Gradients of the Gray Divide:
Demographic and Socioeconomic Factors of the Technology Use of Seniors

Steven G. Opferman
Stanford University
sopferman@stanford.edu

The term "digital divide" refers to unequal access to the resources provided by information and communication technology, often as a result of lack of infrastructure, a lack of digital literacy, and/or a lack of accessible technology (Ragnedda and Muschert 2013). Technology facilitates information gathering, social interaction, and task completion, and those who can't or don't use technology are, more often than not, at a severe disadvantage when compared to those who can and do (Zickuhr 2011).

The digital divide has been connected to a variety of demographic and socioeconomic variables, including income (Vogels 2021), race (Atske and Perrin 2021), ability (Fox 2011), gender (West 2019), and age (Friemel 2016). In this paper, I examine the so-called "gray divide" between younger individuals and seniors.[1] As technology becomes increasingly embedded in modern life, seniors are often being left behind, and as life expectancy increases, seniors are becoming an increasingly significant segment of the population.

Having established that the gray divide exists, the obvious next question is *how can we reduce or eliminate it?* By examining facets of the digital divide separately and comparing seniors to the whole population, it is possible to tailor interventions to efficiently reduce the gray divide.

I separately look at access to infrastructure (do seniors have technology?) and usage of available technology (do seniors use technology?). Finally, I look at how seniors use technology in an attempt to shed light on seniors' motivation (why do seniors use or not use technology?).

My hypothesis is that demographic and socioeconomic characteristics linked to the digital divide will have a similar or stronger link within the older population. I also anticipate that having more and younger people in the household will increase both access and usage. I suspect that seniors with acquired disabilities will have decreased usage of technology, due to the additional complexity of accessible technology.

Literature Review

Research about technology adoption tends to be broad in focus, and so often the oldest ages are combined into one category and considered to be the same. Research that looks at the technology adoption of seniors specifically, however, paints a much more heterogeneous picture. van Deursen and Helsper (2015) suggest that some seniors are more likely to be excluded from

[1] I define the term "seniors" to refer to individuals of age 65 or older. Different authors use different minimums ranging from 55-80, so I picked the lowest age that fits with my personal experience working with older individuals in senior living facilities.

technology than others, for example, due to the intersectional effects of age and other demographic and socioeconomic factors. Boekel et al. (2017) looked beyond use vs non-use, identifying four major clusters of seniors who use the Internet in different ways: maximizers, minimizers, practical users, and social users. Friemel (2016) showed that the support of family and friends is a strong predictor for Internet use.

Renstrom (2020) and Klimova et al. (2018) looked at motivations for seniors to use or not use technology: seniors pick and choose what technologies they will learn to use based on the value that technology will bring them. Friemel (2016) considered the effects of learning environments on success, and Hargittai and Dobransky (2017) show that once controlling for skill, age differences are much less significant.

However, prior work tends to have selection issues that result in biased data. If a survey is conducted online, it will of course be near impossible to reach seniors who don’t use the internet. If a survey is conducted over the phone, it can be difficult to complete the interview if the respondent has technical issues, and finding participants can also be biased towards the technically skilled — people with a cell phone and a landline have better odds than someone without a phone at all. Senior living and health care facilities don't always provide external phone numbers for reaching residents, so they are often left out as well. In-person surveys are expensive and time consuming, and thus are less common and provide a smaller sample size.

Hargittai and Dobransky (2017) looked at 1318 seniors as a subset of 5005 national respondents, but used random number dialing to reach participants and didn’t collect substantial demographic and socioeconomic information. Boekel et al. (2017) looked at 1418 seniors, but only looked at seniors who already use the internet, with no baseline of non-seniors to compare to.

Methods and Design

I began by comparing seniors to the entire population surveyed in the Technology Tracker. In regards to infrastructure access, the survey asks if the respondent has any of the following services: landline phone, mobile phone, fixed broadband internet access, mobile broadband internet access, narrowband internet access, and “TV service with additional channels you pay to receive.” The scope of the question seems to be the respondent’s household, so a service shared with household members would count, even if the respondent themself doesn’t use the service.

