs more appropriately. These two issues are presented and discussed below.

5.1. How does WNH help or not help functionally illiterate and blind users in navigating the web?

Overall, WNH seems to help users in web navigation. Participants from both experiments seemed to have positively accepted the tool; even though not all of them successfully concluded the given task. The evaluation of such a complex and innovative system, involving users with special needs, should analyze it from different perspectives and identify the possible reasons for each individual success or failure. Therefore, WNH evaluation should take into account the following important considerations:

- 1) System behavior: WNH was conceived and developed in a very intricate and *spiral* way. As the system evolved, it was tested with users. The results of such experiments fed WNH back with important needed changes, which were indeed implemented. At some stage, due to time constraints, changes to WNH were frozen, even though it was known that these to-be-fixed issues might have negatively impacted users during the experiments;
- 2) Users' characteristics: web accessibility is directly dependent on digital skills. If users are not acquainted with computers and do not know how to

execute the basic Internet operations, (such as click on links, select items from combo boxes, handle pop-up messages, etc.), finding resources in the web will be seriously compromised. To use an analogy: one cannot drive to the desired place if one does not know how to drive a car. The intention here is to point out that some of the difficulties presented by users when interacting with WNH might have been caused by digital illiteracy, which is a problem not directly tackled by WNH;

- 3) User Interface: some of the difficulties presented by users might have arisen due to an unclear or incomplete interface design;
- 4) New approach: WNH presents a new form of interaction in Internet, with which most users are not familiar. The idea of interacting with a plug-in of the browser instead of with the web page itself is a new concept and might have not been fully clarified to users. Moreover, the automated navigation process might also have contributed to the sense of loss of orientation a few users demonstrated during the experiments;
- 5) Unfamiliar technology and hardware: the use of different screen readers and different keyboards might have impacted blind user navigation;

Below both WNH-see and WNH-read are analyzed considering the topics listed above.

WNH-see

According to the experiments with the blind, WNH-see seemed to help its users in executing the process and accomplishing the desired task.

System Behavior

- Even though none of the WNH-see users successfully reached the end of the process, four out of five participants were very close to accomplishing the task. One of them failed because of the session timeout imposed by the website, which could easily be solved by anticipating all user data inputs to the beginning of the process execution. This will enter the list of items for Future Work tasks;

- Three participants, out of five, failed because of difficulties with the audio captcha. Two of them failed in capturing the read out loud numbers and rewriting them in the blank field. They were not ready to capture them, and once the audio started, they could not quickly type them. The third user, however, had an issue of a different kind: he kept browsing and moving the cursor when the audio captcha was being read out loud by the website. The result was a mix of sounds from both the website and the screen reader, which caused him to miss the read out loud captcha numbers. Users in the current version of WNH-see are not given a second chance during each execution process, an option of re-executing the current step. If missed, the only alternative is to restart the whole process. To overcome this problem in future versions, users should be allowed to repeat current step if desired;
- The first experiment raised the concern that blind users had a particular issue in locating themselves during the automated process execution (as will be more explored below in section “User Interface”). With that in mind, giving users the possibility of restarting the process and/or asking for help at any given moment arose as a requirement that was immediately incorporated in WNH-see for the next experiments. By doing that, WNH-see is giving users the capability of easily recovering from errors or losses during the process. The repercussion of this enhancement was good, as it seemed to help users;
- WNH was designed thinking much more of the success case than of the failure case. It is not well prepared for situations in which users do the unexpected, such as not filling out the form when requested, or filling out with invalid values, or closing a pop-up window without reading its orientations, and so on. In every individual case, the system should be robust, prepared to handle errors and give users the possibility of re-executing the current step execution. Not only did the WNH current version not implement this, but in some cases it might even have misled users by telling them the current step was successfully completed, when it actually had errors. These open issues will be addressed in WNH future versions;

