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Does Heterogeneity in Older Adults’ Digital Media Use Increase as They Age? A Longitudinal Cross-Country Analysis

Abstract

This study investigates whether there is evidence of divergence in older adults’ digital media use as they age. Theoretically, we build on studies of digital media and ageing, contributing to the idea of ‘aged heterogeneity’ and the concept of technology generations. In contrast to previous studies that have mainly approached the topic through qualitative means, we analyse a three-wave (2016, 2018 and 2020) cross-national panel survey (N = 10,805; n = 3889) using linear growth curve models to answer two research questions. The respondents were Internet users aged 60 and over (in 2016). Our results show no evidence of an increasing divergence in digital media use with the age of the respondents. We also found no evidence that increasing heterogeneity is related to specific technology generations or countries. Quite the contrary, we found evidence of ‘aged homogeneity’ in digital media use. However, digital media use increased for all the generations studied except the oldest. The findings contribute to the idea of active ageing with digital media and call for more research on converging media practices.

Keywords: older adults, digital media, heterogeneity, homogeneity, technology generations

1. Introduction

The stereotypic depictions of older adults and the way they use different technologies are characterized by over-homogenization (Ivan & Cutler, 2021; Ivan et al., 2020a). Especially, over homogenization has been associated with the process of designing and implementing algorithms and digital systems (Rosales & Fernández-Ardèvol, 2019) and with collecting data about other technology users (Uricchio, 2017; Ivan & Loos, 2023). In similar vein, a very

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broad definition of ‘old age’ (e.g., aged 45+ or 55+), coupled with not controlling the demographics of the sample and overlooking the constraints of measures instruments, may lead to unintended stereotypic decisions that discriminate against older people (Rosales & Fernández-Ardèvol, 2019). The old age diversity tends to remain hidden in an overtly wide residual category of ‘old people’ (Fernández-Ardèvol et al., 2023). Consequently, marketers of technology products and algorithm developers rely on consumer behaviours they believe are widespread among a homogenized group of ‘old people’ (Ivan & Loos, 2023).

This over-homogenization of older adults as digital technology and media users has been criticized at least for two reasons. First, it contributes to the internalized stereotypes and may become a self-fulfilling prophecy in which product design and marketing contribute to the grey digital divide, which then results in more limited use of technology products by older person (Ivan & Cutler, 2021). Second, it is in a stark contradiction with research showing that older consumers are in some respects even a more heterogeneous group than younger consumer segments (e.g., Moschis, 2003). In fact, gerontologists have argued for a long time that people might become increasingly different with age as societies become more complex and various irregularities mark people’s social realities (Neugarten & Neugarten, 1986; McCosker et al., 2021). The statistical data from different countries (e.g., Eurostat, 2020; 2022; Profile of Older Americans, 2021) indicate not only increase in the share of older population segments (aged 65 years and above) but also increase in their diversity in terms of socio-economic background, education, ethnicity, living arrangements, education, and health.

The concept of ‘aged heterogeneity’ (Dannefer, 1998; Nelson & Dannefer, 1992; Stone et al., 2017) was introduced in gerontology to address how people’s abilities become more diverse with age in later life. Ever since, many studies have presented evidence for increase variability later in life, and shown that this variability relates to many domains, such as physical and motoric abilities, personality features and cognitive abilities (Nelson & Dannefer, 1992). Recent studies show that older adults have much more diverse daily life experiences – including social interaction partners, activities, and places, across and within days – than is normally assumed (Weber et al., 2020; Weber, 2020). On the contrary, some theories suggest that lifestyles may become increasingly similar with age. Such convergence of lifestyles may be due, for example, to socioemotional selectivity (e.g. Carsten, 1992; Carstensen et al., 1999), which is thought to increase toward the end of life. In terms of media consumption, this could manifest as a higher preference for socially and emotionally rewarding and familiar media platforms in later life.

In digital communication and media studies, older adults’ heterogeneity is increasingly recognized. Recently, it has been suggested that aged heterogeneity manifests itself in older adults’ patterns and intensity to use information and communication technology (ICT) and various media platforms (e.g., Hänninen et al., 2021; Loos, 2018; Sourbati & Loos 2019). Nevertheless, so far, these claims have not been properly tested with longitudinal data (except for Taipale et al., 2021; Taipale et al., 2023) following the same respondents (i.e., panel data). In addition, cross-national follow-up studies that could help identifying international trends and country-specific uses of media are still rare (however, see Nimrod, 2017; König et al., 2018; Loos & Ivan, 2022), and have not yet addressed the question of the aged heterogeneity in digital media use.

The aim of this article is to test the tenability of the aged heterogeneity in relation to digital media use across three generations of older technology user, over time and across six countries. To work at this end, we use cross-national longitudinal survey-based panel data,

using sophisticated statistical methods in a theory-driven manner. Previous cross-sectional analyses suggest that while the variability in older adults' digital media use (i.e., watching TV via a computer, reading Internet news, reading e-book) may slightly increase with age, the use of corresponding traditional media platforms (i.e., television, books, newspaper) becomes more homogenous (Taipale et al., 2021). Other studies suggest new digital media may be adopted differently depending on the user's generational attachment to technologies (Bolin 2017a, 2017b), and hence a more nuanced analysis on the relationships and interactions between technology generations, media use and country factors is needed (Ivan et al., 2020b). Following from this, we assume that the use of digital media (e.g., watching television via computer or mobile phones, reading Internet news or e-books) includes more variability than the use of more widely spread personal technologies such as mobile phones or traditional mass media, and that variability increases towards the oldest technology generation. The overall aim of the study is to find out if there is any evidence of age heterogeneity in digital media use, with a focus on five types of media. To meet this aim, the following research questions (RQs) were defined:

RQ1 Are there differences between technology generations in the aged heterogeneity in digital media use?

