Recommendations for accessible human computer interface (HCI) design

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Abstract: This short contribution presents a list of good practices to permit a good relationship between human-computer interfaces and end users, at the time to design (and use) an accessible tool. The experience in the User Centered Design for sonoUno software is taking into account as well as the Standard (ISO, WCAD, WC3) recommendations.

Key words: Sonorization, Human-computer interface, Accessibility, Inclusiveness, ISO for accessibility, WC3 recommendations, Good practices for inclusion and equity.

1. Introduction

The sonorization of the scientific data is a complex problem when we focus the attention on the end user. Several software present different tools and possibilities to transform data into sound - see for example Sonification Sandbox (Davison and Walker 2007), Sonipy (Worrall et al, 2007), MathTrax (https://prime.jsc.nasa.gov/mathtrax/), Sonifyer (Dombois et al, 2008) xSonify (Díaz-Merced et al, 2011), StarSound (Cooke et al.2017), Plan-ethesizer (Riber 2018)- and diverse tools to analyze in a professional way the results, it means for research and not only for education and/or outreach.

However, not in all the cases the user is the center of the development. In this sense, the approach must be not only from the developer or soft designer point of view or the user realty: the virtuous attitude should lead us to involve all stakeholders in this type of development.

The recommendations presented in this short report are part of a long term project devoted to designing a special software for accessing the data in a multimodal way, the sonoUno (García et al, 2019). This development is carried out from a permanent feedback with the users, taking into account Focus Groups analysis, and it is centered on standard alone software, but some of them are applicable to web design too.

Taking in mind that the World Wide Web Consortium makes recommendations focused on web development, it is possible to specify that some business companies (like WebAria) established from web inclusion guidelines (i.e WCAD, WC3, ISO) have success rates based on the decision of developers and around the possibilities of coding programs used for development. We want to highlight that beyond that conducting tests of the tool, interviews and focus groups with potential users is the only way to develop a user centered tool.

2. Recommendations

The next points offer some recommendations based on the analysis that the sonoUno team has done until the moment to center the development on the end user. This proposal is devoted to developing a consciousness about the need of Good Practices in inclusion and equity which, normally, are not part of specific proposals for projects in Sciences.

Probably, the next points can be enlarged or improved, and they must be consider as an starting point for each new development:

1. **The integration with assistive technologies should be a priority from the beginning, ensuring that each person can use the assistive technology that better solves their needs.** For that it is very important to care about the effective integration between assistive technologies and the graphic user interface (GUI) under development (ISO, 2008). Ítem 8.3.3, of the ISO recommendations indicate: Avoid interfering with accessibility features (The software must not disable or interfere with the accessibility features of the platform).

2. **Trying to minimize the time to learn a new tool and bring independence to disabled people must be accepted as a good practice.** At the moment learning a new tool (a new assistive technology or a new interface) for people with disabilities, means a lot of time and help from other people (Billah, 2017). The back-end architecture has to provide a front-end output that will provide a low learning curve towards identification, interpretation and dynamic use of functionalities, and bring independence to peoples with disabilities. Under the UN mandate of humans being entitled to equality, the system will not label people with disabilities by allowing all users to use the system to mainstream equally.

3. **Not pop up windows.** Bahr and Ford (2011) express: “users (participants) considered pop-ups annoying and frustrating and did not enjoy pop-ups” [p.781]. They analyze the user response to pop-up windows and highlight a new way of thinking about HCI.

SonoUno team proposes the use of panels as an alternative for pop-up windows, where the user decides which panels to display. The proposed technique was better than the pop-up windows, but the analysis showed that all the panels open at the same time are difficult to navigate. Maybe navigation between panels with shortcut keys solves the problem, but another analysis with users is required.

4. **Software functionalities should be simple and present linearization between each other.** In 2019 a focus group was conducted on Southampton University (Casado et. al., 2020), the participants detected the linearization of SonoUno software and compared it with other commercial software. To present a framework with a familiar structure, simple language, consistency between vocabulary and functionality linearization, reduces the memory overload. In addition, it was expressed that minimizing the number of transactions to make a task decreases the memory overload.

5. **Documentation, tutorials and training are the main topics.**
   The section 11 of the ISO 9241-171 (2008) describes the online documentation, help and technical support service.

