INSTITUTO UNIVERSITÁRIO DE LISBOA

Too old for technology?
Age stereotypes and technology use by older adults

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CIÊNCIAS SOCIAIS
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Department of Social and Organizational Psychology

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Às minhas avós, Carolina e Deolinda,

que nunca frequentaram uma escola e nunca usaram um computador nas suas vidas.

To my grandmothers, Carolina and Deolinda,

who never attended a school and never used a computer in their lives.

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FCT Fundação para a Ciência e a Tecnologia

REPÚBLICA PORTUGUESA | CIÊNCIA, TECNOLOGIA E ENSINO SUPERIOR

Abstract

Older adults are less likely to use information and communication technologies, limiting their ability to live independently in an increasingly digital world. Despite being stereotyped as lacking technological competence, the influence of age stereotypes on older adults' use behaviours remains largely understudied. This work aimed to investigate whether and how age stereotypes determine technology use in late adulthood. According to stereotype threat theory, the fear of confirming negative stereotypes about their age group may lead older adults to avoid using technology. Across three studies based on longitudinal and cross-sectional designs, higher levels of stereotype threat were associated with lower rates of technology use. In line with the technology acceptance model, this relationship was mediated by anxiety, perceived ease of use, perceived usefulness, and behavioural intention. In turn, as implied by stereotype embodiment theory, the internalization of age stereotypes endorsed earlier in life into self-perceptions of ageing later in life may deter older adults from using technology. Across three studies based on longitudinal data from the Health and Retirement Study and the German Ageing Survey, more positive self-perceptions of ageing were associated with higher levels of technology use. Cognitive functioning mediated this relationship. By confirming the assumptions of both theories, these findings suggest that age stereotypes influence technology use in late adulthood through complementary processes. Future studies should further explore these relationships by integrating both theoretical approaches. Interventions and policies promoting positive intergenerational contact and positive views on age and ageing should thus contribute to the digital inclusion of older adults.

Keywords: ageing, ageism, stereotype threat, stereotype embodiment, technology acceptance.

PsycInfo Codes:

2800 Developmental Psychology

3000 Social Psychology

Resumo

As pessoas mais velhas têm uma menor probabilidade de usar tecnologias de informação e comunicação, impedindo que vivam de forma independente num mundo cada vez mais digital. Apesar de serem estereotipadas como tendo menos competências tecnológicas, a influência destes estereótipos nos seus padrões de utilização permanece pouco estudada. Este trabalho pretendeu investigar se e como os estereótipos etários determinam os comportamentos de utilização de tecnologias das pessoas mais velhas. Segundo a teoria da ameaça do estereótipo, o receio de confirmar estereótipos negativos pode fazer com que os mais velhos evitem usar tecnologias. Três estudos longitudinais e correlacionais verificaram uma relação entre maiores níveis de ameaça do estereótipo e menores taxas de utilização de tecnologias, sendo esta mediada pela ansiedade, facilidade percebida, utilidade percebida e intenção comportamental de acordo com o modelo de aceitação de tecnologias. Por sua vez, segundo a teoria da incorporação do estereótipo, a internalização de estereótipos etários em autoperceções de envelhecimento pode demover os mais velhos de usar tecnologias. Três estudos longitudinais verificaram uma relação entre autoperceções de envelhecimento mais positivas e maiores níveis de utilização de tecnologias, sendo esta mediada pelo funcionamento cognitivo. Ao confirmar os pressupostos das duas teorias, estes resultados sugerem que os estereótipos etários influenciam os comportamentos de utilização de tecnologias das pessoas mais velhas através de processos complementares. Estudos futuros deverão explorar estas relações integrando ambas as teorias. Intervenções que promovam contactos intergeracionais positivos e visões positivas sobre a idade e o envelhecimento poderão contribuir para a inclusão digital deste grupo etário.

Palavras-chave: envelhecimento, idadismo, ameaça do estereótipo, incorporação do estereótipo, aceitação de tecnologia.

Códigos PsycInfo:

2800 Psicologia do Desenvolvimento

3000 Psicologia Social

Samenvatting

Ouderen zijn geneigd minder informatie- en communicatietechnologie te gebruiken en beperken zo hun eigen zelfstandigheid in een almaar digitaler wordende wereld. Al is dit gebrek aan technologische vaardigheden stereotypisch, de invloed van leeftijdsstereotypen op gebruiksgedrag van ouderen blijft grotendeels onderbelicht. Dit werk heeft zich tot doel gesteld te onderzoeken of en hoe leeftijdsstereotypen het technologiegebruik onder ouderen beïnvloeden. De stereotype dreigingstheorie stelt dat de angst om negatieve stereotypen over hun leeftijdsgroep te bevestigen ouderen ertoe kan zetten technologiegebruik te mijden. In drie onderzoeken, gebaseerd op longitudinale en cross-sectionele ontwerpen, werd hogere stereotype dreiging geassocieerd met lagere gehaltes technologiegebruik. In lijn met het technologie-acceptatiemodel, werd deze relatie gemedieerd door angst, ervaren gebruiksgemak, ervaren bruikbaarheid en gedragsintentie. Volgens de stereotype belichamingstheorie wordt de internalisering van ouderdomsstereotypen op zijn beurt bevestigd in de zelfperceptie van het ouder worden en dit doet ouderen huiverig tegenover technologie staan. In drie onderzoeken op basis van longitudinale data van de Health and Retirement Study en de Deutsche Altersurvey, werd positievere zelfperceptie van veroudering geassocieerd met hoger technologiegebruik. Cognitief functioneren medieerde deze relatie. Door de aannames van beide theorieën te bevestigen, duiden deze bevindingen erop dat leeftijdsstereotypen het technologiegebruik in de late volwassenheid beïnvloeden, middels complementaire processen. Toekomstige studies zouden deze relaties verder moeten onderzoeken door beide theoretische benaderingen te integreren. Interventies en beleid ter bevordering van positieve intergenerationele contacten en positieve opvattingen over leeftijd en veroudering moeten zodoende gaan bijdragen aan de digitale inclusie van ouderen.

Zoektermen: veroudering, leeftijdsdiscriminatie, stereotype dreiging, stereotype belichaming, technologie-acceptatie.

PsycInfo Codes:
2800 Ontwikkelingspsychologie
3000 Sociale psychologie

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CHAPTER 1.

General Introduction

The twenty-first century has been marked by two major global transformations: population ageing and technological innovation. Driven by increases in longevity and decreases in fertility, the number and proportion of older people, typically defined as those aged 60 or 65 years and over, is growing worldwide, faster than any other age group (United Nations [UN], 2017, 2020). Simultaneously, there has been an increasing digitalization of contemporary societies (Organization for Economic Cooperation and Development [OECD], 2019a; 2019b). Information and communication technologies, commonly defined as products or services that store, retrieve, manipulate, transmit, or receive information electronically (e.g., the internet, personal computers, mobile phones), have become an integral part of everyday life across multiple contexts, including communication, entertainment, healthcare, education, and work.

Technology holds great promise in supporting the growing population of older people. Existing and emerging digital tools have the potential to promote an active and healthy ageing, allowing older adults to live independently in their homes and communities for as long as possible (Czaja, 2017a, 2017b). There is increasing evidence suggesting that using information and communication technology contributes to better social (e.g., decreased loneliness), emotional (e.g., decreased depression), functional (e.g., increased cognitive performance), and subjective well-being (e.g., increased life satisfaction) in late adulthood (Chopik, 2016; Hartanto et al., 2020; Heo et al., 2015; for reviews, see Fuss et al., 2019; Hunsaker & Hargittai, 2018; Wagner et al., 2010). Technology-based interventions have also been found to be effective in promoting older adults' health and well-being, for example, in managing loneliness and improving cognitive performance and physical activity (Ammann et al., 2012; Peels et al., 2014; for meta-analyses, see Choi et al., 2012; Hill et al., 2016; Lampit et al., 2014).

Yet, older adults consistently report lower rates of technology uptake than the general population, as indicated by their reduced likelihood, frequency, and breadth of technology use (Brandtzæg et al., 2011; Czaja et al., 2006; König et al., 2018; OECD, 2020; Pew Research Center, 2017). The digital exclusion of older adults not only prevents them from reaping the benefits of using technology, but also compromises their ability to live and function independently in an increasingly digital society. Numerous factors have been researched as potential barriers to technology use in late adulthood, including socioeconomic factors (e.g., lower education), age-related changes (e.g., cognitive declines), and attitudinal factors (e.g., higher anxiety and lower self-efficacy; for reviews, see Charness & Boot, 2009; Hunsaker & Hargittai, 2018; Wagner et al., 2010).

Interestingly, relevant proportions of older adults mention their age or being “too old” as reasons for not using technology (Morris et al., 2007; Selwyn et al., 2003), suggesting that perceptions about age and ageing may play an important role in how individuals engage with technology in late adulthood. Surprisingly, very few studies have explored this potential barrier. This thesis aimed to understand whether and how age stereotypes determine technology use among older adults.

1.1. Age Stereotypes

Ageism should be of particular concern in increasingly ageing societies, due to its mostly detrimental impacts on older adults’ health and well-being (Chang et al., 2020; Levy et al., 2020). Ageism can be defined as positive or negative attitudes towards people on the basis of their perceived chronological age (Butler, 1969; Iversen et al., 2009). Based on the tripartite model (Eagly & Chaiken, 1993; Rosenberg & Hovland, 1960), ageist attitudes comprise three different components: cognitive (stereotypes), affective (prejudice), and behavioural (discrimination). Specifically, stereotypes can be defined as qualities perceived to be associated with groups or categories of people (Schneider, 2004). This includes beliefs, traits, roles, behavioural expectations, or physical features, among others. This thesis focuses primarily on age stereotypes about older adults. Although mixed, comprising both positive (e.g., wise, kind, sociable) and negative (e.g., senile, sick, lonely) perceptions (Hummert, 1990; Hummert et al., 1994), age stereotypes about older adults tend to be predominantly negative (Kite & Johnson, 1988; Kite et al., 2005; Ng et al., 2015). According to the stereotype content model (Fiske et al., 2002), older adults are perceived more positively along a warmth dimension and more negatively along a competence dimension: the *warm but incompetent* or *doddering but dear* stereotype (Cuddy & Fiske, 2002; Cuddy et al., 2005).

In the technological domain, older age groups are also negatively stereotyped regarding their competence. Older adults are perceived as less likely and less capable of performing technology-based tasks or engaging in technology-related activities, such as taking and completing a computer course (Ryan & Heaven, 1988; Ryan et al., 1992; Swift et al., 2013). Additional clues about the content of age stereotypes in this domain come from research focusing on older workers, often defined as those aged 50 or 55 years and over. Compared to their younger counterparts, older workers are perceived as less skilled, less experienced, less adaptable, less comfortable, and more fearful of technology (Hanks & Icenogle, 2001; McCann & Keaton, 2013; McGregor & Gray, 2002; Sharit et al., 2009). These stereotypes are prevalent across eastern and western countries (McCann & Keaton, 2013; Van Dalen et al., 2009) and among younger and older age groups (Gibson et al., 1993; McGregor & Gray, 2002).

Stereotypical perceptions can influence behavioural responses towards outgroup members (Cuddy et al., 2007; Talaska et al., 2008). For example, age stereotypes about technological competence may result in discriminatory practices against older workers, such as reduced hiring and training opportunities (Abrams et al., 2016; Gray & McGregor, 2003; McCausland et al., 2015; Rosen & Jerdee, 1976). Equally important, stereotypes can also shape the behaviours of their targets (Wheeler & Petty, 2001). Numerous studies have shown that older adults behave in ways consistent with the stereotypes targeting their age group (for reviews, see Lamont et al., 2015; Meisner, 2012).

Thus, ageist stereotypes about technological incompetence may cause older adults to underperform and underuse technology, potentially contributing to maintain the existing digital inequalities between generations. Surprisingly, the self-fulfilling nature of age stereotypes in the technological domain has been greatly overlooked. This thesis sought to fill this gap by testing the assumptions of the two main theoretical approaches to the behavioural effects of age stereotypes in late adulthood (Swift et al., 2017; Wurm et al., 2017): *stereotype threat* and *stereotype embodiment*.

1.2. Stereotype Threat

According to stereotype threat theory (Steele, 1997; Steele et al., 2002), stereotypes exert their influence on behaviour primarily through a situational experience of threat. Stereotype threat refers to the fear of confirming, or being seen to confirm, negative stereotypes targeting the group to which one belongs (see Shapiro & Neuberg, 2007). This often results in performance decrements when individuals perform tasks in domains in which their ingroup is negatively stereotyped. In their classic work, Steele and Aronson (1995) found that activating racial stereotypes about intellectual ability subsequently lead African American college students to underperform in academic tests. Since then, stereotype threat effects have been extensively researched and documented across different social groups and ability domains (for a review, see Spencer et al., 2016). Among older adults, stereotype threat has been found to disrupt performance across multiple cognitive and physical tasks (for a review, see Lamont et al., 2015). For example, when presented age stereotypes about cognitive declines, older adults perform worse on cognitive tests (Abrams et al., 2008; Abrams et al., 2006).

Given the negative stereotypes about the technological competence of their age group, older adults should be expected to experience stereotype threat in the technological domain, with detrimental consequences to their performance on technology-based tasks. The very few studies exploring this possibility found mixed results. Fritzsche et al. (2009) examined stereotype threat effects on older adults' training performance on computer-based tasks. Interestingly, participants in the threat condition, who were presented information about age differences in training outcomes, performed better than those in the control condition. This was likely due to an increased motivation to disconfirm the stereotype induced by the fact-based manipulation. In turn, Noeltner et al. (2019) found that stereotype threat was indirectly related to worse performance on online information search tasks and that this relationship was mediated by cognitive load. Still, stereotype threat was not experimentally manipulated and cognitive load was measured only after performance. Taken together, these studies do not sufficiently enlighten the potential effects of stereotype threat on technology-related behaviours.

Besides its immediate impact on task performance, another behavioural consequence of stereotype threat is domain avoidance (Steele et al., 2002). Individuals may simply avoid situations or activities in domains in which they risk confirming negative stereotypes about their ingroup. Domain avoidance can be an immediate, short-term reaction (e.g., Murphy et al., 2007) or result from chronic, long-term exposure to stereotype threat (e.g., Woodcock et al., 2012). Based on stereotype threat theory, experiencing stereotype threat in the technological domain may cause older adults to avoid engaging with technology. With the growing digitalization of everyday life and the social pressure to try and adopt technological devices (Luijkx et al., 2015), older adults likely face situations in which they risk confirming ageist stereotypes about technological incompetence and respond by distancing themselves from those situations. On the long run, the repeated exposure to stereotype threat may compromise the regular use of technology in their daily lives. Stereotype threat should thus be associated with lower levels of technology use among older adults.

We therefore investigated the relationship between stereotype threat and technology use behaviour among older adults across three studies conducted as part of two applied projects in the ageing field. Studies 1 and 3 were part of the project *TEConhecimento* (*TEKnowledge*), which aimed to promote technology acceptance and usage among older adults, while Study 2 was conducted as part of the project *SIforAGE – Social Innovation on Active and Healthy Ageing for Sustainable Economic Growth*, which aimed to promote a positive vision of ageing for longer and better lives. Because older adults may simply avoid engaging with technology due to stereotype threat, consequently avoiding any possibility of performing technology-based tasks, in this thesis we departed from the typical experimental studies manipulating stereotype threat and measuring task performance. Instead, we focused on its lasting behavioural implications in the technological domain, namely on the regular use of technology. Moreover, we relied on the assessment of the chronic experience of stereotype threat (Steele et al., 2002; Woodcock et al., 2012). Existing age-based stereotype threat research suggests that, besides being associated with an increased likelihood of experiencing situational stereotype threat, greater chronic stereotype threat relates to both underperformance and avoidance among older age groups. Older workers who experience greater chronic stereotype threat are more likely to report weekly stereotype threat events at work (von Hippel et al., 2019) and behavioural intentions to resign and retire (von Hippel et al., 2013). Additionally, both chronic and situational stereotype threat relate to decreased performance on cognitive tasks among older adults, even though the experimental induction of stereotype threat only elicits situational threat (Kang & Chasteen, 2009). Together, these findings suggest that the assessment of chronic stereotype threat is an appropriate indicator of its situational experience, besides having similar negative behavioural consequences.

1.3. Stereotype Embodiment

In turn, according to stereotype embodiment theory (Levy, 2003, 2009), the influence of stereotypes on behaviours results primarily from a lifelong process of internalization. Stereotype internalization refers to the incorporation of previously held age stereotypes into perceptions about oneself later in life. Children are frequently exposed to stereotypical perceptions about older people and the ageing process from their cultural environment, eventually learning and endorsing them from an early age (Mendonça et al., 2018). These perceptions are continuously reinforced throughout adulthood, as there is no psychological need to question or defend against stereotypes targeting another age group (North & Fiske, 2012). However, as individuals grow older, these stereotypes become increasingly self-relevant: perceptions about their former outgroup turn into perceptions about their new ingroup (i.e., older people). Progressively, age stereotypes held earlier in life become self-perceptions of ageing, that is, perceptions about themselves as ageing individuals and their own ageing process (Kornadt & Rothermund, 2012; Kornadt et al., 2017; Rothermund & Brandtstädter, 2003). In turn, these self-perceptions influence health through multiple mechanisms, namely along physiological (e.g., cardiovascular response to stress; Levy et al., 2000; Levy et al., 2009), psychological (e.g., self-efficacy; Klusmann et al., 2019; Levy, 1996), and behavioural pathways (e.g., healthy lifestyle; Beyer et al., 2015; Levy & Myers, 2004). An extensive body of research has documented the beneficial and detrimental impacts of positive and negative perceptions about age and ageing on multiple health outcomes (for reviews, see Chang et al., 2020; Westerhof et al., 2014), including cognitive functioning (Levy et al., 2012), physical functioning (Levy, Slade, & Kasl, 2002), longevity (Levy, Slade, Kunkel, et al., 2002), and mortality (Levy & Myers, 2005).

Based on stereotype embodiment theory, the internalization of previously held age stereotypes into self-perceptions of ageing, particularly negative stereotypes related to competence, may compromise older adults' perceptions about their own technological ability, consequently undermining their likelihood of using technology. This is consistent with evidence that technology-related self-efficacy, an important determinant of technology use, is lower among older age groups (Czaja et al., 2006; Czaja & Sharit, 1998b; Lee et al., 2019). Research exploring the relationship between stereotypical perceptions about age and ageing and technology use behaviour is scarce and inconclusive at best. Lagacé et al. (2015) found that endorsing more negative age stereotypes was associated with performing fewer technology-related activities among older adults. Similarly, one study showed an association between negative self-perceptions of ageing and lower computer use behaviour (E. Y. Choi et al., 2020), although another study found this relationship to be nonsignificant (Yoon et al., 2016). Besides these cross-sectional findings, an intervention study found that more positive self-perceptions of ageing predicted greater participation in an internet training program and more time spent online over its four months (Cody et al., 1999). In contrast, longitudinal evidence indicated that self-perceptions of ageing did not precede internet use years later (Köttl et al., 2020). Despite these divergent findings, endorsing more positive age stereotypes and having more positive self-perceptions of ageing should be associated with higher levels of technology use among older adults.

We therefore investigated the relationship between self-perceptions of ageing and technology use behaviour among older adults across three studies based on secondary data from longitudinal surveys, which allow analysing data from large samples of the older population over long periods of time. Study 4 was based on the Health and Retirement Study, while Studies 5 and 6 were based on the German Ageing Survey. In line with an extensive body of research testing the assumptions of stereotype embodiment theory, we relied on the assessment of self-perceptions of ageing as an indicator of the internalization of age stereotypes (e.g., Levy & Myers, 2004; Levy, Slade, & Kasl, 2002; Levy, Slade, Kunkel, et al., 2002; for reviews, see Levy, 2009; Westerhof et al., 2014).

1.4. Aim and Overview of the Thesis

The general aim of this thesis was to understand whether and how age stereotypes determine older adults' behavioural engagement with information and communication technology. To this end, we independently tested the assumptions of the two main theoretical approaches on the influence of stereotypes on behaviours: stereotype threat and stereotype embodiment. Three specific aims were common within each theory. The first aim was to explore the relationships between core stereotype-related constructs and use behaviours, namely stereotype threat for the former and self-perceptions of ageing for the latter. The second aim was to identify the mechanisms mediating these relationships. The third aim was to examine whether these relationships generalize across different types of technology.

Figure 1.1 presents an overview of the thesis. Part I includes Chapters 2 and 3, which describe three studies based on stereotype threat theory. Study 1 (Chapter 2) explored the relationship between stereotype threat and desktop/laptop computer use. Its longitudinal design allowed examining potential reciprocal relationships. Studies 2 and 3 (Chapter 3) explored the mediators of the relationship between stereotype threat and technology use within the technology acceptance model (TAM; Davis, 1989) using cross-sectional designs. Study 2 examined stereotype threat more generally in the technology domain and its indirect relationship with internet and desktop/laptop computer use assessed with a more subjective behavioural measure. Study 3 examined stereotype threat more specifically in the computer domain and its indirect relationship with tablet computer use assessed with a more objective behavioural measure.

Part II includes Chapters 4 and 5, which describe three studies based on stereotype embodiment theory. Studies 4 and 5 (Chapter 4) explored the relationship between self-perceptions of ageing and computer use, as well as the mediating role of cognitive functioning. This relationship was examined across different use measures, cognitive domains (episodic memory in Study 4 and processing speed in Study 5), and country samples (from the United States in Study 4 and from Germany in Study 5). These studies used longitudinal designs and secondary data (from the Health and Retirement Study in Study 4 and from the German Ageing Survey in Study 5). Study 6 (Chapter 5) explored the relationship between self-perceptions of ageing and internet use for different online activities, using longitudinal designs and secondary data from the German Ageing Survey. Three dimensions of self-perceptions of ageing were examined among other potential determinants of internet use related to functional ability, social support, and views on ageing.

Finally, Chapter 6 discusses the main findings of the six studies within the stereotype threat and stereotype embodiment theoretical approaches, proposes an integrated model based on these findings and both theories, suggests possible strategies to promote technology use among older adults based on present and past evidence, and emphasizes its potential implications for people of all ages.

Figure 1.1.

Overview of the thesis

Overview

Research Problem

Technology has the potential to support the growing population of older persons. However, older adults are less likely to use information and communication technology. Simultaneously, they are stereotyped as less competent in the technological domain.

Research Question

How do age stereotypes relate to older adults' behavioural engagement with information and communication technology?

Part I: Stereotype Threat

Chapter 2: Study 1

Research Questions:	Main Findings:
What is the longitudinal relationship between stereotype threat and computer use?	Stereotype threat preceded lower levels of computer use a year and a half later.

Chapter 3: Studies 2 and 3

Research Questions:	Main Findings:
Which factors mediate the cross-sectional relationship between stereotype threat and technology use?	Stereotype threat was indirectly related to lower technology use in general and lower tablet use in particular.
What is the role of stereotype threat within the technology acceptance model (TAM)?	These relationships were mediated by anxiety, perceived ease of use, perceived usefulness, and behavioural intention, consistently with TAM predictions.

Part II: Stereotype Embodiment

Chapter 4: Studies 4 and 5

Research Questions:	Main Findings:
What is the longitudinal relationship between self-perceptions of ageing and computer use?	More positive self-perceptions of ageing preceded more frequent computer use years later.
Which factors mediate this relationship?	This relationship was partially mediated by cognitive functioning as indicated by episodic memory and processing speed.

Chapter 5: Study 6

Research Questions:	Main Findings:
Among other factors related to functional ability, social support, and views on ageing, what is the longitudinal relationship between self-perceptions of ageing and internet use?	More positive self-perceptions of ageing about competence preceded more frequent internet use across multiple online behaviours years later.
Which dimensions of self-perceptions of ageing relate to internet use for different online behaviours?	Cognitive functioning as indicated by processing speed also mediated some of these relationships.

PART I.

STEREOTYPE THREAT

CHAPTER 2.

The relationship between stereotype threat and computer use: Longitudinal evidence

Based on the postprint of:

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2.1. Abstract

Besides having lower rates of technology adoption than the general population, older adults are commonly stereotyped as lacking technological ability. Stereotype threat, the fear of confirming negative stereotypes targeting their social group, may lead individuals to distance themselves from the stereotyped domain. This suggests that older adults may underuse computer technology due to stereotype threat. A sample of 86 community-dwelling older adults participated in a two-wave longitudinal study aiming to examine the relationship between stereotype threat and computer use in this age group. An autoregressive cross-lagged panel analysis was conducted using structural equation modelling. As expected, stereotype threat preceded lower levels of computer use a year and a half later. In turn, computer use was unrelated to the later experience of stereotype threat in this domain. These findings suggest that stereotype threat may undermine computer adoption in late adulthood, thus contributing to perpetuate the digital inequalities between younger and older generations.

Keywords: ageing, ageism, stereotype threat, technology, longitudinal.

2.2. Introduction

Older adults continue to lag behind the general population when it comes to using information and communication technology (König et al., 2018; Organization for Economic Cooperation and Development [OECD], 2019b). Unsurprisingly, they are also stereotyped as having less technological ability than younger age groups. Some studies suggest this is particularly common in relation to computer technology. Computer-related activities, such as buying a personal computer and taking a computer course, are seen as requiring high competence but also as being less typical of older individuals (Ryan & Heaven, 1988; Ryan et al., 1992). Compared to younger peers, older adults are perceived as less likely to take and to complete a computer course, and failing the course is more attributed to their age (Ryan et al., 1992). In the workplace, older employees are considered less experienced and less comfortable with computer technology (Hanks & Icenogle, 2001; McGregor & Gray, 2002).

Although they may partly stem from actual age differences in computer performance and usage, these stereotypes may act as self-fulfilling prophecies (Allport, 1954). Numerous studies have repeatedly shown that stereotyped group members tend to behave in stereotype consistent ways (for reviews, see Meisner, 2012; Wheeler & Petty, 2001), suggesting that ageist stereotypes about computer competence may lead older adults to underuse computer technology. This stresses the importance of exploring age stereotypes as potential barriers to computer use in this age group, as this overlooked factor may keep older individuals from taking advantage of its benefits to their health and well-being (Hartanto et al., 2020; Heo et al., 2015).