RQ2 Are there country differences in the aged heterogeneity in digital media use?

To obtain answers to these research questions, we analyse three waves (2016, 2018 and 2020) of the 'Older audiences in the digital media environment: A cross-national longitudinal study' data gathered as part of the Ageing + Communication + Technologies (ACT) project. The survey data collected from Austria, Canada, Finland (not participating 2016), Netherlands, Romania, and Spain were used in analyses. All respondents in the survey were Internet users aged 60 or above in 2016.

2. The Nexus of Aged Heterogeneity and Digital Media Use

Prior literature provides various explanatory frameworks for the aged heterogeneity with connection to digital media usage. In general, these frameworks draw from or are closely related to life events occurring in older age, some of which are more unexpected and severe (e.g., the death of a spouse, onset of dementia) than others (e.g., retirement, becoming a grandparent or great-grandparent). What is common among these life events is that they necessitate adjustments to habitual practices such as media use.

Perhaps most often studies focusing on physical and cognitive changes in later life associate the aged heterogeneity with the diminished or discontinued use of digital media. Such studies typically adopt an approach in which the capabilities of older adults are seen to diminish sooner or later, leading to narrower patterns of use or ultimately to the abandoning of new technology (Friemel, 2016; Hargittai & Dobransky, 2017; Helsper & Van Deursen, 2015; Hunsaker & Hargittai, 2018; König et al., 2018). In contrast, contemporary theories of aging strongly emphasize old age as an active phase of life during which older people navigate following their selected (S) lifegoals and use strategies of optimization (O) and compensation (C) to achieve the desired goals (about the SOC theory, see Baltes & Baltes, 1990). While some older adults are forced to give up using digital media entirely, others remain in good

health, learning new skills and finding ways to benefit from technology. Whether older people significantly reduce the use of everyday of ICT as they age, depends very much on the type of health decline they experience (Levine et al., 2018). Selective and active digital media use may compensate for distressing conditions in later life (Gallistl & Nimrod, 2020)

Time use offers another perspective on the diversity among older adults in their engagement with digital media (e.g., Nimrod & Ivan, 2022). Generally, as people transition into retirement age, they gain more leisure time and increased autonomy to determine its allocation. Depending on their life circumstances, older individuals might opt to dedicate more or less time to digital media activities. Declining sensory, cognitive, and motor functions associated with aging (Loos & Romano Bergstrom, 2014) can lead to a more restricted or selective use of digital media, particularly those reliant on good vision and hand dexterity. Conversely, some older adults might choose to invest more time in digital media to pursue personal life goals, maintain social networks, or counteract diminishing physical mobility and a narrowing social circle (e.g., Hänninen et al., 2021).

While attempts to model aged heterogeneity in media use statistically are rare (Taipale et al., 2021), many studies based on qualitative research designs or theoretical reasoning have applied the notion of ‘aged heterogeneity.’ For example, Loos (2018) and later Sourbati and Loos (2019) applied this notion to investigate websites’ visual imagery and found that the websites’ visuals widely overlooked the heterogeneity of old age characteristics. Elsewhere, Loos (2011) applied the aged heterogeneity approach to analyse older adults’ online information-seeking practices. Hänninen et al. (2021) for one related diversity in digital media usage in old age to within-individual variation pointing out that the same older person might be well-served in the use of one medium but may still require assistance and support in the use of others. This observation underscores that aged heterogeneity is not always or even primarily linked to functional decline in old age, but rather to a range of personal preferences, skills, and emotional attachment to certain technological devices and applications over others (also, Coelho, 2022).

In summary, older people’s media use practices can be located on a broad digital spectrum, just like older people as Internet users (e.g., Lenhart & Horrigan, 2003; Loos, 2012). The spectrum starts from practices of media non-use, goes through different types of assisted and co-use, and finally reaches the other end of media heavy use (Hänninen et al., 2023). An individual’s place on this continuum varies depending on the digital media we are talking about and the context in which it is used (e.g., whether help is available). Such heterogeneity in media use fits well with what is proposed in active ageing and SOC theories. The aged heterogeneity brings to the fore older people as active and contemplative agents who match their digital media use with individual life goals.

3. Technology Generations

While the age heterogeneity thesis can be used to explain why media usage practices ‘fan out’ with age, a generation approach may assist in understanding why people born around the same time develop a similar relationship and trajectories with digital media. The older the age cohorts are, the more time they have had to develop a shared generational identity or ‘we-sense’ (e.g., Bolin 2017a, 2017b; Taipale, 2019).

According to the generation approach, people born during a certain period have experienced the same significant life events in their formative years (typically up to 25 years of age, e.g., Ryder, 1985). This formative period in the life course is crucial for the types of relationships people form with specific media, media formats, and content. It is commonly believed that individuals can more easily master the media they grew up with. Additionally, the concept of a technology generation entails a sense of familiarity and emotional attachment to the media that surrounded them during their formative years.

