Older Adults' Internet Use, Outdoor Activity, and the Urban Environment: Empirical Analysis

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Chapter 1

Introduction

1.1 Topic

In an ageing society, information technology (IT) can be a powerful tool to support older adults in staying physically, mentally, and socially active. Remaining independent and maintaining an active lifestyle is of utmost importance to many older adults. This group is characterized by experiencing inevitable effects of aging such as declining mobility, physical fitness, and mental ability (Spirduso, Francis, & MacRae, 2005). To compensate such effects, older adults increasingly use IT (J. H. Choi et al., 2014; Chopik, 2016; Hill, Betts, & Gardner, 2015). Over the last decade, especially Internet use in older adults has substantially grown around the globe. In 2018, about 66% of Americans age 65 or older used the Internet, compared to only 38% ten years earlier (Pew Research Center, 2019). Internet use has become pivotal for the daily lives of many older adults, particularly as it can support their social ties, leisure activities, and consumer behavior (van Boekel, Peek, & Luijkx, 2017; Vroman, Arthanat, & Lysack, 2015). While Internet use can be interpreted as an indicator of activity involvement, Internet use has also been attributed with enhanced social integration, well-being, and health (Hartanto et al., 2019; Hunsaker & Hargittai, 2018).

A central part of social integration is involvement in public life through participation in activities. Among different types of activities, outdoor activity such as walking, visiting friends and relatives, shopping, and attending social events, belong to the most popular and effective practices to maintain well-being and quality of life in older adults. For several reasons, participation in outdoor activity contributes to active aging: Going outdoors requires higher levels of physical effort than activities performed at home, which helps maintain physical fitness (Kerr, Sallis et al., 2012). In addition, leaving the house increases the chance to meet other persons, and therefore, to preserve or build social ties. Those who have stronger or more social ties enjoy higher levels of social integration, which then contributes to well-being and quality of life (Gabriel & Bowling, 2004). Further, spending time outside in less-known, dynamic environments activates more cognitive processes than staying in the familiar, static environment at home (Bastos et al., 2015). Moreover, older adults also experience more pleasure when being active outdoors than at home (Cabrita, Lousberg, Tabak, Hermens, & Vollenbroek-Hutten, 2017).

Outdoor activity can be distinguished in several ways. First, is the distinction between leisure and errands (King et al., 2017). Leisure activities are performed voluntarily and serve needs for pleasure, enjoyment, and relaxation. For instance, leisure activity includes walking, meeting friends, and attending cultural events. In contrast, errands serve the daily needs of human life such as shopping for groceries, attending medical appointments, and visiting administrative offices (Cabrita et al., 2017). Second, outdoor activity can be categorized into low-effort activities and high-effort activities, depending on the physical resources demanded (Everard, Lach, Fisher, & Baum, 2000). Low-effort activities are characterized by a passive role of the individual. For instance, attending religious services, listening to musical performances, and watching sport events requires rather low physical resources. In performing high-effort activities, older adults take an active role such as singing in a choir, exercising in a gym, and swimming. Third, is the demarcation between activities at the individual level and activities at the community level (Fortuijn et al., 2006). Activities at the individual level are performed alone, whereas activities at the community level include social interaction with other persons in the same activity (e.g., singing in a choir). The latter distinction exemplifies that outdoor activity can be distinguished from very different viewpoints using specific criteria. While each viewpoint leads to distinct categories, the viewpoints can also be used in combination to describe comprehensively the nature of outdoor activity. Therefore, categories originating from different viewpoints are non-exclusive but overlapping. For instance, singing in a choir can be described as a leisure, high-effort, and community activity.

Older adults increasingly acknowledge the Internet as a source of information used to meet others interested in the same offline activities (Nimrod, 2014). However, understanding of how Internet use can influence older adults' behavior of going outdoors is still limited. A few studies found positive relationships between older adults' Internet use and participation in outdoor activity. A study in Finland showed that older adults who used the Internet every day or several times a week participated in more types of leisure activity than others (Näsi, Räsänen, & Sarpila, 2012). Further, older adults who used the Internet for communication participated more frequently in offline social activities, such as visiting friends or family and attending classes (Kim, Lee, Christensen, & Merighi, 2017). Higher levels of Internet use have also been found to be associated with more social engagement, such as participation in social clubs or volunteer work (Chiu, 2019). Results of a longitudinal study in New Zealand suggest that informational Internet use leads to greater diversity of volunteering, defined as the number of organizations engaged in (Szabo, Allen, Stephens, & Alpass, 2019). The latter study, however, found no association with duration of volunteering. Despite a growing number of studies in this field, understanding this relationship is in a

rather premature state, specifically, as prior studies only consider general Internet use and, thus do not enquire specific purposes of Internet use related to outdoor activity. Therefore, investigating the association between older adults' Internet use and their participation in outdoor activity requires differentiation.

Another factor influencing older adults' participation in outdoor activity is the environment in which they live. For instance, prior research found that 70% of all outdoor activity takes place in the vicinity of their home within a radius of five kilometers (Oswald & Konopik, 2015). Specifically, the urban environment can either motivate or hinder participation in outdoor activity. As this environment attains particular meaning for older adults with age-related impairments, it is not surprising that the role of the urban environment in explaining older adults' outdoor activity has been studied extensively (Moran et al., 2014; Rosso, Auchincloss, & Michael, 2011). Research showed that older adults living in a supportive neighborhood environment tend to be more active outside (Eronen, Bonsdorff, Rantakokko, & Rantanen, 2013; Sugiyama & Thompson, 2007). Important environmental factors facilitating outdoor activity are: walkability, presence of gardens and parks, and access to rest areas (Moran et al., 2014). Nonetheless, so far there have been no studies that made allowance for the urban environment to be included when exploring the relationship between Internet use and outdoor activity among older adults. The gained knowledge can inform the design of IT-based products and services (managerial implication) as well as environmental interventions (policy implication) to effectively facilitate participation in outdoor activity.

1.2 Motivation

The past ten years have witnessed tremendous changes in the frequency and intensity of older adults' Internet use, and this development is ongoing. In the last decades, the main purposes were e-mailing, and surfing the web (Fox, 2004). In this day and age, older adults use the Internet for an increasing range of purposes, which also include social networking, online shopping, making medical appointments, and therapeutic monitoring (Generali, 2017; Vroman et al., 2015). This development has been amplified by user-friendly software, plug-and-play hardware as well as affordable technology and services. Here, it has to be noted that older adults' Internet use naturally takes place outside of an organization and work environment because most of them transitioned from working life to retirement. In this non-organizational context, Internet use is self-determined and fully funded by private resources.

Older adults choose activities by purpose to meet their personal needs, and overall to pursue an active lifestyle. The latter is also known as successful ageing (Havighurst, 1963). The Internet can provide new opportunities to stay active and meet this objective. However, understanding older adults' Internet use is made difficult by the non-organizational context, which exhibits great variation in attitudes, behavior, and socio-demographic characteristics.

The specific context of older adults' Internet use deserves further enquiry. Two streams of research can be identified from the literature. On one hand, public health focuses on socio-demographic and economic factors, in particular age, education, income, gender, health, and social context (Gilleard & Higgs, 2008; Vroman et al., 2015; Zhang, Grenhart, McLaughlin, & Allaire, 2017). The objective of public health is to inform policy-makers, thus stakeholders that devise interventions on the societal level. On the other hand, information systems (IS) research mainly focuses on beliefs and attitudes to explain behavior on the individual level. For instance, Niehaves and Plattfaut (2014) investigated older adults' intentions to use the Internet, and identified factors such as self-efficacy, perceived ease of use, and influences by friends and family. Prior research has adapted IS theories such as the Technology Acceptance Model (Davis, 1989) and the Unified Theory of Acceptance and Use of Technology (Venkatesh, Morris, Davis, & Davis, 2003) to the older adults' context (Keränen et al., 2017; Lian & Yen, 2014; Niehaves & Plattfaut, 2014). It is worth noting that these theories have been developed with a focus on explaining organizational IT use.

While public health and IS take different theoretical stances, IS research has begun identifying socio-demographic characteristics as predictors or moderators (Sykes, Venkatesh, & Gosain, 2009; Venkatesh et al., 2003). Likewise, some studies in public health adapted IS theories to examine technology acceptance and adoption in older adults (Bong, Bergland, & Chen, 2019; Nägle & Schmidt, 2012). Following this avenue of research, it is reasonable that further efforts are needed to integrate the two approaches of public health and IS research.

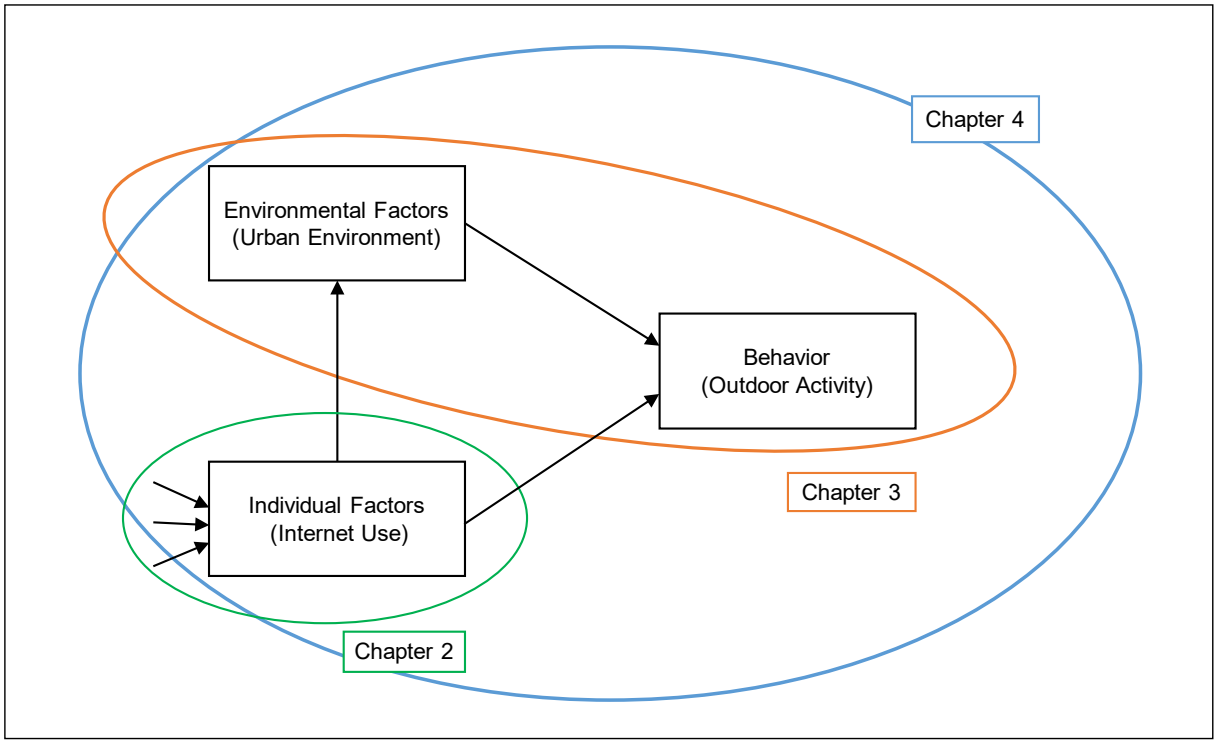
1.3 Objective & Outline

As outlined above, the aim of this thesis is to get a better understanding of the association between Internet use, participation in outdoor activity, and the urban environment. To integrate the approaches of IS and public health research, this thesis builds on a socio-ecological perspective. The main tenet of the socio-ecological perspective is that social and environmental factors in combination affect human behavior (Cunningham & Michael,

2004). As ecological models are defined to have multiple levels of influences, such as intrapersonal, cultural, environmental, and political, this perspective is appropriate for examining the role of predictors for outdoor activity in older adults. From this theoretical angle, Internet use can be contextualized as an individual factor that affects older adults' knowledge about the urban environment and ultimately supports their decision-making with respect to being active outdoors. In combination with other individual and environmental factors as well as precise measurements, it is reasonable to expect improvements in the understanding of the described association. Based on this premise, businesses, providers, and policy-makers can develop Internet-based products and services specifically targeted to the needs of older adults. Subsequently, older adults' acquired knowledge about the urban environment can facilitate their participation in outdoor activity.

Figure 1 shows the thesis' conceptual framework, which comprises three main constructs, namely Internet use as an individual factor, the urban environment as an environmental factor, and outdoor activity as the behavioral outcome. This framework delineates the expected relationships between the constructs as analyzed in three academic studies presented in Chapter 2 to Chapter 4 (Schehl, 2020; Schehl & Leukel, 2020; Schehl, Leukel, & Sugumaran, 2019). The studies rely on primary survey data collected in a larger research project in the summer of 2017. A paper-based questionnaire was mailed to 6170 older adults (age 65+) living in Mönchengladbach, Germany, a city of about 260,000 inhabitants. The 1,302 responses received account for a response rate of 21.5%.

Figure 1.1: Mapping of the three studies onto the conceptual framework



Chapter 2 addresses the factors explaining and predicting older adults' differentiated Internet use. The increase in older adults' Internet use is accompanied by a growing range of purposes performed online. However, prior research does not take into account the enhanced diversity in online activities performed by older adults. In this light, the present study investigates the role of socio-demographic characteristics and perceived behavioral control (PBC) in predicting informational, social, and instrumental online activities among older adults. The study draws upon the digital divide literature, which examines inequalities in the use of the Internet based on socio-demographic factors, such as age, gender, and education (van Dijk, 2005; Warschauer, 2003). Ordinal regression analysis is applied and for each online activity a direct effects model and a model with interactions is defined. By providing a nuanced understanding of older adult's Internet use, the empirical findings have implications for providers to tailor their online services to the needs of older adults as a growing consumer group, and inform stakeholders in designing interventions targeted at older adults.

Investigating the association between older adults' Internet use and their participation in outdoor activity requires identifying the factors that affect outdoor activity, i.e., the urban environment. Hence, Chapter 3 provides an empirical analysis of the association between the urban environment and older adults' outdoor independence. Outdoor independence is defined as the degree to which an individual believes in their ability to be active outdoors.

Thus, independence can be categorized whether one needs support by others or is able to be active by themselves. Next to intrapersonal, cultural, and political influences, human behavior can be explained by environmental influences (Sallis et al., 2006). Hence, an ecological approach (Fisher et al., 2018; Sallis, Owen, & Fisher, 2008) is adopted to examine the role of socio-demographic and environmental factors in explaining outdoor independence. Ordinal regression is used in order to explain different levels of outdoor independence. To be more precise, a hierarchical approach is applied: While the first model only comprises individual factors, the second model also includes environmental factors. The third model adds four interaction terms for individual factors and perceived environmental barriers, which allows to analyze moderation. Based on the empirical findings, insights for political stakeholders, urban planners, and community groups are presented to design age-friendly communities, and as a result, facilitate outdoor independence among older adults.

