Sanders et al., Gerontechnology (2024) 23:1
https://doi.org/10.4017/gt.2024.23.1.849.06

Designing a tip card to facilitate the use of a voice-activated assistant (VAA) for prospective memory support

Edie C. Sanders MS[a,*], Robin K. Stuart MS[a], Walter R. Boot PhD[b]

[a]*Department of Psychology, Florida State University, Tallahassee, FL, USA;* [b]*Division of Geriatrics and Palliative Medicine, Weill Cornell Medicine, New York, NY, USA;*
**Corresponding author: edie.c.sanders@gmail.com*

Abstract

Background: Older adults, especially those living with cognitive impairment, can experience prospective memory challenges that affect their ability to manage day-to-day tasks, maintain their health, and sustain relationships with friends and family. Although voice-activated assistants (VAAs) are hands-free, convenient tools with the potential to support prospective memory, there are often barriers to the adoption of VAAs by older adults.
Objective: To address barriers to the adoption and use of VAAs by older adults, we developed a tip card to facilitate the use of a VAA to support everyday prospective memory tasks and evaluated the usability of the tip card.
Method: The tip card was designed with a human-centered design approach, incorporating the input of a subject matter expert on memory challenges, and provided guidance on how to use the device to perform three PM-related tasks: setting reminders, creating lists, and setting timers. Then, 15 older adults (4 with and 11 without probable mild cognitive impairment) were given an Echo Dot device to use for a 10-day period. Usage logs were extracted from the devices and each interaction was coded according to its purpose.
Results: Using the System Usability Scale (SUS), scores for the device and tip card were both "A" on average, corresponding to a rating of "excellent." Prospective memory-related tasks made up 68% of the total uses of the VAA.
Conclusion: Taken together, these findings support that VAAs, with the help of a tip card, can help older adults with diverse cognitive abilities complete daily memory-related tasks.

Keywords: prospective memory, mild cognitive impairment, voice-activated assistant, usability

Introduction

Prospective memory, the ability to remember and execute a planned action in the future, is critical for maintaining health, autonomy, and social relationships. Failures of prospective memory can result in a variety of adverse outcomes such as deteriorating health, financial difficulties, and social withdrawal, for example, because of missing medical appointments, failing to pay bills, or misremembering the date and time of social events. Prospective memory failures can also damage personal relationships as they are often attributed to character flaws instead of faulty memory (Graf, 2012). In some cases, these lapses can even impact safety, for example, failing to remember to remove food from the burner of a stove at the appropriate time. Unfortunately, prospective memory lapses increase as a normal part of the aging process, particularly for tasks with high strategic demands, such as remembering to perform a specific action at a specific time (Henry et al., 2004; Kliegel et al., 2016; Park et al., 1997; Woods et al., 2015). Even mild cognitive impairment (MCI) can exacerbate memory failures (Costa et al., 2011), and prospective memory impairment is common among older adults with dementia (Huppert et al., 2000). These memory failures are frustrating, both for the older adults living with cognitive impairment and their care partners (Smith et al., 2000).

Technology aids, such as voice-activated assistants (VAAs), have been proposed as useful tools to help those experiencing prospective memory-related challenges (Aggarwal et al., 2006; Wasserman et al., 2020). However, a variety of barriers exist to adopting and using VAAs such as the Amazon Echo Dot, especially among older adults. One challenge is the generally lower rate of adoption and use of many technologies among older people (Hargittai et al., 2018; Pew Research Center, 2019), and their lower technology proficiency relative to younger people (Roque & Boot, 2018). Older adults may not perceive the need for VAAs, impeding adoption (Trajkova & Martin-Hammond, 2020; Wu et al., 2016). This is consistent with models of technology adoption and use that highlight perceived usefulness as a

major driver of the intention to adopt and use new technologies (Chen & Chan, 2014). More specifically, even among older adults who own VAAs, not all make use of device capabilities that could benefit them in daily life (Koon et al., 2020). Although VAAs can support prospective memory, users may not be aware of these specific features. Further, for these devices to be used effectively, users need to know how to phrase voice commands properly to support the desired function (Kim & Choudhury, 2021). Additional instructional support may be helpful to facilitate successful VAA use to benefit memory-related tasks among older adults with and without cognitive impairments.

Previous research has emphasized the usefulness of quick-start guides for technologies that older adults may be unfamiliar with and may present usability challenges (Harrington et al., 2017). Harrington and colleagues took this approach to successfully develop a quick-start guide for the video game system Xbox 360, with the aim of helping older adults engage in exergaming to boost physical activity. The guide took the form of a laminated information sheet on a wooden stand that could be placed next to the gaming system. The guide included information about how to get started using the system and games, how to use gestures to control the system, and information about troubleshooting common issues. Consistent with principles of good human factors, providing *"knowledge in the world"* has the potential to improve older adults' interactions with a variety of potentially useful technologies. External aid is also consistent with the notion of *"environmental support"*, which can help older adults succeed in doing the things that are important to them (Morrow & Rogers, 2008).

The current paper describes efforts to incorporate user-centered design in the development of a tip card meant to encourage prospective memory-related use of the Amazon Echo Dot device among older adults with diverse cognitive abilities. This would allow the device to serve as an assistive technology (McCreadie & Tinker, 2005) more easily. The specific research aims are to (1) determine the perceptions and experiences users have with both the device and tip card, and (2) assess the frequency and types of Echo Dot use participants engaged in over a 10-day period.

The tip card was prototyped with the input of a subject matter expert (SME) and then tested for usability by placing it in the homes of 15 older adults with varying cognitive abilities for a period of 10 days. After the use period, participants were interviewed about their perceptions of and experiences with the tip card and device. The qualitative findings were corroborated by quantitative measures of device and tip card usability and usage patterns.

Methods

Research design overview

This study utilized a mixed methods design, with a user-centered tip card design followed by an in-home use assessment of the Echo Dot and tip card and a semi-structured post-use interview. An Echo Dot device and a tip card were placed together in each participant's home for 10 days. Interactions with the device were recorded and subjected to a thematic analysis to assess for which tasks the device was used. Following the use period, users' experiences with the device and tip card were assessed using semi-structured interviews and a quantitative usability measure.

