Digital inequality among older adults: explaining differences in the breadth of Internet use

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Abstract. An increasing number of older adults integrate the Internet in their daily life. Although undertaking a greater range of online activities offers enhanced opportunities to live a self-determined and socially-connected life, understanding of the breadth of Internet use is still limited. We address this gap by examining how individual factors representing inequalities between groups of older adults in society are associated with the breadth of their Internet use. The study analyzed survey data collected in 2017 from older adults living in a city in Germany (N = 1136, age 65–90 years). The group of Internet users comprised of 69.0% (784) of participants, exhibited high levels of autonomy in outdoor activities (87.8%), and reported, on average, 4.92 online activities (SD = 2.31, range 1–8). Linear regression analysis showed positive associations for perceiving higher levels of behavioral control (PBC) in using digital technologies, being male and younger, and holding an academic degree. No associations were found for having medium level of education, living together with someone, and reporting better health. These findings highlight that despite the increased percentage of users, digital inequality regarding the range of online activities prevails. This inequality impedes subgroups of older adults to prepare for future situations in which online activities could substitute outdoor activities that might not be possible anymore. Interventions for these subgroups should emphasize digital skills that facilitate engagement in diverse online activities covering various purposes and life domains.

Keywords: Digital inequality, Internet skills, older adults, social media, survey

Introduction

Older adults account for a growing share of the population in western societies. In the United States, for instance, the age group 65+ has grown from 13.1% in 2010 to 16.5% in 2019, and is expected to reach 20.6% by 2030 (United States Census Bureau, 2021). Simultaneously, Internet use among older adults in the U.S. has risen from 40% in 2009 to 73% in 2019 (Pew Research Center, 2019). The increase in the rate of Internet adoption is complemented by higher frequency, longer duration, and more purposes of Internet use. As more older adults integrate the Internet in their daily life, a greater share could benefit from positive impacts of Internet use, such as better cognitive functioning (Kamin & Lang, 2020), stronger social connectedness (Yu et al., 2021), and higher levels of mattering (Francis et al., 2019). However, digital inequalities in older adults still exist, even among Internet users (Hargittai et al., 2018).

Previous research offers insights into individual factors associated with older adults' Internet use, highlighting differences between, for instance, men and women, younger and older, and high and low level education (König et al., 2018). A key finding is that individual factors explain variations in the frequency and duration of both overall Internet use and specific online activities. Less is known about predictors of the breadth of Internet use, defined as the range of different online activities in which one engages. Breadth is an important dimension of older adults' Internet use because it indicates the extent to which one uses the Internet for different purposes, and thus currently integrates the online world into their life, such as running errands, leisure, and communication with family and friends (Vroman et al., 2015). Whereas undertaking a higher number of activities assumes mastery of more digital skills, it also offers enhanced opportunities to mitigate age-related limitations in future situations in which online activities could substitute 'offline' activities.

Understanding of the predictors of breadth of Internet use in older adults is limited, with only a few studies investigating this construct. Generalizability of empirical results is undermined by focusing on specific subgroups, such as participants of education programs targeted at retired persons (Seifert et al., 2020), or analyzing data from 2005 (Nayak et al., 2010), which cannot reflect the major changes in both Internet technology and older adults' Internet adoption. The models tested in more recent studies only explain a small part of the variation (van Deursen & Helsper, 2015), or do not report explanatory power. Against this backdrop, our study aims to advance the understanding of the breadth of Internet use in older adults by assessing the role of essential individual factors representing inequalities between groups of older adults in society, and simultaneously expect high explanatory power. The study is based on survey data (N = 1,136), which we collected in 2017 from older adults in Germany.

Literature review

Breadth of Internet use

The range of different online activities performed by an individual is also known as diversity (Yu et al., 2016), multimodality (Wei, 2012), variability (Seifert et al., 2020), and variety (Blank & Groselj, 2014). It complements frequency (how many times per period?), duration (how long per period?), and purposes of use (what is the reason for?), and can be measured by the number of online activities by a person. Online activity can stand for rather specific tasks carried out using an Internet application, such as sending e-mails, posting blog articles, and uploading photos to social networking sites. On the other hand, online activity can include more complex tasks serving far reaching purposes of life, such as purchasing products and conducting financial transactions.