For each service, I calculated the distribution of respondents who did vs did not have the service, for the whole population and for the senior subset. I then performed a permutation test for each service in order to determine how likely to randomly choose a subset as or more extreme than the subset of seniors. I also made side-by-side bar charts for each service to provide a visual reference for how different the distributions were.

If the result of the permutation test is very small, it means that it’s highly unlikely that a random subset would be as or more extreme than the senior subset. We can then assert that there is at least one factor that differentiates seniors from the rest of the population, and is associated with different access outcomes than the population as a whole. I anticipate seeing barely-significant p-values. I think that reasons seniors may not have access to a service are not unique to seniors, but rather driven by demographic or socioeconomic factors. However, being a senior likely exacerbates the pre-existing demographic or socioeconomic factors. As a result, the subset of seniors' access would be close to but less than the population.

Second, I performed the same calculations and made the same bar charts looking at each individual's usage of each device type. In regards to usage, the survey asks if the respondent personally uses "a standard DVD player", "video games console connected to a TV (e.g. Sony PlayStation, Nintendo Wii or Microsoft Xbox)", "a Blu Ray DVD player", "e-reader - digital book reader (e.g. Kindle, Sony Reader, Kobo eReader, Nook eReader)", "an MP3 player/iPod", "a smart watch or wearable tech such as fitness trackers - a wearable computer that may be compatible with a smartphone. Brands include Apple Watch, Pebble, Fitbit and Garmin", "handheld/ portable games player (e.g. Nintendo 3DS, Sony PlayStation Vita)", "smart speakers which can respond to voice commands (e.g. Amazon Echo, Google Home, Apple HomePod)", "VR or virtual reality headsets (e.g. Oculus Rift, PS VR, Samsung gear VR)."

As with access, if the result of the permutation test is very small, we can assert that there is at least one factor associated with being a senior and having different usage outcomes. Because access is required for usage, the p-values should be consistently lower for usage. My hypotheses and the literature also predict that seniors have a very different usage distribution than the population as a whole.

In order to examine the link between demographic/socioeconomic factors and usage, I calculated Pearson correlation coefficients between every feature I considered. I then trained a logistic regression model to predict if a respondent would use a specific device, given the respondent's demographic and socioeconomic factors. My hypothesis that having more and younger people in the household will increase usage predicts positive coefficients for household size and for the number of children in the household, while my hypothesis that seniors with acquired disabilities will have decreased usage of technology predicts a negative coefficient for the various disabilities.

I trained the first logistic regression model on the entire population and the second on just seniors. This allows me to compare the magnitude of factors using the coefficients of the model.

Data

The Technology Tracker is an annual survey performed by the UK's Office of Communications (commonly referred to as Ofcom), which "measures awareness, access, use of and attitudes towards fixed and mobile telecoms, internet, multi-channel TV, and radio, among UK adults" (Ofcom 2020). This data provides participant-level responses and includes many questions about demographics, while also having a relatively large sample size (n=3657) and a significant minority of respondents age 65 and up (23%). Crucially, it seems that the survey is conducted in-person, rather than via phone or online. In a survey studying technology access and ability, it is clearly necessary to perform surveys *not* using technology, to include those without access and/or ability.

The Technology Trackers provides information about each participant's age, retirement status, sex, urban/rural, nationality, race, ability level, income, social class, and household composition.

It also measures access to and usage of a variety of technologies, including the internet, smartphones, radio, tablets, and DVD players.

Findings

I began first with establishing if seniors *have* technology. The results of the permutation tests (omitted for brevity) show that for every service except narrowband, seniors differ significantly from the population as a whole — a higher access rate for some services, and lower for others. I then sought to establish if seniors *use* technology. The permutation tests show that for every device except DVD players, seniors differ significantly from the population as a whole — again, with a higher usage rate for some devices and a lower usage rate for others.

The permutation tests are consistent with the hypothesis that seniors are different from the population, which aligns with the literature (and is an assumed dependency of this paper). Having established that a difference exists, we can try to figure out what the difference is.