The present study aimed to investigate the longitudinal relationship between stereotype threat and computer use in late adulthood. Stereotype threat is the concern or worry about confirming, or being seen to confirm, negative stereotypes about the group to which one belongs (Steele, 1997; Steele et al., 2002). Research has focused primarily on its immediate impact on task performance. Stereotype threat can cause stereotyped group members to unintentionally underperform in stereotype relevant tasks. This has been documented across different social groups and ability domains, including minorities in academics (e.g., Steele & Aronson, 1995) and women in mathematics (e.g., Spencer et al., 1999). Among older adults, stereotype threat has been found to impair performance across multiple cognitive and physical tasks (for a review, see Lamont et al., 2015).

Despite receiving considerably less theoretical and empirical attention, another behavioural response to stereotype threat is to avoid or abandon the domain where the stereotype applies (Steele et al., 2002). Individuals may distance themselves from situations or activities in which they risk confirming negative stereotypes targeting their group. Avoidance can be an acute, short-term reaction to stereotype threat. For example, women exposed to gender-stereotypic television commercials subsequently avoided math items in favour of verbal items on an aptitude test (Davies et al., 2002) and avoided assuming leadership roles in favour of subordinate roles (Davies et al., 2005). Likewise, avoidance and abandonment may result from chronic, long-term exposure to stereotype threat. For instance, stereotype threat experienced by racial/ethnic minority students predicted lower intention to pursue and actual engagement in a scientific career years later (Woodcock et al., 2012; Woodcock et al., 2016). In the workplace, stereotype threat has been associated with higher intentions to resign and retire among older employees (von Hippel et al., 2019; von Hippel et al., 2013).

Applied to the technological domain, one would expect stereotype threat to cause older adults to underuse computers. With the growing digitalization of everyday life (OECD, 2019b), older individuals are increasingly expected and required to interact with computer technology to accomplish their daily activities and responsibilities, for example, when accessing health and public services (eHealth and eGovernment), and may often experience the threat of confirming negative stereotypes about the technological ability of their age group. A likely defence strategy may be to avoid interacting with computers. Over time, the repeated experience of stereotype threat may compromise the adoption or regular use of computer technology. The possibility that older adults may simply avoid engaging with computers due to stereotype threat emphasizes the relevance of looking beyond its short-term impacts on task performance and understand its long-term implications.

Although some studies have examined stereotype threat in the computer domain, none have explored its lasting impact on use behaviour. Koch et al. (2008) found that female students attributed their failure in a computer-related task to their own inability after being exposed to the stereotype that men outperform women in computer tasks. Although this study did not examine behavioural outcomes, these internal attributions may negatively influence computer self-efficacy and ultimately computer adoption. Furthermore, Fritzsche et al. (2009) explored stereotype threat effects on older adults' training performance on a computerized library task. Contrary to their predictions, those in the stereotype threat condition performed better than those in the control condition, possibly because the training intervention between the threat manipulation and performance measurement may have motivated participants to disconfirm the stereotype. Besides examining short-term performance rather than long-term use, this study focused on age stereotypes about learning ability, another prevalent stereotype about older adults (Posthuma & Campion, 2009), making it difficult to disentangle from stereotype threat effects specifically associated with the computer inability stereotype. Overall, these findings are insufficient to conclude whether the detrimental effects on behaviour commonly associated with the experience of stereotype threat also apply to older individuals in the computer domain.

2.3. Study 1

This study sought to understand whether concerns about confirming negative stereotypes may compromise older adults' behavioural engagement with computer technology by examining the longitudinal relationship between stereotype threat and computer use in this age group. Most studies exploring avoidance and abandonment as long-term consequences of stereotype threat have relied on behavioural intention as an indicator of actual behaviour or employed cross-sectional designs that prevent inferences about directionality and causality (Smith et al., 2015; von Hippel et al., 2011; von Hippel et al., 2013; Woodcock et al., 2012). A longitudinal design was chosen to address these limitations and elucidate the temporal and directional relationship between stereotype threat and computer use. Additionally, we focused on desktop and laptop computers, which tend to be perceived as more difficult to use than other types of computerized technologies, such as tablets (Tsai et al., 2015). Because stereotype threat effects on behavioural performance are more pronounced on difficult tasks (Barber et al., 2020), they may be particularly detrimental with regard to desktop and laptop computer use behaviour.

A community sample of individuals aged 60 years or older completed measures of stereotype threat and computer use at two time points a year and a half apart. We hypothesized that stereotype threat in the computer domain (Time 1 [T1]) would significantly relate to lower levels of computer use a year and a half later (Time 2 [T2]). Additionally, we examined the relationship between computer use at T1 and stereotype threat at T2, although no specific hypothesis was proposed. To our knowledge, this is the first longitudinal study to investigate the behavioural consequences of stereotype threat among older adults.

2.3.1. Method

2.3.1.1. Participants

Eligibility criteria included being 60 years or older and living independently in the community. A convenience sample of 114 community-dwelling older adults were recruited across six senior centres in Lisbon, Portugal. Our analysis focused on 86 participants (62 females and 24 males) who completed both phases of the study (retention rate of 75.44%). Their age ranged from 62 to 95 years (*M* = 78.47, *SD* = 7.92) and their education ranged from 0 to 19 years (*M* = 5.10, *SD* = 3.12). Most participants lived alone (53.49%, *n* = 46) or with their spouse (25.58%, *n* = 22). The vast majority were retired (97.67%, *n* = 84).

2.3.1.2. Procedure

This study complied with institutional and international ethical standards for research involving human participants (American Psychological Association [APA], 2017). A local charity in the city of Lisbon and six of its senior centres collaborated in the study and approved the research protocol. Individuals attending the senior centres were invited to participate in a study about computer technology. After providing their informed consent, 114 participants completed a baseline questionnaire (T1). A year and a half later, 86 of those participants completed a follow-up questionnaire (T2). In each senior centre, data collection took place in a quiet room, individually, and with the assistance of a researcher whenever necessary. At both timepoints, participants completed paper-and-pencil questionnaires containing measures of stereotype threat, computer use, and sociodemographic factors.

2.3.1.3. Measures

Stereotype Threat. Three items from Marx and Goff (2005) and Steele and Aronson (1995) were adapted to assess stereotype threat in the computer domain: "I worry that my ability to perform well using computers is affected by my age", "I worry that I am unable to use computers because of my age", "I worry that people feel I am less able to use computers because of my age". Participants responded on a five-point scale: 1 = *strongly disagree*, 2 = *disagree*, 3 = *neither agree nor disagree*, 4 = *agree*, 5 = *strongly agree*. A higher score indicated a greater experience of stereotype threat (Cronbach's alpha: $\alpha_{T1} = .82$, $\alpha_{T2} = .87$). Measures at T1 and T2 were strongly correlated, suggesting good retest reliability ($r = .51$, $p < .001$).

Computer Use. Desktop or laptop computer use was assessed on two dimensions: frequency and duration (Venkatesh et al., 2008). Frequency of use ("How frequently do you use desktop or laptop computers?") was rated on a six-point scale (Davis, 1989): 1 = *never*, 2 = *less than once a week*, 3 = *once a week*, 4 = *several times a week*, 5 = *once a day*, 6 = *several times a day*. Duration of use ("How many hours a week do you use desktop or laptop computers?") was rated on a six-point scale (Czaja et al., 2006): 1 = *never*, 2 = *less than 1 hour a week*, 3 = *between 1 hour and 5 hours a week*, 4 = *between 6 hours and 10 hours a week*, 5 = *between 11 hours and 15 hours a week*, 6 = *more than 15 hours a week*. A higher score indicated a greater level of computer use (Spearman-Brown coefficient: ρ_{T1} = .96, ρ_{T2} = .97). This measure had good retest reliability (r = .56, p < .001).

Covariates. Participants also reported their age, education, sex, living arrangements, occupational status, health status, and computer experience. Health status ("How do you rate your health in general?") was rated on a seven-point scale ranging from 1 (*terrible*) to 7 (*excellent*). Prior experience with desktop or laptop computers ("How long have you been using desktop or laptop computers?") was rated on a six-point scale (Czaja et al., 2006): 1 = *never*, 2 = *less than 6 months*, 3 = *more than 6 months, but less than 1 year*, 4 = *more than 1 year, but less than 3 years*, 5 = *more than 3 years, but less than 5 years*, 6 = *more than 5 years*.

2.3.2. Results

2.3.2.1. Preliminary Analysis

A logistic regression was performed to examine potential differences between those who completed the study and those who dropped out. The dependent variable was coded 1 (*baseline and follow-up*) and 0 (*baseline only*). All covariates, stereotype threat, and computer use assessed at baseline were included as independent variables. None of these variables significantly predicted participation in both waves.

2.3.2.2. Descriptive Analysis

Table 2.1 presents the means, standard deviations, and correlations for the main variables. Stereotype threat scores approached the midpoint of the scale (M_{T1} = 2.90, M_{T2} = 2.72), suggesting that participants experience moderate levels of stereotype threat in the computer domain. In turn, computer use scores were relatively low (M_{T1} = 1.72, M_{T2} = 1.46). Differences across the two time points were examined with repeated measures analysis of variance (ANOVA). Only computer use differed significantly between waves, F (1, 85) = 4.91, p = .029, indicating lower levels of computer use at T2 compared to T1.

Table 2.1.

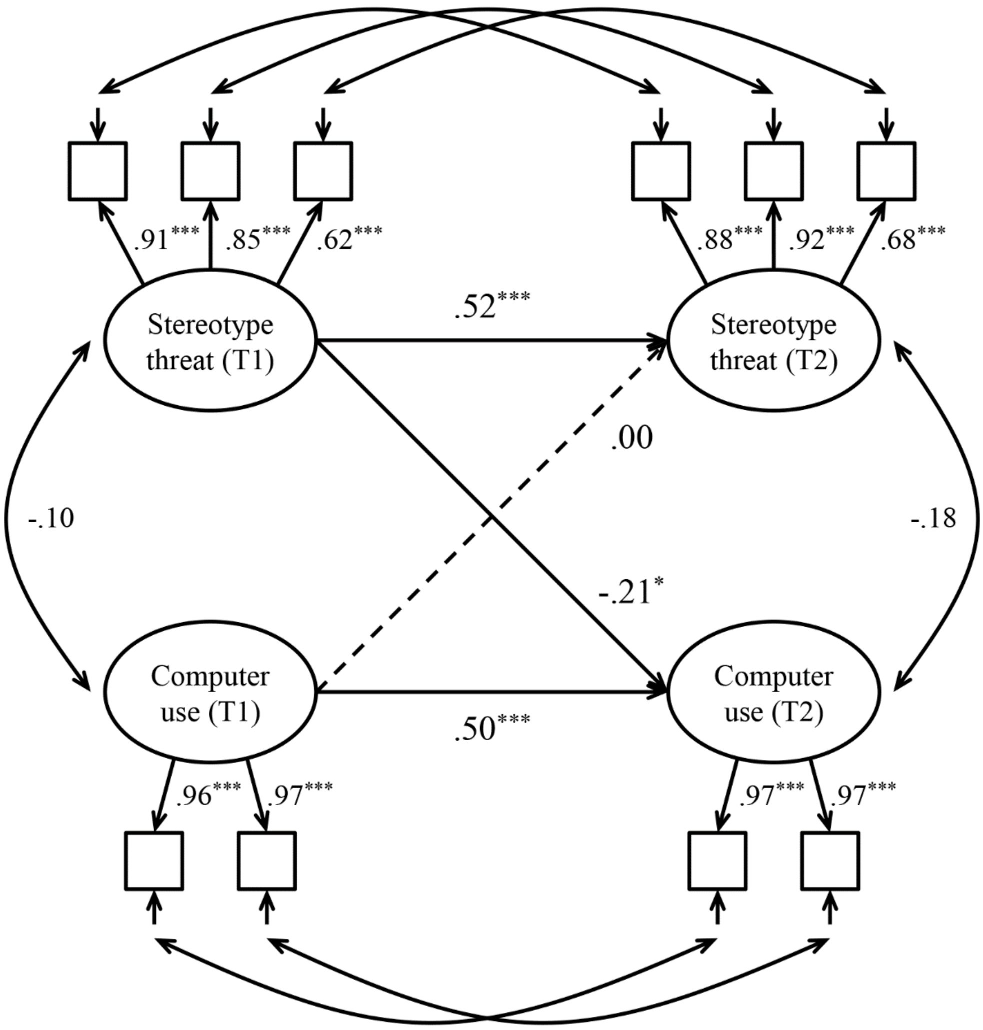
Means, standard deviations, and correlations in Study 1

Variable	*M*	*SD*	1	2	3
1. Stereotype threat (T1)	2.90	1.30	–		
2. Stereotype threat (T2)	2.72	1.35	$.51^{***}$	–	
3. Computer use (T1)	1.72	1.23	$-.32^{**}$	-.16	–
4. Computer use (T2)	1.46	1.05	$-.36^{***}$	$-.32^{**}$	$.56^{***}$

T1 = Time 1, T2 = Time 2. $^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$.

Figure 2.1.

Autoregressive cross-lagged panel model tested in Study 1



Note. All path coefficients are standardized. The dotted lines indicate nonsignificant paths. Age, education, sex, living arrangements, occupational status, health status, and computer experience were included as covariates (omitted for clarity). T1 = Time 1, T2 = Time 2. $^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$.

2.3.2.3. Longitudinal Analysis

Following the analytical approach recommended by Little et al. (2007), an autoregressive cross-lagged panel design was used to examine the relationship between stereotype threat and computer use across two time points. Structural equation modelling (SEM) was performed with Mplus 8 (Muthén & Muthén, 1998-2017) using robust maximum likelihood estimation (MLR), which provides standard errors and chi-square statistics that are robust to nonnormality. Model fit was examined based on the Chi-Square Test (χ^2), the Comparative Fit Index (CFI), the Tucker-Lewis Index (TLI), the Root Mean Square Error of Approximation (RMSEA), and the Standardized Root Mean Square Residual (SRMR). CFI and TLI values of .90 or above and RMSEA and SRMR values of .08 or below were considered indicative of acceptable fit (Browne & Cudeck, 1993; Hu & Bentler, 1999).

As the first step of the longitudinal analysis, we tested the measurement model. Stereotype threat and computer use at two time points were modelled as latent factors with their respective items serving as observed indicators. The residuals of corresponding indicators were correlated across waves. To ensure that the same constructs were measured across time, longitudinal factorial invariance was tested by comparing an unconstrained model with a constrained model in which the factor loadings of corresponding indicators were equated across waves (Little et al., 2007). A Satorra-Bentler scaled chi-square difference test revealed no significant difference between the models, $\Delta\chi^2$ (3) = 1.51, p = .681, demonstrating weak factorial invariance. A comparison of all fit indices with their recommended values suggested a good fit between the measurement model and the data: χ^2 (27) = 25.88, p = .525, CFI = 1.00, TLI = 1.00, RMSEA = 0.00 (90% Confidence Interval (CI) [0.00, 0.08]), SRMR = 0.05.

As the second step, we tested the structural model. Autoregressive paths were specified between each variable at T1 and the same variable at T2. Cross-lagged paths were defined between each variable at T1 and the other variable at T2. Age (in years), education (in years), sex (1 = *female*), living arrangements (1 = *alone*), occupational status (1 = *retired*), health status, and computer experience reported at baseline were included as covariates, as they are known predictors of computer use by older adults (Wagner et al., 2010). The structural model revealed a satisfactory fit to the data: χ^2 (83) = 112.87, p = .016, CFI = 0.95, TLI = 0.94, RMSEA = 0.07 (90% CI [0.03, 0.09]), SRMR = 0.06. Figure 2.1 presents the autoregressive cross-lagged panel model with standardized path coefficients. The autoregressive associations of stereotype threat (β = .52, p < .001) and computer use (β = .50, p < .001) were significant, suggesting the stability of these constructs. Supporting our hypothesis, the cross-lagged association between stereotype threat (T1) and computer use (T2) was significant and negative (β = -.21, p = .017), implying that higher levels of stereotype threat precede lower rates of computer use. In turn, the cross-lagged association between computer use (T1) and stereotype threat (T2) was nonsignificant (β = .00, p = .982), suggesting that computer use is unrelated to the later experience of stereotype threat.

2.4. Discussion

Based on the assumption that stereotype threat leads negatively stereotyped group members to avoid or abandon domains where the stereotype applies (Steele et al., 2002), the present study examined whether older adults underuse computer technology due to stereotype threat. As expected, stereotype threat preceded lower levels of computer use a year and a half later. This suggests that older adults avoid using computer technology due to the threat of confirming the negative stereotype that their age group lacks computer ability. By contributing to the lower rates of technology adoption in this population, stereotype threat may deprive older adults from its potential benefits and exclude them from this growing dimension of everyday life. This supports the notion that stereotype threat has far reaching detrimental consequences in late adulthood (Barber, 2020), as digitally excluded older adults may face greater difficulties, for example, in accessing health information and services, establishing and maintaining social relationships, and accessing employment and training opportunities (Czaja, 2017a).

Another important and novel contribution to stereotype threat research is the finding that computer use did not precede stereotype threat a year and a half later. This suggests that individuals may experience stereotype threat regardless of their prior behavioural engagement with the stereotyped domain. In fact, avoiding or abandoning the domain may not prevent one from continuing to experience stereotype threat. This is consistent with the argument that anyone can potentially experience stereotype threat, as long as one belongs to a negatively stereotyped group (Steele et al., 2002). Whether they are heavy users, light users, or nonusers of computer technology, older adults may still worry about confirming ageist stereotypes about the computer ability of their age group. Importantly, this finding suggests that interventions aiming to promote computer use will not attenuate the experience of stereotype threat in this domain.

This study addressed several limitations of past research exploring the long-term consequences of stereotype threat on behavioural outcomes. First, previous studies focused mainly on intention rather than behaviour (Smith et al., 2015; von Hippel et al., 2011; von Hippel et al., 2013; Woodcock et al., 2012). The few studies exploring behaviour used dichotomous measures of complete engagement or abandonment of the threatening domain (Beasley & Fischer, 2012; Woodcock et al., 2016). In contrast, we relied on a bidimensional measure that conceptualized computer use in terms of frequency and duration (Venkatesh et al., 2008). Second, although prior studies have reliably shown a negative relationship between stereotype threat and behavioural intention, many of them used cross-sectional designs (Smith et al., 2015; von Hippel et al., 2011; von Hippel et al., 2013), which precludes the establishment of directionality and causality. By using an autoregressive cross-lagged panel design, we were able to describe the directional influence between variables. Our findings suggest that, although stereotype threat relates to subsequent patterns of computer use, use behaviour does not relate to the later experience of stereotype threat. Lastly, most of these studies have focused on gender- and race-based stereotype threat either on academic or organizational domains (Smith et al., 2015; von Hippel et al., 2011; Woodcock et al., 2012; Woodcock et al., 2016). The few studies focusing on age-based stereotype threat explored its impact in the workplace (von Hippel et al., 2019; von Hippel et al., 2013). Innovatively, we examined stereotype threat among older adults in the computer domain, an understudied domain in stereotype threat research.

Future studies should explore whether stereotype threat effects on computer task performance may impact computer use behaviour in the long run. Similarly to other domains in which they are negatively stereotyped (Lamont et al., 2015), stereotype threat should disrupt the computer performance of older adults. Computer task performance can influence attitudes towards computers, including computer interest (Czaja & Sharit, 1998b). This suggests that, by hindering older adults' performance, stereotype threat may indirectly compromise their willingness to use computers in the future. Nevertheless, the experience of stereotype threat may undermine computer use and adoption by causing older adults to simply avoid situations in which they risk confirming the stereotype, that is, to avoid any possibility of performance.

The specific tasks or activities that older adults perform when using computers should also be examined in future research. Rather than avoiding computers completely, older adults may resist performing new or unfamiliar tasks for fear of confirming they lack the necessary ability. If older adults avoid using computers due to stereotype threat as our study suggests, this experience should be associated with a limited range of computer activities, in line with evidence that older individuals use computers for fewer purposes compared to younger age groups (Czaja et al., 2006). Likewise, future research should explore the generalizability of these findings to other types of technology. For example, other adults are stereotyped as being less capable of using the internet compared to younger individuals (Swift et al., 2013), so experiencing stereotype threat and its detrimental behavioural consequences should also be expected in this particular domain. However, internet use may not be entirely independent from computer use, as one may access the internet through computers. This further corroborates the need to use more detailed measures of computer use.

Vulnerability to stereotype threat in the computer domain should be investigated in specific groups within the older population. Since older workers are stereotypically perceived as less technologically skilled (Van Dalen et al., 2009), they may also experience stereotype threat effects on technology-related behaviours, particularly in the workplace. Likewise, women are negatively stereotyped with regard to their computer competence and there is evidence of gender-based stereotype threat in this domain (Cooper, 2006; Koch et al., 2008). This suggests that older women may be more susceptible to its detrimental effects on computer use, consistently with evidence of stronger age-based stereotype threat effects on task performance in this group (Lamont et al., 2015).

Our findings highlight the importance of developing effective interventions to counter stereotype threat effects on computer use behaviour. Experimental evidence has shown that informing individuals about stereotype threat (Mazerolle et al., 2016) and promoting either experienced or imagined intergenerational contact (Abrams et al., 2008; Abrams et al., 2006) reduced the negative effects of stereotype threat on older adults' cognitive performance. The latter approach may be particularly promising, as intergenerational contact can also improve attitudes towards older people (for reviews, see Burnes et al., 2019; Marques et al., 2020). Still, intergenerational programs focusing on technology use must be carefully designed, as they may end up reinforcing stereotypical perceptions of older adults as incompetent (Drury et al., 2017). Future studies should identify the best strategies to effectively prevent the lasting impact of stereotype threat in the technology domain in order to bridge the digital divide between generations.

CHAPTER 3.

The mediators of the relationship between stereotype threat and technology use: Cross-sectional evidence from two studies

Based on the postprint of:

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3.1. Abstract

Older adults are often stereotyped as having less technological ability than younger age groups. As a result, older individuals may avoid using technology due to stereotype threat, the fear of confirming negative stereotypes about their social group. The present research examined the role of stereotype threat within the technology acceptance model (TAM). Across two studies, experiencing stereotype threat in the technological domain was indirectly associated with lower levels of technology use among older adults. This was found for subjective (Study 2) and objective measures (Study 3) of use behaviour, and for technology use in general (Study 2) and computer use in particular (Study 3). In line with the predictions of the technology acceptance model, this relationship was mediated by anxiety, perceived ease of use, perceived usefulness, and behavioural intention. Specifically, stereotype threat was negatively associated with perceived ease of use (Studies 2 and 3) and anxiety mediated this relationship (Study 3). These findings suggest that older adults underuse technology due to the threat of confirming ageist stereotypes targeting their age group. Stereotype threat may thus be an important barrier to technology acceptance and usage in late adulthood.

Keywords: ageing, ageism, stereotype threat, technology acceptance model, structural equation modelling.

3.2. General Introduction

Population ageing and technological innovation are two major trends of our time. Virtually every country in the world is experiencing an increase in the proportion of older adults in their population. Worldwide, the number of persons aged 60 years or older is expected to more than double by 2050 and more than triple by 2100 (United Nations [UN], 2017). Simultaneously, the rapid development of new technologies witnessed in recent decades is likely to continue, driven by the cumulative nature of technological change, the convergence of technologies into new combinations, and substantial reductions in costs (UN, 2018).

Yet, older individuals and technological devices are often seen as worlds apart. Various studies suggest that older adults are stereotyped as having less technological ability than younger age groups. For instance, technology-related behaviours, such as buying a personal computer and taking a computer course, are viewed as high competence activities that are less typical of older adults (Ryan & Heaven, 1988; Ryan et al., 1992). An extensive body of research has shown that individuals behave in ways consistent with the stereotypes targeting their group (for reviews, see Meisner, 2012; Wheeler & Petty, 2001). This suggests that age stereotypes about technological inability may cause older adults to underperform and underuse technology, thus contributing to maintain the existing digital divide between generations (Organization for Economic Cooperation and Development [OECD], 2017; Ryan, 2018).

The present research investigated the relationship between stereotype threat and technology use by older adults. Stereotype threat is the concern or worry about confirming negative stereotypes targeting the group to which one belongs (Steele, 1997; Steele et al., 2002). Such concerns can result in performance decrements when individuals perform tasks in domains in which they are negatively stereotyped (Spencer et al., 1999; Steele & Aronson, 1995). For example, when reminded of negative stereotypes about age-related memory declines, older adults perform worse on memory tests (Chasteen et al., 2005; Hess et al., 2003). Stereotype threat has been found to disrupt older adults' performance across a wide range of cognitive and physical tasks (for a review, see Lamont et al., 2015).

Besides underperformance, another behavioural response to the experience of stereotype threat is domain avoidance (Steele et al., 2002). Individuals avoid situations or activities in which they risk confirming negative stereotypes about their group (Davies et al., 2002; Woodcock et al., 2012). For example, experiencing stereotype threat in the workplace has been associated with greater intentions to resign and retire among older workers (von Hippel et al., 2019; von Hippel et al., 2013). Similarly, concerns about confirming negative stereotypes regarding the technological competence of their age group may cause older adults to avoid interacting with technology, thus compromising its regular use in their daily lives. Supporting this argument, longitudinal evidence indicates that stereotype threat is associated with lower levels of computer use in late adulthood (Chapter 2: Mariano et al., 2020). Nonetheless, the mechanisms through which stereotype threat impacts technology use remain unclear.