Chapter 4 examines how the Internet as an emerging information source can facilitate outdoor activity in older adults. Precisely, predictors of community activity and cultural activity in residents of three different neighborhoods are analyzed. Participation in outdoor activity depends not only on the environment in which older adults live but also on the extent of individual's knowledge about opportunities and offerings in their environment. Here, the use of media, traditional media (e.g. newspaper) and new media (e.g. Internet), allows older adults to acquire knowledge to support their decision-making on being active outdoors. Especially the Internet can increase levels of perceived independence and offers potential to pursue a socially active and self-determined life (Seifert & Schelling, 2018). While prior research identified impacts of older adults' Internet use, understanding of the Internet as an information source to enhance outdoor activity is limited. Hence, the aim of this chapter is to integrate the three constructs of the conceptual framework presented in Figure 1. Specifically, the focus is on investigating how informational Internet use affects outdoor activity through providing older adults with useful information about opportunities and offerings in the city. By applying linear regression analyses, the empirical results provide a rationale for the development of digital neighborhood platforms and interventions targeted to the needs of older adults.

This thesis ends with an overarching discussion of the findings in Chapter 5, providing conclusions and implications for research, policy, and practice.

Chapter 2

Understanding Differentiated Internet Use in Older Adults: A Study of Informational, Social, and Instrumental Online Activities[1]

Abstract. Internet use is becoming increasingly important for the daily lives of older adults. Simultaneously, the range of online activities is also broadening. However, previous research in technology adoption mainly focuses on Internet use in general, and only few studies pay attention to various online activities that older adults engage in. Exploration of factors explaining specific online activities is still limited. To bridge this gap, we examined the role of socio-demographic characteristics and perceived behavioral control (PBC) in predicting informational, social, and instrumental online activities in a sample of 1,222 participants (age 65+). Our results show that those who were younger, with higher education, and with higher PBC were more likely to perform all online activities, while men had higher odds than women of performing informational and instrumental but not social online activities. Cultural participation was a positive predictor for all online activities except online banking. For informational online activities, the effect of PBC was moderated such that it was weaker for those with higher education. Based on our empirical results, we contribute to the literature a nuanced understanding of older adults' Internet use.

[1] This chapter is based on joint work with Joerg Leukel from the University of Hohenheim and Vijayan Sugumaran from the Oakland University. The candidate's individual contribution focused mainly on the hypotheses development, literature research, data analyses, and the writing. This article is printed with kind permission of Elsevier. It has been originally published as Schehl, B., Leukel, J., & Sugumaran, V. (2019). Understanding differentiated Internet use in older adults: A study of informational, social, and instrumental online activities. *Computers in Human Behavior*, 97, 222-230. https://doi.org/10.1016/j.chb.2019.03.031.

2.1 Introduction

Internet use in older adults is rising around the globe. This age group is often defined through the transition from working life to retirement, which happens around the age of 65 in many industrial countries. The past ten years have witnessed tremendous changes in the frequency of Internet use, and this development is ongoing. For instance, the share of Americans age 65+ being online has increased from 28% in 2005 to 67% in 2016 (Anderson & Perrin, 2017). Engagement with the Internet has become important for the daily lives of many older adults. Internet use can facilitate their social ties, leisure activities, and consumer behavior (van Boekel et al., 2017; Vroman et al., 2015). Given that deteriorating health often impairs older adults, Internet services can assist in mitigating some of the inevitable consequences of aging. For instance, being online can help prevent isolation and reduce the feeling of loneliness (Chopik, 2016; Khosravi, Rezvani, & Wiewiora, 2016). Therefore, Internet services provide opportunities for older adults to pursue an active and self-determined lifestyle.

Concurrent to the increase of Internet use in older adults, the range of activities performed online has changed dramatically. In the past, the main online activities were surfing the web and e-mailing (Fox, 2004). Recent studies show that older adults use the Internet for a broadening range of activities, which includes for instance, social networking and shopping (van Deursen & Helsper, 2015; Vroman et al., 2015). This development has been amplified by user-friendly and affordable apps and devices (e.g., smartphone, tablet computer).

In light of the changes in older adults' Internet use, understanding of their differentiated online activities is limited. While only few studies have investigated particular online activities (Hunsaker & Hargittai, 2018), many studies are concerned with Internet use in general (Keränen et al., 2017; Seifert, Doh, & Wahl, 2017; Siren & Knudsen, 2017). Other studies ask for several online activities but then aggregate them into a composite variable (Chopik, Rikard, & Cotten, 2017; Macedo, 2017). Some studies investigate a single online activity such as shopping (Lian & Yen, 2014), or a set of topic-related activities such as health (Hong & Cho, 2017). The findings from these studies cannot necessarily be generalized to other online activities. Only a few studies present results for a broader set of online activities (N. G. Choi & DiNitto, 2013; Gell, Rosenberg, Demiris, LaCroix, & Patel, 2013; Nimrod, 2018; van Deursen & Helsper, 2015). However, their regression models exhibit rather low explanatory power, or explained variance has not been reported at all.

Collectively, prior research either does not take into account the enhanced diversity in online activities performed by older adults, or lacks in explanatory power. Our study seeks

to fill this gap in the literature by considering older adults' favorite online activities, and integrating perceived behavior control (PBC) into a digital divide model. PBC refers to one's perceptions of their ability to exhibit a given behavior (Ajzen, 1991), and is an important predictor of actual behavior. Our approach draws upon the digital divide literature, which examines inequalities in use of information technology (IT) based on socio-demographics (e.g., age, gender, and education) (van Dijk, 2005; Warschauer, 2003). This focus is different from theories of technology acceptance, which put emphasis on psychometric characteristics (Davis, Bagozzi, & Warshaw, 1989; Venkatesh & Davis, 2000). Prior research has begun integrating socio-demographic characteristics into such theories. For instance, the Unified Theory of Acceptance and Use of Technology (UTAUT) includes gender and age as moderators of PBC (Venkatesh et al., 2003). Adaptations of UTAUT in the context of older adults have integrated education (Choudrie, Pheeraphuttranghkoon, & Davari, 2018; Macedo, 2017; Niehaves & Plattfaut, 2014). While these adaptations enhanced the explanatory power, we expect similar improvements when we apply a digital divide perspective.

The objectives of our study are to: (1) develop a digital divide model including PBC to explain older adults' online activities and (2) empirically validate our propositions for six online activities using survey data (N = 1,222), which we collected in May 2017 in Germany. We examine three types of online activities, namely informational (i.e., searching the web, viewing pictures/videos), social (i.e., writing e-mails, writing comments/reviews), and instrumental online activities (i.e., banking, shopping), which are most prevalent in older adults (Anderson & Perrin, 2017).

2.2 Literature Review and Hypotheses

2.2.1 Prior Research

Use of IT by older adults, and in particular Internet use, is a vibrant field of research, characterized by multi-disciplinary approaches (Hunsaker & Hargittai, 2018). Much of the literature focuses on Internet use in general, highlighting differences between, for instance, older and younger, men and women, low and high educated. Other studies examine the negative impact of specific health conditions such as frailty on Internet use (Keränen et al., 2017). Further studies demonstrate the importance of psychological characteristics, e.g., showing that Internet use increases with higher levels of subjective norm (Pan & Jordan-Marsh, 2010). Socio-economic characteristics such as income have also been identified to positively predict Internet use (Hargittai & Dobransky, 2017). While prior research makes

clear these factors matter for older adults' Internet use, limited research has examined the role of such factors in explaining differentiated online activities (Hunsaker & Hargittai, 2018).

Research has already acknowledged the increasing diversity of older adults' Internet use, and therefore, administered measurement instruments that include various online activities. The purpose of such instruments is to enhance precision of the construct Internet use; hence, researchers ask participants about their online activities and then aggregate answers into a composite variable. For example, Chopik et al. (2017) measure Internet use by asking about engagement in ten activities and devices (e.g., e-mail, skype, smartphone), and then sum up the yes/no answers to an overall Internet use score. Similarly, Hargittai and Dobransky (2017) report on two studies examining five and six online activities, respectively. In each study, the individual answers (yes/no) were aggregated into a composite variable. In summary, these studies use advanced measurement instruments, however, they do not contribute to a nuanced understanding of online activities.

The first step in enhancing the understanding of older adults' online activities is studying a particular activity or a set of topic-related activities. For instance, Hong and Cho (2017) examine four health-related online activities, namely, seeking health information, buying medicine, connecting with people with similar health problems, and communicating with doctors in the past 12 months (yes/no). In their longitudinal study of Americans aged 55+, they find that younger age, better education, and higher income only enhanced the probability of using the Internet for seeking health information but not for the other activities. By uncovering important differences of predictors, even among related activities, the study by Hong and Cho (2017) underscores the need for a nuanced understanding of specific online activities.

The next step is to examine a much broader range of online activities that older adults engage in. Only a few studies follow this approach. In the study by van Deursen and Helsper (2015), participants were asked about engagement in 23 online activities on a five-point frequency scale (ranging from "never" to "almost daily"). These activities were clustered into eight categories: music and video, shopping, news, information, email, health services, social entertainment, and civic services. Then, mean frequency per category was calculated. van Deursen and Helsper (2015) find that three socio-demographic characteristics only lead to higher use for a subset of activity types, i.e., being men (4), younger (3), and higher educated (1). N. G. Choi and DiNitto (2013) analyze secondary data from the National Health and Aging Trends Study (NHATS) and consider three types of online activities (health-related tasks, shopping/banking, and e-mail/texting). By using

logistic regression analyses, they find contingency upon the type of online activity for several socio-demographic characteristics including age (negative), race/ethnicity (lower odds for minorities), and living arrangement (higher odds for living with a spouse). The study by Gell et al. (2013) also uses data from the NHATS to investigate patterns of technology use. Participants were asked whether they had used the Internet for four health-related Internet tasks in the past (e.g., communication with health care provider). Participants also reported whether they had the used the Internet for five personal tasks (e.g., banking, shopping). The responses (yes/no) were used to derive two dichotomous variables for health-related and personal tasks, respectively. Gell et al. (2013) find that technology use varied significantly by socio-demographics and health status and that reasons for use differed by type of disability and activity-limiting impairments. A recent study by Nimrod (2018) defines four groups of online activities, i.e., native activities, old media, interpersonal communication, and entertainment, with each group including two to four specific activities, e.g., entertainment includes online games and watching TV. Nimrod (2018) finds that socio-demographics only enhanced the probability of use for some activity groups, e.g., being men (old media, interpersonal communication), having a partner (old media), higher education (old media), and higher income (entertainment).

The results of prior studies demonstrate the urgent need for exploring differentiated online activities. However, the regression models developed by van Deursen and Helsper (2015) and Nimrod (2018) exhibit rather low explanatory power (ranging between 2% and 13%), while explained variance in online activity is not available from the studies by N. G. Choi and DiNitto (2013) and Gell et al. (2013). Moreover, Gell et al. (2013) do not report regression results for socio-demographic characteristics except for health conditions. In addition, interpreting the results of Nimrod (2018) should take into account that the scales defined for the four groups of online activities have low levels of internal consistency, with Cronbach's alpha for each group below the common threshold of 0.7 for acceptable consistency. Hence, their aggregation of specific online activities into four groups lacks validity.

Collectively, our discussion of prior research highlights a critical gap in the literature concerning the understanding of differentiated online activities in older adults.

2.2.2 Hypotheses

In developing our proposition, we draw on van Dijk's resources and appropriation theory (van Dijk, 2005, 2006). This theory of the digital divide posits that categorical inequalities in society lead to unequal distribution of resources, which then causes unequal access to

digital technologies. The theory describes a mechanism explaining individual differences in the use of digital technologies; therefore, it is adequate for studying older adults' Internet use (Friemel, 2016; Hargittai, Piper, & Morris, 2018). The notion of categorical inequality represents that inequality is a matter of differences between groups of people and not of individual attributes. The most frequent categories relate to age, gender, education, labor position, and personality. Belonging to certain categories determines the quantity and quality of resources available to an individual. These resources are required and conducive for using technology. For instance, older adults need to have material resources (e.g., computer with Internet access) and mental resources (e.g., openness towards the Internet), and may benefit from social resources (e.g., social support in using the Internet).

While van Dijk's theory relies upon categories, thus socio-demographic characteristics, as the root of explanation, our approach incorporates these categories and integrates PBC as a particular mental resource. In theories of technology acceptance research, perceived behavioral control has been found important for explaining actual IT use (Venkatesh et al., 2003). PBC is within UTAUT the only predictor that has a direct influence on actual IT use and is not fully mediated by intention to use. Note that the role of socio-demographics has also been acknowledged in the technology acceptance literature, and led to adaptations of prior theories (Venkatesh, Thong, & Xu, 2016). Next, we present the hypotheses on socio-demographic characteristics, followed by the hypotheses on PBC.

Gender is an essential categorical inequality in digital divide research, leading to the men category dominating the women category. Gender differences in resources are not due to biological gender but to the roles that are ascribed to them. The process of inequality starts early in life and receives continual reinforcement over lifetime. For instance, in the current generations of older adults, women were less engaged with technology (e.g., in childhood and education) and acquired less computer experience during working life than men. This higher level of experience and proficiency is conducive to Internet use in the retirement phase, assuming that older adults can maintain these resources. Having gained less experience and skills with IT (mental resources), women have higher barriers towards adopting and using innovative IT in later life. However, a few studies suggest that women's Internet use is more likely driven by social and communicative motives (Coelho & Duarte, 2016; Thayer & Ray, 2006; Wagner, Hassanein, & Head, 2010). This higher motivation might compensate the barriers discussed above so that we expect no gender difference in the frequency of social online activities (which is opposite to informational and instrumental activities).

H1. Gender is associated with online activity such that online activity will be more frequent in men than in women.

The level of Internet use varies a lot across generations (Anderson & Perrin, 2017; Magsamen-Conrad, Dowd, Abuljadail, Alsulaiman, & Shareefi, 2015). Although older adults represent the most rapidly growing group of Internet users, frequency of their Internet use is still lower than in younger adults. Such differences are also present in older adults, for instance between young-older adults (age 65-74) and old-older adults (age 75+) (Anderson & Perrin, 2017). In digital divide research, age is an important categorical inequality, which distinguishes young and old. Unequal distribution of two resources emerges. First is motivation to engage with technological innovations (mental resources). Innovation diffusion theory posits age-dependency on diffusion processes, with younger people making up the majority of early adopters while older adults are lagging behind (Gilly & Zeithaml, 1985). Because older adults did not experience today's ubiquitous presence of Internet in childhood and education, they perceive higher barriers to adopt and use Internet-based innovations. Second is the social network assisting in Internet use (social resources). With increasing age, older adults often experience diminishing social networks, e.g., loss of partner and reduced contact with children. Thus, they may have less support from family and friends, and depend more on help by others, which might not be available.

