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Cognitive Function and Digital Device Use in Older Adults Attending a Memory Clinic

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Abstract
This study investigated cognitive function in relation to the use of a computer and a touchscreen device among older adults attending a memory clinic. The entire sample (n = 323) was categorized into four profiles, according to the frequency of digital device use (either daily or non-daily usage). Results showed that on a daily basis, 26% of the sample used both a computer and a touchscreen device, 26.9% used only a computer, 7.1% used only a touchscreen device, and 39.9% used neither type of digital device. There were significant group differences on age, education, and clinical diagnosis (p < .001). Non-daily users of digital devices had significantly lower performance, compared with daily users of both types of digital device, on measures of global cognitive function, processing speed, short-term memory, and several components of executive function (p < .001). Falling behind with regard to the use of digital devices might reflect underlying poor cognitive capacities.

Keywords
Alzheimer's disease, cognition, cognitive aging, mild cognitive impairment, technology

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Introduction

Older adults frequently use long-standing forms of technology, while they are slower to adopt newer forms of technology, such as digital technology (Czaja et al., 2006; Olson, O'Brien, Rogers, & Charness, 2011). It has been well established that compared with younger people, older adults have lower access to and usage of various forms of digital technology. For example, a recent French national survey showed that among older adults aged 70+, 52% of them owned a computer and 31% of them owned a smartphone, while among adults aged between 25 and 39, the rate of computer ownership goes up to 86% and 92% for smartphones (Croutte, Lautié, & Hoibian, 2017). Younger people are exposed to computers and the Internet increasingly early and most of them acquire skills during their childhood or at work. In contrast, older people are only exposed to these forms of digital technology late in their lives and have to learn new skills to use them. Computer use is therefore considered to be a cognitively challenging activity for older adults, involving interactive coordination of psychomotor, sensory, and a number of cognitive capacities (Charness & Boot, 2009; Seelye et al., 2015; Small, Moody, Siddarth, & Bookheimer, 2009).

The use of various forms of digital technology in older adults is influenced by demographic (e.g., age, education, income, gender), attitudinal (e.g., computer efficacy, computer anxiety), and cognitive factors (Czaja et al., 2006). Previous studies consistently report a positive association between computer use and cognitive function in older adults (Czaja et al., 2006; Fazeli, Ross, Vance, & Ball, 2013; Tun & Lachman, 2010). Some authors postulate that older adults with better cognitive abilities are more likely to use a computer (Slegers, van Boxtel, & Jolles, 2012), while others postulate that computer use could help to maintain and enhance cognitive function (Bordone, Scherbov, & Steiber, 2015; Chan, Haber, Drew, & Park, 2016). It has been shown that higher levels of computer use are associated with better executive function, especially the ability to switch between tasks (Tun & Lachman, 2010). In a longitudinal cohort study, computer users displayed better episodic memory and executive function, compared with

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non-users. Furthermore, subjects who increased their computer use over 6 years showed better performance in both cognitive domains, compared with those who diminished their computer use (Kesse-Guyot et al., 2012). In a large-scale longitudinal study on aging, it was found that over time, increased Internet/email use was associated with significant improvement in delayed recall (Xavier et al., 2014). These findings concur with results from the Intelligent Systems for Assessing Aging Change longitudinal aging study, in which the computer usage of a sample of older adults, both subjects with normal cognition (NC) and subjects with mild cognitive impairment (MCI), was unobtrusively monitored at home. It was shown that less daily computer use was associated with smaller hippocampal volume and worse test performances for memory and executive function in cognitively unimpaired older adults (Silbert et al., 2016). Over a 3-year period, owing to cognitive decline leading to difficulties using a computer, MCI subjects showed a significant reduction in the number of days during which they used a computer and mean daily use, compared with cognitively unimpaired older adults (Kaye et al., 2014). Furthermore, results from analyses on computer mouse movement patterns showed that MCI subjects are less efficient and less accurate when using a mouse, compared with cognitively unimpaired older adults (Seelye et al., 2015).

Compared with computers, touchscreen devices, such as smartphones and tablet computers, are more recent forms of digital technology. They have become very popular in younger adults, who use mobile applications to manage various aspects of daily life (e.g., shopping, communication, financial management, reminders, and entertainment). However, the rate of use of these digital devices is still low in older adults who need some training to acquire the skills needed to use them. Intervention studies in which older adults were trained to use a tablet computer show that learning to use a new form of technology improves a number of cognitive capacities, such as processing speed and episodic memory (Chan et al., 2016; Vaportzis, Martin, & Gow, 2017). However, there is a lack of literature on observational studies investigating the relationship between touchscreen device use and cognitive function in older adults. In this study, we analyzed the data from a sample of older adults attending a memory clinic to examine cognitive function in relation to the use of a computer and touchscreen devices.