Building on theories of generation (Mannheim, 1997; Ryder, 1985; Van de Goor & Becker, 2001) and technology adaptation, the concept of technology generations was developed by German sociologists in the early 1990s (Sackmann & Weymann 1994; Sackmann & Winkler 2013). They defined a technology generation as 'groups of birth cohorts whose conjunctive experience with technology is differentiated by social change.' The original study on technology generations was based on qualitative interviews, group discussions, surveys, and secondary data, both in western and eastern Germany. Sackmann and Weymann (1994) provided empirical evidence for the existence of the following technology generations concerning the use of household appliances: (1) Mechanical Technology Generation, born before 1938; (2) Household Revolution Generation, born between 1939–1948; (3) Technology Spread generation, born between 1949–1963; (4) Computer Generation, born between 1964–1980. In their more recent study, using survey data from the National Statistical Bureau of Germany, Sackmann and Winkler (2013) found further evidence for their four-technology generation model, as well as for the fifth generation – the Internet Technology Generation, born after 1989 – characterized by extensive Internet use during their formative years.

Until now, the concept of technology generation has not been tested with cross-cultural and longitudinal data. The only exceptions are Ivan et al. (2020b), and Loos and Ivan (2022), who applied the concept to older Internet users (aged 60 or above) and found differences between 2016 and 2018. In this article, we build upon these two studies, use the same data completed with its third wave (2020), and use statistical methods (growth curve model) that allow directly testing the aged heterogeneity thesis in relation to digital media use. We focus solely on the use of digital media platforms, as prior research shows that digital platforms differentiate among older age cohorts more effectively and reflect greater usage heterogeneity than traditional media formats (Taipale et al. 2021.)

4. Digital Media Use among Older Adults and Country Differences

Basing on cross-sectional data, measures of technology adoption or frequency of use, many studies have demonstrated that digital technology use decreases either linearly (e.g., Helsper & Van Deursen, 2015; Hargittai & Dobransky, 2017; Hunsaker & Hargittai, 2018; König et al., 2018) or even exponentially (Friemel, 2016) with age. Cross-sectional studies have also hinted that the variability in Internet use is increased towards the oldest age groups (Friemel, 2016; Taipale et al., 2021). Without a longitudinal data based on repeated observations from the same individuals, the idea of aged heterogeneity in digital media use cannot be probably tested.

Earlier studies based on the same ACT longitudinal data have shown a high stability over time in older adults' use of various mobile phone functionalities. Additionally, country differences in the scope of used mobile phone functionalities have turned out to be significant

and larger than those of traditional sociodemographic factors (Fernández-Ardèvol et al., 2023; Taipale et al., 2023). The studies also identified a steady trend towards an increasing number of employed mobile phone functionalities among older adults (Fernández-Ardèvol et al., 2023; Taipale et al., 2023). A study based on the 2018 wave of the ACT data indicated that old-age heterogeneity is particularly related to digital media (e.g., watching television on a computer, reading online newspapers and magazines, and reading e-books), while the opposite trend of convergence was related to the use of traditional media (e.g., watching television on a TV set, reading newspapers/magazines in print, or reading books in print) (Taipale et al., 2021).

A glance to official statistics from the studied countries helps identifying the overall country difference in older adults' media use. Most notably, statistics show that watching television on a TV set is clearly the most common media activity in Europe. For example, according to the Eurobarometer survey (2023) conducted in winter 2022/23, 90% of adults aged 55 and above (no more specific age categorization is available) reported watching a TV set every day or almost every day. Correspondingly, a mere 10% of those aged 55 and older, and as many as 28% of individuals aged 14–24, reported watching television over the Internet. Moreover, significant country-based disparities exist in online TV consumption within Europe. In Nordic countries, like Finland (28%), as well as Austria (24%) and the Netherlands (23%) watching television via the Internet on a daily or almost daily basis is much more widespread compared to countries such as Spain (17%) and Romania 16% (Eurobarometer, 2023).

Eurostat (2022) provides also information on the share of population groups using different types of online media in Europe. For example, reading online news sites, newspapers, and magazines (measured as a single activity) among people aged 65 to 74 in 2022 showed large differences between countries. The highest proportions of 65–74-year-olds using these types of online media were found in Finland (78%) and the Netherlands (72%) followed by Spain (54%) and Austria (42%). In Romania, only a quarter of this age group had used online news sites, newspapers and magazines. In contrast, watching TV or videos streamed over the Internet was less common in all other countries than in Finland. More than two thirds of Finns aged 65–74 (68%) and more than half (55%) of the Dutch in the same age group had watched streamed content in 2022. Among Spaniards, the corresponding figure was around a quarter (24%), while it was much lower among Austrian (15%) and Romanian (5%) older adults. In Israel (Pew Research, 2022) and Canada (Statista, 2022), the percentages of adults using different digital media hover around 85–90%, with a drop of 25%–35% for the older population (65–74 years). For example, 86% of adults in Canada use online news sites, compared to 48% of the older population. Similarly, in Israel, the use of online news sites is estimated to be around 89%, with a 20% drop for the older population (Pew Research, 2022, no specific age threshold mentioned).