In line with previous research on age-based stereotype threat in applied settings (von Hippel et al., 2019; von Hippel et al., 2013), stereotype threat effects in the technology domain may be mediated by other known predictors of use behaviour. Specifically, we explore the role of stereotype threat in the context of the technology acceptance model (TAM; Davis, 1989; Davis et al., 1989). Research shows that TAM explains a substantial proportion of the variance in technology use intention and behaviour (Yousafzai et al., 2007a, 2007b) and compares favourably with alternative models such as the theory of reasoned action and the theory of planned behaviour (Chau & Hu, 2001; Davis et al., 1989; Yousafzai et al., 2010). Numerous studies have applied TAM to understand acceptance and usage of various technologies by older adults (Braun, 2013; Ma et al., 2016; Vaziri et al., 2020; for a review, see Chen & Chan, 2011). According to TAM, technology use behaviour is determined by behavioural intention, which is then jointly predicted by two main factors: perceived ease of use and perceived usefulness. Perceived ease of use is the degree to which an individual believes that using the technology would be free of effort. Perceived usefulness is the degree to which an individual believes that using the technology would enhance his or her performance in certain contexts, such as their job or daily life. TAM asserts that people form intentions towards using technology largely based on their cognitive appraisal of how effortless it will be and how much it will improve their performance. Perceived usefulness is also determined by perceived ease of use, in the sense that the easier the technology is to use the more useful it can be. TAM further assumes the influence of external variables, such as system features or user characteristics, the effects of which are fully mediated by perceived ease of use and perceived usefulness.

Within TAM, stereotype threat may serve as the basis for individual beliefs about how easy or difficult it would be to use technology. Specifically, stereotype threat can be expected to negatively influence perceived ease of use. Research exploring the mediating role of anxiety on the negative effects of stereotype threat on task performance provides theoretical and empirical support for this relationship. Stereotype threat may elicit anxiety or apprehension, consequently interfering with individuals’ ability to perform (Steele & Aronson, 1995). Indeed, experimental manipulations of stereotype threat have been shown to induce higher levels of anxiety or negative affect in older adults (Abrams et al., 2008; Abrams et al., 2006; Chasteen et al., 2005;

Swift et al., 2013). TAM positions anxiety as an antecedent of perceived ease of use (Venkatesh, 2000). Anxiety or apprehension about the prospect of using technology is negatively related to perceived ease of use (Powell, 2013), including among older adults (Phang et al., 2006; Ryu et al., 2009). This is consistent with social cognitive theory (Bandura, 1986), which asserts that situations evoking fear or anxiety may lower individuals' expectations of success. This suggests that stereotype threat is negatively associated with perceived ease of use and that anxiety mediates this relationship. Experiencing stereotype threat in the technological domain should make older adults feel more anxious or apprehensive about using technology, which in turn should lower their expectations about how easily they will use it.

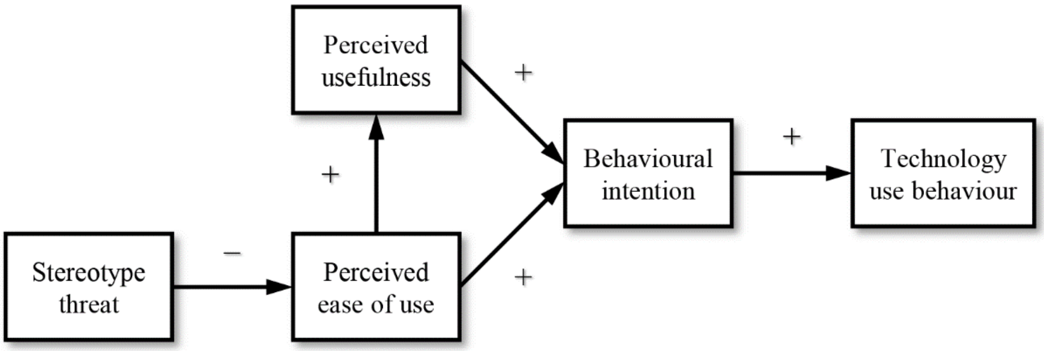
Across two studies, we aimed to understand the processes through which the threat of confirming negative stereotypes about the technological ability of their age group may lead older individuals to underuse technology. In a survey study with a sample of older adults from different European countries, we explored the relationship between stereotype threat and current use of technology (Study 2). Replicating and extending this exploratory work, we examined the link between stereotype threat and actual use of computer technology in a field study where older adults were given the opportunity to freely interact with tablet computers (Study 3). Overall, we expected a negative indirect association between stereotype threat and technology use, which should be mediated by anxiety, perceived ease of use, perceived usefulness, and behavioural intention, in accordance with the relationships specified by TAM.

3.3. Study 2

This survey study aimed to explore the relationship between stereotype threat and technology use among older adults, while also examining potential mediating mechanisms within TAM. Figure 3.1 presents the hypothesized model for Study 2. We predicted that stereotype threat would be negatively related to perceived ease of use (Hypothesis 1), which in turn would be positively related to perceived usefulness (Hypothesis 2). Both perceived ease of use and perceived usefulness would then be positively related to behavioural intention (Hypotheses 3 and 4, respectively), which would finally be positively related to technology use behaviour (Hypothesis 5). Based on these assumptions, we expected stereotype threat to be negatively and indirectly associated with technology use. Given the exploratory nature of this study, we focused on technology in general and targeted a broad sample of older adults from four European countries: France, Germany, Italy, and Portugal.

Figure 3.1.

Hypothesized model for Study 2



3.3.1. Method

3.3.1.1. Participants

In line with previous research on age stereotypes (e.g., Abrams et al., 2006; Levy, 1996), eligibility criteria to participate in the study included being 60 years or older, being able to read and write, living independently in the community, and having grown up in the country. Given the cultural nature of age stereotypes (Ng & Lim, 2020) and the frequent exposure to these culturally shared stereotypical beliefs since early childhood (Marques et al., 2020; Mendonça et al., 2018), only individuals who grew up in each country were considered eligible.

A total of 137 community-dwelling older adults (81 females, 56 males) residing in France (n = 40), Germany (n = 30), Italy (n = 30), and Portugal (n = 37) participated in the study. Their age ranged from 60 to 93 years (M = 70.53, SD = 6.13) and their education ranged from 4 to 24 years (M = 12.36, SD = 3.68). Most participants lived with their spouse (71.53%, n = 98), although close to one fourth lived alone (25.54%, n = 35). The great majority was retired (88.32%, n = 121) and very few were employed (3.65%, n = 5). Most perceived their health as average or better (91.24%, n = 125).

3.3.1.2. Procedure

This study was conducted in accordance with the ethical principles and code of conduct of the American Psychological Association (2017). Participants were invited to complete a questionnaire about technology. After providing their informed consent, participants completed the questionnaire in their native language.

3.3.1.3. Measures

All measures were originally translated from English to French, German, Italian, and Portuguese. Unless otherwise indicated, participants responded using a seven-point scale ranging from 1 (*strongly disagree*) to 7 (*strongly agree*). Item ratings were averaged for each measure, with higher scores indicating greater levels of the corresponding construct. Reliability was assessed with the Spearman-Brown coefficient (ρ) for two-item measures and Cronbach's alpha (α) for three-item measures (Eisinga et al., 2013).

Stereotype Threat. Three items (α = .80) were used to assess stereotype threat based on the measures developed by Marx and Goff (2005) and Steele and Aronson (1995): "I worry that my ability to perform well using technology is affected by my age", "I worry that if I perform poorly using technology, people will attribute my poor performance to my age", "Some people feel I am less able to use technology because of my age". All items were adapted to refer to age stereotypes about technological ability.

Perceived Ease of Use, Perceived Usefulness, and Behavioural Intention. The scales developed by Davis and colleagues (Davis, 1989; Venkatesh & Davis, 2000) were used to assess perceived ease of use (three items, α = .84; e.g., "My interaction with technology is clear and understandable"), perceived usefulness (two items, ρ = .82; e.g., "Using technology improves my performance in my daily life"), and behavioural intention (two items, ρ = .90; e.g., "Assuming I have access to technology, I intend to use it"). All items were adapted to refer to technology use in everyday life.

Technology Use Behaviour. Technology use was assessed based on internet and computer use. For each technology, participants reported their frequency of use using a five-point scale (1 = *never*, 2 = *a few times a year*, 3 = *at least once a month*, 4 = *at least once a week*, 5 = *everyday*; ρ = .87). Internet and computers were chosen based on the consistent finding that older adults are less likely than younger age groups to use them (Czaja et al., 2006; OECD, 2017; Ryan, 2018).

Sociodemographics. Participants reported their age, education, sex, living arrangements, occupational status, and health status. Health status was rated on a seven-point scale ranging from 1 (*terrible*) to 7 (*excellent*).

3.3.1.4. Analysis

To test the hypothesized model, we conducted structural equation modelling (SEM) using Mplus 8 (Muthén & Muthén, 1998-2017) with robust maximum likelihood estimation (MLR). Model fit was examined based on the Chi-Square Test (χ^2), the Comparative Fit Index (CFI), the Tucker-Lewis Index (TLI), and the Root Mean Square Error of Approximation (RMSEA). CFI and TLI values of .95 or above and RMSEA values of .06 or below indicate good model fit (Hu & Bentler, 1999). We also compared the hypothesized model to other plausible competing models to determine whether the proposed causal patterns provided better fit to the data. The Bayesian Information Criterion (BIC) was used to assess the relative fit of the models. BIC differences greater than 10 provide very strong evidence that the model with the lowest BIC is better (Raftery, 1995). Age (in years), education (in years), sex (1 = *female*), living arrangements (1 = *alone*), occupational status (1 = *retired*), health status, and country were introduced as control variables.

3.3.2. Results

3.3.2.1. Descriptive Analysis

Table 3.1 presents the means, standard deviations, and correlations for the main variables in Study 2. Stereotype threat scores approached the midpoint of the scale, suggesting that participants experience some level of stereotype threat in the technology domain. Importantly, stereotype threat was negatively correlated with technology use, as well as with all TAM variables, although more strongly with perceived ease of use. Consistently with TAM predictions, perceived ease of use, perceived usefulness, and behavioural intention were significantly intercorrelated in the anticipated directions. These measures were also positively correlated with technology use. A one-way analysis of variance (ANOVA) revealed no significant differences between countries in stereotype threat, F (3, 133) = 0.51, p = .677, nor technology use, F (3, 132) = 1.57, p = .200.

3.3.2.2. Hypothesized Model

A comparison of all fit indices with their corresponding recommended values provided evidence of good model fit: χ^2 (5) = 3.76, p = .584, CFI = 1.00, TLI = 1.00, RMSEA = 0.00 (90% Confidence Interval (CI) [0.00, 0.10]). The standardized path coefficients of the structural equation model are shown in

Figure 3.2. Overall, the results supported all the hypothesized relationships. Stereotype threat was negatively associated with perceived ease of use (β = -.27, p = .001), which in turn was positively related to perceived usefulness (β = .44, p < .001), supporting Hypotheses 1 and 2. Both perceived ease of use and perceived usefulness had positive relationships with behavioural intention (β = .20, p = .023 and β = .46, p < .001, respectively), which supported Hypotheses 3 and 4. Finally, supporting Hypothesis 5, behavioural intention was positively linked with technology use behaviour (β = .33, p = .002).

Providing further support for these hypotheses, the total indirect effect of stereotype threat on technology use behaviour was significant and negative (β = -.04, p = .023). Similarly, the total indirect effects of stereotype threat on behavioural intention and on perceived usefulness were both significant and negative (β = -.11, p = .003 and β = -.12, p = .009, respectively). Also supporting the relationships proposed by TAM, the total indirect effects of perceived ease of use and perceived usefulness on technology use behaviour were both significant and positive (β = .13, p = .007 and β = .15, p = .002, respectively).

3.3.2.3. Alternative Models

The hypothesized model (BIC = 5335.66) was compared to alternative models in which stereotype threat was modelled as a direct predictor of perceived usefulness (BIC = 5347.88), behavioural intention (BIC = 5347.49), and technology use behaviour (BIC = 5346.17). Overall, BIC differences between the hypothesized and alternative models were greater than 10 and the proposed model had the lowest BIC, suggesting that the hypothesized model provides the best fit to the data.

Table 3.1.

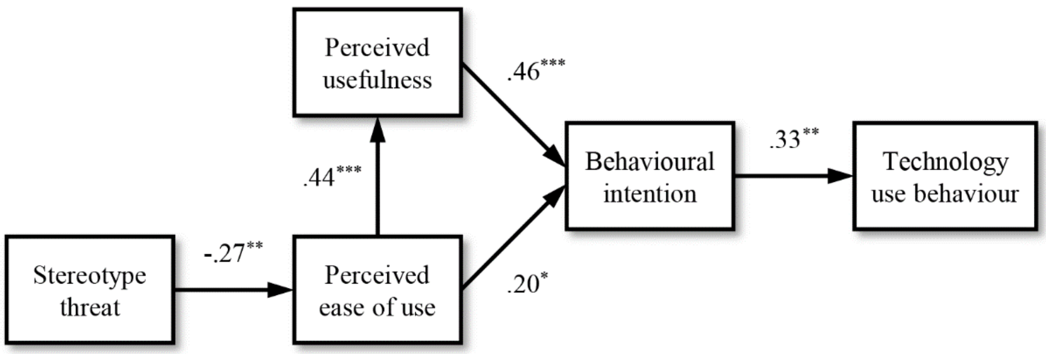
Means, standard deviations, and correlations in Study 2

Variable	*M*	*SD*	1	2	3	4
1. Stereotype threat	3.68	1.63	–			
2. Perceived ease of use	4.63	1.29	$-.32^{***}$	–		
3. Perceived usefulness	5.81	1.23	$-.14^{**}$	$.47^{***}$	–	
4. Behavioural intention	5.84	1.30	$-.16^{**}$	$.46^{***}$	$.60^{***}$	–
5. Technology use behaviour	4.19	1.28	$-.08^{*}$	$.14^{*}$	$.22^{***}$	$.40^{***}$

$^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$.

Figure 3.2.

Results for the hypothesized model in Study 2



Note. All path coefficients are standardized. Age, education, sex, living arrangements, occupational status, health status, and country were included as control variables (omitted for clarity). * $p < .05$. ** $p < .01$. *** $p < .001$.

3.3.3. Discussion

Study 2 suggests that the threat of confirming negative stereotypes in the technological domain is related to technology avoidance among older adults. As predicted, stereotype threat was indirectly associated with lower levels of technology use. Consistently with the relationships posited by TAM, perceived ease of use, perceived usefulness, and behavioural intention mediated this negative association.

Nonetheless, some limitations should be noted. First, although some studies have followed a similar approach (Ke Chen & Alan H. S. Chan, 2014), we targeted technologies in general rather than a particular type of technology. Second, we relied on a self-report measure of current use rather than actual use. Although this is common practice in technology acceptance research, subjective measures of use behaviour have higher correlations with TAM variables relative to objective measures (Yousafzai et al., 2007a, 2007b). These shortcomings may limit the generalizability of our findings, as they may not extend to more specific types of technology and more objective measures of use. In Study 3 we addressed these limitations while also extending the results of Study 2.

3.4. Study 3

This field study aimed to further explore the association between stereotype threat and technology use in a real-world context where older adults were given the opportunity to freely interact with computer technology. Following the introduction of tablet computers in several senior centres, the actual use of these devices by older attendees was recorded for one full month. We predicted that older adults who reported greater concerns about confirming negative stereotypes regarding the computer ability of their age group would use tablet computers less frequently during this one-month period. Furthermore, we expected this relationship to be mediated by computer anxiety, perceived ease of use, perceived usefulness, and behavioural intention in line with the assumptions defined by TAM. Figure 3.3 presents the hypothesized model for Study 3. We predicted that stereotype threat would be positively related to computer anxiety (Hypothesis 1a), which in turn would be negatively related to perceived ease of use (Hypothesis 1b). Perceived ease of use would then be positively related to perceived usefulness (Hypothesis 2) and both perceptions would be positively related to behavioural intention (Hypothesis 3 and Hypothesis 4, respectively). Behavioural intention would then be positively related to tablet computer use behaviour (Hypothesis 5). Thus, Study 3 replicates and extends Study 2 by using an objective measure of use behaviour, focusing more specifically on computer technology, and examining anxiety as an additional mediator of the relationship between stereotype threat and technology use.

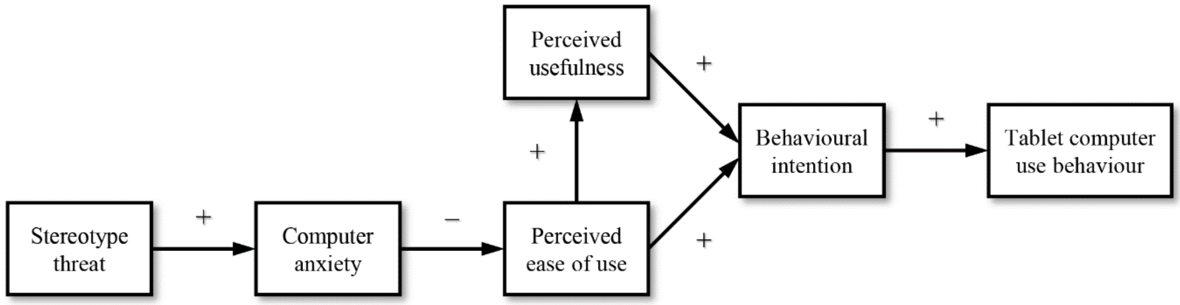
3.4.1. Method

3.4.1.1. Participants

Similarly to Study 2, eligibility criteria included being 60 years or older, being able to read and write, living independently in the community, and having grown up in the country. A total of 109 community-dwelling older adults (81 females and 28 males) attending six senior centres in Portugal participated in the study, ranging from 9 to 31 participants per centre (*M* = 18.17, *SD* = 7.11). Their age ranged from 62 to 95 years (*M* = 78.51, *SD* = 7.59) and their education ranged from 1 to 19 years (*M* = 5.06, *SD* = 2.81). Most participants lived alone (58.72%, *n* = 64) or with their spouse (25.69%, *n* = 28). Almost all were retired (97.25%, *n* = 106). Most perceived their health as average or better (75.23%, *n* = 82). Very few (4.59%, *n* = 5) reported having prior experience with tablet computers.

Figure 3.3.

Hypothesized model for Study 3



3.4.1.2. Procedure

This study was conducted in accordance with the ethical principles and code of conduct of the American Psychological Association (2017). Data collection was carried out in six senior centres (i.e., community centres attended by local older adults for social, leisure, and other activities) located in the same city and belonging to the same institution, thus having similar characteristics. All procedures were maintained identical across senior centres. Older adults attending these centres were invited to participate in a study about computer technology. Participants provided their informed consent before completing the baseline questionnaire.

In each centre, after all participants completed the questionnaire, two tablet computers were made available for public use for one month. During this period, usage sessions were periodically delivered by trained centre personnel, so that participants could become familiar with the tablet computers until being able to use them by themselves. Participants were free to attend these sessions and to use the tablet computers whenever they wanted. Prior to the study, centre personnel participated in a training session to learn research-based guidelines on how to train and assist older adults in using computer technology (Beisgen & Kraitchman, 2003; Jones & Bayen, 1998). The number of days each participant used the tablet computers during that month was registered by the centre personnel. This record was made on calendar-like sheets where they marked the days of the month when each participant used the tablet computers. To ensure anonymity and confidentiality, the match between questionnaire and usage data was based on participants' birthdates. Each tablet computer contained two games designed for cognitive training (Vasconcelos et al., 2012). In one game, players formed as many words as possible with a group of letters presented onscreen, until all possible words were identified. In the other game, players turned two of several playing cards presented onscreen facing down, until all pairs of matching cards were found. Besides these two readily available games, participants were free to use the tablet computers for other purposes.

3.4.1.3. Measures

Unless otherwise indicated, participants responded using a five-point scale (1 = *strongly disagree*, 2 = *disagree*, 3 = *neither agree nor disagree*, 4 = *agree*, 5 = *strongly agree*). Item ratings were averaged for each measure, with higher scores indicating greater levels of the corresponding construct.

Stereotype Threat. Three items (α = .80) were adapted from Marx and Goff (2005) and Steele and Aronson (1995) to assess stereotype threat in the computer domain: “I worry that my ability to perform well using computers is affected by my age”, “I worry that people feel I am less able to use computers because of my age”, “I worry that I am unable to use computers because of my age”.

Computer Anxiety. Two items (ρ = .75) from the corresponding subscale of the Computer Attitude Scale (Loyd & Gressard, 1984a, 1984b) were used to measure computer anxiety (e.g., “Working with a computer would make me very nervous”).

Perceived Ease of Use, Perceived Usefulness, and Behavioural Intention. The scales from Davis and colleagues (Davis, 1989; Venkatesh & Davis, 2000) were adapted to reflect computer use in everyday life to assess perceived ease of use (three items, α = .87; e.g., “I would find computers easy to use”), perceived usefulness (three items, α = .94; e.g., “I would find computers useful in my daily life”), and behavioural intention (two items, ρ = .96; e.g., “Given that I have access to a computer, I predict that I would use it”).

Tablet Computer Use Behaviour. The behavioural measure of tablet computer use was computed by dividing the total number of days each participant used the tablet computers, ranging from 0 to 18 days (M = 6.55, SD = 4.32), by the total number of working days the tablet computers were available in their senior centre during that month, ranging from 18 to 22 days (M = 20.00, SD = 1.79).

Sociodemographics. Besides age, education, sex, living arrangements, occupational status, and health status, participants also reported their prior experience with tablet computers on a six-point scale adapted from Czaja et al. (2006): 1 = *never*, 2 = *less than 6 months*, 3 = *more than 6 months, but less than 1 year*, 4 = *more than 1 year, but less than 3 years*, 5 = *more than 3 years, but less than 5 years*, 6 = *more than 5 years*.

3.4.1.4. Analysis

We followed the same analytical approach outlined in Study 2. Age (in years), education (in years), sex (1 = *female*), living arrangements (1 = *alone*), occupational status (1 = *retired*), health status, and prior experience with tablet computers were introduced as control variables. Effects on tablet computer use behaviour were further controlled for senior centre.

3.4.2. Results

3.4.2.1. Descriptive Analysis

Table 3.2 presents the means, standard deviations, and correlations for the main variables in Study 3. On average, participants used the tablet computers one third of the days they were available in their senior centre. Stereotype threat scores reached the midpoint of the scale, suggesting that participants experience stereotype threat in the computer domain. The correlation between stereotype threat and tablet computer use was negative, despite being marginally significant. Stereotype threat was positively correlated with computer anxiety, which in turn was negatively correlated with perceived ease of use. Perceived ease of use, perceived usefulness, and behavioural intention were intercorrelated in the directions predicted by TAM, while also being positively correlated with tablet computer use.

3.4.2.2. Hypothesized Model

An examination of all fit indices suggested good model fit: χ^2 (34) = 38.51, p = .273, CFI = 0.99, TLI = 0.97, RMSEA = 0.04 (90% CI [0.00, 0.08]). The standardized path coefficients of the structural equation model are shown in Figure 3.4. The results supported all hypotheses. Stereotype threat was significantly and positively related to computer anxiety (β = .52, p < .001), which in turn was negatively associated with perceived ease of use (β = -.38, p < .001), supporting Hypotheses 1a and 1b. Perceived ease of use had a positive relationship with perceived usefulness (β = .62, p < .001), which supported Hypothesis 2. Both perceived ease of use and perceived usefulness were positively associated with behavioural intention (β = .33, p = .001 and β = .39, p < .001, respectively), supporting Hypotheses 3 and 4. Finally, supporting Hypothesis 5, behavioural intention had a positive association with tablet computer use behaviour (β = .23, p = .003).

Providing general support for these hypotheses, the total indirect effect of stereotype threat on tablet computer use behaviour was significant and negative (β = -.03, p = .043). Likewise, the total indirect effects of stereotype threat on behavioural intention (β = -.11, p = .001), perceived usefulness (β = -.12, p = .001), and perceived ease of use (β = -.20, p < .001) were all significant and negative. Supporting the relationships posited by TAM, the total indirect effect of computer anxiety on tablet computer use behaviour was significant and negative (β = -.05, p = .036), while the total indirect effects of perceived ease of use and perceived usefulness on tablet computer use behaviour were both significant and positive (β = .13, p = .008 and β = .09, p = .016, respectively).

Table 3.2.

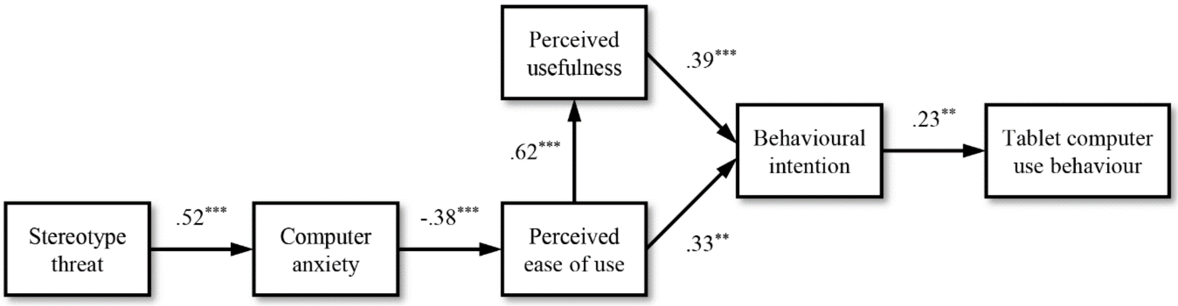
Means, standard deviations, and correlations in Study 3

Variable	*M*	*SD*	1	2	3	4	5
1. Stereotype threat	3.07	1.23	–				
2. Computer anxiety	3.03	1.27	$.58^{***}$	–			
3. Perceived ease of use	2.81	1.31	$-.33^{***}$	$-.47^{***}$	–		
4. Perceived usefulness	3.20	1.39	$-.27^{***}$	$-.35^{***}$	$.70^{***}$	–	
5. Behavioural intention	3.25	1.57	$-.27^{***}$	$-.35^{***}$	$.65^{***}$	$.64^{***}$	–
6. Tablet computer use behaviour	0.33	0.21	$-.08^{\dagger}$	-.06	$.16^{*}$	$.15^{*}$	$.23^{**}$

$^{\dagger}p < .06$. $^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$.

Figure 3.4.

Results for the hypothesized model in Study 3



Note. All path coefficients are standardized. Age, education, sex, living arrangements, occupational status, health status, and prior experience with tablet computers were included as control variables. Effects on tablet computer use behaviour were further controlled for senior centre (omitted for clarity). $^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$.

3.4.2.3. Alternative models

The hypothesized model (BIC = 1771.37) was compared to alternative models in which stereotype threat directly predicted perceived ease of use (BIC = 1806.36), perceived usefulness (BIC = 1802.38), behavioural intention (BIC = 1800.61), and tablet computer use behaviour (BIC = 1803.39). BIC differences between the hypothesized and alternative models were greater than 10. The proposed model had the lowest BIC, indicating that the hypothesized model fits the data better than the alternatives.

