Domestic Interruptions: A Taxonomy and Resumption Strategies

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ABSTRACT

We present a field study that investigates interruptions and strategies for resuming computerized tasks in older adults' homes. The findings will inform the design of an online cognitive assessment tool to be self-administered at home. Specifically, we aim to design technologies to address domestic interruptions that may impact the validity of assessment results. To do this, we develop a taxonomy of domestic interruptions relevant to older adults' technology use. It encompasses personal interruptions (physiological, emotional, mental and behavioral interruptions), household interruptions (social and technological interruptions), and external interruptions (that are generated outside a home that may impact domestic inhabitants). Finally, from the participants' current practices following an interruption, we propose prevention, mitigation, and resumption strategies for reducing the impact of interruptions on task performance. This research will contribute to interruptions research, domestic computing, and the cognitive ageing literature.

Author Keywords

Interruption, home, task resumption, cognitive assessment, older adults, field study, contextual interview.

ACM Classification Keywords

H5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

General Terms

Design, Human Factors, Performance.

INTRODUCTION

Interruptions are often detrimental to the validity of time-sensitive assessments. In this paper we present a study conducted in the homes of 13 older adults (50 and older) to examine potential interruptions that may impede their performance on computer tasks, particularly a computerized cognitive assessment tool. The findings from this study are expected to inform technological designs for preventing and mitigating interruptions, such as the interruptions shown in Figure 1, which may impact the validity of computerized assessments to be taken by older adults in home settings.

The growth of an ageing population, particularly in developed countries, is associated with an increased prevalence of older individuals experiencing cognitive decline. Hence there is a growing demand for diagnostic services for cognitive impairments such as Alzheimer's disease and related dementias. Currently, cognitive impairments are being screened by healthcare providers in clinical settings, most often using paper-based tests such as the Montreal Cognitive Assessment [19]. Computerized testing does exist, such as the CANS-MCI [4], but requires a clinician to be present. The result can be long wait times for testing and diagnosis, and those with impairment are often diagnosed later than they should be. Thus innovation in cognitive testing is an urgent yet unmet need.

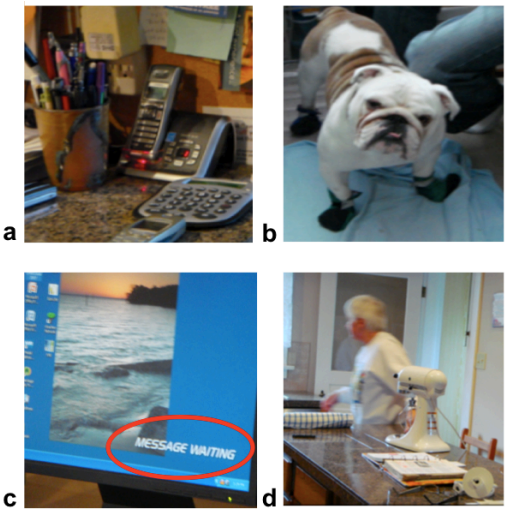

Figure 1. Interruptions in the home: (a) phone calls (b) pets (c) computer notification (circled: message waiting) (d) noises from family members and household appliances.

The study presented in this paper is part of a larger multidisciplinary research project that aims to make cognitive diagnostic services more readily available and to offer a decisive improvement over current paper-based and computerized tools. Cognitive Testing on a Computer (C-TOC) is being iteratively designed and prototyped by researchers and clinicians in neurology, cognitive psychology, and computer science. It takes approximately 30 minutes to complete and consists of 15 different tests, some with multiple trials. Each test assesses a specific cognitive faculty such as memory, language, and spatial reasoning (examples shown in Fig. 2). We expect C-TOC to be used as a screening tool with high sensitivity to mild levels of cognitive impairment, and will thus be used for

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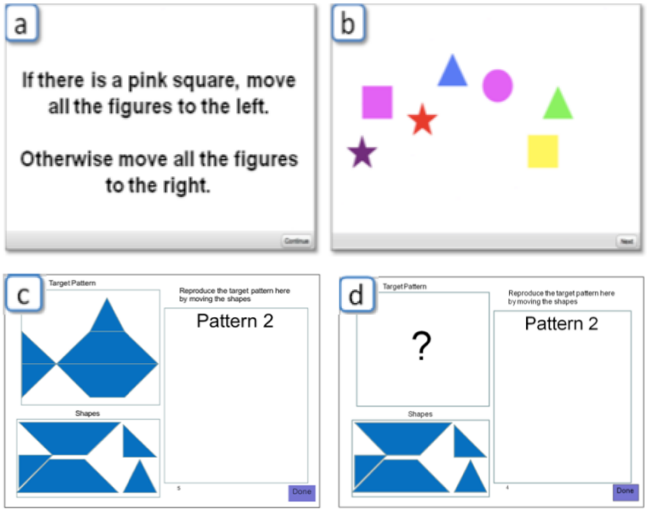

Figure 2. Two C-TOC tasks: (Top) Sentence Comprehension (a) instruction screen (b) execution screen (cannot return to instruction screen) (c) Pattern Construction (target pattern available) (d) Pattern Recall (after several sets of other tasks, target pattern unavailable)

early detection. It will be cost-efficient in that older adults can self-administer the test in the comfort of their home.