5. Data and Methods

5.1. Data

We used data from the 'Older Audiences in the Digital Media Environment' panel survey, which was conducted in 2016, 2018, and 2020. The survey was originally launched and conducted as part of the Aging + Communication + Technologies (ACT) project, coordinated by

Concordia University in Canada. The initial data collection took place in 2016, and focused on respondents aged 60 or older. This data was collected from Austria, Canada, Finland, Israel, the Netherlands, Spain, and Romania. The second and third waves included the same six original countries and one new country, Finland. The same respondents participated in all waves, although some withdrew from the study during the second or third wave. A total of 10,527 people responded to the first wave of data collection, of whom 6,225 and 3,659 participated in the second and third waves, respectively. A total of 7,940 respondents participated in the second wave, of whom 4,398 also answered the third wave. Altogether, 3,612 people responded to all three waves of data collection.

The respondents were recruited from commercial online panels in all countries except for Romania. Similarly, the survey questionnaire was administered online, with the only exception being Romania, where interviews were conducted via telephone due to the low Internet usage rate among the older population. Age and gender quotas were applied for stratified sampling, and the reference figures for quota sampling were derived from official national statistics. Excluding any potential distorting effect of dropouts, the final dataset is representative of Internet users aged 60 and above (in 2016) in each respective country.

In the current study, we analyse a sub-sample of retired respondents to homogenize the sample in terms of the respondents' available time for media use. Data from Israel were excluded due to a substantial number of observations reporting a disproportionate number of hours spent on digital media use (e.g., watching TV via computer for over 30 hours a day). Respondents providing inaccurate age during the follow-up period were also excluded from the analysis (e.g., age increasing by too much or not changing at all between two-year survey waves). Our final sample comprises 10,805 observations from 3,889 individuals.

It is important to note that the sample is not representative of the entire older age population; rather, it is limited to older Internet users. Most respondents in this study may be more active in their media usage compared to their peers, as they have (except for Romania) participated in an online panel. This could potentially introduce some upward bias in our estimates of digital media use, particularly among the oldest respondents belonging to the Mechanical Technology Generation (born before 1938).

5.2. Measures

Our measure of time spent on digital media usage was constructed as a composite indicator of the total time spent (in minutes) on five types of media: watching television via computer, watching television via mobile phone, reading Internet news, reading e-books, and listening to audiobooks. Respondents estimated the total number of hours and minutes they spent on each media or could indicate that they did not use the given media or did not remember. This information was recorded in four distinct variables: hours, minutes, did not use, and do not remember. Cases with extreme values on reported hours were excluded using a standard z-score cut-off criterion, defined as greater than 3 or less than -3, to identify outliers. After this exclusion, reported hours for each media use were transformed into minutes and combined with reported minutes. Respondents who reported not using a specific media at all were assigned a value of zero. Following these adjustments, the measures used in the analyses reflect the total minutes spent on each media type on the day before the date of response. The total measure of digital media usage was constructed by summing the minutes spent on all five media. However, the total minutes could potentially stem from the use of only one of

these five digital media types. The five indicators were chosen to represent commonly known and used media formats, which in these days are available on digital format, and which are designed to deliver contents for the masses. Due to measurement limitations, one-to-one communication and social networking tools were excluded from the analysis.

In addition to the survey wave (i.e., time), the main independent variables in our models are the respondents' technology generation and age. We employed a technology generation approach (Sackmann & Winkler, 1994; 2013) to categorize individuals based on their birth cohort. Following the classification of Loos and Ivan (2022), we assigned respondents to three generations defined by their exposure to specific media technologies during their formative years: the Mechanical Generation (born in 1938 or earlier), the Household Revolution generation (born between 1939 and 1948), and the Technology Spread Generation (born between 1949 and 1963).

Methods

In terms of statistics, we used linear growth curve models to estimate trends in total time spent with digital media and to determine whether there was evidence of increasing differentiation between individuals (i.e. heterogeneity) in these trends. Growth curve models, essentially multilevel or random effects models, use repeated observations of individuals as lower-level units (level 1) and treat individuals as higher-level units (level 2). Multilevel models include both fixed and random effects, hence the term random effects models. Fixed effects are those estimated in standard regression models. Random effects, on the other hand, are not necessarily estimated directly, but are summarised based on estimated variances and covariances (Hox 2017; Goldstein 2010).

Random effects in growth curve models allow us to directly test the aged heterogeneity thesis, which suggests that differentiation in digital media use increases as respondents get older. In practice, we estimate random effects for both the intercept and the slope; the intercept on the initial level (year 2016) and the slope on the trend (change) in digital media use. The random effects of the intercept and slope in turn refer to the degree of individual variation in the initial level and the trend. A positive (negative) covariance of random intercept (RI) and slope (RS) indicates that respondents with a high initial level tend to have a more positive (negative) trend than those with a low initial level. Thus, a significant positive covariance of random intercept and slope in our growth models would indicate increasing heterogeneity in digital media use and support the age heterogeneity thesis. We also acknowledge that the increase or decrease in heterogeneity may be more relevant for some technology generations than others. For example, it may be that respondents belonging to the oldest technology generation (the Mechanical Technology Generation) become more inclined to what might be considered generation-typical media use as they age, and their media use patterns therefore converge rather than diverge. Therefore, we will estimate growth models separately for the three technology generations (see Loos & Ivan, 2022).

