TechSAge Tool: Heuristic Analysis (V1)

Rehabilitation Engineering Research Center on
Technologies to Support Aging-in-Place for People with
Long-Term Disabilities (RERC TechSAge)
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TechSAge Tools Overview

TechSAge has designed this tool series to provide its readers with guides on how to conduct various aspects of human factors research. The tools have a focus on including the target population of adults aging with disabilities. TechSAge Tools are designed to:

1) Introduce a variety of research methods, procedures, and protocols

2) Provide guides and “how tos” about implementation

3) Discuss considerations specific to working with adults aging with disabilities

4) If applicable, recommend appropriate wording to describe the method in publications

5) Point to reliable resources for more in-depth information about the method, procedure, ore protocol presented in the tool

This TechSAge tool is designed to give an overview of what a Heuristic Evaluation is, how to score it, and how to detect heuristic violations. Heuristic evaluations make the design of systems more usable, however, this tool goes further by suggesting additional accommodations to be made by designers who are developing or evaluating systems for older adults with disabilities is also discussed.

Heuristic Analysis

INTRODUCTION

Heuristic evaluation is a process that entails examining the design of a user interface and judging its compliance with a list of predefined principles. These principles are used as a benchmark, helping the evaluators to identify potential usability issues that users may encounter (Nielsen & Molich, 1990). There are multiple heuristics but a commonly used set from the human factors literature is Nielsen's Ten Usability Heuristics (Nielsen & Molich, 1990; Nielsen, 1994). Nielsen developed ten principles (see Table 1); each principle is scored on a 0-4 scale to determine the current usability status (see Table 2). Scoring sheets are recommended to be used to provide context for the reasoning of each score (Figure 1). We have developed a "TechSAge Tool Heuristic Analysis Scoring" excel template. The excel template and example files are available from authors on request.

TABLE 1. NIELSEN'S TEN USABILITY HEURISTICS

Heuristic Principle	Definition
Visibility of system status	Users should be informed what is going on with the system through appropriate feedback
Match between system and the real world	The image of the system perceived by users and presentation of information on the screen should match the model users have about the system
User control and freedom	Users should not have the impression that they are controlled by the system
Consistency and standards	Users should not have to wonder whether different words, situations, or actions mean the same thing. Design standards and conventions should be followed
Error prevention	It is always better to design interfaces that prevent errors from happening in the first place
Recognition rather than recall	The user should not have to remember information from one part of the system to another
Flexibility and efficiency of use	Both inexperienced and experienced users should be able to customize the system, tailor frequent actions, and use shortcuts to accelerate their interaction
Aesthetic and minimalist design	Any extraneous information is a distraction and a slowdown
Help users recognize, diagnose, and recover from errors	Error messages should be expressed in plain language (no codes), precisely indicate the problem, and constructively suggest a solution
Help and documentation	System should provide help when needed

TABLE 2. SCORING GUIDELINES FOR NIELSEN'S TEN USABILITY HEURISTICS

Scoring	
0	Do not agree that this is a usability problem
1	Cosmetic problem
2	Minor usability problem
3	Major usability problem (important to fix)
4	Usability catastrophe (imperative to fix)

Heuristic Evaluation

Heuristic evaluation is an evaluation method used in user interface design to gauge the overall usability of an interface. The heuristics, as defined by Jakob Nielsen, are meant to be broad rules of thumb and not strict, specific usability guidelines.

Evaluator's Name: Product:

1. Visibility of System Status *The system should always keep users informed about what is going on, through appropriate feedback within reasonable time.* Issues	Recommendations Rating *Please rate the overall severity of these issues present in the evaluated product.* *(0 - not an issue, 1 - cosmetic problem, 2- minor usability problem, 3 - major usability problem, 4 - severe usability problem)* 0 1 2 3 4

Figure 1. Example of a scoring sheet for a heuristic evaluation.

Below we present good and bad examples of design related to each of Nielsen's 10 principles. This can be used to provide more context for Nielsen's Heuristics. These examples can also be used to train new evaluators who will be involved in evaluations. Each principle has two short paragraphs, one for a good example and one for a bad, accompanied by images to illustrate the concepts.

HEURISTIC EVALUATION: GOOD AND BAD EXAMPLES

Principle 1: Visibility of system status

GOOD: The user should know what is processing within the system. A well-represented example of this heuristic is the loading circle for the Facebook application on smartphones represented in Figure 2. This animation allows the user to understand that the page is loading—should this circle not be present, the user may think they cannot get the page to refresh when, in fact, the page is refreshing.

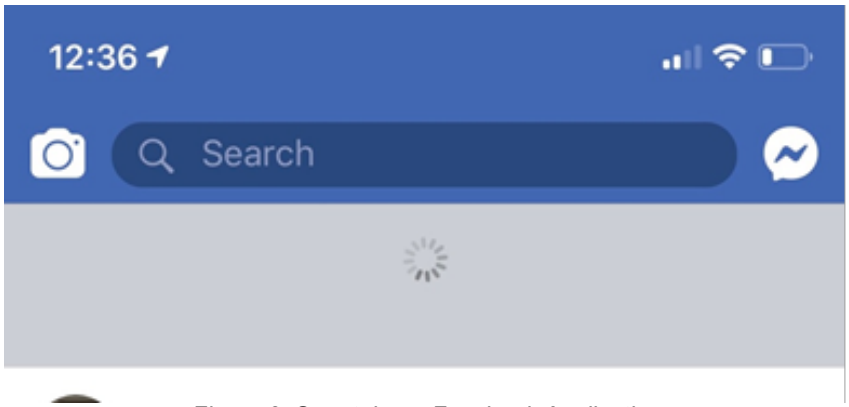

Figure 2. Smartphone Facebook Application

BAD: An example that exemplifies bad visibility of system status is the portable charger pictured in Figure 3. This is a prime example for bad usability as there is not a way to tell if the portable charger itself is charged (Miller, 2016).