Method

Sample

The sample was composed of older adults with unimpaired cognition (normal cognition; NC), patients with MCI, and patients with Alzheimer's disease (AD). They were recruited from a memory clinic between July 2013 and November 2015 and received a comprehensive geriatric assessment including a complete physical examination, biological analyses (measurement of thyroid function, vitamin B12 and folate levels, natremia, calcemia, etc.), and an assessment of cognitive function and of functional status in daily life.

The participants were considered to be cognitively normal if they (a) did not present any cognitive impairment as measured by the neuropsychological test battery from the diagnostic unit, (b) did not present a history of neurological and psychiatric disorders, and (c) did not present any functional impairment.

The subjects were diagnosed with MCI according to Petersen's criteria (Petersen, 2004). They were non-demented, had preserved functional abilities, and performed at or below 1.5 standard deviations from the mean for age and education, according to published norms, on more than one of the neuropsychological tests.

AD was diagnosed according to the criteria of the National Institute of Neurological and Communicative Disorders and Stroke and the Alzheimer Disease and Related Disorders Association (McKhann et al., 1984). These subjects were impaired in several areas, including memory and another cognitive domain as well as in functional activities.

The exclusion criteria for all the participants were as follows: (a) the presence of motor or visual abnormalities affecting the performance on neuropsychological tests, (b) the presence of psychiatric or neurological disorders which could cause cognitive impairment, and (c) a history of alcohol or other substance abuse.

The study was approved by the Paris Descartes University Institutional Review Board (CERES) with the IRB number of 2015800001072. Informed consents were obtained from all the participants.

Neuropsychological Assessment

Global cognitive function was assessed using the Mini-Mental State Examination (MMSE; Folstein, Folstein, & McHugh, 1975). Short-term memory and working memory were measured thanks to the forward and backward digit span (Wechsler, 1997), respectively. Processing speed was evaluated with part A of the Trail Making Test (TMT-A; Reitan, 1992). Executive abilities were assessed using a variety of measures including: part B of the TMT (TMT-B; Reitan, 1992), letter word-list generation (P, 2 min) and semantic category fluency (animals, 2 min), the K-T cancelation test (Halter, 1958; Wu, de Rotrou, Sikkes, Rigaud, & Plichart, 2016), and a tablet computer–based cancelation test (e-CT; Wu et al., 2015). Episodic memory was assessed using the French version of Free and Cued Selective Reminding Test (FCSRT): Rappel Libre/Rappel Indicé à 16 items (RL/RI-16) (Grober & Buschke, 1987; Van der Linden, Coyette, Poitrenaud, & et les membres du GREMEM, 2004). The sum of immediate free recall scores and total recall scores across three consecutive trials were recorded.

Table 1. Demographic Characteristics and Clinical Diagnosis of the Study Sample Classified Into Four Groups According to the Frequency of Digital Device Use (Either Daily or Non-Daily Usage).

	Non-daily use *n* = 129 (39.9%)	Touchscreen daily use only n = 23 (7.1%)	Computer daily use only *n* = 87 (26.9%)	Daily use of both types of devices *n* = 84 (26.0%)	*F* or χ^2	*p* value
Age (*SD*)	78.9 (5.86)	73.8 (7.56)	75.1 (7.08)	72.6 (6.43)	18.1	<.001
Sex, men (%)	43 (33.3)	6 (26.1)	29 (33.3)	33 (39.3)	1.70	.64
Education, >12 years (%)	52 (40.3)	11 (47.8)	59 (67.8)	65 (77.4)	33.9	<.001
Clinical diagnosis, *n* (%)					42.0	<.001
NC (*n* = 112)	24 (18.6)	5 (21.7)	38 (43.7)	45 (53.6)		
MCI (*n* = 127)	53 (41.1)	12 (52.2)	32 (36.8)	30 (35.7)		
AD (*n* = 84)	52 (40.3)	6 (26.1)	17 (19.5)	9 (10.7)		

Note. NC = normal cognition; MCI = mild cognitive impairment; AD = Alzheimer's disease.

