



Review

An Overview of Participatory Design Applied to Physical and Digital Product Interaction for Older People

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Abstract: An understanding of the need for user-centred and participatory design continues to gain universal momentum both in academia and industry. It is essential this momentum is maintained as the population changes and technology develops. The contribution of this work draws on research from different disciplines to provide the design community with new knowledge and an awareness of the diversity of user needs, particularly the needs and skills of older people. A collection of usability and accessibility guidelines are referenced in terms of their applicability toward designing interfaces and interaction for an ageing population, in conjunction with results from studies that highlight the extent to which familiarity and successful interaction with contemporary products decreases according to age and prior experience, and identifies the problems users experience during interaction with technology. The hope is that more widespread awareness of this knowledge will encourage greater understanding and assist in the development of better design methods and better on- and offline products and tools for those of any age, but particularly those within an increasingly ageing demographic.

Keywords: user-centred design; ageing; accessibility; product design; design theory; inclusive and participatory design; design methodology; technology; user; design

1. Introduction

In 2010, the UK population consisted of 10 M people over the age of 65, and this is predicted to rise to 15.5 M by 2030 and to 19 M by 2050 [1]. It is also predicted that by 2066, half a million people in the UK will be over the age of 100 [2]. Whilst ageing has traditionally been associated with a decrease in mobility and social interaction, the rise in Internet use and “ubiquitous connectedness” [3] may have the potential to mitigate some of the detrimental physical and psychological effects that are associated with ageing, such as isolation, access to good nutrition, leisure, and other activities.

However, research suggests that older adults are less likely than younger adults to use technology in general, computers, and the World Wide Web [4]. Literature also suggests that the way in which young people interact with technology differs from those over the age of 25 [5,6]. This “generational effect” coined by Freudenthal refers to younger individuals being capable of interacting more effectively with new technology [7]. Indeed, younger people appear more adept at creating accurate mental models of product interaction and acquiring new and relevant knowledge through experiential learning [8]. Increasing opportunities for social interaction can have positive effects upon individual health and physical and psychological well-being [9], and with more of us spending increasing amounts of time online, designing interactions that encourage and cater more effectively for older users is well justified. A recent European study on Internet use indicated that, on average, 49% of users above the age of 50 accessed the Internet, but that there was a wide variation across countries associated with

numerous factors including previous experience of computers and technology in the workplace [10]. Therefore, if we are to improve the physical and digital product experience for older users, we need to understand in greater detail how their prior experience and knowledge affect interaction and develop greater awareness of the variation in their physical and cognitive capabilities.

2. Older People and Design

For the purposes of this research, older people are defined as those of 60 years of age and above, following Tanner and Harris's observation that "... research studies involving older people usually adopt a chronological definition of old age; for example, selecting samples of people who are over the age of 60 or 65" (p. 9) [11]. Although declines in health and in mental and physical function are more likely in old age, these are by no means inevitable [12]. Whilst there is a correlation between age and morbidity, increasing numbers in their 80's and 90's live in good health, with active lifestyles, and a ready ability to continue to work, suggesting that poor or declining health is not necessarily a direct consequence of older age and that there is distinct heterogeneity in the older population [13]. Older adults, then, are a most diverse demographic group, encompassing a wide range of health and ability states. Goodman-Deane et al. suggest that designers must comprehend the diversity of this group and that the inclusion of older users within the design process is crucial [14]. Indeed, many of the older participants that were involved in the research reported were actively engaged in their communities with busy social lives, being members of committees, charity volunteers, or involved in care duties with grandchildren or spouses.

This reinforces the notion that older adults are not necessarily dependent, lonely, isolated, or incapable. However, discussions with older participants demonstrated that many wished to maintain independent, community-based, active lifestyles, but that technology does not always facilitate or enhance such activity [15,16]. Further, research has shown that older people's interactional performance has been compromised, intentionally or otherwise, by design and decisions within the design process [17]. The goals of usability and inclusive designers are to create interactive technologies that are enjoyable, pleasurable, motivating, satisfying, and easy to use for the largest possible population, and should not be to the detriment of the performance of any subgroups. As success is largely dependent upon users' perception and acceptance of technology and their level of engagement with it [18], greater understanding of older people and the diversity they represent is imperative.

