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The Smartphone in the Memory Clinic: A Study of Patient and Care Partner's Utilisation Habits

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Abstract

Smartphones have shown potential as cognitive aids for adults with cognitive impairments. However, little is known about how patients and their care partners utilise smartphones in their day-to-day lives. In the current study, we collected self-reported smartphone utilisation data from patients referred for neuropsychological evaluations ($N=53$), from their care partners ($N=44$), and from an Amazon Mechanical Turk control sample ($N=204$). Patient participants were less likely to own a smartphone than adults in the control group, with increasing age associated with less utilisation of smartphone features in all groups. Of the patients who owned smartphones, they reported spontaneously utilising their device's cognitive aide features (e.g., reminders and calendars) on only a monthly-to-weekly basis; by comparison, the patients reported utilising the social/general features on the smartphone (e.g., email and internet) on a weekly-to-daily basis. Within the patient group, individuals referred for geriatric cognitive disorder evaluations were less likely to own and use smartphones than individuals referred for other reasons. Interestingly, care partners reported using their smartphones more frequently than control group adults, with 55% of care partners endorsing utilising their smartphone in caring for the patient. Building upon existing smartphone use habits to increase the use of cognitive aide features may be a feasible intervention for some patients, and including care partners in such interventions is encouraged.

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Disclosure of Interest

Microsoft Research, Inc., donated phones for a subsequent intervention trial of smartphones in older adults, which was not the focus of this study and occurred after all data were collected. Otherwise, the authors have no conflicts of interest to report.

Keywords

Technology; Smartphone; Memory aide; Dementia; Aging

Introduction

Smartphones in Older Adults

One of the most dramatic technological changes in the last decade has been the proliferation of smartphones. Far from being limited to children and young adults, older adults have also been impacted by the smartphone revolution. Only 10% of older adults were using smartphones in 2011, but this number climbed to 27% in 2014, and to 42% in 2016 (Anderson, 2015; Pew Research Center, 2017; Smith, 2015). In older adults, smartphone use has been associated with both chronological age and educational attainment. For example, 59% of 65–69 year olds own smartphones, but only 17% of 80+ year olds own smartphones. Furthermore, 65% of adults with a college degree utilise smartphones versus 27% with a high school diploma or less. The latter finding is partially explained by economic differences considering that new smartphones may cost \$700 USD or more (Anderson & Perrin, 2017). In general though, these survey data mirror our experience in a memory clinic, where we frequently see patients and their care partners reference their smartphones as sources of information, entertainment, or, perhaps less commonly, as cognitive aids.

Smartphones as Potential Cognitive Aids

While photo, video, and news applications can help improve social interactions and engagement, smartphones also hold potential from a cognitive rehabilitation standpoint (Armstrong, Nugent, Moore, & Finlay, 2010). Most smartphone devices come with calendars and task management systems that can deliver cues and reminders in multiple sensory modalities (audio, visual, vibration). Such reminder systems have the potential to support prospective memory, or memory for completing future tasks (El Haj, Gallouj, & Antoine, 2017; Ferguson, Friedland, & Woodberry, 2015; Scullin, McDaniel, & Shelton, 2013). In addition to providing reminders at a given time (e.g., appointment at 11am), smartphones can utilise global positioning system (GPS) information to provide reminders at the appropriate location with geotagged/geofenced features (e.g., reminder of grocery list when the device registers the individual is near a grocery store). Finally, for patients with motor or visual limitations, smartphones can support text-to-speech dictation and spoken control. For example, the “always on” voice assistants (e.g., Apple’s Siri, Microsoft’s Cortana, Google Now), can passively listen for keywords to allow for real time interaction with various features of the device. Though technology has long held promise as a cognitive aide (Hersh & Treadgold, 1994; Inglis et al., 2004), contemporary smartphones have further advantages in terms of small size, improved battery life, and commonality of use (thus reducing social stigma associated with their use).