H2. Age is negatively associated with online activity.

Prior studies identify the educational background of older adults as an important predictor of Internet use (Chopik et al., 2017; König, Seifert, & Doh, 2018). The theoretical argument is that educational attainments in early life impact one's material and mental resources in later life. Thus, education is a categorical inequality, which describes the position of individuals and their relationships through positions between low and high. Higher formal education is usually associated with higher income, which then facilitates physical access. In other words, older adults with higher education have greater financial resources than those with lower level education to buy products and services for Internet use, e.g., computers, smartphones, equipment, broadband subscription, and paid content. Higher education may also increase older adults' mental resources for Internet use by allowing them to obtain professions and jobs that are more often characterized by frequent IT use. Gaining IT experiences during working life can prepare for Internet use after retirement through acquiring digital skills. A recent longitudinal study in Italy provides evidence for this lasting effect of school education on digital skills and Internet use of older adults (Kämpfen & Maurer, 2018). On the other hand, less educated older adults more likely lack

the material access and digital skills required, or perceive barriers towards Internet use, which then will undermine their use behavior.

H3. Education is positively associated with online activity.

In van Dijk`s theory, motivation is an important mental resource. For instance, motivation can materialize in the desire to be connected to the Internet and perform online activities that serve personal interests. This motivation can result from one's attitude towards consumer culture. The corresponding categorical inequality in digital divide research is cultural participation, defined as interest in cultural offerings such as movies, theaters, fashion, music events, and sports. Categorical inequalities exist between the curious and disinterested groups of people. The argument is that those who are curious about the outside world and open-minded towards societal developments accumulate higher motivation to engage in unknown domains than the disinterested. The Internet can be a useful tool to fulfill this curiosity. Indeed, prior studies suggest that older adults' cultural participation is associated with more frequent use of web and e-mail (N. G. Choi & DiNitto, 2013; Gilleard & Higgs, 2008; Näsi et al., 2012). Based on the motivational mechanism discussed above, we expect that higher cultural participation will lead to higher frequency of only those online activities that satisfy one's curiosity.

H4. Cultural participation is positively associated with online activity.

Next to the four socio-demographic characteristics, we hypothesize that perceived behavioral control is a positive predictor of older adults' Internet use (K. Chen & Chan, 2014; Heart & Kalderon, 2013). Perceived behavioral control (PBC) represents one's perception of internal and external constraints on behavior (Ajzen, 1991; Taylor & Todd, 1995). In UTAUT, PBC belongs to facilitating conditions, i.e., the degree to which an individual believes that an organizational and technical infrastructure supports their use of IT (Venkatesh et al., 2003). In our context, PBC includes older adults' beliefs in (1) their ability to use a device or service successfully, (2) having sufficient knowledge required for dealing with technology, and (3) receiving support from others in their technology adoption and use, in particular, from family and friends. Through the lens of van Dijk's theory, PBC can be regarded as a form of mental resource. Unlike the categorical inequalities considered above, PBC directly addresses the digital technology to be used; hence, it is a subjective summative evaluation of one's available resources for using this technology. Thus, higher levels of PBC will increase online activity.

H5. PBC is positively associated with online activity.

An important tenet of UTAUT is that socio-demographic characteristics can moderate the effects of psychometric factors such as PBC on behavioral intention and use behavior, respectively (Venkatesh et al., 2003). Moderation means that for a given categorical inequality, the effect of PBC will either be stronger or weaker for the dominating group compared to the subordinated group. First, prior research suggests that women tend to be more sensitive to their belief in mastering a new technology and therefore we assume PBC to be more important for women (Venkatesh, Morris, & Ackerman, 2000). Second, because of decreasing cognitive and physical resources, old-older adults might give more attention to their mastery of digital skills and support by others (Hill et al., 2015); hence, we speculate that the effect increases with age. Third, older adults with higher education have learned to develop problem-solving strategies, which can assist them in overcoming barriers in using new technology (Diehl, Willis, & Schaie, 1995). These strategies are not bound to specific technologies but are of general nature. Therefore, the effect of PBC could be attenuated by high level of education for some online activities.

H6. The association between PBC and online activity is stronger for women (H6a), stronger for older individuals (H6b), and stronger for less educated individuals (H6c).

2.3 Method

2.3.1 Data Collection and Participants

We conducted a questionnaire-based survey targeted at all older adults (age 65+) living in three districts in Mönchengladbach, a city of about 262,000 inhabitants (IT.NRW, 2017). We chose the districts because they differed largely in population density (343; 2,400; 6,069 per square kilometer). Our research is integrated into a larger project, in which municipal stakeholders are taking part. Therefore, we received support from the local municipality in designing the study and collecting data. A municipal provider of geriatric care conducted a pretest to evaluate the questionnaire with respect to validity and comprehension. Based on the feedback obtained from nineteen participants, we made a few minor revisions (e.g., wording of questions and items). Additionally, we received support from the city administration, which provided us with the registered addresses. Further, the questionnaire was complemented by a cover letter signed by the respective district leader. The cover letter described the background of the project and invited citizens to participate.

In May 2017, the paper-based questionnaire was mailed to 6,170 older adults. Citizens were given six weeks to return the questionnaire (a stamped and addressed envelope was provided). They also had the option to fill in the questionnaire online by using an individual

access code. Thirty-six participants chose this option. Considering that 100 addresses turned out to be invalid, the 1,302 responses received account for a response rate of 21.5%. This rate is comparable to prior surveys that also used posted self-administered questionnaires (Palonen, Kaunonen, & Åstedt-Kurki, 2016).

The final sample includes users and non-users of the Internet (N = 1,222), defined by those who answered the question about online activities (scale: frequency ranging from never to daily). Because we use a convenient sample, we assessed whether the sample is representative of the population as a whole with respect to gender, age, and education. Specifically, we compared our sample with the population of older adults living in the city from which the sample was drawn (IT.NRW, 2015). All differences in gender and age (based on 5-year intervals) are marginal. Our sample exhibits a greater share of participants holding a university degree (13.3% vs. 6.5%), while the share of participants with no high school education is smaller (1.2% vs. 6.1%).

2.3.2 Measurements

Answering the questions should impose low cognitive requirements on the participants; hence, we followed recommendations for designing questionnaires for older adults (Jobe & Mingay, 1990; McColl et al., 2001). We took care that the questionnaire is barrier-free with respect to type and size of font, line spacing, layout, and coloring. We also avoided long and complex questions.

2.3.2.1 Predictors

Gender was defined as female or male. Age was calculated based on participant's year of birth. Education was measured by asking participants about their educational background. The question offered nine country-specific options (e.g., secondary education, vocational training, university degree). Based on the answers received, we derived three levels of education, i.e., "low" for primary and lower secondary education, "medium" for upper secondary education and vocational training, and "high" for academic education. This categorization considers definitions by the International Standard Classification of Education (ISCED) and peculiarities of the German education system.

Cultural participation was measured by participation in different cultural events. The rationale is that people who participate in a broader set of cultural activities exhibit greater interest in culture. We defined the question as follows: "How often do you leave the house for ..?" and administered a five-point frequency scale ("never," "few times," "several times per month," "several times per week," and "daily"). Five activities were listed: attendance

of "music event," "theater," "museum," "cinema," and "restaurant, bar or coffee bar." Because we define cultural participation as the interest in culture, our variable should measure the breadth and variety of participation but not its intensity. Therefore, we count the number of activities that were attended (except "never"), thus cultural participation was measured on a scale ranging from 0 to 5 (Gilleard & Higgs, 2008).

Perceived behavioral control was assessed by adopting three items from prior research (Ajzen, 1991; Taylor & Todd, 1995) and adjusting them to our study objective. We defined the items as follows: "I learn fast to deal with technology," "I don't have the knowledge to deal more intensively with technology" (item reversed), and "I know technology well." The five-point scale ranged from "strongly disagree" to "strongly agree." To ensure a common understanding of "technology", the question began with defining it as digital technology such as smartphone (cell-phone with Internet), tablet, and laptop/computer. Cronbach's alpha of our PBC instrument was 0.73, which suggests an acceptable level of internal consistency.

2.3.2.2 Online Activity

Our dependent variable was measured through frequency of six online activities. We chose activities reported in recent surveys as most prevalent in older adults (Anderson & Perrin, 2017), including informational (searching the web, viewing pictures/videos), social (writing e-mails, writing comments/reviews), and instrumental activities (banking, shopping). We defined the question as follows: "How often do you use digital technology for ..?" and used a five-point frequency scale ("never," "few times," "several times per month," "several times per week," and "daily") .

2.3.3 Statistical Analyses

Our hypotheses testing relied upon ordinal regression analyses using IBM SPSS Statistics 25. First, we manually coded all received questionnaires and performed data cleaning prior to statistical analyses. Second, we conducted descriptive analyses (tables of frequencies, means, and standard deviations). Third, we assessed correlations for our independent and dependent variables. Then, we tested the assumptions of ordinal regression analysis including no multicollinearity and proportional odds. With respect to multicollinearity, we examined the Variance Inflation Factor (VIF) for each of the five independent variables. VIFs ranged between 1.13 and 1.26, thus they were below a standard cut-off of 2.5. This result suggests that multicollinearity did not affect our regression models. With respect to the proportional odds assumption, we used parallel lines tests, which reported non-

significance for all regression models; hence, the proportional odds assumption was met. For each online activity, we defined a direct effects only model (which allowed us to test hypotheses H1-H5) and a model with interactions (which allowed us to test hypotheses H6a, H6b, and H6c.)

2.4 Results

2.4.1 Descriptive Statistics

Table 1 shows participant demographic characteristics. The sample was balanced in terms of gender. The largest age group was located between 65 and 74 years (total of 47.9%). On average, participants were 75.42 years old (SD = 7.10). Half of the participants had education at a medium level, while every seventh respondent reported education at a higher level. About one-third attended four or five different cultural activities (M = 3.10, SD = 1.67, on the 0-5 scale). Our sample exhibited considerable variance in perceived behavioral control (M = 2.86, SD = 1.08, on the 1-5 scale): While the lower end included 16.9% (PBC 1-2), the higher end comprised of 20.6% (PBC 4-5).

Table 2.1: Descriptive statistics for the five predictors

Variable	**Scale**	**N**	**%**		**Variable**	**Scale**	**N**	**%**
Gender	Female	608	50.2		Cultural participation	No activity	92	7.6
	Male	603	49.8			1 activity	301	24.8
Age	65-74	573	47.9			2 activities	218	18.0
	75-84	494	41.3			3 activities	180	14.8
	85-94	123	10.3			4 activities	182	15.0
	95+	7	0.6			5 activities	240	19.8
Education	Low	437	35.8		Perceived behavioral control (PBC)	1.0 ≤ PBC < 2.0	199	16.9
	Medium	612	50.1			2.0 ≤ PBC < 3.0	415	35.1
	High	173	14.2			3.0 ≤ PBC < 4.0	323	27.4
						4.0 ≤ PBC ≤ 5.0	244	20.6

Table 2 shows the descriptive statistics for online activities. When aggregating the answers for daily and several times per week, the three most frequent activities were searching the web (37.9 %), writing e-mails (26.9%), and viewing pictures/videos (20.7%).

Table 2.2: Descriptive statistics for online activities

Variable	N	Daily	Several times per week	Several times per month	Few times	Never
Informational online activities						
Searching the web	1,208	16.8%	21.1%	11.3%	9.2%	41.6%
Viewing pictures/videos	1,201	7.4%	13.3%	10.0%	22.6%	46.6%
Social online activities						
Writing e-mails	1,192	10.7%	16.2%	10.6%	15.0%	47.5%
Writing comments/reviews	1,202	0.7%	2.2%	2.8%	16.1%	78.1%
Instrumental online activities						
Banking	1,209	4.1%	7.4%	7.4%	4.1%	77.0%
Shopping	1,208	1.1%	1.5%	11.1%	22.4%	63.9%

Table 3 presents the correlation matrix. For all independent variables, correlations ranged from negligible to weak (highest coefficient of 0.29). Correlations between online activities were moderate to strong. A follow-up exploratory factor analysis identified one factor; however, note that we neither define types of online activities as psychometric constructs nor as reflective constructs. Between predictors and online activities, all correlations were significant and in the hypothesized direction.

Table 2.3: Correlations for predictors and online activities

Variable	1	2	3	4	5	6	7	8	9	10
1.) Gender										
2.) Age	0.06**									
3.) Education	-0.24**	-0.17**								
4.) Cultural participation	0.03	-0.29**	0.25**							
5.) PBC	-0.28**	-0.29**	0.27**	0.26**						
6.) Searching the web	-0.26**	-0.43**	0.34**	0.33**	0.60**					
7.) Viewing pictures/ videos	-0.22**	-0.38**	0.29**	0.30**	0.52**	0.80**				
8.) Writing e-mails	-0.19**	-0.40**	0.30**	0.40**	0.58**	0.79**	0.70**			
9.) Writing comments/ reviews	-0.14**	-0.28**	0.21**	0.22**	0.45**	0.53**	0.56**	0.55**		
10.) Banking	-0.23**	-0.23**	0.23**	0.19**	0.42**	0.49**	0.44**	0.48**	0.42**	
11.) Shopping	-0.20**	-0.33**	0.26**	0.29**	0.52**	0.66**	0.60**	0.65**	0.54**	0.62**

Note. Spearman's rank correlations. Ns range from 1158 to 1211. Gender: 0 = male, 1 = female. Education: 1 = low, 2 = medium, 3 = high. PBC = perceived behavioral control. * $p < 0.05$, ** $p < 0.01$.

2.4.2 Hypotheses Testing

Tables 4 to 6 present the results of our regression analyses, grouped into informational, social, and instrumental online activities. The tables show whether and how gender, age, education, cultural participation, and PBC were associated with online activities. Each table includes the direct effects only model (signified by column heading D) and the model with interactions (signified by column heading D+I) for each online activity. Associations are represented by odds ratios (OR), which state how the probability of achieving higher frequency of online activities changes for one-unit increase in the independent variable (OR > 1 for positive changes, OR < 1 for negative changes). For instance, age affects searching the web such that each one-year increase reduces the probability of higher frequency by 9% (OR = 0.91). In case of education, medium levels increase the probability of higher frequency of searching the web by 46% (OR = 1.46) compared to the reference group (low level of education). Explained variance ranged between 26% and 49% (R2).