Participants

One SME and 15 older adults were recruited for this study. The SME was a faculty member at the University of Illinois at Urbana-Champaign who had expertise in cognitive aging and brain diseases including MCI, Alzheimer's disease, and frontotemporal dementia. All older adult participants were aged 65 and older. Eleven of the older adult participants were cognitively healthy, and 4 qualified as having probable MCI. Older adults without MCI were recruited via a participant registry maintained by the Institute for Successful Longevity (ISL) at Florida State University (FSU). ISL has developed an extensive list of Tallahassee-area older adults interested in participating in research studies. In order to qualify for MCI, one of the following conditions had to be met:
(1) Recruited via the Digital Reminders for Everyday Activity Memory (DREAM) project (see Sanders et al., 2022) for description), the inclusion criteria of which require participants to have a complaint of memory issues that affect their daily life and score within a below-normal threshold on the Telephone Interview for Cognitive Status, (information about the screening procedure is provided in the materials section) OR
(2) Recruited via the ISL registry for a non-MCI group but complained of memory issues and scored within the below-normal threshold on the MoCA (see materials sections) upon its administration in the course of the research, suggesting probable MCI.

Participants who were included in the MCI group due to option B were made aware that they had scored in a range indicative of cognitive impairment and encouraged to consult their primary care provider to assess their memory.

Materials

Demographics

Participants completed a series of lab-developed questions regarding basic demographics, includ-

ing gender, age, level of education, income, employment status, and race.

Cognitive assessments

Modified telephone interview for cognitive status (TICS-M). The TICS-M is commonly used to elucidate the level of cognitive functioning and was employed here to confirm that participants were a) capable of providing informed consent and b) in the range of cognitive ability for which they were being recruited. Fourteen questions assess the interviewee's status on a scale of points out of 50, with a higher score indicating better cognitive functioning. In order to qualify, interviewees for the non-MCI group had to score 35 points or more; interviewees for the MCI group had to score between 25 and 34 points, meaning they were impaired enough to experience cognitive difficulties but not impaired enough to be unable to provide consent.

Montreal cognitive assessment (MoCA). The MoCA (Nasreddine et al., 2005) was developed as a tool for diagnosing patients with MCI in a clinical setting. It assesses 7 domains of cognitive functioning. A higher score out of 30 possible points indicates a higher level of cognitive functioning. Here, the MoCA was administered at the beginning of in-home device setup appointments in order to confirm the participants' group assignment (non-MCI ≥ 26, MCI < 26).

Measures of technology use and attitudes

Wireless network proficiency scale (WNPQ). The WNPQ-8, an abbreviated version of the WNPQ (Roque and Boot, 2021), was collected during each participant's in-home visit to assess their ability to interact with their wireless network. This measure includes statements such as *"Using a PC/laptop I can connect to the WiFi in my home."* Questions are organized in four subscales: basic wireless network tasks using a PC, basic wireless network tasks using a mobile device, advanced wireless network tasks, and miscellaneous wireless network tasks. Respondents indicate how easily they can perform each task on a scale from 0 (*"Don't know task"*) to 5 (Can perform the task *"Very easily"*). Questions within each subscale are averaged, and the averages for each subscale are summed to calculate a composite measure of proficiency. The maximum possible WNPQ score is 20.

Technology readiness index (TRI-2.0). The TRI 2.0 is a 16-item measure of readiness to accept technology, used here to further characterize the sample's general attitudes towards technology. Developed by Parasuraman and Colby (2015), it includes statements such as *"New technologies contribute to a better quality of life"* and *"Technology makes me more productive in my personal life"*. Subjects indicate the extent to which they agree or disagree with each statement. The measure assesses four domains of attitudes toward technology: Optimism, Innovativeness, Discomfort, and Insecurity. Scores from the latter two subscales are reverse-scored and the average of all subscales is calculated to give the overall score. A higher overall score (out of 5 possible points) indicates more positive attitudes towards technology.

Level of technology use. A self-developed measure previously used in a longitudinal study of technology attitudes held by older adults was used to a) determine the technologies that each participant used on a daily basis and b) provide a composite score indicating each participant's level of technology use. Respondents indicate their frequency of use (never, monthly, weekly, daily) for 10 household technologies in the past six months, ranging from less common devices (e.g., virtual reality) to more common devices (e.g., smartphones). For each technology, a score of 0 was assigned if the participant responded that they did not know what the technology was, or they never used it. A score of 1, 2, or 3 was assigned for each technology if the participant responded that they used it monthly, weekly, or daily, respectively. Scores for each technology were summed to give a composite score of technology use with a maximum possible score of 30. A higher composite score indicates more frequent technology use.

Tip card

To encourage prospective memory-related use of the device, a tip card was designed for deployment with the devices in each participant's home. The tip card was drafted using common guidelines for designing materials and systems for older adult audiences. Nielsen's 10 human factors considerations were used, specifically, the guidelines to *"match between the system and the real world"* and to aim for *"aesthetic and minimalist design."* General guidelines were also drawn from Designing for Older Adults: Principles and Creative Human Factors Approaches (Czaja et al., 2019). This first tip card version was iterated based on the results of a virtual SME interview. The interview was semi-structured, consisting of a PowerPoint presentation with two main sections: first, the content of the current tip card was reviewed and specific questions regarding the content were asked. For example, the elements present in the first tip card (title, orienting sentence, device basics, and daily memory-related tasks headings) were shown and the SME's opinion on their relevance to the goals of the tip card was queried. The design of the tip card was then examined by the SME in the same way. The interview was recorded, and suggestions and

comments made by the SME were transcribed. These were implemented in a second version of the tip card, which was reviewed by the SME once more for final approval. Earlier versions of the tip card primarily used examples to help illustrate uses of the Echo Dot to support prospective memory. For the *"Consulting Your Calendar"* section, the card guided users to add an event to their calendar by providing a sample command: *"Alexa, add 'eye doctor appointment' to my calendar for this Thursday at 3:00 pm."* Based on recommendations from the SME, the tip card underwent several simplifications to make it more straightforward. The most significant change involved shifting from example-based instructions to a procedural format. The updated version introduces each potential prospective memory use with *"I want to [task],"* followed by the directive *"Say: Alexa, [command]."* For example: I want to: Create a new reminder; Say: *"Alexa, set a reminder."* This approach reduces the mental effort required for users to interpret examples into actionable commands. Further, this approach prompts the device to ask appropriate follow-up questions (What's the reminder? At what time?), rather than have the user supply all of this information upfront, reducing memory load. It also significantly reduces the amount of text on the tip card. Finally, the tip card headers were simplified around the following themes to allow users to quickly find what they are looking for – Reminders, Lists, and Timers. The final version of the tip card (Appendix) was printed and placed in an 8.5" X 11" plastic sign holder, angled such that it should be easy to read.