Figure 3. Portable Charger

Principle 2: Match Between System and the Real World

GOOD: It is important that the design of a product does not violate our understanding of the world. For example, if you want a user to know that their trash bin on their laptop is full—you display it as a full trash as opposed to an empty one, as represented in Figure 4 (Liyanage, 2016).

Figure 4 Full Recycling Bin

BAD: Users may assume that dragging the disk icon to the trash would delete their files on that disk. In the example in Figure 5, the secondary function of the trash icon (disk ejector) is overextended beyond its more immediate connotation of deletion (Mediati, 2016).

Figure 5 Eject Secondary Function

Principle 3: User control and freedom

GOOD: The user should have the freedom to navigate, change, go back, or fix any aspect for which they made a mistake. For example, when we delete an email on accident in Gmail, it gives us a message to undo the deletion just in case it was a mistake (Figure 6; Rengifo, 2018).

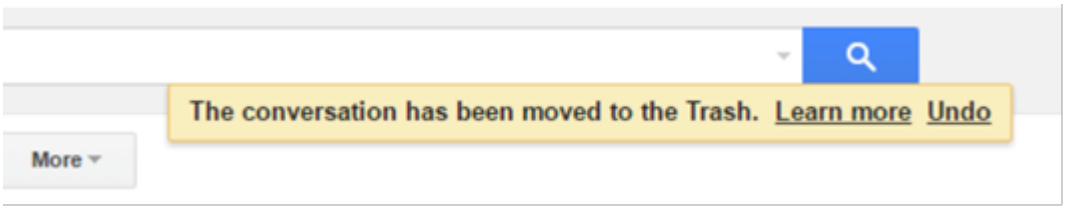

Figure 6 Gmail Undo Email Deletion

BAD: When viewing a product listing on Amazon (Figure 7), there is no clear indication of how to cancel your listing-- the user is only prompted to submit their listing (Ortega, 2010).

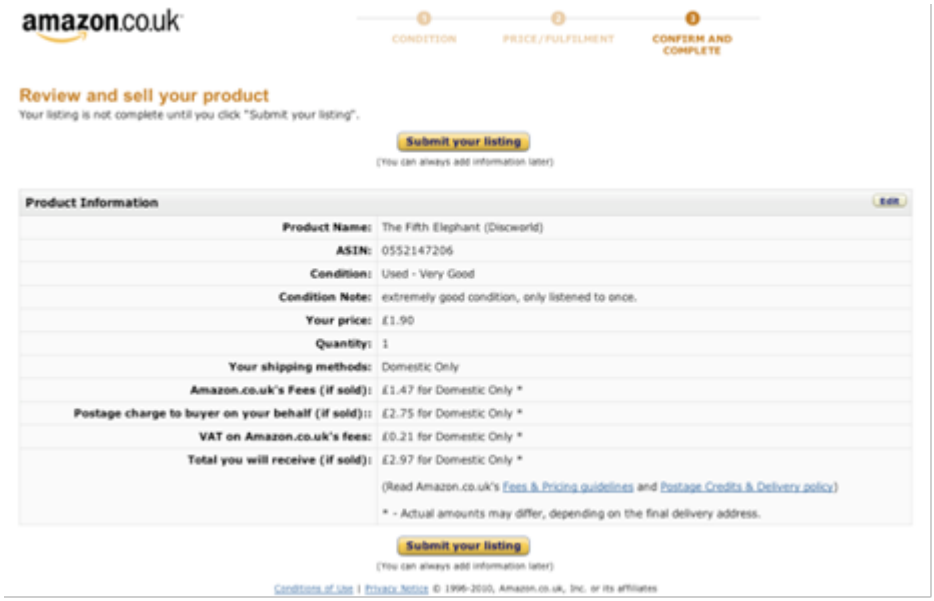

Figure 7 Amazon Product Information Order

Principle 4: Consistency and Standards

GOOD: Consistency and standards refers to keeping concepts the same throughout the product. For example, the navigation bar should always appear the same and stay in the same place. A good example is how Microsoft tools all have a consistent menu bar for the different Microsoft Office applications (e.g., PowerPoint, Word, Excel; Figure 8).

