‘More like a person than reading text in a machine’: Characterizing User Choice of Embodied Agents vs. Conventional GUIs on Smartphones

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ABSTRACT

Embodied conversational agents (ECAs) provide an interface modality on smartphones that may be particularly effective for tasks with significant social, affective, reflective, and narrative aspects, such as health education and behavior change counseling. However, the conversational medium is significantly slower than conventional graphical user interfaces (GUIs) for brief, time-sensitive tasks. We conducted a randomized experiment to determine user preferences in performing two kinds of health-related tasks—one affective and narrative in nature and one transactional—and gave participants a choice of a conventional GUI or a functionally equivalent ECA on a smartphone to complete the task. We found significant main effects of task type and user preference on user choice of modality, with participants choosing the conventional GUI more often for transactional and time-sensitive tasks.

CCS CONCEPTS

• **Human-centered computing** → Ubiquitous and mobile computing; Empirical studies in ubiquitous and mobile computing; Human computer interaction (HCI); Interaction paradigms; Graphical user interfaces; Interaction design; Empirical studies in interaction design.

KEYWORDS

virtual agent, mobile computing, interface modality, experiment

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1 INTRODUCTION

Smartphones are now ubiquitous, and tapping, swiping, and pinching conventional app interfaces comprise an interaction modality that is second nature to most people in developed countries. However, Embodied Conversational Agents (ECAs) represent a still relatively novel modality on mobile devices [7, 18]. ECAs simulate face-to-face conversation with an animated character that uses speech and synchronized conversational nonverbal behavior to provide the look-and-feel of a conversation with a person [10]. ECAs have been deployed and evaluated in dozens of studies on large screen displays [29], but their acceptance and usability on small screens represents an underexplored area of research. Our current effort begins to address this lacuna by studying the kinds of tasks that ECAs are good for on smartphones and situations in which users would prefer ECAs over more conventional smartphone Graphical User Interfaces (GUIs).

In prior work on large screens, ECAs have been shown to have several unique affordances. For example, they provide communication channels such as facial display of affect and gaze and proxemics for conveying immediacy cues that can be important is establishing trust and rapport with users [3, 8]. ECAs can also be effective in providing accessible interfaces for individuals with low domain or computer literacy, by providing a less threatening and more intuitive modality compared to conventional GUIs [5]. ECAs can help improve understanding and retention with grounding behaviors [11], by offering users repair strategies for repeating or rephrasing unfamiliar messages. Finally, by presenting an anthropomorphic interface they can influence users to treat them more socially, for example, by eliciting greater feelings of accountability that can be leveraged in persuasive applications compared to conventional GUIs [22]. Concerns about confusing users or failing to meet their expectations can be addressed by communicating capabilities and limitations, and constraining user inputs to clarify what an ECAs is capable of.

Compared to more conventional tap-and-swipe UIs, ECAs do have their downsides. They take significantly longer to use, given that the conversational model of interaction necessarily makes all operations and choices sequential, grammatically-correct natural language utterances are typically longer than UI text prompts, and listening to speech (about 150 words/minute) is typically slower than reading (around 300 words/minute). Spoken output is also not appropriate in all contexts: users may not be comfortable using speech-based agents in public [20].

A common approach in contemporary UI design is to give users multiple options for performing the same task, exemplified by shortcuts for experienced users [12, 15]. Indeed, one of the motivations for multimodal interfaces is that users should be able to select the subset of available modalities best suited for a particular task. Following this principle, a reasonable approach for including ECAs in the interface is to allow users to perform tasks using either ECAs or conventional UIs whenever possible, allowing them to choose which one to use for a given task and context.

Given such a choice of interface modality for a task, how do users choose which one to use? Jameson and Kristensson provide a roadmap for user preferential choice about the use of computing technology, including choice of interface modality when there is no single "correct" modality to use [16, 17]. They provide a list of factors having to do with: 1) the situation (nature of the task, the environment, and system properties); 2) user characteristics (skills and abilities, evaluation criteria for interaction, demographics); and 3) consequences for interaction (objective aspects of performance such as efficiency and errors and subjective responses such as enjoyment, embarrassment, stress). Given their framework and the nature of the GUI/ECA choice, a user's decision criteria may include: the nature of the task – whether it lends itself more naturally to a brief transaction or a social/narrative interaction; whether the user is under a time constraint; objective aspects of performance—in particular, task efficiency; and personal preference (or dispreference) for the ECA modality, based in part on trust in the ECA.

