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Prompting Technology and Persons With Dementia: The Significance of Context and Communication

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Abstract

Background and Objectives: Smart home auto-prompting has the potential to increase the functional independence of persons with dementia (PWDs) and decrease caregiver burden as instrumental activities of daily living (IADLs) are completed at home. To improve prompting technologies, we sought to inductively understand how PWDs responded to auto-prompting while performing IADL tasks.

Research Design and Methods: Fifteen PWDs completed eight IADLs in a smart home testbed and received a hierarchy of verbal auto-prompts (indirect, direct, multimodal) as needed for task completion. Two researchers viewed archived videos and recorded the observed behaviors of the PWDs and their reflections watching the PWDs. Using qualitative descriptive methods, an interdisciplinary analytic team reviewed transcripts and organized data into themes using content analysis.

Results: Context and Communication emerged as the major themes, suggesting that positive user experiences will require auto-prompting systems to account for a multitude of contextual factors (individual and environmental) such as level of cognitive impairment, previous exposure to task, and familiarity of environment. Communicating with another human rather than an automated prompting system may be important if individuals begin to exhibit signs of stress while completing activities.

Discussion and Implications: Additional work is needed to create auto-prompting systems that provide specific, personalized, and flexible prompts. Holistic conceptualization of "successful task completion" is needed and a positive end-user experience will be key to utility. Such systems will benefit from including positive reinforcement, training, and exploration of how, and whether, direct human involvement can be minimized during the provision of in-home care.

Keywords: Smart home, Activities of daily living, Alzheimer's disease, Independence, Technology, Qualitative analysis: content analysis

Caring for the aging population with dementia is a complex problem. Dementia carries the greatest disease burden of all long-term illnesses (Alzheimer's Disease International, 2013), with family caregivers providing most of the long-term services and support. As a result, many caregivers experience increased rates of depression, financial burden, and changes in health and cognition (Alzheimer's Association, 2016; Fonareva & Oken, 2014; Mausbach, Chattillion, Roepke, Patterson, & Grant, 2013). To address the growing needs of family caregivers (National Academies of Sciences Engineering Medicine, 2017) and promote autonomy among persons with dementia (PWDs), we used qualitative methodology to evaluate community-dwelling PWDs' experiences with prompting technology.

Auto-prompting technologies are currently being designed to mimic caregivers and guide PWDs' completion of everyday activities (see Seelye, Schmitter-Edgecombe, Das, & Cook, 2011 for a review). Caregivers generally provide prompts if a PWD fails to initiate a task on their own (e.g., grooming) or after the individual makes an error during task completion and does not correct it. If a prompt is needed, the caregiver provides a context-appropriate prompt and repeats it until the activity has been completed. Consistent with the action of caregivers, compared to systems that rely on time or location to deliver prompts, context-aware auto-prompting systems have been found to be more effective for daily tasks such as medication management (Hayes et al., 2009; Lundell et al., 2007).

COACH is one example of a context-aware prompting system that was designed to assist with handwashing (Czarnuch, Cohen, Parameswaran, & Mihaildis, 2013; Mihailidis, Boger, Craig, & Hoey, 2008). COACH uses a graded cueing system, similar to caregiver cueing (Seelye et al., 2011; Witte et al., 2009), to deliver prompts when an error in handwashing is detected. Up to four prompts are given and the level of support increases with each prompt: (a) low-guidance verbal prompt; (b) high-guidance verbal prompt; (c) multimodal prompt using a prompt and video demonstration; and (d) caregiver call. An early COACH study reported that false alarm prompts led experimenters to observe general frustration and confusion in PWDs (Mihaildis et al., 2008). *Guide* is another context-aware prompting system. It is more comprehensive and utilizes conversational interactions to guide PWDs through more complex tasks such as morning routines and rehabilitation sequences (O'Neill, Best, Gillespie, & O'Neill, 2013; O'Neill, Moran, & Gillespie, 2010). *Guide* uses bidirectional conversation to reduce frustration and the need for caregiver intervention. *Guide* has been tested in naturalistic settings; however, research remains restricted to eight participants with cognitive impairment with single participant interventions (O'Neill et al., 2013).