2.1. Older Users and the Design of Physical Products

Previous work identified how older individuals fail to recognise modern features and icons, suggesting the existence of a generational effect causing modern symbols and interactional styles to be most suited to those 25 years and younger [5,19]. Linking with the above, elderly users also performed less well in interface information retrieval tasks which required searching hierarchical structures in comparison to younger adults [8]. Such findings explain the difficulties experienced by older people interacting with products and designs that employ menu-driven systems, whilst they may also experience a decline in their cognitive and physical abilities.

In a study investigating generational effects upon interaction with a typical household product available on the high street, Wilkinson et al. [8] examined the extent to which familiarity and interaction with contemporary products decreased according to age. The study determined the effects of age and prior experience upon individuals' performance with products and identified problems users experienced during interaction with technology. The newness of the product to market was crucial in its selection. The aim was to investigate how a product's design communicates aspects of use and knowledge to users with little previous experience of its current embodiment and if, purely due to the product's design, users were hampered in their ability to understand or interact. This also allowed investigation into how effectively knowledge of other interfaces and designs (prior experience) may be transferred during interaction.

The results of the study confirmed the findings of Docampo-Rama [5] and Freudenthal [7] in that there was a moderate correlation between age and reaction time. In the study, older users within the age range 60–80 took longer to complete a simple reaction time task than younger participants within the ranges of 16–25 and 26–59 following existing approaches reported in literature (for an explanation on the categorisation methodologies employed, see Blackler [20], Lewis et al. [21,22], Wilkinson et al. [3,8,15,17]). This study also looked at a wider range of contemporary products including sat-nav systems, mobile phones, laptops, and televisions and consistently found that younger people completed tasks quicker.

- Younger people performed more efficiently and effectively.
- Younger people possessed a greater ability to store and recall information, and were optimally positioned to recognise, understand, and acquire iconic information.
- Increases in age correlated to decreases in the ability to acquire product feature knowledge.
- The younger generation were able to acquire knowledge and accurately determine more product features and appeared advantageously placed to interact more effectively with contemporary technology.

Not only can the use of modern technology be compromised without possessing the necessary experience of expertise, the physical design can negatively impact interaction [23]. The findings above suggest that younger people also interact more regularly and frequently with modern products and can transfer knowledge more readily from one product to another. This will be based on experiential learning but crucially it will also be based upon product aesthetics and icon and feature design. Whilst natural atrophy may play a role in older people's decreasing ability to attain and contain information as they age, as designers, if we want to create truly accessible interactions cross-generationally, we must carefully consider the implications of every interactional design feature and nuance as they apply equally to both on- and offline products and platforms.

Emphasising the importance of user involvement in the design process, understanding an individual's *motivation* for using technology is also key. Rogers and Fisk [24] suggest that whilst older adults are less likely to use technology, once older adults adopt a particular technology, they may use it as frequently as younger adults; whilst older users may require greater persuasion to adopt a technology, if the benefits of that technology are transparent and obvious, older users will engage with it. How that information is conveyed to users is also something we should consider.

2.2. Older Users and the Design of Digital Interactions

Older individuals over 75 have historically been late adopters of widespread technologies such as the Internet, smartphones, tablet PCs, and social networking services, regardless of the fact that these technologies have begun to play an increasing role in maintaining and promoting their health and well-being [25]. In order to understand why there is delayed engagement with technology that may help them maintain their independence and quality of life, it is important to look at specific aspects of online interaction itself. The field of online accessibility amongst older users has been subject to increasing academic interest over the last two decades [26]. This "online interaction" not only refers to the user's immediate interaction with an interface (for example, the ability of the user to click on an icon or read on-screen text), but also the wider behavioural interaction with an online service (for example, the ways in which specific user groups use social networking sites). Older user groups are also one of the most important to consider in terms of optimising online interactions as they now make up the most rapidly growing group of internet users, for both personal and work reasons [27].

Regarding online behaviour, Vuori and Holmlund-Rytkönen carried out a survey of 155 participants aged 55 or over [28]. They found that, whilst different age groups carry out similar online activities, the extent to which the activities are carried out varies between the two groups. This is also highlighted by the Nominet Trust in their review titled Ageing and the Use of the Internet [29],

presented in Table 1. It highlights the differences in Internet usage between older and younger users, particularly the large differences in the use of social networking sites.

Table 1. Internet use by age group; percent in the EU27 member states [30].