Interruptions are pervasive in home environments. Given the goal that C-TOC is to be taken at home as opposed to a controlled clinical setting, it is vital to investigate potential interruptions in and around a home that may hinder older adults' performance on the test. This is because interruptions often have a negative effect on task performance that in turn affects the validity of the test results. While removing all interruptions from a home setting may not be possible, a better understanding of interruptions that emerge in domestic life can help illuminate the design space for technology to prevent, mitigate, and resume from interruptions. We thus conducted a study to examine interruptions in older adults' homes.

This paper makes three contributions. First, we identify a taxonomy of domestic interruptions related to information computing technology (ICT) use in the domestic setting. Second, we identify current practices used by older adults following an interruption. Finally, we propose strategies for preventing interruptions, mitigating the impact of interruptions when they do occur, and resuming the primary task after an interruption. These strategies can be used as guidelines for addressing domestic interruptions in designing computerized cognitive assessments and other applications for use in the home.

RELATED WORK

Human cognitive resources, specifically attentional capacity and working memory, are scarce. Thus interruptions pose a potential threat to task performance as they restrict our ability to focus on the primary task. Our multidisciplinary work entails the need to review research in a variety of literature including interruptions in workplaces, existing taxonomies of interruptions, interruptions in domestic settings, as well as cognitive ageing literature.

There is a wealth of research conducted in controlled settings and in workplaces investigating the impact of interruptions on computerized task performance. In parallel to the fieldwork reported in this paper, we have assessed the impact of interruptions on two of the tests from C-TOC in a controlled laboratory setting [2]. We found that high-demand interruptions caused a resumption lag (the time elapsed when switching from an interrupting task back to the primary task), but did not result in overall lower task performance, relative to non-interrupted tasks; and the same interruptions impacted the two different C-TOC tests differently. By contrast, other studies have shown that interruptions can impact performance negatively [16, 26, 32] in addition to incurring a resumption lag [1, 8, 32].

Interruptions are frequent in workplaces. It has been found that 40% of interrupted tasks were not resumed after interruptions [22]. Jett and George (2003) identified four types of interruptions in workplaces based on a literature review: human *intrusions* (either physically or through other communication channels), *distractions* (interruptions likely in another modality or not in the central field of view, allowing continued execution of primary task), perceived *discrepancy* (diverted from primary task to seek additional knowledge to fill in information gap), and *breaks* (self-initiated). Prior research has also investigated strategies for resuming from interruptions in workplaces. For example, note taking [23] and task rehearsal [12,16] at the point of interruption have been found to help task resumption. While these findings are valuable for informing technology design to address the impact of interruptions in workplaces, they may not be applicable to domestic settings, as they do not consider the intricate and sensitive social factors that constitute the unique demands of domestic life [10]. They also do not cover different kinds of personal interruptions and interruptions external to premises.

There exist several taxonomies for interruptions based on literature reviews. McFarlane (1999) developed a general taxonomy of human interruption that can be used as a tool for describing and analyzing instances of interruption to human beings. Our taxonomy is different in that it is specific to older adults and ICT use and is thus much more descriptive and detailed. Another taxonomy of interruption was developed specifically for hospital settings, which can be used as a tool for identifying potential interruptions when new technology is introduced [3]. Our taxonomy is developed specifically for the domestic setting, encompassing internally generated interruptions, social and technological interruptions within a home, and also interruptions originated beyond the domestic boundary. Moreover, our taxonomy differs from existing ones in that it is developed from primary evidence collected in context, rather than from secondary evidence through literature reviews. We believe that a taxonomy of interruption for the

distinct and intricate domestic setting will be valuable for guiding further investigation into domestic interruptions and for designing telehealth technologies, as well as general domestic computing applications.

While HCI research in domestic settings has received considerable attention, there are few studies that focus on interruptions in the home. These examine the interaction between the technological space and the social space within a home [21], the boundary and the balance between telecommuters' work and home life [20,24], and the interruptibility as a means to evaluate availability of household inhabitants for initiating communication [18,27] or for sending reminders and notifications [13,29].

The cognitive ageing literature suggests that older adults' cognitive capability declines naturally with age, resulting in slower processing speed [25] and reduced activation of working memory [7]. Prospective memory, the ability to remember intentions, is also inhibited in older adults [28], and can be compromised to a greater extent as a result of interruptions [9]. The ability to suppress reactions to distracting or irrelevant information appears to be reduced [11], contributing to further memory interference [31]. Given these changes, it is no surprise to find that older adults have a reduced capacity for multitasking [30]. To our knowledge, there is no prior research investigating potential interruptions faced by older adults in their own home.

METHODOLOGY

We conducted a field study that employed mixed qualitative methods to examine interruptions and strategies to resume interrupted tasks in older adults' homes. Each study session lasted between 1.5 and 3 hours.

