Bridging the technological divide: Stigmas and challenges with technology in clinical studies of older adults.

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Abstract

The COVID-19 pandemic has increased adoption of remote assessments in clinical research. However, longstanding stereotypes persist regarding older adults' technology familiarity and their willingness to participate in technology-enabled remote studies. We examined the validity of these stereotypes using a novel technology familiarity assessment (n = 342) and with a critical evaluation of participation factors from an intensive smartphone study of cognition in older adults (n = 445). The technology assessment revealed that older age was strongly associated with less technology familiarity, less frequent engagement with technology, and higher difficulty ratings. Despite this, the majority (86.5%) of older adults elected to participate in the smartphone study and showed exceptional adherence (85.7%). Furthermore, among those enrolled, neither technology familiarity, knowledge, perceived difficulty, nor gender, race, or education were associated with adherence. These results suggest that while older adults remain significantly less familiar with technology than younger generations, with thoughtful study planning that emphasizes participant support and user-centered design, they are willing and capable participants in technology-enabled studies. And once enrolled, they are remarkably adherent.

Keywords: aging, smartphones, remote cognitive assessment

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At the emergence of the World Wide Web, the internet was only accessible to wealthy, technologically savvy people in Western, educated, industrialized, rich, and democratic (WEIRD) societies. Today, it connects at least 3 billion people around the world [1]. This increase in connectivity has led to a similar growth in daily technology use. As the internet has become more accessible through more devices (e.g., the “internet of things” or IoT), it has become ingrained in the everyday lives of billions of people around the world [2].

What does this mean for clinical studies? Before the SARS-CoV-2 (COVID-19) pandemic, researchers had begun to adopt remote platforms (i.e., Amazon Mechanical Turk, Prolific) to acquire larger, more generalizable samples [3]. The COVID-19 pandemic forced studies to rapidly transition to remote testing methods to continue data collection, which has drawbacks, but also many well-understood advantages over laboratory-based studies [4]. Remote studies allow for increased efficiency of data collection [5] such that recruitment and testing can happen simultaneously for many studies and participants. Converting existing laboratory-based studies to remote paradigms means researchers are not reliant on subject pool databases predominantly comprised of WEIRD participants [6]. Remote clinical studies can reach larger and more diverse samples and garner larger samples of special populations [4, 7, 8]. Finally, allowing individuals to participate in studies from their homes has the potential to increase accessibility for those who might be physically, financially, or otherwise unable to come into a laboratory or clinic to participate.

There are, of course, pitfalls with remote assessments. Participants can take advantage of the format to bias their performance by recording responses and assessment materials manually or with screen capture software. Additionally, participants tested in their natural environments are vulnerable to external distractions otherwise not present in laboratory or clinic settings. Studies using “bring your own device” (BYOD) paradigms are additionally susceptible to distractions from device notifications unrelated to the experiment, and hardware and operating system (OS) differences across devices may influence behavioral data [9]. In aging

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1 populations, perhaps the most critical consideration stems from the so-called “digital divide”
2 which refers to demographic variables, such as age, gender, and socioeconomic status, that
3 influence technology access and use behaviors [10]. For example, in the context of aging
4 research, the digital divide reflects the tendency for older adults to be less likely to use
5 technology than younger adults and for older adults who use technology to do so less [11].

6 Due to technological advances and the popularity of smartphones, affordable
7 smartphones are now widely available, and a greater number of older adults are adopting
8 smartphones into their daily lives. The Pew Research Institute reported that 74% of Americans
9 ages 50-64 and 42% of individuals 65 and older own a smartphone (a 16 and 12-percentage-
10 point increase, respectively, compared with 2015) [12]. However, these data were collected in
11 2017 and, critically, well before the COVID-19 pandemic, which has likely increased technology
12 use among older adults. At our center, we have observed an increase in use of technology
13 among our older adult research participants. From March 2020 to July 2021, use of
14 videoconferencing software among our participants increased ~17%.

15 Despite increases in technology use, there remains considerable skepticism regarding
16 older adults' ability to adapt to new technologies like smartphones and videoconferencing [13]. If
17 these perceptions are correct, then one would expect this digital divide to impact older adults'
18 participation in smartphone-based remote studies. The present study aimed to address these
19 longstanding age-related technology stereotypes by providing quantitative evidence that older
20 adults – even those with little to no technology experience – are willing and capable of
21 participating in intensive technology enabled studies.

