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An Information Behaviour-Based Approach to Virtual Doctor Design

Jaisie Sin
University of Toronto
Toronto, Canada
js.sin@mail.utoronto.ca

Cosmin Munteanu
University of Toronto
Mississauga, Canada
cosmin.munteanu@utoronto.ca

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Abstract
Information behaviour models have been used extensively to explain people's interactions with information, such as in information search and user behaviour in libraries. However, we do not yet know the connection between components of information models and the interface design of digital systems, particularly when these are designed to support marginalized users such as older adults (OAs). Yet, this connection may relate to users' perceptions and subsequent adoption of emerging technologies, such as the autonomous virtual agents (VAs) functioning as advice-dispensing chatbots (increasingly present on mobile devices). We explore here the feasibility of information models in informing our understanding of how OAs may use and perceive a VA. For this, we use the information search process (ISP) model to explain the results of a case study with health information VAs and speculate on the implications of the ISP on the design of mobile-based VAs, chatbots, and voice-based interfaces.

Author Keywords
Information Search Process; Sociotechnical Systems; Virtual Agent; Chatbots; Embodied Interaction; Voice Assistants; UX

ACM Classification Keywords
H.5.2 User Interfaces; J.4 Social and Behavioral Sciences

A Map of the Six Stages of the ISP (stages 1-3)

Initiation | *realization of a gap in knowledge or understanding*
-brainstorming, discussing, understanding approach to problem
-apprehension, uncertainty

Selection | *identification of the general topic to be investigated*
-deliberation of prospective search topics, weighing against task requirements, time, personal interest, and information sources
-optimism; anxiety rises until selection is made

Exploration | *struggling for personal understanding of the **general topic***
-difficulties with information that seem inconsistent/incompatible or that conflicts with previously-held constructs
-uncertainty, doubt

Figure 1: Summary of the characteristics of the first two stages of the ISP, from the perspective of the searcher.

Introduction

Virtual agents (VAs), computer-generated artificially intelligent virtual characters, have been increasing in ubiquity as mobile applications such as health- and finance-related chatbots, with examples including virtual "therapists" and "doctors", such as the Woebot or DocOn [6,15], and financial advising chatbots [3]. Due to VAs' ability to be continuously connected to the internet ("always on") and thus accessible remotely, VAs have great potential in tasks involving the relaying of information pertaining to critical services, such as those related to health and finance, to consumers. However, the transition of such key services to digital platforms like VAs risks marginalizing user groups such as older adults (OAs), who at the same time would benefit the most from these changes due to reasons like increased access to essential services. These risks become amplified by VAs' increasing ubiquity on mobile devices, in contrast to traditional VAs which have been embodied as kiosks, and thus may pose challenges in terms of the trust and adoption of VA technologies.

The aspect of information provision in relation to the design of VA systems is understudied. Here, we explore the applicability of information behaviour theory to VA design through a case study that investigated OAs' perceptions of VAs in an experimental setting. For the study, we had speculated that by better understanding OAs' perceptions of VAs, we can better determine criteria that will assist designers in investigating how to make VAs more adoptable by OAs. Thus, we conducted preliminary research into Virtual Doctors (VDs) to study how various design choices may affect VD adoption by users. Given the lack of prior research on this topic, we hoped that such an investigation would help frame further studies that will more rigorously measure the relationship between design choices and metrics of user adoption. To start, we began with studying two design choices (VA agency and fidelity) and studied their relevance with respect to user adoption factors. The results suggested that OAs' perceptions of VDs did not rely strictly on the anthropomorphic or modality of the interaction, but that their perceptions are more dependent on the information context.

In this paper, we discuss the results of the study and relate them to a model of information seeking behaviour. In doing so, we adopt a sociotechnical approach to VA design and show how sociotechnical facets such as human information behaviour can be used to inform the design of virtual agents, chatbots, and any other systems used by humans to interact with information. By viewing the design of mobile interfaces through the lens of information behaviour, we have an additional valuable framework to use when considering the design of mobile devices and services for improved user experience and the better meeting of users' needs.

Background and Related Work

Telemedicine and Virtual Agents

Telemedicine allows patients and doctors to connect remotely in real-time [7], thus making healthcare and specialized care more accessible. Telemedicine has received positive reception by those who have used such services [8]. Research has demonstrated the use of VAs for various healthcare applications [1, 16, 17]. However, the use of VAs in telemedicine to represent a real doctor is also only a recently emerging development [11], but this possibility has seen growing interest from all ends of the pipeline [12, 15]. Yet, user perceptions and the sociotechnical aspects of telemedicine have yet to be thoroughly studied. In

A Map of the Six Stages of the ISP (stages 4-6)

Formulation | *formation of focused personal* perspective of the topic
- pivotal stage
- certainty, confidence, clarity

Collection | *seeks* ***specific information*** *that is relevant to their focused perspective*
- gathering information on the focused topic
- certainty, confidence, and interest in the topic

Search Closure | *search completion*
- ready to summarize, report, or use findings as a personal synthesis of the topic or problem
- relief, satisfaction/ disappointment

Figure 2: Summary of the characteristics of the third, fourth, and fifth stages of the ISP, from the perspective of the searcher.

turn, the design guidelines and principles informed by this approach are largely unexplored.

