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Research Report

It's only a computer: Virtual humans increase willingness to disclose

Gale M. Lucas[a], Jonathan Gratch[a,*], Aisha King[b], Louis-Philippe Morency[a]

[a] Institute for Creative Technologies, United States
[b] Bard College, United States

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ABSTRACT

Research has begun to explore the use of virtual humans (VHs) in clinical interviews (Bickmore, Gruber, & Picard, 2005). When designed as supportive and "safe" interaction partners, VHs may improve such screenings by increasing willingness to disclose information (Gratch, Wang, Gerten, & Fast, 2007). In health and mental health contexts, patients are often reluctant to respond honestly. In the context of health-screening interviews, we report a study in which participants interacted with a VH interviewer and were led to believe that the VH was controlled by either humans or automation. As predicted, compared to those who believed they were interacting with a human operator, participants who believed they were interacting with a computer reported lower fear of self-disclosure, lower impression management, displayed their sadness more intensely, and were rated by observers as more willing to disclose. These results suggest that automated VHs can help overcome a significant barrier to obtaining truthful patient information.

1. Introduction

Science fiction has long predicted that humans would live alongside computers. Such computers often resemble humans – robots that are embodied, or "virtual human" animated characters that interact with people in a natural way (i.e., via speech). Importantly, Sci-fi writers envisioned a world in which computers develop relationships and become intimate with humans.

Virtual humans (VHs) that can develop intimacy with people are now becoming reality. Researchers have successfully incorporated social skills (e.g., active listening, mimicry, gestures) into VH systems (Bickmore et al., 2005; Gratch, Kang, & Wang, 2013; Gratch et al., 2007). Indeed, compared to their predecessors, VH with such social skills increase feelings of connection and *rapport* (the experience of harmony, fluidity, synchrony, and flow felt during a conversation; Gratch et al., 2013). Equipped with these skills, VHs could be particularly useful as tools. For example, users' experiences can be better standardized with VHs than with human beings. VHs can also provide a "safe" environment, which could encourage learning or honest disclosure of important information.

The healthcare field, in particular, may benefit from this latter potential advantage of VHs: honest disclosure. Failure to provide fully honest responses in medical interviews can result in serious consequences for patient health. Therefore, much research has considered how to gain more detailed and honest medical histories, especially sensitive information, from patients (Maguire, Falkkner, Booth, Elliott, & Hillier, 1996; Roter & Hall, 1987).

Although a number of factors may contribute to patients providing more honest, detailed information to healthcare providers (Beckman & Frankel, 1984), psychological barriers to honest responding are primary factors that can be modified. First, patients might not reveal personal information out of a fear of self-disclosure. They often hold back information because they feel afraid that they are being viewed negatively by the healthcare professional (Farber, 2006). Patients are particularly afraid to disclose personal, sensitive or stigmatizing information. Unfortunately, such information can be the most important for them to disclose to healthcare professionals. Second, patients engage in impression management (Leary & Kowalski, 1990), only disclosing information that will lead healthcare providers to view them positively. They try to selectively represent themselves and their behaviors in ways that they believe will make healthcare professionals view them positively.

When patients respond less honestly, healthcare professionals get a less accurate picture of them and their medical history, which can have serious health consequences. We argue that VHs could be used to reduce these psychological barriers to honest responding (i.e., fear of self-disclosure, impression management). Additionally,

* Corresponding author. Address: Institute for Creative Technologies, University of Southern California, 12015 Waterfront Drive, Playa Vista, CA 90094-2536, United States. Tel.: +1 310 574 5700.

E-mail address: gratch@ict.usc.edu (J. Gratch).

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VH-interviewers could lead patients to behave more openly in a clinical interview context.