   The inter-phase has to foresee the aspects of inter-phase learning aspect, error recovery and help support .The back end of the help support should follow for its display the main focus of the inter-phase to decide for example how the chunks are organized (i.e. in parallel or in series). The corresponding length and complexity have to keep, uniform constancy of display, being sufficiently descriptive while keeping a balance with the existence of words in sign language and accessibility for peoples with reading impairments/disabilities and neurodiverse to avoid cognitive and memory overload, seizures among other factors while at the same time target the conflicting goals of trying to keep the learning, help and error recovery simple while addressing as many interface aspects as possible.
   Focus group participants (Casado et. al., 2020) express the need of training about new tools. It is crucial to strictly rhyme with the “nothing about without us” disability activism slogan involving the user from the beginning analyzing in depth the information and following scientific qualitative data analysis procedures for decisions regarding the interphase. The ideal situation is that if this part is correctly designed, the users do not need other people to rescue them.

6. **The HCI should support the user to be successful and not suffer fatigue, memory and cognitive overload**, accessing, performing and completing the different tasks (Casado et. al, 2020).

7. To give a big picture and a localized picture of the inter-phase: **the HCI have to present different dynamic options to perform and complete**

the user desired task, allow the user to dynamically set different settings, decide and change at will the path followed to perform the latter. This also applies to deciding the path of action and for error recovery. For example, in SonoUno's case, the user should be able to change the timbre at will to produce the sound (Casado et. al., 2020), and to able to perform sound modalities changes in each of the sonification panels destined to mapping (i.e like in the panels of the xSonify If one is mapping in pitch, in the pitch panel one may set the volume for their comfortability and the person can decide the timbre in that same panel).

8. **Unnecessary elements must be avoided**, because these elements confuse the user and clutter the visual display. That is why a User Centered scientific analysis of user perspectives is of utmost importance. Take into consideration that a lot of elements on the HCI make navigation difficult with assistive technology. For example, in the case of the screen readers, assistive technology describes element by element and present serial navigation, then going from one functionality to another inside a framework with a lot of elements is very difficult.

   Another example is peoples with some learning disabilities may face challenges with mental perception (visuospatial tasks) of patterns may need perceptual reference in the inter-phase, based on the triple code model (verbal[1], symbolic, and analog) of sensorial brain stimuli to contrast the progress in the analysis of the display towards interpret the progress and be supported with the analysis.

9. **Need for precision, as applied to task performance and data analysis, is very important**, the user needs to be sure that they are doing exactly what they intend to do and that mechanisms are in place to manage uncertainty; an uncertainty management model should be integrated in the inter-phase. In addition, it is very important that each display (auditory, visual, tactile or combination of each one) are in phase, synchronized and activated at will without interference with the assistive technology and do not express unsynchronized, out of phase and antagonizing information at the rate and complexity decided by the user.

10. **Tests with users are very important** (Metatla et. al, 2015), each person develops different techniques to communicate and receive information and has different approaches to the knowledge and abilities to process the information (Kavcic, 2005).
    One example of a different technique to communicate with an interface is that people with fine motor problems need larger elements on the interface, because to point something small with a pointing device is very difficult for them. On the other hand, if elements displayed in the GUI tare not linearized it forces drastic physical movements to people with orthopedic and neuromuscular disabilities.

[1] Screen reader support, speech support, self voicing

During the focus group (Casado et. al., 2020) a question about 3D display of the plot was added and the participants express that this alternative form of communication will be useful maybe for people who read braille, or people with tactile abilities. The sonoUno team expects to explore more about this assumption.

11. **It is evident that in many fields of outreach scientific contents approach, the tactile models are a support for some audiences.** Such is the case of the exploration of galaxy structures such as Nicolas Bonne and "The Tactile Universe (https://tactileuniverse.org/) or Kim Arcand, with her work "Chandra Tactile Universe", (https://chandra.harvard.edu/tactile/) (see also Bonne, Krawczyk, Gupta, 2018), some defined star (Madura, 2016), or the tactile discovery of planet surface characteristics (Amelia Ortiz, A Touch of the Universe, https://aorgil.blogs.uv.es/a-touch-of-the-universe/), (García, et al 2013, 2017), between other examples. These days, many blind and visually-reduced (BVI) persons do not read Braille; for this, it is needed to take into account that the texts written in that format must be not significant for them. In this sense, the information must be available through sound, and the normal resources are the screen readers, which also must be evaluated permanently.
    This analysis is valid not only for BVI: the proposed material must be adapted for deaf, motor disable, multi disabled, and neurologically diverse. Individuals have multiple, intersecting identities. A person's identities may be permanent or temporary, congenital or acquired, disclosed or undisclosed.