3.4.3. Discussion

Study 3 provides further support for the link between stereotype threat and technology use by older adults. Stereotype threat was negatively and indirectly associated with tablet computer use behaviour for one month. Consistently with TAM, computer anxiety, perceived ease of use, perceived usefulness, and behavioural intention mediated this relationship. By extending the results of Study 2 to computer technology and an objective measure, Study 3 confirms the robustness of its findings while also addressing its shortcomings.

3.5. General Discussion

The present research aimed to explore the relationship between stereotype threat and technology use in late adulthood by examining its role within the technology acceptance model (TAM; Davis, 1989). Across two studies, older adults reported concerns about behaviourally confirming ageist stereotypes about technological inability. Importantly, the experience of stereotype threat was indirectly associated with less frequent technology use in this age group. Confirming the robustness of this relationship, this was observed with subjective (Study 2) and objective measures (Study 3) of use behaviour, and with technology in general (Study 2) and computers in particular (Study 3). Besides being in line with longitudinal evidence that stereotype threat precedes lower levels of computer use among older adults (Chapter 2: Mariano et al., 2020), our work extends this relationship to other types of technological devices and more objective measures of use behaviour, while also identifying its underlying mechanisms.

Findings from both studies consistently revealed that stereotype threat was associated with lower expectations about how easily one will use technology. This is congruent with research indicating that performance expectations mediate stereotype threat effects on task performance. Experimental inductions of stereotype threat have been found to lower older adults' expectations about how well they would perform in memory tests (Desrichard & Köpetz, 2005;

Hess et al., 2009). The mediating role of anxiety observed in Study 3 provides further support for this relationship. Matching experimental evidence showing that stereotype threat raises anxiety levels among older adults (Abrams et al., 2008; Abrams et al., 2006), experiencing stereotype threat in the technological domain was associated with greater anxiety about using technology. Increased anxiety was then related to decreased perceptions about the ease of using technology. This is in line with the prediction that anxiety is an antecedent of perceived ease of use within TAM (Venkatesh, 2000) and with studies demonstrating a negative association between anxiety and perceived ease of use among older adults (Phang et al., 2006; Ryu et al., 2009).

Additionally, stereotype threat was negatively and indirectly associated with perceived usefulness and technology use intention and behaviour. Previous studies also found stereotype threat to be indirectly related to behavioural intentions in stereotype-relevant domains (von Hippel et al., 2019; von Hippel et al., 2013). Perceived ease was positively associated with perceived usefulness and both perceptions were positively linked with behavioural intention, which was then positively related to use behaviour. Taken together, these results confirm the interrelationships between anxiety, perceived ease of use, perceived usefulness, behavioural intention, and use behaviour as proposed by TAM (Davis, 1989; Venkatesh, 2000). Although some studies investigating technology acceptance and usage by older adults found inconsistent evidence for TAM relationships (Ke Chen & Alan H. S. Chan, 2014; Ma et al., 2016), our findings provide full support for its assumptions.

By integrating stereotype threat and technology acceptance literature, this work contributes to existing research in several important ways. Firstly, we focused on domain avoidance, an underexplored behavioural consequence of stereotype threat that has received considerably less theoretical and empirical attention compared to its detrimental effects on task performance. Secondly, while most studies examining domain avoidance rely on self-report measures of behavioural intention as a proxy for actual behaviour (von Hippel et al., 2013; Woodcock et al., 2012), we used an objective measure of use behaviour. Besides being negatively linked with behavioural intention to use technology, stereotype threat was also negatively related to actual behaviour. Lastly, despite the argument that stereotype threat effects may not generalize from laboratory settings to applied contexts (Cullen et al., 2004), findings from our field study in which older adults could freely interact with computer technology suggest that stereotype threat does play an important role in real-world situations.

Our findings also contribute to technology acceptance research. Studies testing TAM overwhelmingly rely on self-report measures of technology use (Chen & Chan, 2011; Yousafzai et al., 2007a), which are more susceptible to reporting biases (Collopy, 1996) and have higher correlations with TAM variables (Yousafzai et al., 2007b) than objective measures. In our field study, we focused on an objective measure of actual use of computer technology which was significantly determined by behavioural intention, thus supporting TAM predictions. Finally, we identified an antecedent of perceived ease of use that is specific to older adults. As members of a negatively stereotyped group in the technology domain, older individuals are susceptible to the experience of stereotype threat, unlike younger age groups who are not targeted by such stereotypes. Chen and Chan (2011) suggest that TAM research should consider age-specific factors to better understand technology acceptance and usage in late adulthood. Moreover, a recent meta-analysis concluded that perceived ease of use is lower among older age groups, suggesting that interventions aiming to promote technology acceptance and usage by older adults should prioritize perceived ease of use (Hauk et al., 2018). By identifying stereotype threat as a correlate of technology-related anxiety and perceived ease of use that is specific to older age groups, we hope to contribute to TAM research by pointing out new ways for intervention.

Researchers have identified various strategies to reduce stereotype threat effects on task performance, which may serve as the basis for intervention development. For instance, exposure to ingroup role models who are successful in the stereotyped domain can lessen stereotype threat effects (Marx & Goff, 2005; Marx & Roman, 2002). Likewise, informing members of stereotyped groups about the effects of stereotype threat may improve their performance on stereotype-relevant tasks (Johns et al., 2005; Mazerolle et al., 2016). Positive intergenerational contact, either experienced or imagined, can lower older adults' vulnerability to stereotype threat effects by reducing anxiety (Abrams et al., 2008; Abrams et al., 2006). Future studies should investigate how to minimize age-based stereotype threat effects specifically in the technological domain.

Some limitations should be acknowledged and addressed in future research. First, cross-country comparisons were not possible in Study 2 given the insufficient sample size in each country. Future research should examine the potential cross-cultural generalizability of these findings. Second, the applied nature of Study 3 may have implicated confounders that were difficult to control. For example, the usage sessions delivered during the month when tablet computers were available in the senior centres may have influenced the factors previously assessed through the questionnaire. We believe this limitation is partly offset by the added value of conferring greater ecological validity to our findings, which were nevertheless consistent across studies. Third, given the cross-sectional nature of these studies, we were unable to infer causality between variables. Future experimental studies should address this shortcoming. Fourth, the effect size of the relationships between stereotype threat and technology use were relatively small. Given the cultural nature of age stereotypes (Ng & Lim, 2020), their influence may be more distal, primarily shaping more proximal predictors of use behaviour. Consistently, our findings suggest that stereotype threat exerts its influence through important determinants of technology use intention and behaviour among older adults, namely anxiety and perceived ease of use (Czaja et al., 2006; Hauk et al., 2018). Lastly, both studies focused solely on general frequency of technology use. While frequency of use may be an appropriate indicator of avoidance, it would also be interesting to explore more specific behavioural outcomes. For instance, stereotype threat may limit the range of activities older adults perform when using technology. Rather than avoiding a technology completely, they may stick to more familiar tasks and avoid exploring new ones. This would be consistent with findings suggesting that older adults use the internet and computers for fewer activities than younger adults (Czaja et al., 2006).

Future studies should identify other potential mediators of the relationship between stereotype threat and technology use. For example, self-efficacy has been found to mediate the negative impact of stereotype threat on older adults' memory performance (Bouazzaoui et al., 2016). Interestingly, self-efficacy is an important predictor of technology use by older adults (Mitzner et al., 2019; Wild et al., 2012) and an antecedent of perceived ease of use within TAM (Venkatesh, 2000). Similarly to anxiety, stereotype threat may undermine older adults' beliefs about their ability to use technology successfully, which in turn may lower their perceptions about how easily they will use it and ultimately compromise technology use intention and behaviour.

Overall, our findings suggest that age stereotypes can hinder technology adoption among older adults by generating concerns about the possibility of confirming the widespread belief that older age groups are less technologically competent. By elucidating the processes through which stereotype threat impacts technology acceptance and usage, this work contributes to the understanding of digital inequalities between younger and older generations.

PART II.

STEREOTYPE EMBODIMENT

CHAPTER 4.

The relationship between self-perceptions of ageing and computer use: Longitudinal evidence from two studies

Based on the postprint of:

Mariano, J., Marques, S., Ramos, M. R., & de Vries, H. (2021a). Cognitive functioning mediates the relationship between self-perceptions of aging and computer use behavior in late adulthood: Evidence from two longitudinal studies. *Computers in Human Behavior, 121*, Article 106807. https://doi.org/10.1016/j.chb.2021.106807

4.1. Abstract

Although information and communication technologies have become an integral part of contemporary societies, substantial proportions of the older population remain distant from these digital tools. This stresses the importance of identifying age-specific factors that facilitate or prevent technology adoption among older age groups. Despite being powerful determinants of behaviour and health in late adulthood, little is known about the role of stereotypical perceptions about age and ageing in the behavioural engagement with technological devices. Across two longitudinal studies, we examined the relationship between self-perceptions of ageing and computer use behaviour, as well as the mediating role of cognitive functioning. Study 4 was based on the 2010, 2014, and 2018 waves of the Health and Retirement Study (n = 3,404). Study 5 was based on the 2014 and 2017 waves of the German Ageing Survey (n = 4,871). Both studies revealed that more positive self-perceptions of ageing were associated with more frequent computer use behaviour. Moreover, this relationship was partially mediated by cognitive functioning. This suggests that perceptions about their ageing experience can influence how individuals behave towards computer technology by impacting important predictors of use behaviour. Interventions promoting positive self-perceptions of ageing may thus contribute to the digital inclusion of middle-aged and older adults.

Keywords: ageism, stereotype embodiment, self-perceptions of ageing, cognition, technology, longitudinal.

4.2. General Introduction

There is growing evidence that information and communication technology contributes to quality of life in late adulthood. Greater levels of computer and internet use have been associated with better health and well-being, including increased life satisfaction and social support, as well as decreased feelings of loneliness and depression (Chopik, 2016; Hartanto et al., 2020; Heo et al., 2015; for reviews, see Hunsaker & Hargittai, 2018; Wagner et al., 2010). Yet, older age groups are less likely to adopt information and communication technology than the general population (König et al., 2018; Organization for Economic Cooperation and Development [OECD], 2019b; Ryan, 2018), which prevents them from taking advantage of these potential benefits. This age-based digital divide underscores the importance of identifying and addressing age-specific barriers to technology uptake in late adulthood. Research exploring age differences in technology use has focused primarily on individual characteristics, with older age groups consistently reporting lower self-efficacy and higher anxiety or discomfort with technology, lower perceived ease of use, perceived usefulness, and behavioural intention to use technology, as well as lower cognitive abilities (Czaja et al., 2006; Czaja & Sharit, 1998b; Lee et al., 2019; for reviews, see Hauk et al., 2018; Wagner et al., 2010).

Surprisingly, little is known about the role of societal factors, such as stereotypical views of age and ageing, in how individuals engage with information and communication technology. Older age groups are often stereotyped as having less technological ability than younger individuals. Older adults are considered less likely and less capable of performing technology-related activities, such as taking and completing a computer course (Ryan et al., 1992; Swift et al., 2013), and older workers are perceived as less skilled and less experienced with technology (McGregor & Gray, 2002; Van Dalen et al., 2009). Stereotypical beliefs about age and ageing have been consistently found to influence older individuals' actions or behaviours (for reviews, see Meisner, 2012; Westerhof et al., 2014), suggesting that negative stereotypes about the technological competence of older age groups may reinforce their lower rates of technology adoption.

The present research sought to understand whether and how stereotypical views of age and ageing may impact technology use in late adulthood. According to the stereotype embodiment theory (Levy, 2009), culturally shared beliefs about older people and the ageing process are internalized since childhood and reinforced throughout adulthood. However, as individuals grow older, these stereotypical perceptions about age and ageing become perceptions about themselves and their own ageing experience, or self-perceptions of ageing (Kornadt &

Rothermund, 2012; Kornadt et al., 2017). This implies that age stereotypes about technological inability may be internalized, causing older individuals to doubt their own ability to use technology and consequently undermining its adoption in their daily lives. This is consistent with evidence that older age groups report lower technology self-efficacy, which is associated with lower technology use (Czaja et al., 2006; Lee et al., 2019; Mitzner et al., 2019).

Still, this may not be the only mechanism through which negative perceptions about age and ageing may preclude technology use in late adulthood. An extensive body of research has documented the beneficial and detrimental impacts of positive and negative age stereotypes and self-perceptions of ageing across multiple health domains (for reviews, see Chang et al., 2020; Westerhof et al., 2014), including cognitive functioning (Levy et al., 2012; Robertson et al., 2016; Seidler & Wolff, 2017; Siebert et al., 2018). Interacting with information and communication technology is cognitively demanding, as suggested by evidence that cognitive functioning is an important predictor of performance (Czaja & Sharit, 1998a; Czaja et al., 2001; Sharit et al., 2015) and usage (Czaja et al., 2006; Mitzner et al., 2019; Tun & Lachman, 2010). This suggests that, by compromising cognitive functioning, negative age stereotypes and self-perceptions of ageing may indirectly undermine technology use behaviour.

Few studies have explored these potential relationships. Lagacé et al. (2015) found that older adults who held more negative beliefs about older people used information and communication technologies for fewer activities than those with more positive age stereotypes. Cody et al. (1999) showed that older adults with more positive self-perceptions of ageing were more likely to complete an internet training program and spend more time online during its four-month duration. In contrast, Yoon et al. (2016) found no significant relationship between self-perceptions of ageing and computer use when controlling for relevant health and sociodemographic factors. Although inconclusive, these findings tend to suggest the existence of positive associations from age stereotypes and self-perceptions of ageing to technology use behaviour. Nonetheless, they do not fully clarify the directionality and causality of the relationships, nor identify potential mediating mechanisms.

To investigate the interplay between self-perceptions of ageing, cognitive functioning, and technology use behaviour, we conducted two longitudinal studies including middle-aged and older adults from different countries, different domains of cognitive functioning, and different measures of use behaviour. We focused on computers for being potentially more cognitively demanding than other types of technology (Tsai et al., 2015). Overall, we predicted that cognitive functioning would mediate the relationship between self-perceptions of ageing and computer use behaviour over time. Specifically, we hypothesized a direct positive association between self-perceptions of ageing and computer use behaviour (Hypothesis 1), such that more positive self-perceptions would relate to higher levels of use behaviour. Additionally, we hypothesized an indirect positive association between self-perceptions of ageing and computer use behaviour through cognitive functioning (Hypothesis 2), such that positive self-perceptions would relate to better cognitive functioning (Hypothesis 2a), which would then relate to greater computer use (Hypothesis 2b). We tested these predictions in both studies while also controlling for relevant health, well-being, and sociodemographic correlates of computer use behaviour, cognitive functioning, and self-perceptions of ageing (for reviews, see Hertzog et al., 2008; Marques et al., 2020; Wagner et al., 2010). Given the wide age range in our study samples, potential age differences between middle-aged and older adults were also investigated.

4.3. Study 4

Based on the Health and Retirement Study, this study examined the relationships between self-perceptions of ageing, cognitive functioning, and computer use behaviour over eight years among individuals aged 50 or older from the United States of America. Given the stereotypical beliefs about memory and ageing, we focused on memory performance as an indicator of cognitive functioning. Memory decline is widely assumed to be an inevitable part of the ageing process, with older age groups being commonly stereotyped as forgetful (Hummert et al., 1994; Ryan, 1992). Age stereotypes have been found to be important predictors of both short-term and long-term memory performance (Levy, 1996; Levy et al., 2012). Although longitudinal research looking specifically at the interplay between self-perceptions of ageing and memory functioning is scarce, some findings suggest a positive association over time (Robertson et al., 2016; Siebert et al., 2018). Longitudinal evidence for the relationship between memory functioning and computer use is mixed, with one study providing support for this relationship over six years (Slegers et al., 2012) and another study showing no association over nine years (Hartanto et al., 2020). Overall, we expected the relationship between self-perceptions of ageing and computer use behaviour to be mediated by cognitive functioning as indicated by memory performance.

4.3.1. Method

4.3.1.1. Participants

The Health and Retirement Study (HRS, Sonnega et al., 2014) is a biennial longitudinal survey of a nationally representative sample of the United States population aged over 50 years and their spouses of any age. The HRS is sponsored by the National Institute on Aging (grant number NIA U01AG009740) and is conducted by the University of Michigan. A "leave-behind" self-completed psychosocial questionnaire has been administered to a rotating half of the sample every four years since 2006. The present study is based on all respondents aged 50 years or older who completed the core interview and the psychosocial questionnaire in 2010, 2014, and 2018 (Time 1 [T1], Time 2 [T2], and Time 3 [T3], respectively; *n* = 3,404), the most recent waves that included the same measures of self-perceptions of ageing, cognitive functioning, and computer use behaviour.

4.3.1.2. Measures

Self-perceptions of Ageing. Five items derived from the Attitude Toward Own Aging subscale of the Philadelphia Geriatric Center Morale Scale (Lawton, 1975) assessed self-perceptions of ageing: (1) "Things keep getting worse as I get older", (2) "I have as much pep as I did last year", (3) "The older I get, the more useless I feel", (4) "I am as happy now as I was when I was younger", and (5) "As I get older, things are better than I thought they would be". Response options ranged from 1 (*strongly disagree*) to 6 (*strongly agree*). Negatively phrased items (1 and 3) were reverse coded so that higher values reflected more positive self-perceptions of ageing (Cronbach's alpha: $\alpha_{T1} = .73$, $\alpha_{T2} = .73$, $\alpha_{T3} = .74$).

Cognitive Functioning. Episodic memory was chosen as an indicator of cognitive functioning and assessed with two free recall tasks (McArdle et al., 2007). A list of 10 nouns was read to participants, who were asked to recall as many words as possible: (1) immediately after their presentation – immediate word recall; and (2) after a delay of approximately five minutes – delayed word recall. Memory performance on each task was coded as the total number of correctly recalled words, ranging from 0 to 10, with higher scores indicating better cognitive functioning (Spearman-Brown coefficient: $\rho_{T1} = .82$, $\rho_{T2} = .86$, $\rho_{T3} = .85$).

Computer Use Behaviour. A single item from a list of different activities assessed general frequency of computer use: "Please tell us how often you do each activity. (…) Use a computer for e-mail, Internet or other tasks?". Response options ranged from 1 (*daily*) to 7 (*never / not* *relevant*), which were reverse coded so that higher values indicated more frequent computer use.

Covariates. Age (in years), education (in years), gender (1 = *female*), marital status (1 = *married*), employment status (1 = *working*), income, subjective health, physical conditions, depressive symptoms, and loneliness assessed at baseline were included as covariates. Income was based on an imputed measure of total household income provided by the HRS, which was log transformed to correct skewness. Subjective health ("Would you say your health is excellent, very good, good, fair, or poor?") was rated from 1 (*excellent*) to 5 (*poor*). Physical conditions were scored as the sum of seven illnesses (hypertension, diabetes, cancer, lung disease, heart condition, stroke, and arthritis). Depressive symptoms were scored as the sum of eight items from the Center for Epidemiologic Studies Depression Scale (CES-D; Radloff, 1977; α = .80). Loneliness was scored as the mean of three items from the short version of the Revised University of California, Los Angeles Loneliness Scale (R-UCLA; Hughes et al., 2004; α = .81). Responses were reverse coded as appropriate so that higher values indicated greater levels of the corresponding construct.

4.3.1.3. Analysis

A three-wave autoregressive cross-lagged panel design was used to test longitudinal mediation (Cole & Maxwell, 2003; Little et al., 2007). Structural equation modelling was performed using Mplus 8 (Muthén & Muthén, 1998-2017) with maximum likelihood estimation (ML). Mediation was examined using percentile bootstrapping with 10,000 resamples to generate estimates and 95% confidence intervals (CI) that indicate the significance of indirect effects. Model fit was examined based on the Chi-Square Test (χ^2), the Comparative Fit Index (CFI), the Tucker-Lewis Index (TLI), the Root Mean Square Error of Approximation (RMSEA), and the Standardized Root Mean Square Residual (SRMR). CFI and TLI values of .90 or higher and RMSEA and SRMR values of .08 or lower were considered indicative of acceptable fit (Browne & Cudeck, 1993; Hu & Bentler, 1999). Model fit comparisons were based on the chi-square difference test ($\Delta\chi^2$).

As the first step of the longitudinal analysis, we tested the measurement model. Self-perceptions of ageing and cognitive functioning were modelled as latent factors with their respective items serving as observed indicators. Residuals of corresponding indicators were correlated across waves. To ensure that the same constructs were measured across time, longitudinal measurement invariance was tested by specifying a series of increasingly constrained models representing various degrees of invariance: configural (equal structure), weak (equal loadings), and strong (equal intercepts). Due to the large sample of the current study, CFI differences of .010 or lower (ΔCFI $\leq$ .010) were considered indicative of no substantial difference in model fit, therefore demonstrating measurement invariance (Cheung & Rensvold, 2002). At least partial strong invariance was demonstrated and equality constraints were applied consistently with the appropriate level of invariance (Little et al., 2007).

As the second step, we tested the structural model. Computer use behaviour and all covariates were modelled as observed variables. Autoregressive paths were specified between the same constructs across waves, while cross-lagged paths were established between different constructs across waves. Stationarity was tested by constraining autoregressive and cross-lagged paths to be equal across waves (Cole & Maxwell, 2003). Differences between an association (e.g., from self-perceptions of ageing at T1 to computer use behaviour at T3) and its reverse pattern (e.g., from computer use behaviour at T1 to self-perceptions of ageing at T3) were also examined. A constrained model in which the associations were constrained to equality was compared to an unconstrained model in which they were allowed to differ.

Lastly, multigroup analysis was conducted to identify potential age differences by comparing middle-aged (50 to 64 years) and older adults (65 years or older). Multigroup measurement invariance was also tested to ensure that the same constructs were measured across groups, demonstrating at least partial strong invariance. A constrained model in which cross-lagged paths were equated across age groups was compared to an unconstrained model in which these paths were allowed to differ.

4.3.2. Results

4.3.2.1. Descriptive Analysis

Sample characteristics at baseline are shown in Table 4.1. Age ranged from 50 to 93 years (M = 64.41). Education ranged from 0 to 17 years (M = 13.44). Most participants were female (60.16%) and married (66.48%). Less than half were working (42.98%). Subjective health averaged between *good* and *very good* (M = 3.44). Participants reported low levels of physical conditions (M = 1.74), depressive symptoms (M = 1.13), and loneliness (M = 1.44).

Table 4.2 presents the correlations between the main variables across the three waves. Self-perceptions of ageing were moderately positive, cognitive functioning was close to the midpoint, and computer use was moderately frequent. Self-perceptions of ageing were significantly and positively related to use behaviour across all waves. Cognitive functioning was significantly and positively associated with both, though more strongly with computer use.

4.3.2.2. Longitudinal Analysis

Firstly, we tested the measurement model. The modification indices suggested correlating the residuals of items 1 and 3 within the self-perceptions of ageing latent factors to improve model fit. Because both items were reverse coded and part of the same measure, their residuals were allowed to correlate at each time point. Because strong longitudinal invariance was demonstrated (see Appendix, Supplementary Table A), loadings and intercepts were equated across waves. The resulting measurement model had good fit to the data: χ^2 (170) = 1094.71, CFI = .967, TLI = .959, RMSEA = .040 (90% Confidence Interval (CI) [.038, .042]), SRMR = .049. Secondly, we tested the structural model. Stationarity was demonstrated, $\Delta\chi^2$ (7) = 11.86, p = .105, so path coefficients were equated across waves. The resulting structural model had adequate fit to the data: χ^2 (447) = 3091.05, CFI = .935, TLI = .925, RMSEA = .042 (90% CI [.040, .043]), SRMR = .050. Figure 4.1 presents the autoregressive cross-lagged panel model with standardized path coefficients (β), while the unstandardized path coefficients (b) are reported below.

Table 4.1.

Sample characteristics at baseline in Study 4 and Study 5

	Study 4			Study 5		
Variable	*M* (*n*)	*SD* (%)	*Range*	*M* (*n*)	*SD* (%)	*Range*
Age	64.41	8.93	50 – 93	63.92	10.58	40 – 94
Education	13.44	2.71	0 – 17	2.41	0.58	1 – 3
Gender (*female*)	(2048)	(60.16)	0 – 1	(2474)	(50.79)	0 – 1
Marital status (*married*)	(2263)	(66.48)	0 – 1	(3564)	(73.17)	0 – 1
Employment status (*working*)	(1463)	(42.98)	0 – 1	(1812)	(37.20)	0 – 1
Income (log)	4.65	0.59	0 – 6.32	3.42	0.25	2.09 – 4.70
Subjective health	3.44	1.00	1 – 5	3.58	0.79	1 – 5
Physical conditions	1.74	1.26	0 – 6	2.50	1.81	0 – 11
Depressive symptoms	1.13	1.76	0 – 8	6.25	5.72	0 – 40
Loneliness	1.44	0.52	1 – 3	1.76	0.54	1 – 4
Region (*East Germany*)	–	–	–	(1607)	(32.99)	0 – 1

Table 4.2.