Table 2.4: Ordinal regression analyses for informational online activities

		Searching the web				**Viewing pictures/videos**			
		D		**D + I**		**D**		**D + I**	
		OR	p	OR	p	OR	p	OR	p
Gender (=female)		0.69	0.003**	0.38	0.016*	0.71	0.007**	0.34	0.007**
Age		0.91	<0.001**	0.88	<0.001**	0.93	<0.001**	0.89	<0.001**
Education (reference: low)	High	4.34	<0.001**	25.78	<0.001**	2.17	<0.001**	15.55	<0.001**
	Medium	1.46	0.005**	2.97	0.018*	1.50	0.003**	2.55	0.040*
Cultural participation (reference: 0)	5	2.12	0.008**	1.98	0.018*	3.05	<0.001**	2.88	0.001**
	4	2.80	<0.001**	2.73	0.001**	3.11	<0.001**	3.13	<0.001**
	3	1.46	0.201	1.44	0.231	2.38	0.006**	2.38	0.007**
	2	1.70	0.072	1.67	0.091	2.22	0.011*	2.23	0.012*
	1	1.32	0.342	1.33	0.341	1.96	0.030*	2.03	0.026*
PBC		2.72	<0.001**	1.70	0.463	2.22	<0.001**	0.79	0.734
PBC × Gender				1.22	0.128			1.28	0.052
PBC × Age				1.01	0.370			1.02	0.096
PBC × Education High				0.57	0.004**			0.56	0.001**
PBC × Education Medium				0.78	0.104			0.83	0.200
N		1140				1131			
R2		0.48		0.49		0.36		0.37	

Note. D = direct effects. D + I = direct and interaction effects. OR = odds ratio. PBC = perceived behavioral control. R2 = pseudo r-squared (Nagelkerke's). * p < 0.05, ** p < 0.01.

Table 2.5: Ordinal regression analyses for social online activities

		Writing e-mails				Writing comments/reviews			
		D		D + I		D		D + I	
		OR	p	OR	p	OR	p	OR	p
Gender (=female)		0.87	0.270	0.63	0.267	0.98	0.895	0.54	0.328
Age		0.92	<0.001**	0.89	<0.001**	0.93	<0.001**	0.86	0.004**
Education (reference: low)	High	2.96	<0.001**	5.90	0.006**	1.74	0.020*	9.33	0.010**
	Medium	1.15	0.318	1.76	0.237	1.00	0.996	0.92	0.908
Cultural participation (reference: 0)	5	5.26	<0.001**	5.07	<0.001**	3.72	0.018*	3.62	0.022*
	4	4.95	<0.001**	4.84	<0.001**	4.15	0.012*	4.29	0.011*
	3	3.26	<0.001**	3.20	0.001**	3.64	0.025*	3.63	0.026*
	2	2.81	0.002**	2.77	0.003**	3.52	0.029*	3.56	0.029*
	1	1.74	0.103	1.74	0.106	2.77	0.079	2.85	0.074
PBC		2.70	<0.001**	1.29	0.732	2.70	<0.001**	0.62	0.643
PBC × Gender				1.11	0.418			1.19	0.338
PBC × Age				1.01	0.258			1.02	0.133
PBC × Education High				0.81	0.270			0.64	0.059
PBC × Education Medium				0.87	0.347			1.01	0.947
N		1125				1133			
R2		0.46		0.47		0.31		0.32	

Note. D = direct effects. D + I = direct and interaction effects. OR = odds ratio. PBC = perceived behavioral control. R2 = pseudo r-squared (Nagelkerke's). * p < 0.05, ** p < 0.01.

Table 2.6: Ordinal regression analyses for instrumental online activities

		Banking				Shopping			
		D		D + I		D		D + I	
		OR	p	OR	p	OR	p	OR	p
Gender (=female)		0.54	<0.001**	0.66	0.468	0.74	0.033*	0.80	0.129
Age		0.95	<0.001**	0.95	0.244	0.93	<0.001**	0.95	0.146
Education (reference: low)	High	2.10	0.001**	2.58	0.243	2.07	<0.001**	4.80	0.038*
	Medium	1.09	0.650	0.90	0.874	1.22	0.218	3.84	0.018*
Cultural participation (reference: 0)	5	1.42	0.362	1.45	0.337	2.96	0.004**	2.93	0.004**
	4	1.21	0.639	1.24	0.587	3.06	0.003**	3.01	0.004**
	3	1.31	0.514	1.33	0.490	2.85	0.007**	2.81	0.008**
	2	1.50	0.323	1.53	0.300	2.10	0.061	2.10	0.061
	1	1.03	0.942	1.04	0.921	1.50	0.310	1.50	0.306
PBC		2.24	<0.001**	2.28	0.357	2.77	<0.001**	5.95	0.031*
PBC × Gender				0.94	0.706			0.80	0.129
PBC × Age				1.00	0.987			0.99	0.606
PBC × Education High				0.95	0.805			0.76	0.197
PBC × Education Medium				1.06	0.774			0.69	0.033*
N		1138				1138			
R2		0.26		0.26		0.39		0.39	

Note. D = direct effects. D + I = direct and interaction effects. OR = odds ratio. PBC = perceived behavioral control. R2 = pseudo r-squared (Nagelkerke's). * p < 0.05, ** p < 0.01.

As the tables indicate, women were less likely to search the web (OR = 0.69, p = 0.003), to view pictures/videos (OR = 0.71, p = 0.007), to use online banking (OR = 0.54, p < 0.001), and to shop online (OR = 0.74, p = 0.033) but gender had no effect on frequency of writing emails and writing comments/reviews. Age had a negative effect on all online activities, with odds ratios between 0.91 and 0.95 (p < 0.001). High levels of education increased the probability of usage for each online activity (OR ranging from 1.74 to 4.34). However, medium levels of education led to higher probability only for searching the web and viewing pictures/videos (OR = 1.46 and OR = 1.50, respectively). Cultural participation was positively associated with all but one online activity (banking), and dependent on the number of cultural activities attended. PBC had a direct effect on each online activity, while the six odds ratios exhibited rather low variance (in the interval between 2.22 and 2.77).

We analyzed whether gender, age, and education moderated the effect of PBC (models provided in the D+I columns). Our results show that high levels of education reduced the effect of PBC for searching the web and viewing pictures/videos. In case of shopping, medium levels of education lowered the effect of PBC.

To further explore the nature of the interaction effects, we conducted a follow-up analysis, in which we split the sample based on education as the only significant moderator variable. We then repeated the regression analysis (direct effects) for each subsample. Education has three levels, thus we retrieved odds ratios of PBC differentiated for the low, medium, and high levels. With respect to searching the web, OR decreased with higher education, i.e., 3.72 for low, 2.57 for medium, and 2.05 for high. This decrease also held true for viewing pictures/videos with 2.78 for low, 2.19 for medium, and 1.66 for high. In case of online shopping, PBC had the weakest effect for participants with medium levels of education (OR = 2.44), whereas the effect was strongest for the participants with high levels (OR = 3.49).

Table 7 provides a summary of our hypotheses testing. Hypothesis H1 about gender was supported for informational and instrumental activities but not for social activities. The hypotheses about direct effects of age (H2-), education (H3+), and PBC (H5+) received full support. Cultural participation explained all online activities except online banking, which supports H4. Our results showed no moderation of PBC by gender and age, which is contrary to hypothesis H6a and H6b, respectively. High education increased the effect of PBC compared to low education in case of informational activities, which lends support for hypothesis H6c.

Table 2.7: Summary of hypotheses testing

Hypothesis	**Online activities**		
	Informational	Social	Instrumental
H1: Gender	Supported	Rejected	Supported
H2: Age	Supported	Supported	Supported
H3: Education	Supported	Supported	Supported
H4: Cultural participation	Supported	Supported	Supported for shopping
H5: PBC	Supported	Supported	Supported
H6a: PBC × Gender	Rejected	Rejected	Rejected
H6b: PBC × Age	Rejected	Rejected	Rejected
H6c: PBC × Education	Supported	Rejected	Supported for shopping

Note. PBC = perceived behavioral control.

2.5 Discussion

2.5.1 Findings

Our research set out to analyze the factors explaining differentiated online activities in older adults using primary survey data collected in Germany. We examined three types of online activities, namely, informational, social and instrumental. Overall, our study results suggest that the role of some predictors is contingent upon the online activity.

With respect to the two informational online activities, we find that their frequency was predicted by all the factors studied. We observe that the odds for highly educated adults were twice as high for searching the web than for viewing pictures/videos. This stronger effect can be explained by findings from cognitive research showing that actively searching the web requires more resources than consuming multimedia content (Litt, 2013). Further, we observe that those with higher cultural participation were more likely to search the web and to view pictures/videos. We construe this relationship that one's curiosity and interest in consumer culture can be satisfied by using search engines and multimedia platforms that allow access to culture content. Participation in one or more cultural activities predicted viewing pictures/videos, whereas this effect started at four or more cultural activities for searching the web. This difference could be due to web search being a more focused activity requiring a deeper interest in culture. For instance, users need to formulate explicit search queries by themselves, and validate search results in an iterative process leading to the final success. Older adults will activate these resources depending on their interest in consumer culture; hence, the frequency of searching the web will increase at a higher level of cultural participation compared to viewing pictures/videos.

For the two social online activities, we find the pattern that age, education, cultural participation, and PBC were predictors, while gender was not. Social online activity was the only type for which gender was not a predictor. This finding corroborates our expectation that women's higher motivation towards social use can outweigh lower experience and lack of digital skills (Scheerder, van Deursen, & van Dijk, 2017). Further, the effect of higher education was considerably stronger for writing emails than for writing comments/reviews. An explanation could be that individuals with higher education tend to prefer communication channels that allow personal, complex and structured messages. Note that writing comments/reviews on the Internet is different from writing emails, because comments/reviews are most often non-personnel, anonymous and writing may require less mental resources.

Considering the two instrumental online activities, men and those who were younger, with higher education, and reported higher PBC had greater odds for online banking and shopping. However, cultural participation only enhanced the frequency of shopping but not banking. Specifically, participation in three or more cultural activities predicted shopping online, while there was no effect at all for banking. This difference suggests that online shopping can be a tool for older adults to satisfy their curiosity. Note that banking is a necessary activity for all individuals, irrespective of their interest in consumer culture.

Our digital divide model integrates PBC, which was a positive predictor for all six online activities and its direct effect was rather similar (as signified by the small range of odds ratios). It is worth noting that the effect was neither moderated by gender nor age. Based on the mechanism described in our hypotheses development, it is likely that women's trust in PBC did not differ from men. Similarly, the assumed age-related decrease of cognitive and physical resources did not lead to more sensitivity to believe in PBC. However, we find that education moderated PBC for the two informational online activities, i.e., high education attenuated the effect. This finding could be explained by motivational differences, such that those with high education more likely regard the Internet as a useful tool for knowledge acquisition. This specific motivation could counterbalance lower levels of PBC, which is possible because motivation and PBC are both mental resources. We acknowledge that only a limited number of prior studies in the older adults context tested moderators (Choudrie et al., 2018; Lian & Yen, 2014). This limitation of the empirical knowledge also holds true for UTAUT, as articulated by Venkatesh et al. (2016) in a comprehensive review of UTAUT-based studies.

In summary, we believe that our empirical findings contribute to the literature by providing a better understanding of differentiated online activities in older adults. Our approach

enabled us to uncover important differences in the roles of gender, cultural participation and PBC as predictors.

2.5.2 Implications

Our study results have the following implications for research. First, as the range and scope of online services is increasing, opportunities exist to test the validity of our propositions for further online activities. Our research provides the foundation for deeper inquiry as signified by the high explanatory power for six online activities that vary considerably. Of particular interest are social networks and messaging services (e.g., Facebook, Twitter, WhatsApp), and health-related online services, which attain increasing importance for this target group. Second, based on our model, fellow researchers can examine the usefulness of further categorical inequalities such as ethnicity and household (van Dijk, 2005, 2006). Ethnicity is a personal categorical inequality, which differentiates majority and minority. Household as a positional category assigns individuals to single or family. Third, because we find education as a moderator of perceived behavioral control in case of informational online activities, future research can now focus on educational subgroups (Hargittai et al., 2018). For instance, studies could differentiate further levels of formal education, and in particular, consider experiences obtained during working life.

Our research also has important practical implications. Our results help identify subgroups requiring training, assistance or tailored online services. This identification is possible because of the categorical inequalities underlying our digital divide model. Moreover, subgroups can be derived from combining two or more subordinated groups. The largest subgroup comprises older women with low education and lack of cultural participation. Their risk of exclusion from the digital world will be amplified if their belief in mastering the Internet (PBC) is rather low; this risk is even more critical, because they cannot compensate PBC with high education. First, training should target the advancement of digital skills. Informational, social, and instrumental activities require different skill sets. Some online activities demand more mental resources (e.g., for information processing and decision-making), e.g., searching the web and online banking, because the user takes a much more active role. Training of particular skills, such as retrieving and evaluating rich information, will also enhance PBC, which is key for all online activities. Second, the enhanced understanding of older adults' online activities can support policy-makers and other societal stakeholders in devising legislation and interventions targeted at older adults. For instance, legislation should guarantee fair use of a broad set of different online services for all groups defined by categorical inequalities. Third, implications arise for online service

providers to tailor their services to the requirements of the groups discussed above. For instance, recent advancements in Internet-based applications allow implementing responsive user interfaces aligned with individual needs, ranging from devices and network quality to diverse user preferences.

2.5.3 Limitations

The results of this study should be interpreted in light of its limitations. The first limitation is the cross-sectional nature of the study, which does not allow us making causal inferences. Older adults' use of the Internet is a process that evolves over time. Cross-sectional data only provides a snapshot of that process. Longitudinal studies are required to validate our propositions. The second limitation of the study is its focus on six online activities, which naturally cannot reflect the full diversity of older adults' online activities. Our selection was motivated by spanning a wide array including informational, social, and instrumental online activities. In addition, our measurement of online activities relied upon self-reported frequencies measured on an ordinal scale. Thus, our data is subjective and approximate. Asking the participants to recall the time spent for such activities could yield continuous data of higher precision. However, this approach was not feasible for our target group of older adults, since they might not be able to recall their time spent. Self-reports were also used in the few studies investigating specific online activities, either by engagement, i.e., yes/no (N. G. Choi & DiNitto, 2013; Hong & Cho, 2017), or scaled frequency, e.g., five-point scale as in our study (Nimrod, 2018; van Deursen & Helsper, 2015). Third, our moderation analysis did not include experience for which UTAUT posits an increasing effect of PBC (Venkatesh et al., 2003). Fourth, our survey targeted older adults living in an urban area in Western Europe; hence, our results may not necessarily be generalized to older adults living in rural areas or other regions.