Usability assessment tools

System usability scale (SUS). The SUS (Brooke, 2013; Brooke, 1996) was designed as a quick and easy way to assess user perception of a product. It consists of 10 statements such as *"I would like to use this system frequently"* and *"I thought the system was easy to use"* that are rated on a scale of 1 (strongly disagree) to 5 (strongly agree). Each item is scored individually based on the scale position, but these scores are not meaningful on their own. The SUS score is calculated by summing each item's score and multiplying the sum by 2.5. SUS scores have a range of 0 to 100. A score above 68 is considered above average, while a score below 68 is considered below average. Scores correspond to letter grades and adjectives for the usability of the product, with higher scores indicating a better letter grade rating or a more positive adjective (Bangor et al., 2009). This measure was included at the end of the final telephone interview to get a simple quantitative indicator of participants' views of both the device and tip card.

Post-use semi-structured interview. The interview was designed to provide an opportunity for users to share their individual experiences with the device in detail. It consisted of 12 questions relating to both the device and the tip card (for example, *"Did you experience any difficulties using the Echo Dot device during the 10-day period?"*). Interviews were conducted via telephone within several days of completing the 10-day use period and generally took less than half an hour.

Procedure

First, a telephone screening was conducted to identify and test potential participants. MCI participants were recruited from the Center for Enhancing Neurocognitive Health, Abilities, Networks and Community Engagement (ENHANCE)'s center's list of prescreened participants. Non-MCI participants were recruited from the volunteer population of older adults maintained by the ISL. Those who passed the prescreening were mailed a participation packet containing a cover letter, consent form, reminder slip for the date and time of the in-home device setup, demographics questionnaire, and technology use/readiness questionnaires.

In-home device setups were conducted following all relevant COVID-19 guidelines. During the in-home setup, the researcher worked with the participant to locate a suitable location in the home for the device and accompanying tip card to sit. The researcher followed a pre-established training protocol in which the participant was briefed on device basics (turning the device on and off, what the four device buttons did, etc.) and how to conduct the memory-related tasks posted on the tip card. After a description of the possible uses of each memory-related tip card task, participants were encouraged to practice creating a timer, setting a reminder, and creating a new list using the phrasing provided on the tip card. They were instructed not to unplug the device or to move it, not to use the device for medication reminders (due to the risk of negatively affecting adherence), and not to delete the voice recordings from the Amazon Alexa app. Participants were also instructed not to allow anyone else (either other members of the household or visitors) to use the device over the 10-day use period, as Amazon does not differentiate who is speaking in usage log recordings. Research Alexa accounts, linked to email accounts generated by research staff, were created by the experimenter and were not linked to participant identities to help protect the privacy and confidentiality of their data. Usage logs were labeled with a non-identifying, arbitrary participant number, and linked to identifying information in a password-protected file only accessible to study staff.

Table 1. Participant demographics and technology use.

ID	Age	MCI?	Gender	MoCA	Technology use	Technology readiness	Wireless network proficiency
P01	71	Yes	F	25	15	4.00	8
P02	79	Yes	F	25	12	3.38	16
P03	85	Yes	F	25	14	2.44	4
P04	88	Yes	M	22	12	3.88	17
P05	66	No	M	30	12	3.63	13.5
P06	82	No	M	29	12	3.50	12
P07	66	No	M	29	11	3.06	16.5
P08	70	No	F	30	15	3.63	13
P09	69	No	M	27	12	3.19	13
P10	73	No	F	29	12	2.44	15.5
P11	66	No	F	28	12	3.31	15
P12	67	No	F	29	10	3.81	15
P13	70	No	M	27	14	2.88	10
P14	75	No	F	27	14	3.38	13
P15	75	No	F	27	9	2.81	16.5

Following the 10-day use period, final interviews were conducted via telephone. These interviews lasted about 30 minutes in length depending on the level of detail given by each participant. They were recorded and transcribed for final coding and analysis.

Data analysis

Perceptions of the Echo Dot and tip card

Demographics and technology use. Age, gender, WNPQ scores, TRI scores, and technology use scores are calculated and reported for each participant. Data regarding race and employment status are summarized.

Usability grades. The SUS was implemented twice during the post-use period interview, once regarding participants' experience with the Echo Dot, and once regarding their experience with the tip card. Following scoring guidelines provided by https://uiuxtrend.com/sus-calculator/, scores below 51 points correspond to a letter grade of F, 51 to 67 correspond to D, 68 corresponds to C, 69 to 80.3 corresponds to B, and any score above 80.3 corresponds to a grade of A. Each grade corresponds to an adjective describing the usability of the device. An A corresponds to *"Excellent,"* a B corresponds to *"Good,"* a C corresponds to *"Okay,"* a D corresponds to *"Poor,"* and an F corresponds to *"Awful."* SUS scores and their corresponding letter grade are calculated and reported for each participant.

Interview thematic analysis. Post-use period interviews were semi-structured to direct interviewees to describe specific aspects of their experience with the device and tip card, as well as to allow for more broad and spontaneous descriptions. A thematic analysis was conducted on interview transcriptions to elucidate the common topics participants brought up. Thematic analyses are a useful tool for coding initial data points and relating them to larger, broader themes. Braun and Clarke's (2006) criteria were followed for this analysis as they are commonly used as guidelines for performing a methodologically sound analysis. They detail the following six steps: (1) Familiarize yourself with the data, (2) Generate initial codes, (3) Search for themes, (4) Review themes, (5) Define and name themes, and (6) Produce a report.

In adherence to these steps, codes were created as interviews were completed. Codes were assigned to the smallest data units of the interviews, which were sentences. The message of each sentence was recorded; some data units consisted of multiple sentences when those sentences were all used to communicate one single idea. After two interviews had been coded, initial themes were identified by grouping codes according to whether they were referencing the device or tip card. A thematic map was then created to further group those codes into meaningful themes. As the second author conducted this analysis, a research assistant did the same process independently (using the same two interviews). The two compared their work, discussing any differences until an agreement could be reached. In this way, a single codebook was created. Following the development of this codebook, the second author coded the transcribed interviews of the remaining participants.