To date, evaluation of the efficacy of prompting technology has primarily centered on coding whether the prompt was helpful (i.e., task step accurately completed following prompt) and by gathering user feedback about prompting via focus groups, semistructured interviews, or Likert-based questionnaires (Czarnuch et al., 2013; O'Neill et al., 2013; Seelye, Schmitter-Edgecombe, Cook, & Crandall, 2013; Wolters et al., 2015). For example, Seelye and colleagues (2013) found that a verbal indirect prompt (e.g., the oatmeal will burn if the stove is left on), which oriented the person back to task, provided enough assistance for older individuals with mild cognitive impairment to accurately readjust their task performance such that more direct level prompts were not needed. In another study (Van Etten, Weakley, Schmitter-Edgecombe, & Cook, 2016), compared to older adults endorsing few cognitive complaints, older adults endorsing cognitive complaints self-reported greater preference for the more supportive multimodal prompt (verbal and visual) as opposed to verbal indirect and direct prompts. Although these methods allow for evaluation of user accuracy and provide some insight into the user's perception of the system, predetermined questions may constrain understanding of prompting technologies. Furthermore, dementia is known to affect cognitive domains that are necessary for accurate reflection, identification, and communication of one's experience. Thus, obtaining accurate feedback from PWDs may not be feasible.

To circumvent this issue, we took a different approach. Rather than asking PWDs to reflect on their experiences, we reviewed archived video data of PWDs performing tasks while receiving auto-prompts and recorded our observations of their behaviors. Observational methods that code aspects of a participant's experience while interacting with technology have been used in prior work (e.g., Mihaildis et al., 2008; Boyd et al., 2015); however, these codes are typically quantitatively analyzed and reported. We used qualitative research methods to evaluate transcripts of recorded behaviors. We applied cognitive rehabilitation theory (CRT) as an overarching framework for interpretation so findings might best inform development of effective strategies to support aging in place. CRT is a holistic theoretical model which aims to help individuals with cognitive impairment learn real-world tasks and improve daily functioning by emphasizing the importance of personal context, environmental context, and social systems in accordance with rehabilitation techniques (Cipriani, Bianchetti, & Trabucchi, 2006; Wilson, 1997; Wilson, 2002). Effective task completion occurs when a rehabilitation technique is tailored to individual contextual factors and when it addresses a person's level of cognition, emotional state, and motivation level. For example, techniques within the CRT framework should result in an enjoyable task completion experience and provide assistance appropriate to the individuals' level of cognition. The CRT framework is applicable to care paradigms for persons with mild cognitive impairment (Correa Miotto et al., 2008) and dementia (Bahar-Fuchs, Clare, & Woods, 2013; Clare, 2003; Clare, Wilson, Carter, Roth, & Hodges, 2002). Study researchers were from psychology and nursing disciplines. Research questions were: (a) How does a person with dementia respond to smart home voice prompting for instrumental activities of daily living (IADL) assistance?; (b) What behaviors and physical activity follows a prompt?; and (c) When are smart home voice prompts an effective solution (i.e., resulting an in action with intended result) for IADL assistance?

Design and Methods

The video data of PWDs completing IADLs in a naturalistic setting was gathered as part of a larger study evaluating auto-prompting (Seelye et al., 2013). The study was reviewed and approved by the Institutional Review Board at Washington State University.

Sample

Of the 25 PWDs that were part of the larger study, 15 participants were included in this study because video footage was available and they met the *Diagnostic and Statistical Manual of Mental Disorders-IV-TR* (American Psychiatric Association, 2000) criteria for dementia. See Table 1 for participant demographics and cognitive status variables.

Design

We trained two students (hereafter referred to as Recorders) to view the archived videos of PWDs completing a set of eight scripted IADLs (see Table 2 for detailed activity descriptions). The eight activities were completed in the same order by all participants in a smart home testbed (i.e., furnished university apartment with sensors, actuators, cameras, and a prompting system installed) where three small, stationary web cameras mounted to the ceiling captured silent video footage of PWDs in the kitchen, living room, and dining room. If the PWD failed to complete a task step (e.g., failed to turn water on), s/he received a prerecorded prompt which assisted the PWD in getting back on task. Prompts were delivered based on a graded hierarchy (indirect, direct, then multimodal). Study participants were told that they would receive a verbal prompt or be told to move to the closest computer screen (either in kitchen or living room) if they experienced difficulty completing an activity. Participants did not receive training with the auto-prompting technology prior to beginning the activities. Two experimenters monitored participants during the original experiments, delivered activity instructions, and initiated the delivery of prerecorded activity step prompts to help when necessary from an upstairs room equipped with an intercom system and a computer displaying live video feeds from the cameras. When an error occurred, the experimenter typed in an appropriate code and the indirect prompt, prerecorded for the task step, was instantly delivered over a laptop computer speaker to the PWD. The indirect prompt was designed to orient the person back to the task (e.g., it looks like the water is still running). If the indirect prompt failed to assist the PWD with the task step, a direct prompt which told the participant what to do (e.g., press the handle down to turn off the faucet) was then initiated. If the direct prompt failed, the participant was told to go to a laptop computer (in either kitchen or living room), where they then received a multimodal prompt (i.e., direct prompt along with video showing the participant what to do).