Participants

Participants were 13 healthy adults aged 50 and above (mean age 62.7), free from cognitive impairment and motor impairment in their hands. They were required to own and use a computer at home. Participants were recruited through posters placed in community centers in a large city in North America, and through snowball sampling. An online survey was then used to screen for participants with a wide range of computer experience, communication applications used, as well as general computer usage. Our participants consisted of computer novices, using only basic applications like word processing and email, to computer experts, having extensive experience, including configuring and building computers from component parts and using advanced applications such as sophisticated photo-editing suites. In terms of residence, our participants were almost evenly split between single homes (7) and multi-family complexes, specifically apartments (6).

Methods

There were no preparation instructions given to participants before the study sessions. We simply asked to visit their homes at a time when they normally use their computers. Further, if a participant usually uses his/her computer when family members are in the home, we requested that those members be around for our visit. Each study session involved a single participant progressing through three stages. Data collection was by note-taking and video-recording. Interview and observation data were transcribed and analyzed using open coding to identify emergent themes.

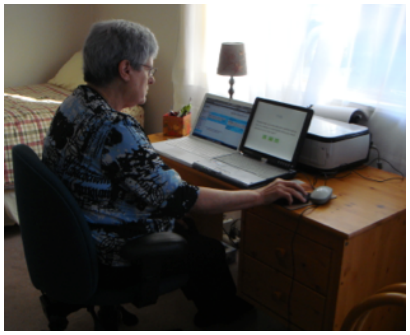

Figure 3. C-TOC running on a notebook computer placed to the right of the participant's computer; participant uses the two computers as "one big computer".

Stage 1: Contextual interview. We explored participants' communication practices including the use of computer-mediated communication tools (e.g., Skype), social media applications (e.g., Facebook), and cell phones through semi-structured interviews. We also enquired about interruptions that would occur in their home, how interruptions were handled, and participants' general task resumption strategies.

State 2: Using C-TOC. We observed participants using the C-TOC prototype. Ideally we would have had C-TOC running on the participant's computer. However, due to limitations of the current C-TOC prototype, we chose a dual-computer set up for our study (Fig. 3). The prototype ran on the researchers' notebook computer while the participant's computer was positioned wherever it normally was, in its usual state. For example, if applications such as email, chat tools, and calendars were usually running, we asked participants to leave them open and running when they started to work with C-TOC. This set up allowed us to observe the activities taking place on participants' computers during the study while they used C-TOC. To compensate for the reduced realism, we asked participants to use the notebook computer together with their own computer as if they were one big computer. That is, if there were things that they would normally attend to in their own computer, they should feel free to behave in their usual way during the study. A drawback of this setup was that these other applications could have become visual distractions to the participants. In a real deployment, most commonly a single computer setup, these applications would likely be obscured by C-TOC. This did not seem to be an issue in our study, however, as our participants generally focused on C-TOC and mostly only attended to their own computer when there were computerized notifications.

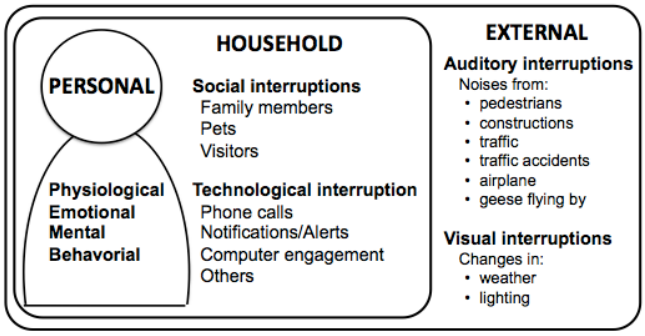

Figure 4. Taxonomy of domestic interruptions.

Stage 3: Post-study interview. Participants were interviewed about their experience with C-TOC. They were also asked about observed interruptions that occurred while they were using C-TOC. We also inquired into their specific strategies for task resumption.

TAXONOMY OF DOMESTIC INTERRUPTIONS

Our findings provide a better understanding of the different kinds of interruptions that emerge in domestic space. Whenever possible, we use concrete empirical instances acquired through the ethnographic inquiry for illustration. Many of the findings we present were reported by our participants during the interviews and a smaller number were observed. Findings that were observed are specifically noted as such.

In this section, we present a taxonomy of interruptions related to older adults' ICT use in the domestic setting. This taxonomy consists of three broad categories of interruptions that emerged from our field study that could potentially impact an older adult's performance on computerized tasks, including computerized assessments: personal, household, and external interruptions (Fig. 4).

Personal Interruptions

Personal interruptions refer to interruptions generated internally within a person; we identified physiological, emotional, mental, and behavioral interruptions.

Physiological. These are interruptions that were generated in response to physiological needs. Common examples were thirst, hunger, bathroom trips, and illnesses. Our participants emphasized that they could become very distracted when they were hungry or thirsty, making them unable to concentrate. "*If I'm hungry, that's priority over plugging into the computer"* (P7).

This kind of interruption often forced them to leave their primary task in order to meet the physiological need. Particularly among ageing adults, illnesses of varying levels of severity are common and have contributed to many instances of interruptions that caused participants to lose focus or to leave their primary task. P4 had arthritis and fibromyalgia. "*I... have arthritis and fibromyalgia so I don't like to sit [at the computer] too long, I might just get up and move around for 5 minutes*" (P4). Another participant was suffering from depression and her mind would be unclear after taking her medication. Thus, she would have to switch her focus from time to time so that she would not become too irritated. Also, P9 had had several minor heart attacks, leaving him with episodic memory problems. "*I have to get up and walk away [from the computer]. I... have that kind of memory… I got to walk away and… refocus…*" (P9).