22 **Results**

23 Two cohorts of adults were administered a technology familiarity assessment, the first
24 sample was recruited from Prolific (www.prolific.co), and the second sample was older adults
25 from the Charles F. and Joanne Knight Alzheimer Disease Research Center (Knight ADRC)
26 who were enrolled in an ongoing smartphone-based study of cognition and risk of AD.

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Demographics: The Prolific sample included forty younger (aged 18-30), forty-one middle-aged (aged 31-55), and forty older adults (aged 56-76) who met inclusion criteria and were recruited to participate. One older adult failed to respond correctly to one or more attention checks that were embedded in the technology assessment to ensure adequate effort. Given the possibility that they either did not understand the instructions or were not engaged in the task, this older adult was removed before analysis. The Knight ADRC sample included 243 older adults (aged 66 - 93 years old). Seventeen participants were removed from analyses due to a Clinical Dementia Rating™ (CDR™) [14] greater than 0, indicating a clinical diagnosis of dementia. In addition, three participants were removed before analysis due to missing demographic data, and two were removed for failing the attention checks. Altogether, the analyses included 121 younger, middle-aged, and older adults from Prolific and 221 older adults from the Knight ADRC.

Technology Familiarity: First, the relationship between age and recognition of technology-related icons was examined. Seven participants (four from the Knight ADRC 62 to 76 and three from the Knight ADRC 77 + group) were removed before analysis for having an icon knowledge score greater than 3 standard deviations below the mean for their age group. As shown in Figure 1, there was a strong negative relationship between age and technology-related icon knowledge (i.e., percent correct), $r(333) = -0.47$, $C[-0.54, -0.38]$, $p < 0.001^1$. There were no relationships between technology-related icon knowledge and either self-reported gender, race, or education over and above the effect of age, $ps > 0.10$.

¹ Follow-up Bonferroni-adjusted pairwise comparisons indicated that, there were no age group differences across the Prolific samples, $ps > 0.16$. The Knight ADRC 62 to 76 group showed less icon knowledge than all groups (except for the Knight ADRC 77 + group), $ps < 0.04$ and the Knight ADRC 77 + group had lower icon knowledge scores as compared to all groups, $ps < 0.04$. Overall, the Prolific participants showed better icon knowledge than the Knight ADRC participants, $p < 0.001$.

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1 **Figure 1.** Icon recognition scores by age.

2
3 Second, personal smartphone usage was examined. As shown in Table 1, there were no
4 differences across age groups in the percentage of participants who reported owning a
5 smartphone for more than 5 years, $\chi^2(4, N = 342) = 4.68, p = 0.32$ or having a cellular data
6 plan, $\chi^2(4, N = 342) = 2.14, p = 0.71$. However, older participants reported finding their
7 smartphones less user-friendly than younger participants, $F(4, 318) = 15.85, p < 0.001$. Self-
8 reported gender, race, and education were unrelated to these personal smartphone usage
9 variables, $ps > 0.12$.