Measurement of Digital Device Use

Participants reported how often they used a computer and a touchscreen device (tablet computer or smartphone). They were classified either as daily users (use of any aforementioned digital device at least once a day) or non-daily users. The sample was categorized into four profiles, according to the frequency of digital device use (either daily or non-daily usage): (a) non-daily use of any digital device, (b) daily use of a touchscreen device only (tablet computer or a smartphone), (c) daily use of a computer only, and (d) daily use of both a touchscreen device and a computer.

Statistical Analysis

We first described the groups (digital device use profiles) using mean and standard deviation for age and percentage for gender, education level (without a college degree vs. with a college degree and higher), and clinical diagnosis (NC vs. MCI vs. AD). Groups were compared using one-way analyses of variance and chi-square tests. Post hoc least significant difference (LSD) tests and post hoc chi-square tests according to Fisher's exact approach under the Bonferroni correction were used in case of significant effects.

We further compared group performances on neuropsychological tests by conducting one-way analyses of covariance (ANCOVAs), adjusting for age, education, and clinical diagnosis. Post hoc analyses were further performed with LSD tests.

Results

Data from 323 subjects were analyzed. The mean age of the sample was 75.9 years, with a standard deviation (*SD*) of 6.98. The proportion of women was 65.5% and of subjects with a college degree and higher was 57.9%. The percentage of subjects classified as having NC, MCI, and AD was 34.7%, 39.3%, and 26.0%, respectively. A majority (60.1%) of the sample used at least one type of digital device on a daily basis. Half of the sample used a computer daily and half of the daily computer users were also daily users of a touchscreen device. About one third of the sample used a touchscreen device every day and most of them (78.5%) were also daily computer users.

Table 1 presents the demographic variables and clinical diagnosis for the study sample, classified into four groups according to daily use or non-daily use of digital devices. There were significant group differences in age, education, and diagnosis (all p values <.001).

Subjects using both types of digital devices on a daily basis were younger compared with all other groups (all p values <.005).

Figure 1 depicts the distribution of lower education level versus higher education level in four profiles of digital device use. There was a higher percentage of subjects with higher education in the group using both types of digital devices (p < .006). On the contrary, the percentage of subjects with higher education was lower among older adults who used neither form of digital device on a daily basis. All p values are <.006.

Figure 2 depicts the distribution of diagnostic groups in four profiles of digital device use. Among participants using both types of devices daily, there was a higher percentage of NC subjects and a lower percentage of AD patients. By contrast, in the group which used neither digital device daily, there was a lower percentage of NC subjects and a higher percentage of AD patients. All p values are <.004.

Table 2 presents the sample's neuropsychological test scores. ANCOVAs were used to compare scores on neuropsychological tests among four profiles of digital device use, controlling for age, education, and clinical diagnosis. Non-daily users of a digital device had significantly lower performances, compared with daily computer users, on several measures, such as TMT-A, TMT-B, K-T, e-CT, and forward digit span. Moreover, compared with daily users of both types of digital devices, non-daily users had significantly lower scores not only on the above measures but also on the MMSE and performed marginally worse on the immediate free recalls of the RL/RI-16 (p = .072).