2.6 Conclusion

Understanding older adults' Internet use is important for the design of online services, training programs and policies targeted for the elderly. Although Internet use is changing tremendously and the range of online activities is broadening, the literature is insufficient in informing us about the factors explaining specific online activities. Our study contributes a nuanced understanding of older adults' Internet use by examining four socio-demographic characteristics (i.e., gender, age, education, and cultural participation) and perceived behavioral control in predicting informational, social, and instrumental online activities. Our results shed light on the important differences of gender and cultural

participation (direct effect) and education as a moderator of PBC in case of informational online activities. The findings have implications for providers to tailor their online services to the needs of older adults as a growing consumer group, and informs policy-makers and societal stakeholders in designing programs and interventions targeted at older adults.

Chapter 3

Associations Between Individual Factors, Environmental Factors and Outdoor Independence in Older Adults[2]

Abstract. The degree to which individuals can accomplish outdoor activity by themselves or require support is an important facet of successful ageing. While prior research focuses on participation in outdoor activity, understanding of older adults' outdoor independence is limited. We adopt an ecological approach to examine the role of individual factors and environmental factors in explaining outdoor independence. Our sample comprised older adults aged 65+ living in a medium-sized city in Germany (N = 1070). The results show that being male, younger, and healthier was positively associated with outdoor independence, while living together was not. Further, outdoor independence decreased with higher levels of perceived environmental barriers. This negative association was moderated such that it was stronger for the less healthy and older participants. Based on our empirical findings, we offer insights for policy makers, urban planners, and community groups to design age-friendly communities, and consequently facilitate outdoor independence among older adults.

[2] This chapter is based on joint work with Joerg Leukel from the University of Hohenheim. The candidate's individual contribution focused mainly on literature research, data analyses, and the writing. This article is printed with kind permission of Springer Nature. It has been originally been published as Schehl, B. & Leukel, J. (2020). Associations between individual factors, environmental factors, and outdoor independence in older adults. *European Journal of Ageing,* 17(3), 291-298. https://doi.org/10.1007/s10433-020-00553-y.

3.1 Introduction

In an ageing society, remaining independent and maintaining an active lifestyle is important to many older adults. Active behavior can delay ageing processes and contribute to successful ageing (Diggs, 2008). A particular type of activity is outdoor activity such as shopping, visiting friends, and attending social events. Outdoor activity can enhance quality of life (Vagetti et al., 2015) and is perceived as more pleasurable than activity performed at home (Cabrita et al., 2017).

Participation in outdoor activity depends on the environment in which older adults live. In other words, older adults residing in a supportive environment tend to be more active outside (Eronen et al., 2013; Sugiyama & Thompson, 2007). The role of the environment in explaining older adults' outdoor activity has been studied extensively (Moran et al., 2014; Rosso et al., 2011). The overall finding is that various environmental conditions should be considered, e.g., quality of sidewalks, availability of resting places, and access to amenities. While previous research offers important insights into activity patterns of particular subgroups, understanding of older adults' outdoor independence is limited. Outdoor independence is defined as the degree to which an individual believes in their ability to be active outdoors. For instance, independence can be categorized whether one needs support by others or is able to be active by themselves. However, little is known about the factors affecting outdoor independence. The paucity of prior research is surprising given that independence is an important predictor of many outdoor activities.

To understand how people interact with their environment, ecological models have been found useful (Fisher et al., 2018; Sallis et al., 2008). The main tenet of the ecological approach is that multiple levels of influences, such as intrapersonal, cultural, environmental, and political, explain human behavior. Previous research developed such models for explaining participation in outdoor activity (Cunningham & Michael, 2004; Sallis et al., 2006). In a similar vein, our study adopts the ecological perspective to examine the role of individual and environmental factors for outdoor independence in older adults. Understanding of how individuals interact with their environments helps to develop effective approaches to improve behaviors. Hence, environments and policies must be created to facilitate healthful choices, and older adults must be educated and motivated about those choices (Sallis et al., 2008).

With respect to individual factors, previous research provides empirical support for several variables being associated with outdoor activity. For instance, men and women seem to have different opportunities and needs to participate in outdoor activity (Bennett, 1998;

Lee, 2005; Sjögren & Stjernberg, 2010), e.g., women reported to feel unsafe going out after dark and fear crime as a barrier to outdoor activity (Eyler et al., 1999). Given that the group of older adults is often characterized by a decline in mobility and mental ability as well as functional impairments (Spirduso et al., 2005), it is not surprising that with increasing age participation in physical outdoor activity decreases (Sjögren & Stjernberg, 2010; Wu et al., 2016). Similarly, many older adults are experiencing limitations in physical functioning, which impair them in their mobility and independence to leave the house. Thus, being in poor health undermines participation in outdoor activity (Chaudhury, Campo, Michael, & Mahmood, 2016). As many older adults tend to leave the house more often when they have partners or friends who accompany them, it is also reasonable to assess participants' living situation when considering older adult's outdoor activity (Chudyk, McKay, Winters, Sims-Gould, & Ashe, 2017; Sugiyama & Thompson, 2007).

With respect to environmental factors, the literature provides a comprehensive account of environmental features, which either support or hinder older adults in remaining independent and active (Kerr, Rosenberg, & Frank, 2012; Moran et al., 2014; Rosso et al., 2011). Of particular importance are perceptions of environmental barriers, which have been found to be more related to outdoor activity than the objective environment (Wu et al., 2016). Individuals who have higher perceptions of environmental barriers, are less likely to be active outdoors. For instance, bad signage or missing signs can impede individuals to cross streets, which specifically affects older adults with declining sense of vision and navigation (Chaudhury et al., 2016). Further, dangerous sidewalks enhance the risk of falling due to uneven conditions, steepness, and high curbs (Rosenberg, Huang, Simonovich, & Belza, 2013). Similarly, poor lighting of sidewalks have been found to increase the danger of falling (Rosenberg et al., 2013). As older adults often depend on places to sit and rest due to diminishing physical fitness, lack of resting places hinder older adults to leave the house and therefore are perceived as high barrier for outdoor activity (Chaudhury, Mahmood, Michael, Campo, & Hay, 2012; Moran et al., 2014). Likewise, lack of public toilets is a severe problem for older adult's outdoor mobility, especially for those suffering from incontinence (Moran et al., 2014; Risser, Haindl, & Ståhl, 2010). Another barrier identified in the literature is the distance to essential destinations such as groceries and pharmacies (Nathan, Wood, & Giles-Corti, 2014; Rantakokko et al., 2014). Next to these factors, participation in outdoor activity can also depend on whether older adults live in the city center or in a peripheral area (Krogstad, Hjorthol, & Tennøy, 2015).

In summary, the ecological approach provides a rationale for examining how individual and environmental factors are associated with outdoor independence. This approach allows us

to assess the strength of these factors and their interplay. Specifically, the purpose of our study is to investigate individual and environmental factors related to outdoor independence in older adults. We assess the role of gender, age, subjective health, living arrangement, neighborhood, and perceptions of environmental barriers. The results of our study will inform the planning of age-friendly communities and have policy implications for facilitating sense of outdoor independence among older adults.

3.2 Methods

3.2.1 Study Design and Participants

Our study was based on a cross-sectional survey that we conducted in the summer of 2017. This survey targeted all older adults (65+) living in three neighborhoods of a medium-sized city in Germany. While two neighborhoods exhibited high population density (6,056 and 2,400 per square kilometer, respectively), the third neighborhood had a clearly rural character and its population density was much lower (343 per square kilometer). A local municipal provider of geriatric care was involved in the survey, in particular by pretesting the questionnaire and implementing the survey. Further, we received support from the city administration, which provided us with the registered addresses. The paper-based questionnaire was mailed to 6,170 older adults. It was complemented by a cover letter signed by the respective district leader. We received 1,302 valid responses within six weeks (response rate: 21.5%, considering that 100 addresses were invalid). This rate is comparable to prior surveys that used posted self-administered questionnaires (Palonen et al., 2016). Participants also had the option to fill in the questionnaire online by using an individual access code; this option was chosen by thirty-six participants.

The current study includes 1,070 participants, who answered questions on socio-ecological factors and outdoor independence (no missing values). We evaluated whether our convenient sample is representative of the population as a whole. Specifically, we compared our sample with the population of older adults living in the city from which the sample was drawn. We retrieved data from a database provided by the state (IT.NRW, 2017). The share of women in our sample (50.0%) and the population (51.0%) was very similar. There were only marginal differences with respect to age groups, categorized into 65-69 years (25.5% vs 25.7%), 70-79 years (45.5% vs. 46.9%), and 80 years and older (29.0% vs. 27.4%). The share of participants with no high school education was smaller in our sample (1.1% vs. 6.1%), while the share of older adults holding an academic degree was greater (14.7% vs. 6.5%).

3.2.2 Measurements

The study examined the role of individual and environmental factors associated with outdoor independence. Individual factors included gender, age, subjective health, and living arrangement. The main environmental factor under study was perceived environmental barriers. In addition, we controlled for neighborhood.

3.2.2.1 Outdoor Independence

Outdoor independence was measured by asking participants: "Which of the following activities do you accomplish on your own, for which do you need support?". We chose shopping, visiting doctors, attending events, and visiting friends as activities being most prevalent in older adults (Szanton et al., 2015). We administered a four-point scale ranging from "not possible even with support" (0), "with personal support only" (1), and "independent only on known routes" (2) to "independent (without support)" (3). The answers were summed to produce an independence score ranging from zero to twelve. Scale reliability was excellent (Cronbach's alpha of 0.94). The scores were then mapped onto four groups indicating the level of outdoor independence, defined as very low for 0-3, low for 4-7, medium for 8-11, and high for 12.

3.2.2.2 Individual Factors

Gender was defined as female or male. Age was calculated based on participant's year of birth. Subjective health was operationalized by perceptions of one's individual health. We defined the question as follows: "How satisfied are you with your health state?". Answer options ranged from "very bad" (1), "rather bad" (2), "moderate" (3), and "rather good" (4) to "very good" (5) (Idler & Benyamini, 1997). Living together was assessed by asking participants about the number of people living in their household. Then, we derived a dichotomous variable (yes or no) (Chudyk et al., 2017; Sugiyama & Thompson, 2007).

3.2.2.3 Environmental Factors

The main environmental factor in our study was perceived barriers defined as perceptions of how far the built environment hinders one's outdoor activity (Rantakokko et al., 2017; Sugiyama & Thompson, 2007). We operationalized this factor by asking: "To what extent do the following circumstances prevent you from going outdoors?". We defined a six-item instrument based on prior research (Moran et al., 2014; Rosso et al., 2011): Bad signage / missing signs; dangerous sidewalks; poor lighting of sidewalks; lack of resting places; lack of public toilets; long distances. Participants evaluated the relevance of each barrier using a five-point scale (Michael, Beard, Choi, Farquhar, & Carlson, 2006). The scale ranged from

"not at all" (1), "somehow" (2), "moderately" (3), and "strongly" (4) to "very strongly" (5). Finally, we calculated the mean of the six items. Therefore, perceived barriers was defined as a continuous variable. Cronbach's alpha of our instrument was 0.86, which indicates a good level of internal consistency. In addition, we controlled for neighborhood (urban or rural) (Krogstad et al., 2015).

3.2.3 Statistical Analyses

Descriptive statistics included the mean, standard deviation, minimum, maximum, and frequencies. Bivariate correlations for all variables were assessed by using the Spearman correlation test (no variable was normally distributed). Because our dependent variable was measured on an ordinal scale with four categories, we conducted ordinal regression analysis. This analysis determined odds ratios (OR), which represent how the probability of achieving a higher level of outdoor independence changes for one-unit increase in the independent variable (OR > 1 for positive changes, OR < 1 for negative changes). We followed a hierarchical approach: While the first model only comprised individual factors, the second model also included environmental factors. The third model added four interaction terms for individual factors and perceived barriers, which allowed us to examine moderation. We mean centered all metric variables to assist in interpreting the model with interactions by giving age, subjective health, and barriers meaningful zero-points (Dalal & Zickar, 2012). For each model, we tested the assumptions of ordinal regression analysis, in particular, no multicollinearity and proportional odds. Multicollinearity was assessed using Variance Inflation Factors (VIF), which were between 1.07 and 1.33. This result showed that multicollinearity did not affect our regression models (Hair, Black, Babin, & Anderson, 2014). The proportional odds assumption was verified by using the parallel lines test for each regression model. The p-values were between 0.170 and 0.423; hence, the proportional odds assumption was met, meaning that the slope of regression lines is the same for each level of outdoor independence (Garson, 2012). All statistical analyses were carried out using IBM SPSS Statistics 25. The significance level was 5%.

3.3 Results

Table 1 shows descriptive statistics for the independent variables. The sample was balanced in terms of gender. Almost half of the participants were between 65 and 74 years (46.0%), while 11.5% were older than 84 years. With respect to subjective health, good/very good accounted for 52.2%, and bad/very bad was reported by 10.4%. More than two thirds of the participants lived with someone (70.7%). About every seventh reported that

environmental barriers did not at all prevent them from going outdoors (16.7%), while 19.2% had strong or very strong perceptions of environmental barriers. The number of participants per neighborhood was similar, with two-thirds living in the urban neighborhoods.

Table 3.1: Participant characteristics, *N* = 1070

Variable	n	(%)	M (SD)	Range
Gender				
Male	535	(50.0)		
Female	535	(50.0)		
Age[a] (years)			74.99 (6.93)	65 – 98
65 – 74	483	(46.0)		
75 – 84	448	(42.6)		
85 – 94	112	(10.7)		
≥ 95	8	(0.8)		
Subjective health (1-5)			3.52 (0.88)	1 – 5
Very bad	20	(1.9)		
Bad	91	(8.5)		
Moderate	401	(37.5)		
Good	433	(40.5)		
Very good	125	(11.7)		
Living together				
Yes	757	(70.7)		
No	313	(29.3)		
Barriers[b] (1-5; b)			2.14 (0.96)	1 – 5
1	179	(16.7)		
$1 < b \leq 2$	408	(38.1)		
$2 < b \leq 3$	294	(27.5)		
$3 < b \leq 4$	173	(16.2)		
$4 < b \leq 5$	32	(3.0)		
Neighborhood				
Urban	728	(68.0)		
Rural	342	(32.0)		

[a] We defined four age groups for the sake of clarity.

[b] Higher scores indicate higher levels of perceived environmental barriers.

With respect to outdoor independence, the frequencies for the levels were as follows: Very low independence was reported by 44 participants (4.1%) and low independence by 98

(9.2%). Also 98 older adults indicated a medium level (9.2%) and 830 stated high independence (77.6%).