Information Seeking Behaviour

Many models try to explain the approach by which humans obtain information. One highly referenced model that breaks down the steps of information seeking behaviour is the Information Search Process (ISP) [10], which was proposed and developed by Carol Kuhlthau and quantitatively and longitudinally verified and refined. Subsequently, ISP maps the information seeking journey in terms of the feelings, thoughts, and actions of the searcher against six stages of Initiation, Selection, Exploration, Formulation, Collection, and Search Closure (as shown in Figures 1 and 2), which can occur in multiple sessions and across an extended period of time.

Experimental Investigation

Here, we present a case study to illustrate the applicability of the ISP. Extensive details about the study such as the selection, inclusion, recruitment criteria, details of the observations of participants, and study protocol of the study can be referenced in the corresponding CHI 2019 Late-Breaking Work Paper [13] and in [14]. We conducted a 2x2 study of different VA interfaces to see how anthropomorphism might impact OAs' perceptions of VAs. We compared four different interfaces based on the VA's fidelity of representation (voice-only vs. embodied) and the agency of the doctor (human vs. machine/robot), as summarized in Figure 3 and visualized in Figure 4. The Wizard-of-Oz methodology [9] was used for the VoiceVA and VideoVA interfaces. The interfaces were displayed on an ASUS Transformer Book 10.1" tablet.

Five OA participants (aged 60+; two male, three female) were recruited for the study, which was conducted in a research lab located in a large metropolitan area. The participants tried using each of the four interfaces in turn to discuss preassigned health topics with the doctor (i.e. Hypertension, Osteoporosis, Shingles, and Type II Diabetes). As conversational icebreakers, participants were suggested some leading questions (Figure 5). The order of presentation of the four interfaces and the specific interface-health topic pairs were counterbalanced between participants. Although this research was preliminary and exploratory in nature (and thus no hypothesis testing was carried out as there was little prior knowledge in which to ground a hypothesis), it was still important to counterbalance the conditions.

After each interface was tried, participants were asked post-task interview questions about their perceptions, confidence, and adoption of the respective interfaces. After all four interfaces were tried, participants were asked post-session interview questions that compared their experiences based on fidelity and agency.

Results and Discussion

Inductive thematic analysis, as developed by Braun & Clarke [4], was used to code and analyze the themes from the post-task and post-session interview data. The results are based on analysis of the high-level themes and their composite subthemes. The results indicated a connection between the fidelity and agency of the doctor and the type of information that older adult users preferred receiving from the particular interface. Thus, here we relate the VA interaction process and the study findings to the Information Search Process (ISP) [10], a well-cited information model, to explore how

Agency of Doctor	Fidelity of Representation	
	Voice-calling	**Video-calling**
Human	Voice-calling a Person (VoiceDr)	Video-calling a Person (VideoDr)
Robot	Voice-calling a Robot (VoiceVA)	Video-calling a Robot (VideoVA)

Figure 3: Summary of the 2x2 Design resulting in four conditions in the study. The combination of human and voice-calling (top left of the table) is reflective of the most common form of telemedicine. On the other hand, the commercial trend is moving towards video-calling a robot (bottom right of the table).

ISP can inform the findings and future research, design, and evaluation of VAs, as described in the next paragraphs.

Stage 1 of **Initiation** was triggered in the study by the nature of the task to ask the doctor for information related to the respective health topic. In a real setting with an OA, a search may be triggered upon the OA hearing of a diagnosis with a medical condition.

A voice-only robot interface seems to be preferred for Stage 2 of **Selection**. The OA participants reasoned that speaking to a robot meant that work previously done by a human doctor can be offloaded to a robot so that the doctor's time can be focused into more important tasks (P2, P4), that OAs can feel less discomfort contacting a robot for seemingly repetitive, uninformed, or embarrassing questions (P2, P4, P5), and that healthcare would be more accessible for OAs since they can contact a robot on a moment's notice (P1, P3, P5). These remarks suggest the impression that a robot doctor suits the information search actions in Selection, where searchers cast their net wide to form a perspective on a topic. These results also suggest that a robot doctor would best help searchers navigate and cope with the feelings of confusion, uncertainty, and doubt that arise in the Selection stage.

Moreover, the robot was also indicated to be more suitable for the **Selection** stage due to its diminished presence of identity (e.g. nationality, place of schooling), especially when combined with voice-calling, when the robot was simply a voice (P1, P4, P5). The voice-only robot interface was seen to be less distracting, which would be beneficial in the Selection stage, where the focus is on the searcher's goal of forming a personal perspective on a topic, without being distracted by any irrelevant details.

In stage 3 of **Exploration,** for reasons similar to those in the Selection stage, the voice-only robot interface also seems to be preferred for the Exploration stage.