Table 1. Demographic Data

Age Group	Prolific 18 to 30 N = 40 ¹	Prolific 31 to 55 N = 41 ¹	Prolific 56 + N = 40 ¹	Knight ADRC 62 to 76 N = 113 ¹	Knight ADRC 77 + N = 108 ¹	p-value ²
Age	24.85 (3.95)	38.00 (6.14)	62.64 (5.18)	72.79 (2.76)	81.91 (4.15)	<0.001
Gender						0.044
Female	15 (38.0%)	16 (39.0%)	17 (44.0%)	54 (48.0%)	58 (54.0%)	
Male	22 (55.0%)	25 (61.0%)	22 (56.0%)	59 (52.0%)	50 (46.0%)	
Transgender Female	1 (2.5%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	
Transgender Male	1 (2.5%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	
Gender Non-Conforming	1 (2.5%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	
Race						<0.001
Black or African American	5 (12.0%)	7 (17.0%)	2 (5.0%)	19 (16.8%)	9 (8.3%)	
White	30 (75.0%)	29 (71.0%)	38 (95.0%)	92 (81.4%)	99 (92.0%)	
Other ³	5 (12.0%)	3 (7.3%)	0 (0.0%)	2 (1.8%)	0 (0.0%)	
Prefer Not to Answer	0 (0.0%)	2 (4.9%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	
Education	14.72 (2.21)	16.40 (2.02)	15.72 (2.64)	16.70 (2.08)	16.19 (2.51)	<0.001
APOE4 Status						0.25
Negative				72 (65%)	78 (74%)	
Positive				38 (35%)	28 (26%)	
Years of Smartphone Ownership						0.32
Less than 1 year	0 (0.0%)	3 (7.3%)	1 (2.6%)	5 (4.7%)	11 (11.0%)	
1-3 years	1 (2.5%)	1 (2.4%)	5 (13.0%)	12 (11.0%)	11 (11.0%)	
3-5 years	8 (20.0%)	1 (2.4%)	6 (15.0%)	14 (13.0%)	14 (12.0%)	
More than 5 years	31 (78.0%)	36 (88.0%)	27 (69.0%)	75 (71.0%)	63 (64.0%)	
Has Cellular Data Plan						0.71
Yes	38 (97%)	39 (95.0%)	39 (100.0%)	95 (90.0%)	81 (82.0%)	
No	1 (2.6%)	2 (4.9%)	0 (0.0%)	3 (2.8%)	3 (3.0%)	
Not sure	0 (0.0%)	0 (0.0%)	0 (0.0%)	8 (8.2%)	15 (15.0%)	
Smartphone User Friendliness (1 = Very Easy; 5 = Very Difficult)	1.20 (0.46)	1.27 (0.55)	1.59 (0.68)	1.81 (0.96)	2.25 (1.04)	<0.001

¹ Mean (SD); n (%)² Pearson's Chi-squared test; Omnibus Analysis of Variance³ American Indian, Alaska Native, Native Hawaiian, Pacific Islander, or Asian

1 As shown in Figure 2, there were omnibus age effects in self-reported frequency for all
2 technology tasks assessed, $ps < 0.002$, suggesting a strong relationship between age and
3 frequency of technology use. Interestingly, when modeled concurrently with age, there were no
4 associations between frequency of technology use and self-reported gender, race, or education.

5 Difficulty ratings for performing everyday technology tasks are displayed in Figure 3.
6 Similar to the frequency results, there were omnibus age group differences in difficulty ratings
7 for all technology tasks assessed, $ps < 0.02$, except for “Use a self-checkout lane at a grocery
8 store,” $p = 0.06$, which did not reach significance. There were no differences in participants’ self-
9 reported difficulty as a function of race. However, there were several differences as a function of
10 gender and education, above and beyond the effect of age, that reached the corrected
11 significance threshold. Specifically, females reported “Set up a new modem/router in your
12 home” as being more difficult than males, $p < 0.001$, and for the tasks “Search for information
13 using a Web browser,” “Add an attachment to an email message,” “Download and install a new
14 software program on a home computer,” “Download and install a new app on a personal
15 smartphone,” “Purchase items online,” and “Log in to an online account using a public computer
16 (no passwords saved),” more years of education was associated with decreased difficulty
17 ratings, $ps < 0.002$.

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Figure 2. Participants' reported frequency performing technology-based tasks. Error bars represent 95% confidence interval.

1 **Figure 3.** Participants' reported difficulty performing technology-based tasks. Error bars represent 95% confidence interval.

2

3

1 *Ambulatory Research in Cognition (ARC) Study Metrics:* The focus of the present study was to
2 investigate whether older adults are willing and able to participate in remote assessment studies
3 on their smartphones, as such we report enrollment and refusal rates, the reasons participants
4 chose not to participate, and adherence rates for an intensive smartphone-based remote
5 cognitive assessment study at the Knight ADRC called Ambulatory Research in Cognition
6 (ARC). The ARC study uses a measurement “burst” design that assesses cognition repeatedly
7 with a maximum of 28, 3-minute testing sessions spread over a week.

8 As shown in Figure 4, 445 individuals in the Knight ADRC cohort were approached with
9 the opportunity to participate in the ARC study. Of the individuals approached, 86.5% consented
10 to participate. For the 13.5% who were not interested in participating, we examined whether
11 these individuals chose not to participate because they were hesitant to partake in a study
12 requiring smartphone use or if they chose not to participate due to non-technology-related
13 reasons (e.g., time constraints, general lack of interest in participation, etc.). Of the 60
14 individuals who elected not to participate in the study, 33 mentioned technology (specifically,
15 smartphone) hesitancy. The remaining 27 indicated non-technology-related reasons (see Figure
16 4 for a more detailed breakdown).