Breadth of use is a distinct dimension of Internet use, which is particularly important in the context of older adults. Breadth can signify how well older adults are prepared for future situations in which online activities could further complement and substitute offline activities being hindered, or rendered impossible, by age-related limitations (Spirduso et al., 2005). Of particular relevance is reduced mobility so that older adults become more or less homebound (Webber et al., 2010). When any distance is a barrier, online services can step in, e.g., for maintaining social ties with loved ones, purchasing goods and services, managing financial transactions, and ordering prescriptions. In other words, undertaking a wider range of online activities offers potential to mitigate some of the consequences of age-related limitations in outdoor mobility. Moreover, social online activities can help mobile older adults to connect with friends and relatives that are homebound (Quan-Haase et al., 2017).

The relationship between older adults' online and offline activities can be explained by the process of how individuals adapt themselves to age-related changes, in particular restricted mobility. In the model of selective optimization with compensation (Baltes & Baltes, 1990), selection denotes that older adults reduce the number of domains they engage in due to age-related impairments lowering resources available to them. Selection thus includes abandoning domains (and their offline activities) as well as maintaining current domains. This process is specifically relevant for domains requiring physical performance that cannot be replaced by online activities (e.g., participation in sports, and travelling). Optimization describes that older adults enrich and augment their current resources to enhance functioning and involvement in selected life domains. Individuals deliberately invest in resources and seek for instruments, such as digital technology, that allow them to engage in domains that provide positive experience, emotions, and goal attainment. Compensation refers to accomplishing the same outcome in a specific domain by enlisting alternate means. It differs from selection in that the goal

is maintained, but new means are used to compensate for loss or reduction of skills and behavioral capacities. The finding of alternative means includes digital technology that allows for substituting offline activities by corresponding online activities.

Previous research examined differentiated relationships between online and offline activities, and provides evidence for the process of selection, optimization, and compensation. The compensation process is supported by a longitudinal study in the Netherlands, which hypothesized that using social network sites and online shopping moderates the negative effect of mobility restrictions on subjective well-being (van Ingen et al., 2017). Results point to buffering effects due to compensation of missed social interactions and offline shopping. Another study showed that self-rated health was negatively associated with leisure Internet use but positively associated with social Internet use (Lifshitz et al., 2018), suggesting that less healthy persons can compensate for lack of physical resources and optimize their digital resources. Further studies report on compensation to cope with physical constraints, e.g., due to surgery or accident (Nimrod, 2020), sighting problems (Bianchi, 2021), and perceived ageing deficits (Sun et al., 2016). Taken together, these findings suggest that engaging in various online activities facilitates older adults' adaptation to current and future mobility limitations.

Predictors studied in previous research

Predictors of breadth are not necessarily the same as for other dimensions of Internet use in older adults; hence, specific research examining breadth of use is required. In our discussion of previous research, we consider quantitative studies that measured breadth of use by counting the number of online activities but not devices, such as smartphones and computers (Olsson et al., 2019; Seifert & Cotten, 2020), or a combination of online activities and devices (Chopik et al., 2017).

Previous research has conceptualized and measured breadth in different ways, reflecting the major changes in both Internet technology and older adults' Internet adoption in the past 15 years. Naturally, early studies were limited in the type and number of online activities, because social media were in their beginnings, and neither smartphones nor tablet computers were available. For instance, a study from 2005 in the United Kingdom only considered four instrumental online activities (e.g., shopping, banking) (Nayak et al., 2010). A study by Hargittai and Dobransky (2017), using data from 2009 in the U.S., focused on capital-enhancing activities, i.e., activities from which people may benefit through better information for decision-making and overall enhanced life chances (DiMaggio et al., 2004). It included two social activities related to forums, blogs, and video-sharing sites. The more recent studies by van Deursen and Helsper (2015) and Seifert et al. (2020) defined broader sets of online activities (23 and 17,

respectively) covering informational, social, instrumental, and recreational types of activities.

Individual differences in older adults' Internet use can be explained by sociodemographic factors and technology-related factors, which include perceptions of technology use. As this is the common theme of previous research, gender appeared to play no more role in explaining breadth of use (Seifert et al., 2020; van Deursen & Helsper, 2015). It is important to note that breadth of use implies having access to the Internet and belonging to the group of Internet users, which are still subject to gender differences in older adults (König et al., 2018). Findings are also consistent for the roles of age (negative association) and income (no association). A study by Seifert et al. (2020) found positive associations for higher levels of education and living together with someone.