Table 2 presents the correlation matrix. For all independent variables, most correlations were weak, and the correlation between subjective health and perceived barriers was moderate (r = -.42). Correlations between predictors and outdoor independence were statistically significant, with independence decreasing for participants being female (r = -.16), older (r = -.43), and reporting higher perceived barriers (r = -.42). Outdoor independence was higher for those who were healthier (r = .47) and lived together (r = .20). Neighborhood was not correlated with outdoor independence (r = -.01, p = 0.88).

Table 3.2: Correlations for predictors and outdoor independence, *N* = 1070

	1.	2.	3.	4.	5.	6.
1. Gender (female)						
2. Age	.08**					
3. Subjective Health	-.07*	-.28**				
4. Living together	-.22**	-.24**	.12**			
5. Barriers	.14**	.31**	-.42**	-.19**		
6. Neighborhood	.02	-.02	-.03	-.09**	.01	
7. Outdoor independence	-.16**	-.43**	.47**	.20**	-.42**	-.01

Note. Spearman's rank correlations (two-tailed). * p < .05, ** p < .01.

Table 3 provides the results of the ordinal regression analyses. Model 1 includes the four individual factors, of which gender, age, and subjective health were associated with outdoor independence. By adding environmental factors, Model 2 shows that women were less likely to be independent outdoors (OR = 0.65). The probability for the next level of outdoor independence was 12% lower for each one-year increase in age (OR = 0.88). This probability was 185% higher for each one-unit increase in subjective health (OR = 2.85). Living together was not associated with outdoor independence. Concerning the environmental factors, perceived barriers exhibited a negative association (OR = 0.57) and this association remained after controlling for neighborhood. Adding environmental factors to the regression model led to an increase of explained variance by 7% (R2 = 0.54), which suggests that individual factors and environmental factors worked in concert. To further explore this finding, we assessed interactions between individual factors and environmental barriers.

As the results of Model 3 indicate, the interaction between environmental barriers and subjective health was statistically significant, i.e., the negative association of perceived environmental barriers was stronger for the less healthy (OR = 1.38). Further, the role of

perceived barriers was smaller for younger participants (OR = 0.98). Subsequently, inserting interaction terms further increased the explanatory power to 66%. Gender, age, subjective health, and barriers remained statistically significant in Model 3. We note that each reported OR can only be interpreted as the unique impact on outdoor independence when all other mean-centered variables are zero.

Table 3.3: Associations between individual factors, environmental factors and outdoor independence (ordinal regression models), *N* = 1070

	Model 1 Individual factors			Model 2 Environmental factors added			Model 3 Interaction terms added		
Variable	OR	95% CI	p	OR	95% CI	p	OR	95% CI	p
Gender (female)	0.61	0.46–0.80	**<.001**	0.65	0.49–0.86	**.003**	0.74	0.56–0.97	**.028**
Age (years)	0.87	0.86–0.89	**<.001**	0.88	0.86–0.89	**<.001**	0.91	0.89–0.93	**<.001**
Subjective health (1-5)	3.17	2.70–3.72	**<.001**	2.85	2.41–3.36	**<.001**	2.12	1.81–2.49	**<.001**
Living together (yes)	0.83	0.63–1.09	.177	1.03	0.78–1.36	.842	0.91	0.68–1.23	.540
Barriers (1-5)				0.57	0.49–0.65	**<.001**	0.77	0.61–0.97	**.029**
Neighborhood (urban)				0.99	0.75–1.32	.954	1.00	0.77–1.29	.977
Barriers x Gender							0.83	0.64–1.07	.154
Barriers x Age							0.98	0.96–1.00	**.040**
Barriers x Subjective health							1.38	1.18–1.62	**<.001**
Barriers x Living together							1.06	0.81–1.38	.686
R2		.47			.54			.66	
R2 change		n/a			.07			.12	

Abbreviations. OR = odds ratio; CI = confidence interval; R2 = pseudo r-squared (Nagelkerke's).

Note. Age, subjective health, and barriers were mean-centered. Link function: Complementary Log-log.

3.4 Discussion

This study investigated individual and environmental factors linked to outdoor independence in older adults. The ecological approach offered a structure for investigating this link. Our study is first in testing the role of individual factors in explaining outdoor independence, and thus contributes to understanding this important facet of active aging. In combination with environmental factors our model is effective by explaining two-thirds

of the variance in outdoor independence. Overall, our study results suggest that both individual and environmental factors should be considered to understand outdoor independence.

With respect to individual factors, we found that being male, younger, and healthier was positively associated with outdoor independence. Previous studies have shown that individual factors are similarly associated with participation in outdoor activity, either measured by duration or frequency. For instance, gender differences were found for participation in both light and moderate-to-vigorous physical activity, with lower levels of participation for women but not in case of walking for transportation (Chudyk et al., 2017). Higher age also undermined participation, e.g., in terms of total activity count, steps taken per day, levels of physical activity (Chudyk et al., 2017), and outdoor recreational activity (Wu et al., 2016). Results of previous research are consistent for the positive role of health for participation in outdoor activities (Sugiyama & Thompson, 2007). Prior findings for the role of social factors such as living arrangement, marital state, and social network are less conclusive (van Holle et al., 2015). In our sample, living together with someone did not enhance the odds of outdoor independence. An explanation for this result may be that our measure did not reflect the extent to which one receives social support by the partner or family (Carlson et al., 2012; Corseuil Giehl, Hallal, Brownson, & d'Orsi, 2017); hence, specific types of social support may also facilitate outdoor independence.

Our results underscore the relevance of the environment such that when supportive features exist, older adults can remain independent and active (Kerr, Rosenberg et al., 2012). Environmental barriers have been studied extensively in the older adults' outdoor activity literature (Moran et al., 2014; Rosso et al., 2011). While previous studies showed a negative association between perceived environmental barriers and outdoor activity, we find a similar association for outdoor independence. Moreover, the combination of perceived barriers and individual factors should be considered when examining outdoor independence. By analyzing whether individual factors moderate the influence of perceived environmental barriers, we treated the older population as a diverse group. We find that the negative association of environmental barriers was stronger for less healthy and older participants. Ageing is often accompanied with deteriorating mobility, physical fitness, and mental abilities, which culminate in lower levels of subjective health. These inevitable developments make older adults feel intimidated and unsafe, thus, impeding them to leave the house. Consequently, those less healthy older adults might have lower levels of confidence in their ability to be active outdoors. While prior research tested interaction effects derived from ecological models, few studies found such interactions (Carlson et al.,

2012; Slaug, Iwarsson, & Björk, 2019; van Holle et al., 2015). In our context of outdoor independence, the results demonstrate that subjective health and age as individual factors, and perceived barriers as an environmental factor work in concert; hence, together they even have a stronger impact.

Collectively, our study results provide strong evidence for the usefulness of the ecological approach to explain outdoor independence. Our study complements previous research that focused on participation in outdoor activity. The usefulness lies in being able to assess the role of individual factors, environmental factors, and their interactions. Indeed, we find two meaningful interactions between subjective health, age, and environmental barriers, which further enhances the explanatory power of our model.

Two constructs related to outdoor independence can be identified from the extant literature, namely, mobility and autonomy. Mobility consistently emerges as an important facet of older adults' outdoor activity. As outdoor mobility is connected to many necessary daily activities as well as leisure activities, it is not surprising that a decline in outdoor mobility is associated with lower levels of quality of life (Rantakokko et al., 2014). Previous research showed that barriers to outdoor mobility can be attributed to personal, social, environmental, technical, and legal aspects (Risser et al., 2010). Particularly, older adults rated inconsiderate car drivers and lack of public toilets as the most important barriers to outdoor mobility. This issue gained increasing prominence on a European level. For instance, the European Union's project SIZE (Life quality of senior citizens in relation to mobility conditions) focused on older adults' mobility and transport situation as well as experts' views on this (Amann, Reiterer, Risser, & Haindl, 2006). Specifically, the results of SIZE provide guidance for implementing relevant policies to maintain older adult‘s mobility. Although mobility is important for older adults' outdoor activity, we note that outdoor mobility must not be confused with outdoor independence. While mobility is defined as the ability to move easily outside, our study examined whether older adults can accomplish outdoor activities with or without support.

Autonomy occurs as another construct in the context of outdoor activity. Several studies applied the Impact on Participation and Autonomy Questionnaire (IPAQ) (Cardol, Haan, Jong, van den Bos, & Groot, 2001) to assess autonomy in participation outdoors (Portegijs, Rantakokko, Mikkola, Viljanen, & Rantanen, 2014; Rantakokko et al., 2017). It is worth noting that the conceptualization of autonomy in previous research is different from outdoor independence. Autonomy represents participation in outdoor activity, but does not differentiate whether one needs support. In our study, we examined whether older adults require support by others or can be active outdoors by themselves.

We believe that our findings have three practical implications. First, our results help identify subgroups requiring support most urgently. One particular group is older women. Our results suggest that women are at higher risk of losing their feeling of outdoor independence. Therefore, appropriate activity-promotion strategies are needed, tailored to the needs of women. Second, understanding the predictors of outdoor independence can assist policy-makers, urban planners, and community groups in designing interventions targeted to the needs of older adults. The perceived environmental barriers can be addressed by, e.g., barrier-free signs to increase orientation, safe sidewalks, improved lightning of sidewalks as well as shorter distances to resting places, public toilets, and amenities. Such environmental components can be implemented by municipalities, local businesses, and civil associations. By transforming the infrastructure into an age-friendly and barrier-free environment, feelings of independence will be strengthened, and ultimately, participation in outdoor activity will be enhanced. Third, older adults' outdoor independence can also be facilitated by providing services that arrange companionship. Implementing and maintaining such social interventions would require less resources than environmental interventions, especially when considering the severely limited public budgets.

The results of this study should be interpreted in light of its limitations. As it is the nature of surveys using self-reports, participants' overestimation of outdoor independence might be possible; hence, our data is subjective and rather approximate. While our study focuses on a core set of individual and environmental factors, future research can examine the usefulness of further factors. Of particular interest are mobility (Risser et al., 2010) and social support (Fisher et al., 2018), which are both essential for this target group. Fellow researchers could also consider objective measures of the environment, which can be retrieved by GIS databases (Nathan et al., 2014; Wu et al., 2016).

3.5 Conclusion

The contribution of this study is an empirically validated model explaining outdoor independence through individual and environmental factors. Using an ecological approach, our study results suggest that the immediate environment is an essential attribute to understand older adults' outdoor independence. The perceptions of how far the built environment hinders one's activity largely determine outdoor independence. Further, our analysis revealed that being female, older, and less healthy enhanced the risk for low levels of outdoor independence. However, outdoor independence was not associated with living together. Perceived environmental barriers were more important for those who reported

lower levels of health and were older. This result indicates that environmental interventions should target less healthy older adults, because behavioral changes can most likely be expected in this subgroup. Collectively, our findings contribute a profound understanding of factors associated with outdoor independence. Specifically, our research provides the foundation for deeper inquiry as signified by our model explaining about two-thirds of the variance. We believe that our results offer insights for policy makers, urban planners, and community groups to design age-friendly communities, which then ultimately can facilitate outdoor independence among older adults.

Chapter 4

Outdoor Activity Among Older Adults: Exploring the Role of Informational Internet Use[3]

Abstract. The Internet has the potential to enable older adults to live a socially active and self-determined life. An important facet of active aging is participation in outdoor activity. Previous research has shown that older Internet users participated more frequently in outdoor activities. However, understanding of how Internet use can influence the behavior of going outdoors is still limited. To bridge this gap, the goal of this study was to examine whether informational Internet use specific to opportunities and offerings in the city facilitates participation in outdoor activity. Primary survey data from individuals aged 65+ living in a medium-sized city in Europe (N = 1,117) was analyzed. The results show that Internet as an information source predicted community activity for participants living in urban neighborhoods but not in a rural neighborhood. Further, informational Internet use predicted cultural activity for residents living in all three neighborhoods. The results thus emphasize the positive effect of informational Internet use on behavior through providing older adults with useful information about opportunities and offerings available in their neighborhood. Taken together, the findings provide a rationale for the development of digital neighborhood platforms and interventions targeted at older adults' digital skills.

[3] This manuscript is printed with kind permission of Taylor & Francis Group. It has been originally published as Schehl, B. (2020). Outdoor activity among older adults: Exploring the role of informational Internet use. *Educational Gerontology*, 46(1), 36-45. https://doi.org/10.1080/03601277.2019.1698200.

4.1 Introduction

The population of older adults is the most rapidly growing age group worldwide. While aging is often accompanied by a decline in mobility, physical fitness, and mental ability (Spirduso et al., 2005), active behavior can help mitigating some of the effects of aging (Diggs, 2008). Outdoor activity, such as walking, cycling, and attending social events, is an important facet of successful aging. Specifically, outdoor activity can facilitate physical performance (Kerr, Sallis et al., 2012), social ties (Bertera, 2003), and quality of life (Vagetti et al., 2015). For instance, greater participation in cultural activities can reduce the mortality risk for older adults (Adams, Leibbrandt, & Moon, 2011) and more frequent involvement in social activities can lower the risk for cognitive impairments and depression (Kelly et al., 2017).

Previous research found that older adults residing in a supportive neighborhood environment tend to be more active outside (Moran et al., 2014; Rosso et al., 2011). Participation in outdoor activity, however, depends not only on the environment in which older adults live but also on the extent of individual's knowledge about opportunities and offerings. Here, media use allows older adults to acquire knowledge to support their decision-making with respect to being active outdoors. Traditional media, such as newspaper and radio, can inform individuals about opportunities and offerings. New media, such as the Internet, can also help individuals gain knowledge about specific activities, stay connected to others, and receive social support (Y.-R. R. Chen & Schulz, 2016). Further, Internet use can increase levels of perceived independency and decrease levels of loneliness (Cotten, Anderson, & McCullough, 2013; Nilsen et al., 2018; Seifert & Schelling, 2018). Thus, the Internet offers potential to pursue a socially active and self-determined life.

It is worth noting that Internet adoption among older adults has increased substantially over the last decade. For instance, about 58% of U.S. Americans age 65 or older used the Internet in 2015, compared with only 28% ten years earlier (Perrin & Duggan, 2015). Thus, it is not surprising that older adults progressively go online to search for information about events, activities, and community services (van Boekel et al., 2017; van Deursen & Helsper, 2015). The knowledge acquired online can be useful for maintaining and developing social contacts and staying actively engaged in the community (Morrison & Barnett, 2011). Indeed, an increasing share of older adults acknowledge the Internet as an important information source to meet others interested in the same offline activities (Nimrod, 2014).