Unanswered Questions on Smartphone Use in Older Clinical Samples

An extensive literature on electronic memory aids (PDAs, voice recorders, pagers) suggests that patients with cognitive impairments can train to use such devices (Rispoli, Machalicek,

& Lang, 2014). Smartphones are arguably more complex devices than PDAs, pagers, and voice recorders, and therefore, researchers are beginning to assess the feasibility and acceptability of training patients to use smartphone cognitive aids. When middle-aged (average age of 41.5(SD= 9.5) patients with moderate-to-severe memory problems from traumatic brain injury, stroke, or tumours were trained to use smartphone reminder systems, they viewed the reminder system favorably (Evald, 2015), continued to use the smartphones up to 19 months after the intervention (Svoboda et al., 2015), and they self-reported improved prospective memory performance (Ferguson, Friedland, & Woodberry, 2015). Despite promising results, these studies have been conducted in middle-aged adults, leaving a gap in our knowledge regarding whether smartphone cognitive aids can be used in older adults (for extensive review and discussion of existing work, see Armstrong, Nugent, Moore, & Finlay, 2010, and de Joode et al., 2010). To begin to fill the knowledge gap on how smartphones are used in older clinical populations, the current work focuses on understanding how, and to what extent, individuals referred for evaluations and their care partners spontaneously employ smartphone devices.

With regards to smartphone utilisation in older patients, there are no published reports of how those who have, or are at risk for, cognitive disorders (hereafter, “patients”) spontaneously employ smartphone devices. For example, though we suspect that patients commonly use smartphones for social functions such as phone calls and emailing, it is unknown whether older adult patients in particular spontaneously employ cognitive aide features such as calendars, alarms, and voice-activated reminders. Understanding how older adult patients spontaneously use their smartphones is important because spontaneous use can be predictive of how effective an aide will be for cognitive rehabilitation (Sohlberg & Mateer, 2001). Conversely, limited use can signal that an aide is not yet recognized or understood by the population that might derive the most benefit. Furthermore, if demographic features are associated with smartphone usage, then that would inform which populations could be targeted for intervention studies.

A related question is how the presence of cognitive or other disorders that might prompt a neuropsychological evaluation impacts smartphone utilisation. In typical clinical practice with older adults, three types of individuals are seen: a) adults with subjective cognitive complaints but no cognitive impairments beyond the normal age-related decline, b) adults with subjective cognitive complaints who have a psychiatric or other medical condition that influences cognition, and c) adults who have a neurological problem impacting cognition. We elaborate on each group in the following section, but the take-home message is that because each group has some cognitive change (due to normal aging or disease), they all have the potential to benefit from utilising cognitive aids.

With normal aging, changes in cognitive skills can impact daily technology use. For example, older age was cross-sectionally associated with less frequent utilisation of daily technologies (Roupa et al., 2010). Furthermore, in the clinical setting, recent evidence showed that cognitively normal older adults who have subjective cognitive complaints may be at the earliest identifiable stages of neurodegenerative processes. In two longitudinal studies, 30% of individuals with normal cognitive screens but subjective cognitive complaints developed mild cognitive impairment within 7 years (Chen et al, 2017; Rabin,

Smart & Amariglio, et al 2017); that 30% conversion rate was substantially higher than the 5% conversion rate in cognitively healthy adults who were not referred for screening. Thus, even the population of individuals who do not demonstrate clinical cognitive impairment could benefit from understanding smartphone use to help with normal age-related changes and to build compensatory habits during a phase in which the earliest stages of neurodegeneration may be occurring.

Patients with cognitive complaints due to comorbid psychiatric or other medical conditions may similarly benefit from cognitive aids (Koenig, Bhalla, & Butters, 2014). Such patients show altered use of smartphones, with negative mood phases associated with decreased frequency of use (e.g., Faurholt-Jepsen et al., 2015). Given the demands on care for those with medical illnesses (i.e., timed medication administration, recurrent visits to the doctor), smartphone training could serve as a useful adaptive strategy for reducing the cognitive burden of care.

For patients with neurological disorders, the presence of even mild cognitive impairment may interfere with the ability of individuals to use, understand, or respond to changes in day-to-day technologies (Malinowsky et al., 2010; Rosenberg & Nyberg, 2014). In sum, most adults who are referred for neuropsychological evaluation could conceivably benefit from cognitive aids, and it is therefore important to understand to what extent these clinical populations are spontaneously using the cognitive aids on their smartphones.

A final group to consider are the care partners of patients. It is an unanswered question whether, and how, smartphones are utilised by care partners to support their caregiving role. Caregiving for older individuals with cognitive or psychiatric disorders is associated with a host of psychological, biological, and economic impacts (Astrom & Lu, 2009). For example, the care partner role is associated with increased stress in part because of an increasing demand on cognitive processing: A care partner may have to remember the patients' medications, appointments, and other prospective memory tasks/chores in addition to their own. Furthermore, when spouses assume the role of care partner in later life, they may also be challenged by their own age- or health-related cognitive decline, further increasing the need for compensatory systems. Thus, care partners may stand to benefit the most from smartphone cognitive aids if such aids reduce caregiver burden and improve patient-centered outcomes. Again, though, there is no empirical work to determine to what extent care partners are spontaneously utilising their smartphone devices (cognitive aids, social features) to aide in their day-to-day responsibilities.