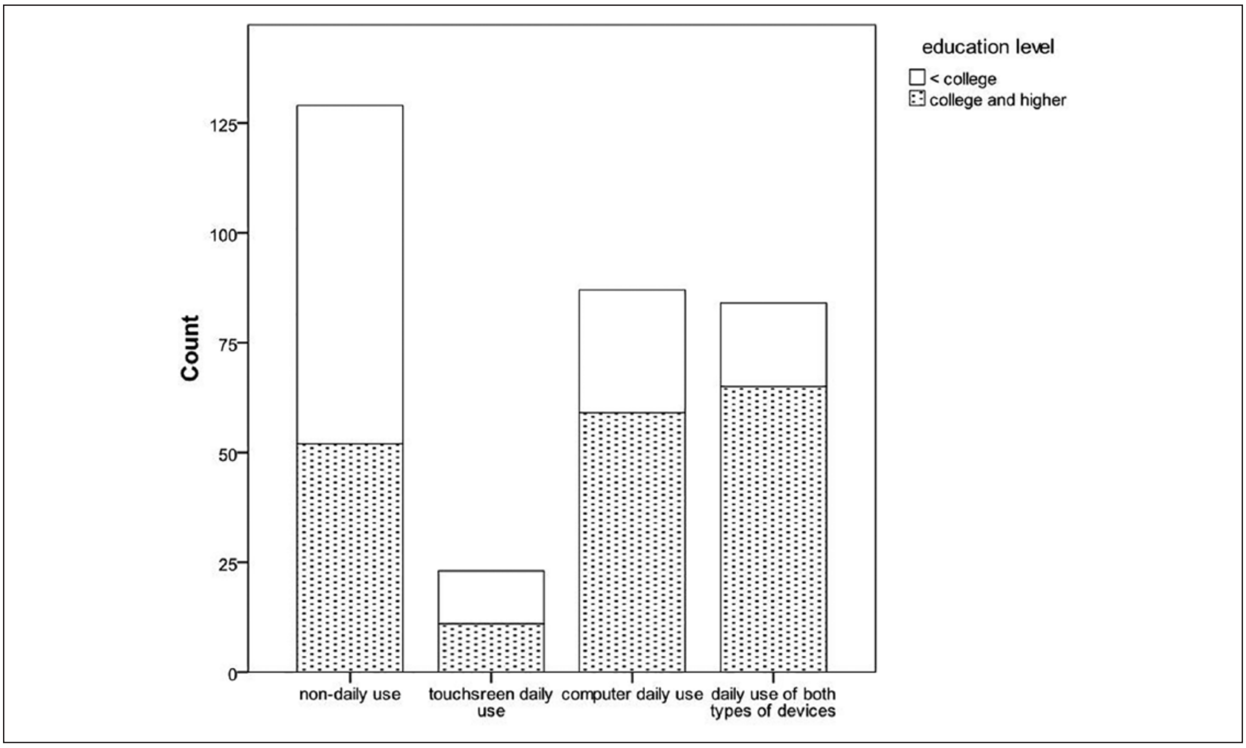

Figure 1. The distribution of education level in four profiles of digital device use.

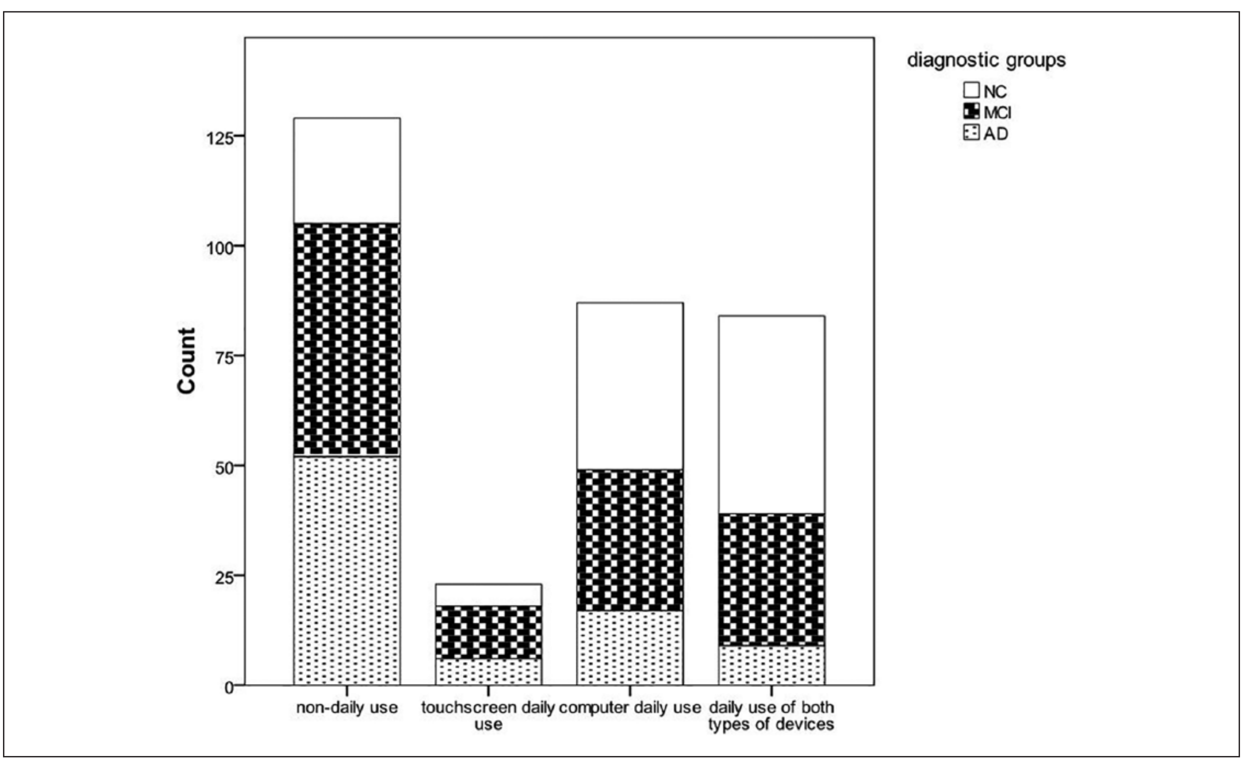

Figure 2. The distribution of diagnostic groups in four profiles of digital device use.
Note. NC = normal cognition; MCI = mild cognitive impairment; AD = Alzheimer's disease.