The relationship between Internet use and participation in outdoor activity has been examined in a few studies. A study in Finland showed that older adults who used the

Internet every day or several times a week participated in more types of leisure activity than others (Näsi et al., 2012). Further, older adults who used the Internet for communication participated more frequently in offline social activities, such as visiting friends or family and attending classes (Kim et al., 2017). Associations have also been found for older computer users being more likely than non-users to join community organizations and do volunteer work (Cresci, Yarandi, & Morrell, 2010). Results of a longitudinal study in New Zealand suggest that informational Internet use leads to greater diversity of volunteering, defined as the number of organizations engaged in (Szabo et al., 2019). This study, however, found no association with duration of volunteering. Despite the growing number of studies in this field, the understanding of the relationship between older adults' use of the Internet as an information source and their outdoor activity is impeded by two assumptions. First, previous research examined Internet use in general but not the specific purpose of acquiring knowledge about opportunities and offerings in the city (Ihm & Hsieh, 2015; Kim et al., 2017). General Internet use covers a wide range of purposes, including many purposes for which no causal link with outdoor activity can be stated. This limitation holds true for the most prevalent purposes, such as writing e-mails, watching videos, and shopping online (Anderson & Perrin, 2017). Second, previous studies do not make allowance for the distinction between urban and rural neighborhoods, for which the role of informational Internet use could be different. Individuals living in rural neighborhoods might rely more on traditional information sources, such as regional newspapers or friends; hence, traditional and new information sources should be assessed collectively.

Against this backdrop, the aim of the present study is to examine how the Internet as an emerging information source can facilitate community activity as well as cultural activity among older adults. Informational Internet use is precisely defined as information search regarding events in the city. Hereby, the Internet is set in comparison with traditional information sources. Using survey data from individuals aged 65 and older (N = 1,117), the associations were compared in three different neighborhoods. Associations are expected to be present, but not for community activity by participants living in the rural neighborhood. The latter expectation is motivated by the fact that individuals living in rural neighborhoods have a greater sense of community (Kitchen, Williams, & Chowhan, 2012), hence, their participation in outdoor activity will less likely be driven by media use. Overall, the study aims to contribute a differentiated understanding of older adults' outdoor activity by examining the role of information sources in predicting community and cultural activity for residents in three different neighborhoods.

4.2 Method

4.2.1 Sample and Data Collection

This study is based on a survey, which was conducted in the summer of 2017. The survey targeted all older adults (age 65+) living in three neighborhoods of Mönchengladbach, a city with around 260,000 inhabitants in Germany. While two neighborhoods exhibited high population density (6,056 and 2,400 per square kilometer, respectively), the third neighborhood had a clearly rural character and its population density was much lower (343 per square kilometer). With the support from the local municipality, a paper-based questionnaire was mailed to 6,170 older adults. They were given six weeks to return the questionnaire (a stamped and addressed envelope was provided). Considering that 100 addresses turned out to be invalid, the full sample included 1,302 older adults, which accounts for a response rate of 21.5%. This rate is comparable to prior surveys that also used posted self-administered questionnaires targeting older adults (Palonen et al., 2016). In the current study, participants with missing values on key variables were excluded, which resulted in a final sample of 1,117 participants (M_{age} = 75.37, SD = 7.05). There were only marginal differences in age, gender, and education between the sample and the population of older adults living in the city (total of 44 neighborhoods), from which the sample was drawn. The study was non-interventional and all participants provided written informed consent. This research was conducted in accordance with the university's guidelines and procedures.

4.2.2 Measures

4.2.2.1 Outdoor Activity

Two distinct types of outdoor activities were examined, namely, community activity and cultural activity. The first dependent variable is community activity, defined as how individuals are embedded in the social circles offered by religious, political, social welfare, and recreational organizations (Wenger, Dykstra, Melkas, & Knipscheer, 2007). In this study, community activity was operationalized by a three-item instrument comprising "association activities," "meeting friends," and "trips." The second dependent variable is cultural activity, recognized as an integral part of social life (Toepoel, 2011). Cultural activity was measured by a three-item instrument including attendance of "music events," "theaters," and "museums." The extent to which participants are active outdoors was measured by asking the following question: "How often do you perform the following activities?" A five-point ordinal frequency scale was administered, which ranged from

"never" (0), "few times" (1), "several times per month" (2), and "several times per week" (3) to "daily" (4). For each type of outdoor activity, the answers were summed to produce an activity score ranging from 0 to 12 (Chiu, 2019).

4.2.2.2 Information Sources

The study's focus was on the role of using the Internet as a source of information about events in the city. Internet as a new information source was contrasted with four other sources, including "regional newspaper," "local TV," and "radio" as traditional sources as well as "friends/neighbors." Participants reported on frequency of each source used. The question was worded as follows: "How often do you use the following sources to inform yourself about events in your city?" A five-point ordinal scale was offered ranging from "never" (0), "few times" (1), "several times per month" (2), and "several times per week" (3) to "daily" (4).

4.2.2.3 Covariates

Variables were used to control for socio-demographic characteristics, which can be associated with older adults' outdoor activity (Moran et al., 2014; Rosso et al., 2011) . Gender was defined as female or male, and age was calculated based on participant's year of birth. Subjective health was assessed by asking about perceptions of one's individual health. Answer options ranged from "very bad" (1), "rather bad" (2), "moderate" (3), and "rather good" (4) to "very good" (5) (Idler & Benyamini, 1997). Further, participants were asked about the number of people living in their household to derive household composition as a dichotomous variable (living with someone versus living alone) (Sugiyama & Thompson, 2007). Years in neighborhood was measured by asking about how many years participants already lived in their neighborhood (van Cauwenberg, van Holle, Bourdeaudhuij, van Dyck, & Deforche, 2016). The question offered a four-point ordinal scale ranging from "less than one year" (1), "one to five years" (2) and "six to fifteen years" (3) to "more than fifteen years" (4).

4.2.3 Statistical Analyses

As a first step, descriptive statistics according to the three neighborhoods were assessed. Bivariate correlations for all variables were examined using the Spearman correlation test (no variable was normally distributed). To test the associations between information sources and outdoor activity, linear regression analyses were performed. Separate models for each outdoor activity and each neighborhood were defined. The six regression models provided standardized coefficients, confidence intervals, p-values and adjusted R^2 as

measures of association. All statistical analyses were carried out using IBM SPSS Statistics 25.

4.3 Results

4.3.1 Descriptive Statistics

Table 1 presents participants' socio-demographic characteristics. The sample was balanced in terms of gender, and most participants belonged to the age group 65-74. With respect to subjective health, good/very good was reported by about half of the participants and bad/very bad by about every tenth. More than two thirds of participants lived with someone. Overall, participants resided for a long time in their neighborhood, with four out of five participants reporting duration of more than 15 years.

Table 4.1: Sample characteristics for the three neighborhoods

Variable	Urban 1 (n = 424)	Urban 2 (n = 344)	Rural (n = 349)
Gender			
Female	51.2%	49.4%	47.9%
Male	48.8%	50.6%	52.1%
Age			
65-74	43.9%	45.9%	46.4%
75-84	43.9%	42.4%	42.7%
85-94	12.3%	10.5%	10.3%
95+	0.2%	1.2%	0.6%
Subjective Health			
Very bad	1.9%	1.7%	2.6%
Bad	11.6%	9.0%	7.2%
Moderate	39.2%	35.8%	37.5%
Good	37.3%	42.2%	39.8%
Very good	10.1%	11.3%	12.9%
Household composition			
Living with someone	63.4%	72.2%	78.5%
Living alone	36.6%	27.6%	21.5%
Years in neighborhood			
Less than 1 year	1.9%	1.2%	0.0%
1 to 5 years	4.5%	6.4%	2.3%
6 to 15 years	8.5%	10.8%	6.6%
More than 15 years	85.1%	81.7%	91.1%

Table 2 shows frequencies of information sources used, according to the three neighborhoods. About half of the participants used the Internet to search for information about events in the city, specifically, every fourth participant searched for information several times per week or daily. With respect to traditional media, most participants read regional newspaper and listened to the radio several times per week or daily, whereas frequencies were lower for watching local TV (between 12.0% and 20.7%) and consulting friends or neighbors (between 33.5% and 47.0%).

Table 4.2: Frequency of sources used for information about events in the city (N = 1117)

Variable	Urban 1 (n = 424)	Urban 2 (n = 344)	Rural (n = 349)
Source: Internet			
Daily	13.2%	14.5%	12.9%
Several times per week	11.8%	11.6%	10.9%
Several times per month	4.7%	8.1%	7.7%
Fewer times	16.7%	17.7%	20.1%
Never	53.5%	48.0%	48.4%
Source: Regional newspaper			
Daily	60.6%	70.3%	77.4%
Several times per week	8.5%	7.6%	6.0%
Several times per month	5.4%	5.2%	2.6%
Fewer times	11.3%	7.0%	6.6%
Never	14.2%	9.9%	7.4%
Source: Local TV			
Daily	9.4%	6.1%	6.6%
Several times per week	11.3%	8.4%	5.4%
Several times per month	8.5%	4.7%	4.0%
Fewer times	31.4%	23.5%	19.2%
Never	39.4%	57.3%	64.8%
Source: Radio			
Daily	44.8%	48.8%	43.6%
Several times per week	11.3%	13.7%	12.6%
Several times per month	9.0%	4.4%	5.2%
Fewer times	18.9%	19.2%	21.8%
Never	16.0%	14.0%	16.9%
Source: Friends/Neighbors			
Daily	8.5%	5.8%	14.3%
Several times per week	25.0%	30.5%	32.7%
Several times per month	30.2%	34.3%	24.6%
Fewer times	28.1%	23.0%	23.8%
Never	8.3%	6.4%	4.6%

The scores for community activity were quite similar in neighborhood Urban 1 (M = 3.46, SD = 0.09), Urban 2 (M = 3.42, SD = 0.09), and Rural (M = 3.72, SD = 0.09). Almost half of the participants had a score equal or greater than four, while only every twentieth participant reported no community activity. With respect to cultural activity, there were

only marginal differences in the activity scores for neighborhood Urban 1 (M = 1.68, SD = 0.06), Urban 2 (M = 1.64, SD = 0.07), and Rural (M = 1.69, SD = 0.07). Seven percent had a score equal or greater than four, and one fourth reported no cultural activity.

Between-neighborhood differences in informational Internet use and outdoor activity were examined by conducting Kruskal-Wallis tests. The test results were statistically non-significant for informational Internet use (p = .350) and cultural activity (p = .887). A Mann-Whitney U-Test showed that community activity was greater for rural residents than for those living in neighborhood Urban 2 (p = .025). The latter surpassed community activity for neighborhood Urban 1 (p = .022).

Table 3 presents correlations among the independent variables. Correlations between socio-demographic variables and information sources were either statistically non-significant (9 cases), very weak (13 cases), or weak (2 cases). The only exception was a moderate negative correlation between age and Internet as an information source (r = .41). In addition, Internet use was more frequent for participants being male (r = .21), healthier (r = .25), living with someone (r = .18), and residing longer in their neighborhood (r = .09).

Table 4.3: Correlations among independent variables (*N* = 1117)

	1.	2.	3.	4.	5.	6.	7.	8.	9.
1. Source: Internet									
2. Source: Regional newspaper	.10**								
3. Source: Local TV	-.01	-.07*							
4. Source: Radio	.14**	-.02	.13**						
5. Source: Friends/neighbors	.23**	.09**	.13**	.20**					
6. Gender	.21**	.06*	-.08**	-.05	.02				
7. Age	-.41**	.07*	-.04	-.16**	-.12**	.07*			
8. Subjective health	.25**	.14**	-.04	.06	.16**	-.08**	-.28*		
9. Household composition	.18**	.18**	-.08*	.07*	.04	.23**	-.23**	.12**	
10. Years in neighborhood	-.09**	.15**	.05	-.04	.04	-.05	.17**	.03	.11**

Note. Spearman's rank correlations. Gender: 0 = female, 1 = male; Household composition: 0 = living alone, 1 = living with someone; Years in neighborhood: 1 = less than one year, 2 = one to five years, 3 = six to fifteen years, 4 = more than fifteen years. * p < .05, ** p < .01.

4.3.2 Linear Regression Models

Table 4 shows the regression results for community activity. Internet as an information source was associated with community activity for urban residents (Urban 1: ß = 0.194; Urban 2: ß = 0.155) but not for those living in the rural neighborhood. Concerning the traditional information sources, friends/neighbors were the most relevant source, and

associations could be found in each neighborhood. While local TV and radio did not predict community activity, regional newspaper was associated with community activity for urban residents only. Among all information sources, the strongest association was found for friends/neighbors (ß = 0.331, Urban 1). Being younger and healthier predicted greater community activity. Further, longer residency was a predictor of community activity when living in the rural neighborhood. Explained variance was 39% for neighborhood Urban 1, 28% for neighborhood Urban 2, and 29% for the rural neighborhood.

Table 4.4: Linear regression analyses for community activity

Variable	Urban 1 (n = 424)		Urban 2 (n = 344)		Rural (n = 349)	
	ß	95% C.I.	ß	95% C.I.	ß	95% C.I.
Source: Internet	0.194***	[0.133, 0.355]	0.155**	[0.056, 0.294]	0.028	[-0.086, 0.155]
Source: Regional newspaper	0.138**	[0.072, 0.263]	0.139**	[0.052, 0.293]	0.092	[-0.000, 0.258]
Source: Local TV	0.033	[-0.062, 0.157]	-0.027	[-0.169, 0.094]	0.009	[-0.123, 0.149]
Source: Radio	-0.001	[-0.093, 0.090]	-0.004	[-0.109, 0.100]	0.013	[-0.092, 0.121]
Source: Friends/neighbors	0.331***	[0.425, 0.709]	0.187***	[0.150, 0.478]	0.239***	[0.228, 0.530]
Gender	-0.052	[-0.493, 0.106]	0.017	[-0.271, 0.385]	0.068	[-0.089, 0.569]
Age	-0.183***	[-0.072, -0.025]	-0.171**	[-0.069, -0.017]	-0.324***	[-0.104, -0.054]
Subjective health	0.214***	[0.285, 0.619]	0.266***	[0.330, 0.709]	0.171***	[0.147, 0.527]
Household composition	0.003	[-0.303, 0.325]	-0.020	[-0.471, 0.317]	-0.054	[-0.643, 0.179]
Years in neighborhood	0.030	[-0.153, 0.335]	-0.060	[-0.421, 0.096]	0.195***	[0.482, 1.320]
R2 (adjusted)	0.39		0.28		0.29	

Note. ß = standardized coefficient. Comparison gender is male. Age is a metric measure. Subjective health, years in neighborhood, and source are ordinal measures. Comparison household composition is living alone.
* p < .05, ** p < .01, *** p < .001.