In this work, we report results from a within-subjects, repeated trials study, to determine the factors that would lead users to choose an ECA over a functionally-equivalent conventional UI on a smartphone. We hypothesize that: H1. Users will choose the ECA for tasks that are more narrative or social in nature, and the conventional UI for tasks that are more transactional in nature; H2. Users who like conversational agents will choose the ECA more often than the conventional UI; H3. Users will choose the conventional UI more often when under time constraints; H4. Users will remember more from interactions with the ECA compared to conventional UI interactions.

2 RELATED WORK

Modality Preference/Choice. Although there are many studies comparing different interface modalities for various tasks, contexts, and user populations, few studies have assessed the outcome of user choice of modality in a given situation. Brumby, et al., looked at user choice between GUIs and audio interfaces for in-car devices in a multitasking situation within a simulated driving exercise [9]. They found that participants who prioritized doing a task while driving tended to select the faster yet more distracting visual interface over the audio interface, and as a result had poorer lane-keeping performance. Xiao, et al., studied giving users the choice of an ECA character compared to assigning them an ECA character [28]. They found that giving users that choice greatly increased the likability and usefulness of the character and enjoyability of the task, and that trust was lower when an inappropriate character was assigned to them. In our case, the focus is not on modality appropriateness, but on preference given task type and constraints. When given a choice, users often have a favorite they routinely use [1, 13]. Thus, investigating if user preferences are affected by task and context is important.

Embodied Conversational Agent UIs. Virtual agents as a user interface modality affect user choice in a unique way. Van Vugt, et al., investigated body shape similarity between users and agents and found that users found fatter (non-ideal) characters more trustworthy and credible, and preferred them over slim (ideal) ones [26]. Baylor investigated the influence of age, attractiveness, and "coolness" of agents on the motivation of students towards engineering as a career [2]. Undergraduate women preferred learning from agents who were male and attractive, even though they were considered "uncool", not like themselves, and not who they aspired to be. Ring, et al., found that perceptions of an agent varied based on the task [24]. Specifically, toon-shaded characters were rated more likable and caring compared to realistic characters in social task contexts, while more realistic characters were found more appropriate for medical tasks. Similarly, Parmar, et al., showed that an agent's attire impacts user's perceptions and task performance [21]. Thus, ECA design adds further complexity to users' interaction preferences.

Comparison of ECAs to Functionally Equivalent GUIs. Few studies have looked at the user perceptions of ECAs compared to functionally equivalent GUIs. Bickmore, et al., studied an agent-based conversational search engine interface designed to allow individuals with low health and computer literacy to identify and learn about clinical trials on the Internet [5]. In a comparison with conventional search engine UI, they found that the participants were more satisfied with the ECA interface and rated the clinical trials they found using the agent as better meeting their search criteria. Wang, et al., evaluated a virtual counselor agent for collection of electronic family health histories as compared with the Surgeon General's My Family Health Portrait conventional UI tool [27]. Participants were highly satisfied with the agent-based interface and rated it as easy to use and follow. Further, the agent interface identified a greater number of health conditions overall as compared with the conventional UI.

These studies show that agent-based interfaces have the potential to improve task performance and user experience. Yee, et al., performed a meta-analysis of empirical studies that compare interfaces with and without ECAs [29]. Their analysis revealed that adding a visual representation of an agent to an interface significantly improves user experience both in terms of task performance as well as subjective attitudes as compared to not having an agent. Furthermore, this effect is larger than the effect of realism of the agent. They further found significantly greater effect sizes for subjective assessments (i.e., questionnaire ratings, interviews) compared to behavioral measures (i.e., task performance, memory).