User Interface

- The explanation given to blind users of how to interact with WNH-see was not an easy task. Showing it visually to sighted users, as was done in the tutorial video for WNH-read users, was immediate, and proved to be helpful. However, how should one explain to a blind user where WNH is located, what belongs to WNH plug-in, what belongs to the browser and what belongs to the web page itself, and so on? Sighted users have the advantage of clearly seeing these limits, the frontiers between each of these units. Blind users, however, need to be told of these limits. Indeed, during the experiments, some of the users leaked out of the plug-in into the website page, without even noticing it, and started interacting with the page. In these cases, the experiments were restarted. It is indispensable that future versions of WNH-see audibly mark these delimitations, so blind users will identify whether they are moving out or not from WNH-see. This will be addressed in Future Work;
- The first experiment gave evidence of the sense of loss of orientation demonstrated by the user, since he could not locate himself in the process execution. While sighted users watch the movements of WNH on the screen and see the ongoing automated process on screen, blind users do not have a clue of what is taking place, unless these movements are somehow narrated to them. As this was considered to be a critical aspect of the tool, this enhancement was implemented for the further experiments: once the step is executed, WNH-see pops-up a message that will be read out loud by the screen reader, containing the information of how many steps are behind the execution and how many are left to complete the task. However, there are still many improvements left for future versions, such as: letting users know the nature of each accomplished step (if some button was clicked, or some field was filled in), instead of only reporting that step 'x' was concluded and 'y' are still left;

New Approach

- The new approach of having an automated process execution was a surprise to some users, but all of them seemed to accept and understand it well. There were no major concerns concerning this topic;

Unfamiliar technology and hardware

- Participants of the experiments had visible difficulties with both JAWS screen reader and with laptop keyboards. Some participants do not usually use JAWS when navigating, so they were not quite familiar with its shortcut commands. But this difficulty was not critical and did not have great impact on the results, since the experiment required the use of only very few shortcut commands (tab, to move forward; shift-tab, to move back; and enter, to pick the element). Concerning the speech of the screen reader, only one participant complained about not fully understanding its Portuguese with an English accent, but it seems it did not put the experiment into jeopardy. Concerning the laptop keyboard, all blind users manifested lack of confidence in using laptop keyboard instead of desktop keyboard. They not only presented difficulties with it, but some of them might have even missed the audio captcha because of it;

WNH-read

WNH-read also seemed to help its users in executing the process and accomplishing the desired task.

System Behavior

- Although only one user successfully accomplished the task three others were very close to it. These didn't finish because of the same session timeout issue experienced with WNH-see users. Therefore, the same solution proposed in WNH-see, to anticipate user data inputs to the beginning of the process execution, will be applied in WNH-read. This will be left to Future Work tasks;
- The WNH-read experiment expected users to trigger the desired script and interact with WNH, till the point they were asked to select some data in the web page itself, and to resume the execution process through WNH-read by clicking on the "Execute" button. However, after selecting the data on the web page, none of the users went back to the WNH. They all started with WNH and dropped it at some point. Although this was not the desired behavior, it should not be treated as a failure. In all five experiments, WNH served as a starting point to the process, and users were conducted to a point from which some of them could easily conclude the process. This behavior shows two distinct approaches for the system:

- i) even if not conducting the user to the end of the process, WNH is still relevant and important, since it helps users *advance* in the overall process. Or, in other words, it brings users closer to their final goal; ii) it also suggests future thoughts for WNH: instead of conducting users through the whole process, WNH could be seen as an aid that permeates user interactions, assisting users when needed and/or solicited. Users would be able to ask for WNH guidance not only from the beginning of the process, but from somewhere in the middle as well. This nevertheless is left for Future Work;
- As with WNH-see, WNH-read is also not robust concerning users' errors and/or unexpected behaviors. If users by mistake fill an invalid data into some input field, WNH-read will report the step was successfully accomplished, even though it has errors. In order to be transparent with users and not misguide them, future versions of WNH-read should take the mission of implementing validations and checking the correctness of every individual executed step. These new implementations will be addressed in Future Work;