1.1. Type of assessment method influences disclosure through psychological factors

Current evidence suggests that different types of assessment produce different levels of disclosure by affecting two key psychological factors: rapport and also anonymity – or the sense that one's identity is protected. Generally, research has shown that greater feelings of rapport lead people to disclose more (Burgoon, Guerrero, & Floyd, 2009; Gratch et al., 2007, 2013; Hall, Harrigan, & Rosenthal, 1995; Miller, Berg, & Archer, 1983). Important for our focus on assessment methods, research also shows that differences in disclosure between assessment formats are mediated by feelings of rapport and, specifically, rapport leads patients to disclose more personal information (Dijkstra, 1987; Gratch et al., 2007, 2013). Indeed, because computer- and self- administered assessment lack any human element, these traditional assessments do not evoke the same feelings of rapport or social connection. Specifically, when there is not a human or human-like agent present in some way, shape, or form, people feel less socially-connected during the assessment (DeVault et al., 2014; Gratch et al., 2007, 2013).

Initial evidence suggests that several features in "the human element" are important in increasing rapport, including both verbal and non-verbal behavior. For example, we know that listeners who are naturally more verbally receptive and attentive, who use more follow-up questions for example, produce greater disclosure from reticent interviewees (Miller et al., 1983). Beyond the words uttered, nonverbal behavior – including facial expressions, gaze, gestures and postures – powerfully influences feelings of rapport (Burgoon et al., 2009; Hall et al., 1995). Specifically in virtual humans, verbal and non-verbal backchannels (agreement, head nods) create greater feelings of rapport (and thereby disclosure) than those that do not employ these backchannels (Gratch et al., 2007, 2013).

Besides rapport, anonymity is another key psychological factor that leads to differences in disclosure between assessment formats. Indeed, much of the research exploring the effect of anonymity on disclosure has done so by contrasting different assessment methods such as: computer-mediated interviews, face-to-face interviews, computer-administered assessment, and standard self-assessment. Research shows that computer-mediated interviews are felt to be more anonymous than face-to-face interviews, just as computer-administered assessment is when compared to self-administered by paper-and-pencil, and this resultant anonymity leads to increased disclosure (see Weisband & Kiesler, 1996). We now turn to consider the effect of computer-administered assessment methods, specifically, on disclosure.

1.2. Computer-administered assessment improves disclosure

"The possibility that people would tell an impartial machine personal or embarrassing things about themselves, *without fear of negative evaluation*, has been raised since the first uses of computers for communication" (Weisband & Kiesler, 1996, p. 3, italics added). Since these initial uses of computers for assessment, researchers have established that computer-administered assessment methods can solicit more honest, open responding. We refer to these more well-studied assessment methods (such as computer-administered self-assessment questionnaires, web-based self-administered health screenings, and computer-mediated interviews) as traditional computer-administered assessments to contrast them from the newer computer-administered assessment method that we will focus on in this paper: virtual human interviewers. A meta-analysis of this literature (Weisband & Kiesler, 1996) found that computer-administered assessment methods lead to greater disclosure of personal information than non-computerized methods.

The effect of computer-administered assessment on honest responding is particularly valuable in medical and mental health settings due to the intimate nature of the information required in such contexts. Although computer-administered assessments can improve honest responding for even mundane private information (Beckenbach, 1995; Joinson, 2001), these effects are especially strong when the information is illegal, unethical, or culturally stigmatized (van der Heijden, Van Gils, Bouts, & Hox, 2000; Weisband & Kiesler, 1996). As many behaviors that harm mental and physical health fall into this category (e.g., drug use, unsafe sex, suicide attempts), computer-administered assessments can be especially important in health domains. For example, when asked to disclose information about suicidal thoughts by computer-administered assessment methods, participants not only felt more positively about the assessment than with traditional assessment methods, but, more importantly, they gave more honest answers (Greist et al., 1973).

Why would people give more honest responses to a computer? Computer-administered assessment formats allow for a "sense of invulnerability to criticism, an illusion of privacy, the impression that responses 'disappear' into the computer" (Weisband & Kiesler, 1996, p. 3). Several studies have confirmed that respondents perceive computer-administered assessments to be more anonymous than non-computerized methods (Baker, 1992; Beckenbach, 1995; Joinson, 2001; Sebestik, Zelon, DeWitt, O'Reilly, & McGowan, 1988; Thornberry, Rowe, & Biggar, 1990).