Internet Usage	16–24 Year Olds	55–74 Year Olds
Use the Internet on average at least once a week	90	37
Send or receive email	90	85
Post to chat sites, blogs, or social networking sites	80	20
Use the Internet for phone or video calls	35	20
Use the Internet to read news and newspapers	45	50
Use the Internet for learning	80	35
Search for information on courses	50	20
Follow e-learning courses	10	5

Pfeil et al. expanded on this finding through their study of the social networking site MySpace [31]. They identified that older users made less use of the different media available (such as videos and music) and less use of the “comment” features of the site. Analysis of the US Current Population Data found similar results in terms of the use of online functions and features by older people. Specifically, older users do not make as much use of the more advanced functions of the Internet when compared to younger users [32]. These findings could suggest that older users do not want as many features as younger users, or that they require more assistance to understand and encouragement to use these features. In a Swiss study of 1212 individuals aged between 65 and 84 in residential care facilities, 14% regularly accessed the Internet. Internet users were increasingly likely to be younger, male, living for a shorter period within care facilities, living within shared facilities, healthier, and functionally unimpaired [33]. This reinforces the importance of understanding the needs, requirements, and capabilities of older users if systems are to be developed that facilitate use.

Cleaver [34] highlighted the preferences that older users have in terms of interface layout, including easy navigation with simple, polite, and clear messages. Hawthorne [35] states that websites can be made more usable for older adults if they incorporate larger fonts, specific frequencies of sound, layouts that minimise the need for precise mouse movement, have fewer distractions, are easy to learn, and provide memory cues. Kurniawan and Zaphiris [36] take this further to present a set of “research-derived ageing-centred web design guidelines” which have been subject to expert and user validation. These include minimal use of graphics and colour, reducing the reliance on the users’ memory, clear navigation, and a simple layout.

3. Involving Older People in the Design Process

A survey of the UK design industry in 2010 reinforced concerns regarding a lack of diversity within the design community, revealing that the average UK designer was male, white, and 38 years old, with only 7% coming from ethnic minority backgrounds [37]. Historically, the design community has been accused of failing to understand and engage with distinct user groups, preferring to design from their personal experience and capability: *If I can do this, then so will all the users of the product I am designing*. Such an approach may alienate the user base as a lack of user understanding will be transferred into products that become unsatisfactory, unappealing, and unusable to users. Failing to engage with users or user groups in this manner misses a commercial design opportunity and an opportunity to design products that satisfy needs in a market-leading way [38].

3.1. Involving Users in Physical Product Development

With the primary goal being to gain insight into human behaviour, attitudes, experience, and knowledge applied during interaction, a combination of both a quantitative, scientific approach and the application of more qualitative, ethnographic techniques has the potential to yield the most valuable data [17]. Multidisciplinary research that bridges cognitive theory, psychology, design,

manufacturing, and engineering provides us with possibly the best approach to enhancing our understanding of humans' unique needs and capabilities, and the best chance of designing products, systems, or services that are more appropriate, usable, and accessible.

Although there is some debate regarding the best approach to take to design for older users, the gold standard of user-centred design is generally accepted as the involvement of a representative selection of real users in design and development from the start of the process. This is reflected in the belief that all people have something to offer at every stage of the design process [39]. This is an idea reflected in the following model of Participatory Design (Figure 1).

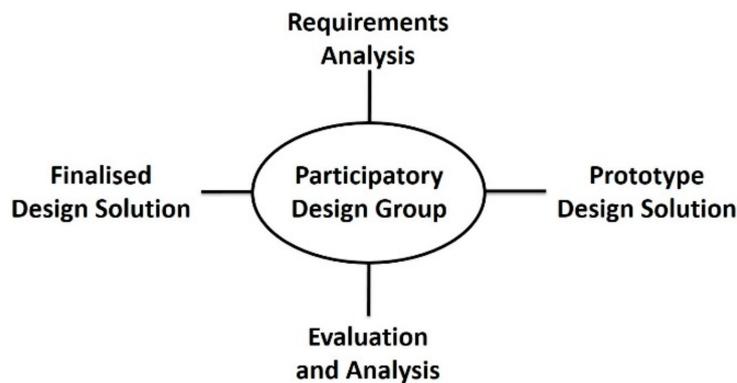


Figure 1. Participatory Design interaction within the Design Process [15].