1 **Figure 4.** ARC study enrollment rates.

We were also interested in whether demographic characteristics such as self-reported gender, race, or education may have been a factor in participation. As shown in Table 2, the demographics of the individuals who declined to participate in ARC closely resembled those who chose to enroll (see Table 1). This suggests that neither self-reported gender, race, nor education appeared to influence whether or not an individual decided to participate in ARC.

Table 2. Individuals who Declined ARC Participation	
Characteristic	N = 60[†]
Age	81.34 (6.43)
Gender	
Female	34.0 (57.6%)
Male	25.0 (42.4%)
Unknown	1
Race	
Black or African American	5.0 (8.5%)
White	54.0 (91.5%)
Unknown	1
Education	15.98 (2.36)
APOE4 Status	
Negative	40.0 (67.8%)
Positive	19.0 (32.2%)
Unknown	1
[†] Mean (SD); n (%)	

Next, the frequency of specific words mentioned in participants' refusal reasons (recorded manually at the time of consent) is shown in Figure 5. Consistent with the refusal reason breakdown reported above, the words "phone," "smartphone," and "technology" were amongst the most common words used in the explanations participants gave for not wanting to participate – indicating that technology hesitancy was indeed a deterrent for the small proportion of older adults' who were approached but chose not to participate in ARC.

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Figure 5. Words used by individuals who declined to participate in the mobile assessment study.

As shown in Figure 6, not only were older adults quite willing (86.5% enrollment rate) to participate in the mobile assessment study, they also did exceedingly well at completing the 28 repeated testing sessions. The median adherence rate, defined as the percentage of sessions that participants completed, was 85.71%, with adherence rates ranging from 11% to 100%. The modal adherence rate was 96.43% with the distribution of adherence rates being highly left-skewed (see Figure 6).

Figure 6. Histogram of adherence rates for participants enrolled in the mobile assessment study. Dashed (red) line indicates the median adherence.

Finally, we examined whether any relationships existed between adherence and participant demographics or technology familiarity. Specifically, we tested whether gender, race, education, or technology familiarity/knowledge influenced ARC adherence. Neither technology

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task frequency ratings, $ps > 0.10$, nor perceived technology task difficulty ratings, $ps > 0.21$, were associated with adherence. Furthermore, adherence did not differ as a function of self-reported gender, $p = 0.27$, race, $p = 0.89$, years of education, $p = 0.20$, nor technology icon recognition accuracy, $p = 0.10$.

Discussion

We investigated age differences in technology knowledge, familiarity, and usage and examined older adults' willingness to enroll and to adhere to an intensive smartphone-based remote cognitive assessment. First, we compared younger, middle-aged, and older adults on technology familiarity, knowledge, perceived difficulty, and usage habits using a novel technology familiarity assessment. Second, we examined participation in the smartphone-based ARC study focusing on enrollment rates, refusal factors, and adherence rates. Finally, we investigated whether technology familiarity and interactions with demographic characteristics, including gender, race, and education, influenced participation in the smartphone study.

Regarding age differences in technology familiarity, we found robust, negative associations between age and technology familiarity. As expected, older age was associated with less technology knowledge (icon recognition accuracy), lower smartphone user-friendliness ratings, less frequency of technology use, and more difficulty performing everyday technology tasks. However, despite these apparent age differences in technology knowledge and familiarity, the majority (86.5%) of older adults approached about participating in the intensive smartphone-based study of cognition at the Knight ADRC elected to participate and showed exceedingly good adherence (85.71% of sessions completed). Of the individuals who declined to participate, ~50% cited technology hesitancy as the reason they did not want to participate in the study. However, among those enrolled, neither technology familiarity, knowledge, perceived difficulty, nor self-identified gender, race, or education was associated with participants' adherence. Ultimately, we argue that the notion that older adults are uninterested and/or unable to participate in smartphone-based remote assessment studies is based on biases such as

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1 ageism, not empirical data. Further, the present findings do not support the claim that self-
2 reported gender, race, or level of education make an individual more or less willing or able to
3 participate in remote smartphone-based studies.