The Current Study

To better understand how patients referred for neuropsychological evaluations and their care partners utilise smartphones, we administered a modified version of the Media and Technology Usage and Attitudes Scale – Smartphone Subscale (MTU-SS) (Rosen et al., 2013) to a mixed sample of patients and care partners at a large neuropsychology clinic. We contrasted their reported use of smartphone features with that of a control group recruited via Amazon Mechanical Turk's (AMT) online survey platform. We sought to address three aims. First, we investigated how demographic factors (age, education, gender) related to smartphone ownership and use in our clinical and control samples. Second, we examined

how patients, care partners, and control adults spontaneously utilised the different features of their smartphone (e.g., cognitive aide features versus social/general features). Third, because there are virtually no data on spontaneous use of technology in geriatric cognitive disorder or care partner populations, we explored smartphone usage patterns in these groups in particular. The ultimate goal of collecting the smartphone utilisation data is to help inform the feasibility and development of smartphone interventions in targeted populations.

Methods

Participants

Participants were a convenience sample of 100 individuals (patients or care partners) presenting for neuropsychological evaluation at Baylor Scott & White clinics in Temple and Round Rock (Texas, United States). Of the completed surveys, one was excluded because the written results were incomprehensible, and two other surveys were excluded because it was unclear whether the patient or care partner completed the survey.

We recruited an additional normative control group via online respondents from Amazon's Mechanical Turk (AMT) service. AMT respondents agree to complete various online tasks for payment and this survey method is commonly employed in social science research with results corresponding very well to in-laboratory survey assessments (see Paolacci & Chandler, 2014, for a review). Survey data from AMT has been demonstrated to provide useful data for examining clinically related questions, for example, because of online participants' honesty/willingness to endorse symptoms, strong internal reliability, and adequate test-retest reliability (Shapiro, Chandler, & Mueller 2013; Arditte et al, 2016). Furthermore, AMT samples have been found to be relatively more diverse than traditional sources of information, such as American undergraduate respondents (Buhurmeister et al, 2011)

For the current study, we utilised an AMT recruitment approach initially similar to our previous work (Fergus & Scullin, 2017). In brief, 204 adult AMT respondents were paid \$1 USD for completion of our modified MTU-SS and basic demographic information. Recruitment was limited to AMT users located within the United States and over the age of 18. Informed consent and questionnaires were completed using a secure online survey program.

Privacy and Confidentiality

In the clinical sample, individuals were assured that participation was voluntary and that their survey responses would not be linked with the outcome of the neuropsychological evaluation. We selected this procedure for data collection to protect confidentiality and increase participation. Patients and care partners could independently complete the questionnaire even if the other individual did not participate and even if they did not own a mobile phone (which they indicated on the survey). With the above privacy protections in place, the Baylor Scott & White institutional review board (IRB) reviewed the questionnaire packet and protocol and determined it was exempt from further IRB oversight. In the AMT sample, no personally identifiable information was collected and individuals completed an

online informed consent. The AMT study procedures were reviewed and approved by the Baylor University IRB.

Instruments

Participants in all samples provided demographic data, which also clarified whether the individual owned a mobile phone of any kind and whether it was a smartphone. On the survey, we used the following definition: “*A smartphone is a cellular phone that has many of the same functions as a computer, including, email capability, Internet access, and a touchscreen interface.*” We also included the following question to assess care partner usage of the phone “*If you are a family, friend, or caregiver, do you use your phone to help with the patient (i.e. keep track of their appointments or medications for them, etc.).*”

To assess smartphone usage, we utilised a modified version of the MTU-SS (Rosen et al., 2013). The MTU-SS was designed to capture self-reported frequency of use for nine features of smartphone devices (e.g., email, news, searching for information). We utilised the verbatim items from Rosen et al.’s questionnaire, beginning with the stem “How often do you ...”. We also added five questions that used the same stem and rating scale, but with the goal of assessing usage of cognitive aide features: to-do lists, alarms, reminders, calendars, and voice-activated features. We retained the original response scale, with individuals rating their use of each smartphone feature on a 1–10 scale. Consistent with the original survey design, the numerical responses were anchored with monthly, weekly, daily, and hourly frequency markers (1 = never, 2 = once a month, 3 = several times a month, 4 = Once a week, 5 = Several times a week, 6 = Once a day, 7 = Several times a day, 8 = Once an hour, 9 = several times an hour, and 10 = all the time).