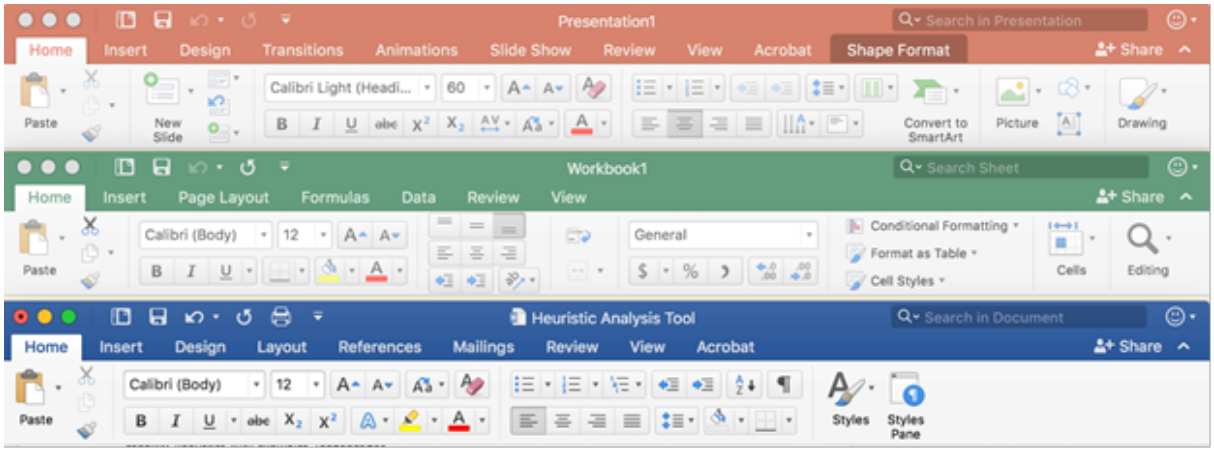

Figure 8. Microsoft Tool Banners

BAD: As represented in Figures 9, 10 and 11, there is a violation of the consistency and standards principle as each main menu changes depending on the page that the user is on. This violates having consistency between windows, making the website harder to navigate (Wong, 2019.)