User characteristics

- Although the selected users for the experiment were such that they had previous computers and Internet experience, many of the issues found were related to digital literacy. Three of the participants showed low fluency in dealing with html elements (e. g. not knowing where to click the link, or how to select dates in a combo box list). Although this cannot be pointed to as a WNH-read rupture/failure, its designers, developers and volunteers should bear in mind that this phenomenon will not be uncommon in its target public, and therefore they should try to minimize as much as possible these interferences. This, nevertheless, brings the discussion to another topic of utmost importance. The immediate purpose of WNH, as already seen, is to help users in web accessibility. In the long term, though, it is expected that WNH-read, as a side effect, might help improve literacy skills and bridge the digital accessibility gap amongst users. Although there is an imminent risk that users will avoid interacting with the web page and restrict their navigation to only those sites that contain shared scripts, another possible scenario is that users will slowly get used to the Internet and "take more risks", exercising both Internet

navigation and their reading skills. With that in mind, WNH designers, developers and volunteers should find the equilibrium to assist users according to their needs, as a helping device, but take care not to turn WNH into a substitute for web navigation, which would lead to the undesired consequences of maintaining the illiteracy *status quo* of this group of people;

User Interface and New Approach

- As for the WNH interface, the first user of WNH-read didn't understand from the instructions how different from a normal navigation this interaction would be. In other words, she didn't understand what it means to interact with a plug-in, how and where to do that. Indeed, making a regular internet user understand what a browser plug-in is can be not an easy task; explaining the same thing, with the aid of a text, to a functional illiterate and less experienced internet user proved it to be even harder. The choice made was to create a video tutorial that visually showed, with no oral explanations, how to interact with WNH. The results seemed to be satisfactory. All four following users watched the tutorial before starting to interact with WNH and they all easily found out how to trigger the process execution. The success of this approach, however, might mask possible problems in WNH-read interface. Since not all users will have watched the tutorial video before, when WNH-read becomes fully operational, they might face other difficulties not perceived in these experiments. For these cases, it is important to run experiments that show no tutorial video and specifically investigate this aspect of the WNH-read system. Some interface issues identified during the first experiment were fixed, as pointed out in Figure 20. Other issues were left to be fixed in Future Work;
- Moreover, few enhancements and improvements concerning WNH user interface need to be accomplished in future versions in order for WNH to be fully operational. Two of them are worth mentioning now:
 - i. WNH, maybe due to its peculiar target public, should treat intuitiveness as a must-have attribute. WNH current version is still not a fully intuitive system, and much work concerning the semiotics of the interface should be done;

- ii. WNH should let users follow closely the execution of the process. They should be informed at each step of the execution where they are and what needs to be done next. The current WNH-see version (for the blind) has a taste of this future feature, and bringing that feature to WNH-read should be of no major difficulty;

5.2. How can WNH be improved to suit these two (blind and functionally illiterate) different classes of users with special needs more appropriately?

As stated in section 3.2.4, WNH was, naively or not, thought to be a single solution with minor customizations to attend different classes of users. The original idea was that both functionally illiterate and blind users could equally benefit from a tool that automates web processes when navigating the web, and that the main difference between the two interactions would be the use of screen readers in the blind navigation.

As the experiments began, though, the results were different from expected. The first two experiments run were with functionally illiterate users, and during these experiments, the following new requirements were already identified:

- 1) Omit unnecessary visual elements from WNH interface in order not to visually confuse users;
- 2) Facilitate users' finding of the button which triggers the list of functionalities by making it blink;
- 3) Explain how to use WNH through a tutorial demo;

As the experiments with the blind started, specific requirements for that group of users were also identified. They are:

- 1) A notification, at every iteration, of the current step and how many are left to accomplish the task (as shown in Figure 18);
- 2) The possibility of restarting the process or asking for help at every moment;

- 3) Information to users concerning the limits of WNH (when the cursor crosses the frontiers);
- 4) The possibility of replaying the audio captcha, if requested by users;

As it can be noticed, the two solutions demand specific proper customizations. What was once thought of as being tiny adjustments to meet different users exigencies presents itself today as almost two different and parallel tools (with, of course, an immense common ground between them).

This, nonetheless, might be only the tip of the iceberg. The experiments undergone are very few, and the nature of the experiments is also very basic. It won't be surprising if future experiments, with more users and more tasks in different sites, turn out to demand even more customizations.

Considering again the second contribution question "How can WNH be customized to attend these two (functionally illiterate and blind) different classes of users with special needs", the most important lesson learnt is that: **automated web processes do help users in navigating the web. However, everything seems to indicate that each class of users will need specific solutions with tools better tailored to its specific needs.**