Procedure

Clinical participants completed the questionnaire while waiting for appointments or in between other testing procedures using a paper and pencil format. Individuals who were judged by the treating providers to not be able to understand or meaningfully communicate their responses were not approached for participation. The number of individuals who refused the survey was not tracked. Data collection took place primarily over a 5-month period in the summer and early fall of 2016.

For the AMT sample, participants could complete the study from any computer in the United States with Internet access. The study was posted with other potential HITs (“Human Intelligence Tasks”) on AMT using a single batch, which restricts AMT respondents with the same worker identification number from taking the study twice. Data were collected in August 2017.

Analysis Plan

To address Aim 1—whether demographic factors related to smartphone use—we conducted t-tests (for age differences between owners and non-owners) and non-parametric Spearman’s rho correlations (e.g., correlating reported smartphone usage with ordinal-level variables such as education that was grouped by high school or less, some college to college degree, and graduate work) and chi square tests for evaluating demographic differences between

groups. We suspected based on the literature review above that age would differ across the AMT and patient/care partner groups. Therefore, we selected an older individual group from the broader AMT sample to best allow comparisons in smartphone use (Aim 2 analyses).

To address Aim 2—determine relative use of cognitive aide features and social/general features—we created two theoretically-motivated subscales. The cognitive aide subscale was composed of five items with potential compensatory features: to-do lists that can help organize and plan daily activities, calendars that can remind the user of important dates, reminder functions and alarms that can aide with prospective memory tasks, GPS directions that can help with navigational difficulties (item utilised from the original MTU-SS), and voice-activated features that can access the aforementioned features. The remaining MTU-SS items were averaged to create a social/general use subscale. We evaluated the psychometric properties of these subscales using inter-item correlations and Cronbach's alpha to ensure adequate internal consistency. To determine if patients and care partners utilised their phones differently for social/general use or cognitive aide purposes, we first performed a MANOVA with group (Patient, Care Partner, older AMT) as the independent variable and the two usage scales as dependent variables (cognitive aide and social/general use). Because of our particular interest in group level results, we utilised post-hoc ANOVAs to compare the groups on cognitive aide and social/general use and paired *t* test comparisons (including Cohen's *d* effect size estimates) to compare within group differences in specific phone feature use.

To address Aim 3—explore how specific subgroups use the smartphone use—we used chi squares and t-tests to contrast specific subgroups on demographic variables and smartphone use. One analysis compared patients referred for cognitive disorders versus patients referred for other reasons (i.e., other specific neurological or psychiatric diagnoses). A second analysis compared care partners who reported to using their smartphones to help with their caregiving role.

Results

Comparison of Smartphone Owners versus Non-Owners

Mobile phone ownership differed significantly between groups (Aim 1). Of the patient participants ($N = 53$), 90.6% reported owning a mobile phone and 75.4% described their phone as being a smartphone. In contrast, 100% of care partners ($N = 44$) reported owning a mobile phone and 90.9% reported that this device was a smartphone. Of the AMT respondents ($N = 204$), 98.5% reported owning a cellular phone and 96% endorsed owning a smartphone. The group difference in smartphone ownership was statistically significant ($\chi^2(2, N = 301) = 23.5, p < .01$; Cramer's $V = .28$).

In the patient group, non-smartphone owners ($N = 13$; 92.3% of the non-smartphone owning patients) were typically individuals who were referred for evaluation of known or suspected geriatric cognitive disorders. Furthermore, patient smartphone owners were younger ($M = 61.3$ years) than patient non-smartphone owners ($M = 75.9$ years), $t(50) = 3.60, p < .001$. This age difference was also observed in the non-patient groups (AMT + Care Partners): Individuals who owned smartphones were younger (59.5 versus 38.5 years; $t(238) = 4.90, p$

$< .001$, $d=1.51$). In both patient and non-patient groups, smartphone ownership did not relate gender ($\chi^2(1) = 1.25$, $p = .26$; $\chi^2(1) = .52$, $p = .77$) or education ($\chi^2(2) = 4.86$, $p = .18$; $\chi^2(2) = .81$, $p = .37$). For all subsequent analyses on how participants use specific features of their smartphones, we omit the non-smartphone owners.