4 In addition to these findings, several important broader implications can be drawn from
5 this investigation. The high enrollment and adherence rates for the ongoing ARC smartphone
6 study provide evidence that researchers can ameliorate accessibility limitations and technology
7 hesitancy among older adults with cost-effective strategies that encourage and facilitate
8 participation. For example, as done for several individuals enrolled in ARC (see Figure 4),
9 investigators can provide participants who cannot afford, or who do not otherwise have access
10 to, a study-eligible smartphone with a readily affordable model that meets requirements for
11 study participation. Additionally, our ARC study team found that informing participants that
12 onboarding (i.e., app download, set up, walk-through, etc.) is done alongside study personnel
13 (either in person or via videoconference) reduced hesitancy and concerns about overcoming
14 technology-related challenges unassisted. Moving forward, although further research is certainly
15 warranted, smartphone-based remote assessments may offer a more practical and logistically
16 plausible solution for large-scale studies. Allowing individuals to participate in research studies
17 and health monitoring assessments on their own schedules and in their natural environments
18 may increase engagement, sample size, and diversity, and make participation more accessible
19 for many who may otherwise be unable or unwilling to come to the lab or clinic for in-person
20 studies.

21 The findings of this study should be considered in light of broader considerations and
22 limitations which may be addressed in future studies. First, as mentioned in the introduction, the
23 present study's focus was to examine the claim that older adults' lack of technology familiarity
24 may inhibit their willingness/ability to participate in smartphone-based studies. ARC test
25 performance as a function of age and CDR status, reliability, and correspondence with in-lab
26 measures will be explored in future studies. Second, it is important to note that because we

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used an online recruitment platform (i.e., Prolific), the older adults recruited from Prolific may be more technologically savvy than older adults in the general population (see Footnote 1). We included this participant sample because they provide an important comparison group comprised of more technologically familiar older adults who frequently participate in online studies, as opposed to the Knight ADRC participants that were recruited through a more traditional clinical setting. The technology familiarity of the general population of older adults most likely lies somewhere in between these two groups. Finally, the Knight ADRC participants consist of highly educated and primarily White older adults motivated to engage in extensive imaging and fluid biomarker studies. However, with these important limitations considered, it is notable that the participant sample demonstrated expected age-related trends regarding technology adoption and demonstrably less technology familiarity, yet were clearly capable of participating in an intensive smartphone-based cognitive assessment regardless of gender, race, or education level.

Our findings suggest that the majority of older adults who were approached elected to participate in the ARC study and showed exceptional adherence despite the influence of age on technology familiarity. Furthermore, neither technology familiarity, knowledge, perceived difficulty, nor self-identified gender, race, or education were associated with participants' adherence. Ultimately, these results suggest that lingering concerns related to the "digital divide" between younger and older adults may reflect underlying biases and ageist attitudes. Videoconference, online, and smartphone-based remote assessments may offer more accessible, inclusive, and logistically plausible solutions for large-scale clinical studies with older adults.

Methods

Participants: Two samples of participants were recruited for the purposes of this study: The first sample included younger, middle-aged, and older adults recruited and tested online using Prolific (prolific.co) and compensated for participation. Inclusion criteria for the Prolific studies

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1 included native English-speaking ability and United States as current country of residence. The
2 second sample included community volunteers enrolled in longitudinal studies of aging and
3 dementia at the Knight ADRC. All participants consented to participate in the study, and the
4 Institutional Review Board approved all procedures at Washington University in St. Louis.

5 *Technology Familiarity:* An assessment to measure age differences in technology acceptance,
6 knowledge, familiarity, perceived difficulty, and usage was developed *de novo* for the purposes
7 of this study. The theoretical foundation for this study used constructs from the Technology
8 Acceptance Model [15, 16]. Assessment constructs were focused on participant smartphone
9 use behavior and ease of use. The assessment was administered using Qualtrics software and
10 consisted of several sections that combined objective measurements and self-reported ratings.
11 The objective items tested familiarity with multiple-choice questions regarding smartphone and
12 social media icons. Participants were shown 17 icons and asked to select what the icon
13 represents from one of three options (the icons and survey can be viewed here:
14 <https://tinyurl.com/erh7s7j9>). There were 11 smartphone-related icons (power, WiFi, location,
15 delete, search, refresh, Bluetooth, airplane mode, settings, close, and share) and 7 software
16 application-related icons (Instagram, Cash, Netflix, Facebook, Zoom, and Spotify) that
17 participants were asked to identify in this section. Next, participants were asked if they owned a
18 smartphone (defined for participants as “a mobile phone that has a touchscreen interface,
19 internet access, and capable of running downloaded applications”). If they responded yes, they
20 were asked a series of questions related to their smartphone usage. These questions included
21 “How long have you owned a smartphone?”, “Does your phone plan include cellular data (i.e.,
22 you can access the Internet on the phone without needing a WiFi connection)?” and “How user-
23 friendly do you find your smartphone? Think about things such as how intuitive the functions are
24 and how easy it is to find what you are looking for.” Response options for these questions can
25 be viewed in Table 1.