Table 1. Sample Demographics and Cognitive Status Variables ($N = 15$)

	Mean (*SD*)	Range
Demographics		
Age (years)	74.6 (7.0)	59–91
Education (years)	16.4 (2.7)	12–20
Gender	73% M, 17% F	--
Ethnicity	100% Caucasian	--
Cognitive Status		
TICS total score	24.7 (4.6)	17–31
	Score (descriptor)	*n*
CDR global score[a]	0.5 (very mild)	3
	1 (mild)	7
	2 (moderate)	3

Note: CDR = Clinical Dementia Rating scale; TICS = Telephone Interview of Cognitive Status.
[a]$n = 13$; CDR score missing for two participants.

Prior to reviewing the archived videos, Recorders were given the research questions and told that we were seeking to understand the experience of older adults receiving computerized prompting for task completion. We *did not tell* Recorders how or when the prompts would be delivered, what the steps of each task were, or that participants had dementia. This was done to decrease Recorders' assumptions about the behaviors of participants in the videos. Recorders were told they would be viewing archived videos of older adult participants interacting with a smart home prompting system that was under development. To achieve intercoder consistency, Recorders were asked to record only observable physical behaviors and to hold at bay any inferable emotions, motives, or thoughts about what they might believe the participant was experiencing. For example, if a participant looked like they were "frowning," we had the Recorder transcribe the action as "turning mouth downwards," as this behavior could be inferred as frowning or simply heavily concentrating. The lead investigator reviewed the first two transcripts of each Recorder and provided feedback to the Recorders prior to the Recorders coding the remaining videos. Recorders also had no contact with each other about the study. Both Recorders coded all 15 participant videos. One Recorder was a Junior undergraduate psychology major and the second was a recent high school graduate; both were completing a summer research fellowship.

Observational Data Collection

Recorders coded data on computers with dual monitors so they could simultaneously view videos from three camera angles and record observations. Recordings were made in a preset table with the headings: Tasks, Behavioral Observations, and Recorder's Comments. Recorders could pause the videos as needed. After completing a transcription, Recorders wrote a half-page reflection of their observations and impressions of the participant's receipt of auto-prompting. This document included: (a) the Recorder's personal experience watching the participant; (b) any emotions, questions, or inferences about the participant's experience; and (c) other salient aspects of the Recorder's experience. This additional reflection, which was later layered onto the observed behaviors document during analysis and used to

Table 2. Detailed Description of Eight Scripted Activities.

Activity	Activity description	Number of steps
1. *Household Chore: Change light bulb*	Change a light bulb, making sure to select the correct wattage light bulb from the storage drawer.	6
2. *Hygiene: Wash hands*	Wash hands in the kitchen sink choosing correct soap and using towel to dry.	6
3. *Household chore: Clean kitchen countertops*	Use soap and a sponge to wipe kitchen countertops.	8
4. *Telephone use: Use telephone and phonebook*	Look up a specified number in the yellow pages of a phone book, operate a telephone, call the number, and write down a message, press a button to repeat the message if necessary.	6
5. *Household chore: Sort and fold laundry*	Fold and sort a basket that is full of laundry for a man, woman, and small child.	2
6. *Meal preparation: Cook oatmeal on the stove*	Boil water on the stove and cook oatmeal according to the recorded directions, which also includes the addition of brown sugar and raisins.	9
7. *Organization: File mail into mail organizer*	Sort and organize bill statements correctly into filing drawer.	2
8. *Hobby: Give instructions how to play a card game*	Retrieve a deck of playing cards, set up a chosen card game, and tell experimenter how to play the card game.	5

inform early emerging concepts, provided analytic team members a way of connecting Recorders' impressions, biases, and influencing thoughts to the PWD's experience. This was important because the Recorder was acting, in essence, as the voice of the PWD.

Analysis

Qualitative descriptive (QD) methods were used to analyze the content of transcripts, which were Recorders' written observations of behaviors exhibited by the PWDs and their reflective documents. We conducted a simple inquiry with low inference interpretations that remained close to the original source (Kahlke, 2014; Sandelowski, 2000). The analytic team reflected on research questions and CRT tenets (e.g., that learning is multidimensional and contextual) just prior to individually engaging in inference interpretation and again during team discussions. Emerging themes were evaluated for their fit and alignment with CRT. Themes were iteratively reworked as needed. For example, CRT's emphasis on the importance of personal context informed theme and subtheme development by guiding discussion of person characteristics that influenced the prompting experience (e.g., gender, a person's approach and ability to complete activities). Additional factors that correspond with CRT's emphasis on context (e.g., level of cognitive impairment, testbed setting, option to communicate and ask for help) and emotional state of being were also discussed.