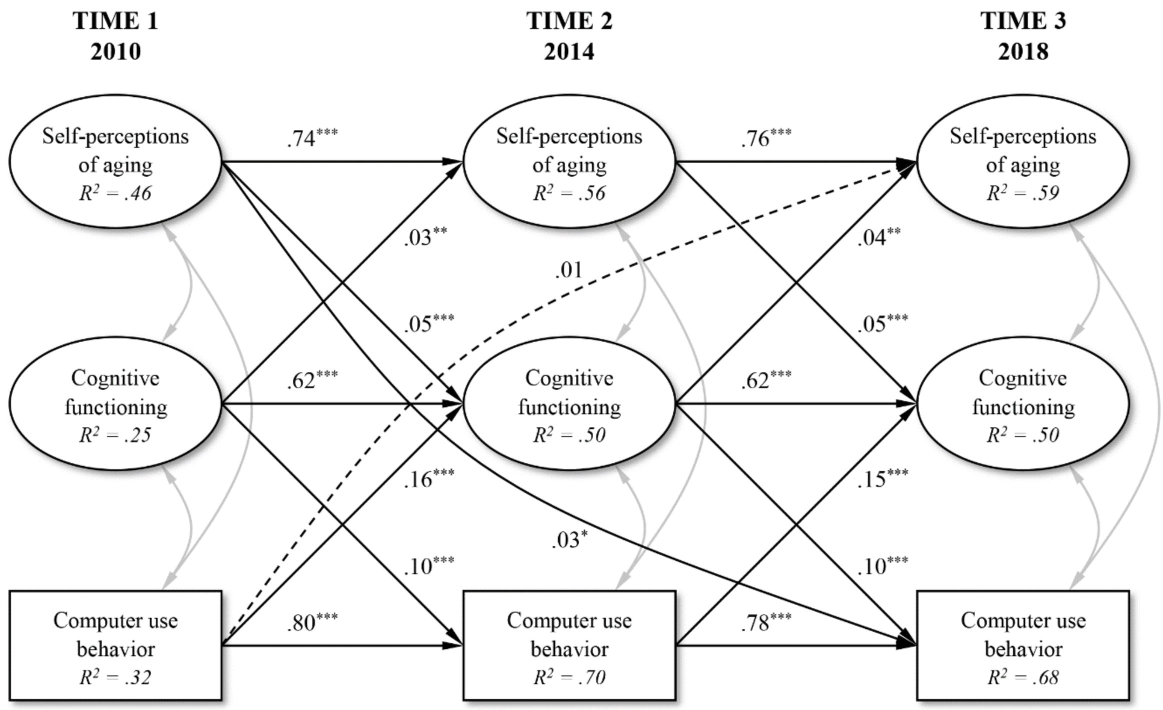
Means, standard deviations, and correlations in Study 4

Variable	*M*	*SD*	*Range*	1	2	3	4	5	6	7	8
1. Self-perceptions of ageing 2010	4.18	1.07	1 – 6	–							
2. Self-perceptions of ageing 2014	4.12	1.06	1 – 6	.59***	–						
3. Self-perceptions of ageing 2018	4.04	1.08	1 – 6	.56***	.63***	–					
4. Cognitive functioning 2010	5.32	1.47	0 – 10	.15***	.13***	.14***	–				
5. Cognitive functioning 2014	5.20	1.55	0 – 10	.17***	.18***	.19***	.57***	–			
6. Cognitive functioning 2018	5.12	1.64	0 – 10	.16***	.16***	.18***	.55***	.58***	–		
7. Computer use behaviour 2010	5.07	2.54	1 – 7	.17***	.16***	.17***	.33***	.34***	.37***	–	
8. Computer use behaviour 2014	5.16	2.52	1 – 7	.17***	.17***	.19***	.33***	.35***	.37***	.83***	–
9. Computer use behaviour 2018	5.09	2.54	1 – 7	.17***	.18***	.19***	.35***	.37***	.41***	.77***	.82***

* $p < .05$. ** $p < .01$. *** $p < .001$.

Figure 4.1.

Autoregressive cross-lagged panel model tested in Study 4



Note. All path coefficients are standardized. The dotted lines indicate nonsignificant paths. R^2 represents the proportion of explained variance. * $p < .05$. ** $p < .01$. *** $p < .001$.

The autoregressive associations of self-perceptions of ageing (b = .76, p < .001), cognitive functioning (b = .67, p < .001), and computer use behaviour (b = .79, p < .001) were all significant, substantial, and positive. Supporting Hypothesis 1, the direct association from self-perceptions of ageing at T1 to computer use behaviour at T3 was significant and positive (b = .10, p = .021). Also supporting Hypothesis 2, the indirect association from self-perceptions of ageing at T1 to computer use behaviour at T3 was significant and positive (b = .017, p < .001, 95% CI [.010, .025]). The cross-lagged associations from self-perceptions to cognitive functioning (b = .09, p < .001) and from cognitive functioning to use behaviour (b = .20, p < .001) were all significant and positive, consistently with Hypotheses 2a and 2b, respectively. Lastly, the total association from self-perceptions of ageing at T1 to computer use behaviour at T3 was also significant and positive (b = .12, p = .007). Taken together, these results indicate that cognitive functioning partially mediates the relationship between self-perceptions of ageing and computer use behaviour over eight years.

In turn, although the direct and total associations from computer use behaviour at T1 to self-perceptions of ageing at T3 were both nonsignificant, the indirect association via cognitive functioning was significant and positive (direct: b < .01, p = .517; indirect: b = .002, p = .005, 95% CI [.001, .003]; total: b < .01, p = .225). Still, all these associations were significantly different and weaker than their corresponding reverse patterns, that is, from self-perceptions at T1 to use behaviour at T3 (direct: $\Delta\chi^2(1) = 6.67$, p = .010; indirect: $\Delta\chi^2(1) = 14.93$, p < .001; total: $\Delta\chi^2(1) = 8.84$, p = .003). The cross-lagged associations from use behaviour to cognitive functioning (b = .08, p < .001) and from cognitive functioning to self-perceptions (b = .02, p = .005) were also significant and positive, although significantly different and weaker than their corresponding reverse associations ($\Delta\chi^2(1) = 44.52$, p < .001 and $\Delta\chi^2(1) = 9.97$, p = .002, respectively). Although these results provide some evidence of reciprocal relationships between constructs, the associations from self-perceptions at T1 to use behaviour at T3 were consistently stronger.

4.3.2.3. Multigroup Analysis

Finally, we tested whether the relationships between self-perceptions of ageing, cognitive functioning, and computer use behaviour differed between middle-aged adults (50 to 64 years, M_{age} = 57.27, SD_{age} = 4.01, n = 1,816) and older adults (65 to 93 years, M_{age} = 72.58, SD_{age} = 5.27, n = 1,588). Partial strong multigroup invariance was demonstrated (see Appendix, Supplementary Table A), so loadings and intercepts were equated accordingly across groups.

The constrained model did not differ significantly from the unconstrained model, $\Delta\chi^2$ (14) = 18.69, p = .177, indicating comparable cross-lagged associations across age groups.

4.3.3. Discussion

Study 4 suggests that individuals' beliefs about their ageing experience influence their behaviour toward technology in late adulthood. As predicted, self-perceptions of ageing were associated with computer use behaviour over eight years, with more positive self-perceptions being related to higher levels of use behaviour. Moreover, cognitive functioning partially mediated this relationship, such that positive self-perceptions were associated with better cognition, which was then related to greater computer use.

Nonetheless, some limitations should be noted. Firstly, despite controlling for employment status, we were unable to fully account for potential confounding effects of computer use in the workplace due to the general measure of use frequency. Secondly, we focused solely on episodic memory as an indicator of cognitive functioning, which limits the generalizability of these results to other domains of cognition. Study 5 aimed to address these limitations, while also extending the findings of Study 4.

4.4. Study 5

Based on the German Ageing Survey, this study further explored the relationships between self-perceptions of ageing, cognitive functioning, and computer use behaviour over three years among individuals aged 40 or older from Germany. To avoid potential confounding effects of computer use for work activities, we focused on use behaviour during individuals' free time. Moreover, we focused on processing speed, an important contributor to age differences in cognitive functioning (Salthouse, 1996). Self-perceptions of ageing have been found to be reciprocally related to processing speed over time (Seidler & Wolff, 2017). Although processing speed is an important predictor of computer-based task performance (Czaja & Sharit, 1998a; Czaja et al., 2001; Sharit et al., 2015), longitudinal evidence for an association between processing speed and computer use is lacking (Slegers et al., 2012). Overall, we expected the relationship between self-perceptions of ageing and computer use behaviour to be mediated by cognitive functioning as indicated by processing speed.

4.4.1. Method

4.4.1.1. Participants

The German Ageing Survey (DEAS, Klaus et al., 2017) is a nationally representative cohort-sequential survey of the German population aged 40 years or over. The DEAS is funded by the German Federal Ministry for Family Affairs, Senior Citizens, Women and Youth (BMFSFJ; grant number 301-6083-05/003*2) and is organized by the German Centre of Gerontology (DZA). Data collection consists of a computer-assisted personal interview and a “drop-off” self-completed questionnaire. The present study is based on all respondents aged 40 years or older who completed the personal interview and the drop-off questionnaire in 2014 and 2017 (Time 1 [T1] and Time 2 [T2], respectively; n = 4,871), the most recent waves that included the same measures of self-perceptions of ageing, cognitive functioning, and computer use behaviour.

4.4.1.2. Measures

Self-perceptions of Ageing. As in Study 4, five items from the Attitude Toward Own Aging subscale of the Philadelphia Geriatric Center Morale Scale (Lawton, 1975) assessed self-perceptions of ageing. Response options ranged from 1 (*strongly agree*) to 4 (*strongly disagree*). Positively phrased items were reverse coded so that higher scores reflected more positive self-perceptions of ageing (Cronbach’s alpha: $\alpha_{T1} = .72$, $\alpha_{T2} = .75$).

Cognitive Functioning. Processing speed was chosen as an indicator of cognitive functioning and assessed with the Digit Symbol Substitution Test (Wechsler, 1955). The test sheet included a key pairing symbols with digits 1 to 9 and a list of those same digits randomly repeated 100 times with blank spaces underneath. Participants were asked to copy the corresponding symbol under each digit. After completing seven examples as practice, participants filled as many blanks as possible within 90 seconds. Processing speed was coded as the total number of correct responses, ranging from 0 to 93, with higher values indicating better cognitive functioning.

Computer Use Behaviour. A single item assessed computer use: “How often do you work with computers in your spare time, i.e., use of internet, e-mails, or playing computer games?”. Response options ranged from 1 (*daily*) to 6 (*never*) and were reverse coded so that higher scores indicated more frequent computer use.

Covariates. Age (in years), education, gender (1 = *female*), marital status (1 = *married*), employment status (1 = *working*), region (1 = *East Germany*), income, subjective health, physical conditions, depressive symptoms, and loneliness assessed at baseline were included as covariates. Education was based on the International Standard Classification of Education (ISCED; United Nations Educational, Scientific and Cultural Organization [UNESCO], 1997) with three levels: low (ISCED 0-2), medium (ISCED 3-4), and high (ISCED 5-6). Region was reported as East or West Germany. Income was based on the monthly household income, which was log transformed to correct skewness. Subjective health ("How would you rate your present state of health?") was rated from 1 (*very good*) to 5 (*very bad*). Physical conditions were scored as the sum of 11 illnesses. Depressive symptoms were scored as the sum of 15 items from the German version of the Center for Epidemiologic Studies Depression Scale (CES-D; Hautzinger & Bailer, 1993; Radloff, 1977; α = .85). Loneliness was scored as the mean of six items from the Loneliness Scale by Gierveld and Tilburg (2006; α =.83). Responses were reverse coded as appropriate so that higher values indicated greater levels of the corresponding construct.

4.4.1.3. Analysis

A two-wave autoregressive cross-lagged panel design was used to test longitudinal mediation (Cole & Maxwell, 2003; Little et al., 2007). We followed the same analytical approach as in Study 4, with some exceptions. Only self-perceptions of ageing were modelled as latent factors. Cognitive functioning, computer use behaviour, and all covariates were modelled as observed variables. Given the two-wave design, stationarity was assumed true as observed in Study 4 (Little et al., 2007). Following the procedure recommended by Cole and Maxwell (2003), the indirect association of self-perceptions of ageing on computer use behaviour through cognitive functioning was estimated based on the product of path *a* (i.e., the regression of cognitive functioning at T2 on self-perceptions of ageing at T1) and path *b* (i.e., the regression of computer use behaviour at T2 on cognitive functioning at T1). An analogous procedure was used to estimate the indirect association of computer use behaviour on self-perceptions of ageing through cognitive functioning.

4.4.2. Results

4.4.2.1. Descriptive analysis

Table 4.1 presents the sample characteristics at baseline. Age ranged from 40 to 94 years (M = 63.92). Education averaged between *medium* and *high* (M = 2.41), with slightly under half of participants having high education (45.68%). About half were women (50.79%) and the majority was married (73.17%). Close to one third were employed (37.20%). A similar proportion lived in East Germany (32.99%). Subjective health averaged between *average* and *good* (M = 3.58). Physical conditions (M = 2.50), depressive symptoms (M = 6.25), and loneliness (M = 1.76) were low.

Correlations between the main variables across the two waves are shown in Table 4.3. Similarly to Study 4, self-perceptions of ageing were moderately positive, cognitive functioning was at the midpoint, and computer use was moderately frequent. Self-perceptions were significantly and positively related to use behaviour across waves. Cognitive functioning was significantly and positively associated with both, but more strongly with computer use.

4.4.2.2. Longitudinal Analysis

Firstly, we tested the measurement model. As suggested by the modification indices, the residuals of items 1 and 3 within the self-perceptions of ageing latent factors were allowed to correlate at each time point. Strong longitudinal invariance was demonstrated (see Appendix, Supplementary Table B). The measurement model had good fit to the data: χ^2 (35) = 499.09, CFI = .966, TLI = .956, RMSEA = .052 (90% CI [.048, .056]), SRMR = .036. Secondly, we tested the structural model, which had adequate fit to the data: χ^2 (189) = 2204.23, CFI = .931, TLI = .911, RMSEA = .047 (90% CI [.045, .049]), SRMR = .036. Figure 4.2 presents the autoregressive cross-lagged panel model with standardized path coefficients (β). The unstandardized path coefficients (b) are reported below.

The autoregressive associations of self-perceptions of ageing (b = .82, $p < .001$), cognitive functioning (b = .73, $p < .001$), and computer use behaviour (b = .79, $p < .001$) were all significant, substantial, and positive. Supporting Hypothesis 1, the direct association from self-perceptions of ageing at T1 to computer use behaviour at T2 was significant and positive (b = .11, p = .039). Also supporting Hypothesis 2, the indirect association from self-perceptions of ageing at T1 to computer use behaviour at T2 was significant and positive (b = .029, $p < .001$, 95% CI [.016, .042]). The cross-lagged associations from self-perceptions at T1 to cognitive functioning at T2 (b = 2.04, $p < .001$) and from cognitive functioning at T1 to use behaviour at T2 (b = .01, $p < .001$) were both significant and positive, in line with Hypotheses 2a and 2b, respectively. Lastly, the total association from self-perceptions of ageing at T1 to computer use behaviour at T2 was also significant and positive (b = .14, p = .010). Overall, these results show that cognitive functioning partially mediates the relationship between self-perceptions of ageing and computer use behaviour over three years.

Table 4.3.

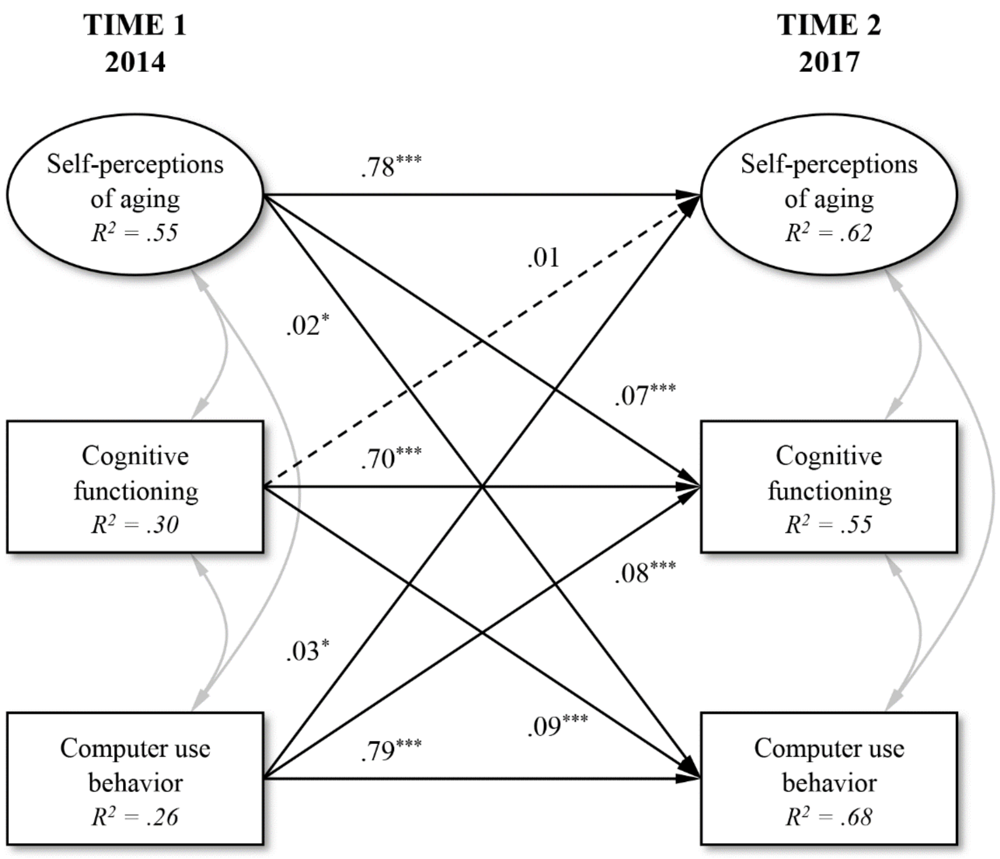
Means, standard deviations, and correlations in Study 5

Variable	*M*	*SD*	*Range*	1	2	3	4	5
1. Self-perceptions of ageing 2014	3.01	0.53	1 – 4	–				
2. Self-perceptions of ageing 2017	2.96	0.54	1 – 4	.64***	–			
3. Cognitive functioning 2014	46.26	13.02	1 – 92	.18***	.20***	–		
4. Cognitive functioning 2017	45.57	13.70	0 – 91	.17***	.22***	.73***	–	
5. Computer use behaviour 2014	4.04	2.12	1 – 6	.16***	.18***	.31***	.32***	–
6. Computer use behaviour 2017	4.18	2.13	1 – 6	.16***	.19***	.34***	.36***	.82***

* $p < .05$. ** $p < .01$. *** $p < .001$.

Figure 4.2.

Autoregressive cross-lagged panel model tested in Study 5



Note. All path coefficients are standardized. The dotted lines indicate nonsignificant paths. R^2 represents the proportion of explained variance. * $p < .05$. ** $p < .01$. *** $p < .001$.

In turn, although the direct and total associations from computer use behaviour at T1 to self-perceptions of ageing at T2 were both significant and positive, the indirect association via cognitive functioning was nonsignificant (direct: $b = .01$, $p = .042$; indirect: $b = .000$, $p = .405$, 95% CI [.000, .001]; total: $b = .01$, $p = .033$). These associations were significantly different and weaker than those from self-perceptions at T1 to use behaviour at T2 (direct: $\Delta\chi^2$ (1) = 4.40, $p = .036$; indirect: $\Delta\chi^2$ (1) = 90.69, $p < .001$; total: $\Delta\chi^2$ (1) = 7.08, $p = .008$). The cross-lagged association from use behaviour at T1 to cognitive functioning at T2 was significant and positive ($b = .55$, $p < .001$), as well as significantly different and stronger than its reverse association ($\Delta\chi^2$ (1) = 50.49, $p < .001$). The cross-lagged association from cognitive functioning at T1 to self-perceptions at T2 was nonsignificant ($b < .01$, $p = .397$), besides being significantly different and weaker than its reverse association ($\Delta\chi^2$ (1) = 25.52, $p < .001$). These results provide some evidence of reciprocal relationships between constructs.

4.4.2.3. Multigroup Analysis

Finally, we tested whether the relationships between self-perceptions of ageing, cognitive functioning, and computer use behaviour differed between middle-aged adults (40 to 64 years, $M_{age} = 55.38$, $SD_{age} = 6.21$, $n = 2{,}510$) and older adults (65 to 94 years, $M_{age} = 73.01$, $SD_{age} = 5.47$, $n = 2{,}361$). Partial strong multigroup invariance was demonstrated (see Appendix, Supplementary Table B). The constrained and unconstrained models did not differ significantly, $\Delta\chi^2$ (6) = 8.49, $p = .205$, suggesting no age differences in the cross-lagged associations.

4.4.3. Discussion

Study 5 provides further support for the relationship between self-perceptions of ageing and computer use behaviour, as well as the role of cognitive functioning. Consistently with Study 4, positive self-perceptions were associated with greater use behaviour over three years and this relationship was partially mediated by cognitive functioning. Besides addressing its shortcomings, Study 5 reinforced the findings of Study 4 by extending them to another country sample, cognitive domain, and use measure.

4.5. General Discussion

The present research examined self-perceptions of ageing as potential determinants of information and communication technology use in late adulthood. Across two longitudinal studies, more positive perceptions about individuals' ageing experience were associated with more frequent computer use over time. This relationship was partially mediated by cognitive functioning, such that more positive self-perceptions of ageing were associated with better cognitive performance, which was then associated with higher levels of computer use behaviour. Confirming the robustness of these findings, this was replicated across different dimensions of cognitive functioning, different measures of computer use, and two samples from different countries, namely American individuals aged 50 or older over eight years and German individuals aged 40 or older over three years. Although past research exploring this relationship revealed mixed findings (Cody et al., 1999; Yoon et al., 2016), both studies confirmed longitudinally the positive association between self-perceptions of ageing and computer use behaviour, while also identifying cognitive functioning as an underlying mechanism.

These findings emphasize the importance of considering societal factors to better understand how older individuals relate to information and communication technology (Lagacé et al., 2015; Chapter 2: Mariano, Marques, Ramos, Gerardo, et al., 2021; Chapter 1: Mariano et al., 2020). Internalizing stereotypical beliefs about age and ageing into self-perceptions of ageing (Levy, 2009) may positively or negatively impact relevant predictors of use behaviour, thus facilitating or hindering technology use. Although our studies focused on cognitive functioning, self-efficacy may also play a mediating role. Following from the stereotype embodiment theory (Levy, 2009), stereotypes about older age groups as less technologically competent may be internalized, leading older individuals to perceive their own ability to use technology more negatively and consequently avoid using technology. This is consistent with studies showing that older age groups tend to report lower technology self-efficacy (Czaja et al., 2006; Czaja & Sharit, 1998b; Lee et al., 2019). In fact, existing evidence suggests that cognitive performance and technology self-efficacy are interrelated determinants of use behaviour. Czaja et al. (2006) found that fluid cognition and computer self-efficacy mediated the relationship between age and technology use. Specifically, those with better cognitive performance were more likely to have positive beliefs about their computer ability, indicating that older individuals also base their self-efficacy beliefs on their level of cognitive functioning. This suggests that self-perceptions of ageing may indirectly influence technology use through multiple interrelated pathways and that interventions targeting perceptions about own ageing may simultaneously address different determinants of use behaviour. Promoting positive perceptions about age and ageing has been shown to reliably improve health-related behaviours and outcomes, namely physical activity and functioning (Brothers & Diehl, 2017; Levy et al., 2014; Wolff et al., 2014). Future research should examine whether similar interventions would be equally effective in promoting cognitive functioning and technology use among older age groups.

Despite some inconsistencies between studies, reciprocal relationships were observed between self-perceptions of ageing and computer use behaviour, indicating that these factors may influence each other mutually over time. More frequent use behaviour was directly associated with more positive self-perceptions over three years, but not over eight years. Moreover, greater use behaviour was indirectly associated with positive self-perceptions via episodic memory, but not through processing speed. These findings suggest that, to some extent, computer technology may also influence how older individuals perceive their ageing experience by contributing to their health and well-being. Nonetheless, the strength of the associations observed in both studies indicates that self-perceptions of ageing are primarily an antecedent rather than an outcome of use behaviour. Furthermore, Cody et al. (1999) found no support for the impact of technology use on self-perceptions of ageing, as older adults' perceptions about their own ageing did not significantly change after participating in an internet training program over four months. Given these inconclusive findings, future research should further explore the potential of information and communication technology to improve self-perceptions of ageing.

Our studies also contribute to research exploring the relationship between cognition and information and communication technology by corroborating the consistent finding that better cognitive performance is associated with higher use behaviour in late adulthood (Czaja et al., 2006; Mitzner et al., 2019; Tun & Lachman, 2010). Although past research has considered cognitive functioning either as an antecedent or an outcome of technology use in isolation, recent studies began to explore their reciprocal relationships over time. Kamin and Lang (2020) found evidence of bidirectional associations between global cognition and internet use over two years among individuals aged 50 or older across 14 European countries. Yu and Fiebig (2020) observed similar reciprocal patterns over four years among Chinese individuals aged 45 or older. Hartanto et al. (2020) also found reciprocal associations between computer use and executive function over nine years among Americans aged 30 or older. Adding to this research, our findings indicate that computer use is reciprocally associated with episodic memory over eight years and processing speed over three years in American and German samples of individuals aged 50 and 40 years or older, respectively. Furthermore, our studies contribute to research on the relationship between self-perceptions of ageing and cognitive functioning. Although existing evidence on the longitudinal association from age stereotypes and self-perception of ageing to memory performance has been somewhat inconsistent (Levy et al., 2012; Robertson et al., 2016), we found a reciprocal relationship over eight years. Consistently with Seidler and Wolff (2017), self-perceptions of ageing were also associated with processing speed over three years, although not reciprocally. Overall, our findings suggest that self-perceptions of ageing mainly determine, rather than reflect, cognitive functioning in late adulthood.

Future studies should examine the interplay between self-perceptions of ageing, cognitive functioning, and technology use behaviour in greater detail. For instance, age stereotypes and self-perceptions of ageing are multidimensional constructs (Kornadt & Rothermund, 2012; Steverink et al., 2001) and their impact is stronger when the dimensions match the outcome domains (Levy & Leifheit-Limson, 2009). This suggests that specific dimensions that are more closely related to the technological domain, such as individuals' perceptions about cognitive decline as they age, may be particularly influential with regard to their use behaviour. Concerning cognitive functioning, existing evidence suggests that self-perceptions of ageing influence fluid but not crystallized abilities (Siebert et al., 2018). Although both fluid and crystalized cognition are important correlates of technology use (Czaja et al., 2006), self-perceptions of ageing may only influence use behaviour to the extent that they positively or negatively impact fluid functioning. Because our studies focused on episodic memory and processing speed, two components of fluid functioning, future research should explore the role of crystallized cognition on the relationship between self-perceptions of ageing and use behaviour. Future studies should also investigate the generalizability of our findings to different technological devices and activities. By identifying cognitive functioning as a mediating mechanism, our studies suggest that self-perceptions of ageing may be particularly beneficial or detrimental in relation to more cognitively demanding devices or activities. Future research should examine this possibility by considering other information and communication technologies and relying on more detailed measures of use behaviour that specify which activities are performed with a given device. Lastly, the mutual influence between computer use behaviour and cognitive performance raises the interesting hypothesis that self-perceptions of ageing may indirectly determine cognition through technology use. Indeed, the stereotype embodiment theory (Levy, 2009) asserts that the internalization of age stereotypes into self-perceptions of ageing impacts functioning and health through behavioural pathways. Future studies should explore this possibility while also using more comprehensive indicators of technology use and functional health.