With respect to technology-related factors, one stream of research adopts constructs from theories that have been developed in the information systems (IS) literature to explain the individual acceptance of new information technologies (Venkatesh et al., 2012). Theories, such as the Technology Acceptance Model (TAM) (Davis, 1989), posit that different individual reactions to using the technology shape one's behavioral intentions, which then affect actual use. Nayak et al. (2010) adopted this rationale and found that perceived usefulness (PU) and attitudes towards using (ATT) the Internet, but not the perceived ease-of-use (PEOU) and relevance for tasks, were associated with a wider range of online activities. Their model explained about 24% of the variance in breadth of use, whereas TAM-based models often explain more than one-half of the variance in older adults' behavioral intention to use (Alexandrakis et al., 2020; Li et al., 2019). General attitudes towards the Internet may also matter, as suggested by van Deursen and Helsper (2015). This factor represents one's evaluation of the Internet and thus is different from ATT in TAM. The strength of the association was weak and had little practical significance for the breadth of use; this finding is coincident with the model explaining a small part of the variance (9%).

Other research adopts different theoretical perspectives to conceptualize how older adults evaluate their capabilities, resources, and skills required for using digital technology. For instance, older adults who indicated stronger perceptions of adaptivity to using technology in current life, undertook a higher number of online activities (Seifert et al., 2020). In addition, reporting more technology-related biographical experiences, thus throughout previous life, also enhanced breadth of use. Another group of factors includes proxy measures of Internet skills, which are defined as one's ability to use the Internet, such as to navigate a browser, search for information, and determine the credibility of online sources (Litt, 2013). In the study Hargittai and Dobransky (2017), older adults rated their understanding of six Internet-related terms (e.g., 'Internet browser cookie', 'refresh and reload'); hence, this factor does not reflect actual understanding of

the terms but has been denoted as self-reported 'Web-use skills'. The study by Quan-Haase et al. (2018) assessed the extent to which older adults consider themselves to be skilled in using the Internet. Quan-Haase et al. (2018) used this factor, denoted as 'self-reported digital skill level', in combination with the number of online activities to derive six clusters spanning from non-users to savvy users.

Overall, the body of research discussed above underscores the importance of differences in older adults' breadth of Internet use. Previous studies show that breadth of use is associated with sociodemographic and technology-related factors. However, understanding of this phenomena is limited because of (1) lack of explanatory power compared to models explaining other dimensions of Internet use (Nayak et al., 2010; van Deursen & Helsper, 2015), (2) examination of subgroups that were relatively young (Hargittai & Dobransky, 2017) or participated in educational programs (Seifert et al., 2020), and (3) data collected prior to the rise of mobile devices and social media. The present study addresses these limitations to enhance the understanding of the breadth of Internet use in older adults.

The present study

Our study draws on the theory of digital inequality, which describes a mechanism explaining individual differences in the use of information and communication technology (ICT) (van Dijk, 2005, 2006). This theory has been found useful for analyzing various facets of ICT use. With respect to older adults, digital inequality theory has been applied to understanding, for instance, use versus non-use of the Internet (Friemel, 2016), frequency of general ICT use (Choi et al., 2020), and breadth of Internet use (Hargittai & Dobransky, 2017).

The theory's mechanism begins with categorical inequalities between groups of people in society. These inequalities will lead to unequal distribution of resources required for accessing and ultimately using ICT. Many categorical inequalities relate to sociodemographic characteristics, such as gender, age, education, and health. Categorical implies that at least two groups for each inequality exist such that one group possesses more resources than the other group. For instance, groups can be defined as male versus female, young versus old, high versus low education, and good versus poor health. Then, the resources available to an individual will be, at least to some extent, determined by the groups they belong to. The theory assumes different types of resources, including material resources (e.g., having a computer for Internet access, or webcam for video conferencing), mental resources (e.g., motivation to adopt new ICT, or cognitive ability to process information from digital media), and social resources (e.g., support in learning new ICT or solving technical problems).