The analytic team consisted of four experts representing the areas of neuropsychology, gerontological nursing, and assistive technologies. Content analysis was the primary method of organizing data into themes. Analyzed documents included: (a) Recorders' documents, including observations and reflections (n = 2); and (b) a spreadsheet documenting demographics (e.g., age, ethnicity, gender, years of education), performance on the Clinical Dementia Rating scale (CDR; Morris, 1993) and the Telephone Interview of Cognitive Status (TICS; Brandt & Folstein, 2003), prompt level and number of prompts provided for each task per participant, protocol deviations (e.g., the experimenter talked directly to a participant, or a task was discontinued), and amount of time on task and total testing time. See Table 3 for details regarding number and types of prompts provided and task completion time. There were 15 pairs of transcripts, or a total of 30 transcripts, analyzed.

With each pair of transcripts, analytic team members individually read the transcripts and took note of discrepancies and similarities across the two Recorders' observations. Simple summaries detailing initial thoughts and identifying similarities across transcripts were created by each team member. Verbatim text from Recorders' observation and reflection documents supporting emerging concepts (of similarities) were cited with their corresponding line numbers to provide a clear audit trail. After simple summaries were created for five individuals, analytic team members compared notes (via discussion) and a comparison document was created based on analytic team members' simple summaries; this occurred three times during analysis. Iterative and reflexive methods of comparison were used at all stages. Group consensus was sought and obtained at each comparative step. Conflicts were resolved by returning to the original text to seek further insight while concurrently rereviewing the research questions and CRT. Recorders were asked to further comment as needed. Rigor was enhanced by including analytic team members from multiple disciplines and using the techniques of researcher triangulation and peer review (Neergaard, Olesen, Andersen, & Sondergaard, 2009). No themes that emerged early on were dropped; however, several themes were subsumed by more prominent themes. The final result was a holistic comparative low inference narrative which

Table 3. Prompting Response Rates in Accordance With Task Completion ($N = 13$[a])

	Successful with no prompt(s) (*n*)	Successful with prompt(s) (*n*)	Unsuccessful with prompt(s) (*n*)	Task not attempted (*n*)[b]
Change light bulb	1	10	1	1
Time to complete (range in minutes)[c]	2	1–6	3	--
Wash hands	9	4	--	--
Time to complete (range in minutes)	1	1–2	--	--
Clean countertops	7	4	2	--
Time to complete (range in minutes)	1–5	2–6	3–5	--
Telephone	1	6	3	3
Time to complete (range in minutes)	9	2–18	8	--
Sort laundry	6	4	2	1
Time to complete (range in minutes)	3–8	4–11	2–3	--
Cook oatmeal	1	2	2	8
Time to complete (range in minutes)	9	11–12	8	--
File statements	6	5	1	1
Time to complete (range in minutes)	1–6	1–7	2	
Card game	--	4	1	8
Time to complete (range in minutes)	--	4–9	5	--

Note: [a]Prompting response rate information was unavailable for two participants. [b]Participants may not have attempted a task due to technical difficulties, fatigue, lack of time remaining during the testing session, or an indication that they did not know any card games ($n = 5$). Because participants were instructed to follow a recipe for the Oatmeal task which they had written down during the Telephone task, those who unsuccessfully completed the Telephone task ($n = 6$) were not instructed to attempt the proceeding Oatmeal task. [c]When a condition's $N = 1$, the individual's completion time, rather than range, is reported in minutes.

achieved consensus from all team members. A quality audit, which assessed for methodological and theoretical coherence, clear term definitions, and well-substantiated interpretations was obtained from an expert with 20+ years of experience in qualitative research work (Dr. Roxanne Vandermause).

Results

Findings are arranged by major themes and the subthemes that inform them. Themes and subthemes are supported with verbatim quotes from original transcripts (i.e., the observation transcripts or the reflective documents of Recorders; referred to in-text as "observed" or "reflected") and/or language used in simple summaries and comparative analytic documents (presented in italics).

Two major themes, which both aligned with CRT's emphasis on personal and environmental context and social system, emerged as common across all transcripts: *Context* and *Communication*. *Context* included subthemes regarding the *Individual* and the *Environment*. *Communication* included subthemes regarding *Artificial* ways of communicating and the *Need for Humans* when confused or stressed.

Context

The context in which PWDs received and acted upon prompting was important at the individual level to task completion. The appropriateness of prompting (i.e., prompt type, given when needed) affected PWDs' mood and behavior and impacted intended outcomes. Depending on contextual factors such as level of impairment, number and type of prompts received and the appropriateness of prompting, prompting resulted in successful task completion or in negative expressions.

