AgeCI: HCI and Age Diversity

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Abstract. We present an overview of recent works in which age is an important driving factor for Human-Computer Interaction design and development. These serve as starting grounds to discuss current practices and highlight challenges that might serve as beacons for future research in the field.

Keywords: age diversity, overview.

1 Introduction

Age related approaches to HCI, with some notable exceptions, are nowadays strongly focused on the elderly [20] boosted by applications in areas such as ambient assisted living [40] and, although to a lesser degree, on children. Nevertheless, age related characteristics of different age groups [48,39] make it important that users are not just divided in two (elderly and remaining users) or three (children, adults and elderly) categories. Even when the physical and cognitive characteristics of users seem equivalent, intrinsic differences in motivation and social needs as observed, for example, between teenagers and adults [49], might pose challenges regarding which methodologies to use to include them in the design process, elicit opinions or collect data.

The challenges posed to HCI by age diversity have led researchers to follow different methodologies to support design and development and assess user performance using different modalities, devices and user interfaces. We consider that the community might profit from an integrated view regarding how age associated characteristics/differences are addressed, not necessarily coinciding with an universal design approach. This should highlight and contribute to a first level of organization of the plethora of design and development methods that can be used by researchers in order to improve their work for specific age groups.

This paper is intended to present a general overview of the literature covering age-related issues and methodologies in HCI by focusing on the most recent surveys, studies, trends and challenges (mostly published after 2010) on the subject.

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While selecting the surveyed literature we wanted to cover works regarding different age groups in four main categories: input/output modalities, target devices,applications and contributions to guidelines and methodologies. This provides us the grounds to highlight aspects that we consider might profit from further attention and discussion by the HCI community.

This article is organized as follows: Section 2 presents a brief overview (given the range and complexity of such matters [48]) of human characteristics affected by age, the motivating factors for differenced/adaptable approaches in HCI design and development; Section 3 presents a survey on recent literature regarding HCI works for which age is a driving factor covering aspects concerning different input/output modalities, the target devices, applications (and their graphical user interface) and main contributions on the form of reviews, guidelines and methodologies (and frameworks); Section 4 discusses some of the challenges depicted by the surveyed literature and some desirable routes for future work in the field; finally, section 5 presents some conclusions.

2 Age Related Characteristics

Literature is prolific in describing ageing effects and these can be felt at different levels in the individual. It is nevertheless important to consider intrinsic characteristics of particular age groups that might affect performance, for example due to early levels of motor skills development.

Researchers should consider physical, motor and perceptual limitations and cognitive changes, but must also contemplate socio-cultural aspects regarding other factors such as social integration (e.g., the need to fit a certain social group), cultural backgrounds and how different resulting mental models are used to organize information, influencing performance [39,57].

Physical and sensorial — Children might exhibit limitations due to their height, arms length and finger and hand size [47]. Furthermore, their motor skills might still not be mature enough resulting, for example, in visual-motor dis-coordination [25], reduced precision and inability to perform fine movements [48,5]. Although evolution occurs continuously, studies show that, important improvements in these aspects occur between six and eight years of age [25] and they refine and get more consistent by the age of 12 [2].

Physical performance is progressively affected by ageing resulting in reduced fine motor skills [11], strength and speed, sometimes leading to tremors. It is important to note that even if these aspects are not very pronounced, the effects of long term immobility might also pose problems, such as articulation and muscle pain, precluding certain interaction gestures/positions (e.g., long time standing or with arms in a fixed/rigid position). With age, a decreasing sensibility is also observed in hands and fingers. Physical limitations, although not expected to directly affect interaction, might pose problems. For example, if a user has trouble walking and uses a walking aid (cane or frame), the hands will have to deal with it and are less available for interaction.

With age, vision is affected in many different ways and naturally occurring changes often include reduced visual acuity, with decreased focus on near objects, different colour perception, increased sensibility to glare and decreased brightness perception [30,57]. These may also be aggravated by diseases such as diabetes.