Emotional. Emotional interruptions identified in our field study were often associated with anxiety generated as a result of unfavorable life circumstances. For example, P3 was very anxious and worried because her mother had been hospitalized for critical illnesses. Her anxiety level would also increase dramatically every time her phone rang, in fear of hearing bad news from the hospital. Another participant P4 was constantly worried about her husband, who was suffering from dementia. We observed that she became very agitated when her husband answered the phone during the study. She also told us about her frustration after she had finished the C-TOC tasks. This echoes previous findings that unpredictable and uncontrollable interruptions can induce personal stress that can negatively affect performance after interruptions [6]. "*I know it was my office number. He [her husband] knows not to answer but he thinks I'm not home. He tried to be helpful but it's actually worse… So I figured that it's important that they leave a message. But now that he's spoken makes it worse. He wouldn't tell me who has called. My anxiety level was going up [sounding angry]… so you noticed that I couldn't read [the instructions] because normally I read very fast. I couldn't read that sentence… I was distracted. Yeah, I was distracted"* (P4).

Many participants commented that the ticking clock icon displayed in some of the C-TOC tasks for reminding them that the task was being timed made them feel uneasy or anxious. Similarly, some participants reported that they would feel anxious if they were being watched over the shoulder while working at a computer, as was the case when they used C-TOC in the study.

Mental. Participants who liked to multi-task acknowledged that their mind could easily wander off from their primary task. This was particularly salient among those who were also curious about their surroundings or desired to maintain a good awareness of their immediate environment. P11 and P13 both considered themselves very easily distracted so they would often stray off to explore different computer applications. They also pointed out that their mind would more easily wander off when the primary task was mundane or unimportant. Our findings were encouraging with regard to the participants' attitude towards cognitive assessments like C-TOC, as all our participants regarded assessments as important and they all wanted to know about their cognitive health.

Behavioral. In the study, we saw participants checking their cell phone for new calls or messages, even when there was no indication of any new communication. Similarly, several participants (P7, P11, P13) reported that they normally

switch constantly between applications such as email, Facebook, browser, and their primary task at the computer.

P11, a retired school principal, pointed out how her posture would affect the level of concentration she placed on a task. Specifically, she associated sitting upright with a formal and more serious task, while sitting comfortably in a couch to work at her MacBook would not provide the same level of concentration, thus would be more easily interrupted.

Household Interruptions

In our field study, we identified a variety of household interruptions (Fig. 1), a snapshot of which coincides with what was described by P4: *"It happens when you have a workman and the computer is going, the home phone is going, the cell phone is GOING [raised tone] and yes, that's very distracting and they're all important. Plus there can be something burning in the stove too [giggle loudly]…and I'm very gadget challenged…"*

We classified household interruptions into social interruptions and technological interruptions. Based on the definitions of social space and technological space identified within a home in [21], we regard social interruptions as interruptions that are generated from "the social structure of the household and the activities performed within the household" and technological interruptions as those that emerge from "the technological environment within the household".

Social interruptions

Family members were identified to be the key interrupters within the social space of a household, followed by pets, and occasionally visitors, both expected and unexpected.

Family members. Our participants reported that their family members often interrupted them when they were working at their computer. Most of our participants lived only with their spouse, whereas 2 participants lived with their children, one also with a grandchild, and another participant always babysat her grandchildren. As expected, participants who had young children in the home were more frequently interrupted. For example, during the study, we saw that the 2-year-old granddaughter constantly demanded P11 to play with her. Similarly, we had to momentarily pause the study several times with P6 due to his wife and daughter (they embraced him when returning from skiing, and initiated several short conversations with him).

We also found it interesting that the general physical movement of family members in and around a household could be interruptive. For example, P7's attention was intermittently diverted to his wife during the study when she was moving around doing chores in the house. Moreover, the level of interruptions and thus anxiety could intensify when family members were in undesirable situations, as were the cases with P3 whose mother was critically ill and P4 whose husband had dementia.

Pets. Five participants each had one or more dogs in their household. Their pets, one way or another, interrupted all five participants during the study sessions. P9 owned six small puppies. He always cuddled one or more puppies on his lap so he was often distracted when working at his computer. He also had to leave his computer to attend to his puppies from time to time. "*If something odd, something going on outside, they [the puppies] will bark… I can tell by the intensity of their barks… that I should get up and check on to it or they don't shut up [chuckling]. And they know too"*.

During the study, we observed that P10's big dog constantly made loud noises from breathing, drinking water, snoring, and scratching walls and carpets, in addition to explicitly demanding attention and care, e.g., gesturing to get on the participant's lap. "*It's very distracting 'cause you can see [the dog] has been making loud noises. If I ever close the door, he would stand outside and cry 'cause he cries. He's just so social. He just loves being with people. But he does it 'huh huh huh' [imitating the dog's crying]"*.