Agent-based Smartphone UIs. Smartphone-based ECA interfaces provide a great avenue of availability and accessibility of ECAs for various helpful applications. Philip, et al., used smartphone-based ECAs to help individuals with sleep concerns during COVID-19 confinement [23]. The agent helped the users maintain a sleep diary and provided personalized sleep recommendations. Their study demonstrated that the smartphone ECA was able to help users improve their sleep quality. Bickmore, et al., report a design

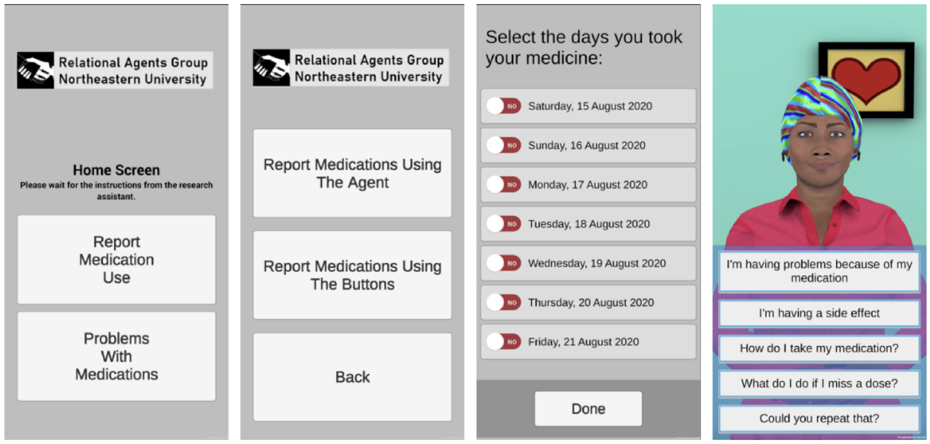

Figure 1: Starting from the left is (1) the home screen of the application, (2) the task choice screen, (3) medication reporting using toggles, and (4) the start of the medication side-effect conversation with the virtual agent.

study showing that an animated ECA on a handheld device was more effective at building trust with users compared to static agent images or text-only interfaces [4]. Kang, et al., describe similar studies into user reactions to an animated virtual agent on a smartphone compared to a static agent image or no image, and found that users have longer conversations with the animated agent [18] and rated agents with a more human appearance higher on satisfaction and perceived co-presence [19].

3 APPLICATION DESIGN

For our study, we selected a domain in which we could provide users with tasks that afforded social and affective information exchange, as well as more transactional interactions. We selected medication adherence counseling, given that counseling on side-effects and other medication problems allows for expression of empathy, and reporting on medication-taking, which is more transactional in nature, given prior reports of successful ECAs for this task [6]. Our specific test cases were drawn from an application for atrial fibrillation self-care management [7].

3.1 Virtual Agent Framework

We developed our smartphone ECA based on the framework described in [7]. The dialog scripts were based on content developed by clinicians for the atrial fibrillation management app. Participants had an introductory conversation with the ECA consisting of a greeting, affiliative humor and social chat to build rapport, and a brief explanation of the agent’s purpose and the application’s capabilities. During conversations about medication issues and medication reporting, the agent displays non-verbal behavior and empathic feedback, such as saying “I’m sorry to hear that” with a facial display of concern when the user indicates they are having issues.

3.2 Conventional UI

The application is developed using the Unity3D game engine and the built-in UI library to display conventional UI elements, such as buttons, labels, and dropdown menus. The application is built for the Android and iOS mobile platforms and the design follows best practices for smartphone applications, for example, having one task per screen and using consistent font, elements, and colors [12, 15].

On the home screen, participants see two task-related buttons, one for reporting medication use and another for reporting problems with medications (Figure 1). For each of these tasks, the participants then see a choice between doing the task using the ECA or using the conventional UI. For medication reporting with the agent, the agent asks the user to report which days they took the medicine over the past week and the user responds via conversational dialogue options. When reporting using the UI, the user sees a screen with toggle buttons to indicate yes or no. Similarly, for discussing medication side-effect symptoms with the agent, the user uses in-dialogue responses to discuss issues and recommendations, while in the UI they select their problem from a dropdown menu and read the recommendations in text form. This allows users to freely choose which type of interface to use for each task.

4 EVALUATION STUDY

We conducted a 2x2 (task-type by constraint) counterbalanced within-subjects experiment designed to test our hypotheses regarding user choice of ECA (AGENT) or conventional UI (UI). Participants completed four tasks: (A) reporting medication intake; (B) getting recommendations for medication side-effects; (C) recommendations for side-effects with the chance of being interrupted mid-task; and (D) reporting medication intake as quickly as possible (Table 1).