Although such traditional computer-administered (e.g., computer-administered self-assessment questionnaires, web-based self-administered health screenings) increase anonymity, they cannot generally engage in rapport-building like human interviewers, and rapport itself fosters self-disclosure (Bickmore et al., 2005; Gratch et al., 2007, 2013), especially in medical contexts (Beckman & Frankel, 1984; Maguire et al., 1996; Roter & Hall, 1987). Therefore, these types of assessment each have pros and cons when it comes to encouraging disclosure.

1.3. The present research

VH-interviewers may offer the best of both worlds: with recent aforementioned developments, VH-interviewers can engage in rapport-building like their human counterparts; and, like traditional computer-administered assessments, VH-interviewers should also increase willingness to disclose by anonymity. When interacting with a VH, participants usually believe (or can be led to believe) that their responses are not currently being observed by another human being. If participants believe that no other human is observing their responses, they should also feel that it is "safe" to express themselves honestly and disclose more personal information.

Therefore, we predicted that, while interacting with a VH-interviewer, holding the belief that the VH is run automatically by the computer –without oversight by a human being – will increase willingness to disclose. Specifically, being told that the VH is automated should reduce psychological barriers to disclosure (fear of self-disclosure, impression management) and increase open, disclosive behavior in the interview.

To test these hypotheses, we conducted a study in which all participants interacted with a VH during a semi-structured interview, see Fig. 1 (DeVault et al., 2014). The VH was either teleooperated by humans (like a puppet) or fully-automated. More importantly, we independently manipulated whether participants believed the VH was controlled by humans (human frame) or a computer program (computer frame). Rather than comparing

Fig. 1. Interview with virtual human interviewer. In this study, all participants interacted with a virtual human during a semi-structured interview. Interviewees were told, by random assignment, either that the virtual human interviewer was teleo-operated by a human (like a puppet) or that it was fully-automated.

interviews conducted by VH with those conducted by human beings, participants were led to believe that the VH-interviewer was either automatically operated or teleo-operated by a human. Therefore, we were able to isolate a single factor: whether participants believe that their responses are being observed by another human being or not.

By manipulating frame, we were able to test whether believing that responses are not currently being observed by another human being (computer frame) helps increase willingness to disclose compared to believing that responses were being observed (human frame). We expected this manipulation to influence participants' responses to measures of fear of self-disclosure (Carleton, Collimore, McCabe, & Antony, 2011) and impression management (Li & Bagger, 2007), which were taken immediately after the interview.

Additionally, videotapes and transcripts of these interviews were analyzed to investigate whether believing the VH was operated by a computer also led participants to *behave* more openly during the interview. Specifically, video of participants' faces was analyzed by Computer Expression Recognition Toolbox (CERT; Bartlett et al., 2006; Donato, Bartlett, Hager, Ekman, & Sejnowski, 1999). CERT automatically detects facial actions, including expression of basic emotions like sadness (see Fig. 2). While it is against cultural norms to display sadness in such an interview context (Matsumoto, 1991), if VHs can increase comfort with disclosure

Fig. 2. Computer Expression Recognition Toolbox (CERT). Videotapes of participants' interviews were analyzed to test if interacting with an automated VH led participants to behave more openly during the interview. We considered the extent to which participants expressed the emotion of sadness. In order to get as objective a measure as possible of displayed sadness, video of participants' faces was analyzed by Computer Expression Recognition Toolbox (CERT). CERT automatically detects facial actions, including expression of basic emotions like sadness.

when it appears to be automated, participants may allow themselves to display more intense expressions of sadness in front of the VH. Additionally, to assess whether participants verbally expressed greater willingness to disclose information when the VH appeared to be automated, interview transcripts were coded by an objective (blind) observer. Specifically, transcribed answers to 8 of the main interview questions were each rated on the extent to which the participant showed intent to disclose personal information on that question.