Similarly P11 had had to intentionally tire her two dogs out early in the day of the study so that she was able to participate. Otherwise her dogs would constantly demand attention. *"She [her dog] had been playing all morning. I tired her out this morning intentionally so that she can be quiet now. But you know, I could be sitting here to work and she would put her paw on [my forearm] and something like that."*

Visitors. All the participants indicated that visitors had the highest priority such that they would put aside the primary task when visitors were present. *"If somebody is at the door, I'll definitely have to go to the door"* (P9). *"If I have visitors, I will shut my computer down"* (P7).

Technological Interruptions

All our participants owned and used a computer at home, as required by the study. Collectively, our participants' primary computing resources were 4 PC desktops, 1 Mac desktop, 4 notebooks, 3 MacBooks, and 1 iBook. All our participants also owned and used a cell phone.

In our field study, we identified several salient types of interruptions generated in the technological space within a household: phone calls, notifications/alerts, computer engagement, and other technological interruptions.

Phone calls. All the participants owned and used a "regular" cell phone except P10 who had a smartphone, but none had a data plan; 8 participants also had a landline, 5 of whom only turned their cell phone on when they went out.

Phone calls were found to be one of the largest sources of distraction in a home. As opposed to chat tools in which *plausible deniability* made it more acceptable for people to postpone responses [17], telephone calls were often perceived to require immediate attention and response. Therefore most of the participants would attend to a ringing phone even though it might interrupt their train of thought. Some participants also placed a very high priority on phone calls such that they would always answer the phone when it rang. For example, P1 always attended to phone calls although she disliked phone interruptions because she

found it difficult to shift her attention. "*You started something and you have to talk to somebody about something different [over the phone]. Yeah, changing topic, I'd rather not do that*" (P1).

Some participants would ignore phone calls if they were busy at the time. Yet, many pointed out that it was difficult to entirely ignore a ringing phone as they would still feel anxious, thus distracted, when the phone was ringing. To help alleviate the impact of phone calls, P4 and P5 used the ring tone features to distinguish callers. They found it less disruptive as they were able to identify the callers from a recognizable ring tone without checking the caller ID.

Notifications/Alerts. Although texting or SMS (Short Message Service), and digital calendars are popular applications on cell phones, only 4 participants (P4, P5, P10, P11) had adopted SMS and only P10 had set audio and visual alerts for new messages. P10 was also the only participant who used a calendar on her cell phone. This participant always set multiple reminders on her smartphone to alert her at different times before important calendar events. *"If I put this appointment in it, I will put it in for last night to remind me that it's happening tomorrow morning and I would have it again this morning to remind me that it's today. So I… set the times that it reminds me"* (P10).

Other technological notifications within a home were largely generated from applications running on the computer such as calendars, email, and chat tools in the form of auditory signals and/or visual pop-ups (e.g., Fig. 1c). P4 and P9 were the only participants to use a calendar on their computer. P9 had only turned visual reminders on as P9 had hearing difficulty and thus disliked audio signals. P4 had configured it with both visual and audio notifications in similarly staggered ways like P10's calendar reminders on her smartphone. *"[The online calendar] today reminding me about three times that you're coming"* (P4).

Email notifications were generally turned off on our participants' computers. *"No… I don't use any email alerts. I just check my email when I feel like it. I check it a couple of times during the day and if there's anything really important, tough [looking helpless]"* (P7). In fact, most participants would log out and then turn off their email application as soon as they finished checking emails. Several participants would also turn off their computer immediately afterwards.

Most participants used chat tools on their computer occasionally. Seven of the participants would only turn on their chat tools to engage in pre-arranged chat communications with their family and friends. These pre-arrangements were usually made through phone calls, SMS, or email. The other participants always left their chat tools running whenever their computers were on. These participants had also set up both audio and visual notifications for new chats. *"My skype makes the… musical sound… And if there's a message, I have a little red sign that someone is trying to message me. So when I come back and see that, I know that there's a message waiting for me"* (P4).

In addition, all our participants, except P9, disliked text chats as they found it too time-consuming and too slow to type in real time at the computer.

Computer engagement. All our participants, except P1, would concurrently run multiple applications and toggle between these applications, on their computer. They also pointed out that it could be very distracting, particularly when they were supposed to focus on a specific task.

Our participants spent a substantial amount of time on social networking tools, specifically Facebook, and many indicated that they often had the urge to look through the postings and pictures on Facebook uploaded by their family and friends and to engage in "wall" communications when they were at their computer. Some participants also spent considerable amount of time in playing online games with their friends on Facebook.

Internet diversion is prevalent since chained hyperlinks are so common in websites that people can easily lose track of their original goal when browsing online. Many participants acknowledged that they often got carried away from what they originally planned to do at the computer by chasing hyperlinks one after another. *"If I sit at my computer, I have my email and Facebook going and I'm working on other stuff, that can distract me… I can get distracted if I'm working on something and then I go to do… google search to get information or whatever, come across something that's interesting, ah one link to another, then never ending"* (P10).

Other technological interruptions. We identified other types of technological interruptions that could impact older adults' performance on computerized tasks in the domestic space: interruptions coming from entertainment systems and those coming from household utilities.