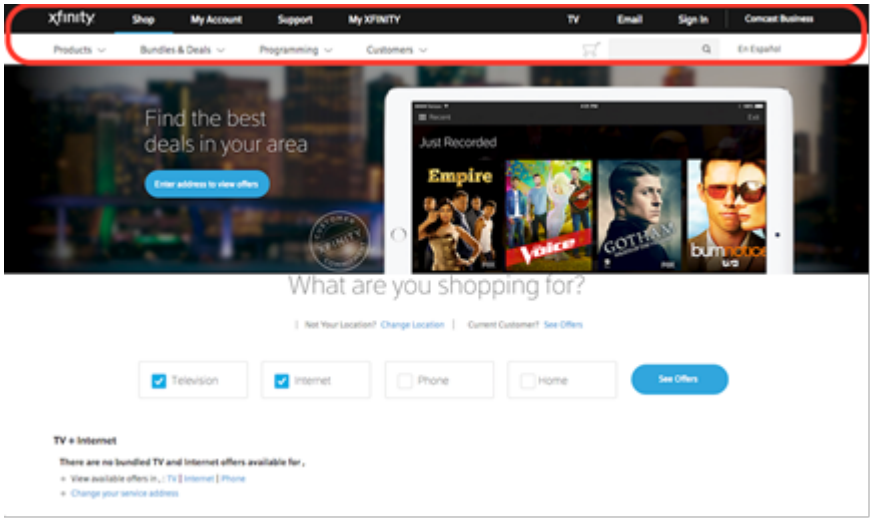

Figure 9. Xfinity Website Inconsistent Menu 1

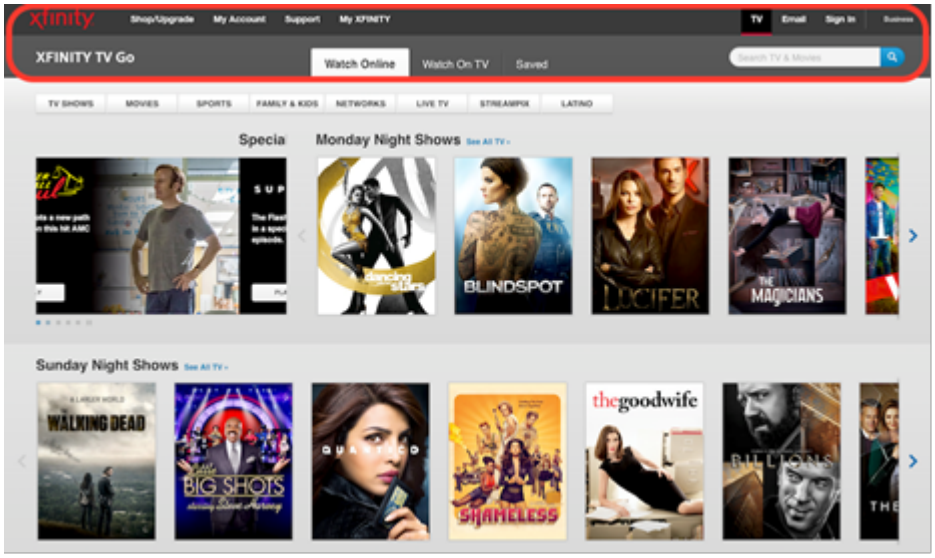

Figure 10 Xfinity Website Inconsistent Menu 2

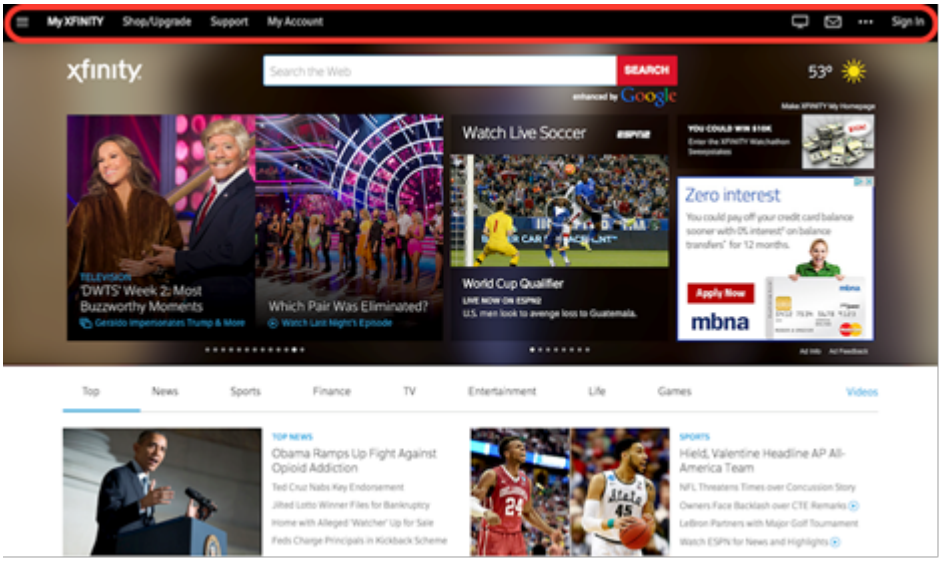

Figure 11. Xfinity Website Inconsistent Menu 3

Principle 5: Error Prevention

GOOD: Error prevention is an aspect that should be used to help users catch themselves making a mistake before it is too late. A good example of this, is with Microsoft Word. If the user attempts to exit a file that has not been saved yet, it provides the option to cancel the exit and save the document (Figure 12).

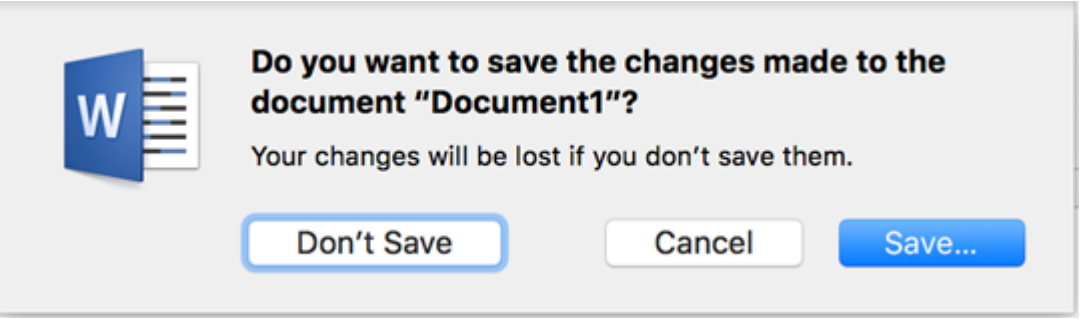

Figure 12. Microsoft Word Warning Message

Another form of error prevention is the red underlining for misspelled words (Figure 13).

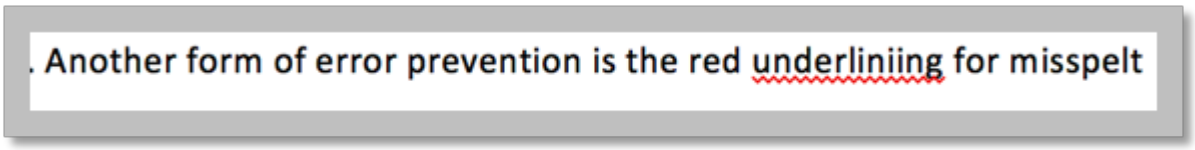

Figure 13. Underline Warning Message

BAD: The following bad example is an example from a Google Form (Figure 14). Screenshot A shows a prompt as it is presented to the user. There is no indication of any word/character constraints for the user's response. If the user were to prepare a lengthy response in a separate document and then copy it over to the form, they would be met with an error message shown in Screenshot B. The form does notify the user of the error before they try to submit the form, but it does not clearly indicate the response field constraints before the user starts typing. A better design would indicate the allowable number of characters for the response as well as display a character counter so the user can see how many characters they have used as they are typing.

Screenshot A

Describe a time in which you were a leader. *

Your answer

Screenshot B

Describe a time in which you were a leader. *

Lorem ipsum dolor sit amet, consectetur adipiscing elit, sed do eiusmod tempor incididunt ut labore et dolore magna aliqua. Ut enim ad minim veniam, quis nostrud exercitation ullamco laboris nisi ut aliquip ex ea commodo consequat. Duis aute irure dolor in reprehenderit in voluptate velit esse cillum dolore eu fugiat nulla pariatur. Excepteur sint occaecat cupidatat non proident, sunt in culpa qui officia deserunt mollit anim id est laborum. Lorem ipsum dolor sit amet, consectetur adipiscing elit, sed do eiusmod tempor incididunt ut labore et dolore magna aliqua. Ut enim ad minim veniam, quis nostrud exercitation ullamco laboris nisi ut aliquip ex ea commodo consequat. Duis aute irure dolor in reprehenderit in voluptate velit esse cillum dolore eu fugiat nulla pariatur. Excepteur sint occaecat cupidatat non proident, sunt in culpa qui officia deserunt mollit anim id est laborum.

Must be fewer than 750 characters

Figure 14. Google Form Constraints

Principle 6: Recognition Rather than Recall

GOOD: This heuristic principle suggests that, anywhere possible, one should not assume the user remembers what symbols mean within a website. It is the job of the product designer to make the product as easy to use as possible, this includes lessening the memory load for the user. An example of how to properly reduce user memory load can be found in Figure 15. Google will render the prior searches completed when the user begins to type a sentence/question.