Hearing loss is also observed with a particular emphasis on low volume sounds and higher frequencies [52].

Cognitive — Such as happens with the motor skills, the cognitive skills of young children are also under development [48,31] and vary much with age. One important characteristic is that children have short attention spans [10,47], i.e., the amount of time they manage to focus on a particular task is small. Attention is also much more easily given to aspects that stand out, even if they are not relevant to the current task [48] (e.g., coloured animated clown on screen instead of the instructions to reach the next stage). Furthermore, small children might have limited or no spelling skills.

Teenagers also present some important cognitive differences when compared with children and adults. These differences affect judgement, decision-making and risk-taking [49]. Teenagers are more willing to take risks and have a strong desire for autonomy and to develop an individual identity [16,41]. Furthermore, they seek association with peers and are highly susceptible to their influence (e.g., brands, technologies, clothes).

With advancing age, changes are felt affecting memory, information processing and intelligence. Working memory is used as a working space for storing information which needs to be readily available or used to perform decisions and comprehend written and spoken language [57]. Its decline therefore results in a slowdown in learning new (large amounts of) information, but also in a reduced capability to process complex information. This, added to increasing times to access long term memory elements, significantly affects the time required to perform tasks.

Changes to intelligence can be explained recurring to the concepts of fluid and crystallized intelligence [48,6]. Fluid intelligence refers to the ability to reason abstractly and to adapt to new situations despite of acquired knowledge. On the other hand, crystallized intelligence deals with the ability to use skills, knowledge and experience accumulated through the years. While both types of intelligence increase during childhood and early adulthood, between the ages of 30 and 40, fluid intelligence starts to decline while crystallized intelligence continuously increases and only starts declining much later in life [6]. By reviewing the literature regarding web navigation, Hanson [20] points out that crystallized intelligence is a particular advantage for older adults towards younger adults when faced with complex ill-defined tasks that require some thought and benefit from acquired experience.

Is is also important to understand that people can sometimes present several limitations. Even if taken individually they are of minor gravity, they might interact with each other resulting in a performance degradation that is far superior than that expected for the individual disabilities. [18,20].

It is important to note that all these age related effects are subject to individual variability precluding treating each of the age groups as a homogeneous group [32,43] and further stressing the importance of using proper methodologies that help design HCI for age diversity.

3 HCI for Age Diversity

To provide an overview of the various aspects involved we briefly analyse how research in the field can yield insight on the age-related aspects influencing user performance concerning different input/output modalities, devices and applications and how these results have contributed to propose guidelines and methodologies that might support further (systematic) developments. Notable previous surveys regarding specific age groups are those by Wagner et al. [54], for the elderly, and Read et al. [42] for children).

3.1 Interaction Modalities

The many existing modalities are not equally adequate or adopted by the users of different ages. Several recent studies investigated preferences and user performance.

Weiss et al. [56] remark that studies on modality preference are often restricted to younger users. In their study, they addressed the effects of age on modality preference (speech, touch and 3D gestures), but no evidence of such effects was found.

The most common interaction modality for desktop computers is the mouse. Mouse pointing performance has been assessed for particular age groups (e.g. children [25]) or comparing among age groups (e.g. young adults, adults and elderly [21]). In summary, main findings show evidence that speed and accuracy improve with age, for small children and that adults tend to perform better than young adults and the elderly. The latter, although performing slower than the remaining age groups did not commit more errors.