Use of the Echo Dot

Amazon Echo devices record each interaction a user has with the device. Recordings, or *"usage logs"* as they are referred to here, are accessible by the owner of the Amazon account associated with the device. Usage logs detail what the user said to the device and how the device responded. Interactions of each participant with their device were extracted from their research-associated Amazon account. The purpose of each interaction was identified and recorded in a codebook. The most common device uses were calculated across participants. Total uses, most common type of device use, and total PM-related uses of the device were calculated for each participant individually.

Results

Participant characteristics

Table 1 details the demographic information and technology-related scores of the sample (5 M, 10 F, Mage = 73.5). The sample was primarily white.

Table 2. Individual System Usability Scale (SUS) ratings and corresponding letter grades

ID	Device	Device grade	Tip card	Tip card grade
P01	100	A	90	A
P02	92.5	A	100	A
P03	87.5	A	97.5	A
P04	82.5	A	80	B
P05	95	A	100	A
P06	90	A	95	A
P07	75	B	90	A
P08	77.5	B	82.5	A
P09	85	A	92.5	A
P10	80	B	82.5	B
P11	97.5	A	92.5	A
P12	97.5	A	95	A
P13	97.5	A	90	A
P14	80	B	87.5	B
P15	70	B	90	A
Average	87.2	A	91.0	A

Most participants were retired, although several were employed either full- or part-time. All participants indicated that they lived independently in either a home or an apartment.

Participants were all daily users of a variety of technologies, primarily the internet, computers, and smartphones. Technology use scores ranged from 9 to 15 (M = 12.4, SD = 1.72). Participants showed a wide range of wireless network proficiency and attitudes toward technology. Wireless network proficiency scores ranged from 4 to 17 (M = 13.2, SD = 3.58), and technology readiness scores ranged from 2.44 to 4 (M = 3.29, SD = .49). Participants consisted of a sample of older adults with diverse cognitive abilities. Scores on the MoCA ranged from 22 to 30 (M = 27.3, SD = 2.3). The MoCA cutoff score for probable MCI is 26; therefore, 4 participants who scored from 22 to 25 were classified as probable MCI. One participant in this group had been recruited from the DREAM project and had therefore also qualified as MCI by scoring under the cutoff on the TICS-M, with their status further qualified with the MoCA. The other 3 participants in this group had been recruited from the ISL registry but were classified as MCI after scoring below the MoCA cutoff. All 3 of these participants indicated that they had memory issues.

Participants in both Kim and Choudhury (2021) and Pradhan et al. (2020) were recruited from senior living facilities. The sample in the current work is made up completely of independently living older adults, thereby assessing the device usage and tip card perceptions of a population of people who have the unique need of aging in place.

Perceptions of the Echo Dot and tip card

Usability scores

SUS ratings for the Echo Dot and the tip card are reported in Table 2. The average SUS score for the Echo Dot was 87.2 (SD = 9.4), corresponding to a score of *"A"* or *"excellent."* The average SUS rating for the tip card was 91.0 (SD = 6.1), also corresponding to a score of *"A"* or *"excellent."* SUS scores for both the device and tip card ranged only from a B to an A.

Interview themes

Thematic analysis of interviews provided context for the usability ratings and usage logs. *Table 3* outlines all the themes found and their most common codes and shows the number of participants who mentioned each of the listed codes. The following sections describe the most common codes within each theme and specify the total number of times each theme was mentioned across all 15 interviews.

Device usefulness. The perceived usefulness of the device was mentioned 26 times. Within the theme, the most common code (mentioned by 6 participants) was that the device helped to replace pen-and-paper tasks such as writing down shopping lists. Being able to access shopping lists on the Amazon Alexa app specifically was brought up by 3 participants. For example, participant P06 said:

"…One of the convenient things I found was that… especially with the grocery list, which is one of the things I use it a lot for, it's very convenient because it shows up on my cell phone. So I don't have to write it anyplace else, it shows up on my cell phone so when I get to Publix (a grocery story) or wherever I'm going I just go to my cell phone and there's the list. That's very convenient."

Using the device for listening to music was also common (9 participants played music over the 10-day use period) and was mentioned by 3 participants during the interviews. In addition, several participants mentioned that they were actively thinking of future uses for device functions they hadn't used yet. Participant P07 was using the Amazon Alexa app on their tablet because his smartphone was an older model that could not support the software needed to run the app; he explained during the interview that:

"I would use lists, too, but I would have to get a better phone. I talked to a friend, and they have

Table 3. Most common codes for each theme from interviews

Theme	Code	# Participants
Device usefulness	Mentions using the device to replace paper-and-pencil PM tasks	6
	Being able to access the lists on their phone	3
	Mentions using the music functionality specifically	3
Critique of the device	Have to be careful in how you enunciate to the device	3
	Have to be quick in speaking/responding to the device	2
Positive view of the device	Fun	3
	Personification of the device	3
	I loved it/I'm enthusiastic	2
	Now interested in other Amazon devices	2
Negative view of the device	Boring, wishes the device were more sophisticated/intelligent	2
Device suggestion	Suggests including the ability to alphabetize lists	1
Tip card usefulness	Used TC the most at the beginning, use fell off	7
	Found TC helpful as a reminder for phrasing later on in the use period	5
Critique of tip card	TC was easy to read except when there was a glare from overhead lights	1
	Did not have an ideal, eye-level place for the TC	1
	The TC took up a lot of space	1
Positive view of tip card	I loved it/I'm enthusiastic	1
	Likes design elements of TC	9
Tip card suggestion	Suggests addition to TC of more non-PM-related capabilities	2
	Suggests including troubleshooting on TC	2
	Suggests including more (simplified, shortcut) phrases on the TC	1
Positive view (Device and Tip Card)	Liked that the TC provides a formula, and the device specifies what info is needed	1

one of these and they use it for their grocery lists. They like the app on their phone because you can check it off as you're buying them at the store."