Individualization of a prompting system is needed to provide for specific, personalized prompts. The level of impairment (physical, emotional, cognitive), type of prompt needed, and historical backgrounds varied greatly among PWDs. The prompting system was unable to accommodate individualized needs. This resulted in several types of prompting failures: *prompt needed but not given, prompt received but not needed, and prompt received but error not recognized*. These prompting failures led to poor task outcomes. For example, in some instances individuals completed tasks uniquely but inappropriately and the prompting system was unable to respond in a helpful manner. One elderly male, possibly because he had little previous exposure to the task, had an unexpected result on the laundry task. The Recorder observed: "…he did not fold the laundry. He threw it all on the couch or on the coffee table next to the laundry basket. Things were in disarray." Another participant poured an entire bottle of cinnamon into her oatmeal. Though this participant completed the task as requested, the end product would not have been enjoyable for her. The prompting system was unable to handle these errors and did not provide corrective prompts. At other times, participants were completing tasks in a way that appeared to be familiar to them, and not necessarily wrong, but they received prompts indicating they were completing a task incorrectly. For example, one participant used dish soap in place of hand soap when completing the hand

washing task. When he received a prompt to use hand soap, he was observed responding with "shrugging his shoulders with palms turned up." In other instances, participants thought they were completing tasks correctly, but received multiple prompts because they were not (e.g., using the wrong wattage for the lightbulb task). These experiences resulted in confusion or frustration.

Additionally, the prompting system only prompted when a task was erroneously completed. After receiving multiple prompts (increasing in hierarchy), several participants were observed exhibiting behaviors reflective of feeling unsure or uncertain about continuing (e.g., "hesitating" or "pausing"). The Recorder observed one participant "looking nervously at [the] lamp" after having received multiple prompts. Positive feedback prompting was not provided. The system's generalized approach to excluding positive reinforcement may have impacted some participants' experience in a negative way.

Tasks that required more prompting and/or led to unsuccessful task completion (e.g., telephone use; see Table 3) resulted in more frequent demonstrations of frustration. There also appeared to be a relationship between responses to prompting and level of cognitive impairment (see Table 4). All participants with moderate dementia (CDR = 2; *N* = 3) exhibited negative behaviors indicative of confusion or frustration as they received repeated prompts. For example, one individual with moderate dementia was observed exhibiting body language that changed from a relaxed posture to "fists clenched," another was "clasping the ends of either side of his unzipped jacket," yet another with "hands still on hips, throws hands in the air." Participants with mild dementia (CDR = 1; *N* = 7) exhibited a mixed pattern of behavior. Some started out reacting pleasantly to earlier task prompts and then moving to frustration and confusion as they worked through later tasks and received additional prompts. Others responded with increased focus and attention following task prompts, and were able to complete the majority of tasks. Participants with very mild dementia (CDR = 0.5; *N* = 3) demonstrated less frustration and better task completion and needed lower-level prompts. For example, one participant with very mild dementia was observed to be completing tasks "easily and efficiently."

Environmental components associated with the prompting study itself influenced participants' experiences and was threaded throughout all transcripts. The influence of the testbed setting was captured across multiple participants. For example, one participant was observed repeatedly looking at the camera and "flash[ing] a cheesy smile," which one Recorder reflected on as seeming "nervous." The analytic team interpreted this as a *camera effect* or an awareness with being on camera. Additionally, multiple PWDs were observed having difficulties locating items for task completion (e.g., cooking ingredients, pen, paper). Locating items for everyday activities may be easier for PWDs in their more familiar home setting. Although the components of the testbed environment may be different than those in an individual's real-world setting, it is expected that the environment will impact PWDs' experiences with prompting.

Communication

Prompting was an unnatural, one-way form of communication that sometimes caused confusion, resulting in PWDs attempting a two-way communication with the experimenter. When prompted, some participants increased their attention to the task at hand while others became inattentive. Attentive PWDs changed their actions or behaviors to align with prompting and task completion, though not all completed the task successfully. Inattentive PWDs completion of tasks varied greatly. Postprompt emotions were commonly exhibited and were both positive (e.g., smiling) and negative (e.g., frustration).

Artificial is the word that best describes observed participant-prompting system interactions. Prompts followed a strict format with specific language, were hierarchical, and did not provide a means for the participant to interactively respond. Participants appeared to expect a level of flexibility and interactiveness that was absent. For example, three participants stood out to the analytic team because they

Table 4. Task and Prompting Information According to CDR Severity (*N* = 12[a])

	CDR Global Score		
	0.5 (very mild)	1 (mild)	2 (moderate)
Sample size (*N*)	2	7	3
Tasks not attempted	4	14	3
Tasks attempted	12	42	21
Tasks attempted requiring prompt(s)	33%	59%	76%
Tasks attempted requiring multimodal prompt(s)	0%	26%	14%
Tasks attempted needing human intervention[b]	0%	43%	57%
Overall success rate for attempted tasks	86%	75%	60%

Note: CDR = Clinical Dementia Rating scale.