Descriptive Data for the Smartphone Owning Samples

To further address Aim 1, demographic data for the smartphone-owning patients, care partners, and AMT adult participants are presented in Table 1. Overall, the patient, care partner, and AMT groups differed in age ($F(2, 265) = 94.99$, $p < .01$, $\eta^2 = .42$), with Sidak post-hoc tests revealing significant differences between all groups in the expected direction (patient age > care partner age > AMT age). The groups did not differ significantly in education level ($\chi^2(6, N=276) = 10.03$, $p = .12$), gender ($\chi^2(6, N= 276) 5.80$, $p = .06$), or ethnicity ($\chi^2(8, N = 276) = 8.57$, $p = .38$).

Because the AMT sample was significantly younger than our smartphone-owning patient and care partner samples, we selected the 40 oldest adults from the AMT sample who owned smartphones as a control group for the remaining analyses (henceforth referred to as the Older AMT group; see Table 1). Overall, the patient, care partner, and Older AMT groups still differed in age albeit with a small effect size ($F(2, 109) = 4.54$, $p = .01$, $\eta^2 = .07$) and Sidak post hoc tests revealed that the Older AMT sample was equivalent in age to the care partner group ($p = .9$). There were no significant differences in educational attainment or gender across the three groups (p values for all χ^2 tests $> .15$).

Cognitive Aide and Social/General Use Subscale Psychometrics & Relation to Demographics

To examine how participants reported to using their smartphone (Aim 2), we created cognitive aide and social/general use subscales. Across the patient, care partner, and AMT samples, inter-item reliability values for the smartphone subscales were strong for both the cognitive aide scale ($\alpha = .84$ average inter item correlation = $.48$ $p < .05$) and the social/general use scale ($\alpha = .89$, average inter item correlation = $.51$, $p < .05$). As such, this grouping of items was considered an adequate approach for further analysis.

Spearman rho correlations between the smartphone use subscales and demographics variables (age, ordinal-level educational variable) are presented in Table 2. Age was negatively related to smartphone use for both cognitive aide and social/general use purposes across groups. In contrast, higher education had only weak relationships with smartphone use in the patient and AMT samples. There were no gender differences on social/general and cognitive aide use ($p > .3$ for all comparisons), except for in the AMT sample in which men reported to using cognitive aide features marginally more frequently than women ($t(194) = -2.02$, $p = .05$, Cohen's $d = .29$).

Comparison of Cognitive Aide and Social/General Use Items Within and Between Groups

Our second aim was to determine the relative use of smartphone cognitive and social/general use features. The descriptive data for both subscales, as well as each individual MTU-SS item, are presented in Table 3. Email and Apps were used more frequently, whereas video

streaming and voice interaction were used least frequently. Overall, paired sample t-tests demonstrated that participants reported using the cognitive aide features less commonly than the social/general features in the patient group ($t(39) = -3.53, p < .01; d = -.45$), the care partner group ($t(39) = -5.64, p < .01$; Cohen's $d = -.55$), and the older AMT group ($t(39) = -6.52, p < .01$, Cohen's $d = -.98$).

A MANOVA comparing average cognitive and social/general use scores for the patient, care partners, and older AMT groups, indicated a significant effect of group on smartphone usage ($F(4, 232) = 2.49, p = .04$, Wilk's $\Lambda = .92$, partial $\eta^2 = .02$). Using our planned follow-up analyses, there were no statistically significant differences in the three groups on social/general phone use ($F(2, 117) = 1.97, p = .14$). Interestingly, however, there was a statistically significant group difference in cognitive aide use ($F(2, 117) = 4.65, p = .01$), with post-hoc tests revealing that care partners reported to using cognitive aide features more often than the older AMT control group ($p < .01$, Cohen's $d = .73$).

We further examined the percentage of participants reporting daily use (scores of 6 or higher on MTU-SS) of cognitive aide features, with the rationale that daily utilisation may be necessary for a cognitive aide to be effective in the context of a chronic cognitive condition. Figure 1 illustrates that patient and care partners tended to use the cognitive aide features of the smartphone on a daily basis more than the older AMT sample, though the group difference failed to reach statistical significance ($\chi^2(2, N=120) = 5.44, p = .06$). However as can be seen in Figure 1 cognitive aide use was less in the Older AMT group than either caregivers or patients ($p < .05$). There were a similar percentage of participants across groups who used the social/general features of their smartphones daily ($\chi^2(2, N=120) = .88, p = .64$).