In order to compare the relative strength of characteristics in the population and to the senior subset, I trained a logistic regression model on the population and a second model on the senior subset for each technology. I then calculated the difference between the magnitudes of the senior coefficient and the population coefficient, then counted the number of differences greater than 0.5 (an arbitrary value that produced decent spread). These results are shown in Table 1.

Device	**Significant Magnitude Differences (%)**
Handheld Games	0.619
Smartwatch	0.547
VR Games	0.500
Game Consoles	0.428
Smart Speaker	0.428
iPod	0.238
Home Internet	0.238
eBook Reader	0.190
Radio	0.190
Tablet	0.142
DVD Player	0.119
Smartphone	0.119
Digital Radio	0.071

Table 1

These percentages indicate roughly how much more strongly the demographic and socioeconomic factors affect seniors in comparison to the whole population. Listed in order, the effect seems to approximate the ordering I'd expect from a complexity vs value trade-off: smartphones are medium complex and high value, while smartwatches are medium complexity and low value. This supports my hypothesis that seniors face compounding effects of the digital divide, and aligns with the literature of justifying usage.

In order to understand the relationship between household composition and usage, I looked at the coefficients of the logistic regression model trained on seniors. The results are shown in Table 2.

Device	**Household Size (θ_1)**	**Children in Household (θ_2)**
DVD Player	-0.01	0.41
Game Consoles	0.99	-1.91
iPod	0.12	-1.43
eBook Reader	0.11	0.03
Handheld Games	0.05	-1.25
Smartwatch	-0.12	1.65
Smart Speaker	0.67	0.43
VR Games	0.82	-1.3
Smartphone	0.08	-0.25
Radio	-0.0	-0.08
Digital Radio	0.27	-0.68
Home Internet	0.45	-1.15
Tablet	0.51	-0.36
Average	*0.303*	*-0.453*

Table 2

As you can see, the household size coefficient is, on average, positive, while the children-in-household coefficient is, on average, negative. My hypothesis was that both would be positive, because the social context of being around others (especially kids) would provide motivation and/or support for the respondent. The data falsifies my hypothesis, and seems to indicate that the social context described in the literature can come from cohabitants, but not from children in the same household. This could be because seniors commonly live with children when they are no longer capable of living independently.

To test my final hypothesis, that seniors with acquired disabilities will have decreased usage of technology, I again looked at the coefficients of the logistic regression model trained on seniors; for brevity, Table 3 shows the average across all disabilities for each device.

Device	**Disability (average θ)**
DVD Player	0.137
Game Consoles	0.650
iPod	0.214
eBook Reader	0.092
Handheld Games	0.442
Smartwatch	0.857
Smart Speaker	0.362
VR Games	-0.248
Smartphone	0.180
Radio	-0.042
Digital Radio	-0.112
Home Internet	0.207
Tablet	-0.176
Average	*0.197*

Table 3

It appears that, on average, having a disability is actually connected to using technology, so my hypothesis is falsified. However, a specific disability likely affects only specific technology (for example, a blind person probably likes the radio more than average, while a person who is hearing impaired less so). We can see these more specific relationships in a heatmap of correlation coefficients (Figure 1).