Critique of the device. Device critiques were mentioned 22 times. The two most common codes within this theme were related to difficulty in getting the device to recognize commands: 3 participants mentioned the experience of needing to be careful to enunciate clearly when speaking to the device, and 2 participants mentioned the additional need to speak quickly and be prepared when interacting with Alexa. P07 said: *"I guess the only difficulty I found was if I was putting something in a list, or a reminder – mostly the lists – if it was more than multiple words, I had to say the second word quicker than I would have. Because it was only saving that first word, so I'd have to take that one off and then try it again for each item that I was putting on there."*

Positive view of the device. Positive views of the device were expressed 15 times. The device was described by 3 participants as *"fun"* to interact with, and Alexa was personified by 3 participants. The device was referred to many times as *"her"* or *"she"* and was described during multiple interviews as being another *"presence"* or *"person"* in the house. For example, P06 stated that: *"Yeah, it was difficult getting – I shouldn't say difficult, but it was strange, in a word, to realize that there's somebody – although it's obviously a machine, but it's still almost like a person that's around waiting for you to say something. So you've got to get over that feeling. It was kind of weird but eventually you came to accept her as a member of the family."*

The next most frequently mentioned codes within this theme were directly stating enthusiasm for using the device (mentioned by 2 participants) and describing a significant interest in the capabilities of related technologies (also mentioned by 2 participants). Two participants stated that they would like to adopt more Amazon technologies; P05 said:

Table 4. Individual participant device uses. Total Usage Logs indicates the number of usage logs that were discernable and related to specific actions. The complete number of Amazon interaction logs including discernable log entries, entries that were associated with waking or stopping the device, and entries that were not intended for the device are shown in parentheses.

ID	Total usage logs	Most common use	Total PM-related uses
P01	31 (79)	Reminders	26 (84%)
P02	75 (175)	Lists	66 (88%)
P03	24 (41)	Reminders	22 (92%)
P04	52 (139)	Reminders	20 (38%)
P05	207 (386)	Entertainment	69 (33%)
P06	25 (65)	Lists	25 (100%)
P07	40 (65)	Lists	35 (88%)
P08	75 (201)	Lists and Reminders	62 (83%)
P09	94 (188)	Lists and Entertainment	39 (41%)
P10	61 (120)	Lists	49 (80%)
P11	52 (81)	Reminders	48 (92%)
P12	63 (173)	Weather	14 (22%)
P13	44 (101)	Entertainment	14 (31%)
P14	22 (49)	Lists	15 (68%)
P15	63 (132)	Timers	53 (84%)
Average	66.4	N/A	44.7 (68%)

"In fact, after a couple days we happened to go over to Best Buy and we went over to the Amazon table to look at products to, like - to do an upgrade. We have some Ring cameras we're gonna put up that some of this stuff can be synced. I just started looking more and more into what these can do…"

Negative view of the device. Negative views of the device were expressed 3 times. Two participants expressed disappointment with the device in terms of its artificial intelligence capabilities. P09 described interacting with the device as *"boring"* and wished that Alexa were more sophisticated and intelligent as a conversational partner. Several participants were conversational with the device as a form of entertainment, asking her questions such as *"Are you alive?"* For P09, the device's ability to answer such questions was not to a standard that made it worthwhile to interact with.

Device suggestion. Participant P07 provided a suggestion for the device, which included the ability to alphabetize lists. Lists are assorted by section once transferred from the device to the Amazon Alexa app for shopping use, but P07 felt that alphabetization would have been more useful for their needs had they been able to use this function while shopping. They said:

"I guess the only thing that would be useful… because it's probably not something that, um, that it does, would be to - if you could alphabetize, um, lists."

Tip card usefulness. The perceived usefulness of the tip card was mentioned 23 times across the interviews. The most frequently mentioned code within the theme was using the tip card at the beginning of the 10-day period with use gradually falling off (mentioned by 7 participants). The next most common theme, mentioned by 5 participants, was finding the tip card useful as a reminder of how to phrase things when speaking to the device. P03's interview contains an example of both these codes; regarding how often she used the device, she says:

"Well, at first, it was like every day. But then I got the hang of how to do it, so then I didn't need to use it. But it was very helpful in the beginning- the phrasing of it, of whatever I wanted to use it for. It was helpful."

Critique of the tip card. Critiques of the tip card were mentioned 3 times. The size of the tip card (8.5" X 11") was found to be too large for one participant. Another P14 did not have an eye-level place to put the tip card, resulting from the constraint of having limited options for placing the device itself, which must be plugged into the wall. Participant P10 had a similar placement issue where her kitchen lights created a glare from the plastic tip card holder resulting in difficulty reading its contents. Participant P14 said:

"I didn't have the ideal place to put it. Uh, because I just didn't have a – it wasn't at eye level. But that was just me. It was just where the set up was, you know, it was down – it was down a little lower, so, but, it was – it was fine."

Positive view of the tip card. Positive views of the tip card were expressed 10 times. Nine participants mentioned that they liked the design elements of the tip card, and 1 participant expressed general enthusiasm for the tip card. Participant P05 said:

"I think it's set up fine to where you don't – everything was spaced out well enough to where you don't look at something and have to figure out oh my gosh what it is I'm, I've, you know I've got the device on, I need to hurry and figure out what it is. I think it's all extremely clear the way the colors are and all of that. I think it's set up just fine."

Tip card suggestion. Suggestions for the tip card were mentioned 6 times and included adding guidance for more than prospective memory-related tasks, adding a troubleshooting guide for

common issues with the device, and including alternative phrasing for the prospective-related tasks already on the card. For example, P06 described using the phrase *"modify list"* instead of the tip card's *"I would like to add to my list"* instruction and suggested including such alternatives on the tip card. Participant P05 said:

"*Maybe – maybe to include some additional phrases, because initially what I was doing is um… You know, I was going in, I was deleting something, and then going back and saying okay, set it, and then kind of going through the process, you know, all of the steps for an item 'til I thought, you know, I wonder if I can just tell the device to modify it… So that might be helpful to include in there, you know, like device, uh, modify a reminder or device modify something on my list.*"

Positive view (device and tip card). Participant P05 expressed positive views of the device and tip card together as a system:

"*…We use the device to set a reminder. It then asks you the questions that are necessary… It becomes to me just intuitive because it asks you the questions that you need to do whatever exercise it is you're engaged in. So in that sense, the tip card kind of gets you in the door and then the Echo takes over from there.*"

Use of the Echo Dot

Between the 15 participants, there were 1,995 recorded usage logs (also referred to as *"interactions"*) in total. Of these, 797 were used in the final analyses; logs that were incomplete, not discernable, or otherwise compromised were not included, nor were logs that corresponded to waking the device (*"Alexa"* or *"Hey, Alexa"* statements) or telling the device to stop speaking or listening. All further descriptions of the data are presented in this refined context.