All the participants had a TV set in their living room; 7 of them had their "computer space" close to the TV. Also, 2 of them (P2, P7) always had their TV on loud when they were at their computer. They acknowledged that they would often subconsciously listen in to news and TV shows even though they were not watching. They also indicated that the broadcast content often determined the degree of distraction to their primary task. Some content would blend in as ambient noises while others might capture their full attention that they had to stop their task in order to focus on the broadcast. To illustrate, P2 mentioned that reports about the Fukushima tsunami (March 2011) drew his undivided attention whenever the TV was turned on. Moreover, P10's adolescent son always turned the TV on loud and that often interrupted the participant. *"I was sitting at the computer the other night and [my son] had the TV on... It was loud and the dog was doing his thing [making noises]… I had to really concentrate and focus. I… got up to close the doors. Doesn't make a huge difference but it helps"* (P10).

Another source of interruption coming from entertainment channels was the radio or music player. Whether the broadcast from these channels was disruptive generally depended on the content or choice of music genre, as some were more distracting than the others. P13's radio was playing at high volume throughout the study and he sometimes talked about what he heard from the radio, even when he was using C-TOC.

We had not expected that noises from household items such as kitchen utensils and electric appliances including the dishwasher and laundry machine would stand out to be so disruptive when one was working on a task that required considerable attention and focus. In our field study, we observed interruptions brought about by the frequent and casual opening and closing of cabinets and loud noises from operating kitchen appliances like a blender (P7), as well as alarms set off by an oven and microwave timer (P11). Our participants reported that they would become anxious and distracted when they knew that food was being cooked in the kitchen, in fear of burning the food (P4, P6). For example, P6 was roasting a turkey in the oven during the study and the continual sizzling sound coming from the oven was so disruptive that he had trouble focusing in the study. In fact, some of our participants, (e.g., P6 and P11) had to leave momentarily to attend to the interruptions during the study. P10 reported that the need to mentally juggle her time in order to complete her laundry would also be interruptive.

External Interruptions

In addition to interruptions self-generated within an individual and those generated within the household space, disruptive interruptions that originated from outside the domestic boundary were also identified in our field study.

Our participants reported a variety of auditory external interruptions, e.g., noises from people, traffic and traffic accidents, as well as outside construction. Specifically, noisy neighbors had forced P10 to leave her primary task on a regular basis and, on some occasions, to leave her premises entirely. Passers-by such as kids riding skateboards and workmen talking loudly while working outside would also cause our participants (P4, P10, P12) to quit their tasks. Similarly, P8, who lived in an urban area, was distracted quite frequently, and would go out to his balcony to investigate the source of screaming brakes or loud noises from car collisions.

Visual interruptions including those generated by nature were also reported in the study. For example, changes in weather (e.g., snowing) and daylight (e.g., sudden overcast) had reportedly caused our participants (P3, P4, P12, P13) to lose focus on their primary task. In particular, P13 who regarded himself as a "king of distraction" was always curious about his surroundings and would easily lose concentration. He told us that he intentionally placed his computer by the window so that he would not miss anything that was happening outside his apartment. The study was conducted in his living room that was away from the windows, as the physical setting of his usual workspace was so cluttered that no additional person could be present. He became curious when he heard noises coming from the outside. *"See, now there are geese going by [loud noises from the geese]. I'll go out the balcony and go and look why the geese are flying… That interests me… I just want to know what's going on… That's another reason I have computers facing the window there. That's specifically [done] so that I won't miss any of those… Some people put their computer in a place where they won't be distracted. I put mine in a place where I can watch it"* (P13).

IMPACT OF INTERRUPTIONS ON PRIMARY TASK

In general, as an interruption occurs, there exists a range of possible impacts on the primary task. People may manage to largely ignore the interruption and continue to focus on the primary task. Alternatively, they may leave the primary task to attend to the interruption. The latter was reported in our study. *"Sometimes it's too distracting, I might decide not to do it for an hour, two hours, depends on what stage I am at…"* (P4). But participants reported that they most often remained on the primary task while attending to interruptions at the same time. In these situations, people were distracted from their primary task to varying degrees.

Collectively our findings revealed that how participants addressed interruptions and their primary task was determined by these parameters: importance of primary task, individual attentional capability, availability of external intervention, importance of interruption, as well as interruption demand and duration. As the importance of the primary task, an individual's attentional capability, and the availability of external help (e.g., a family proxy intercepting incoming phone calls) increase, there is a higher likelihood that the person will remain on the primary task even when interruptions occur. On the other hand, as the importance of the interrupting task and the demand and duration of the interruption increase, the person will more likely leave the primary task. To illustrate, *"If something is very urgent, you have very little time, the adrenaline will usually kicks in and you have to do [the primary task], and you just do it"* (P4). *"You tune out because you have to be doing something [important]…you have to concentrate"* (P13).