Smartphone Utilisation in Participants with Known/Suspected Geriatric Cognitive Disorders

For the patients that completed the survey, 62.5% were referred for evaluation of a known or suspected geriatric cognitive disorder, 5.0% were referred for a question related to an underlying movement disorder, 7.5% were referred for cognitive deficits after stroke, 5.0% were referred for cognitive impairment in Multiple Sclerosis, and 20.0% were referred for other or unspecified reasons. Given the prevalence and burden of geriatric cognitive disorders as well as their relevance in memory disorder clinics, our third aim was to explore how smartphones might be differently utilised in individuals referred for geriatric cognitive disorders versus individuals referred for other reasons (i.e., other specific neurological or psychiatric diagnoses). The individuals referred for evaluation of possible geriatric cognitive disorders who owned smartphones ($N = 25$) reported significantly less social/general use of the phone ($M = 4.63, SD = 2.25$) than individuals referred for other reasons ($N = 15; M = 6.69, SD = 2.28; t(38) = -2.79, p < .01, d = -.91$), though there was a statistically similar reported use of cognitive aide features ($M = 3.88, SD = 2.43$ versus $M = 4.97, SD = 2.58; t(38) = -1.35, p = .18$).

Smartphone Use in Caregiving

All care partners identified themselves as family members, with 51.3% describing themselves as spouses. Table 2 demonstrated that care partners used their smartphone as often, or more often, than our AMT sample. An important remaining question though is whether care partners used their smartphones more because of their caregiving role. We found that 55% of care partners reported utilising their smartphone to help with some aspect of caring for the patient. When comparing care partners who did versus did not utilise their smartphones for their caregiving role, the groups did not differ in age ($t(31) = .08, p = .93$), gender ($\chi^2(1, N=40) = 1.21, p = .27$), or education ($\chi^2(2, N=40) = 1.46, p = .48$). Care partners who utilised their smartphones for their caregiving role reported nominally, but not statistically significantly, greater frequency of use of social/general features ($M = 6.43, SD = 2.08$ versus $M = 5.49, SD = 1.74; t(38) = -1.53, p = .13$) and cognitive aids ($M = 4.25, SD = 2.04$ versus $M = 5.34, SD = 2.27, t(38) = -1.59, p = .12$).

Discussion

Smartphone use is pervasive in daily life, even amongst older populations referred for clinical neuropsychological evaluation. In the current study, we evaluated three primary questions: how do demographic factors impact smartphone usage in clinical and non-clinical samples (Aim 1), how do these groups utilise the various features of their devices day to day (Aim 2), and how are smartphones used in caregiving and patient subgroups (geriatric cognitive disorder referrals). We address each aim below.

Demographic Factors and Smartphone Ownership and Utilisation (Aim 1)

In keeping with population-based studies (Anderson, 2015; Pew Research Center, 2017), our results revealed a significant relationship between age and smartphone ownership: Non-smartphone owners were older than smartphone owners in each group. Furthermore, age was negatively correlated with reported use of cognitive and social/general features. Given that our study was a cross-sectional design, it will be important to re-evaluate this relationship over time to tease apart cohort effects from declining usage due to biological aging (Malinowsky et al., 2010). We suspect that both factors contribute to the age effect. For example, smartphone owning patients overall reported similar usage patterns to care partners and an older adult AMT control group; however, patients with geriatric cognitive disorders (who also were older than other patients) reported less frequent social usage than patients referred to the memory clinic for other reasons. As such, individuals with geriatric cognitive disorders may need personalized training on smartphone devices to glean the most benefit. Future research should obtain neuropsychological data and follow adults prospectively to definitively address the mechanism(s) for age-related decline in smartphone use.

Beyond chronological age, we found that higher education level was modestly related to greater smartphone utilisation (including cognitive aide features). This pattern was especially pronounced in the patients. In the general U. S. population, smartphone ownership may relate to education level as a result of economic factors (Pew Research Center, 2017). In clinical samples, further work is necessary to determine the extent to which smartphone use reflects economic disparities versus one's cognitive capacity to use the smartphone (e.g.,

education is one measure of cognitive reserve; Stern, 2012). Given that patients who utilise smartphones use cognitive aide features more often than older controls, it would also be interesting to explore if such increase is an attempt to compensate for deficits, which might represent a form of technological cognitive reserve.

How Do Patients, Care Partners, and Older Adult Controls Use Their Smartphones (Aim 2)?

Smartphone-owning patients reported using their smartphone at a similar frequency as the older AMT control group. That null difference is striking because one could argue that the older AMT group, a group that is completing a survey online, may be more technologically savvy than the general population. Thus, at least some older patients own and regularly use smartphones.