According to Schulz et al., the development of successful technology requires teams that not only include clinicians, social and behavioral scientists, and policy experts, but also include engineers, human factors specialists, computer scientists, designers, and informaticists [25]. The Participatory Design Group emphasised in the above model encapsulates everyone involved in the design process—the user, the client, the clinician, the engineer, the designer, the manufacturer—offering everyone the opportunity to feed in at every stage to ensure all aspects are considered as the process begins and develops. Whilst optimal, it may not be practicable for everyone to sit around the same metaphorical design table at the same time. Regardless, it is imperative that good dialogue is maintained between participants and stakeholders, and that all input is considered and acknowledged. Thus, everyone—and particularly the widest range of users or potential users available—can and should have the opportunity to feed into determining the initial requirements specification and analysis, providing feedback as prototypical design solutions are developed, and assisting in the evaluation and feedback processes in order to arrive at a finalised design solution. At the very least, this will satisfy the need identified. At best, it will do so in a way that will make it a market leader and a product capable of capitalising on commercial opportunity by differentiating itself from competition on account of exceeding user requirements and doing so in a way that positively engages users. Such approaches help practitioners to more accurately capture the needs of the end users in the context of use [40,41] and ensures the enhancement of interaction for all users and particularly older users that, as shown, have been disenfranchised in the past [17]. It should be stressed, however, that there is no reason to restrict such approaches to the design of physical products alone as they are equally applicable to any technology development; on-or-offline, physical or digital.

3.2. Involving Users in Digital and Online Design

In both physical and digital product development, there is a clear need for academia to continue to develop tools and techniques to support designers. Kurniawan and Zaphiris [36] suggest that web developers lack understanding of older audiences, particularly as these web designers are often young. This implies that they either are not equipped with the tools and techniques required, or they are not using the ones available. It is therefore essential that these tools are also developed in an accessible and user-centred way to ensure their uptake and application.

In web development, a commonly used approach is to follow guidelines. However, it is well known that guidelines can be difficult for designers to use in practice [42]. Furthermore, Hart et al. [27] carried out a study evaluating 40 websites with older users and concluded that the flaws of each approach mean it is essential to use both guidelines and usability testing when designing websites for older adults and involving them within the design process.

However, Kurniawan and Zaphiris [36] suggest that web design guidelines can help designers ensure websites are developed with greater levels of usability and accessibility. There are many guidelines available to, and used by, web designers in industry. These include

- ISO/IEC 40500:2012-IT-W3C Web Content Accessibility Guidelines 2.0 [43];
- ISO 9241-171:2008-IT-Accessibility and Ergonomics [44];
- ISO/IEC 24786:2009-User Interfaces [45];
- Section 508 of the Telecommunication Act 1998 [46];
- Jakob Nielsen's Usability Heuristics Jakob Nielsen [47];
- The RNIB See it Right guidelines (compliant with the Disability Discrimination Act) [48];
- National Institute on Ageing's guide to Making Your Website Senior Friendly [49].

There are a range of tools available to complement guideline use, such as WebAim from the University of Utah [50] and the 69 tools listed on the W3C's Web Accessibility Evaluation Tools list [51]. However, it is essential that these tools are developed in a user-centred way; otherwise, it is unlikely that they will be used [52].

There is also some debate regarding the aim of the design. Some have suggested that older people require their own websites specifically tailored to their needs [53]. An example of this from industry is the accessible text-only version of the Tesco website, which led to markedly increased new revenue [54]. Yet this could be stigmatising to older users, and stigmatising by design should be avoided if designers wish to enjoy the perceived benefits of increased uptake and adoption [15,38].

It has been suggested that older users simply require the kind of "good interaction design" that all users will benefit from [28]. The well-known Usability Heuristics presented by Jakob Nielsen [47] include several factors that have been identified as improving online interactions for older adults. An example of this is the heuristic of "recognition rather than recall" which minimises the amount that users have to rely on their memory. Approaches such as Inclusive Design advocate designing for the widest possible audience, but this could result in a suboptimal solution for all users. There are several other factors that add to the complexity of the situation. For example, individual differences between people within the older population also play a part, such as education levels, health, and experience [14,26], as well as having access to appropriate support and training [55].

Whilst the challenge of designing for older users is complex, there is some evidence from industry that they are being considered in the design of online services and interactions. Unique events have also been implemented to foster and encourage internet use, geared specifically toward older individuals, such as Digital Unite's Silver Surfer Day, UK Online's It's Never Too Late campaign, and the Hamilton Davies Trust's Itea and Biscuits. There are examples of websites and online services that have been designed with the older adult in mind, such as the UK Government's ".Gov" website which was tested and refined extensively with real users through four rounds of lab-based testing [56]. However, Hart et al. [57] identified 25 websites designed specifically with an older audience in mind and found that some of them failed to follow even the more rudimentary guidelines. As many as 95% of the sites under scrutiny did not provide navigation aids, suggesting that there is still a need to increase education and awareness.