Adopting the theoretical perspective discussed above, the present study focused on categorical inequalities that have been found important for Internet use in older adults. The set of factors was limited to essential categories, because we wanted to test how well they explain differences in the range of online activities, while retaining a parsimonious structure. We considered gender, age, education, household composition, and self-rated health as sociodemographic factors as well as perceived behavioral control (PBC) as a technology-related factor. In technology acceptance research, PBC is defined as one's perceptions of internal and external constraints on behavior (Taylor & Todd, 1995). Having low perceptions of these constraints means that one perceives high behavioral control, which will then facilitate technology use. Technology acceptance research adopted PBC from the theory of planned behavior (TPB), in which PBC denotes one's perceptions of the ease (or difficulty) of performing the behavior of interest, which then influences both intentions and behavior (Ajzen, 1991). We integrate this perceptual factor to represent older adults' evaluation of internal conditions (e.g., skills, knowledge) and external conditions (e.g., social support) facilitating their engagement in various online activities. Using survey data collected from a diverse target group, we both expected considerable variation in PBC and the range of online activities.

Method

Participants

The study was based on a self-administered survey targeted at all older adults (65+) living in three neighborhoods of a city with around 260,000 inhabitants in Germany. We designed the survey in cooperation with a municipal provider of geriatric care. This provider conducted a face-to-face pilot study involving nineteen older adults to validate the feasibility of the survey instrument. Data collection took place in the summer of 2017 by mailing the questionnaire to 6,170 individuals. The questionnaire also included instructions on how to answer the questions online by using an individual access code; thirty-six individuals chose the online option. The response rate within six weeks was 21.5% (1,302 valid responses, 100 addresses were invalid). Considering that our survey used a posted self-administered questionnaire, this rate is similar to previous surveys targeted at older adults (Palonen et al., 2016).

The sample included data from 1,136 participants who answered all the questions about online activities and individual factors (no missing values). We verified whether this sample was representative of the city population 65+. With respect to gender, the share of men in our sample (49.2%) and the population was similar (49.0%). When comparing age groups, all differences were marginal (65-69: 27.2% versus 25.7%, 70-79: 46.4% versus 46.9%, and 80+: 26.4% versus 27.4%). We note that a greater share of

participants held an academic degree (14.8% versus 6.5%), mirrored by less participants with no high school education (1.1% versus 6.1%).

Measurements

Dependent variable

Breadth of Internet use was derived from answers to questions about the frequency of eight online activities. We included activities that serve social, informational, and instrumental purposes. Prior research operationalized these purposes by similar online activities to examine the relationship with dimensions of older adults' psychological well-being (Hofer et al., 2019; Lam et al., 2020; Szabo et al., 2019). Specifically, we considered three activities for social purposes and distinguished different media of communication (items as follows: 'writing e-mails,' 'sending pictures and videos,' and 'writing comments and reviews'). Three activities belonged to informational purposes ('searching the Internet for information (e.g., using Google),' 'using the Internet to inform myself about events in the city,' and 'viewing pictures and videos'). Instrumental purposes were covered by two activities ('using banking services on the Internet (online banking)' and 'purchasing on the Internet (online shopping)'). Answer options were organized on a five-point ordinal scale (never, few times, several times per month, weekly, and daily). An index was then calculated by counting the number of online activities that participants engaged in, irrespective of whether they performed this activity daily or only a few times. Those who indicated at least one activity were assigned to the group of users (n = 784).

Independent variables

The independent variables included gender, age, education, household composition, self-reports about health, and PBC. *Gender* was coded as female (0) or male (1). *Age* was derived from the participant's year of birth. *Education* was defined as an ordinal variable with three categories as follows: low for primary and lower secondary education; medium for upper secondary education and vocational training; high for academic education. The categories were based on the International Standard Classification of Education (ISCED) (United Nations, 2011). *Household composition* indicated whether one reported living in a household of two or more persons (coded as 1), or alone (coded as 0). *Self-rated health* was measured by asking participants about their global health state. Answer options included 'very bad' (1), 'rather bad' (2), 'neutral' (3), 'rather good' (4), and 'very good' (5). To characterize the mobility of Internet users and non-users, we included *outdoor autonomy* as a supplementary self-reported measure. Autonomy was defined as whether

one can accomplish specific outdoor activities by themselves, thus without support and on unknown routes. We considered six outdoor activities (shopping, walking, using public transportation, visiting doctors, visiting friends & family, and attending events), and used the corresponding dichotomous variables in descriptive analysis.