The existing digital divide between generations underscores the need to promote the adoption of technological tools among the older population by addressing the factors that contribute to these inequalities. Stereotypical perceptions about age and ageing can be one such factor. Often shaped by societal views of the ageing process and older people, negative perceptions about their own ageing may deter individuals from engaging with information and communication technology in late adulthood. Support for the longitudinal relationship between self-perceptions of ageing and computer use behaviour was found among American and German middle-aged and older adults. The mediating role of cognitive functioning further suggests that self-perceptions of ageing exert their influence through major determinants of use behaviour. Future studies should investigate self-efficacy as another potential mediator. Thus, self-perceptions of ageing emerge as an important modifiable factor to consider when promoting technology use among older age groups.

CHAPTER 5.

The relationship between self-perceptions of ageing and internet use: Longitudinal evidence

Based on the preprint of:

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5.1. Abstract

In an increasingly digital world, those who remain offline may face greater challenges across multiple contexts of everyday life. Besides being less likely to be internet users, older age groups go online less frequently and for fewer activities. This longitudinal study examined a broad range of mostly understudied, yet potentially influential determinants of internet use in late adulthood within three domains: functional ability, social support, and views on ageing. Based on the 2014 and 2017 waves of the German Ageing Survey, comprising 3,479 respondents aged 40 years and older, we examined the longitudinal relationships between twelve potential determinants and seven online activities, controlling for relevant sociodemographic factors. Cognitive functioning and competence self-perceptions of ageing emerged as the most influential and transversal antecedents of internet use, given their widely complementary associations with multiple activities. Better cognitive functioning preceded contacting friends and relatives, searching for information, banking, and shopping more frequently three years later, while positive self-perceptions of ageing about competence preceded contacting others, searching for new relationships, seeking information, banking, entertainment, and creating contents more often. Furthermore, cognitive functioning mediated the indirect relationships between competence self-perceptions of ageing and internet use for contacting others, information searching, and shopping. Informational and instrumental forms of received social support also played determinant roles, although for fewer activities. These findings elucidate which factors to consider when developing effective strategies to promote specific internet uses among middle-aged and older adults. Emphasis should be placed on competence self-perceptions of ageing given their potential to influence cognition.

Keywords: cognition, self-perceptions of ageing, social support, internet, technology.

5.2. Introduction

Information and communication technologies have progressively shaped almost every aspect of everyday life over the past few decades. A key driver of this digital transformation, the internet has fundamentally changed how individuals communicate with each other, access and share information, purchase products and services, or spend their free time. Inevitably, those who remain offline are likely to face greater challenges across different social spheres. The COVID-19 pandemic is perhaps the most striking example of the overlap between digital and social inequalities, with digitally excluded individuals experiencing more difficulties in adapting to rapid social changes (Beaunoyer et al., 2020; Seifert et al., 2021). Age remains an important dimension of digital inequality. Despite substantial increases in adoption rates over the years, older age groups are still less likely to be internet users, besides going online less frequently and for fewer activities (Brandtzæg et al., 2011; König et al., 2018; Organization for Economic Cooperation and Development [OECD], 2020; Pew Research Center, 2017). Identifying the factors facilitating or preventing internet use in late adulthood is thus critical to inform interventions and policies aiming to minimize existing digital inequalities between generations.

Although extensive, research on the determinants of internet use typically suffers from at least three important shortcomings. Firstly, most studies rely on general indicators of use behaviour, often comparing users with nonusers, which limits a more nuanced understanding of its predictors. Besides having lower levels of general use, older age groups tend to engage in fewer online activities (Brandtzæg et al., 2011; Czaja et al., 2006). Understanding the factors that influence internet use for different purposes would allow promoting specific activities more effectively. Secondly, most studies opt for cross-sectional designs, which preclude inferences about directionality and causality. Longitudinal designs would permit describing the temporal and directional relationships between factors, including potential mutual influences. Thirdly, most studies focus primarily on potential predictors of internet use that are hardly modifiable or addressable through training or intervention, such as sociodemographic factors (Scheerder et al., 2017). Identifying the most influential and easily changeable determinants would enable more effective approaches to promote internet uptake. Beyond sociodemographics, the present study used a longitudinal design to examine a broad range of mostly understudied, yet potentially influential determinants of internet use belonging to three domains: functional ability, social support, and views on ageing.

5.2.1. Functional Ability

Interacting with information and communication technology involves the coordination of cognitive, physical, and perceptual abilities (Charness & Boot, 2009; Rogers, Stronge, et al., 2005). As such, age-related changes in functioning have long been acknowledged as potential barriers to internet engagement in late adulthood (Becker, 2004). Among these functional domains, cognitive functioning is perhaps the most well-established determinant of internet use (Czaja et al., 2006; Freese et al., 2006). Multiple studies have shown that cognitive abilities, such as working memory and processing speed, are important predictors of internet-based task performance, such as information searching (Czaja et al., 2013; Sharit et al., 2008; Sharit et al., 2015). Longitudinal evidence further suggests that better cognition is reciprocally related to greater use, indicating that internet use is both determined by and a determinant of cognitive functioning (Kamin & Lang, 2020; Yu & Fiebig, 2020).

Compared to cognition, the roles of physical and perceptual functioning have been considerably less studied. Declines in motor control and coordination, coupled with the propensity to develop disabling conditions, may compromise how individuals physically interact with technology, for example, when using a computer mouse or a touch screen (Rogers, Fisk, et al., 2005; Smith et al., 1999). However, existing evidence on the relationship between physical functioning and internet use is mixed. Gell et al. (2015) found that those with better physical functioning were more likely to use the internet for online activities related to communication, health, shopping, and banking. In contrast, Choi and DiNitto (2013a, 2013b) observed that physical functioning was unrelated to internet use for similar purposes. Perceptual ability may also be essential in learning and maintaining the regular use of information and communication technology. Regarding internet use, existing evidence suggests that visual functioning plays a more prominent role than auditory functioning. While greater use has been consistently associated with better vision (N. G. Choi et al., 2020; Echt & Burridge, 2011; Gell et al., 2015), past studies found nonsignificant associations with hearing (N. G. Choi et al., 2020; Gell et al., 2015), despite some findings indicating that internet use is lower when hearing difficulties are moderate or severe (Henshaw et al., 2012).

5.2.2. Social Support

Although help and support offered by family, friends, and other members of their social network can facilitate individuals' engagement with information and communication technology (Peek et al., 2016), social support remains an understudied determinant of internet use in late adulthood. Greater perceptions of social support have been shown to be associated with higher levels of technology use in general and internet use in particular (Chan, 2018; Erickson & Johnson, 2011; Heo et al., 2015; for a review, see Fuss et al., 2019). Yet, these findings are mainly interpreted and discussed in terms of the potential of technological tools to foster supportive relationships through online interactions, even though their predominantly cross-sectional nature does not clarify this assumed directional influence. Although some intervention studies corroborate the argument that internet use enhances perceptions of social support (Cody et al., 1999; Czaja et al., 2018), there is also evidence of mutual influences. Cody et al. (1999) found that older adults with higher perceived social support were more likely to complete an internet training program and that these perceptions further improved over its four-month duration. Nonetheless, social support did not relate to time spent online nor use frequency for various online activities, suggesting that its role as an antecedent may be limited.

Existing research does not fully elucidate how different types of social support may determine internet use. A distinction is often made between support received in the past and support perceived as available in the future (Schwarzer & Knoll, 2007). Kamin et al. (2020) found that received technology-related support was associated with using more technological devices over and above perceived support, indicating that actually receiving social support may be more influential than its perceived availability. Social support can also be differentiated into informational support (e.g., giving advice and guidance), instrumental support (e.g., providing material and practical assistance), and emotional support (e.g., offering empathy and caring) (Cohen, 2004). Among them, informational and instrumental support, for example, in the form of guidance on how to perform certain tasks or assistance with technical difficulties that one may encounter, are likely to be the most determinant for internet use (Francis et al., 2018; Luijkx et al., 2015).

5.2.3. Views on Ageing

Stereotypical views of age and ageing are important determinants of behaviour and health in late adulthood (Meisner, 2012; Westerhof et al., 2014). The ageing process is commonly expected to entail losses and declines (Heckhausen et al., 1989) and older people are generally perceived as less competent than other groups (Cuddy & Fiske, 2002). This also applies to the technological domain. Older age groups are seen as less capable of performing computer- and internet-related activities, such as shopping online, and these views are held by older individuals themselves (McGregor & Gray, 2002; Ryan et al., 1992; Swift et al., 2013). According to the stereotype embodiment theory (Levy, 2009), stereotypical views of age and ageing become increasingly self-relevant as individuals age, eventually being internalized as perceptions about themselves and their own ageing, or self-perceptions of ageing (Kornadt & Rothermund, 2012). The internalization of incompetence stereotypes into self-perceptions of ageing, particularly those associated with technological inability, may thus undermine individuals' perceptions about their ability to use technology successfully and ultimately compromise their use behaviours.

Existing evidence is mixed, with studies suggesting that self-perceptions of ageing determine, but are not determined by, internet use (Cody et al., 1999) and studies indicating the exact opposite (Köttl et al., 2020). Since Cody et al. (1999) found self-perceptions of ageing to be associated with time spent online and internet use for news but not for other activities, a more detailed look at the relationships between different dimensions of self-perceptions of ageing and different purposes of internet use may help clarify these divergent findings. Positive self-perceptions of ageing, particularly those associated with competence, should relate to greater internet use, as their influence is stronger when the stereotypical perceptions match the behavioural outcomes (Levy & Leifheit-Limson, 2009) and technology-related behaviours are perceived as requiring high competence (Ryan & Heaven, 1988).

The age individuals perceive themselves to be, that is, their subjective age (Kotter-Grühn et al., 2016), may also influence internet engagement. Because technology-related behaviours are seen as more typical of younger ages (Ryan & Heaven, 1988; Ryan et al., 1992), older individuals who feel younger than their actual age should be more likely to go online. Consistently, existing cross-sectional evidence suggests that younger subjective age relates to greater internet use (Eastman & Iyer, 2005; Seifert & Wahl, 2018).

5.3. Study 6

Based on the 2014 and 2017 waves of the German Ageing Survey, this study examined twelve factors related to functional ability, social support, and views on ageing as potential determinants of internet use across seven online activities: contacting friends and relatives, searching for new social contacts, searching for information, banking, entertainment, shopping, and creating contents. We tested the reciprocal relationships between the twelve factors and the seven behaviours over three years, while also controlling for known sociodemographic correlates of internet use (Hunsaker & Hargittai, 2018; Wagner et al., 2010). Overall, we expected better functional ability (i.e., better cognitive, physical, visual, and auditory functioning), higher social support (i.e., higher informational, instrumental, and emotional received support, as well as higher perceived support), and positive views on ageing (i.e., positive competence, physical, and social self-perceptions of ageing, as well as younger subjective age) to be associated with greater internet use behaviours three years later, even though we did not formulate specific hypothesis for each online activity. Given the wide age range of the study sample, which included individuals aged 40 years and older, potential age differences between middle-aged (40 to 64 years) and older adults (65 years and older) were also investigated.

5.3.1. Method

5.3.1.1. Participants

The German Ageing Survey (DEAS, Klaus et al., 2017) is a nationally representative survey of the German population aged 40 years and older. Data collection comprises a computer-assisted personal interview and a self-completed drop-off questionnaire. In the 2014 and 2017 drop-off questionnaires, respondents who indicated having access to the internet subsequently reported their frequency of use for specific activities. Thus, the present study is based on all respondents aged 40 years and older who completed the drop-off questionnaire and reported having internet access at both waves (2014 = Time 1 [T1] and 2017 = Time 2 [T2]; n = 3,479).

A logistic regression was performed to examine potential differences between those with and without internet access among respondents aged 40 years and older who completed the drop-off questionnaire at 2014 and 2017 (n = 4,871). The dependent variable was coded 1 (*with internet access at both waves*) and 0 (*without internet access in at least one wave*). All covariates were included as independent variables. Chronological age (b = -0.12, Wald χ^2 (1) = 363.57, p < .001), gender (b = -0.27, Wald χ^2 (1) = 9.81, p = .002), marital status (b = 0.30, Wald χ^2 (1) = 4.36, p = .037), living arrangements (b = 0.33, Wald χ^2 (1) = 4.24, p = .040), region (b = -0.73, Wald χ^2 (1) = 62.68, p < .001), education (b = 0.99, Wald χ^2 (1) = 150.66, p < .001), and income (b = 3.22, Wald χ^2 (1) = 179.33, p < .001) were significant predictors, with individuals who were younger, male, married, living alone, in West Germany, and had higher income and education levels being more likely to have internet access. Nonetheless, the majority of respondents reported having internet access at both waves (71.42%). Among them, almost all had access at home (98.68%) and almost one third had access at work (34,49%) at baseline.

5.3.1.2. Measures

Unless otherwise indicated, responses were reverse coded as appropriate so that higher values reflected greater levels of the corresponding construct.

Functional Ability. Cognitive functioning was assessed with the Digit Symbol Substitution Test (Wechsler, 1955), a measure of processing speed that is indicative of age-related changes in global cognition (Hoyer et al., 2004; Salthouse, 1996). Based on a code pairing symbols with digits 1 to 9, participants were asked to copy the symbol matching each digit presented on a list within 90 seconds. Cognitive functioning was coded as the total number of correct responses, ranging from 0 to 93, divided by 100 to facilitate interpretation. Physical functioning was assessed with the corresponding subscale of the 36-item short-form health survey (SF-36; Ware & Sherbourne, 1992). Participants reported whether and how their health limited their activities of daily living across ten items (e.g., "bathing or dressing yourself"; α_{T1} = .88, α_{T2} = .90) and three response options: (1) *yes, limited a lot*; (2) *yes, limited a little*; (3) *no, not limited at all*. Visual functioning ("Do vision problems cause you trouble reading the newspaper (possibly even when using a vision aid)?") and auditory functioning ("Do you have hearing problems on the telephone (possibly even when using a hearing aid)?") were assessed with single items and response options ranging from 1 (*no difficulties*) to 4 (*impossible*).

Social Support. Three types of received social support were assessed with single items: informational ("How often in the past 12 months have you asked someone for advice in making an important decision?), instrumental ("How often in the past 12 months did someone who does not live in this household help you with homework?"), and emotional ("How often in the past 12 months did someone comfort you or cheer you up?"). Response options ranged from 1 (*often*) to 4 (*never*). For each support type, responses from participants who reported having no one to ask for support were coded as 4 (*never*). Perceived social support ("How do you think you could get help from persons in your social environment in difficult situations?") was assessed with seven items (e.g., "If I have a problem, there is someone who can tell me how to handle it"; α_{T1} = .87, α_{T2} = .87) and response options ranging from 1 (*strongly agree*) to 4 (*strongly disagree*).

Views on Ageing. Three dimensions of self-perceptions of ageing were assessed with the AgeCog scale (Steverink et al., 2001; Wurm et al., 2007). The four-item subscales of ongoing development (e.g., "Ageing means to me that I can still learn new things"; α_{T1} = .77, α_{T2} = .79), physical loss (e.g., "Ageing means to me that I am less energetic and fit"; α_{T1} = .77, α_{T2} = .79), and social loss (e.g., "Ageing means to me that I feel lonely more often"; α_{T1} = .71, α_{T2} = .71) were used as measures of competence, physical, and social self-perceptions of ageing, respectively. Response options ranged from 1 (*strongly agree*) to 4 (*strongly disagree*). Subjective age was assessed by asking participants their felt age ("Forget your actual age for a moment: How old do you feel, if you had to express it in years?"). Proportional discrepancy scores were calculated as the difference between felt age and chronological age, divided by chronological age (Rubin & Berntsen, 2006), representing how younger or older individuals feel relative to their chronological age. Negative values indicate feeling younger than their actual age, while positive values indicate feeling older.

Internet Use. Participants who first indicated having internet access ("Do you have access to the Internet?") then reported their frequency of internet use ("How often do you use the internet for the following purposes?") for seven different online activities, from 1 (*daily*) to 6 (*never*): (1) "Contact with friends and relatives (e.g., e-mail, Facebook, chat, video telephony)"; (2) "Search for new social contacts (e.g., friends, partner, like-minded persons)"; (3) "Search for information (e.g., news, advisers, Wikipedia)"; (4) "Banking business (e.g., online banking)"; (5) "Entertainment (e.g., listening to music, watching films, playing games, watching television)"; (6) "Shopping (e.g., Amazon, eBay, online pharmacy)"; (7) "Create own contents (e.g., texts, photos, music, uploading videos for blogs, websites, online selling)". Specific internet uses were based on each item, while general internet use was based on their mean (α_{T1} = .69, α_{T2} = .70).

Covariates. Chronological age, gender (1 = *female*), marital status (1 = *married*), occupational status (1 = *employed*), living arrangements (1 = *alone*), region (1 = *East Germany*), education, and income assessed at baseline were included as covariates. Region was reported as East or West Germany. Education was based on the International Standard Classification of Education (ISCED; United Nations Educational, Scientific and Cultural Organization [UNESCO], 1997) with three levels: low (ISCED 0-2), medium (ISCED 3-4), and high (ISCED 5-6). Income was based on the monthly net household income in euros, which was log transformed to correct skewness.

5.3.1.3. Analysis

A two-wave autoregressive cross-lagged panel design was used to test the reciprocal relationships between internet use behaviours and functional ability, social support, and views on ageing factors (Cole & Maxwell, 2003; Little et al., 2007). Structural equation modelling was performed using Mplus 8 (Muthén & Muthén, 1998-2017) with robust maximum likelihood estimation (MLR), which provides standard errors and chi-square test statistics that are robust to nonnormality. Model fit was examined based on the Chi-Square Test (χ^2), the

Comparative Fit Index (CFI), the Tucker-Lewis Index (TLI), the Root Mean Square Error of Approximation (RMSEA), and the Standardized Root Mean Square Residual (SRMR). CFI and TLI values of .90 or higher and RMSEA and SRMR values of .08 or lower were considered indicative of acceptable fit (Browne & Cudeck, 1993; Hu & Bentler, 1999). As the first step of the longitudinal analysis, we tested the measurement models. Constructs assessed with multiple items, namely physical functioning, perceived social support, and competence, physical, and social self-perceptions of ageing, were modelled as latent factors with their respective items serving as observed indicators. Residuals of corresponding indicators were correlated across waves. Modification indices suggested correlating the residuals of items 7-8 and 8-9 within the physical functioning latent factors to improve model fit. Since these items belonged to the same measure and referred to similar activities (i.e., walking), their residuals were correlated at each wave. To ensure that the same constructs were measured across time, longitudinal measurement invariance was tested by specifying increasingly constrained models representing various degrees of invariance: configural (equal structure), weak (equal loadings), and strong (equal intercepts). Given the large sample size, CFI differences of .010 or lower were considered indicative of no substantial difference in model fit, therefore demonstrating measurement invariance (Cheung & Rensvold, 2002). Because strong invariance was demonstrated, loadings and intercepts were equated across waves in subsequent analyses (Little et al., 2007). All models had acceptable fit to the data (see Appendix, Supplementary Table C). As the second step, we tested the structural models. A single model was specified for the seven specific internet uses (Model 1). An additional model was specified for general internet use (Model 2), based on the mean score of the seven items representing specific uses. Constructs assessed with single items, general and specific internet uses, and covariates were modelled as observed variables. In each model, cross-lagged paths were established between the twelve constructs related to functional ability, social support, and views on ageing at T1 and the internet constructs at T2, as well as between the internet constructs at T1 and the twelve constructs at T2. Autoregressive paths were specified between each construct at T1 and the corresponding construct at T2. All models had acceptable fit to the data (see Appendix, Supplementary Table D). Finally, multigroup analyses were conducted to identify potential age differences by comparing middle-aged (40 to 64 years) and older adults (65 years and older). Multigroup measurement invariance was tested to ensure that the same constructs were measured across groups, demonstrating strong invariance (see Appendix, Supplementary Table C). Comparisons were based on the Wald chi-square test (Wald χ^2).

Table 5.1.

Sample characteristics at baseline in Study 6

Variable	*M* (*n*)	*SD* (%)	*Range*
Chronological age	61.12	9.80	40 – 87
Middle-aged adults	55.03 (2187)	6.26 (62.86)	40 – 64
Older adults	71.42 (1292)	4.84 (37.14)	65 – 87
Education	2.51	0.55	1 – 3
Income (log)	3.48	0.24	2.26 – 4.70
Gender (*female*)	(1691)	(48.61)	0 – 1
Marital status (*married*)	(2686)	(77.21)	0 – 1
Occupational status (*employed*)	(1654)	(47.54)	0 – 1
Living arrangements (*alone*)	(526)	(15.12)	0 – 1
Region (*East Germany*)	(1001)	(28.77)	0 – 1
General internet use	2.73	0.87	1.00 – 6.00
Specific internet uses			
Contacting friends and relatives	3.85	1.74	1 – 6
Searching for new social contacts	1.48	0.96	1 – 6
Searching for information	4.47	1.38	1 – 6
Banking	2.68	1.78	1 – 6
Entertainment	2.59	1.78	1 – 6
Shopping	2.25	1.11	1 – 6
Creating contents	1.77	1.20	1 – 6

5.3.2. Results

5.3.2.1. Descriptive Analysis

Table 5.1 presents the sample characteristics at baseline. Chronological age ranged from 40 to 87 years (*M* = 61.12). Education averaged between *medium* and *high* (*M* = 2.51), with slightly over half of participants having high education (53,09%). Almost half were female (48.61%). A similar proportion was employed (47.54%). The majority was married (77.21%) and few lived alone (15.12%). Close to one quarter lived in East Germany (28.77%). Regarding specific internet uses, searching for information (*M* = 4.47) and contacting friends and relatives

(*M* = 3.85) were the most frequently performed activities, followed by banking (*M* = 2.68), entertainment (*M* = 2.59), and shopping (*M* = 2.25). Creating contents (*M* = 1.77) and searching for new social contacts (*M* = 1.48) were the least performed.

5.3.2.2. Longitudinal Analysis

Table 5.2 presents the unstandardized (*b*) and standardized (β) estimates of the cross-lagged associations between the factors related to functional ability, social support, and views on ageing at baseline (T1) and the general and specific internet use behaviours three years later (T2). Cognitive functioning and competence self-perceptions of ageing (T1) were significantly and positively associated with wider ranges of specific internet uses (T2). Contacting friends and relatives (b = .852, p < .001), searching for information (b = .795, p < .001), banking (b = .452, p = .006), and shopping (b = .416, p = .001) were more frequent among individuals with better cognitive functioning, despite searching for new social contacts less often (b = -.322, p = .025). In turn, those with more positive self-perceptions of ageing about competence were more likely to contact others (b = .333, p < .001), search for new social bonds (b = .263, p < .001), search for information (b = .221, p = .003), engage in online banking (b = .148, p = .027), online entertainment (b = .358, p = .001), and create contents (b = .324, p < .001). Two types of received social support (T1) were also significantly and positively associated with specific internet uses (T2), although for fewer activities. Contacting others (b = .104, p < .001) and shopping (b = .045, p = .008) were more frequent among those who received informational support more often, while banking (b = .042, p = .037), shopping (b = .041, p = .005), and creating contents (b = .063, p = .001) were more likely among those who received instrumental support more frequently. Other factors (T1) were significantly related to internet use exclusively for information seeking and shopping (T2). Going online to search for information and shop was more frequent among individuals with better physical functioning (b = .250, p < .001 and b = .096, p = .024, respectively), lower perceived social support (b = -.150, p = .008 and b = -.084, p = .044, respectively), and more negative physical self-perceptions of ageing (b = -.473, p < .001 and b = -.173, p = .022, respectively). Also, looking for new relationships (b = -.207, p = .013) and online entertainment (b = -.265, p = .047) were more common among those with more negative social self-perceptions of ageing. Visual and auditory functioning, received emotional support, and subjective age (T1) had no significant associations with internet use for any purpose (T2). Overall, cognitive functioning (b = .297, p = .003) and competence self-perceptions of ageing (b = .096, p = .013) were the only factors significantly and positively associated with general internet use, further corroborating their transversal role as antecedents of internet use across multiple activities. The multigroup analysis revealed no significant differences between middle-aged and older adults in the cross-lagged associations between functional ability, social support, and views on ageing factors at baseline (T1) and internet use behaviours three years later (T2).

Table 5.3 presents the unstandardized (*b*) and standardized (*β*) estimates of the cross-lagged associations between the general and specific internet use behaviours at baseline (T1) and the factors related to functional ability, social support, and views on ageing three years later (T2). Contacting friends and relatives was significantly and positively associated with visual (b = .010, p = .047) and auditory (b = .016, p = .001) functioning, informational (b = .034, p < .001) and emotional (b = .032, p < .001) received support, and perceived support (b = .011, p = .019). Searching for new social contacts was significantly and negatively associated with cognitive (b = -.006, p = .001) and physical (b = -.019, p = .011) functioning. Searching for information was significantly and positively associated with competence self-perceptions of ageing (b = .018, p = .005). Banking was significantly and positively associated with auditory functioning (b = .008, p = .043) and competence self-perceptions of ageing (b = .014, p = .005). Entertainment was significantly and negatively associated with received informational support (b = -.022, p = .012). Shopping was significantly associated with cognitive functioning (b = .006, p = .005) and received instrumental support (b = -.034, p = .044). Creating contents had no significant associations with internet use for any activity. Overall, general internet use was significantly and positively associated with cognitive (b = .004, p = .019), physical (b = .017, p = .015), and auditory (b = .028, p < .001) functioning, perceived social support (b = .016, p = .022), competence (b = .040, p < .001), physical (b = .015, p = .030), and social (b = .027, p = .001) self-perceptions of ageing. The multigroup analysis revealed significant differences between middle-aged and older adults in the cross-lagged associations of contacting friends and relatives (T1), namely with perceived social support (T2), Wald χ^2 (1) = 6.91, p = .009 (middle-aged: b = .020, p = .001; older: b = -.005, p = .478); with competence self-perceptions of ageing (T2), Wald χ^2 (1) = 4.43, p = .035 (middle-aged: b = .004, p = .546; older: b = -.019, p = .031); and with physical self-perceptions of ageing (T2), Wald χ^2 (1) = 3.88, p = .049 (middle-aged: b = .010, p = .068; older: b = -.007, p = .285); as well as in the cross-lagged associations of searching for information (T1), namely with visual functioning (T2), Wald χ^2 (1) = 5.59, p = .018 (middle-aged: b = -.019, p = .029; older: b = .013, p = .205); and with auditory functioning (T2), Wald χ^2 (1) = 6.05, p = .014 (middle-aged: b = .017, p = .031; older: b = -.015, p = .149).