Interfaces using touch have been increasingly used, as a result of the technological advances in the field. Herztum et al. [21] and Findlater et al. [15] show that touch screens are easily used by the elderly and their use reduced the performance gap between young and older adults when compared to performances on traditional desktops (a survey on multi-touch for elders can be found in [29]). Jochems et al. [24], present a comparative study for three input devices (mouse, touch screen and eye-gaze control) and conclude that, irrespective of age group, touch screens attain the best performance (shorter execution time), most notably for elderly. Culen et al. [13] briefly describe a set of experiments also using touch with elderly, in different application scenarios, and analyse some of the challenges faced in using such technology regarding, e.g., how motor disabilities affecting movement accuracy might affect usage. Hwangbo et al. [23] report that older adult performance in pointing tasks can be improved by adding audiotactile feedback. Rodrigues et al. [45] assessed how different QWERTY keyboard variants, on touch screens, influenced young and old adults performance.

Regarding interaction with touch screens and focusing on gestures, Aziz et al. [5] assessed which gestures (e.g., tap, drag-and-drop, pinch, spin) children from two to twelve years old were able to use and found some evidence that children bellow age four had difficulty in performing some of the gestures. In a study by Arif et al. [4], older adults seemed to favour pen gestures (faster; better accuracy) instead of touch and no such effect was observed on children. Furthermore, according to Stoessel [50], gestures result in improved performance and satisfaction for the elderly who mostly favour single-finger gestures.

Anthony et al. [2] assess the performance of children and adults while using a touch screen and identify performance differences between the two age groups along with several technical challenges to use this modality. For example, gesture recognition modules have a poorer performance for children gestures and it is advisable that age-specific recognizers are trained. Furthermore, the gestures should be tailored in order to make conceptual sense to the child.

Jochems et al. [24] present a study where eye-gaze is combined with different methods for input validation (keyboard space key, foot pedal and speech) with an advantage for the keyboard key, mostly due to user familiarity with the keyboard vs the foot pedal and to time coordination problems between the moment an object is fixated and the speech input is performed.

Speech interfaces have also been subject to user performance assessment, in particular considering the elderly. Aman et al. [1] provide some insights about well known issues regarding automatic speech recognition problems with the elderly [53] and how to cope with them. Portet et al. [38] assess acceptability of voice interfaces in a smart home context. Although with a particular focus on the elderly, the authors perform a user study involving different age groups and conclude for overall acceptance provided the system does not drive users to a lazy lifestyle. Considering children and speech interfaces, an example, involving conversational agents, can be found in Prez-Marin [35].

Sometimes, when choosing the input/output modalities it is relevant to not only consider the specific motor and cognitive characteristics and limitations of the target age group (and context) but also how these will impact on other aspects, such as skills development in children. The work by Antle et al. [3] is a good entry point to these concerns. The author conducts a study in which children use three different ways of interacting with a spatial puzzle task (physical, graphical and tangible interfaces). For example, the mouse and graphical user interface, although serving the intended purpose, favoured a trial and error approach which might limit skills development for which the tangible interface was more suited.

3.2 Target Devices

As interaction modalities are not of universal use in all situations - be it devices or even concrete applications - they are, in most occasions, tightly related with the device used. Nevertheless, researchers have also assessed user performance considering devices (mobile phones, tablets, interactive TVs, desktop computers, etc.) as a whole, in different application scenarios. Boosted by the recent technological developments and current research trends, mobile devices are the most assessed platform.

Leung et al. [27] have performed a study in order to understand how the elderly learn to use mobile devices. By conducting the study for three groups (young adults, adults and older adults) they were able to identify which aspects were specific of older adults. For example, older adults significantly used less trial and error and preferred to learn alone. Therefore, better support should be provided for trying out tasks. A thorough review regarding handheld computers and their use by older adults can be found in Zhou et al. [59].

In a study by Zhou et al.[60], they conclude that the use of mobile phones is guided by age-dependent user requirementsand that older users had more difficulties than younger users to use multi-tap and touch and hold features.

Perrinet et al. [36], while studying different methods to input text using virtual keyboards in digital television applications, have detected significant differences in writing speed and error rates among age groups (not including children) even considering just expert users.