Perceived behavioral control (PBC) was measured by adapting a validated three-item instrument to the context of older adults (Ajzen, 1991; Venkatesh et al., 2003). To prevent that participants who did not know the Internet would not answer this question, we used the term 'digital technology', which we defined as 'for instance, smartphone (cell-phone with Internet), tablet, and laptop/computer'. The items were worded 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.' Participants indicated their agreement with each statement on a 5-point scale ranging from 1 (strongly disagree) to 5 (strongly agree). Scale reliability for the users group was good (Cronbach's alpha of 0.81).

Data analysis plan

We first conducted descriptive analysis for the full sample, and then turned to the users group. We assessed bivariate correlations for all variables using the Spearman correlation test, because the metric variables PBC and breadth of use did not conform to normal distribution. For determining associations with breadth of use, we conducted multiple linear regression (MLR) analysis. We tested the assumptions of MLR, but there were no deviations. Specifically, multicollinearity was assessed by variance inflation factors (VIF). They ranged from 1.08 to 1.49, which is below a conservative cut-off of 2.5. We report unstandardized coefficients, 95% confidence intervals (CI), exact p-values, and adjusted r-squared *(R2)* as a measure of explained variance. All statistical analyses were carried out using IBM SPSS 25. The level of significance was set at 5%.

Results

Sample characteristics

Table 1 presents participants characteristics for the non-users and users groups, respectively. In the full sample, the distribution of men and women was similar, while the share of men was greater in the users' group (56.6%) compared to the non-users' group (37.8%). The average age of Internet users was 73.35 years (SD = 6.14), thus lower than that of non-users (M = 79.75, SD = 7.08). Every fifth user had education at high level, compared to less than every twentieth non-user. Users were more likely to live with someone (seven out of nine) than non-users (five out of nine). The majority of users rated their general health state as good or very good (58.1%), but this was not the case for non-

users (32.4%). Similarly, self-reported autonomy in outdoor activities was greater for users than for non-users (mean share of 87.8% versus 61.8%). Among Internet users, the mean level of PBC was at 3.18 on the 1-5 scale (*SD* = 1.05). The higher end (PBC ≥ 4) accounted for 29.0%, and the lower end (PBC ≤ 2) for 17.2%.

Table 1. Participants characteristics, *N* = 1136.

Variable		Non-users (*n* = 352)		Users (*n* = 784)	
		n	%	*n*	%
Gender	Male	133	37.8	444	56.6
	Female	219	62.2	340	43.4
Age[a]	65 – 69	35	9.9	274	34.9
	70 – 74	43	12.2	200	25.5
	75 – 79	92	26.1	189	24.1
	80 – 84	100	28.4	80	10.2
	≥ 85	82	23.3	41	5.2
Education	Low	167	47.4	227	29.0
	Medium	179	49.1	401	51.1
	High	12	3.4	156	19.9
Household composition	Living with someone	198	56.3	602	76.8
	Living alone	154	43.8	182	23.2
Self-rated health	Very bad	12	3.4	13	1.7
	Rather bad	52	14.8	54	6.9
	Moderate	174	49.4	261	33.3
	Rather good	95	27.0	353	45.0
	Very good	19	5.4	103	13.1
Outdoor autonomy	Visiting doctors	246	69.9	722	92.1
	Shopping	224	63.6	704	89.8
	Visiting friends & family	231	65.6	697	88.9
	Walking	206	58.5	672	85.7
	Public transportation	210	59.7	669	85.3
	Attending events	188	53.4	665	84.8

[a] Age was defined as a metric variable. For the sake of clarity, we report categories here.

Table 2 shows frequencies of online activities among Internet users. The most frequent activities were general information search (84.9%), viewing pictures or videos (77.2%), writing e-mails (75.1%), and looking for information about city events (73.5%). On the other hand, only a few Internet users went online for banking (33.8%) and writing comments or reviews (31.9%). Overall, the differentiated frequencies and total use percentages presented in Table 2 show considerable variation, providing support for our selection of online activities to calculate an index for the breadth of Internet use. On average, Internet users reported 4.92 activities (*SD* = 2.31). Specifically, one activity was reported by 11.7%, two by 9.3%, three by 8.4%, four by 10.2%, five by 12.4%, six by 16.1%, seven by 17.5%, and eight by 14.4% of the users.