Before performing each task, participants completed tutorials using both types of interfaces for the two task types: reporting medication and getting recommendations for side-effects. Then, using the same application, they performed each task in a randomized order, choosing which interface they want to use for each (UI or AGENT), and filled out an app satisfaction questionnaire following each task (Table 2). Following the side-effect tasks, participants were asked to recall the recommendations. A metric of memorability was computed as a ratio of the recollections and those

Table 1: The tasks performed by participants were based on features implemented from our case study application: reporting taking anticoagulation medication and understanding their potential side-effects for patients with atrial fibrillation.

Style Tag	Description	IV – Task Type	IV – Constraint
Task A	Report that you took your medication yesterday and 2 days ago	Medication reporting	None
Task B	Find out what you should do about a bleeding side-effect	Side-effect recommendation	None
Task C	Find out what to do about a dizziness side-effect. You will receive a text message that you need to respond to as quickly as possible.	Side-effect recommendation	Constraint (interruption)
Task D	Report taking your medication 4 days ago, as fast as possible. This task will be timed	Medication reporting	Constraint (time)

Table 2: The single Likert-scale 7-point items for the (1) application, (2) agent satisfaction scales, and (3) additional items, their anchors, internal consistency, and comparison of means, depending on participants' choice of interface.

	Item	Anchor 1	Anchor 2	
(1)	How satisfied are you with the overall app?	Not at all	Very satisfied	Cronbach's α =0.83
	How much would you like to continue using the app?	Not at all	Very much	
	How easy was it to use the app?	Very difficult	Very easy	Agent: M=6.17(1.05)
	How likely are you to recommend the app?	Not at all likely	Very likely	UI: M=6.13(0.86)
(2)	How satisfied are you with the animated character?	Not at all satisfied	Very satisfied	F(1)=1.12, n.s. Cronbach's α =0.96
	How much would you like to continue working with the character?	Not at all	Very much	Agent: M=5.59(1.16)
	How much do you trust the character?	Not at all	Very much	UI: M=4.81(1.77) F(1)=8.02, p<.05
	How much do you like the character?	Not at all	Very much	
	How would characterize your relationship with the character?	Complete stranger	Close friend	
	How much do you feel that the character cares about you?	Not at all	Very much	
	How much do you feel that you and the character understand each other?	Not at all	Very much	
(3)	How much time do you feel it took you to complete the task?	Too little	Too much	

that the app had provided. Lastly, participants filled out questionnaires assessing their perceptions of the agent (Table 2) and had a semi-structured interview. The 'Bond' subscale of the Working Alliance Inventory (WAI) was used to measure participants' trust and confidence working with the agent [14].

4.1 Quantitative Results

A total of 48 participants completed our study: 69% female, 73% had college degrees, and their average age was 36.17 (12.5) years. Most participants used computers regularly, all but one owned a smartphone, and all used their phones regularly. Most (84%) used a software application to monitor some aspect of their health and 50% used dedicated health technology apps. We evaluated the impact of various factors on interface choice (AGENT or UI) using chi-square tests for single nominal factors, and logistic regression with a Wald test for multiple factors.

Participants' choice of interface depended on which task they were faced with, $X^2(3)=8.04$, p<.05. The type of task being performed, i.e., either medication reporting or discussing medication side-effect symptoms, significantly impacted the participants' choice of interface, $X^2(1)=6.95$, p<.05. UI was chosen significantly more often than AGENT for medication reporting tasks, $X^2(1)=6$, p<.05 (Figure 2a). Constraints have a significant effect on participants' choice of interface, $X^2(2)=6.37$, p<.05. Specifically, participants facing a time constraint when medication reporting chose UI more frequently than AGENT, $X^2(1)=9.01$, p<.05 (Figure 2b).

Participants that had a working alliance with the agent lower than the median in our sample, chose UI twice as often as AGENT, $X^2(1)=4.17$, p<.05. Conversely, those with a higher than average working alliance chose both interfaces at the same frequency. Working alliance with the agent is also significantly positively correlated with being satisfied with using AGENT, r=0.66, p<.05. Those with a higher than average working alliance are significantly more satisfied with AGENT than those with low working alliance, M=6.1 (0.51) vs. M=4.23 (1.57), F(1)=115.07, p<.05. Moreover, participants with a lower than average agent satisfaction rating chose UI more often than AGENT, $X^2(1)=9.79(1)$, p=.05, and those that chose AGENT for their task are more inclined to recommend the app to someone than those who chose UI, M=6.07 (1.36) vs. M=5.86 (1.12), W(1)=5294.5, p<.05.