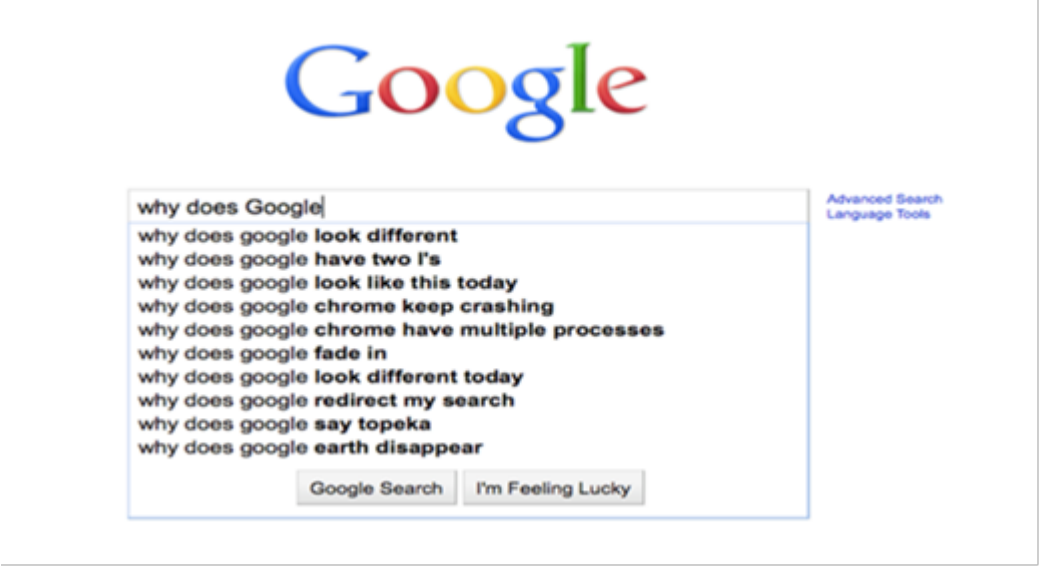

Figure 15. Google Search Engine (Liyanage, 2016).

BAD: Shown in Figure 16, an image of the National Library of China, the links that have been clicked on in prior searches did not change their color, which typically indicates that the link has already been viewed. Without the change in coloring, the user must remember which links they visited and which they did not. (A Pilot Evaluation of the World Digital Library, 2019).

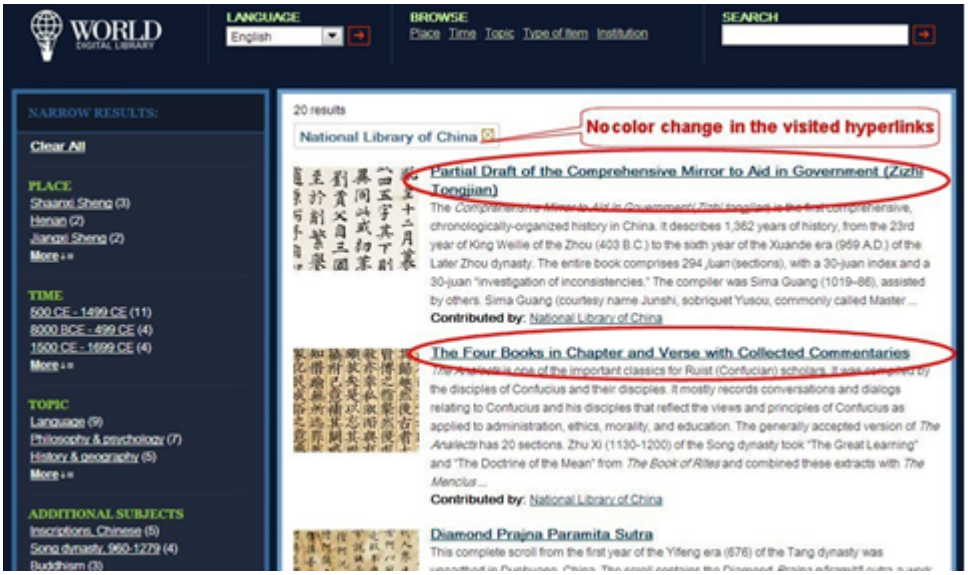

Figure 16. National Library of China Hyperlink Violation

Principle 7: Flexibility and Efficiency of Use

GOOD: This principle suggests that the product being designed should be easily tailored to the user and allow freedom to control settings, appearance, and much more, in order to provide autonomy to the user within the product. Chrome does this by allowing the users to add extensions to the webpage for quick links/tools the user uses most. For example, the google scholar and citation extensions can be used to facilitate creating American Psychological Association citations, and convert a normal google search into a scholar search without having to re-enter search terms (Figure 17).

Figure 17. Google Chrome Extensions

BAD: In this example, Figure 18, the “Medicine Units” is required to be in milligrams (mg), which causes a limitation for input. This limits the flexibility should the user need to enter a different unit of measurement (UTHealth, 2019).

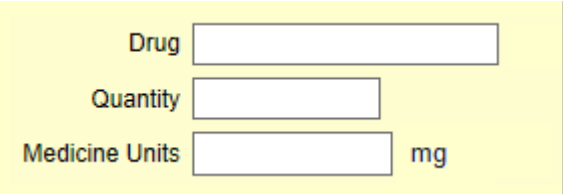

Figure 18. Medicine Units Restricted to ‘mg’

Principle 8: Aesthetic Minimalist Design

GOOD: Having a minimalist design will make the product easier to use and the objective of the product clear. Wikipedia search engine, shown in Figure 19, is a good example of this as it is clear that you need to select your language and then simply type in what you want to search on the website.

Figure 19. Wikipedia Homepage

BAD: A bad example, represented in Figure 20, shows that there are too many buttons on the remote control, which can distract from the main features that are used the majority of the time. On the right, there is an example of what a simplified version of the remote could look like.

