



Reporting Mental Health Symptoms: Breaking Down Barriers to Care with Virtual Human Interviewers

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A common barrier to healthcare for psychiatric conditions is the stigma associated with these disorders. Perceived stigma prevents many from reporting their symptoms. Stigma is a particularly pervasive problem among military service members, preventing them from reporting symptoms of combat-related conditions like posttraumatic stress disorder (PTSD). However, research shows (increased reporting by service members when anonymous assessments are used. For example, service members report more symptoms of PTSD when they *anonymously* answer the Post-Deployment Health Assessment (PDHA) symptom checklist compared to the *official* PDHA, which is identifiable and linked to their military records. To investigate the factors that influence reporting of psychological symptoms by service members, we used a transformative technology: automated virtual humans that interview people about their symptoms. Such virtual human interviewers allow simultaneous use of two techniques for eliciting disclosure that would otherwise be incompatible; they afford *anonymity* while also building *rapport*. We examined whether virtual human interviewers could increase disclosure of mental health symptoms among active-duty service members that just returned from a year-long deployment in Afghanistan. Service members reported more symptoms during a conversation with a virtual human interviewer than on the official PDHA. They also reported more to a virtual human interviewer than on an *anonymized* PDHA. A second, larger sample of active-duty and former service members found a similar effect that approached statistical significance. Because respondents in both studies shared more with virtual human interviewers than an anonymized PDHA—even though both conditions control for stigma and ramifications for service members' military records—*virtual human interviewers that build rapport* may provide a superior option to encourage reporting.

Keywords: virtual humans, assessment, disclosure, psychological symptoms, anonymity

INTRODUCTION

People are reluctant to disclose information that could be potentially stigmatizing. One area where this failure to disclose honest information has particularly large consequences is mental health. Due to the stigma associated with mental health problems (Link et al., 1991, 2001), people are reluctant to report symptoms of such disorders. The consequences are significant—mental health problems exact

a significant toll on society (World Health Organization, 2004; Insel, 2008; National Institute of Mental Health, 2010; World Economic Forum, 2011).

The majority of individuals who seek mental health services report facing stigma and discrimination (Thornicroft et al., 2009). Accordingly, stigma and discrimination acts as a significant barrier to care and honest reporting of symptoms, which individuals must overcome. They may try to deal with stigma using coping methods that are more or less effective (Isaksson et al., 2017); however, if they cannot successfully cope, stigma and the resultant unwillingness to report symptoms end up preventing people from accessing or receiving treatment, leaving the disorder unresolved. These barriers to care pose a large problem for society since mental health problems are costly, both in terms of money and social capital (Insel, 2008) and unresolved mental health problems continue to accrue increasing costs (World Health Organization, 2004; Insel, 2008; National Institute of Mental Health, 2010; World Economic Forum, 2011).

In the current work, we explore this problem among military service members, given that failure to disclose symptoms is often cited as a barrier to care in the military [Institute of Medicine (IOM), 2014; Rizzo and Shilling, in press]. Service members are reluctant to report symptoms of combat-related conditions like posttraumatic stress disorder (PTSD), which is typified by persistent mental, behavioral, and emotional symptoms as a result of exposure to physical or psychological trauma. Not only are service members more likely to have PTSD than civilians (Vincenzen, 2013; Schreiber and McEnany, 2015) but also as a result of the perceived stigma surrounding the condition (Hoge et al., 2004, 2006), they are particularly reluctant to report symptoms (Olson et al., 2004; Appenzeller et al., 2007; Warner et al., 2007, 2008, 2011; McLay et al., 2008; Fear et al., 2010; Thomas et al., 2010). The reluctance of service members in the United States Military to report PTSD symptoms is especially intensified when they are screened for mental health symptoms using the official administration of the Post-Deployment Health Assessment (PDHA; Hyams et al., 2002; Wright et al., 2005) since this information becomes documented in their military health records. Indeed, there are pragmatic military career implications (such as the perception of possible future restrictions from certain job placements and from obtaining future security clearances) for having been screened positive for mental health conditions.