Participants' perceptions of the time it took to complete the side-effect tasks (B and C) depended on their choice of UI or AGENT, W(1)=1472, p<.05. Namely, the time it took to complete tasks using UI was rated as 'too short' while AGENT was 'just right', M=2.85

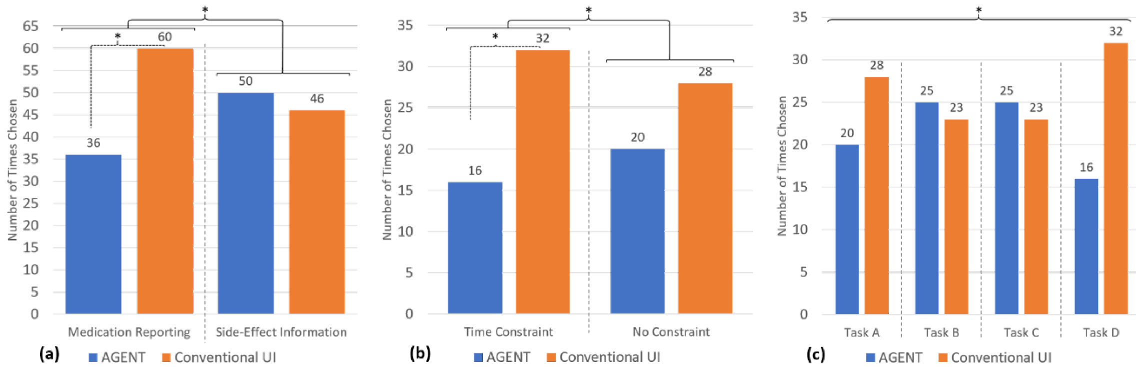

Figure 2: Frequency of participants' interface choices by (a) task type (A+D vs. C+B), (b) time constraint (A vs. D), and (c) task. The tasks are A. reporting medications without constraint, B. getting side-effect recommendations without potential interruption, C. side-effect recommendations while potentially being interrupted, and D. reporting medications under time pressure. * marks a significant difference where p<.05.

(1.48) vs. M=3.54 (1.33). Additionally, participants that use text messaging at a rate above the median in our sample have a significant preference for using UI over AGENT, $X^2(1)=4.49$, p<.05. Those who use text messaging to a lesser extent prefer the agent interface. There were also patterns to participants' choice of interface across tasks. A third (33.3%) of the participants chose the conventional UI for all four tasks, and 18.8% chose the agent interface for all tasks. Participants' age is significantly positively correlated with choosing AGENT (r=.348, p<.05) and agent satisfaction (r=.334, p<.05).

Finally, the participants who chose UI for the medication side-effect (Task B) retained significantly more information compared to those who chose AGENT, 50% (18%) vs. 46% (21%), F(1)=5.32, p<.05.

4.2 Qualitative Results

Interviews were recorded and transcribed, resulting in a total of 5 hours and 11 minutes of audio files and 190 pages of transcription used. We conducted a thematic analysis of the interview transcripts, guided by our research hypothesis and a framework of user modality choices [17]. Our analysis followed the general inductive approach [25], where we inductively coded all transcripts for initial concepts, compared them across interviews, and clustered the themes into higher-level codes. Themes conceptualized from the data describe participant motivations behind their interface choice. During the semi-structured interviews, participants' discussed how the effect of time, environmental factors, their personal preferences, and the nature of the task drove their choice to use the conventional UI or the AGENT. We explore these themes in the following paragraphs.

Simplicity of task and its emotional burden on the user influenced the participants' interface choice. Participants reported that they preferred the conventional UI (buttons and text) to complete the medication logging task and preferred the agent for the more information-intensive tasks (side-effects problem solving): *"logging in the medication. . .was really easy to do without the agent, because it showed...a mini calendar...the last few days. So it was easy to- to get there. But with the side effects, I felt like I would remember it more hearing it verbally than like, reading it in paragraph form"* [P27]. Additionally, some participants felt that the side-effect problem solving task could induce anxiety: *"I'd imagine people suffering from side effects are a little bit panicky, or they're at the very least unhappy with...the situation"* [P34]. P34 elaborated, *"[they] would prefer to be comforted, which the character definitely is"*, further emphasizing how social qualities associated with the agent (e.g. "reassuring"- P5) were better suited for tasks that potentially induce affective responses such as stress.