Table 2. Frequency of online activities among Internet users (in %), $N = 784$.

Online activity	Never	Few times	Monthly	Weekly	Daily	Total use[a]
Searching for information	15.1	13.3	15.6	31.4	24.7	84.9
Viewing pictures/videos	22.8	33.0	13.9	19.1	11.1	77.2
Writing e-mails	24.9	20.9	15.2	23.5	15.6	75.1
Informing about city events	26.5	27.3	9.4	16.8	19.9	73.5
Sending pictures/videos	37.1	26.0	16.3	15.1	5.5	62.9
Shopping	46.9	32.9	16.2	2.3	1.7	53.1
Banking	66.2	6.0	11.1	10.8	5.9	33.8
Writing comments/reviews	68.1	23.7	4.1	3.1	1.0	31.9

[a] Activities sorted in ascending order by total use, which was defined as the sum of few times to daily use.

Table 3 presents the correlation matrix for the Internet users' group. Correlations between the independent variables included in the regression analysis were all weak. Breadth of Internet use was greater for participants being male ($r_S = 0.20$) and younger ($r_S = 0.29$), having higher education ($r_S = 0.25$), living with someone ($r_S = 0.13$), rating their health state better ($r_S = 0.22$), and having higher levels of PBC ($r_S = 0.55$).

Table 3. Correlation matrix for Internet users, $N = 784$.

	1.	2.	3.	4.	5.	6.
1. Gender						
2. Age (years)	0.02					
3. Education	0.23^{**}	-0.11^{**}				
4. Household composition	0.18^{**}	-0.16^{**}	0.13^{**}			
5. Self-rated health	0.04	-0.23^{**}	0.13^{**}	0.08^{*}		
6. Perceived behavioral control	0.24^{**}	-0.16^{**}	0.22^{**}	0.09^{*}	0.27^{**}	
7. Breadth of Internet use	0.20^{**}	-0.29^{**}	0.25^{**}	0.13^{**}	0.22^{**}	0.55^{**}

Note. Spearman's rank correlations (two-tailed). Gender: 0 = female, 1 = male. Education: 1 = low, 2 = medium, 3 = high. Household composition: 0 = living alone, 1 = living with someone. Self-rated health ranges from 1 (very bad) to 5 (very good). Perceived behavioral control measured on a continuous scale from 1 to 5. Breadth of Internet use measured on a discrete scale from 1 to 8.

* $p < 0.05$, ** $p < 0.01$.

Linear regression analysis

Table 4 shows the regression results for online activities among Internet users. Model 1 only includes sociodemographic variables, of which, gender, age, high education, and self-rated health were associated with breadth of Internet use. By adding PBC, model 2 shows that explained variance increased from 17.9% to 34.8%. Each one-unit higher perception of behavioral control added one online activity ($B = 0.98$). In the presence of PBC, the relationship between self-rated health and breadth was no longer statistically significant ($p = 0.433$). While the number of online activities was greater for men than for women ($B = 0.30$), the 95% CI was very wide (0.01–0.58), and the p-value was only

slightly below the level of significance (p = 0.040). The coefficient corresponds to an increase by 3.8% (0.30/8), and the CI indicates an increase between zero and 7.3% (0.58/8). Each one-year higher age reduced the number of activities by 0.08. Participants with high education were engaged in more online activities than participants with low education (B = 0.84). We found no evidence for living with someone enhancing the breadth of Internet use. In supplementary analysis (not tabulated), we tested whether sociodemographic variables moderated the association between PBC and breadth of use. Given that all interaction terms were statistically non-significant and *R2* did not change, this analysis did not yield support for a moderated association.

Table 4. Results of linear regression analysis for breadth of Internet use, N = 784.