2. Material and methods

2.1. Participants

Two hundred and thirty nine participants (149 males, 90 females) were recruited via Craigslist. All participants who met requirements (i.e. age between 18 and 65, and adequate eyesight) were accepted. Sample size was determined by the iterative development process for the automated system utilized in this research (see DeVault et al., 2014).

2.2. Design and procedure

In this study, all participants interacted with a rapport-building VH (Fig. 1). Human interviewers employ a variety of skills to reduce patient fear of self-disclosure, and several research efforts have examined how to automate and incorporate these skills into VH systems. For example, the rapport agent by Gratch and colleagues (Gratch et al., 2007, 2013) uses vision and prosodic analysis to provide active listening behaviors (e.g., smiles, head nods and postural mimicry). The Relational Agents work of Bickmore and colleagues combines these nonverbal skills with verbal techniques including expressions of empathy, social dialogue and reciprocal self-disclosure (Bickmore et al., 2005). Empirically, these techniques have been shown to increase feelings of rapport, thereby increasing self-disclosure as well as feelings of trust and self-efficacy (e.g., Bickmore et al., 2005; Gratch et al., 2007, 2013).

The virtual interviewer used in this study builds on this existing technological base and is part of a larger research effort to examine the feasibility of virtual health agents for mental health screening. This kiosk-based system is aimed at clients resistant to seeking traditional care and combines the advantages of traditional web-based self-administered screening, which allows for anonymity, with a VH interface, which fosters the rapport-building techniques employed by the Rapport- and Relational-agent work.

The virtual human conducts a semi-structured screening interview with a single user via spoken language (DeVault et al., 2014). The interview is structured around a series of agent-initiated questions organized into phases: initially there is a rapport-building phase where the agent asks general introductory questions (e.g., "where are you from originally?); this is followed by a clinical phase where the agent asks a series of questions about clinical symptoms (e.g., "How easy is it for you to get a good night's sleep?"); finally, the agent ends with a series of more positive questions designed to return the patient to a more positive mood (e.g., "What are you most proud of?"). At each phase, the agent is able to ask follow-up questions (e.g., "Can you tell me about that?"), provide verbal empathetic feedback (e.g., "I'm sorry to hear that"), and produce nonverbal behaviors (e.g., nods and expressions) to convey active and empathetic listening.

The system itself was developed in an iterative fashion (DeVault et al., 2014): an analysis of face-to-face interviews informed the design of a semi-automated system, which in turn, informed the creation of a fully-automated AI prototype. Analysis of the face-to-face interviews produced a library of questions, follow-up questions and verbal and nonverbal feedback behaviors that could be used by the agent. The semi-automated system used human operators (teleo-operated method), operating the system from another room, to drive the selection and timing of these library-elements during a series of interviews. While the basic order of questions was structured into phases, operators had to decide (1) when to take the turn from the user, (2) if to ask a follow-up question, (3) if to provide verbal empathetic feedback and (4) when to provide nonverbal behaviors such as nods and smiles. The low-level realization of these behaviors was determined by automation. These operator choices serve as a corpus of training data from which a fully-automated system was created. Both the semi-automated (teleo-operated) and fully-automated (AI) versions of the interviewer are used in this study. That is, participants either interacted with the VH when it was teleo-operated by humans or when it was fully-automated. In all of these interactions, the VH interacts verbally and nonverbally in a semi-structured manner with a participant.

More importantly for the present research, we independently manipulated whether participants *believed* the VH was controlled by humans (human frame) or a computer program (computer frame). After giving consent, participants received an explanation of the system, which served as a manipulation of frame. They were randomly assigned to a computer frame or a human frame: some participants were *told* that they would be interacting with an automated system, and others were *told* that they would be interacting with a human-controlled system. The experimenter introduced participants to the system using graphic representations as well as verbal descriptions that manipulated frame. Participants in both frames were told that there would not be any real human in the room with them, and thus their responses would be "anonymous" (in that "mere presence" was removed). Although anonymity in terms of "mere presence" was held constant across conditions, our frame manipulation varied in terms of "mere belief". In the computer frame, participants were led to believe that their responses *were not* being observed. They were told:

> ...*Our virtual human uses artificial intelligence to have a conversation with you, yet preserves your anonymity. The system gets audio and visual input from you. It uses a Speech Recognition tool to understand what you're saying, then uses a complex series of equations to choose the best way to respond...*

In the human frame condition, participants were led to believe that their responses *were* being observed. They were told:

> ... *Our virtual human is like a puppet. It allows a person in another room have a conversation with you, yet preserves your anonymity... My colleague will be sitting in the other room, and will be able to see and hear you on this screen. [She] has access to a set of pre-recorded questions and responses that will be used to have a conversation with you....*

All participants were randomly assigned to either the computer or human frame, regardless of which method they *actually* experienced. That is, independently of what they were told (frame condition), in reality, some participants interacted with our VH when it was controlled by a human (teleo-operated method), whereas other participants interacted with our VH when her responses were fully automated (AI method). Accordingly, the study consisted of a 2 (frame: computer vs. human) $\times$ 2 (method: teleo-operated vs. AI) design.

In the teleo-operated method, operators were blind to framing condition. However, in 21 teleo-operated sessions, operators learned the condition; accordingly, those sessions were excluded from analyses. Additionally, after interacting with our VH, participants completed a manipulation check: they selected whether the VH was "controlled by a computer" or "controlled by a human". Those who failed the manipulation check were also excluded. Together, these exclusions left 154 subjects, 77 in each framing condition. This data set includes 57 teleo-operated interactions and 97Artificial Intelligence interactions. Of those, in 9 interactions with the Artificial Intelligence, the computer system malfunctioned; these sessions were also excluded.

2.3. Measures

After the dialogue concluded, participants completed a number of questionnaires. First, to measure fear of self-disclosure, participants completed a modified version of the Brief Fear of Negative Evaluation Scale – Straightforward Items (Carleton et al., 2011). Specifically, items were modified to refer to their fear that participants felt during the interaction with our VH. For example, on a scale from 1 (strongly disagree) to 5 (strongly agree), participants responded to items like "I was afraid of the interviewer noticing my shortcomings." Participants then completed the impression management subscale of the Balanced Inventory of Desirable Responding (Li & Bagger, 2007). On a scale from 1 (strongly disagree) to 5 (strongly agree), participants responded to items like "I never regret my decisions". For both of these measures, participants' total scores were calculated for analysis.

Additionally, videotapes and transcripts of these interviews were analyzed to investigate whether believing the VH was operated by a computer also led participants to behave more openly during the interview. First, we considered the extent to which participants felt comfortable expressing the emotion of sadness. In particular, it is against cultural norms to display sadness, especially during an interview with someone who you don't know (Matsumoto, 1991); therefore, participants can express their willingness to disclose by allowing themselves to display more intense expressions of sadness in front of the VH. The emotion of sadness is also particularly telling for self-disclosure because more sensitive personal information is often accompanied by this basic emotion, more so than others. In order to get as objective a measure as possible of displayed sadness, video of participants' faces was analyzed by Computer Expression Recognition Toolbox (CERT), see Fig. 2. This system automatically detects facial actions, including expression of basic emotions (i.e., sadness; Bartlett et al., 2006; Donato et al., 1999). For each video-recorded frame, CERT represents the intensity of sadness expressed on the participant's face on a scale from 0 to 1, with higher scores indicating greater sadness. For our study, overall ratings of sadness were taken by averaging across all frames of the interview video.

Second, to assess participants' willingness to disclose without the limitations of self-report methods, we employed an objective (blind) observer to rate the extent to which participants verbally expressed willingness to disclose information. The observer read interview transcripts for 8 questions from the more sensitive, intimate phases of the interview, as described above. Specifically, these 8 questions were selected because they were asked to more participants than any other questions during these latter phases of the dialogue. They also were open enough to allow participants to respond with as much or little personal information as they were comfortable sharing. The questions included:

"How close are you to your family?"
"Tell me about a situation that you wish you had handled differently."
"Tell me about an event, or something that you wish you could erase from your memory."
"Tell me about the hardest decision you've ever had to make."
"Tell me about the last time you felt really happy."
"What are you most proud of in your life?"