Similarly, P10 believed that her mental strength would help her remain focused on the primary task when she perceived the need to do so. *"I can get refocused… if I choose to [focus]… I can tune things out"* (P10). The following quotes illustrate how other factors impact the participants' primary task. *"[My husband] has a phone down in his studio actually so I'll usually just let him answer it if he's down there"* (P1). *"[My mother] is pretty old so we got lots of emergency phone calls. We'd just go [to the hospital], doesn't matter what we're doing"* (P3).

CURRENT TASK INTERRUPTION PRACTICES

We identified practices that our participants currently employed at the point of interruption and after interruption

to help them resume the primary task. These practices were mostly identified in the contextual interviews.

Preparation at Point of Interruption

Participants were found to take notes, rehearse the interrupted task, or leave the computer screen untouched at point of interruptions.

Note-taking and rehearsal. P4 and P10 had the habit of taking notes while working on a task and specifically at a point of interruption, although we did not observe this behavior during the study. They reported that they would usually refer to these notes as reminders for rebuilding their train of thought after interruptions, similar to the findings in [Parnin]. *"I use sticky notes… I write myself a note… if I have some kind of train of thought… jot down something. I am a jotter so to speak… it helps me to remember better… that's sort of my memory jot, my way to get refocused"* (P10). *"I usually have points written down… basically go back to my notes… So you have to be pretty organized and so if you're not organized, you're not at the stage to complete"* (P4). Similarly, P13 made digital notes at breakpoints. *"I'll actually make a note saying I'll get back to this. I usually use OneNote on Windows… if I'm on Mac and I'll run and get on the other computer and make a note of it. So… at least that's stored somewhere. And I'll stumble over it somewhere later on"* (P13).

Taking mental notes has been found to be beneficial to resumption lag [5] and we also observed several participants making mental notes when using C-TOC. For example, P6 softly rehearsed the task instructions repeatedly to himself before leaving the computer to attend to the sizzling turkey in the oven; he succeeded in resuming the interrupted task afterwards.

It's all there! 10 out of 13 participants reported that they relied on the intact visual content of a task as a crucial element for task resumption. If the task content remained visible after interruption, odds were good that the task could be recovered and resumed at the point where interruption occurred. Some participants would also explicitly leave the mouse cursor at its exact point as a reinforcing visual cue for task resumption. *"It's all there. I might just have to re-read the last bit..."* (P1). *"'Cause everything was just sitting there [the computer]. So it's just sitting there and is opened… the screen shows me... they are right here"* (P2).

This practice however would not be useful for some tasks such as the C-TOC Sentence Comprehension task (Fig. 2). If interruptions occur after the instruction screen, it may not be easy to resume, as the instruction screen will not be accessible once the execution screen is displayed. Some participants failed to correctly execute this task after being interrupted during the study. Others indicated that they would not have been able to resume the task had they been interrupted.

Post-Interruption Resumption Practices

From our observations and the post-study interviews, we identified several practices that our participants employ following an interruption. We asked about both their practices for tasks that they frequently perform (e.g., word processing, spreadsheets, and web browsing) and practices that they would employ for interrupted C-TOC tasks. The practices reported and observed do not necessarily result in task resumption at the breakpoint. Further, some of these practices may not be applicable to C-TOC.

Starting over. Several participants reported that they sometimes chose to restart an interrupted task rather than trying to resume it. This was particularly the case for those who believed that their memory had been declining or for tasks that they were not familiar with. For example, P4 would occasionally go back to the beginning of a legal document after an interruption because there were often many unfamiliar terms and conditions in the document. *"Yeah, sometimes, I have to, well, depends on where I stopped, I may have to read that… all over again"* (P4).

Restarting a C-TOC task was not possible in the current prototype. However, some participants did express that it would be useful if they could restart C-TOC tasks when interruptions occurred.

Backtracking. Participants reported that if the visual content of an interrupted task was available, they could then try to backtrack to a point where they could resume the task. Reviewing most recent entries in an open document for resuming a task was also identified in [23]. Our participants also reported that the amount of backtracking required depended on the type of primary task and their familiarity with the task. Several participants believed that backtracking could also be helpful for resuming certain C-TOC tasks that consist of multiple steps, e.g., the Trails (connecting dots) and Sentence Production (making a sentence from a list of words) tasks.

Recalling. When the visual content of an interrupted task was not available, some participants would try to recall what had been done before the interruption. In our study, we did not observe our participants trying to recall any interrupted tasks. But most participants made explicit effort in recalling while performing memory tasks such as the Pattern Recall task that required them to rebuild a shape from memory (Fig. 2d).

Skipping to the next task. We observed several participants quickly finish an interrupted C-TOC task after returning from an interruption. Subsequent interviews revealed that they did whatever was minimally required just to get that task done, rather than put effort into completing the task correctly. Their belief was that they would not have been able to correctly resume the interrupted task. Therefore they opted to "trash" the current C-TOC task and move on to the next one. They also reported that it would be too stressful if they had to force themselves to perform well on the interrupted tasks. "*I'm not going to put stress and strains on myself to try to remember that… To the best of my recollection… I'm not going to worry about it [the interrupted*

C-TOC task]. I'm not going to sweat over it… I'm basically throwing this one into the garbage can and so let's move forward" (P13).