[a]CDR score missing for two participants and prompting response rate information unavailable for one additional participant. [b]Human intervention could have occurred through the intercom system or face-to-face.

repeatedly returned to the computer screen where instructions were given. One participant was observed to be "moving his mouth a lot in deliberate ways." The Recorder noted he appeared to be trying to communicate with the system. Analytic simple summaries on all participants except one highlighted the concept that *communication goes both ways* and that participants were seeking *two-way communication*. This situation (participants seeking bidirectional communication but not receiving it) was interpreted as being connected to participants' *unsure, flustered, nervous* behavior.

Participants responded to prompts with either increased *attention to task*, or with *inattention*. Six participants responded to prompts with high attention to task. For example, the Recorder observed one participant "hold[ing] air in cheeks, then releases and leans down slightly farther" and another participant being "very deliberate in taking out several papers from the pile now, and putting them in different piles." Five participants responded with behaviors that were not initially categorized as attention to task, but later were thought to be indicative of attending to the prompt request. These behaviors were *frustration* ($N = 1$) and *hesitation* ($N = 4$). Other language used to exemplify the notion of increased attention was: *thinking*, *reevaluates*, *without hesitation*, *immediately*, and *promptly*. Three participants were particularly inattentive after prompting as evidenced by a lack of change in their behaviors. It appeared the prompt had either been ignored, or had not mentally registered. Task completion varied greatly for this group. One participant continued to struggle after receiving several prompts. The Recorder observed: ". . . he still spent a lot of time looking through the phone book . . ." At other times, prompts resulted in worse task completion, increased confusion, and discontinuation of the task, an effect opposite of their intended purpose. For example, one PWD was observed grabbing the garbage can after receiving a prompt to get the laundry basket.

In concert with an action (or inaction), almost all participants exhibited postprompt emotions. Two participants lacked emotion, for example, the Recorder observed that one PWD's "face seems expressionless." The majority of participants exhibited negative emotions. Observed behaviors such as "hands on hips," "shrugging," and "clenching fists" were thought to represent signs of *frustration*, *confusion*, *uncertainty*, *hesitancy*, or *uneasiness*. Three participants receiving prompts exhibited signs that they were happy or content, at least in part. These PWDs were observed "smiling" and/or "laughing" and appeared to be *pleased with self*. One received the highest level of prompt (multimodal) for at least one task, one received multiple mid-level prompts (direct), and one received only one prompt (indirect). The participant receiving only the indirect prompt was also noted to be *hesitant* and *confused* but was not described as being frustrated. The two participants receiving higher-level prompting were also described as being frustrated during some of the prompting experience. It is assumed that for these three participants, receiving prompts was not a negative experience in total.

The ***need for humans*** was expressed in the behaviors of multiple participants who attempted to communicate with experimenters, or with the prompting system itself (see subtheme Artificial above). Face-to-face contact with the experimenter was infrequent but when it occurred it was when the participant was exhibiting signs of stress and significant confusion. Experimenters were observed entering the room to talk to PWDs while they were exhibiting body language consistent with stress (i.e., "waving hands around," "fists clenching," and "furrowed brow"). The times when participants were able to speak directly with an experimenter were marked by observed positive facial expressions and body language such as "smiling," "ease," and "relax[ation]."

Discussion

To improve prompting technologies development for PWDs, we used qualitative methodology and a CRT framework to evaluate recorded observations of PWDs behavior as they completed IADLs and received prompts when errors occurred. Consistent with a CRT framework, to create a prompting system that will support successful everyday activity completion for PWDs, this work suggests that individual, social and environmental contextual factors must be considered alongside end-user needs and emotional experience with the system. Below we answer the research questions and further discuss implications for prompting technology development.

RQ1: How does a person with dementia respond to smart home voice prompting for IADL assistance?

RQ2: What behaviors and physical activity follows a prompt?

In many cases, PWDs acting on auto-prompting instructions appeared to understand what to do, as evidenced by a 76% task completion rate after being provided with prompts (see Table 3). Furthermore, 43% of participants required only indirect prompts for successful task step completion, 42% required at least one direct prompt, and 15% required a multimodal prompt. PWDs' postprompting physical activities included initial movement with intention to complete the task they were prompted on. Subsequent physical activities depended on the PWD's understanding of the prompts. Most often, PWDs responded to prompts with increased attention and an attempt to follow through on the prompt provided. When the prompt facilitated the task step completion, PWDs responded positively. When PWDs were unable to complete the task step, they responded negatively. Task step incompletion lead to frustration without human intervention, thereby reducing prompting technology usefulness for both PWDs and their caregivers.