The Nominet Trust [29] stated that "there is room for improvement in designing user-friendly technologies for older people" (p. 9). They acknowledged that industry often fails to recognise the different needs of older people and that older people are not used enough in the making of design decisions. Whilst discussing the methods used in the web design industry that include User Centred Design, HCI Methods, Ethnography, and methods from the Social Sciences, Eisma et al. [58]

commented that the methodologies used were only partly appropriate for achieving the desired goals. Fourteen years later, it is clear that there is still room for improvement in this area.

4. Discussion

When designing for and with clients, there is a need to consider their influence on the design process too. The client is a key influence [59] and could impact the extent to which the user is considered. Cornish et al. [60] suggest that the notion a designer will always be able to take visual accessibility into account even if it is not in the brief may be misguided. As the client supplies the brief and sets the budget and time constraints, the client may need to be enlightened in this regard.

There is a need to learn from other sectors. Web design can learn from other industries with a greater focus on user-centred design, particularly with regard to meeting the needs of older users. This is more apparent in safety-critical industries [59]. Rail [61] and Healthcare [62] have implemented accessibility legislation to ensure visually accessible graphic design.

There is a need to develop legislation and policy to drive the understanding and implementation of accessibility. According to the Nominet Trust, European policy takes a positive stance with regard to supporting older people with Internet use, and the European Commission notes the importance of widening access and e-Literacy so that everyone can use these new technologies to access public and commercial services [29]. However, the Nominet Trust state that there is insufficient understanding of how to support older people in their use of the Internet and the development of additional policy is constrained by the absence of an underpinning research base, concluding that policy needs to take a far more fine-tuned approach to e-Inclusion at both national and trans-national levels.

There is a need to educate stakeholders in the design process to overcome existing misconceptions and barriers. Cornish et al. [59] carried out interviews with seven graphic designer–client pairs (some with experience of web design) and identified a number of misconceptions that could be acting as barriers. For example, the participants believed that

- Visually accessible design is just for the severely visually impaired;
- Considering the user’s visual capabilities is more time consuming and difficult than it is worth;
- You cannot create both stylish and accessible designs.

The Conceptual Step-Through in Figure 2 summarises the key points made so far.

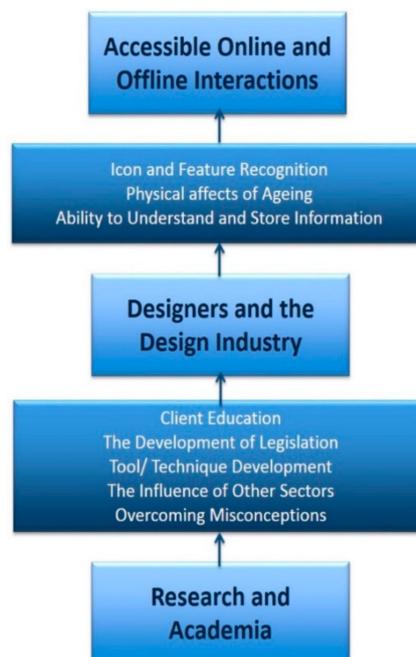


Figure 2. Conceptual Step-Through.

Whilst not exhaustive, Figure 2 highlights the areas that research and academia should focus upon to inform designers and the design industry. It then suggests particular areas of focus for designers to consider with the aim of creating more accessible on- and offline interactions for all members of society and particularly older adults.

5. Conclusions

Whilst product designers in industry are typically constrained in terms of time and budget that frequently prevent them from consulting with end users [63], the potential return on such investment cannot be overstated. Inclusive design is viewed as an approach that aims to optimise the creation of interfaces, artefacts, and products that are accessible to as many users as possible, while minimising the cognitive and physical effort involved [64,65]. Therefore, not only do such user-centred approaches have the potential to reduce subsequent (re)development costs, they also contribute toward the deployment of technology that is more usable, understandable, and intuitive to a larger market from the start [38]. The intention of this work is to highlight that increasing the consideration of the users' full range of skills and capabilities and the differences across the generations will not only improve interaction for an ageing population but improve interaction for all users of physical and digital products. Ultimately, there is a golden opportunity to improve product interaction, irrespective of age, experience, or cognitive or physical capability, and this, we suggest, is what should drive future design.