Table 4 depicts each participant's total and most common uses of the Echo Dot, as well as their total number of PM-related uses of the device. Total number of device uses over the 10-day period ranged from 22 to 207 (M = 66.4). All participants used the device for PM-related tasks; on average, these consisted of 68% of each participant's total use. Nearly all participants' top uses of the Echo Dot were PM-related, with lists being the most common (7 participants) followed by reminders (5 participants) and entertainment (3 participants). It should be noted that 2 participants had 2 equally common top uses (lists and reminders; lists and entertainment). Two participants used alarms, which were not specified on the tip card or trained during the in-home setup.

Discussion

The current study aimed to examine the perceptions and experiences older adults with diverse cognitive abilities have with an Amazon Echo Dot, and a tip card meant to encourage prospective memory-related use of the device. The study also aimed to assess the frequency and types of Echo Dot use participants engaged in over a 10-day period. 15 older adults with and without probable MCI were given an Echo Dot and a tip card for 10 days and were then interviewed about their perceptions of and experiences with the device and tip card. Quantitative measures of device and tip card usability and device usage patterns were supplemented with qualitative feedback from participants.

Usability ratings of the Echo Dot and the tip card (*Table 2*) were both overwhelmingly positive, indicating that the overall usability of the device and tip card were both excellent. All participants gave the device and tip card usability scores equating to either an *"A"* or a "B," indicating that even those who rated the device or tip card lower still found them useful and easy to use. Interestingly, when completing the SUS for the tip card, the statement *"I think that I would like to use the tip card frequently"*, drew more than one response from several participants. These participants described a high-to-medium rating for the tip card in the first few days of the use period but made a point to mention a lower rating for the later portion of the use period. It became clear that while the tip card was useful for all participants initially, many did not find it necessary once they had a handle on the main PM functions detailed in the card. Qualitative interview data shows that 7 participants reported using the tip card most at the beginning of the 10-day period, after which use of the tip card *"fell off."* Overall, it is clear that the device and tip card were both viewed as useful and easy to use, and the tip card was most useful at the beginning of the use period when participants were still getting used to the PM-related commands.

In their final interviews, participants provided a variety of feedback for the Echo Dot and tip card related to their usefulness as well as positive and negative views, overall expressing more positive than negative views for both the device and tip card. The themes and subsumed codes expressed in these interviews (*Table 3*) are consistent with the views found in prior research on older adults' use of VAAs. Many participants personified the device, replicating themes found in Trajkova and Martin-Hammond's (2020) focus groups of Echo Dot users. Further, focus group members in that work who mentioned memory complaints also stated that the device was useful for replacing pen-and-paper strategies for remembering appointments and shopping lists; this idea was also expressed several times in the interview portion of the present research.

That the interviews in this research are consistent with focus group findings from recent work which had a much longer (minimum 1 year) device use period suggests that the present methodology was successful in giving participants a long enough time period with which to become familiar with the device and have meaningful interactions with it.

The views expressed by participants in this work support the usefulness of the tip card as a VAA device aid. In a recently published study, Kim and Choudhury (2021) placed Google Home devices in the homes of 12 older adults in assisted living facilities for a period of sixteen weeks. From a series of interviews, it was found that the challenges to device use faced by this group were mostly related to an unfamiliarity with the basics of the device and its functionality. In time, these challenges were overcome by those who had overall positive experiences with the device, and those participants became more affected by the persisting issues with the device's limited speech/artificial intelligence technology. Participants who did not have positive experiences with the device were less likely to move past the initial challenge of getting used to it. While the current research focused on a much shorter use period, participants expressed similar challenges with the device. However, in contrast to Kim and Choudhury's findings, the participants here had the benefit of a tip card which helped them develop a baseline of knowledge regarding the device and was described as facilitating positive experiences with the device, such that nearly all participants planned to continue using it after the study period was over (2 even outlining future plans to buy more VAA devices). Kim and Choudhury's study suggests a need for some type of aid that helps older adults overcome challenges related to both an initial *"learning curve"* phase of device adoption and a continued need to remember how to best work with the limited device to achieve one's goals. The prevalence of positive attitudes towards the tip card, both general and related specifically to its usefulness, suggests that the tip card designed in the current research fits well into this space.

Koon et al. (2020) reported that their participants lacked an awareness of the default capabilities of the Echo Dot. In this research, thematic analysis indicates that the tip card served as a useful tool for overcoming this barrier. For example, within the theme of tip card usefulness, a common code was that the device provided a starting point, or base of knowledge, from which participants felt they could expand their breadth of device use. Over time, users were able to figure out their own preferred phrases instead of the phrases provided on the tip card.

Regarding the use of the Echo Dot, there was a wide range in participants' total number of Echo Dot uses over the 10-day period from 22 to 207 uses (*Table 4*). No matter the total uses, all participants used the devices for PM-related tasks such as lists, reminders, and timers. In fact, nearly all participants' most common uses of the Echo Dot were PM-related, primarily lists, followed by reminders. The two participants who used alarms, which were not specified on the tip card or trained during the in-home setup, may have thought of alarms as an extension of reminders or timers. It is possible that the tip card may encourage the use of the Echo Dot in a way that can help older adults with and without MCI complete daily memory-related tasks.

Prior research found less use of VAAs for PM-related tasks than what was found in this study. In their focus groups of older adults who had owned an Echo device for at least one year, Trajkova and Martin-Hammond (2020) found that alarms, timers, and reminders (as well as using the device to check the time) were mentioned less often than using the device to listen to music. Pradhan et al. (2020) found in the usage logs of their 7 participants that Internet- and entertainment-related interactions were much more common than any PM-related tasks. Grocery lists, the most common PM-related use in that study, were utilized by all but one person but only accounted for 4.5% of all usage logs. In contrast, all participants in the current study used the device for PM-related tasks, and these tasks made up the majority of total device interactions. This suggests that the tip card was useful in encouraging PM-related use.

