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The effects of aging on the use of handheld augmented reality in a route planning task

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ABSTRACT

Technology may offer benefits for the older population in keeping their independence and connection to society. However, adopting new technologies, such as augmented reality (AR) by older adults may be difficult due to decline of cognitive and physical abilities as well as due to hostility and apprehension regarding the use of technology. In the current study, we compared performance of older and younger participants in a route planning task of public transportation, implemented using both a handheld see-through AR interface, and a standard non-AR application on a mobile phone. Faster task completion times but also higher error rates were associated with the use of the AR interface, regardless of the age of the participants. Older adults showed significantly slower performance compared to younger participants while using the AR application, however, error rates were not significantly different. No trial-to-trial learning was observed for the AR interface, indicating that the AR see-through technology is intuitive and easily adopted. Finally, elderly participants reported on average better user experience for the AR interface compared to younger participants, and preferred the AR over the non-AR application. Our findings highlight the potential of AR technology for older adults, as a possible aid tool to manage everyday tasks, such as navigation and planning.

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1. Introduction

There is a widely acknowledged view of the importance of keeping older adults in sync with the latest technological developments. As well as connecting with family and friends, technology can assist older adults in increasing social support, improving access to medical information, enabling them to participate as citizens in decision making processes and more (Selwyn, Gorard, Furlong, & Madden, 2003). As adults get older, their cognitive, perceptual and motor abilities decline and they might suffer from a wide range of deficits such as vision and hearing problems, decline in working memory, and decline in information processing speed (Czaja & Lee, 2009; Fisk, Rogers, Charness, Czaja, & Sharit, 2009). Some of these disabilities affect and create difficulties for older adults to adopt the use of novel technologies (Leonardi, Mennecozzi, Not, Pianesi, & Zancanaro, 2008). This is unfortunate, as technology introduces various opportunities to assist older adults, and can be used to allow the elderly to live more independently, for example, by monitoring

health issues (Korman, Weiss, & Kizony, 2016) and aiding for age-related cognitive and sensory-motor deficits (Moffatt & McGrenere, 2010; Mynatt & Rogers, 2001; Czaja, Guerrier, Sankaran, & Thomas, 1993).

Augmented Reality (AR) is a relatively novel technology in which virtual elements are added to the real world view, interactively and in real time. AR technology allows the user to see the real world with virtual objects superimposed on top of it (Azuma et al., 2001). While AR research dates back to the 90's and possibly earlier, lately it has become more mature and available to the mass, mostly by means of computationally-strong handheld devices. By displaying the required information in context, AR can reduce the cognitive load needed to switch attention between the physical world and the information source (Kim & Dey, 2009; Tang, Owen, Biocca, & Mou, 2003). Given the age-imposed declines in working memory capacity and in information processing speed, this may be especially beneficial for older adults. Till now, limited research has been conducted to explore the possible use and benefits of AR for the older population. AR cues were shown promise for improving elderly driver safety by increasing hazard detection likelihood without interfering with other driving tasks (Schall et al., 2013), and in reducing navigation errors and distraction, helping address older

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adults' decreased spatial cognition ability in a driving navigational interface (Kim & Dey, 2009). Still, there is lack of systematic studies addressing whether the new affordances offered by AR technologies are of benefit or hindrance to the elder population.

The general aim of our study was to empirically examine the feasibility of AR technology for older adults. In particular, we tested how older adults interact and use AR for a route planning task, examining the deficits and the constraints to their performance as compared to young adults. Both older and younger participants completed a route planning task using both a see-through handheld AR application, and a regular (non-AR) phone application. We measured task completion time, error rate, device movements and subjective opinions. These measures were used to assess performance, learning and user experience of participants when using an AR interface.

The paper is structured as follows. We continue to discuss the adoption and use of novel technology by older adults and specifically their use of virtual and augmented reality in the current section. Section 2 describes the methodology employed in the study, and Section 3 provides the results. Section 4 discusses the findings and the limitations of the current study, conclusions are drawn in Section 5.

1.1. Older adults' attitudes and adoption of new technologies

The older population is increasing over the years. This demographic shift emphasizes the need to enhance the well-being, independence and social inclusion of older adults. As society becomes more and more digital-dependent across all domains, and many services and resources are available only digitally, technology adoption is becoming imperative in order to function and participate in today's modern world. Thus, it is essential to enable and encourage the adoption of new technologies by older adults and improve their digital and technological literacy.