DISCUSSION

Our findings reveal that interruptions in the homes are diverse and non-trivial, potentially impacting primary tasks in different ways and to different degrees. We recognize the difficulty of addressing external interruptions, as they are largely unpredictable and likely beyond the control of the interrupted inhabitants. It is however important to be aware of their potential impact while we focus on addressing the personal and the household interruptions.

Our findings on current practices employed for task resumption provide insights for developing strategies to prevent interruptions before they occur, mitigate the impact of interruptions when they do occur, and help resume the primary task after interruptions. We note that our findings encompass both observations of our participants resuming C-TOC tests after interruptions, as well as their reports on how they generally approach resuming computerized tasks. Hence, the strategies that we propose should be applicable to a variety of applications including, but not limited to, home-based computerized assessments, such as C-TOC.

Prevention strategies

Prevention strategies can make use of mechanisms such as pre-assessment reminders and warnings to prompt an individual to remove or to take precautions to avoid foreseeable interruptions that may occur during the assessment. For example, reminders for turning off communication and social networking tools can be displayed prior to the start of an assessment. In addition, if a task is segmented, such as C-TOC is with respect to its 15 tests, reminding or warning mechanisms can be tailored for each segment. For example, an individual can be reminded before they start the memory tasks that instructions will only be displayed once. More generally, for an e-commerce transaction, such as booking a flight, the user can be warned that a segment of the task will time out. The individual can then, if necessary, take steps to prevent impending interruptions.

Specific to technological interruptions, mechanisms like a simple button click that can be used to disable all notifications, or to detect the imminence of technological interruptions including phone calls would be useful.

Mitigating strategies

Not all interruptions are preventable. Therefore, it is desirable to design mechanisms to mitigate the impact of interruptions when they do occur during the use of C-TOC. We found two coordination mechanisms identified by McFarlane (1999) particularly relevant to C-TOC design: immediate and mediated solutions.

For interruptions that must be addressed immediately, even in the midst of time-sensitive tasks, we suggest providing a mechanism for the interrupted individual to report being interrupted. The assessment results can then be evaluated accordingly or an isomorphic set of new tasks can replace the interrupted task set. We recognize the possibility of an individual reporting being interrupted when s/he is actually stumbling over a task. However, our findings indicate that older adults desire fair evaluation of their cognitive functioning. Therefore we expect this solution to be feasible. Yet, there is no easy solution if an individual fails to report an interruption during an assessment. We believe that giving a person more than one opportunity to be tested through longitudinal assessments would help but this raises many other issues including budgetary constraints. In fact, many participants, particularly those who often experience anxiety in testing situations, also suggested multiple assessments for diagnosis.

For interruptions that can be mediated, technology can be designed to withhold or postpone the interruptions until the active assessment module is completed. The interruptions can then be handled at the end of the module. Using the flight booking example, notifications for non-urgent emails and chat messages can be withheld until either the transaction is completed or the task segment times out.

Resumption strategies

The strategies that we propose here include those for recapturing an individual's attention from interruption, as well as for facilitating the resumption of an interrupted task.

Notification mechanisms could be used to invite an interrupted individual to return to an assessment task. However this is not likely as straightforward as it seems; it may not be easy to differentiate an individual who has been interrupted from one who is struggling to do the task. Undesirable consequence may result in the latter case; an individual's level of anxiety may increase from inaccurate notifications, thus negatively impacting her/his performance on the assessment. In the former case, a notification system that delivers auditory and/or visual signals may be useful for re-capturing individual's attention that has drifted. However, when and how these notifications should be delivered poses a design challenge [29]. For example, notifications that are intended to help an individual to return to a task may themselves be disruptive to the individual, i.e. to interrupt an interrupting task, as was found in [13]. Other issues such as the mode(s) of notification, the timing, and the frequency to deliver these notifications should be considered, and will require further research.

While providing easy mechanisms for note taking at the point of interruption would facilitate task resumption in many applications, this strategy would circumvent the purpose of certain C-TOC tasks, such as the memory tasks, which were designed to assess recall. In fact, C-TOC takers should be reminded that note taking using external aids is not allowed for these tasks.

For applications that allow note taking, support could be offered in the form of a screen capture that can then be

reviewed after interruptions. Alternatively, a replay of the history of an interrupted task or the use of explicit markers to indicate the state of the interrupted task could also be useful to resume an interrupted task [23]. In the flight booking scenario, a replay of flights that have been considered and compared would help facilitate the transaction as the user can continue to review other flight possibilities.

CONCLUSION AND FUTURE WORK

Our research goal has been to design and develop a computerized cognitive assessment tool for older adults to self-administer at home for prescreening dementia. We set out to investigate interruptions in and around the home setting that potentially impact task performance on the assessment. We aim to design technologies to prevent, mitigate, and help resume from different interruptions. This is a challenging task that no one has addressed before.

We developed a taxonomy of domestic interruptions related to older adults' technology use in the home, encompassing personal, household, and external interruptions. While the taxonomy may not be exhaustive, it provides a useful roadmap for further focused investigations into different types of interruptions for technology design. We also proposed strategies for addressing interruptions at different temporal stages. Future work thus includes designing and prototyping these technological mechanisms for evaluation in context.

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