The present study did not thoroughly explore whether participants' interactions with the device changed over time. It is possible that extended exposure to a VAA might impact user experience and behavior. Perhaps as participants become more comfortable with the device, they might use it more frequently. Alternatively, the novelty of the device might wear off with time, and so participants might use the device less frequently. Future research should enable participants to interact with a VAA for a longer period to investigate potential trends or changes in usage patterns and usability ratings. Future research should also include a measure of participants' subjective memory, particularly prospective memory, to explore associations between perceived memory ability and PM-related usage of the device. Finally, future research should implement the tip card developed in the present research within other older adult samples, such as older adults with more severe cognitive impairment, or older adults with lower technology proficiency. This will allow for further enhancements and modifi-

cations of the tip card to best support older adults in their use of VAAs to support PM.

Conclusion

This research contributed to the greater literature in 3 ways. First, the sample population included older adults with diverse cognitive abilities, which allowed the investigation of perceptions and experiences within a group that included people who experience daily memory failures and those who do not. Second, those memory issues were addressed and supported directly by a tip card designed with the input of an expert on cognitive impairment in older adults. Third, in contrast to some recent studies, this sample was required to have a certain level of experience and confidence with using WiFi networks and smartphones, inherently making this a group of mid- to high-technology-using older adults.

It was found that older adults with a variety of cognitive abilities, who use computers and the internet on a daily basis, used a VAA device frequently for PM-related tasks including setting reminders, creating timers, and using digital to-do lists. This implicates an important role of VAA technology in supporting the daily activities of PM-impaired older adults. To a lesser degree, participants also used the devices for entertainment purposes such as playing music, checking the weather, and searching the internet for information. Not only are VAA devices such as the Echo Dot useful for supporting daily memory, but they are also a multi-faceted technology with a range of potential uses, making them a technology with high utility.

These major use patterns can be explained by the most common interview themes expressed by participants after their 10-day use period. Both the device and tip card were perceived as highly useful and easy to use, with many interviewees expressing positive attitudes towards the tip card. The tip card was overall regarded as beneficial and helpful. Together, results suggest that VAAs, paired with a tip card, can be used by older adults with diverse cognitive abilities to aid the completion of daily prospective memory-related tasks.

Acknowledgments

This study was supported by a grant from the National Institute on Disability, Independent Living, and Rehabilitation Research (NIDILRR grant number 90REGE0012-01-00). NIDILRR is a center within the Administration for Community Living (ACL), under the U.S. Department of Health and Human Services (HHS). The contents of this article do not necessarily represent the policies of NIDILRR, ACL, or HHS, and our research findings should not be viewed as having the endorsement of the U.S. Federal Government.

Partial results from this paper were presented within a talk at The Gerontological Society of America 2022 Annual Scientific Meeting on November 4th in Indianapolis, IN, USA.

References

Aggarwal, N. T., Wilson, R. S., Beck, T. L., Bienias, J. L., & Bennett, D. A. (2006). Motor dysfunction in mild cognitive impairment and the risk of incident Alzheimer disease. Archives of Neurology, 63(12), 1763–1769. https://doi.org/10.1001/archneur.63.12.1763

Bangor A., Kortum P., Miller J.A. (2009). Determining What Individual SUS Scores Mean: Adding an Adjective Rating Scale. Journal of Usability Studies, 4(3), 114-123.

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. Qualitative Research in Psychology, 3(2), 77–101. https://doi.org/10.1191/1478088706qp063oa

Brooke, J. (1996). "SUS: a "quick and dirty" usability scale". In P. W. Jordan; B. Thomas; B. A. Weerdmeester; A. L. McClelland (eds.). Usability Evaluation in Industry, 189. London: Taylor and Francis

Brooke, J B (2013). SUS – a retrospective. Journal of Usability Studies, 8 (2), 29-40.URL: http://www.usabilityprofessionals.org

Chen, K., & Chan, A. H. S. (2014). Predictors of gerontechnology acceptance by older Hong Kong Chinese. Technovation, 34(2), 126–135. https://doi.org/10.1016/j.technovation.2013.09.010

Costa, A., Caltagirone, C., & Carlesimo, G. A. (2011). Prospective memory impairment in mild cognitive impairment: an analytical review. Neuropsychology Review, 21(4), 390–404. https://doi.org/10.1007/s11065-011-9172-z

Czaja, S. J., Boot, W. R., Charness, N., & Rogers, W. A. (2019). Designing for older adults: principles and creative human factors approaches (3rd ed.). CRC Press.

Graf, P. (2012). Prospective memory: Faulty brain, flaky person. Canadian Psychology/Psychologie canadienne, 53(1), 7–13. https://doi.org/10.1037/a0026516

Hargittai, E., Piper, A. M., & Morris, M. R. (2018). From internet access to internet skills: digital inequality among older adults. Universal Access in the Information Society, 18(4), 881-890. https://doi.org/10.1007/s10209-018-0617-5

Harrington, C. N., Hare, K. J., & Rogers, W. A. (2017). Developing a quick-start guide to aid older adults in interacting with gesture-based video games. Proceedings of the Human Factors and Ergonomics Society 61(1), 32–36. https://doi.org/10.1177/1541931213601503

Henry, J. D., MacLeod, M. S., Phillips, L. H., & Crawford, J. R. (2004). A Meta-Analytic Review of Prospective Memory and Aging. Psychology and Aging, 19(1), 27–39. https://doi.org/10.1037/0882-7974.19.1.27

Huppert, F. A., Johnson, T., & Nickson, J. (2000). High prevalence of prospective memory impairment in the elderly and in early-stage dementia: Findings

from a population-based study. Applied Cognitive Psychology, 14(SpecIssue), S63– S81. https://doi.org/10.1002/acp.771

Kim, S., & Choudhury, A. (2021). Exploring older adults' perception and use of smart speaker-based voice assistants: A longitudinal study. Computers in Human Behavior, 124. https://doi.org/10.1016/j.chb.2021.106914

Kliegel, M., Ballhausen, N., Hering, A., Ihle, A., Schnitzspahn, K. M., & Zuber, S. (2016). Prospective Memory in Older Adults: Where We Are Now and What Is Next. Gerontology, 62(4), 459–466. https://doi.org/10.1159/000443698

Koon, L. M., McGlynn, S. A., Blocker, K. A., & Rogers, W. A. (2020). Perceptions of digital assistants from early adopters aged 55+. Ergonomics in Design, 28(1), 16–23. https://doi.org/10.1177/1064804619842501

McCreadie, C., & Tinker, A. (2005). The acceptability of assistive technology to older people. Ageing & Society, 25(1), 91-110.