Table 5.2.

Unstandardized (b) and standardized (β) estimates of the cross-lagged associations between functional ability, social support, and views on ageing variables at T1 and internet use variables at T2

	Internet T2 Specific Uses *(Model 1)*														Internet T2 General Use *(Model 2)*	
	Contacting friends and relatives		Searching for new social contacts		Searching for information		Banking		Entertainment		Shopping		Creating contents			
	b	(*β*)	*b*	(*β*)	*b*	(*β*)	*b*	(*β*)	*b*	(*β*)	*b*	(*β*)	*b*	(*β*)	*b*	(*β*)
Functional ability																
Cognitive functioning T1 → Internet T2	**.852*****	(.062)	**-.322***	(-.038)	**.795*****	(.073)	**.452****	(.032)	.244	(.016)	**.416****	(.047)	.222	(.024)	**.297****	(.042)
Physical functioning T1 → Internet T2	.048	(.012)	.002	(.001)	**.250*****	(.080)	-.037	(-.009)	.140†	(.033)	**.096***	(.038)	.072	(.027)	.057†	(.028)
Visual functioning T1 → Internet T2	-.032	(-.008)	-.047	(-.020)	-.008	(-.002)	-.012	(-.003)	.015	(.004)	-.060†	(-.025)	-.069	(-.027)	-.019	(-.010)
Auditory functioning T1 → Internet T2	.087	(.021)	.031	(.012)	.082	(.025)	.028	(.006)	-.010	(-.002)	.054†	(.020)	.056	(.020)	.037	(.017)
Social support																
Received informational support T1 → Internet T2	**.104*****	(.058)	.023	(.021)	.042†	(.029)	.027	(.015)	-.038	(-.019)	**.045****	(.039)	.026	(.021)	.018	(.019)
Received instrumental support T1 → Internet T2	.031	(.018)	.013	(.012)	.024	(.017)	**.042***	(.024)	.006	(.003)	**.041****	(.036)	**.063****	(.054)	.020†	(.022)
Received emotional support T1 → Internet T2	.028	(.015)	-.028	(-.024)	.000	(.000)	.022	(.011)	.005	(.002)	-.003	(-.002)	-.034	(-.026)	.002	(.002)
Perceived social support T1 → Internet T2	.029	(.008)	-.041	(-.019)	**-.150****	(-.052)	-.100†	(-.027)	-.011	(-.003)	**-.084***	(-.036)	-.086	(-.036)	-.048	(-.025)
Views on ageing																
Competence self-perceptions of ageing T1 → Internet T2	**.333*****	(.099)	**.263*****	(.127)	**.221****	(.082)	**.148***	(.043)	**.358****	(.098)	.097†	(.045)	**.324*****	(.144)	**.096***	(.055)
Physical self-perceptions of ageing T1 → Internet T2	-.107	(-.025)	-.018	(-.007)	**-.473*****	(-.139)	-.079	(-.018)	-.113	(-.025)	**-.173***	(-.063)	-.093	(-.033)	-.094†	(-.042)
Social self-perceptions of ageing T1 → Internet T2	-.168	(-.048)	**-.207***	(-.096)	.153	(.055)	.049	(.014)	**-.265***	(-.070)	.079	(.035)	-.150†	(-.064)	-.007	(-.004)
Subjective age T1 → Internet T2	.083	(.012)	.023	(.005)	-.088†	(-.016)	-.054	(-.008)	-.115	(-.015)	-.036	(-.008)	.016	(.003)	-.036†	(-.010)

Note. T1 = Time 1 (2014), T2 = Time 2 (2017). Values in bold are significant at $p < .05$. † $p < .10$. * $p < .05$. ** $p < .01$. *** $p < .001$.

Table 5.3.

Unstandardized (b) and standardized (β) estimates of the cross-lagged associations between internet use variables at T1 and functional ability, social support, and views on ageing variables at T2

	Internet T1 Specific Uses *(Model 1)*														Internet T1 General Use *(Model 2)*	
	Contacting friends and relatives		Searching for new social contacts		Searching for information		Banking		Entertainment		Shopping		Creating contents			
	b	(*β*)	*b*	(*β*)	*b*	(*β*)	*b*	(*β*)	*b*	(*β*)	*b*	(*β*)	*b*	(*β*)	*b*	(*β*)
Functional ability																
Internet T1 → Cognitive functioning T2	.001	(.015)	**-.006****	(-.045)	.001	(.015)	.001	(.020)	-.001	(-.014)	**.006****	(.048)	.000	(-.004)	**.004***	(.031)
Internet T1 → Physical functioning T2	.006	(.023)	**-.019***	(-.038)	.010†	(.031)	.005	(.020)	-.006	(-.021)	.009	(.022)	-.001	(-.003)	**.017***	(.031)
Internet T1 → Visual functioning T2	**.010***	(.039)	-.009	(-.018)	-.005	(-.014)	.003	(.011)	.001	(.003)	.009	(.022)	-.005	(-.013)	.011	(.022)
Internet T1 → Auditory functioning T2	**.016****	(.066)	-.010	(-.024)	.004	(.013)	**.008***	(.033)	-.003	(-.013)	.012†	(.031)	-.007	(-.019)	**.028*****	(.058)
Social support																
Internet T1 → Received informational support T2	**.034*****	(.066)	.004	(.005)	-.004	(-.006)	-.007	(-.014)	**-.022***	(-.044)	.017	(.021)	.002	(.003)	.033†	(.032)
Internet T1 → Received instrumental support T2	.016	(.029)	.008	(.008)	.001	(.002)	-.003	(-.006)	-.012	(-.023)	**-.034***	(-.039)	.011	(.014)	.000	(.000)
Internet T1 → Received emotional support T2	**.032*****	(.066)	-.018	(-.020)	-.005	(-.008)	-.006	(-.013)	-.004	(-.008)	.017	(.022)	-.010	(-.014)	.024	(.025)
Internet T1 → Perceived social support T2	**.011***	(.040)	-.007	(-.014)	-.006	(-.017)	-.001	(-.003)	-.001	(-.003)	.013†	(.031)	.006	(.015)	**.016***	(.030)
Views on ageing																
Internet T1 → Competence self-perceptions of ageing T2	-.006	(-.020)	-.002	(-.005)	**.018****	(.048)	**.014****	(.048)	-.004	(-.015)	.002	(.004)	.004	(.009)	**.040*****	(.067)
Internet T1 → Physical self-perceptions of ageing T2	.003	(.012)	-.003	(-.007)	.001	(.002)	.007†	(.033)	-.005	(-.020)	.007	(.020)	.000	(-.001)	**.015***	(.031)
Internet T1 → Social self-perceptions of ageing T2	.010†	(.034)	.004	(.008)	.003	(.008)	.009†	(.034)	-.007	(-.026)	.011	(.025)	.000	(.001)	**.027****	(.047)
Internet T1 → Subjective age T2	.003	(.022)	-.005	(-.017)	-.006†	(-.032)	.001	(.005)	.003	(.021)	-.005	(-.022)	-.002	(-.010)	-.006†	(-.019)

Note. T1 = Time 1 (2014), T2 = Time 2 (2017). Values in bold are significant at $p < .05$. † $p < .10$. * $p < .05$. ** $p < .01$. *** $p < .001$.

Table 5.4.

Unstandardized (b) and standardized (β) estimates of the main associations between competence self-perceptions of ageing at T1 and internet use at T2 mediated by cognitive functioning

	Internet T2 Specific Uses *(Model 3)*														Internet T2 General Use *(Model 4)*	
	Contacting friends and relatives		Searching for new social contacts		Searching for information		Banking		Entertainment		Shopping		Creating contents			
	b	(*β*)	*b*	(*β*)	*b*	(*β*)	*b*	(*β*)	*b*	(*β*)	*b*	(*β*)	*b*	(*β*)	*b*	(*β*)
Competence self-perceptions of ageing T1 → Cognitive function T2	**.010***	(.041)	**.010***	(.041)	**.010***	(.041)	**.010***	(.041)	**.010***	(.041)	**.010***	(.041)	**.010***	(.041)	**.010***	(.041)
Cognitive functioning T1 → Internet T2	**.875*****	(.064)	**-.304***	(-.036)	**.809*****	(.074)	**.463****	(.033)	.259	(.017)	**.425****	(.048)	.239	(.026)	**.307****	(.043)
Direct: Competence self-perceptions of ageing T1 → Internet T2	**.339*****	(.101)	**.259*****	(.125)	**.225****	(.084)	**.151***	(.044)	**.356****	(.098)	.100†	(.046)	**.321*****	(.143)	**.097***	(.055)
Indirect: Competence self-perceptions of ageing T1 → Internet T2	**.009***	(.003)	-.003	(-.001)	**.008***	(.003)	.005†	(.001)	.003	(.001)	**.004***	(.002)	.002	(.001)	.003†	(.002)
Total: Competence self-perceptions of ageing T1 → Internet T2	**.348*****	(.104)	**.256*****	(.124)	**.234****	(.087)	**.156***	(.045)	**.359****	(.099)	.104†	(.048)	**.324*****	(.144)	**.100****	(.057)

Note. T1 = Time 1 (2014), T2 = Time 2 (2017). Values in bold are significant at $p < .05$. † $p < .10$. * $p < .05$. ** $p < .01$. *** $p < .001$.

5.3.2.3. Complementary Mediation Analysis

Because competence self-perceptions of ageing and cognitive functioning stood out as antecedents of internet use, each one preceding an ample range of online activities, we further explored the interplay between these factors in determining internet use. According to the stereotype embodiment theory (Levy, 2009), stereotypical views of age and ageing become embodied through psychological, physiological, and behavioural mechanisms, ultimately influencing functioning and health (Brothers et al., 2021). Various longitudinal studies have shown that positive self-perceptions of ageing relate to better cognitive functioning over time (Levy et al., 2012; Robertson et al., 2016; Seidler & Wolff, 2017). This suggests that competence self-perceptions of ageing may indirectly influence internet use through cognition. Therefore, we tested the mediating role of cognitive functioning in the relationship between competence self-perceptions of ageing and internet use.

To test longitudinal mediation (Cole & Maxwell, 2003; Little et al., 2007), the structural models were re-specified with additional cross-lagged paths between competence self-perceptions of ageing at T1 and cognitive functioning at T2, as well as between cognitive functioning at T1 and competence self-perceptions of ageing at T2 (Models 3 and 4). Bias-corrected bootstrapping with 1000 resamples and maximum likelihood estimation (ML) was used to generate estimates and 95% confidence intervals (CI) that indicate the significance of indirect effects (Cheung & Lau, 2008).

Table 5.4 presents the unstandardized (b) and standardized (β) estimates of the main associations that constitute the mediation of cognitive functioning in the relationships between competence self-perceptions of ageing (T2) and general and specific internet use behaviours (T1). As expected, competence self-perceptions of ageing at T1 were significantly and positively associated with cognitive functioning at T2, indicating that individuals with more positive perceptions about their competence as they age were more likely to have better cognitive functioning three years later. The indirect associations between competence self-perceptions of ageing (T1) and internet use (T2) through cognitive functioning were significant and positive for contacting friends and relatives (b = .009, p = .041, 95% CI [.002, .020]) searching for information (b = .008, p = .036, 95% CI [.002, .019]), and shopping (b = .004, p = .049, 95% CI [.001, .010]), suggesting that more positive self-perceptions of ageing about competence relate to better cognitive functioning, which in turn relate to more frequent internet use to contact others, seek information, and shop. Also, the indirect associations with online banking (b = .005, p = .075, 95% CI [.001, .013]) and general internet use (b = .003, p = .063, 95% CI [.001, .008]) were marginally significant and positive. A multigroup analysis revealed no significant differences between middle-aged and older adults in the indirect associations, nor in the cross-lagged association between competence self-perceptions of ageing (T1) and cognitive functioning (T2).

Regarding the mediating role of cognitive functioning in the relationships between general and specific internet use behaviours (T1) and competence self-perceptions of ageing (T2), the cross-lagged association between cognitive functioning (T1) and competence self-perceptions of ageing (T2) and all indirect associations were nonsignificant.

5.4. Discussion

To understand which factors facilitate or prevent internet engagement in late adulthood, the present study sought to identify potential determinants of internet use for specific purposes over three years, while controlling for relevant sociodemographic predictors. Among twelve factors related to functional ability, social support, and views on ageing, cognitive functioning and competence self-perceptions of ageing emerged as the most influential and transversal antecedents, given their widely complementary associations with internet use across multiple activities. Consistently with the notion that navigating the internet is cognitively demanding and can be hindered by age-related cognitive declines, better cognitive functioning preceded contacting friends and relatives, searching for information, banking, and shopping more frequently three years later. This complements past cross-sectional and longitudinal evidence linking better cognitive performance with greater general internet use (Czaja et al., 2006; Freese et al., 2006; Kamin & Lang, 2020; Yu & Fiebig, 2020) by further elucidating which online behaviours are particularly dependent on cognition. Designing web interfaces and training programs that minimize cognitive demands should thus facilitate internet engagement, especially for this set of activities (Rogers, Stronge, et al., 2005).

Furthermore, perceiving the ageing process as involving maintained or increased capabilities, such as the ability to learn new things, preceded contacting others, searching for new social contacts, seeking information, banking, engaging in online entertainment, and creating contents more frequently three years later. This confirms longitudinally that positive self-perceptions of ageing may encourage internet use (Cody et al., 1999) and clarifies which online behaviours are more likely to be facilitated by these perceptions. As implied by the stereotype embodiment theory (Levy, 2003, 2009), internalizing beliefs that ageing entails competence gains may enhance individuals' perceptions about their own capabilities, including their ability to use the internet, thus increasing the likelihood of going online for multiple purposes. Because stereotypical beliefs about older people and the ageing process shape how they perceive themselves as ageing individuals (Kornadt & Rothermund, 2012), interventions aiming to promote these activities should consider countering negative age stereotypes, particularly those related to competence (Brothers & Diehl, 2017; Levy et al., 2014; for reviews, see Burnes et al., 2019; Marques et al., 2020).

The mediating role of cognitive functioning in the relationship between competence self-perceptions of ageing and internet use further elucidates the interplay between these determining factors. Replicating past longitudinal findings (Robertson et al., 2016; Seidler & Wolff, 2017) and corroborating theoretical assumptions that stereotypical views of age and ageing are internalized and embodied, influencing functioning and health in late adulthood (Levy, 2009; Wurm et al., 2017), individuals with more positive self-perceptions of ageing about competence were more likely to have better cognitive functioning three years later. In turn, better cognition preceded higher internet use for contacting others, information seeking, and shopping. At least for these activities, competence self-perceptions of ageing may indirectly facilitate internet use by contributing to better cognitive functioning. To some extent, interventions should prioritize targeting self-perceptions of ageing given their potential to influence cognition.

Besides cognitive functioning and competence self-perceptions of ageing, social support may also promote internet engagement for certain purposes. Receiving informational support preceded contacting friends and relatives and shopping more frequently three years later, while receiving instrumental support preceded banking, shopping, and creating contents more often. This suggests that obtaining support in the form of advice and practical assistance may facilitate internet use for some activities, arguably the most challenging ones, consistently with past qualitative studies on social support and technology use in late adulthood (Francis et al., 2018; Luijkx et al., 2015). Interestingly, the mere belief that support is available may not be enough for individuals to go online. In fact, lower expectations about the availability of social support preceded more information seeking and shopping behaviours, perhaps as a way of coping with the perceived lack of help from others. This seemingly counterproductive influence of perceived support may stem from individuals’ reluctance to ask for support to avoid burdening others, even if they perceive this support to be available (Luijkx et al., 2015). Nonetheless, perceiving its availability may be a precondition to request and receive social support (Kamin et al., 2020).

Other functional domains seem considerably less determinant than cognition. Only better physical functioning preceded greater internet use for information searching and online shopping, possibly for being more physically challenging to perform successfully. Navigating the internet may be less affected by visual, auditory, and physical limitations as access is possible through various devices, requiring distinct forms of interaction with different perceptual and physical demands. Indeed, older age groups are increasingly going online primarily through mobile devices (Pew Research Center, 2019), which tend to be seen as easier to use (Tsai et al., 2017; Tsai et al., 2015). Apart from self-perceptions of ageing about competence, other dimensions of views on ageing were also less influential. Those who perceived their own ageing as involving social losses were more likely to search for new relationships and engage in online entertainment, while those who perceived physical declines as part of their ageing experience engaged in information searching and online shopping more often. Taken together, these findings suggest that individuals may perform certain activities to cope with losses and declines perceived to be associated with their ageing process, even though competence-related self-perceptions of ageing are the primary drivers of online engagement.

Internet use also has the potential to determine functional ability, social support, and views on ageing. Adding to previous longitudinal studies showing reciprocal relationships between general internet use and cognitive performance (Kamin & Lang, 2020; Yu & Fiebig, 2020), our findings further suggest that learning and engaging in online shopping may be particularly helpful in preserving cognitive functioning. Consistently with past cross-sectional (Fuss et al., 2019) and intervention studies (Cody et al., 1999; Czaja et al., 2018), our findings confirm longitudinally that internet use may also determine social support. Those who contact friends and family over the internet more frequently are more likely to receive informational and emotional support, as well as to perceive support to be available among middle-aged adults. This reinforces the argument that higher levels of social support are primarily attributable to the internet's potential to facilitate communication and enable supportive relationships between individuals and their social networks (Czaja, 2017b). Besides their determinant role, self-perceptions of ageing related to competence also seem to improve with internet use for information searching and online banking, as well as for contacting others among older adults. Given its potential to support users in a multitude of ways (Czaja, 2017a), being online is likely to contribute to their sense of competence as ageing individuals, with important benefits to their health and well-being (Westerhof et al., 2014).

Some limitations should be acknowledged. Firstly, although our study comprised an ample range of relevant factors expected to predict internet use, including many sociodemographic covariates, the potential influence of unknown confounders cannot be entirely ruled out, so causal inferences should be made with caution. Secondly, only individuals with internet access reported their internet use behaviours, which limits the generalizability of our findings. Nonetheless, the majority of potential participants (i.e., more than two thirds) indicated having internet access and were therefore included in the sample. Lastly, some measures may have been insufficiently comprehensive to fully grasp the determinant role of their corresponding constructs. For example, although dexterity difficulties can be expected to be particularly detrimental to internet use (Rogers, Stronge, et al., 2005), the physical functioning measure assessed both fine and gross dimensions of motor ability. Unlike received support, perceived support could not be broken down into different types, thus limiting their direct comparison. Domain specific measures assessing internet-related social support would also be informative (Kamin et al., 2020). The large number of significant antecedents of information searching and shopping compared to other activities also suggests the need to distinguish the different types of information and products that people seek and buy online. These and other measures would benefit from greater specificity and multidimensionality in future studies.

Several strengths should also be emphasized. Our study examined the joint contribution of multiple, often overlooked determinants of internet use, highlighting the most influential. We focused on an extensive set of online activities to understand whether and how different factors facilitate or prevent specific uses. The longitudinal design allowed clarifying past, largely cross-sectional evidence and identifying mutual influences in some cases. In sum, our findings underscore the importance of considering stereotypical views on age and ageing (Cody et al., 1999; Lagacé et al., 2015; Chapter 4: Mariano, Marques, et al., 2021a; Chapter 3: Mariano, Marques, Ramos, Gerardo, et al., 2021; Chapter 2: Mariano et al., 2020) and age-related changes in cognitive functioning (Czaja et al., 2006; Freese et al., 2006) when promoting internet use in late adulthood.

CHAPTER 6.

General Discussion

Older adults tend to be negatively stereotyped regarding their competence (Cuddy & Fiske, 2002), including in the realm of technology (Ryan et al., 1992). The present thesis investigated how stereotypical perceptions about older people and the ageing process relate to individuals' behavioural engagement with information and communication technology in late adulthood. Across six studies testing the predictions of two major theoretical approaches to the effects of stereotypes on behaviours, we found general support for the argument that age stereotypes influence technology use among older age groups.

6.1. Stereotype Threat

Across three studies (1 to 3), higher levels of stereotype threat were associated with lower rates of technology use. Older adults reported experiencing stereotype threat in the technology domain in general (Study 2) and in the computer domain in particular (Studies 1 and 3). Experiencing stereotype threat was negatively related to different types of technology use, namely desktop and laptop computer use (Studies 1 and 2), tablet use (Study 3), and internet use (Study 2). This was observed using longitudinal (Study 1) and cross-sectional (Studies 2 and 3) designs and more objective (Study 3) and subjective (Studies 1 and 2) measures of use behaviour. This relationship was mediated more distally by anxiety (Study 3) and perceived ease of use (Studies 2 and 3) and more proximally by perceived usefulness and behavioural intention (Studies 2 and 3).

Consistently with stereotype threat theory (Steele, 1997; Steele et al., 2002), these findings suggest that the threat of confirming negative stereotypes about the technological competence of their age group leads older adults to avoid and thus underuse different kinds of information and communication technology. In line with age-based stereotype threat research showing that stereotype threat elicits anxiety and negative affect (Abrams et al., 2008; Abrams et al., 2006; Chasteen et al., 2005; Hess et al., 2009; Swift et al., 2013), experiencing stereotype threat in technological domains induces anxious feelings about current or future use of technology among older adults. According to the technology acceptance model (Davis, 1989; Venkatesh, 2000), this greater anxiety undermines their perceptions about how easy it is and, indirectly, how useful it is to use technology. These lower expectations about easiness and usefulness then jointly contribute to lower use intentions and ultimately lower use behaviours.

6.2. Stereotype Embodiment

Across three studies (4 to 6), more positive self-perceptions of ageing were associated with higher levels of technology use. Self-perceptions of ageing, both more general (Studies 4 and 5) and more specific to competence (Study 6), were positively related to general computer use (Studies 4 and 5) and specific internet uses (Study 6). Based on longitudinal designs, this relationship was found over eight (Study 4) and three years (Studies 5 and 6) among middle-aged and older adults from the United States (Study 4) and Germany (Studies 5 and 6). Importantly, self-perceptions of ageing were associated with use behaviours above and beyond other potential determinants related to functional ability, social support, and views on ageing (Study 6). Cognitive functioning mediated the relationship between self-perceptions of ageing and computer use (Studies 4 and 5) and internet use for some activities (Study 6).

As implied by stereotype embodiment theory (Levy, 2003, 2009), these findings suggest that internalizing stereotypical perceptions about older people and the ageing process endorsed earlier in life into perceptions about themselves and their own ageing later in life (Kornadt & Rothermund, 2012; Rothermund & Brandtstädter, 2003) determines older adults' engagement with information and communication technology. Consistently with evidence that age stereotypes and self-perceptions of ageing influence cognitive functioning (Levy et al., 2012; Robertson et al., 2016; Seidler & Wolff, 2017), internalizing negative beliefs about age and ageing may precipitate cognitive declines in late adulthood, possibly by determining lifestyle choices, stress levels, or depressive symptoms (for a discussion, see Seidler & Wolff, 2017). The prominent role of self-perceptions of ageing specifically related to competence further suggests that the internalization of stereotypical perceptions about the diminished competence of their age group (Cuddy & Fiske, 2002) can weaken older adults' confidence in their own capabilities (Klusmann et al., 2019). Ultimately, these lower levels of cognitive functioning and technology self-efficacy end up hindering their use behaviours (Czaja et al., 2006; Mitzner et al., 2019).

6.3. Integrating Stereotype Threat and Stereotype Embodiment

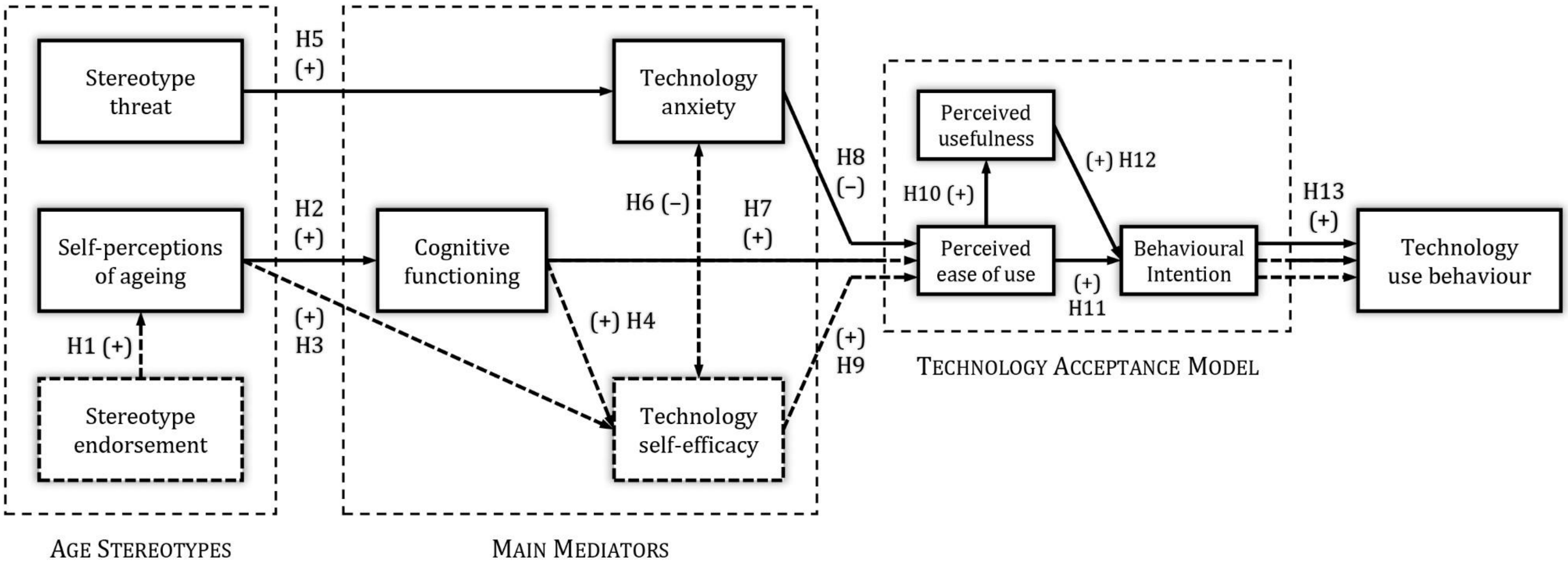
By confirming the predictions of both theoretical approaches, these findings suggest that age stereotypes determine technology use in late adulthood through distinct, yet complementary processes. Based on stereotype threat, stereotype embodiment, and technology acceptance frameworks, as well as on empirical evidence from the present work and past research, we propose an integrated model that describes the influence of age stereotypes on technology use in late adulthood, which is presented in Figure 6.1. The dashed lines represent constructs and relationships that were not included or tested in the six studies.