Prompts in this study were only provided when PWDs completed a task step incorrectly. Behaviors reflective of

uncertainty occurred when multiple prompts were given. Thus future prompting systems need to include positive feedback. Like anyone, PWDs are vulnerable to discouragement when struggling to complete a task without concurrent positive feedback. Although prompts for incorrect steps helped in achieving success, some PWDs' behaviors indicated a poor end-user experience. A lack of positive feedback after completing the steps correctly may have negatively influenced their perceptions of the system and their self-perception of their ability to complete tasks.

The current state of the science is such that prompting systems may not be sophisticated enough to provide prompting at the level of individualization which is needed so that additional stress is not added. Prompting systems need to be flexible so that if tasks are done differently, given the variety of ways to complete a task, the PWD does not receive unnecessary prompts. There were also examples where errors were committed but the prompting system was not capable of providing a prompt to rectify the error. Redefining "successful" task completion is an important consideration if positive postprompt behaviors are desired. Researchers have historically focused on developing systems that identify and correct errors in task-step execution. Our findings suggest that success goes beyond task completion. Therefore, future evaluations of the efficacy of prompting systems should include the PWD's experience as well as the quality of the final product.

RQ3: When are smart home voice prompts an effective solution for IADL assistance?

Prompting appeared to be a more effective solution for less cognitively impaired persons, for those who were responsive to prompts, and when lower-level prompts were used. PWDs with very mild dementia were generally responsive to prompts, needed fewer higher-level prompts, and demonstrated less confusion and better task completion rates following prompts (see Table 4). In contrast, participants with moderate dementia required a greater percentage of tasks be prompted and were observed to exhibit a negative response. On occasion, prompting resulted in worse task completion. Receiving multiple prompts appeared to increase the PWD's negative experience. Progress toward task completion appeared halted when stress increased and prompting assistance was most effective when PWDs were not experiencing negative states of being.

To improve positive emotional responses and increase task completion, especially those with moderate dementia, researchers should provide prompts consistent with the individuals' level of cognition. Here, the techniques of errorless versus errorful learning may be useful (Clare & Wilson, 2004; Sohlberg, Ehlhardt, & Kennedy, 2005). Errorless learning aims to reduce errors during the acquisition phase and to help those with memory impairment avoid inaccurate learning (Clare et al., 2000; Ehlhardt, Sohlberg, Glang, & Albin, 2005). Errorless learning techniques break tasks down into small steps, immediately correct errors, and fade out the use of prompts (Sohlberg et al., 2005) while errorful learning aims to evoke cognitive effort by providing minimal assistance. Research (Page, Wilson, Shiel, Carter, & Norris, 2006) suggests that errorless learning may be more beneficial for individuals with moderate dementia. The prompting system in this study may have been more successful if it had utilized errorless learning and provided stronger prompting support (i.e., multimodal cueing). This is consistent with findings from a prompting study finding that persons with cognitive concerns preferred multimodal prompting over indirect and direct verbal prompting (Van Etten et al., 2016).

Also, the PWDs in this study had no prior experience with the prompting system and participants appeared to be both expecting and seeking two-way communication. Attempts to communicate with either the system or the experimenter commonly co-occurred with expressions of negative emotions by the PWD. In cases where the experimenter intervened, the body language of participants was seen to change from that of distress to one marked by positive facial expressions and body language, including smiling and a more relaxed stance. Prompting systems need to be capable of providing some degree of interaction, so PWDs who attempt bidirectional communication receive an appropriate or helpful response leading to decreased distress. PWDs needing reorientation or further instructions may respond better to human-to-human interaction rather than to human-to-system interaction. Providing practice with the technology and introducing a prompting system early in cognitive decline may improve trust, comfort, and familiarity with the technology.

Although the environment was naturalistic, it was not the PWD's own home, resulting in some difficulties locating items. Furthermore, some PWDs grew fatigued in the latter portions of the test battery. Once this occurred, prompting appeared to be less effective. Though PWDs will not undergo test batteries in the real-world setting, contextual in-home factors exist that could lead to fatigue and PWDs experiencing fatigue in the home setting may respond similarly. Future prompting systems may need to assess fatigue levels and prompt the PWD to rest instead of complete a task. Completing tasks at a time when the PWD is less fatigued may result in the need for less prompts and a more enjoyable experience.