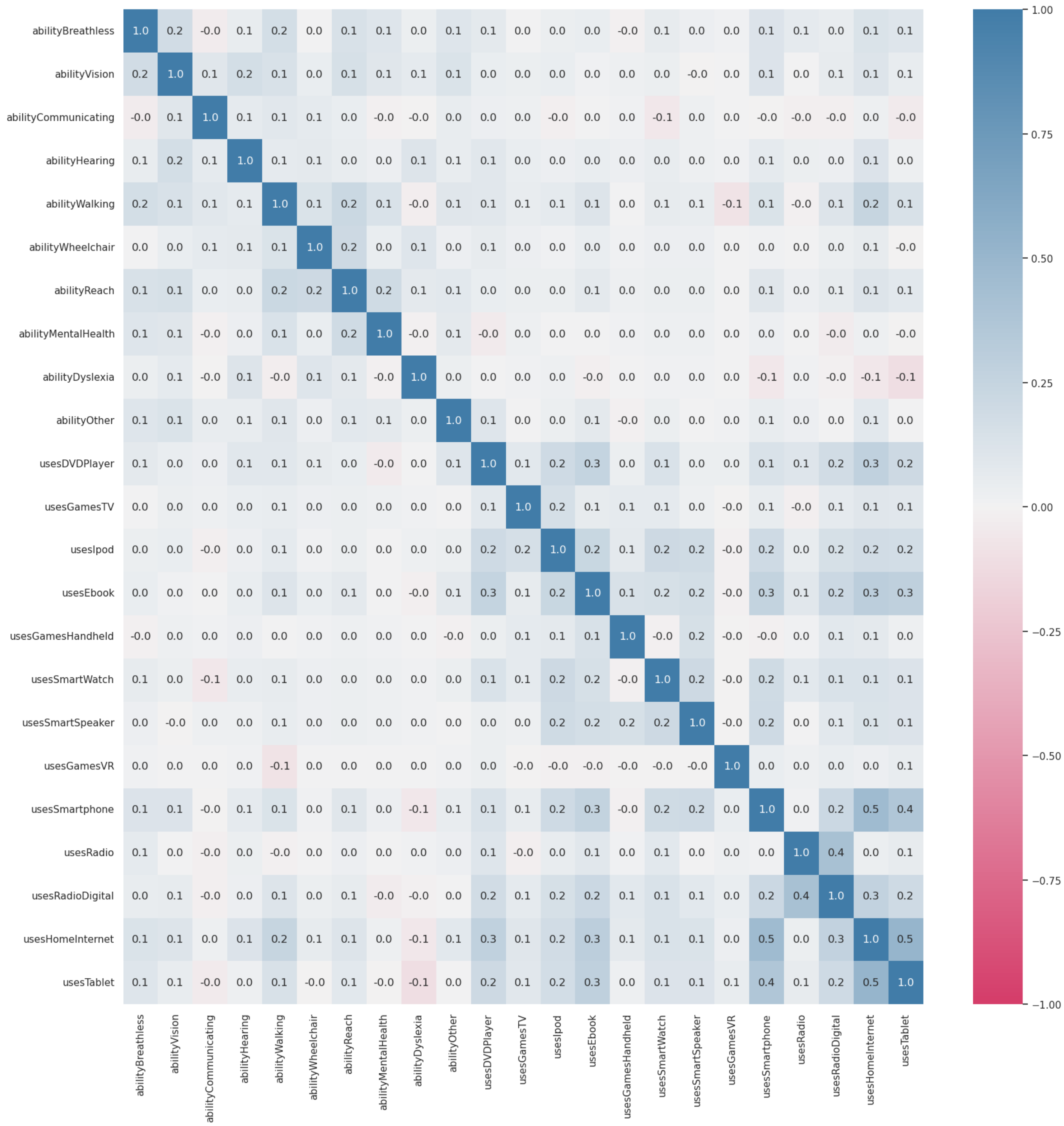

Figure 1

Interestingly, we see only very weak correlations between usage and ability. This finding casts doubt on the idea that lack of accessible technology is a significant cause of the gray divide.

Discussion and Conclusion

The Technology Tracker does have its limitations. It doesn't include, for example, questions about social relationships that would be crucial for examining the social context of technology usage. Seniors are a difficult group to survey, even in the best of circumstances, so it's likely that the seniors represented in the data use technology more and better than the average senior. Since the data is from the UK, there are limitations about how generalizable the data is: places that don't speak English may be different, for example, and certainly geographic locations with significantly worse infrastructure would also change the results.

Though in some ways limited, the Technology Tracker provides a large amount of rich data that could certainly provide more insights. The study has been run since 2004, so analyzing trends over time as technologies develop would be possible. No data has been released since the beginning of the COVID-19 pandemic, but the world's increased reliance on technology in response to lockdowns would be interesting to study, though perhaps confounded by the sharp increase in deaths among seniors. The survey also asks some qualitative questions about if the respondent plans on getting a device within the next year, which could provide deeper insights into the effect of choice on usage. It would also be interesting to break down the ages even further and see if trends arise there.

As the generations who have grown up with technology age, it will be fascinating to observe how new technologies are used by older individuals. We need to ensure that everyone has access to all that technology can offer.

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