Table 5 presents the regression results for cultural activity. Internet as an information source predicted cultural activity of participants living in all three neighborhoods (Urban 1: ß = 0.202; Urban 2: ß = 0.127; Rural: ß = 0.162). Among the traditional information sources, participants who used regional newspaper reported more cultural activity. Local TV was a predictor for older adults living in neighborhood Urban 2, while all other information sources were not related to cultural activity. The covariates showed a pattern of results similar to community activity, with younger age and better subjective health enhancing cultural activity for residents of each neighborhood. Explained variance was 27% for neighborhood Urban 1 and 21% for the other neighborhoods.

Table 4.5: Linear regression analyses for cultural activity

Variable	Urban 1 (n = 424)		Urban 2 (n = 344)		Rural (n = 349)	
	ß	95% C.I.	ß	95% C.I.	ß	95% C.I.
Source: Internet	0.202***	[0.094, 0.268]	0.127*	[0.015, 0.211]	0.162**	[0.052, 0.243]
Source: Regional newspaper	0.140**	[0.047, 0.196]	0.155**	[0.051, 0.250]	0.133**	[0.038, 0.243]
Source: Local TV	-0.012	[-0.098, 0.074]	0.117*	[0.020, 0.236]	-0.029	[-0.140, 0.076]
Source: Radio	0.045	[-0.034, 0.109]	-0.020	[-0.104, 0.069]	0.029	[-0.060, 0.109]
Source: Friends/neighbors	0.071	[-0.024, 0.197]	0.007	[-0.126, 0.144]	0.094	[-0.008, 0.232]
Gender	-0.083	[-0.458, 0.011]	-0.042	[-0.381, 0.158]	-0.002	[-0.268, 0.255]
Age	-0.116*	[-0.041, -0.004]	-0.175**	[-0.056, -0.013]	-0.276***	[-0.071, -0.031]
Subjective health	0.294***	[0.312, 0.573]	0.286***	[0.282, 0.594]	0.116*	[0.021, 0.323]
Household composition	0.066	[-0.062, 0.429]	-0.003	[-0.334, 0.314]	-0.124*	[-0.729, -0.076]
Years in neighborhood	-0.117**	[-0.444, -0.063]	-0.092	[-0.409, 0.016]	0.085	[-0.037, 0.630]
R2 (adjusted)	0.272		0.207		0.207	

Note. ß = standardized coefficient. Comparison gender is male. Age is a metric measure. Subjective health, years in neighborhood, and source are ordinal measures. Comparison household composition is living alone. * $p < .05$, ** $p < .01$, *** $p < .001$.

4.4 Discussion

The present study explored the role of informational Internet use, compared with traditional information sources, in predicting outdoor activity among older adults living in three different neighborhoods. The regression analyses adjusted for various key variables, such as age, subjective health and years living in the neighborhood.

A major finding was that informational Internet use predicted cultural activity, irrespective of the neighborhood older adults were living in. This finding may indicate that individuals use the Internet to inform themselves about cultural events and offerings, which in turn leads to more participation in cultural activity. Further, results show that participants who used the Internet or regional newspaper as an information source participated in more cultural activity. To the researcher's knowledge, this is the first study that focused on Internet use as an information source specific to events in the city. It is important to note that previous research only considered general Internet use, such as frequency of writing emails or browsing the Web, and thereby cannot provide a rationale for the observed associations with outdoor activity.

Contrary to the results for cultural activity, informational Internet use predicted participation in community activity only for urban residents but not for those living in the rural neighborhood. A possible explanation for these differences may be that individuals living in rural neighborhoods have a greater sense of community (Kitchen et al., 2012). This

explanation is supported by the fact that friends/neighbors was the most important predictor, whereas traditional media played no role. As shown in the analyses of between-neighborhood differences, the frequency of informational Internet use was very similar across neighborhoods. However, Internet use had no impact on older adults living in the rural neighborhood.

With respect to socio-demographic characteristics, results showed that being younger and healthier was related to greater participation in both types of outdoor activity, and these relationships existed for participants independent from their neighborhood. This finding is consistent with previous studies (Lefrancois, Leclerc, & Poulin, 1997; Szanton et al., 2015).

Overall, the present study provides evidence that using the Internet as an information source can encourage older adults to diversify their interests and explore a wider range of community and cultural activities. Given that older adults increasingly use the Internet to maintain independence and pursue an active lifestyle, this research represents an important step in understanding the relationship between their informational Internet use and outdoor activity.

On a political level, the empowerment of older adults by improving their information literacy has gained increasing prominence. For instance, the European Union's Horizon 2020 research program aims to keep older people active and independent through innovative research. Specifically, the program encourages the possibilities brought by new information technologies to foster an age-friendly society (European Commission, 2014). These developments show that results of the present study will also be valuable for decision-makers and stakeholders in the political system.

The present research also has important practical implications. For example, interventions targeted at older adults' skills in using the Internet for informational purposes should be implemented in the communities (Arthanat, Vroman, Lysack, & Grizzetti, 2019; Hargittai et al., 2018). Older adults should be encouraged to go online because the Internet increasingly provides neighborhood information. This development has been part of the move from traditional media to online media, which is an ongoing process. For instance, digital neighborhood platforms that facilitate informal help and social interaction can help to stay active (Müller, Hornung, Hamm, & Wulf, 2015). The study results underscore the need to develop online services that provide neighborhood information and consider older adults as an important customer group for these services. This implication is relevant for local businesses, municipalities, volunteer organizations, and health care providers. The development of such online services should specifically address the needs of older adults,

namely, by designing user-friendly and barrier-free interfaces that adjust to individual capabilities in cognition, vision, and motor function (Calhoun & Lee, 2019; Czaja, Boot, Charness, & Rogers, 2019). To ensure digital inclusion of older adults, factors that impact social exclusion from the Internet should be taken into account (Schehl et al., 2019; Seifert, Hofer, & Rössel, 2018).

The results of the present study must be interpreted in light of its limitations. This research relied upon self-reported frequency as one dimension of information technology use, which can also be conceptualized through duration and intensity (Venkatesh, Brown, Maruping, & Bala, 2008). Although self-reports were used in prior studies on older adults' Internet use and participation in outdoor activity (Ihm & Hsieh, 2015; Kim et al., 2017; Szabo et al., 2019), future studies could include duration and intensity to obtain continuous data. The same limitation holds true for the assessment of traditional information sources. Another limitation is the cross-sectional nature of the data, which does not allow making causal inferences of the phenomena. Therefore, longitudinal studies are required to assess cohort effects and provide stronger support for the tested associations.

4.5 Conclusion

This study contributes to a differentiated understanding of older adults' outdoor activity by examining the role of information sources in predicting community and cultural activity for residents in three different neighborhoods. Specifically, this research provides an explanation of how informational Internet use affects outdoor activity by providing older adults with useful information about opportunities and offerings in the city. Results shed light on the differences between individuals living in urban and rural neighborhoods in case of community activity, whereas there were no differences for cultural activity. Irrespective of the type of neighborhood older adults are living in, the role of informational Internet use offers a rationale for the development of interventions targeted at older adults' digital skills. Hence, the findings underscore the need to develop online services that provide neighborhood information and consider older adults as an important customer group for these services.

Chapter 5

Conclusions

A growing number of studies show positive effects of Internet use on active ageing (Hartanto et al., 2019; Hunsaker & Hargittai, 2018). An emerging field of research is understanding the relationship between older adults' Internet use and their participation in outdoor activity. However, little is known about the role of specific online activities, such as searching for information about offerings and opportunities in the neighborhood. Previous research mainly considered general Internet use, e.g., writing emails and browsing the Web, which does not provide a rationale for increased outdoor activity. Another important factor affecting outdoor activity is the urban environment in which older adults live. For these reasons, the interplay between individual Internet use and the urban environment should be considered. This approach is pursued in the present thesis by adopting an ecological perspective. This dissertation is first in comprehensively assessing the associations between older adults' differentiated Internet use, the urban environment, and their participation in outdoor activity.

The three studies in this thesis provide empirical insights into patterns of factors associated with older adults' Internet use and outdoor activity and, collectively, contribute an enhanced understanding of the associations between older adults' Internet use, the urban environment, and outdoor activity. The results shed light on important differences in the roles of socio-demographic variables as predictors. The ecological approach has been found useful to integrate the relevant phenomena into a conceptual framework, which can be empirically validated. Hence, the ecological approach provides a theoretical underpinning for this dissertation, by its main tenet that multiple levels of influences, such as intrapersonal, cultural, environmental, and political, explain human behavior.

Chapter 2 set out to analyze the factors explaining differentiated Internet use in older adults. Three types of online activities, namely, informational, social, and instrumental, were examined. The empirical findings contribute to the literature by providing a better understanding of differentiated online activities in older adults. The main finding of the study is that the role of some predictors is contingent upon the online activity. Specifically, results shed light on important differences of gender and cultural participation as well as education as a moderator. Because education has been found as a moderator of PBC in

case of informational online activities, future research can now focus on educational subgroups (Hargittai et al., 2018). For instance, studies could distinguish further levels of formal education, and in particular, consider experiences obtained during working life. In this study, the integration of constructs from the field of public health and information systems made it reasonable to explain differentiated Internet use among older adults. By providing a nuanced understanding of older adult's Internet use, the empirical findings have implications for providers to tailor their online services to the needs of older adults as a growing consumer group, and inform stakeholders in designing interventions targeted at older adults.

Chapter 3 investigated individual and environmental factors related to outdoor independence in older adults. The roles of gender, age, subjective health, living arrangement, neighborhood, and perceptions of environmental barriers were assessed. Again, important differences in the roles of socio-demographic variables have been found. The results show that being male, younger, and healthier was positively associated with outdoor independence, while living together was not. Further, perceived environmental barriers were more important for those who reported lower levels of health and were older. This study is first in testing the role of individual and environmental factors in explaining outdoor independence, and thus contributes to the understanding of this important facet of active aging. Thus, the contribution of this study is an empirically validated model explaining outdoor independence through individual and environmental factors. Specifically, the research provides a foundation for deeper inquiry as signified by the statistical model explaining about two-thirds of the variance. The results offer insights for policy makers, urban planners, and community groups to design age-friendly communities, which then ultimately can facilitate outdoor independence among older adults.

Chapter 4 examined whether informational Internet use specific to opportunities and offerings in the city facilitates participation in outdoor activity. The study is first in assessing Internet use as an information source specific to offerings and opportunities in the city in order to explain older adults' outdoor activity. The results highlight differences between individuals living in urban and rural neighborhoods in case of community activity, whereas there were no differences between neighborhoods for cultural activity. Irrespective of the type of neighborhood older adults are living, the results emphasize the positive effect of informational Internet use on behavior through providing older adults with useful information about opportunities and offerings available in their neighborhood. Hence, this study contributes to a differentiated understanding of older adults' outdoor activity by examining the role of information sources in predicting community and cultural activity for

residents in three different neighborhoods. Taken together, the findings underscore the need to develop online services that provide information about opportunities and offerings in the neighborhood and consider older adults as an important customer group for these services.

In summary, this thesis contributes to a relevant growth of knowledge on older adults' Internet use and outdoor activity. Specifically, it contributes to the empirical literature on older adults' Internet use and outdoor activity which still has not found a clear explanation of the associations. To reveal patterns, the studies in this thesis resort new promising methods by using an ecological approach and integrating constructs from the field of public health and information systems research. The approach in this thesis uncovered important differences in the roles of individual factors as well as environmental factors in explaining older adults' outdoor activity.

Based on this contributions, important implications for research can be identified. This dissertation provides a foundation for deeper inquiry in the field of older adults' Internet use and outdoor activity. Future research can use the conceptual framework as a basis to investigate further types of online activities as well as further types of outdoor activities. For instance, social networks and messaging services attain increasing relevance for the group of older adults (Smith & Anderson, 2018; Szabo et al., 2019). Social Internet use can offer exchange of information about the neighborhood and provide support to meet friends or relatives outdoors. In this thesis, self-reported frequency as one dimension of Internet use and outdoor activity was assessed but future studies could also include duration and intensity of Internet use and outdoor activity. This more detailed assessment would reveal data of higher precision. Furthermore, the findings of this dissertation offer a basis for additional efforts in the integration of the two approaches of public health and IS research. As IS research has begun identifying socio-demographic characteristics as predictors and studies in public health adapted IS theories to examine information technology acceptance and adoption in older adults, future studies should consider both approaches in this growing field of older adults' research.

This dissertation also has some practical implications. As all three studies showed that socio-demographic predictors play important different roles, the findings are specifically relevant for providers to identify specific groups of older adults. For instance, developers and providers can tailor their services to the needs of older adults, e.g., by designing responsive and barrier-free interfaces that adapt to individual capabilities in cognition, vision, and motor function (Calhoun & Lee, 2019; Czaja et al., 2019). Further, older adults must be considered as customer group for online activities and services. Hence, to ensure

digital inclusion of this group, factors that promote older adults' exclusion from the digital world should be taken into account (Seifert et al., 2018). In addition, understanding the predictors of online activities can assist decision-makers in devising legislation and interventions aimed at older adults. For example, interventions targeted at older adults' skills in using the Internet for informational purposes should be implemented in the communities (Arthanat et al., 2019; Hargittai et al., 2018). Older adults should be encouraged to go online because the Internet increasingly provides information about opportunities and offerings in the neighborhood. Concluding, the findings of this dissertation provide a rationale for the development of online services that offer neighborhood information and ultimately support older adults to be active outdoors.

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Declaration of Authorship

Declaration in lieu of oath in accordance with § 8 paragraph 2 of the regulations for the degree "Doctor of Economics" at the University of Hohenheim.

1. I, Barbara Schehl, declare that this thesis on "Older Adults' Internet Use, Outdoor Activity, and the Urban Environment: Empirical Analysis" and the work presented in it is my own and has been generated by me as the result of my own original research.

2. I have the approval of my co-authors to use the joint work in this dissertation and they endorse my individual contribution to the respective article.

3. I have used no sources or auxiliary means other than the ones acknowledged in this dissertation. I also have not used the illegal support of a third party, such as the help of a professional dissertation agency or consultancy. Where I have quoted from the work of others, the source is always given.

4. I affirm that the digital version submitted to the Faculty of Business, Economics and Social Sciences is identical to the hard copy.

5. I am aware of the meaning of this affirmation and the legal consequences of false or incomplete statements.

I hereby confirm the correctness of this declaration. I affirm in lieu of oath that I told the absolute truth and have not omitted any information.

Hohenheim, 30.06.20 — Place, Date

B. Schehl — Signature