Table 1
Total score means and standard errors for frame conditions and method conditions.

	Frame		Method	
	Computer	Human	Teleo-operated	AI
Fear of self-disclosure	16.54 (0.69)	18.61 (0.63)*	17.19 (0.76)	17.95 (0.54)
Impression management	56.29 (1.33)	59.76 (1.16)*	57.68 (1.39)	58.38 (1.08)
Sadness displays	0.12 (0.02)	0.08 (0.01)*	0.11 (0.02)	0.09 (0.01)
Willingness to disclose	1.11 (0.15)	0.56 (0.13)*	0.69 (0.16)	0.98 (0.12)

Note: * = $p < .05$. ** = $p < .01$.

"What's something you feel guilty about?"
"When was the last time you argued with someone and what was it about?"

Participants' responses to each of these questions were transcribed and then, separately, rated for willingness to disclose personal information on that question. Specifically, each answer was rated on a scale from −3 (*completely unwilling to disclose*) to +3 (*completely willing to disclose*). Two coders rated a subset of 18 transcripts in this manner to estimate inter-rater reliability. Because inter-rater reliability was sufficient for this subset ($\alpha = .78$), a single coder rated all subsequent transcripts. To gauge overall willingness to disclose, our blind coder's ratings for all questions were averaged together to create a metric of overall rated willingness to disclose.

3. Results

We conducted 2 (frame: computer vs. human) × 2 (method: teleo-operated vs. AI) ANOVAs on each measure of willingness to disclose (fear of self-disclosure, impression management, sadness displays, and observer ratings of willingness to disclose). Means and standard errors for each effect are provided in Table 1. As depicted in Figs. 3a, 3b, 3c, 3d, results confirmed our hypotheses: *automated* VHs are able to increase willingness to disclose. Participants who were told that the VH-interviewer was fully automated (computer frame) reported significantly lower fear of self-disclosure, $F(1, 130) = 4.90$, $p = .03$, and impression management, $F(1, 141) = 3.88$, $p = .05$, than participants who were told that the VH-interviewer was teleo-operated by a human (human frame).[1]

Additionally, telling participants they were interacting with a computer led them to *behave* more openly during the interview. Participants who were told that the VH-interviewer was fully automated allowed themselves to display more intense expressions of sadness, $F(1, 115) = 4.48$, $p = .04$, as rated by CERT (*20,21*).[2] Likewise, those who were told that the VH-interviewer was fully automated showed greater willingness to disclose on average across the 8 interview questions, $F(1, 141) = 7.58$, $p = .007$, as rated by an objective observer who read the interview transcript.

In addition to manipulating frame, the present study also varied whether participants *actually* interacted with a VH that was teleo-operated by human or fully-automated. We assumed that only the *belief* that responses will not be observed would affect honest responding, not whether the responses would actually be observed or not. As expected, there was no significant effect of method (teleo-operated versus AI), $Fs < 2.10$, $ps > .15$, or interaction of frame*method, $Fs < 0.67$, $ps > .41$.

[1] Eleven participants failed to complete the FNE, and thus were not included in this ANOVA analysis.
[2] Intensity ratings of expressed sadness by CERT were unavailable for 26 participants (i.e., failed to track their faces).

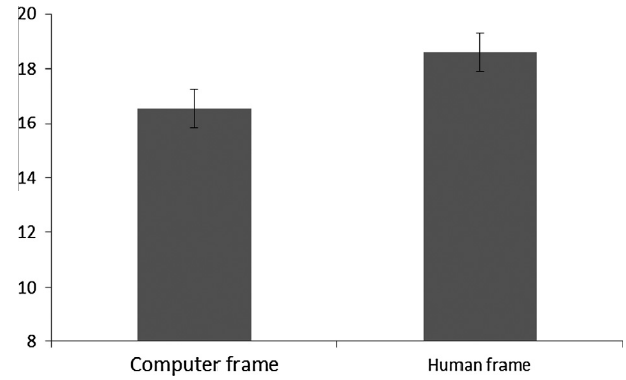

Fig. 3a. Fear of self-disclosure in computer versus human frame. Participants who were told that the virtual human interviewer was fully automated (computer frame) reported significantly lower fear of self-disclosure than those who were told that the virtual human was teleo-operated by a human (human frame).