Due to the limited number of countries in our studied sub-sample, implementing a three-level model is not feasible. To address the nonindependence of respondents (meaning that respondents from the same country may be more similar to each other), we incorporated country as a predictor in all growth models. Additionally, we conducted separate growth models for each country. This approach accounts for the possibility that the process of aged heterogeneity may only become apparent within specific cultural and societal contexts.

In all models, we estimated the growth process as a linear time trend. This choice was due to the fact that we had only three measurement points available.

6. Results

Table 1 presents descriptive statistics of the time-use variables in the sample. Participation rates in digital media use varied greatly depending on the measure used and were very low for several measures (e.g., 96 to 98% of respondents did not watch TV on mobile phones or listen to audio books). About 38% of respondents reported not using any of the five types of digital mass media. All measures were highly skewed and contained a large proportion of zeros. For these reasons, we decided to use only total time spent with different types of digital media in further analyses.

Table 1. Descriptive statistics by country and survey wave

Country		2016		2018		2020	
		mean	sd	Mean	sd	mean	sd
Austria	Total digital media (min.)	61.21	88.42	59.76	89.31	67.60	98.38
	TV via computer (min.)	35.50	70.44	32.19	72.89	33.13	76.35
	TV via mobile (min.)	1.59	7.46	3.02	12.36	3.99	18.03
	Internet news (min.)	15.81	26.55	15.69	26.24	20.34	31.99
	Ebooks (min.)	8.94	30.61	9.50	31.32	8.72	31.29
	Audiobooks (min.)	1.48	12.28	1.35	13.70	2.07	15.86
	N	617		654		679	
Canada	Total digital media (min.)	50.81	81.30	50.34	74.08	62.96	97.63
	TV via computer (min.)	7.24	30.00	9.04	34.00	17.75	64.60
	TV via mobile (min.)	0.70	7.63	0.47	4.57	0.18	3.02
	Internet news (min.)	24.81	41.72	24.01	39.04	26.34	41.79
	Ebooks (min.)	17.24	48.55	17.44	46.61	17.39	48.11
	Audiobooks (min.)	0.91	13.08	1.18	9.58	2.40	22.62
	N	368		388		423	
Finland	Total digital media (min.)			38.79	60.79	50.48	74.90
	TV via computer (min.)			12.29	39.28	16.21	52.86
	TV via mobile (min.)			0.74	5.53	1.00	7.72
	Internet news (min.)			22.36	31.54	30.03	37.73
	Ebooks (min.)			0.78	7.99	1.10	9.88
	Audiobooks (min.)			2.91	20.70	2.65	20.67
	N			668		713	

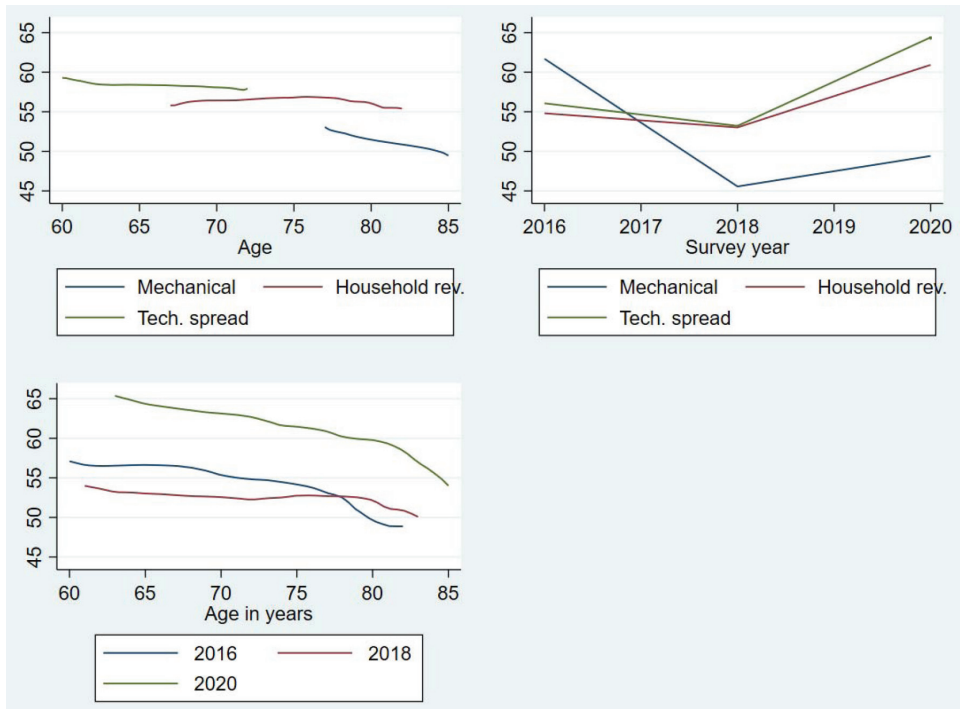
Netherlands	Total digital media (min.)	43.58	69.86	46.33	75.98	58.49	82.66
	TV via computer (min.)	9.75	36.10	11.83	41.13	12.58	41.12
	TV via mobile (min.)	0.18	1.95	0.82	6.34	2.11	15.97
	Internet news (min.)	20.31	32.69	20.88	32.42	25.49	38.38
	Ebooks (min.)	13.60	36.64	13.44	37.65	16.46	43.12
	Audiobooks (min.)	0.26	3.71	0.07	1.13	2.13	21.14
	N	271		320		368	
Spain	Total digital media (min.)	77.36	88.71	76.54	86.01	82.46	96.36
	TV via computer (min.)	13.84	42.90	12.94	38.42	14.30	49.62
	TV via mobile (min.)	1.33	11.31	3.10	16.29	2.38	14.10
	Internet news (min.)	39.44	47.14	37.96	43.63	40.70	45.02
	Ebooks (min.)	23.01	50.98	24.56	55.99	25.68	56.28
	Audiobooks (min.)	1.50	12.23	0.84	8.27	1.89	13.51
	N	607		707		791	
Romania	Total digital media (min.)	27.24	51.80	29.96	56.16	37.83	65.48
	TV via computer (min.)	8.54	38.86	6.82	30.39	8.65	33.87
	TV via mobile (min.)	1.44	11.40	2.29	16.51	3.63	20.74
	Internet news (min.)	15.14	31.47	17.30	31.53	21.40	34.29
	Ebooks (min.)	1.59	11.71	3.96	20.37	1.95	11.66
	Audiobooks (min.)	0.76	8.67	1.95	12.35	2.65	15.51
	N	405		421		432	