12. **Need to explore the unknown**. In general, people with disabilities don't have the opportunity to explore. During the focus group session (Casado et. al, 2020) after use of the sonoUno, visual impaired people at different aspects of computer literacy and scientific expertise expressed the need to be able to explore the data with precision, certainty, effectivity, efficiency and in a reasonable time.

13. Related to the previous point, **the user needs to be informed about all the changes** (changes may be due to updates, to elements in the GUI, elements in the menus and in the sub-menus, location and description of accessed functionalities, scenery as a whole etc). Any change, including the minimal ones, must be informed in each sensory display (auditory, visual, tactile or combination of each one). In addition, the user must be able to locate and orientate, spatially in the interface.

14. **Assumptions should not be made,** each assumption will leave behind people with disabilities or different learning and copying styles, which are outside the initial considerations.
    For example, the assumption that each person uses the computer, excludes people who do not have this ability (Casado et. al, 2020). The assumption of everyone being able to interpret the displayed information

following the same multi sensorial clues leaves out people with sensorial biases.

15. **Multisensorial and multiplatform approaches have to be implemented because not all people can access all platforms.** For example, even if Linux is free, people who use the library of their university have to adjust to the platform available on this site. In this approach the assistive technologies, and sonoUno has been developed taking into account this framework.

16. **The HCI should allow the users to undo and remember their actions** (ISO, 2008).

17. **Alonso et. al. (2008) enunciate some usability requirements**: ranging from task adequacy (the task should be competent according to the tools available to the user, for example take into account that BVI are forced to communicate serially with the computer); dimensional trade-off (the interface should present balance between different sensorial styles); behavior equivalence (all sensorial styles should present the same information, for example all the visual elements should be presented on an auditory display); semantic loss avoidance (relevant information should be presented on all sensorial styles); device-independency (the interface should work with a wide range of assistive technologies).
    The previous study also concluded that novice users want all the info, while expert users only want what they need. The interface has to consider the user's opinion and let them choose what and how to display the information.

18. Mulliken (2018) perform a study about library websites with BVI people and some of the conclusions was: the first time on the website consume more time because they have to explore the web page; the information inconsistency between different web libraries difficult the task; and the user expect that the assistive technology (screen reader in this case) communicate all the display; among others. On digital inter phases the user needs support on total and partial awareness of scenery changes, orientation, mobility, free will to dynamically decide the interaction path.

19. **Of utmost importance is to evaluate the digital accessibility laws existent**, the root of those laws, strictness and government enforcement of their success criteria to accomplish all the goals in this document complying with those laws. (so far we have found 25 countries with Laws)

20. **The User has to strictly guide the development; and not the thinking and the assumptions of a development team or the possibilities of coding platforms.** The developing team has to find a way for users to guide the development to achieve for peoples with

disabilities to have access to the same amount and quality of information as the non disabled peers.

21. **Is critical that people feel that they are important, and their opinion is valuable for the developer**, because disabled people are used to not being taken into account.

22. **Finally, making a user centered design means to hear the user and to be sure that the interface is usable.** Assumptions should not be made, is a better practice to perform a focus group or interviews analysis with potential users and analyze possible solutions.

3. Conclusions

Anyone may develop a disability at any time. Disabilities may develop regardless of cultural heritage, people from different racial groups, ethnicities, religious groups, members of the LGBTIQ+ community, different genders, sexual identities, language groups, ages, socio-economic status, other under-represented groups, and the intersections of these identities. Our development will strictly and continuously consult these members of the community seeking for them to be protagonists, propose and oversee the generation of the new resources and tools for inclusion.

In this era where computers are so powerful, systems and interfaces adjusted to each functional diverse person shouldn't be a utopia. To this end updated guidelines (like as presented here) and frameworks based on user centred studies are mandatory, in addition to machine learning techniques.

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