Variable	Model 1			Model 2		
	B	95% CI	*p*	*B*	95% CI	*p*
Intercept	9.75	[7.62, 11.89]	**<0.001**	6.70	[4.75, 8.65]	**<0.001**
Gender *(reference: female)*						
Male	0.74	[0.43, 1.05]	**<0.001**	0.30	[0.01, 0.58]	**0.040**
Age	–0.10	[–0.12, –0.07]	**<0.001**	–0.08	[–0.10, –0.06]	**<0.001**
Education *(reference: low)*						
Medium	0.32	[–0.03, 0.67]	0.072	0.18	[–0.13, 0.49]	0.256
High	1.23	[0.78, 1.67]	**<0.001**	0.84	[0.44, 1.24]	**<0.001**
Household composition *(reference: living alone)*						
Living with someone	0.16	[–0.20, 0.52]	0.396	0.18	[–0.15, 0.50]	0.283
Self-rated health	0.32	[0.15, 0.50]	**<0.001**	0.07	[–0.10, 0.23]	0.433
Perceived behavioral control				0.98	[0.84, 1.11]	**<0.001**
Adjusted *R2*	0.179			0.348		

Note. B = unstandardized coefficient. CI = confidence interval. Self-rated health ranges from 1 (very bad) to 5 (very good). Perceived behavioral control measured on a continuous scale from 1 to 5. Breadth of Internet use measured on a discrete scale from 1 to 8.

Values in bold indicate statistical significance ($p < 0.05$).

Discussion

By examining the differences in the range of online activities by older adults, this study provides empirical evidence for the prevailing digital inequality among Internet users. Breadth of Internet use varied considerably by perceived behavioral control, age, and education. Although we found a positive association for male gender, the increase in the number of online activities was of little practical significance. We found no support for digital inequality by household composition and self-rated health. In summary, the study results suggest that a few but persistent categorical inequalities between subgroups of older adults explain more than one-third of the variation in the breadth of use.

Specifically, we found that older adults with stronger perceptions of behavioral control in using digital technology showed a greater range of online activities. PBC appeared as the most important predictor of breadth of use in our sample, highlighting that PBC represents a distinct categorical inequality in the target population. We adopted this construct from theories of technology acceptance research (Taylor & Todd, 1995; Venkatesh et al., 2012). PBC both reflects facilitators that are internal to the individual (e.g., skills, knowledge) and facilitators that are external (e.g., help from others) (Ajzen, 2002). From the perspective of digital inequality theory, PBC is a type of mental resource specific to the behavior under study.

We highlight similarities and differences of PBC with technology-related factors examined in previous research. Subjective technology adaptivity is a much broader construct than PBC by incorporating three constructs into one higher-order factor (Kamin & Lang, 2013). Two of the three constructs, perceived adaptive utility and perceived safety of technology, correspond to PU and computer anxiety (ANX, reversed) in technology acceptance research, respectively. However, a comprehensive synthesis of prior technology acceptance research showed that PBC is conceptually and empirically different from PU and ANX (Venkatesh et al., 2003). An alternative perceptual factor explaining breadth of use could be technophobia, an exaggerated, usually inexplicable and illogical fear of using the Internet (Nimrod, 2018). Similar to PBC, technophobia represents an internal constraint on behavior, but it reflects on the difficulty of using the Internet through subscales for personal failure, human versus machine ambiguity, and perceived convenience. The latter subscale resembles both PU and PEOU in TAM; hence, technophobia could be regarded as a higher-order construct comprising some facets of PBC as well as PU and PEOU.

With respect to proxy measures of Internet skills, PBC is similar by representing a belief towards performance of a specific behavior (which we operationalized as using digital technology). However, Internet skills represent an internal facilitator of behavior, whereas PBC includes internal and external facilitators. Therefore, PBC has greater coverage of possible facilitators. On the other hand, the higher-order concept of PBC does not allow a differentiated assessment of Internet skills. Compared to self-reported Web-use skills (WUS), PBC directly represents a belief towards behavior, whereas WUS represents a belief towards the understanding of technical terms deemed relevant to using the Internet (Hargittai & Dobransky, 2017). It is noteworthy that three of six terms are not specific to Internet use but are valid for computer use in general (‘operating system’, ‘spyware and malware’, ‘JPEG file’). Measurements of Internet skills that include specific technical terms, online activities, and platforms should account for changes in Internet technology and adoption by older adults (Litt, 2013). Our findings about the facilitating role of PBC are consistent with the topology of Internet users proposed by Quan-Haase et al. (2018), which relies on self-reported digital skill level and the number

of online activities. In this taxonomy, the relationship between the two dimensions is nonlinear, because breadth of use also depends on sociodemographic factors, as shown in our study.