Large country differences in the level of digital media are also seen in Table 1. The total time of media use varied from 27 minutes in Romania (in 2016) to 82 minutes in Spain (in 2020). There also seems to be a positive trend in digital media use: the total number of minutes in 2020 is higher than those in two previous survey waves. In most of the countries, the time spent on watching TV via computer and reading Internet news was most accountable for the total time measure. By contrast, listening to audiobooks and watching TV using mobile phone were very rare activities in all countries.

Figure 1 shows the development of total time spent using digital media by respondent age, survey year and technology generation. This allows us to estimate the relative importance of the effects of age, survey year and technology generation on digital media use. Figure 1 reveals that, except for the Mechanical Technology Generation, age has a consistently negative effect or no effect at all on digital media use. For this oldest technology generation, the decline in digital media use with age is more pronounced. It should be noted, however, that the number of observations for the Mechanical Technology Generation is smaller than for the others. As far as the effect of age is concerned, there do not seem to be any clear systematic differences between the three survey years. The only exception is the higher overall level of media use in 2020. Across all three waves, there was a clear decline in digital media use

among the oldest respondents. To sum up, these results indicate an overall negative trend in digital media use by age.

Figure 1. Effects of age, technology generation cohort and survey year on digital media use (minutes)



Note: Local polynomial smoothing for age. Age restricted to 60-85 (4 % of respondents excluded).

There are also clear differences in the level of digital media use, both by survey year and by technology generation. First, there was a clear shift in the overall trend for all three technology generations in 2018. The development of digital media use was negative between 2016 and 2018, especially for the Mechanical Technology Generation. However, between the 2018 and 2020 survey waves, there was an increase in digital media use for all technology generations. These findings provide support for both technology generation and survey year effects. It is likely that the shift in the survey year effect is related to the outbreak of the COVID-19 pandemic in 2020.

Table 2 presents fixed and random effects from linear growth models predicting total time spent using digital media. The three models test the need for random intercepts (1), slopes (2) and their covariance (3). The random parameters indicate the amount of variation between individuals in their initial status and trend. The fixed effects, in turn, represent the average intercept (i.e., initial level in 2016) and average slope (i.e., trend along with country differences in initial level). The intercept and slope fixed effects are significant in all models. A positive coefficient on the slope indicates an overall increasing trend in time spent on digital media. There are also clear cross-country differences in the initial level of digital media use. In contrast, individual level factors, including technology generation, have no effect on the initial level of digital media use, except for a weak positive effect of education and a negative effect of age.

Random effects show that there is significant individual variation in both the initial level (random intercept) and the trend (random slope) of digital media use. The third model shows a small negative covariance between the intercepts and slopes, indicating a decrease in differences over time (i.e., convergence in media use). However, this negative covariance is not statistically significant. Thus, there was little evidence of an overall increase in differentiation in digital media use over the period. However, there was evidence of significant variation in the individual trend (i.e., slope) of digital media use.

Table 2. Estimates from linear growth models on digital media use

		Model 1.	Model 2.	Model 3.
Fixed	Intercept	71.4***	75.8***	75.4***
	Slope ¹	7.1***	7.4***	7.4***
	Age (centred at 60)	-1.1*	-1.2*	-1.2*
	Country (ref. Austria).			
	Canada	-9.6*	-10.3*	-10.2*
	The Netherlands	-12.9**	-14.1**	-14.1**
	Romania	-33.5***	-33.8***	-33.8***
	Spain	17.0***	16.7***	16.7***
	Finland	-20.3***	-21.4***	-21.4***
	Generation (ref. Mechanical)			
	Household Revolution	-8.2	-11.0	-10.8
	Technology Spread	-12.5	-16.4	-16.2
	Male (ref. female)	-1.2	-1.0	-1.0
	Spouse (ref. no spouse)	-2.3	-2.1	-2.1
	Education (ref. primary)			
	Secondary	6.5	6.4	6.4
	Tertiary	9.9*	9.6*	9.7*
	Income (ref. below average)			
	Average	2.7	2.6	2.7
	Above average	2.5	2.6	2.6
Random	Intercept	2871.2	2475.7	2593.9
	Slope	-	445.3	505.2
	Cov. intercept & slope	-	-	-86.3
	Residual	3804.6	3367.6	3321.7
Observations		7692		
Log likelihood		-44235	-44192	-44192
P-value LR-test ²		<0.001	<0.001	0.385