3.3 Applications

Regarding the evaluation of overall user performance and satisfaction using complete applications (i.e., with no specific focus on the platform or particular modalities, but on the graphical user interface), it is also important to approach users according to their characteristics and age related approaches have been proposed.

Website usability, considering the age factor, has been addressed by several authors. Punchoojit et al. [39] observed that age influenced the performance of users on different culturally oriented sites. Bergstrom et al. [46] used eye tracking while assessing the usability of websites, comparing young and older adults. They observed that older adults looked to the centre of the screen more frequently, looked to the peripheral left less frequently and took longer to look to the top periphery. Martens et al. [31] cover the design challenges and children's performance in using digital resources (review in Wirtz et al. [57]).

Game development and other applications, mostly for educational purposes, have also been addressed [51,33,34] advocating for participatory design and proposing methodologies to elicit contributions from children at different levels of the design and development cycle.

Studies have also focused on how individual elements in the graphical user interface can be modified to improve understandability to certain age groups (e.g., mobile device icons [26]) or performance in pointing and selection (e.g., target expansion [22]) and on how particular input modalities affect the way graphical user interfaces should be designed (e.g., touch [2]). Brajnik et al. [8] conclude that the inclusion of specialists (on-screen tutors) and tool tips does not have the same positive impact in older adults as in young adults probably due to the potential benefits of such design choices being out-weighted by the increasing complexity of the user interface felt by older adults.

3.4 Methodologies, Guidelines and Heuristics

Regarding children, the works by Read and colleagues have covered several aspects of child computer interaction and a recent review of the field can be found in [42].

Guha et al. [19] review the literature on Cooperative Inquiry and propose how this method can be used to support design with (and to) children by analysing a set of wrong assumptions concerning the work with children as design partners. Since children, nowadays, differ considerably from those of ten years ago given they are more independent and information active, the methods used must, therefore, consider such differences. The authors also emphasize, including examples taken from their experience, that adults working as proxies for children simply do not work as expected and methods have been proposed to tackle age-related issues (e.g., children's short attention spans [34,9]) or harder situations involving children with special needs (e.g., [17]).

Developing games involving children has been addressed, for example, by Tan et al. [51] and Moser et al. [33] by proposing methodologies that guide children's involvement along all the design and development cycle. Rounding et al., [47] discussed evaluation of user interfaces by children. Brown et al. [10] identify challenges of conducting usability studies, designed for adults with young children and found that issues like the smaller attention span of small children and the influence of the research setting (academic usability lab) need to be seriously considered in these cases.

Poole et al. [37,41] look into interface design for teenagers and provide a general description of notable cognitive/emotional and physical changes, assess the different challenges in research involving this age group and propose a set of best practices. Fitton et al. [16] point out that teenagers require a different approach than children or adults and that they might provide valuable insights regarding aspects for which younger children are too young and adults lack the technical skills. They gather a set of research questions concerning, for example, the methods used to engage teenagers in participatory design or which contexts (school, home, research lab) might be more appropriate to work with them.

Barros et al. [7] evaluate a mobile user interface for the elderly. Multiple evaluation stages are performed and a wide set of recommendations for inclusive design and design for older adults. In a similar approach, Ferreira et al [14] present a methodology using elderly centered design to support the development of a mobile application. Zhou et al. [59] and Liu et al. [28] present a literature review regarding the use of handheld computers by the elderly and provide a set of recommendations regarding input/output, menus, main required functions and applications.

Lynch et al. [30] discuss the importance of accounting for differences regarding elderly performance on websites and propose weighted heuristics to assess the usability of websites for this age group. Instead of putting all the heuristics at the same level the authors, based on input by older adults, proposed different weights for each, according to their importance, and managed to predict, based on the heuristics, differences in elderly performance for three websites.

4 Discussion

Considering the reviewed literature we identify several aspects deserving further attention from the HCI community and concerning age-related factors.