5.1. How Might Older People Benefit?

User perception of products and interaction are often based upon the user's prior experience of other similar products. If the design of the artefact misleads them or their ideas about its manipulation, based solely upon the design of the artefact itself, do not transfer well, it is likely to result in poor performance and product abandonment. If as we age there is a tendency to reduce our interaction with products, the more that can be done to facilitate successful and enjoyable interaction when older users do interact, the likelier we are to encourage users to continue to engage with our products for longer. Incorporating design features that resonate not only with younger but older users increases the likelihood of successful interaction and a positive perception of the product by all users.

It has been argued that technological, economic, and social changes have increased social isolation, and that assistive technologies for the elderly have overlooked this issue [16]. However, technologies can be designed to provide increased social connectivity and assist users to communicate inside and outside the home. Integrating connectivity into the design maintains access to social networks and encourages physical and virtual interaction.

Maintaining personal identity is a key facet in terms of mental well-being, and an aspect of personal identity is derived from individuals understanding their position within a group or network. Technologies designed with enhanced understanding of users' needs and requirements may help older users to establish a sense of normality and motivate them to explore new avenues of interest and engage in new activities. This provides mental and physical stimulation and can enhance individuals' self-belief and foster renewed confidence in their on- and offline capabilities.

By understanding in greater detail the information that individuals bring to product interaction, and the diversity of their prior experience and capability as well as the information interaction necessitates they acquire, designers can utilise this knowledge in the creation of designs that fit more effectively and more immediately into the users' existing knowledge base. This then improves intuitive interaction, accessibility, and usability, as users are able to operate at a more unconscious, automatic, and skilled-based level [66].

The Consideration Framework shown in Figure 3 places the user at the centre of the process and mirrors the aim to heighten product engagement by following the traditional principles of user-centred and participatory design.

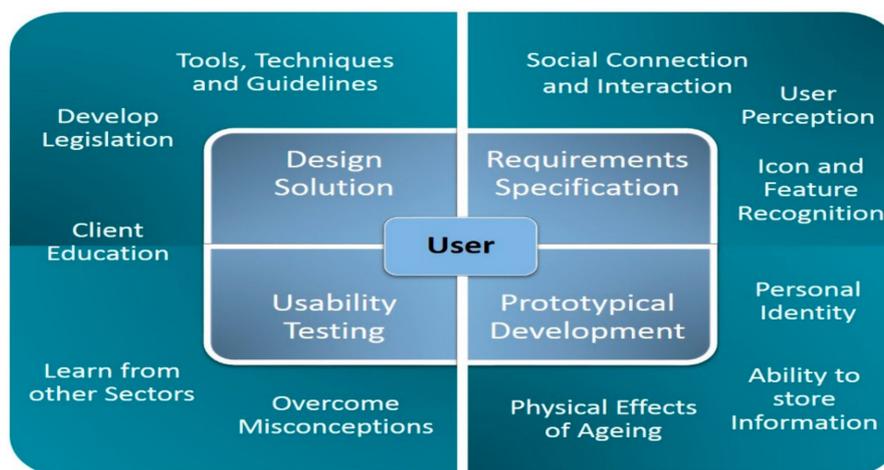


Figure 3. Consideration Framework.

The framework reminds us that user input should be sought at each and every stage of the design process, and that users play a central role. Toward the periphery and to the right are some of the humanistic elements to be considered, and toward the left, concepts that we suggest designers address before embarking upon research and design activities involving older adults.

5.2. Closing Remarks

The idea that user-centred and participatory design ensures a better end product fit continues to gain universal momentum. Whilst academia has long expounded the benefits of user consideration, industry acceptance grows apace as the realisation that strategically involving users within the design process equates to greater adoption and engagement out of the box. This, in turn, results in significantly reduced development costs, higher rates of uptake, and a more immediate return on investment. We would do well to remember that unlike younger generations, older individuals interact at a more conscious level and consider the effects of their behaviour throughout interaction.

Older adults are also less familiar with contemporary technologies and are therefore disadvantaged in terms of the mental models of interaction they have to draw on or make inferences from. If they are to realise the benefits afforded to them in terms of increased online engagement and social interaction, both on- and offline product design must cater to these and other aspects of the aging population. Only in this way will we, as inclusive designers, ensure improvements not only in interaction but in the ongoing quality of life of older individuals.

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