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Next, participants were asked to rate the frequency with which they perform certain smartphone activities on a 6-point scale ranging from “Never” to “All the time.” Participants were asked to rate how often they performed the following 13 activities: “Make phone calls,” “Browse the web/Search for information,” “Use apps (for any purpose),” “Listen to music/podcasts/audiobooks/radio,” “Watch videos,” “Play games,” “Check the news,” “Take pictures,” “Record video,” “Check email,” “Text,” “Check social media,” and “Get directions/Use GPS.”

Finally, participants were asked to rate how easy or difficult it would be for them to perform 13 specific technology-related tasks using a 5-point scale ranging from “Extremely easy” to “Extremely difficult.” Participants were asked to assume that they were doing the task themselves with their current technology knowledge. Tasks included: “Touch-type on a keyboard (using both hands, not looking at keys),” “Search for information using a Web browser,” “Add an attachment to an email message,” “Set up a new modem/router in your home,” “Change your home WiFi password,” “Log in to a virtual private network (VPN),” “Download and install a new software program on a home computer,” “Download and install a new app on a personal smartphone,” “Use a self-checkout lane at a grocery store,” “Purchase items online,” “Log in to an online account using a public computer (no passwords saved),” “Change the privacy settings on a social media profile,” and “Set up automatic bill payments online.”

Several attention checks were included throughout the survey to ensure that participants read the instructions carefully and responded thoughtfully to the prompts [17]. These included one in the technology task frequency rating section, which read “This is an attention check - please select 'Never,’” one in the difficulty rating section, which read “This is an attention check - please select 'Extremely difficult,’” and a final question at the end which asked participants to indicate how many attention checks they noticed throughout the study (0, 1, 2, or 3 with 2 being the correct answer). Participants were excluded if they failed to respond with the indicated

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1 answer to one of the two attention checks embedded in the rating sections (but not if they
2 incorrectly remembered how many attention checks there were throughout the survey).

3 *Ambulatory Research in Cognition (ARC) Study:* In the present study, we focus on the
4 enrollment rate, reasons participants elected not to participate, and study adherence rates in an
5 ongoing smartphone-based study of cognition in normal aging and AD. The mobile assessment
6 study from which the relevant metrics were drawn is called Ambulatory Research in Cognition
7 (ARC) which uses a measurement “burst” design based on principles from ecological
8 momentary assessment. Specifically, participants performed frequent but brief tests of episodic
9 memory, attentional control, and processing speed administered at four pseudo-random times
10 per day over seven consecutive days. Participants received notifications before each three-to-
11 five-minute assessment. Each session consisted of the three cognitive tasks (which tapped into
12 the domains described above) and surveys regarding mood, sleep, fatigue level, and
13 assessment context. Participant adherence is operationalized as the number of sessions
14 completed throughout the seven-day visit period divided by 28 total assessment opportunities.
15 The measures included in ARC have shown superior reliability and are correlated with age, in-
16 clinic cognitive measures, and AD biomarkers [18], and have demonstrated sensitivity to time-
17 of-day effects [19]. Cross-sectional results of the cognitive measures, longitudinal performance,
18 and relationships with AD biomarkers were not the focus of this report and will be disseminated
19 elsewhere.

20 *Statistical Analyses:* We assessed participants' technology knowledge, familiarity, and usage
21 habits by comparing their responses to the survey questions using two-tailed *t*-tests, Pearson's
22 correlations, and between-subjects analysis of variance (ANOVAs). We also adjusted for
23 multiple comparisons using Bonferroni adjusted alphas. Graphical representations and
24 frequencies were used to describe the following: willingness to participate in ARC, individuals
25 study refusal reasons, and adherence rates (i.e., adherence over seven consecutive days of
26 cognitive assessments). Additionally, we examined the relationships between adherence and

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1 participant demographics and technology familiarity to directly test whether differences in race,
2 education, gender, or technology familiarity/knowledge influence an individuals' ability to
3 participate in a smartphone-based study.