Time and the user's environmental context are situational factors that affect user interface choice: *"if I'm in a rush and I want to track it [medication], or if I'm going to forget if I don't do it now, I may not want to speak to the agent"* [P39]. Although P39 enjoyed their interaction with the agent, time constraint had a greater causal effect on their choice than their subjective response to the agent interaction. Most participants expressed the same view when time was a constraint, suggesting that time constraints might lead users to put more weight on objective aspects of the interface (in this case speed of input) than their subjective response to the interface when making a UI choice. Participants who imagined using the medication adherence application in a real-world context indicated that maintaining their privacy would be an important concern driving interface choice. Participants compared the benefits of the conventional UI to the AGENT when using the medication adherence application in public spaces: *"I probably use the buttons more...it's more accessible. . .if I was waiting in line somewhere,...[it] might be noisy. . .I'd be more likely to use buttons, rather than kinda have my medical history or medical situation, audible to others"* [P22].

Personal preferences influenced the interface choice particularly among those who completed all tasks using only one interface. Those who preferred the AGENT *"preferred talking to her than reading... I just gravitated towards the agent, just because she felt more like a person than reading text in a machine"* [P25]. Those who completed all tasks using the conventional UI generally preferred reading text over listening to text: *"[reading was] much faster than having to talk to the character. . .I thought the character talked very slowly, and ... I was getting impatient"* [P4]. Some who chose the UI for all tasks reported difficulty retaining information heard orally:

"if you miss something, like sometimes when hearing stuff, you just miss stuff" [P9]. For some, reading was less distracting because *"listening to [the agent] is nice maybe for some people. . .I think it's more distracting. You're not really listening to the details as much as [when you're] reading"* [P42]. Others disliked the AGENT's social chat: *"I guess maybe some people would like that. But...I just want to get the information directly"* [P9].

5 CONCLUSION

Users chose the conventional UI significantly more often for transactional tasks (medication reporting) compared to the AGENT, but did not demonstrate a clear choice between modalities for the narrative tasks (side effect information), providing support for H1. We also found that participants who did not like or trust the ECA modality (below the median on working alliance) chose the conventional UI twice as often as the AGENT over all tasks, while those who liked and trusted the agent chose the AGENT and conventional UI at equal rates, providing support for H2. We also found support for H3: when confronted with a time constraint participants chose the conventional UI significantly more often than the AGENT. Participants remembered more about side effect information when delivered by the UI than when provided via AGENT, leaving H4 unsupported.

We also observed patterns of preference for the ECA based on participant demographics. Those with low smartphone literacy (as evidenced by lower-than-median texting) and older users chose the AGENT more often overall, paralleling prior results demonstrating that individuals with low domain and computer literacy exhibit stronger satisfaction with ECAs compared to those with higher levels of literacy [30]. In interviews, participants indicated they chose the conventional UI because they felt it was faster, more direct, and had fewer privacy concerns, while those who chose the agent indicated that it was interactive, fun, and interesting, and would be better at information-rich tasks and comforting.

Overall, the results indicate that for quick transactional tasks, tasks under time pressure, or in situations in which privacy is a concern, a conventional UI should be provided. However, in other situations, ECAs could be offered as an alternative, especially for users who are older, have lower smartphone literacy, or simply prefer ECAs. There are several limitations to our study beyond the small convenience sample used. The test tasks and experimental setting lacked some degree of ecological validity, and it is not clear how our results will generalize to free-living longitudinal user behavior. We also used relatively simplistic tasks that were not familiar or relevant to our study participants.

There are many exciting directions for future research. The way interface choices are offered—including the order they are presented in, the nature of any tutorials, and guidelines from the app presenter—could all have strong influences on user choice and should be explored. User behavior over time would be important to study, to determine whether there are patterns of choice that emerge. Automatically providing one interface over the other depending on task type and context of use also represents an important area of exploration. Finally, it would be important to determine whether our results hold for other kinds of apps and tasks beyond medication management.

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