For stage 4 of **Formulation**, the study design did not explicitly ask for participants to relate the general health topic to themselves, and thus no conclusions on the relationship between VAs and the Formulation stage can be drawn.

Video-based human interfaces seem to be preferred for Stage 5 of **Collection**. This is because such interfaces were indicated as preferred by OAs for questions that were more focused and specific to the OA. One example of such a question was how one could tell if a pain in their joints is due to arthritis or due to osteoporosis (P2). Such a question implies that the searcher already has background knowledge to form a focused perspective of the topic and thus can ask questions that are more personally relevant – this indicates that the searcher is likely at the Collection stage. At this stage, the participant is more receptive to and desiring of contact with a human doctor for the personal connection factor. A video-calling interface, where the participant could see the doctor's face, was seen as more personal and conducive to a back-and-forth conversation (P5). The process is further enabled by a human doctor's perceived ability to be better able than a robot to identify a patient's real question, even if a patient lacked the knowledge to articulate it (P4). This observation may contribute to the human's role in the Collection stage to help the searcher extend their knowledge in the search focus.

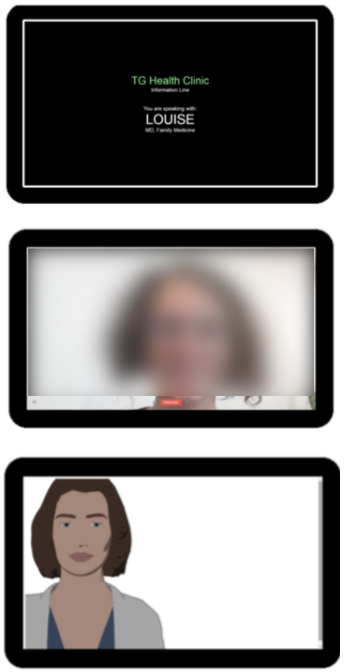

Figure 4: The four interfaces. In VoiceDr (top), participants heard the voice of the doctor. In VideoDr (middle), participants spoke and saw the doctor, who also played the "Wizard" in the WoZ set up in VoiceVA (also top) and VideoVA (bottom). In VoiceVA and VideoVA, Litebody [2] and CereProc's CereVoice Engine Software Development Kit [5] provided the visual and audio for the AI, respectively.

For Stage 6 of **Search Closure**, due to practical considerations given the context and our participants, the study was designed to conclude after one round of questions. Participants did not ask repeated questions until they were satisfied with the answer, and thus no conclusion about Search Closure can be drawn.

Conclusion and Future Work

When the study was conceived, the expectation was a one-on-one relationship between VA design choices and user perceptions. However, it was discovered that the relationship is more complicated and that user perceptions of VAs are related to the information context. This relationship between design elements and user information context was unexpected; however, not only can this relationship be explained through models of information behaviour, but these models can help inform the design and further investigation of the design of VAs, chatbots, and voice-based interfaces. It prompts a question about "how one might one better understand a users' information context to lead to the design of better adopted mobile VAs, chatbots, and voice-based interfaces alike?"

It also prompts questions that ask what types of interfaces are best for each stage of the ISP, as well as questions that are more specific to the types of interfaces that were explored in this study. For example, one could ask "how might we better design chatbots and voice-based VA interfaces to facilitate the Selection and Exploration stages of the Information Search Process?" Another question could be "how might we better design human-based video interactions to better facilitate the Collection stages of the Information Search Process?"

Factoring in information behaviour, such as the ISP, is one way to incorporate a sociotechnical approach to building designs that better accommodate users' needs and increase their likelihood of adoption of key systems. Next steps for this research are to conduct comprehensive studies that seek out more participants and consider further refinement based on additional criteria (such as OAs' experience with technology, ability, education, and socioeconomic status). Additionally, such studies will seek to reveal potential correlations between VA acceptance factors and OAs' internet and smartphone literacy, factor other VA components and their relationship with ISP such as fidelity of representation, and study how ISP applies to OAs with medical conditions prevalent in this user group (e.g. dementia). We also intend to explore the influence of VA design on OAs' perceptions of these technologies in other critical information spaces such as the fields of law and finance, where VAs are also emerging as digital alternatives to traditional forms of information services.

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1. What is <health condition>?
2. What causes <health condition>?
3. How would I know if I have <health condition>?
4. How is <health condition> diagnosed?
5. What happens if I don't treat my <health condition>?
6. Can you cure <health condition>?
7. How do I prevent <health condition>?
8. What should I do if I think I have <health condition>?

Figure 5: Examples of questions for the four health topics discussed during the main part of the experiment (Hypertension, Osteoporosis, Shingles, Type II Diabetes). <health condition> refers to one of: "Hypertension", "Osteoporosis", "Shingles", and "Type 2 Diabetes". Each participant engaged with all the topics across the experiment, with topics randomized and counter-balanced over the combinations of experimental conditions described in Table 4.

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