4 **Data Availability**

5 The corresponding author (J.H.) can provide the dataset and document on analyses performed
6 upon reasonable request.

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12 **Author Contributions**

13 All authors discussed the results and contributed to the final manuscript.

14 **Competing Interests**

15 The authors declare no competing financial interest.

16 **Word Count:** 3671/5000

References

1. Int. Telecommun. Union. 2014. The World in 2014: ICT Facts and Figures. Geneva, Switz.: Int. Telecommun. Union
2. Wilson, R.E., Gosling, S.D., & Graham, L.T. (2012). A review of Facebook research in the social sciences. *Perspect. Psychol. Sci.* 7:203–20
3. Musch, J., & Reips, U. D. (2000). A brief history of Web experimenting. In *Psychological experiments on the Internet* (pp. 61-87). Academic Press.
4. Gosling, S.D., Vazire, S., Srivastava, S., John, O.P. (2004). Should we trust Web-based studies? A comparative analysis of six preconceptions about Internet questionnaires. *Am. Psychol.* 59:93–104
5. Crump, M.J.C., McDonnell, J.V., & Gureckis, T.M. (2013). Evaluating Amazon's Mechanical Turk as a tool for experimental behavioral research. *PLOS ONE* 8:e57410
6. Henrich, J., Heine, S.J., Norenzayan, A. (2010). The weirdest people in the world? *Behav. Brain Sci.* 33:61–135
7. Gosling, S. D., & Mason, W. (2015). Internet research in psychology. *Annual Review of Psychology*, 66(1), 877-902. <https://doi.org/10.1146/annurev-psych-010814-015321>
8. Weinberg, J.D., Freese, J., McElhattan, D. (2014). Comparing data characteristics and results of an online factorial survey between a population-based and a crowdsourcing-recruited sample. *Sociol. Sci.* 1:292–310
9. Passell, E., Strong, R. W., Rutter, L. A., Kim, H., Scheuer, L., Martini, P., ... & Germine, L. (2021). Cognitive test scores vary with choice of personal digital device. *Behavior Research Methods*, 1-14.
10. Merriam-Webster. (n.d.). Digital divide. In *Merriam-Webster.com dictionary*. Retrieved September 20, 2021, from <https://www.merriam-webster.com/dictionary/digital%20divide>
11. McDonough, C. C. (2016). The effect of ageism on the digital divide among older adults. *Journal of Gerontology and Geriatric Medicine*, 2(8), 1-7.

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12. "Record shares of Americans now own smartphones, have home broadband." Pew Research Center, Washington, D.C. (2017) <https://www.pewresearch.org/fact-tank/2017/01/12/evolution-of-technology/>
13. "The Internet and the Pandemic." Pew Research Center, Washington, D.C. (2021) <https://www.pewresearch.org/internet/2021/09/01/the-internet-and-the-pandemic/>
14. Morris, J. C. (1993). The clinical dementia rating (CDR): current version and scoring rules. *Neurology*, 41, 1588-1592.
15. Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS quarterly*, 319-340.
16. Portz, J. D., Bayliss, E. A., Bull, S., Boxer, R. S., Bekelman, D. B., Gleason, K., & Czaja, S. (2019). Using the technology acceptance model to explore user experience, intent to use, and use behavior of a patient portal among older adults with multiple chronic conditions: descriptive qualitative study. *Journal of medical Internet research*, 21(4), e11604.
17. Oppenheimer, D. M., Meyvis, T., & Davidenko, N. (2009). Instructional manipulation checks: Detecting satisficing to increase statistical power. *Journal of experimental social psychology*, 45(4), 867-872.
18. Hassenstab, J., Aschenbrenner, A. J., Balota, D. A., McDade, E., Lim, Y. Y., Fagan, A. M., ... & Dominantly Inherited Alzheimer Network. (2020). Remote cognitive assessment approaches in the Dominantly Inherited Alzheimer Network (DIAN) Using digital technology to drive clinical innovation in brain-behavior relationships: A new era in neuropsychology. *Alzheimer's & Dementia*, 16, e038144.
19. Wilks, H. M., Aschenbrenner, A. J., Gordon, B. A., Balota, D. A., Fagan, A. M., Balls-Berry, J. E., ... & Hassenstab, J. (2021, July). Sharper in the Morning: Cognitive Sundowning Revealed with High-Frequency Smartphone Testing. In *2021 Alzheimer's Association International Conference*. ALZ.