Subjects using a touchscreen device daily only performed significantly worse on the K-T cancelation test than subjects using both types of digital devices daily. There was also a trend toward significance for the difference between the two groups on the TMT-B (p=.057). Finally, daily touchscreen users did not perform significantly differently from non-daily users of a digital device.

Table 2. Comparison of Neuropsychological Test Performance Among Four Profiles of Digital Device Use.

	Non-daily use (*n* = 129)		Touchscreen daily use only (*n* = 23)		Computer daily use only (*n* = 87)		Daily use of both types of devices (*n* = 84)		*F*	*p*
MMSE	25.5 (3.52)	*N* = 126	26.4 (3.27)	*N* = 23	27.3 (2.62)	*N* = 85	28.3 (1.64)	*N* = 83	4.328	.005[a]
K-T	30.2 (12.8)	*N* = 122	33.5 (12.2)	*N* = 22	41.1 (12.1)	*N* = 83	46.2 (11.6)	*N* = 83	7.791	<.001[a,b,c]
e-CT	26.8 (9.73)	*N* = 129	31.7 (8.66)	*N* = 23	34.9 (8.11)	*N* = 87	39.1 (7.44)	*N* = 84	9.868	<.001[a,b]
TMT-A	59.6 (27.8)	*N* = 105	50.1 (23.2)	*N* = 20	41.6 (12.3)	*N* = 74	38.5 (13.8)	*N* = 70	5.100	.002[a,b]
TMT-B	197.2 (125.3)	*N* = 105	188.0 (146.2)	*N* = 20	120.5 (83.3)	*N* = 74	90.1 (44.3)	*N* = 70	5.242	.002[a,b,c]
Phonemic fluency	18.7 (7.30)	*N* = 100	21.2 (8.02)	*N* = 19	22.9 (7.90)	*N* = 74	23.0 (6.59)	*N* = 73	0.856	.464
Category fluency	21.9 (9.85)	*N* = 101	24.7 (9.70)	*N* = 19	28.2 (10.0)	*N* = 74	29.6 (8.78)	*N* = 74	1.468	.224
Digit span forward	5.10 (1.08)	*N* = 103	5.40 (0.94)	*N* = 20	5.67 (1.01)	*N* = 74	5.79 (1.06)	*N* = 76	3.326	.020[a,b]
Digit span backward	3.59 (0.99)	*N* = 103	3.80 (1.11)	*N* = 20	4.23 (1.04)	*N* = 74	4.25 (1.01)	*N* = 76	1.211	.306
Free recall	18.7 (10.2)	*N* = 106	25.4 (9.90)	*N* = 19	24.4 (10.0)	*N* = 75	27.9 (8.28)	*N* = 79	3.168	.025[a]
Total recall	39.1 (11.4)	*N* = 106	41.6 (8.78)	*N* = 19	42.1 (9.43)	*N* = 75	44.4 (6.40)	*N* = 79	0.577	.631

Note. MMSE = Mini-Mental State Examination; CT = cancelation test; TMT = Trail Making Test.
[a]Non-daily use < daily use of both types of devices.
[b]Non-daily use < computer daily use only.
[c]Touchscreen daily use only < daily use of both types of devices.

Discussion/Conclusion

This study investigated the relationship between digital device use and cognitive function in a sample of older adults recruited from a memory clinic. The sample was divided into four groups: non-daily use of any type of a digital device, daily use of a touchscreen device only, daily use of a computer only, and daily use of both types of digital devices. We found that more than half of the sample used a digital device daily. Over a third of the sample were daily users of a touchscreen device, and a great majority of them were also daily computer users. Non-daily use of any digital device was associated with older age and a lower level of education, which is consistent with previous findings (Slegers et al., 2012; Tun & Lachman, 2010; Werner, Carlson, Jordan-Marsh, & Clark, 2011). Furthermore, there was a higher percentage of AD patients among non-daily users of any type of a digital device. This group of subjects performed worse in several cognitive measures, compared with those using daily a digital device.