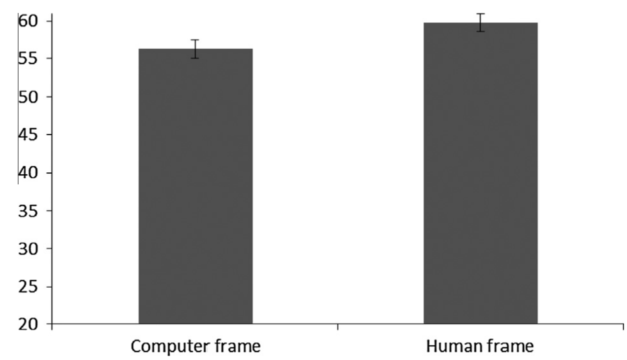

Fig. 3b. Impression management in computer versus human frame. Participants who were told that the virtual human interviewer was fully automated (computer frame) engaged in significantly less impression management than those who were told that the virtual human was teleo-operated by a human (human frame).

4. Discussion

Overall, this paper provides the first empirical evidence that VHs can increase willingness to disclose in a clinical interview context. Additionally, we show that VHs are able to have this impact because they allow patients to feel as though their responses are not currently being judged. Because the only difference between frames was the belief that another human was observing responses during the interview session, we can establish that the power of VH-interviewers to elicit more honest responding comes from the sense that no one is observing or judging. Participants' unsolicited anecdotal remarks echo the importance of this factor:

"I wish you hadn't told me that other people were in the other room listening in. It was weird, like, I don't even know these people. I would have said a lot more stuff if they weren't there."

"[I] would have felt more comfortable if nobody was watching."

Likewise, participants who believed the agent was *automated* stated:

"This is way better than talking to a person. I don't really feel comfortable talking about personal stuff to other people."

"A human being would be judgmental. I shared a lot of personal things, and it was because of that."

Generally, these findings help to illuminate differences between assessment formats such as face-to-face interviews, traditional computer-administered assessments, and VH-administered inter-

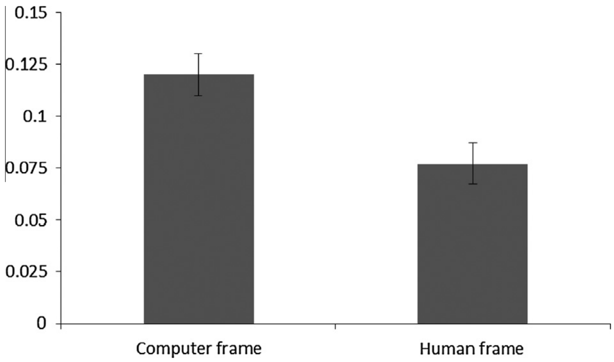

Fig. 3c. Sadness intensity in computer versus human frame. Compared to participants who were told that the virtual human was teleo-operated by a human (human frame), those who were told that the virtual human interviewer was fully automated (computer frame) allowed themselves to display more intense expressions of sadness as rated by CERT.