Figure 20. Remote Control Complex and Simplified

Principle 9: Help Users Recognize, Diagnose, and Recover from Errors

GOOD: Errors are going to be inevitable, even if correct precautions have been made to avoid them. Thus, when a mistake is made there needs to be help so the user can understand what went wrong and what needs to be done to correct the problem. This happens often when entering usernames and passwords to log into websites. Below, in Figure 21, is an example from MailChimp (Rengifo, 2018).

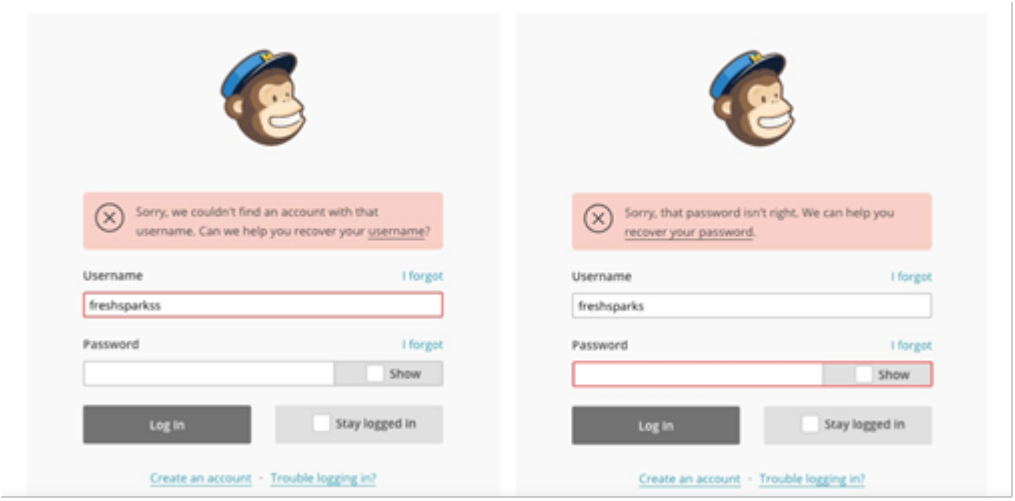

Figure 21. MailChimp Login Page

BAD: Figure 22 presents a bad example of Principle 9 because the error message offers no understandable information about the issue above the system level (Pande, 2018).

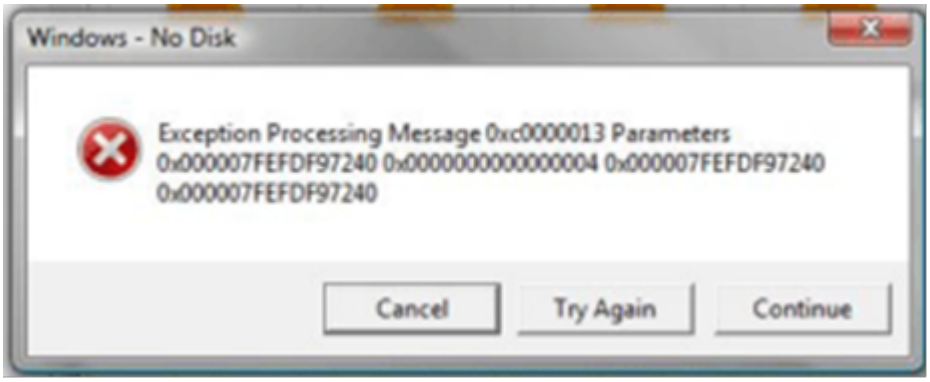

Figure 22. Vague Error Message

Principle 10: Help and Documentation

GOOD: A user interface should allow the user to autonomously get through the website. This means that there should be no prior training or education necessary to retrieve information. However, if a user does become lost within the site or screen, then there should be proper help. Below is an example of GoDaddy's help page, Figure 23, which provides frequent issues as well as a search engine (Liyanage, 2016).