Our findings are globally in concordance with previous studies reporting a positive association between digital literacy and cognitive capacities. In our study, the subjects who did not use any digital device on a daily basis performed more poorly on measures of processing speed, short-term memory, and several components of executive function, compared with those who used a computer on a daily basis. Furthermore, we found a larger gap between those in the non-daily use category and those who used both types of digital devices on a daily basis. The two groups differed significantly not only on the aforementioned measures but also on global cognitive function and marginally on free recall. It is suggested that using various forms of digital technology is a mentally stimulating activity, which involves acquiring new skills, which in turn stimulate several cognitive abilities, such as executive function, memory, and reasoning (Park, Gutchess, Meade, & Stine-Morrow, 2007; Vaportzis et al., 2017). Along the same lines, it is suggested that using digital devices might lead to developing new skills (e.g., higher order thinking skills or instrumental activities of daily living [IADL]) and influence human cognition (Kaye et al., 2014; Parsey & Schmitter-Edgecombe, 2013) and brain plasticity (Gindrat, Chytiris, Balerna, Rouiller, & Ghosh, 2015; Small et al., 2009). Therefore, learning to use digital technology might increase cognitive and brain reserve, which protects individuals from cognitive decline (Stern, 2012; Valenzuela, Sachdev, Wen, Chen, & Brodaty, 2008). Computer use is considered to be a protective factor that might delay or prevent the progression of cognitive and functional decline (d'Orsi et al., 2014; Geda et al., 2011; Xavier et al., 2014). Computer use was associated with a decreased risk of incident MCI in a population-based cohort study, following a sample of cognitively intact older adults during a period of 4 years (Krell-Roesch et al., 2017). In another cohort study following community-dwelling older men for up to 8.5 years, the risk of dementia was found to be reduced in computer users, in comparison to non-users. In addition, the risk of dementia appeared to decrease with increased frequency of computer usage (Almeida et al., 2012).

An interesting finding is that there was no difference between subjects who did not use any digital device daily and subjects who exclusively used a touchscreen device on a daily basis on any cognitive measures. Furthermore, among daily users of a touchscreen device, those who also used a computer on a daily basis outperformed those who did not on two measures of executive function, tapping mainly into mental flexibility. These findings suggest that older subjects who were not daily computer users and who used a touchscreen device, a more user-friendly device than a computer, might have poorer mental flexibility, a fact which hinders them from using a computer more frequently. Another explanation is that using a computer on a daily basis helps enhance or maintain a higher level of executive functioning (Small et al., 2009; Tun & Lachman, 2010).

Digital devices are becoming a necessity in helping people handle everyday tasks. The use of digital devices is increasingly considered to be an aspect of complex IADL (Kaye et al., 2014; Melrose et al., 2016; Muñoz-Neira et al., 2012). Falling behind in the use of digital devices might reflect underlying poor cognitive and functional capacities. These older adults might also be disadvantaged and marginalized as they may miss out on important communications, social connections, and several services (Gell, Rosenberg, Demiris, LaCroix, & Patel, 2015). Interventions which aim to train older adults to use digital devices might help them maintain their independence and enhance their cognitive function by engaging in cognitively stimulating activities, as some studies have shown (Chan et al., 2016; Vaportzis et al., 2017). It is expected that the implementation of this kind of intervention may decrease incidence rates of dementia over the coming decades (Xavier et al., 2014). These kinds of interventions also allow the digital divide, which limits accessibility of resources and services for older adults, to be bridged (Woodward et al., 2012).

The study has some limitations. Information regarding the use of digital devices was self-reported and digital proficiency was not thoroughly assessed. Furthermore, the clinical sample used in the study is not representative of older adults as a whole.

In conclusion, this study confirms the positive relationship between cognitive ability and daily use of digital devices. Older adults using both a computer and a touchscreen device daily showed higher capacities in a variety of cognitive domains, compared with those who used no digital device on a daily basis. Interventions aimed at training older adults to use digital devices might allow not only the digital divide, which limits accessibility of resources and services, to be bridged but also enhance cognitive function and enable independence to be maintained for longer in older adults.

Declaration of Conflicting Interests

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Ethical Approval

The study was approved by the Université Paris Descartes institutional review board (CERES) under the IRB number: 2015800001072.

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