Stereotype embodiment theory asserts that this influence is primarily dispositional (trait), as it is rooted on an internalization process that unfolds throughout the lifespan (Levy, 2009). Stereotypical perceptions about age and ageing endorsed in younger ages are assimilated into perceptions about oneself as an ageing individual in older ages (Kornadt & Rothermund, 2012; Rothermund & Brandtstädter, 2003). In turn, stereotype threat theory asserts that this influence is primarily situational (state). Simply knowing that the stereotype exists is sufficient to experience the threat of behaviourally confirming it, regardless of personally held beliefs about their ingroup (Steele et al., 2002). Hence, endorsing positive age stereotypes, particularly those about competence, should only relate to positive self-perceptions of ageing (Hypothesis 1).

Furthermore, according to stereotype embodiment theory, age stereotypes operate primarily through unconscious and cognitive (*cold*) processes (Levy, 2009; Wheeler & Petty, 2001). In particular, the internalization of competence stereotypes likely shapes individuals' beliefs about their ability to perform successfully (Klusmann et al., 2019), especially in domains perceived to require high levels of competence, such as technology (Ryan & Heaven, 1988). Moreover, internalizing age stereotypes into self-perceptions of ageing ultimately impacts functioning and health (Brothers et al., 2021), including cognitive functioning (Studies 4 to 6; Levy et al., 2012; Robertson et al., 2016; Seidler & Wolff, 2017). Positive self-perceptions of ageing should thus relate to both better cognitive functioning (Hypothesis 2) and higher technology self-efficacy (Hypothesis 3). Because older adults can base their self-efficacy beliefs on their cognitive abilities (Czaja et al., 2006), better cognitive functioning should also relate to higher technology self-efficacy (Hypothesis 4). In turn, according to stereotype threat theory, age stereotypes operate primarily through motivational and affective (*hot*) processes (Wheeler & Petty, 2001). Particularly, experiencing stereotype threat should elicit greater anxiety among older adults (Abrams et al., 2008; Abrams et al., 2006), including anxious feelings about current or future use of technology (Study 3). Greater stereotype threat should thus relate to higher technology anxiety (Hypothesis 5). In sum, while technology anxiety should be the main mediator of stereotype threat effects on technology use, cognitive functioning and technology self-efficacy should be the main mediators of the effects of stereotype endorsement and self-perceptions of ageing.

Figure 6.1.

Integrated model describing the influence of age stereotypes on technology use among older adults



Note. The dashed lines represent constructs and relationships that were not included or tested in the six studies.

Yet, according to social cognitive theory (Bandura, 1986, 1997), anxiety and self-efficacy have reciprocal relationships (Hypothesis 6). As stated by Bandura (1997, p. 152), “perceived inefficacy to cope with potential threats leads people to approach such situations anxiously, and experience of disruptive arousal may further lower their sense of efficacy that they will perform skilfully”. In other words, as individuals experience higher levels of anxiety, they may report lower self-efficacy. Inversely, as their self-efficacy levels increase, individuals may report a corresponding decrease in anxiety. Consistently, research has found support for the negative relationship between technology-related self-efficacy and anxiety, including among older adults (Compeau & Higgins, 1995; Compeau, Higgins, & Huff, 1999; Czaja et al., 2006; Fagan, Neill, & Wooldridge, 2004). Given this mutual influence, although stereotype threat has been shown to relate to decreased self-efficacy and performance expectations (Bouazzaoui et al., 2016; Desrichard & Köpetz, 2005; Hess et al., 2009), this relationship is likely mediated by increased anxiety (Chung et al., 2010). Likewise, although self-perceptions of ageing have been shown to relate to decreased technology anxiety (Yoon et al., 2016), this relationship is likely mediated by increased self-efficacy.

Better cognitive functioning (e.g., Studies 4 to 6; Czaja et al., 2006; Mitzner et al., 2019), lower technology anxiety (e.g., Czaja et al., 2006), and higher technology self-efficacy (e.g., Mitzner et al., 2019), have all been shown to directly relate to greater technology use among older adults. Yet, according to the technology acceptance model (Davis, 1989) and subsequent extensions (Ke Chen & Alan Hoi Shou Chan, 2014; Venkatesh, 2000), better cognition (e.g., Ziefle & Bay, 2006), lower anxiety (e.g., Study 3; Phang et al., 2006), and higher self-efficacy (e.g., Ke Chen & Alan H. S. Chan, 2014) contribute to positive perceptions about the ease of using technology (Hypothesis 7, 8, and 9, respectively). As previously discussed, perceived ease of use should positively relate to perceived usefulness (Hypothesis 10), both should positively relate to behavioural intention (Hypothesis 11 and 12), which should then positively relate to use behaviour (Hypothesis 13).

Integrating stereotype threat, stereotype embodiment, and other relevant theories raises additional questions. Bandura (1997) argues that, despite their mutual influence, self-efficacy is the primary determinant of behaviour relative to anxiety, with individuals being more likely to act based on their self-efficacy beliefs than to rely on their anxious feelings. Consistently, research exploring anxiety and self-efficacy as joint predictors of technology use suggests that self-efficacy is the most reliable determinant of use behaviour compared to anxiety (Compeau & Higgins, 1995; Compeau et al., 1999; Czaja et al., 2006; Fagan et al., 2004). To some extent, this suggests that stereotype internalization as postulated by stereotype embodiment theory may be the primary process through which age stereotypes influence use behaviours, since technology self-efficacy is likely to be its main mediator. Still, existing evidence suggests that stereotype threat can erode self-efficacy (Bouazzaoui et al., 2016). For instance, Koch et al. (2008) found that female students under stereotype threat attributed their failure in technology-based tasks to their own inability, an internal attribution that probably undermines technology self-efficacy on the long run.

Along with our findings, these hypotheses further emphasize the relevance of integrating stereotype threat and stereotype embodiment theories to better understand technology use among older adults. Future research should test the proposed integrated model, while also examining the strength of the associations of threat-related and embodiment-related constructs with technology use.

6.4. Potential Interventions

Our findings provide valuable insights on how to effectively counter the negative influence of age stereotypes in the technological domain in late adulthood. Also based on stereotype threat and stereotype embodiment lines of research, as well as studies on ageism more generally, two main intervention strategies may be particularly promising and transversal to both theories: promoting positive contacts between younger and older generations and promoting positive views on age and ageing (for reviews, see Burnes et al., 2019; Marques et al., 2020).

6.4.1. Positive Intergenerational Contact

Intergroup contact theory (Allport, 1954; Pettigrew, 1998) and research (for reviews see, Pettigrew & Tropp, 2006; Pettigrew et al., 2011) suggest that contact with outgroup members improves attitudes towards the outgroup as a whole. In addition to direct interactions, these positive attitudinal outcomes can result from indirect forms of intergroup contact, including extended contact (i.e., simply knowing that ingroup members have positive relationships with outgroup members; Wright et al., 1997) and imagined contact (i.e., mentally simulating positive encounters with outgroup members; Turner et al., 2007). Despite being more effective in reducing prejudice, intergroup contact can improve both affective and cognitive outcomes (Tropp & Pettigrew, 2005).

Indeed, intergenerational contact research suggests that extended contact (e.g., Drury et al., 2016), imagined contact (e.g., Turner et al., 2007), and direct contact, especially contact quality rather than contact frequency (e.g., Drury et al., 2016; Schwartz & Simmons, 2001), have the potential to improve attitudes towards older adults at younger ages, including stereotypical perceptions (Caspi, 1984; Schwartz & Simmons, 2001). Furthermore, experienced and imagined intergenerational contact have been found to reduce stereotype threat effects on older adults' cognitive performance by reducing anxiety (Abrams et al., 2008; Abrams et al., 2006). Thus, interventions and policies facilitating positive intergenerational contact, either in direct or indirect forms, can be beneficial for both present and future older adults, including in the technological domain, in at least two important ways: (1) increasing the likelihood of endorsing positive age stereotypes in younger ages, eventually internalizing them as positive self-perceptions in older ages (stereotype embodiment theory); and (2) decreasing the likelihood of experiencing the adverse effects of stereotype threat on behavioural outcomes in late adulthood (stereotype threat theory).

6.4.2. Positive Views on Age and Ageing

Intervention studies have also shown that presenting positive information about older people and the ageing process effectively enhances older adults' age stereotypes and self-perceptions of ageing, subsequently shaping functioning and behaviour over time, such as physical functioning and activity (Brothers & Diehl, 2017; Levy et al., 2014; Wolff et al., 2014). For example, in line with stereotype embodiment theory, Levy et al. (2014) found that the implicit exposure to positive age stereotypes at weekly intervals over four weeks improved age stereotype endorsement, which subsequently improved self-perceptions of ageing, which finally improved physical functioning. Similar interventions promoting positive age stereotypes and self-perceptions of ageing, especially those associated with competence, may thus facilitate technology use among older adults, both present and future, partly by contributing to preserve cognitive functioning.

Likewise, exposure to ingroup role models can lessen stereotype threat effects (Marx & Goff, 2005; Marx & Roman, 2002; McIntyre et al., 2003), especially when individuals perceive them as competent in the relevant domain (e.g., Marx & Roman, 2002), as similar to themselves (e.g., Marx & Ko, 2012), and when presented with multiple role models (e.g., McIntyre et al., 2005). Self-efficacy should play a mediating role (Bandura, 1997), as being presented with role models improves individual beliefs about their own ability to perform successfully, subsequently improving task performance (Bagès et al., 2016). Despite the lack of age-based stereotype threat research on role models, positive portrayals of older people as competent, including in the technological domain, should attenuate its negative effects on older adults' technology use.

Still, because past studies did not focus on older age groups as targets or technology use behaviours as outcomes, future research should test the effectiveness of these strategies in ameliorating the adverse effects of age-related stereotype threat and stereotype internalization in the technological domain, while also identifying their underlying mechanisms.

6.5. Potential Impacts

Two aspects of our social world have become even more salient with the COVID-19 pandemic: (1) older people are stereotypically perceived in negative ways (e.g., vulnerable), especially regarding their competence (Swift & Chasteen, 2021); and (2) contemporary societies are increasingly dependent on technology (e.g., telework), with digitally excluded individuals facing greater challenges (Beaunoyer et al., 2020). Findings from six studies suggest that these seemingly unrelated trends actually converge towards the digital exclusion of older adults. Both the fear of confirming negative stereotypes about their age group (stereotype threat, Studies 1 to 3) and the internalization of these age stereotypes into perceptions about themselves and their ageing experience (stereotype embodiment, Studies 4 to 6) can turn older adults away from information and communication technology, preventing or at least hindering its regular use in their daily lives. This detachment from the technological domain has important implications for older adults at different levels. On one hand, it keeps them from taking full advantage of the benefits of using technology to their social, emotional, functional, and subjective health and well-being (e.g., Chopik, 2016; Hartanto et al., 2020; Heo et al., 2015). On the other hand, it limits their ability to live independently in an increasingly digital society that, more than ever before, expects its citizens to use technology in various contexts. Taken together, these findings reinforce the notion that ageist stereotypes affect older adults in a myriad of ways and in a multitude of domains, ultimately impacting their quality of life (for reviews, see Barber, 2020; Levy, 2003).

The scientific relevance of this work is substantial and manifold. Research on the influence of age stereotypes in late adulthood has largely focused on health and functioning as the main outcomes (for meta-analyses, see Lamont et al., 2015; Westerhof et al., 2014). Hence, most studies have focused on how to minimize their effects on cognitive and physical performance and functioning (e.g., Abrams et al., 2008; Abrams et al., 2006; Levy, 1996; Levy et al., 2014). Simultaneously, research examining the determinants of technology use by older adults has rarely taken into account the role of stereotypical perceptions about age and ageing (for reviews, see Chen & Chan, 2011; Wagner et al., 2010). Adding to this literature, associations between age stereotype-related constructs and technology use in late adulthood were repeatedly found across six studies, extending previous research on stereotype threat and stereotype embodiment, as well as on technology acceptance and usage by older adults. Incidentally, these findings also provide evidence that technology use contributes to health and well-being in this age group (e.g., cognitive functioning, Studies 4 to 6), further emphasizing the need to address the adverse effects of age stereotypes in the technological domain.

Importantly, this work contributes to inform policies and interventions. Fostering positive intergenerational contact and spreading positive information about age and ageing (for reviews, see Burnes et al., 2019; Marques et al., 2020) emerge as promising strategies to promote technology use behaviours among older age groups, ultimately contributing to their quality of life. Programs encouraging direct and indirect forms of quality contact, including extended and imagined contact, between younger and older generations, from early childhood to late adulthood, should challenge the negative stereotypes about older people and their detrimental influence on technology use (e.g., Abrams et al., 2008; Abrams et al., 2006). Likewise, initiatives disseminating positive facts and portrayals of older people and the ageing process, including multiple older role models demonstrating technological competence (e.g., Marx & Roman, 2002; McIntyre et al., 2005), or information about gains and growth that come with ageing (e.g., Brothers & Diehl, 2017; Levy et al., 2014), should result in similar benefits. More research is needed to evaluate the effectiveness of these and other strategies in promoting technology engagement and, indirectly, health and well-being in late adulthood, so that relevant stakeholders can implement policies and interventions addressing the negative views on age and ageing and their insidious consequences.

Although older age groups would be the main beneficiaries of such efforts, the findings reported in this thesis are relevant to virtually everyone. Everybody ages. Most people aspire to live long and healthy lives, which inevitably means reaching old age. As future targets of ageist stereotypes in later life (and their adverse effects on health and behaviour), ageism should concern people of all ages. On one hand, age stereotypes and ageing narratives have become more negative over the last two centuries (Ng et al., 2015; Ng & Chow, 2020), a tendency that is likely to continue with population ageing (North & Fiske, 2015). On the other hand, existing and emerging technologies, such as virtual and augmented reality, artificial intelligence, and robotics, will continue to evolve and become widespread (Czaja, 2017a). As younger generations grow older and reach late adulthood, future older individuals may also experience the effects of age-based stereotype threat and stereotype internalization, possibly distancing themselves from technological innovations that will emerge in the future. This challenges the argument that the digital divide between generations is a temporary phenomenon that will eventually disappear over time, as younger cohorts who are more technologically literate grow older. In fact, this positions age-related stereotypes on a par with age-related declines as important risk factors for the digital exclusion of both present and future older adults.

The United Nations has proclaimed 2021-2030 as the Decade of Healthy Ageing (Dixon, 2021; World Health Organization [WHO], 2020), a global collaboration that brings together governments, civil society, international agencies, professionals, academia, the media, and the private sector to improve the lives of older people, their families, and the communities in which they live. Combatting ageism is one of its four priority action areas. With the publication of the *Global Report on Ageism* (Mikton et al., 2021; WHO, 2021), the World Health Organization has launched its *Global Campaign to Combat Ageism* (de la Fuente-Núñez & Officer, 2021), which aims to change the way we think (stereotypes), feel (prejudice) and act (discrimination) towards age and ageing. This constitutes an unprecedented and timely opportunity to combat ageism in its different forms, including its damaging effects. Specific efforts should be made to prevent the contribution of age stereotypes to the digital inequalities between age groups.

In conclusion, this thesis and the publications resulting from this work provide an important basis on which to build further research and novel interventions aiming to promote technology use among older adults.

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Appendix

Supplementary Table A.

Tests of measurement invariance in Study 4

Model	χ^2	*df*	CFI	TLI	RMSEA (90% CI)	SRMR
Longitudinal Invariance						
Configural	1017.436	150	.969	.956	.041 [.039, .044]	.048
Weak (or Metric)	1038.312	160	.968	.958	.040 [.038, .043]	.049
Strong (or Scalar)	1094.706	170	.967	.959	.040 [.038, .042]	.049
Multigroup Invariance						
Configural	1182.370	344	.969	.962	.038 [.035, .040]	.047
Weak (or Metric)	1198.394	351	.969	.962	.038 [.035, .040]	.048
Strong (or Scalar)	1510.852	358	.957	.950	.044 [.041, .046]	.051
Partial Strong	1471.434	357	.959	.951	.043 [.041, .045]	.051

Supplementary Table B.

Tests of measurement invariance in Study 5

Model	χ^2	*df*	CFI	TLI	RMSEA (90% CI)	SRMR
Longitudinal Invariance						
Configural	473.215	27	.967	.946	.058 [.054, .063]	.036
Weak (or Metric)	474.352	31	.968	.953	.054 [.050, .059]	.036
Strong (or Scalar)	499.085	35	.966	.956	.052 [.048, .056]	.036
Multigroup Invariance						
Configural	533.004	71	.966	.957	.052 [.048, .056]	.038
Weak (or Metric)	538.631	76	.966	.960	.050 [.046, .054]	.039
Strong (or Scalar)	745.052	81	.951	.946	.058 [.054, .062]	.048
Partial Strong	657.901	80	.958	.952	.054 [.051, .058]	.045

Supplementary Table C.

Tests of measurement invariance in Study 6

Model	χ^2	*df*	CFI	TLI	RMSEA (90% CI)	SRMR
Longitudinal Invariance						
Configural	6621.521	1517	.938	.932	.031 [.030, .032]	.037
Weak (or Metric)	6708.004	1541	.937	.932	.031 [.030, .032]	.041
Strong (or Scalar)	6757.707	1565	.937	.933	.031 [.030, .032]	.041
Multigroup Invariance						
Configural	8619.355	3141	.934	.931	.032 [.031, .032]	.044
Weak (or Metric)	8676.002	3170	.934	.931	.032 [.031, .032]	.049
Strong (or Scalar)	8986.400	3192	.930	.928	.032 [.032, .033]	.051

Supplementary Table D.

Model fit of the structural models in Study 6

Model	χ^2	*df*	CFI	TLI	RMSEA (90% CI)	SRMR
Longitudinal Analysis						
General internet use	11239.318	2958	.917	.908	.028 [.028, .029]	.040
Specific internet uses	12599.724	3624	.922	.907	.027 [.026, .027]	.037
Mediation Analysis						
General internet use	12408.963	2956	.918	.908	.030 [.030, .031]	.040
Specific internet uses	13734.145	3622	.922	.906	.028 [.028, .029]	.037

Note. χ^2 = Chi-Square Test, *df* = Degrees of Freedom, CFI = Comparative Fit Index, TLI = Tucker-Lewis Index, RMSEA = Root Mean Square Error of Approximation, CI = Confidence Interval, SRMR = Standardized Root Mean Square Residual.

Summary

Information and communication technology holds great promise in supporting the growing population of older people. Yet, older adults are less likely to use technology compared to the general population. This digital exclusion not only prevents them from taking advantage of its potential benefits, but also limits their ability to live independently in an increasingly digital world. Besides being commonly stereotyped as less technologically competent than younger age groups, older adults often mention their age or being "too old" as reasons for not using technology. Surprisingly, the potential influence of stereotypical perceptions about older people and the aging process on older adults' use behaviours remains largely understudied. This work aimed to fill this gap by investigating whether and how age stereotypes determine technology use in late adulthood. To this end, we independently tested the predictions of two major theoretical approaches to the effects of stereotypes on behaviours: stereotype threat and stereotype embodiment.

According to stereotype threat theory, the fear of confirming negative stereotypes associated with their age group may lead older adults to avoid using technology. We examined the relationship between stereotype threat and technology use across three studies conducted as part of two applied projects in the aging field. As expected, higher levels of stereotype threat were associated with lower rates of technology use (Studies 1 to 3). This was shown using longitudinal (Study 1) and cross-sectional (Studies 2 and 3) designs, objective (Study 3) and subjective (Studies 1 and 2) behavioural measures, and across different types of technology, namely desktop and laptop computer use (Studies 1 and 2), tablet use (Study 3), and internet use (Study 2). In line with the technology acceptance model, this relationship was mediated more distally by anxiety (Study 3) and perceived ease of use (Studies 2 and 3) and more proximally by perceived usefulness and behavioural intention (Studies 2 and 3).

In turn, as implied by stereotype embodiment theory, the internalization of negative age stereotypes endorsed earlier in life into negative self-perceptions of aging later in life may deter older adults from using technology. We examined the relationship between self-perceptions of aging and technology use across three studies based on secondary data from the Health and Retirement Study and the German Ageing Survey. As predicted, more positive self-perceptions of aging were associated with higher levels of technology use and cognitive functioning mediated this relationship (Studies 4 to 6). Self-perceptions of aging, both more general

(Studies 4 and 5) and more specific to competence (Study 6), were positively linked to general computer use (Studies 4 and 5) and specific internet uses (Study 6). This was shown using longitudinal designs (Studies 4 to 6), samples from the United States (Study 4) and Germany (Studies 5 and 6), and over time intervals of eight (Study 4) and three years (Studies 5 and 6).

By confirming the assumptions of both theories, these findings suggest that age stereotypes determine technology use in late adulthood through distinct, yet complementary processes. Future studies should further explore these effects by integrating both theoretical approaches. Interventions and policies promoting positive intergenerational contact and positive views on age and aging should thus contribute to the digital inclusion of older adults.

Curriculum Vitae

João Miguel Lourenço de Oliveira Mariano was born on 26 April 1986 in Lisbon, Portugal. He completed his secondary education at Francisco Simões Secondary School in 2004. He started pursuing an integrated master's degree in Psychology at the Faculty of Psychology of the University of Lisbon in 2008, corresponding to a bachelor's degree (2008 – 2011) and a master's degree with specialization in Applied Social Cognition (2011 – 2013).

After completing his higher education in 2013, he worked as a research assistant at Iscte – Instituto Universitário de Lisboa in international projects in the fields of ageing and technology, most notably *OLA – Organizational Life Assistant (for future active aging)* in 2015 and *SIforAGE – Social Innovation on Active and Healthy Ageing for Sustainable Economic Growth* in 2016, under the supervision of Dr. Sibila Marques. He also obtained a postgraduate degree in Data Analysis in the Social Sciences at Iscte – Instituto Universitário de Lisboa in 2015.

In 2016, he started working on his PhD project at Iscte – Instituto Universitário de Lisboa as part of the doctoral program *LiSP – Lisbon PhD in Social Psychology*, under the supervision of Dr. Sibila Marques, and at Maastricht University, under the supervision of Prof. Dr. Hein de Vries, through an agreement between both universities. In his second year as a PhD candidate, he completed the course *Health Communication & Health Promotion: Theory and Practice* at Maastricht University. He has presented his research at national and international conferences and published in international scientific journals.

Publications

Publications presented in this thesis:

Mariano, J., Marques, S., Ramos, M. R., Gerardo, F., & de Vries, H. (2020). Too old for computers? The longitudinal relationship between stereotype threat and computer use by older adults. *Frontiers in Psychology, 11*, Article 568972. https://doi.org/10.3389/fpsyg.2020.568972

Mariano, J., Marques, S., Ramos, M. R., Gerardo, F., Cunha, C. L., Girenko, A., Alexandersson, J., Stree, B., Lamanna, M., Lorenzatto, M., Mikkelsen, L. P., Bundgård-Jørgensen, U., Rêgo, S., & de Vries, H. (2021). Too old for technology? Stereotype threat and technology use by older adults. *Behaviour & Information Technology*. https://doi.org/10.1080/0144929X.2021.1882577

Mariano, J., Marques, S., Ramos, M. R., & de Vries, H. (2021a). Cognitive functioning mediates the relationship between self-perceptions of aging and computer use behavior in late adulthood: Evidence from two longitudinal studies. *Computers in Human Behavior, 121*, Article 106807. https://doi.org/10.1016/j.chb.2021.106807

Mariano, J., Marques, S., Ramos, M. R., & de Vries, H. (2021b). Internet use by middle-aged and older adults: Longitudinal relationships with functional ability, social support, and self-perceptions of aging. *Psychology and Aging, 36*(8), 983-995. https://doi.org/10.1037/pag0000643

Publications related to this topic:

Marques, S., Mariano, J., Mendonça, J., De Tavernier, W., Hess, M., Naegele, L., … Martins, D. (2020). Determinants of ageism against older adults: A systematic review. *International Journal of Environmental Research and Public Health, 17*(7), Article 2560. https://doi.org/10.3390/ijerph17072560

Mendonça, J., Mariano, J., & Marques, S. (2016). Lisbon street campaign against ageism: A promising multi-stakeholder initiative. *Journal of Intergenerational Relationships, 14*(3), 258-265. https://doi.org/10.1080/15350770.2016.1195216

Publications unrelated to this topic:

Marques, S., Mariano, J., Lima, M. L., & Abrams, D. (2018). Are you talking to the *future* me? The moderator role of future self-relevance on the effects of aging salience in retirement savings. *Journal of Applied Social Psychology, 48*(7), 360-368. https://doi.org/10.1111/jasp.12516