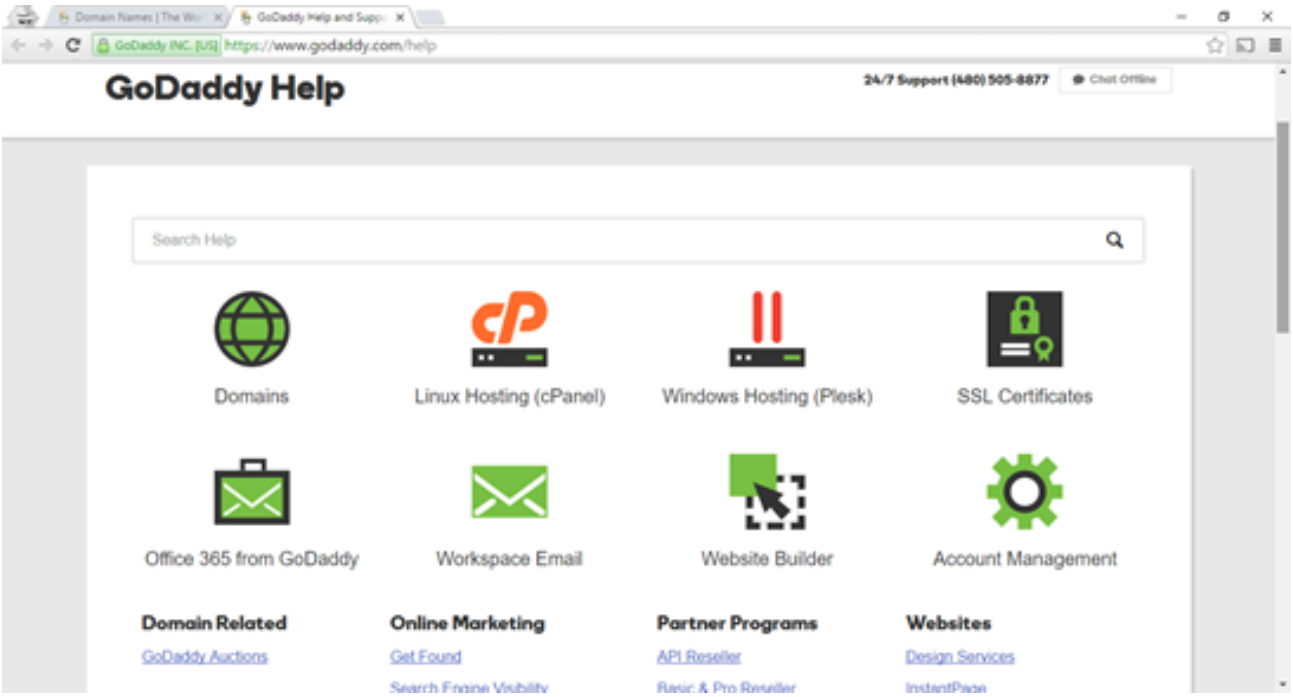

Figure 23. GoDaddy Help Page

BAD: If a user is lost within a product, the steps they need to take for assistance should be clear. A bad example of help and documentation can be found on the mobile application for LinkedIn (Figure 24). On their home screen, there is no location to go to find help (even if you click through all the main navigation buttons located on the bottom of the screen). You can see in Figure 12 there is no help button.

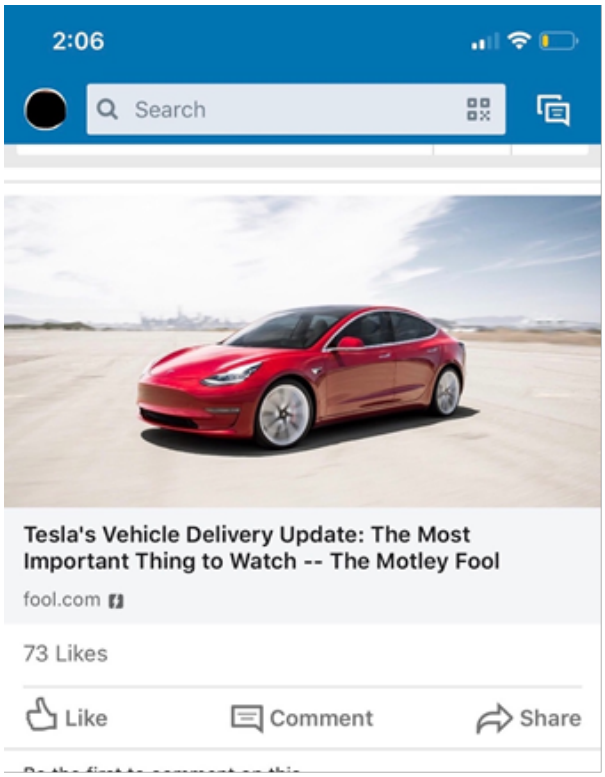

Figure 24. LinkedIn Website with no Help Button

WORKING WITH OLDER ADULTS WITH DISABILITY

Assistive Technologies

Design changes may need to be made to ensure a system is usable for persons with disabilities, such as adults aging with disability. It is important to keep in mind that systems should be compatible with assistive technology, such as screen readers and captioning software. In one study, including head-controlled keyboard/mouse and text-to-speech software options for reading documents aloud improved usability of online shopping services and accessing health-related information (Lawhon, Ennis, and Lawhon, 1996). While assistive technology is not explicitly stated in Nielsen's usability guidelines, the need to be compatible with assistive technology is consistent with the 'user control and freedom' and 'flexibility and efficiency of use' principles.

Instructional Materials

Nielsen's usability principle of 'help and documentation' is described as having a system provide help when needed. There are a range of accessibility barriers for older adults with disabilities. Disabilities, such as blind/low vision, deaf or hard of hearing, psychological disabilities, cognitive disabilities, motor impairments, and memorability can raise unique barriers for technologies. By providing help and documentation, you can reduce the user's need to recall information. A possible solution to addressing users with cognitive impairments is to present them with simple and usable guides (Ilyas, 2012). Although some might require a user guide, using the user guide can assist those with a range of cognitive abilities.

Visuals, Audio, and Text

Using multimodal information to present an aspect of an interface, such as icons, diagrams, vocal explanation, and text for important aspects of an interface aids users who may have hearing, visual, or cognitive impairments. Moreover, multimodal information benefits users without impairments as well.

World Wide Web Consortium (W3C) and Web Accessibility Initiative (WAI)

There are laws in place for web accessibility in the United States. The Worldwide Consortium (W3C) and Web Accessibility Initiative (WAI) programs have developed a set of heuristics to make websites accessible to all users, including adults aging with disabilities. User Agent Accessibility Guidelines were developed to make user agents accessible to people with disabilities. These guidelines are made primarily for web developers to be applied to technologies used to render websites but they are generally good concepts to follow for technology developments, as well.

The heuristics for User Agent Accessibility Heuristics are presented in table 3 (UAAG 2.0). More information on these specific heuristics can be found in the resources section.