Because prompting was experimenter-driven, false alarms did not occur in this study. Prompting systems need to pick up a variety of errors (especially safety-related errors) confidently and with a low false alarm rate. Based on prior research (Mihaildis et al., 2008) and PWDs' responses to prompts they felt were not needed, it is expected that false alarms will further increase frustration and impact system use. For individuals with moderate dementia, prompting may be more effective for common and familiar tasks (e.g., handwashing). The initial focus for future prompting systems may need to be on prompting for common tasks where errors can consistently be registered

by the prompting system with few false alarms. Once prompting for common daily tasks can be accomplished successfully (using a holistic definition of success) then the design focus can move to encompass more complex tasks, such as cooking.

Limitations

Our results are limited in part by the design of the original, larger study. Recorder observations were limited to what could be seen by three stationary cameras. The view included a majority of the testbed area where the tasks were completed, but anything occurring outside the cameras' views was not captured. No audio was recorded. Access to PWDs' verbalizations may have strengthened our results by providing richer accounts of PWDs' experiences and overt perceptions of the prompting system. However, viewing videos without audio facilitated a greater focus on behaviors and nonverbal communication cues, possibly leading to a purer interpretation of PWDs' experience with the prompting system. Recorders viewed many hours of videos without audio, and maintaining strict documentation of only observed physical movements and behaviors without adding their own interpretation (e.g., "it seems like…" or "it's as if s/he is…") on PWDs' state of being on the observation documents proved difficult. The analytic team used Recorders' reflections as well as any perceptions included in the observation documents and acknowledge that the Recorders gave voice to PWDs' experiences. PWDs also had no prior experience with the prompting system and it is possible that some of the observed behaviors may have diminished or heightened with experience and future research is needed. Because experimenters provided prompts only when deemed necessary, false alarms could not be evaluated. Furthermore, human interference and error in the delivery of prompts may have occurred. It is also unclear whether the need for human contact might have changed if PWDs did not have access to human contact or had been provided training with the auto-prompting technology.

The small sample size also limits the ability to achieve stability in the data and the lack of diversity in the sample limits richness and transferability. All of the participants included in this study were Caucasian and spoke English as their first language. The majority of participants were also well-educated, having completed an average of 16 years of education.

Future Research

Future research should: (a) include measures of PWDs' "attitude" and end-user experiences while receiving prompting; (b) consider the level of cognitive impairment of the PWD alongside the types of prompts to be delivered and a holistic conceptualization of success; (c) consider including errorless learning techniques; (d) have flexible predetermined maps for step-by-step task completion so individual variances can be accommodated; (e) consider the impact of factors like fatigue and experience with the technology; and (f) include more diverse populations. Prototypes should include positive feedback, features that improve trust (e.g., bidirectional communication), and the ability to accommodate the needs of individuals with greater cognitive impairment. Research teams should be multidisciplinary and should include: psychology, nursing, engineering and computer science, and others specializing in gerontology. Additionally, these teams should include both qualitative and quantitative research methodologists. Further application of qualitative research methods may provide deeper understandings of individual preferences, the importance of context, and PWDs' emotional experiences while receiving prompting.

Implications

Auto-prompting systems have the potential to support caregivers and extend PWDs' independence, reducing the number of PWDs needing residential memory care. Our findings indicate that prompting systems will be more effective when the PWD is attentive to the prompt and does not experience negative states of being as a result of being prompted (i.e., confusion, frustration). PWDs with lower levels of cognitive impairment and their caregivers may be the first to benefit from this technology. Early introduction and training to increase comfort, familiarity, and trust may also be important. Including the perspectives (needs and wishes) of PWDs will be vital for clinical translation. To realize safe and efficacious auto-prompting beyond the testbed setting, researchers and clinicians should be mindful of a PWD's mental and emotional state of being and should support policy addressing "do no harm" practice models.

Conclusions

In this study, two Recorders viewed archived videos of PWDs receiving prompting for IADL assistance in a testbed setting. Successful task completion occurred when the PWD was less cognitively impaired, attentive to the prompt and low-level prompts were given. Unsuccessful task completion was attributed to lack of previous exposure to the task, inattentiveness to the prompt, and to higher levels of impairment, fatigue, and task complexity. Unsuccessful task completion was accompanied by behaviors indicative of confusion, stress, and frustration. Additional multidisciplinary work is needed to improve understandings of how individual and environmental factors impact PWDs' experiences with prompting. Future research may benefit from using a framework that underscores holistic humanism, and which deems positive emotional experiences as important to success. PWDs' experiences with prompting systems are multidimensional and contextual. Identifying the factors that influence an individual's experience and success with using prompting systems is important before these systems can be used on a large scale.

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Conflict of Interest

None reported.

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