¹Time coded as 0 = 2016, 1 = 2018, 2 = 2020

²Likelihood-ratio test. Model 1: vs. standard linear model; Model 2: vs. Model 1; Model 3: vs. Model 2

*** p<.001, ** p<.01, * p<.05

Next, we explore what factors might explain these differences in trend. This was done by adding the interaction term of time and other factors to the model with both random intercept and slope but excluding the covariance between slope and intercept. According to these analyses, we found significant interactions of country and technology generation with the time trend. First, there was a significant positive trend in time spent with digital media in all countries except Austria. Second, Finland had a more positive trend than Austria and Spain. Regarding technology generations, we found a significant positive time trend only for younger technology generations.

6.1. Generational Differences in the Aged Heterogeneity

In order to find out whether the aged heterogeneity thesis might hold for some specific technology generations, we conducted growth modes separately for each technology generation. If not, the analyses would provide further support for the previous analysis presented in Table 2, which shows no trends indicative of age heterogeneity in media use. Due to space limitations, we only report results for the models with random intercept, slope, and their covariance (Table 3). There is no evidence of growing differences within any of the technology generations during the follow-up period was detected. For all technology generations, the covariance of the random intercept and slope is negative, but statistically significant only for the Mechanical Technology Generation. In other words, we found no support for the aged heterogeneity thesis in digital media for any of the technology generations. Nevertheless, the fixed estimates show that the overall trend is positive and statistically significant for the two younger generations. For the Mechanical Technology Generation there is a negative, but insignificant trend. This means that, on average, the use of digital media has increased for all generations except for the Mechanical Technology Generation.

Table 3. Estimates from linear growth models of digital media use by technology generation

		Technology generation		
		Mechanical (before 1939)	Household Revolution (1939-1948)	Technology Spread (1949-1963)
Fixed	Intercept	91.4***	61.2***	64.9***
	Slope ¹	-4.6	6.4**	8.0***
	Age (centered at 60)	-0.5	-0.7	-1.2
	Country (ref. Austria).			
	Canada	-14.7	-11.0	-7.6
	The Netherlands	-47.5**	-6.1	-15.8**
	Romania	-63.1**	-20.6**	-35.4***
	Spain	-13.1	18.5***	14.9**
	Finland	-23.6	-19.7**	-23.4***
Random	Intercept	4592.2	2648.0	2515.8
	Slope	621.5	453.8	520.4
	Cov. intercept & slope	-1187.4	-165.3	-50.0
	Residual	2644.9	3188.7	3499.2
Observations		495	3344	4938
Log likelihood		-2799	-19105	- 28479
P-value LR-test ²		<0.001	0.226	0.701

¹Time coded as 0 = 2016, 1 = 2018, 2 = 2020

²Likelihood-ratio test vs. model with only random intercept and slope.

*** p<.001, ** p<.01, * p<.05

6.2. Country Differences in the Aged Heterogeneity

In the last phase of our analyses, we estimated growth models for digital media use separately for each country. Finland was excluded from the analyses because Finnish respondents participated in only two waves, and we cannot separate the error variance from individual heterogeneity in change (see Hesser, 2015). As Table 4 shows, a significant positive covariance of intercept and slope (i.e., evidence of increasing differentiation/divergence) was found only in Austria. In other countries there was either no covariance or the covariance was negative (i.e., indicating convergence in digital media use), but non-significant. We performed further analyses by technology generation separately for Austria. According to these results, the positive covariance of random intercept and random slope (divergence) was found only for two younger generations, but it was not significant in any of them. In other words, no support for age heterogeneity was found there either.

Table 4. Estimates from linear growth models of digital media use by country

		Austria ¹	Canada	Netherlands	Romania	Spain
Fixed	Intercept	71.3***	62.3***	26.3**	10.2	58.7***
	Slope ²	3.1	6.1*	7.4**	5.3**	2.6
	Generation (ref. Mechanic.)					
	Household rev.	-16.2	-21.2	19.0	22.6*	15.3
	Technology spread	-8.3	-10.1	15.6	15.6	20.1
Random	Intercept	2792.1	3668.1	2676.9	802.0	3733.2
	Slope	47.0	1421.1	347.9	454.2	523.8
	Cov. intercept & slope	362.6	-756.8	-39.8	-102.9	-195.7
	Residual	4843.2	2645.8	2632.7	1995.6	4006.9
Observations		1937	1160	956	1258	2089
Log likelihood		-11354	-6678	-5405	-6835	-12203
P-value LR-test ³		0.024	<0.001	<0.001	<0.001	<0.001

¹ Finland was excluded because the country participated in only two waves, and hence the error variance cannot be separated from individual heterogeneity in change.

² Time coded as 0 = 2016, 1 = 2018, 2 = 2020.

³ Likelihood-ratio test vs. model with only random intercept and slope.