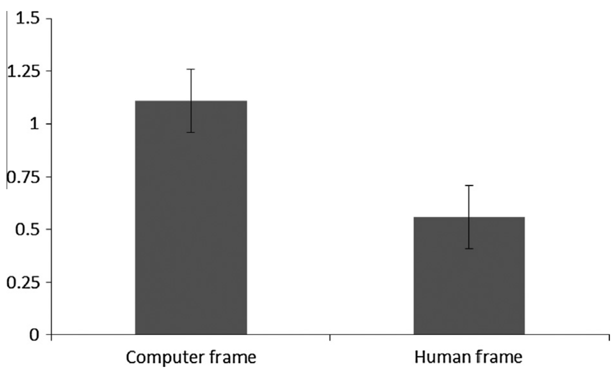

Fig. 3d. Observer rated willingness to disclose in computer versus human frame. Compared to participants who were told that the virtual human was teleo-operated by a human (human frame), those who were told that the virtual human interviewer was fully automated showed greater willingness to disclose on average across interview questions as rated by an objective observer who read the interview transcript.

views. The primary advantage that face-to-face interviews have over traditional computer-administered assessments is rapport, which is useful for encouraging disclosure in medical contexts (Beckman & Frankel, 1984; Maguire et al., 1996; Roter & Hall, 1987). Although participants would feel greater rapport in face-to-face interviews, face-to-face interviews trade-off anonymity for this rapport (Baker, 1992; Beckenbach, 1995; Joinson, 2001; Sebestik et al., 1988; Thornberry et al., 1990). Unlike traditional self-administered questionnaires, both face-to-face interviews and computer-administered assessments make it possible to use more complex questionnaires. But, computer-administered questionnaires do so without the aid of an interviewer, saving time and money.

However, VH-administered interviews could have all of these benefits. VH-interviewers can develop rapport and administer more complex questionnaires without a human interviewer – and therefore also without feeling as though responses are being judged, according to this research. However, further testing is required. Although research has found that rapport helps to elicit self-disclosure by comparing VH-interviewers with rapport-building skills to those without such skills (Bickmore et al., 2005; Gratch et al., 2007, 2013), these rapport-building VH-interviewers have not been directly compared to traditional computer-administered assessments or face-to-face interviews.[3] Such comparisons would also further explicate the role that rapport plays in how these assessments encourage honest responding.

In this paper, we consider the effect of using VHs during a clinical interview that is psychological in nature. However, VHs could be useful across medical domains. A cancer patient, for instance, might be afraid to admit to experiencing side effects because she is worried the cancer might spread if her doctor, in turn, decides to lower her treatment dosage. However, information about the side effects could be important for her oncologist to know. Our research suggests that interviewing with a VH should increase such patients' willingness to disclose.

[3] See DeVault et al. (2014) for initial work in this area.

5. Conclusion

And so, the "possibility that people would tell an impartial machine personal or embarrassing things about themselves without fear of negative evaluation" has been born out. Here we demonstrate that VHs can help overcome psychological barriers to honesty in clinical interviews. Indeed, interviewing with an automated VH makes participants more willing to disclose. Providing more open and honest responses in medical interviews can help patients to receive better care and avoid serious consequences. Therefore, the benefits of VH-administrated clinical interviews could be substantial.

Less obvious than the social benefits might be the potential economic benefits, as VH-administrated clinical interviews could possibly become cost-effective on a larger scale. Though developing VH-interviewer systems require substantial initial investment of expertise, time, cost, and manpower, such an extensive initial investment may be cost-effective if the system becomes utilized widely. Indeed, once a system has been developed, the cost of creating copies of the VH-interviewer would usually be much smaller, and the cost-savings in the long-run of such wide-spread usage could exceed the (albeit substantial) cost for that initial investment to develop the system. Indeed, disclosure has benefits for physical and psychological health, both of which carry with them a huge economic burden that could be lessened with this technology (Higgins, 1994). Additionally, VH-interviewers can be used to reach patients for whom it would otherwise be more costly to provide health screening services, such as those who are in a remote or sparely populated location. Successful VH-administered assessments could spawn additional money-saving uses of VHs in medicine, such as using VHs to role-play with healthcare professionals to improve their social skills. Again the benefits of such innovations may not be limited to economics. For example, using VH for this kind of role-playing for training purposes could also reduce healthcare professionals' fear of being evaluated negatively by their peers (Fannon, 2003). Therefore, patient and provider alike could one day possibly benefit from this "soothing effect" of interacting with a virtual human – after all, it's only a computer.

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