However, we found that across samples, individuals do not commonly utilise smartphone cognitive aide features. Put pragmatically, the participants reported using their smartphones on a daily basis for email, but only reported using cognitive aide features once each week. On the one hand, these findings might discourage use of smartphones as cognitive aids if few patients or care partners do not already use them regularly. On the other hand, the high degree of utilisation of smartphone devices in general may offer an opportunity for training patients to use the cognitive aide features. In support of this optimistic outlook, even though less than 1/3 of patients and care partners reported daily use of cognitive aide features, both patients and care partners reported utilising the cognitive aide features more often than the older adult AMT control group. A potential intervention point for the practicing provider would be to build on the existing daily smartphone habit of emailing, and train patients on additional smartphone features such as cognitive aids (e.g., reminders; see Sohlberg & Mateer's, 2001, principles).

One of the least frequently used features of the smartphone included voice features (less than once per week). Yet, voice-activated personal assistants (e.g., Siri, Cortana) hold potential as cognitive aids, particularly for individuals with visual, motoric, or cognitive limitations. Future research should determine whether voice features are not utilised because individuals do not know they are available, are unsure how they work, or have difficulty using them. The rapid advances in smartphone natural language processing could make voice-activated features a viable avenue for cognitive interventions.

While the degree of smartphone usage in older adult patient and care partner samples will likely vary across clinical settings, cultures, and socio-demographic groups, the present results are encouraging in that smartphone usage appears to be happening frequently enough that it might be built on as a habit by rehabilitative clinicians.

Of Particular Interest: Geriatric Cognitive Disorders and Care Partners (Aim 3)

The presence/suspicion of a geriatric cognitive disorder was associated with less smartphone ownership and decreased frequency of smartphone usage. Part of this relationship was likely due to the aforementioned impact of age, as individuals who were referred for evaluation of geriatric cognitive disorders were older. However, of the individuals who did own smartphones, general use was less common than other patients, but cognitive aide use was similar. Focused screening and training on technology may be required to help patients with

geriatric cognitive disorders to utilise smartphone devices fully. However, at least a subset of patients already use smartphone devices regularly, which clinicians can build upon to increase reliance on cognitive aide features.

Care partners, who are known to have heightened responsibility day to day, reported the highest levels of smartphone usage, with more than half of care partners reporting that they used their smartphones to support caregiving responsibilities. Indeed, a novel finding of the present work was that care partners reported using their smartphones even more frequently than the age-matched AMT control subgroup. Given the numerous tasks that caregiving entails, there is potential to tailor smartphone apps to aide in the caregiving process. Whether tracking medication dosages and timing, keeping track of appointments, or encouraging self-care via connections with online communities, smartphones may help to shoulder some of the burden of care, thereby helping families and patients alike.

Limitations and Future Directions

There are limitations to the current study. This was a convenience sample of predominantly white individuals who agreed to fill out the survey. As such, we do not know how the observed rates of utilisation will generalize to other samples as would be achieved by a population-based epidemiological study. Given how little is known about smartphone use in the neuropsychology clinic in general, the current data build on the existing literature by highlighting that at least some, if not many, patients and care partners actively use smartphones. A second limitation was the reliance on self-reported smartphone use, which may diverge from objective smartphone usage. For example, the MTU-SS scale may be prone to recall biases or even the presence of memory deficits itself. Measuring smartphone use objectively – phone calls, emails, application use, GPS use, etc. – is certainly a worthwhile future research goal. However, such objective measurement comes with concerns over privacy protection that were beyond the scope of the current work. A third limitation was that the participants constituted a mixed sample of individuals who presumably could have no cognitive impairment, various dementias, and movement disorders (with various degrees of cognitive impairment), and future studies need to investigate which specific patient groups/cognitive profiles may use, or benefit the most from, smartphone cognitive aide features. Inclusion of information pertaining to particular cognitive profiles (i.e. amnesic versus dysexecutive), degree of cognitive impairment, or diagnostic types will be relevant to tailoring interventions to individual cases. A final concern could be raised about how representative the AMT sample is as a control population. In reviewing the literature on AMT samples for social science research, Chandler and Shapiro (2016) concluded that AMT samples have similar limitations to convenience samples, but in general tend to be younger, more liberal, more educated, have more Caucasian and Asian respondents, and be more socially anxious than the general population. Most of these variables should not impact the current results, however, age is associated with smartphone use and the older AMT sample was not as old as our patient group though this effect size was small. Similarly, the AMT control group was recruited one year later than the patient group and would be expected to be more technologically savvy. All of those factors should skew the results toward greater smartphone use in the AMT control group than the patient group. Therefore, it is noteworthy that the patients often

reported using their phones as frequently as the AMT control group. Future studies using tightly matched control groups would be helpful at drawing more definitive conclusions.