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

7. Discussion and Conclusions

In this study we have investigate the diversity in older people's digital media use between 2016 and 2020, and asked tried to find out evidence for the aged heterogeneity in digital media use. Contrary to previous studies on mobile communication and Internet use (Coelho, 2022; Hänninen et al., 2021; König et al., 2018; McCosker et al., 2021; Taipale et al., 2021) that have suggested for the high or even growing diversity in digital media among older people, our results did not provide virtually any support for the aged heterogeneity thesis. Quite the contrary, the differences between individuals did not increase, but remained the same or decreased, as our respondents aged. Age heterogeneity may be evident in the use of individual media and communication technologies at any given time, but it does not seem to surface when examined through an aggregate measure that aims to a more comprehensive account of the phenomenon. At the same time, Hhowever, the overall time use on digital media increased over the years, yet there was first a decline in the time-use between 2016 and 2018, and after which the use increased again by 2020 probably. The biggest single explanation for the recorded increase is likely to be the positive impact of COVID 19 pandemic on older adult's digital media consumption. In short, our results show significant variation in the individual trends (i.e., slope) of digital media use, but no evidence of an increased variation ('fan-out') over time. Rather than heterogeneity, we found evidence of 'aged homogeneity' in digital media use.

Regarding the concept of technology generations, the overall trend of using more digital media was found in the younger technology generations: the Household Revolution (born 1939-1948) and the Technology Spread Generation (born between 1949-1963), while in the Mechanical Technology Generation (born before 1938) the use of digital media decreased over time. What we found is in line with the previous study (Taipale et al. 2023) which showed that older adults move not only from 'narrow use' to 'medium use' and 'wide use' of different mobile phone features, but also vice versa, and that age was a predictor in such an equation. The current study supports this idea by reinforcing the fact that for a particular technology generation, the Mechanical Technology Generation, media use may decrease over time. The results of the current study also showed clear cross-country differences in the initial level of digital media use. The fact that country of residence was the only strong predictor in explaining the initial level of media use, while age and education played a relatively weak role, is important to investigate further. Austrian older adults are the only sample where we did not find an increased trend in digital media use over the years. These results highlight the importance of complementing questionnaire-based survey data with a more in-depth qualitative approach. Overall, the Austrian sample resembles the Romanian sample more in terms of media use. One potential explanation is that both countries have a large rural population with lower digital media use than the older urban population.

These results can be seen to have implications on the theories of ageing and digital inequalities. First, the aged heterogeneity (Dannefer, 1998; Nelson & Dannefer, 1992; Stone et al., 2017) should be applied to older people's media use cautiously. It may well be that diversity manifest itself more in life experiences, needs and motivations to use technology – that change across the later life course (e.g., McCosker et al., 2021) – than to chronological ageing and ageing-related impairments, especially when we are studying the 'younger old.' What speaks for active ageing with digital media is that our respondents intensified their digital media use between 2018 and 2020. Even though this observation period is relatively short, the study showed older adults' ability and willingness to react to 'external factors' such as the pandemic by modifying their media behaviour (as suggested by the SOC theory, Baltes & Baltes, 1990). Noteworthy is also the finding that, apart from a weak negative effect of age and positive effect of education, sociodemographic background factors did not have effects on the initial level of digital media use in the studied sample. This implies that the role of socio-demographics is relatively small or in some cases non-existent, when it comes to the diverse trajectories and the volume of digital media use in later life.

As no overall evidence of growing differences in digital media use was found, we then investigated whether differentiation would relate more to technology generations (RQ1) or respondents' country of residence (RQ2). The technology generations are assumed to differ in their media habits because of socialization with different household technologies and meanings ascribed to them (König et al., 2018). But again, we did not find any evidence of the increased diversity in any technology generation. This finding alludes that neither different generational attachment to new technology produces more diversity in digital media technology as older adults age. Lastly, we investigated whether differentiation in media use could be related to country differences. Separate models for each country did not provide evidence for the aged heterogeneity either. In fact, the tendency in almost every country (except for Austria) was rather towards convergence of digital media use. This is to say, difference in communication culture, economic resources and technological infrastructure at hand does not

seem to lead in different paths of convergence/divergence in digital media use as older people age.

8. Limitations and Future Research

As the present study analysed respondents recruited through online survey panels (except for Romania), the generalisability of the results is limited to older Internet users. They are likely to be in better physical condition and on average more skilled and active Internet users. There were few respondents aged 90 and over. A much longer observation period would be needed to show how respondents belonging to the Technology Spread Generation (the youngest generations) use media when they reach the same age as respondents belonging to the Mechanical Generation (the oldest generation). Another significant limitation of the study relates to its measures. While the time spent on digital media included more variation than, for example, simple measures of use vs. non-use, the total time measure used in the analyses was mainly informed by two time measures: time spent watching TV on a computer and time spent reading online. It also included information on only five different digital media activities, leaving out many others that used by older adults (e.g. social networking sites, listening music). In fact, the narrow scope of the media activities studied may not allow for the detection of all heterogeneity in digital media use or its changes over time.

Our results suggest that age differences may in some cases be more related to motivations and reasons for using digital media than to actual use. This calls for more in-depth research in the future. In addition, future studies should consider the ethnic and cultural diversity of the older population. Finally, more attention should be paid to the possibility of discovering increasing similarity (convergence) in older adults' media use as they age. While striving to better recognise the heterogeneity of older people as media users, it should not be forgotten that they may also start to resemble each other more, especially at a very old age, as their physical and cognitive abilities change.

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