Morrow, D. G., & Rogers, W. A. (2008). Environmental support: an integrative framework. Human Factors, 50(4), 589–613. https://doi.org/10.1518/001872008X312251

Nasreddine, Z. S., Phillips, N. A., Bédirian, V., Charbonneau, S., Whitehead, V., Collin, I., Cummings, J. L., & Chertkow, H. (2005). The montreal cognitive assessment, MoCA: A brief screening tool for mild cognitive impairment. Journal of the American Geriatrics Society, 53(4), 695–699. https://doi.org/10.1111/j.1532-5415.2005.53221.x

Nielsen, J. (1994, April 24). 10 usability heuristics for user interface design. Retrieved March 25, 2021, from https://www.nngroup.com/articles/ten-usability-heuristics

Parasuraman, A., & Colby, C. L. (2015). An updated and streamlined technology readiness index: TRI 2.0. Journal of Service Research, 18(1), 59-74. https://doi.org/10.1177/1094670514539730

Pew Research Center. (June 12, 2019). Mobile Fact Sheet [Fact sheet]. https://www.pewresearch.org/internet/fact-sheet/mobile/

Park, D. C., Hertzog, C., Kidder, D. P., Morrell, R. W., & Mayhorn, C. B. (1997). Effect of age \ on event-based and time-based prospective memory. Psychology and Aging, 12(2), 314–327. https://doi-org.proxy.lib.fsu.edu/10.1037/0882-7974.12.2.314

Pradhan, A., Lazar, A., & Findlater, L. (2020). Use of intelligent voice assistants by older adults with low technology use. ACM Trans. Comput.-Hum. Interact. 27(4), Article 31. https://doi.org/10.1145/3373759

Roque, N. A., & Boot, W. R. (2018). A new tool for assessing mobile device proficiency in older adults: the mobile device proficiency questionnaire. Journal of Applied Gerontology, 37(2), 131-156.

Roque, N. A., & Boot, W. R. (2021). A new tool for assessing older adults' wireless network proficiency: The wireless network proficiency questionnaire. Journal of Applied Gerontology: The Official Journal of the Southern Gerontological Society, 40(5), 541–546. https://doi-org.proxy.lib.fsu.edu/10.1177/0733464820935000

Sanders, E. C., Stuart, R., Exum, A., & Boot, W. R. (2022). Enhancing neurocognitive health, abilities, networks, & community engagement for older adults with cognitive impairments through technology: a scoping review introducing the ENHANCE Center. Disability and Rehabilitation: Assistive Technology, 19(2), 302–312. https://doi.org/10.1080/17483107.2022.2087770

Smith, G., Del Sala, S., Logie, R. H., & Maylor, E. A. (2000). Prospective and retrospective memory in normal ageing and dementia: A questionnaire study. Memory, 8(5), 311-321. Spíndola, L., & Brucki, S. M. D. (2011). Prospective memory in Alzheimer's disease and mild cognitive impairment. Dementia & Neuropsychologia, 5(2), 64-68. https://doi.org/10.1590/S1980-57642011DN05020002

Trajkova, M., & Martin-Hammond, A. (2020). "Alexa is a toy": Exploring older adults' reasons for using, limiting, and abandoning echo. Conference on Human Factors in Computing Systems – Proceedings, 1-13. https://doi.org/ 10.1145/3313831.3376760

Wasserman, V., Emrani, S., Matusz, E. F., Peven, J., Cleary, S., Price, C. C., Ginsberg, T. B., Swenson, R., Heilman, K. M., Lamar, M. & Libon, D. J. (2020). Visuospatial performance in patients with statistically-defined mild cognitive impairment. Journal of Clinical and Experimental Neuropsychology, 42(3), 319-328. https://doi.org/10.1080/13803395.2020.1714550

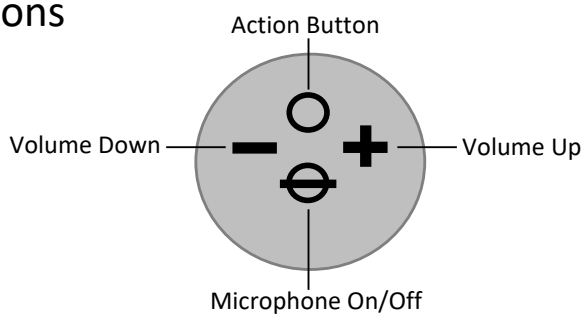
Woods, S. P., Ludicello, J. E., Moran, L. M., Carey, C. L., Dawsone, M. S., & Grant, I. (2008). HIV-associated prospective memory impairment increases risk of dependence in everyday functioning. Neurospychology, 22(1), 110-117. https://doi.org/10.1037/0894-4105.22.1.110

Wu, Y. H., Cristancho-Lacroix, V., Fassert, C., Faucounau, V., De Rotrou, J., & Rigaud, A. S. (2016). The attitudes and perceptions of older adults with mild cognitive impairment toward an assistive robot. Journal of Applied Gerontology, 35(1), 3–17. https://doi.org/10.1177/0733464813515092

Appendix I – Amazon Echo Dot Tip Card

Amazon Echo Dot Tip Card

Device Buttons



Reminders

I want to:	Say:
Create a new reminder	**"Alexa, set a reminder."**
Get rid of a reminder	**"Alexa, delete a reminder."**
Check what reminders are currently set	**"Alexa, what reminders have I set?"**

Lists

I want to:	Say:
Create a new list	**"Alexa, start a new list."**
Remove completed items from a list	**"Alexa, I want to take something off of my list."**
Check what is currently on your list	**"Alexa, what is on my list?"**

Timers

I want to:	Say:
Set a new timer	**"Alexa, set timer."**
Cancel a timer	**"Alexa, cancel my timer."**
Check how much more time is left	**"Alexa, what are my timers?"**
Stop the timer after it has gone off	**"Alexa, stop."**