Hill, Betts and Gardner (2015) discuss the digital divide of older adults, in which digital technology can either increase their isolation from society or facilitate their well-being. Older adults are a heterogeneous group with regards to their digital use. While some embrace digital technologies, others are more reluctant, and seldom use technological devices such as computers or mobile phones (Vroman, Arthanat, & Lysack, 2015). Studies have shown that, overall, older adults are slower in adopting technologies than younger adults (Czaja et al., 2006; Olson, O'Brien, Rogers, & Charness, 2011). While age-related declines in cognitive, perceptual and motor skills may be related to the lower adoption rates of older adults (Rogers, Stronge & Fisk, 2005), most researchers argue that the main reasons are rather due to the negative attitudes to technology in this population. Older adults may perceive new technologies as a barrier, with feeling of low self-efficacy, anxiety and hostility related to its initial use (Czaja et al., 2006; Mitzner et al., 2010). This may limit their confidence and interest in using novel digital technologies. In addition, for the majority of the older population, technology is perceived as unfamiliar and alien (Leonardi et al., 2008). This avoidance of technology may cause isolation and loss of participation in activities within their communities (Hill, Betts and Gardner, 2015).

New technologies may offer many benefits to older adults that may compensate for loss of mobility and other lifestyle changes and limitations associated with aging. Technologies can empower older adults and facilitate in everyday tasks such as hobbies, social connectedness, social inclusion and more (Hill, Betts, Gardner, 2015; McMellon & Schiffman, 2002). In a study examining older adults' attitudes toward technologies, participants clearly viewed their benefits as outweighing the costs, mentioning communication, information access, health monitoring, and leisure and

entertainment as the main benefits (Mitzner et al., 2010). It seems that older adults are happy to adopt new technologies when they clearly see the benefits that it brings to them, and are eager to learn more about new forms of technology whenever they perceive it as useful (Fisk et al., 2009; Heinz, 2013).

Apart from the perceived usefulness that technology may offer older adults, perceived ease of use is also an important factor for technology adoption (Davis, 1989). However, older adults often perceive technology to be difficult to use and too complex to learn (Hawthorne, 2006). Reasons for this vary, and may relate to the decline in working memory associated with age (Fisk et al., 2009) as well as less technological experience as compared to younger adults, decreasing opportunity for positive transfer (Leung, Findlater, McGrenere, Graf, & Yang, 2010). Nonetheless, it is clear that learnability, ease of use, and most of all, the intuitiveness of the technology or interface has a crucial role in the way older adults perceive the technology and ultimately, adopt it.

While overall older adults are slow in adopting new technologies, mobile devices such as smart phones and tablets are rapidly becoming popular with this population (Pew Research Center, 2014), probably due to their usefulness and obvious benefits. In fact, many older people think that mobile phones are more accessible than PC's (Plaza, Martín, Martín, & Medrano, 2011), and older people have better access to mobile technologies in comparison to previous technologies (Gell, Rosenberg, Demiris, LaCroix, & Patel, 2015). In the early stage of mobile phones, older people were using them mainly for safety and security reasons. Later, mobile phones evolved as a communication device for everyday life both in leisure and in work contexts. In addition, mobile devices have various functionalities and affordances that provide older adults with benefits such as a feeling of security and safety, communications functionalities, enjoyment and leisure and the ability to maintain their independence and freedom of movements (Plaza et al., 2011). This increase in adoption is encouraging, and may indicate that indeed, when technology is deemed useful and easy to use, it may be widely adopted by older adults. Our study examines the potential of a new kind of mobile technology – augmented reality – to be used and adopted by older adults.

1.2. Augmented reality and older adults

Augmented reality (AR) has the potential to become an inherent part of our everyday lives and to change the way we interact with our world. AR allows overlaying a virtual layer of information or graphics on top of the real world, to enable a new level of information contextualization (Azuma et al., 2001). AR can be used in a multitude of situations in which augmented information can benefit the user when overlaid in a real-world environment. For example, AR can be used to help in navigation by adding the directions as augmented information on top of the real-world view (Kim & Dey, 2009), to enhance cultural heritage experiences (Vlahakis et al., 2002), to be used in gaming (Paavilainen et al., 2017), and more.

Being a novel technology, AR is still relatively unknown to the general public, both younger and older adults alike. Thus, apart from a couple of usage instances, such as with the popular AR game Pokemon Go (Paavilainen et al., 2017), it is yet to be adopted by the general public. However, given its high potential, and the ongoing improvements in technology, studies have been conducted on various aspects of AR, mostly focusing on applications, various technological and interaction aspects, and interface guidelines (Billinghurst, Clark, & Lee, 2015). With respect to AR adoption, technological challenges, formation of standards and compatibility of social practices were mentioned as possible barriers (Martínez, Skournetou, Hyppölä, Laukkanen, & Heikkilä, 2014), all of which

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