Despite limitations, the aforementioned questions exist because research into employing smartphones to remediate cognitive problems is still in its infancy (Armstrong et al., 2010; Ferguson et al., 2015; Svoboda et al., 2015). The current study highlights that some, if not many, patients and care partners use smartphones on a daily basis, but less frequently use the cognitive aide functions that might be most helpful in a rehabilitation context.

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Figure 1.

Percent of respondents reporting daily use of cognitive aid features versus social/general features of their smartphone, by group membership.

Note: AMT refers to the Amazon Mechanical Turk sample. $N=40$ for each group.

Table 1

Demographic and descriptive data for the sample. Some percentages may not add to one hundred because of rounding errors or missing data.

	Patients (n=40)	Care Partners (n=40)	Total Amazon Mechanical Turk Sample (N= 196)	Older Amazon Mechanical Turk Subsample (N=40)
Variable	Mean(SD)			
Age	61.33(13.33)	54.03(15.11)	34.85(11.5)	53.98(6.90)
	Percentage			
Gender - Female	55.0%	75.0%	54.6%	70.0%
Education-High School or Less	25.0%	15.0%	13.5%	12.5%
Education-Some College or College Degree	60.0%	57.5%	73.1%	77.5%
Education-Graduate Degree	15.0%	27.5%	13.5%	10.0%
Ethnicity-White	77.5%	84.2%	73.0%	85.0%
Ethnicity-Hispanic	12.5%	5.3%	6.6%	2.5%
Ethnicity-Black	10.0%	7.9%	10.20%	10.0%

Table 2
Spearman rho correlations between demographic factors and smartphone use patterns.

Smartphone Activity	Patients		Care Partners		All Amazon Mechanical Turk Respondents		Older Amazon Mechanical Turk Sample	
	Age	Education	Age	Education	Age	Education	Age	Education
Cognitive Aide Features	-.37 *	.30 *	-.38 *	.02	-.19 *	.05	-.05	-.02
Social/General Use Features	-.53 *	.34 *	-.55 *	-.12	-.19 *	.18 *	-.38 *	.09

Note=
* $p < .05$;

Table 3

Frequency of smartphone feature use in patients, and care partner, and AMT respondents.

Function	Patients (N=40)		Care Partners (N=40)		Amazon Mechanical Turk Sample (N=196)		Older Amazon Mechanical Turk Sample (N=40)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Social/General Use Items								
Email	6.62	3.18	7.60	2.68	6.43	2.48	5.63	2.91
Browse	6.45	3.04	7.00	2.70	6.78	2.11	6.10	2.36
Music	3.15	3.13	3.68	2.99	4.87	2.47	4.20	2.33
Pictures	5.85	2.93	6.63	2.72	4.90	1.90	4.38	1.69
News	5.13	3.13	5.28	2.68	5.28	2.30	5.13	2.52
Video	2.98	2.70	3.58	2.78	3.28	1.91	2.78	1.73
Using Apps	6.82	3.29	7.68	2.18	7.22	2.16	6.68	2.36
Searching for Information	6.35	3.18	6.63	2.66	6.62	2.29	5.93	2.59
Cognitive Aide Items								
Directions	4.88	3.27	5.92	3.04	4.18	2.43	2.98	1.83
Calendar*	4.85	2.93	5.85	3.04	4.49	2.52	4.05	2.45
To Do Lists*	3.63	3.02	3.83	2.60	3.64	2.69	2.68	2.34
Set Alarm*	4.83	3.46	5.83	3.10	5.15	2.34	4.15	2.40
Reminders*	4.43	3.10	4.22	3.21	3.78	2.65	2.98	2.27
Voice Interaction*	3.03	3.02	3.44	2.81	3.07	2.65	3.45	3.12
Summary Scores								
Cognitive Aide	4.29	2.51	4.85	2.21	4.05	1.3	3.38	1.75
Social/General Use	5.40	2.41	6.00	.31	5.67	1.49	5.10	1.75

Note: Items marked with asterisks were added to the original MTU-SS. Voice interaction refers to personal assistant services like “Siri”, “Hey Google”, and “Cortana” on various platforms. The scale ranges from 1 to 10 (1 = never, 2 = once a month, 3 = several times a month, 4 = Once a week, 5 = Several times a week, 6 = Once a day, 7 = Several times a day, 8 = Once an hour, 9 = several times an hour, and 10 = all the time).