TABLE 3. USER AGENT ACCESIBILITY HEURISTICS

Heuristic	Description
Principle 1: Perceivable	Users can access agent output
Principle 2: Operable	Users can communicate with the user agent
Principle 3: Understandable	Allowing the user to easily operate the agent
Principle 4: Access	Allow the user to adjust the agent to their preferences with controls
Principle 5: Comply	Compliance with WCAG guidelines

PUBLICATION EXAMPLE

TechSAge researchers have conducted heuristic analyses to assess the potential usability barriers for different types of technologies for adults aging with impairments. An example of this is described in the journal article, 'Telepresence Heuristic Evaluation for Adults Aging with Mobility Impairment' shown in Figure 25.

Telepresence Heuristic Evaluation for Adults Aging with Mobility Impairment

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George Mason University, Fairfax, VA

[3] School of Psychology
George Institute of Technology, Atlanta, GA

Mobility is a key component for older adults to maintain wellness and health while aging-in-place independently. However, older adults with mobility impairments may experience challenges in remaining socially connected. Telepresence systems hold much potential to help older adults with mobility impairments. However, telepresence systems are not specifically designed with this population's capabilities and limitations in mind – creating many potential usability barriers. We conducted a heuristic evaluation of three telepresence systems. The results of the evaluation indicated a range of design issues. Issues related to the base height, un-adjustable screen height, camera resolution, microphone/speaker quality, and sensor sensitivity were categorized as hardware problems. Usability issues caused by poor network connectivity, lack of privacy settings, lack of notifications of the system status, and limited control of the system were identified as software problems. It is critical that designers consider and address these findings to ensure that telepresence systems are usable by individuals with a wide range of abilities.

Figure 25. Wu, Thomas, Drobina, Mitzner & Beer, 2017

This article describes the method used for their heuristic analysis in Figure 26. Also, from this same journal article, we show an example of the discussion section in Figure 27, in which the heuristic analysis is described.

Heuristic Evaluation Procedure

Three trained researchers evaluated 3 telepresence systems: BeamPro, Double, and VGo (Table 3). The evaluators had expertise in aging, aging with impairment, and human-technology interaction. Leveraging this expertise, the heuristic evaluation emphasized identifying usability challenges that may be encountered by older adults with mobility impairments.

Because this target population might use telepresence systems to support aging-in-place, each of the systems was tested in a home environment as both the perspective of the pilot user (the remote operator, Figure1a) and the local user (the user who is next to the telepresence system, Figure1b). The pilot user is defined as a user remotely logged into the system, while the local user is co-located with the system.

Each test session lasted approximately 2 hours. Each researcher evaluated each telepresence system separately. During each evaluation session, each researcher completed a list of tasks as a pilot user. These tasks included: invite users, initiate a new calling session, drive around and avoid obstacles, change system settings, hold a conversation with local user, and end a calling session. The local user tasks included: connecting the system to the network, inviting users, and initiating conversation with the pilot user. The evaluators assigned severity ratings to cases where a heuristic was violated. Based on frequency, impact, and persistence of a problem, severity was rated from 1, very little impact on the user, to 5, large impact on the user. In this paper, we report issues only categorized with a severity rating of 3 or above. Next, evaluators reviewed their individual notes together to refine the identified violated principles and categorize the violated principles into three use cases: local user, pilot user, and both. Within each of the use cases, there were 3 sub-categories: hardware, GUI, and both. The evaluators compared

Figure 26 Method

DISCUSSION

General Summary of Findings

Telepresence technology has the potential to help older adults with mobility impairments age-in-place and remain socially connected. However, no such systems are specifically designed for this target user group. The needs and capabilities of older users with mobility impairment should be considered in the design of telepresence; otherwise, the technology may not be able to be adopted by this population.

In this study, we evaluated three different telepresence systems using a heuristic evaluation, with special emphasis on identifying issues that may influence our specified user population. The original Nielson 10 heuristics were used. Additionally, we added another five heuristics specific to telepresence hardware (Lewis et al., 2014) and networking. Some general themes from the heuristic evaluation that were identified related to both the systems' hardware and software. Hardware limitations that were documented related to the size of the systems and stability of the systems. These hardware considerations are important for use in home settings, where clutter is often a challenge (Kristoffersson, Coradeschi, & Loutfi, 2013). Also, adjustable height is recommended, particularly for users in seated positions (i.e., those who use a wheelchair). Lastly, issues regarding the GUI, ease of system navigation were found, as well as network and privacy concerns. An easy to use GUI is just as crucial as easy to use hardware for providing users a successful interaction (Kristoffersson, Coradeschi & Loutfi, 2013).

Figure 27. Discussion Section (Wu et al., 2017)

SUMMARY

This TechSAge tool, although not comprehensive, was designed to be a quick guide for illustrating heuristic evaluations. This tool has described what a Heuristic evaluation is, why it is used, and how it can assist in identifying potential usability issues. Also included was an example of how to track scoring for the principles. Further, the tool provided examples of Nielsen's ten principles for heuristic evaluations that can be used to help evaluators identify potential usability threats. Finally, the tool discusses heuristics that can improve accessibility for those with disabilities, as well as improve usability for all users.

RESOURCES

- **Iterations in the Design Process (Rengifo, 2018)**
  - https://blog.prototypr.io/iterations-in-the-design-process-41bd8d01f244
  - Rengifo, E. (2018, March 28). Iterations in the Design Process. Retrieved from https://blog.prototypr.io/iterations-in-the-design-process-41bd8d01f244.
- **Visability of System Status: The Good and the Bad (Miller, 2016)**
  - http://sp16.cs179.org/2016/03/08/visibility-of-system-status-the-good-and-the-bad/
  - Miller, A. (2016, March 8). Visibility of System Status: The Good and The Bad. Retrieved from http://sp16.cs179.org/2016/03/08/visibility-of-system-status-the-good-and-the-bad/.
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