With respect to digital inequality by age, our study corroborates results from previous research (Hargittai & Dobransky, 2017; Seifert et al., 2020; van Deursen & Helsper, 2015). Although the current population of older adults had witnessed the rise of the online world only in their middle or later stages of life, pre-retirement knowledge of online services as well as pre-retirement ICT use differs largely between different age cohorts. For those between 65 and 75 years, it is more likely that they have experienced the digitization of their workplace and daily life compared to the old-older adults. What our study suggests is that this categorical inequality also affects those who are already online by undermining their ability to integrate a wider range of online activities in their daily life. While previous studies showed associations between ICT use before and during retirement (Chang et al., 2015; König et al., 2018), it is important to note that pre-retirement ICT use is subject to categorical inequalities beyond age, such as gender and education.

Educational differences in society are an important root of digital inequality in older adults. Higher educational attainments in early life have a long lasting impact on one's resources for ICT use in later life (Kämpfen & Maurer, 2018). Although our study results indicate digital inequality by education as well, we found an increase in the breadth of Internet activity only for participants holding an academic degree but not for mid-level education (compared to low levels of education). Given that every fifth Internet user had an academic degree, education advantaged a rather small group with a privileged background.

Taken together, our study offers important insights into older adults' breadth of Internet use. Although the surveyed sample exhibited considerable variance in breadth of use, PBC, age, educational background, and self-rated health, eight out of nine Internet users reported no limitations in their ability to leave the house for offline activities of everyday life. Therefore, the prevalence of compensation processes due to such age-related limitations in our sample would be rather low. Nevertheless, engagement in a wider range of online activities can prepare for future situations in which age-related mobility restrictions undermine outdoor activities. The compensating role of online activities in such situations has been demonstrated for various life domains (Bianchi, 2021; Nimrod, 2020; van Ingen et al., 2017). However, those who might benefit the most from instrumental Internet use tend to use it less frequently (Schwaba & Bleidorn, 2021).

Our findings have implications for practice because they inform about specific subgroups who only perform few online activities despite the variety of online services available to them. These subgroups should be targeted by training programs, personnel assistance, and online services adapted to accommodate age-related limitations in

cognition, vision, and motor function (Czaja et al., 2019). Internet users should be empowered in their perceptions of behavioral control in effectively using digital technology. Generational differences among Internet users should be taken into account by motivating and assisting old-older adults to try out additional online activities. As our descriptive analysis shows, all of the less prevalent online activities are those that demand greater commitment from the user, and this barrier should be addressed. Noting that gender differences appeared to be of minor relevance, our results collectively suggest that social interventions should focus on enhancing technology-related knowledge and motivational resources.

Some limitations of our study must be noted, which also offer opportunities for future research. First, the set of online activities from which our dependent variable was derived only included eight activities but no health-related activity, which might be particularly relevant to older adults. However, our dependent variable exhibited greater variation than measures used in previous research (Seifert et al., 2020; van Deursen & Helsper, 2015), suggesting that our measurement is suitable to ascertain the breadth of Internet use. Second, we focused on individual factors representing categorical inequalities in society, although further inequalities might also be relevant, such as pre-retirement ICT use, actual Internet skills (van Deursen & van Dijk, 2010), and one's social network (Friemel, 2016). Third, because our sample was drawn from a medium-sized city in Germany, the results may not necessarily be generalized to older adults living in rural areas or other regions. Fourth, our analysis relied upon cross-sectional data, which does not allow causal interpretation of associations between study variables. Future research using longitudinal designs is required to validate the persistence, strength, and variability of observed associations.

Conclusion

Digital inequality in older adults is a prevailing phenomenon, even among Internet users. Only a handful of studies have examined inequality regarding the breadth of Internet use, although partaking in a wider range of online activities is an important component of digital mastery and could help mitigate age-related limitations in outdoor mobility and thus enhance life experience. Analyzing survey data, we found substantial variation in the breadth of use in the diverse group of older adults. The results of our regression analysis show that the number of online activities in the users' group was considerably greater for participants perceiving greater behavioral control in dealing with digital technology, being younger, and having obtained an academic degree, while gender differences were of less importance. Our study demonstrates that variation in the breadth of Internet use can effectively be attributed to essential categorical inequalities in the target population. Collectively, these results contribute to better understanding of this dimension of Internet

use, which complements frequency, duration, and purposes of use.

Disclosure statements

No potential conflict of interest was reported by the authors.

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