With the rapid technological advances, previous evaluation studies need to be reviewed — One very important aspect, as stressed by Hwangbo et al. [23], is that previous studies covering human performance for different input devices should be constantly reviewed since recent advances in technology might have considerable impact [6]. For example, extrapolating evaluation results gathered for mobile phones to smartphones is not straightforward as user requirements and expectations shift [60];

Lack of simultaneous assessment of performance for multiple age groups limits generalization of outcomes and comparison with other studies — Researchers often consider only specific age groups (e.g., children or adults) when assessing their performance using particular modalities or devices. This, although providing data for a particular scenario, only allows indirect comparisons between age groups. In fact, in most cases, even if the main purpose is to address the needs of a specific age-group, it is important to include additional groups in order to provide insight into which are the unique needs of the target group [27]. In an interesting article by Martens [31], the author points out that even the diversity among different age-stages, for children, should motivate duplication of previous studies to cover these intrinsic differences. Therefore, evaluation studies that assess performance for a wide range of ages would allow a greater insight into age differences and provide additional value to HCI;

Designing for adults and then adapting to another age-group can hinder more adequate solutions — One important aspect to consider is that it is still common that children and old adults are only involved in the design process at the time of the first prototypes. This, although valuable, works to modify an existing technology/approach, usually developed by adults, to cope with age related limitations instead of considering the broader context and a possible different approach to the problem from the start [58,40];

Ageing does not always translates to cognitive disadvantage — Contrary to what is common belief in HCI, Ball et al. [6] show evidence that older adults have some advantage in familiar tasks which depend on crystallized intelligence, i.e., skills learned over a lifetime and are outperformed by young adults when presented with unfamiliar tasks which profit from fluid intelligence (ability to deal with unknown situations). If these aspects are well understood, tasks can be designed to profit from them as previously highlighted.

Systematic multidisciplinary approach to understanding age-related characteristics and their impact is important — A systematic assessment of the physical and emotional characteristics of different age groups along with the challenges they pose to the individual and to HCI, and a collection of experimental results and best practices derived from the literature (in the line of what is proposed by Revelle [44], for children, and by Poole et al [37], for adolescents) might provide an important contribution to the HCI community.

Systems Used by Diverse Ages Should Aim for Coping with Diversity — Most works in the literature aim for approaches focused in particular age groups, rarely considering age diversity. It would be interesting to see works that gather efforts to develop devices, interaction patterns and user interfaces that can cope well with age diversity and the related challenge of intergenerational co-design (e.g., [58]). The effort of providing adaptive user interfaces is already performed, to some extent, in multimodal scenarios, to cope with different user limitations [] and might also be considered for age diversity.

Age estimation, e.g. [12], to the best of our knowledge, has not been used in the context of HCI design and might make it possible that, based on different user models, the interface could be age customized.

Research and evaluation methods must be adequate to the subjects ages and environment — The methodologies followed, for example, to elicit information from users, including them in the design process, should consider their physical and cognitive characteristics and account for the environments in which the systems will be used [42]. It is also important not to look into age groups with a set of preconceived ideas, but to actually test if these ideas have real impact considering the target users and context [20,55].

5 Conclusions

As mentioned, this paper does not aim to be a thorough survey of age-related aspects in HCI design, development and evaluation. Its purpose is to gather recent literature that spans what researchers are currently doing regarding age diversity. From the surveyed literature it is clear that several challenges still need to be tackled by the community or might provide clues for new research lines. Overall, age-related issues are being addressed for some age groups, but some of the research still relies on a preconceived idea of their characteristics, on adapting existing designs instead of building new ones, including users since design, and lacks methodologies that allow comparison among studies.

This article is just the first stage of what we consider should be a systematic approach to HCI for Age Diversity and many improvements to the presented work are possible (some of them not considered here due to a lack of space). For example, the surveyed works should gradually cover older publications and be organized according to a taxonomy that allows looking into the literature through different angles (age groups, devices, etc.).

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