To address this reluctance to disclose PTSD symptoms on the PDHA, we examine whether a new technology, namely virtual human-interviewers, can be used to increase willingness of service members to report PTSD symptoms compared to the PDHA. Virtual humans are digital representations of humans that can portray human-like characteristics and abilities and can be used to interview people in a natural way using conversational speech (see **Figure 1**). We first describe empirical work that provides a theoretical basis for how virtual human interviewers might increase the willingness of service members to report PTSD symptoms, followed by the research questions addressed in the current work. We then describe and discuss results from two studies that examine the effectiveness of virtual human interviewers designed to foster service member reporting of mental

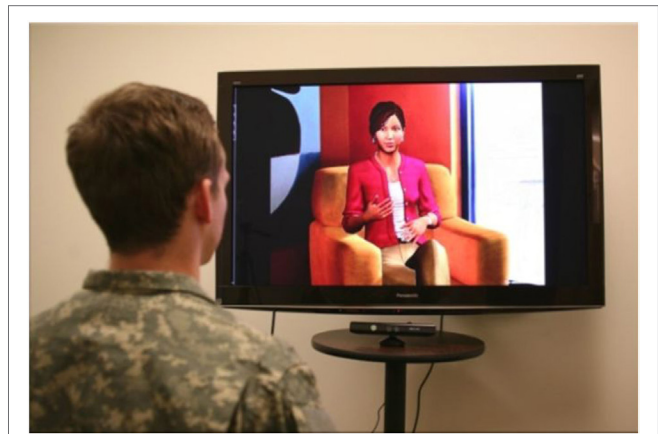


FIGURE 1 | Interview with our virtual human interviewer.

health symptoms that might otherwise be withheld when using traditional self-report checklists (such as the PDHA).

Related Work

Anonymity is theorized to support the potential effectiveness of virtual human interviewers for increasing reports of health-related symptoms. Previous research suggests that anonymized forms of assessment increase reporting. For example, respondents reveal more honest information during computerized self-assessments (Greist et al., 1973; Beckenbach, 1995; Weisband and Kiesler, 1996; van der Heijden et al., 2000; Joinson, 2001), and they appear to do so because they perceive these assessments to be more anonymous than non-computerized human interviewing methods (Sebestik et al., 1988; Thornberry et al., 1990; Baker, 1992; Beckenbach, 1995; Joinson, 2001). Although anonymized assessments can improve honest reporting for even mundane private information (Beckenbach, 1995; Joinson, 2001), these effects are especially strong when the information is illegal, unethical, or culturally stigmatized (Weisband and Kiesler, 1996; van der Heijden et al., 2000). As many behaviors that are harmful to mental and physical health fall into this category (e.g., drug use, unsafe sex, suicide attempts), anonymized forms of assessment can be especially important in healthcare assessment. For example, when asked to disclose information about suicidal thoughts using a computer-administered assessment, participants not only felt more positive about the assessment compared to traditional methods, but also gave more honest answers (Greist et al., 1973).

Relevant to the focus of the current work, anonymity has been shown to increase reporting disclosure of PTSD symptoms among service members (Olson et al., 2004; McLay et al., 2008; Warner et al., 2011). One study indicated that following a combat deployment, the sub-sample of service members who *anonymously* answered the routine PDHA symptom checklist reported twofold to fourfold higher mental health symptoms and a higher interest in receiving care compared to the overall results derived from the standard administration of the PDHA, which is identifiable and linked to service members' military records (Warner et al., 2011).

Initial research on the use of virtual humans to conduct clinical interviews suggests that interviewees are indeed more open to virtual human interviewers than their human counterparts (Slack and Van Cura, 1968; Lucas et al., 2014; Pickard et al., 2016). Because a conversation with a virtual human interviewer may be viewed as more anonymous, users may be more comfortable disclosing about highly sensitive topics and on questions that could lead them to admit something stigmatized or otherwise negative. For example, during a clinical interview with a virtual human interviewer, participants disclose more personal details when they are told that the virtual human is autonomous than when they are told that the virtual human is operated by a person in another room (Lucas et al., 2014). Pickard et al. (2016) reported that individuals are more comfortable disclosing to an automated virtual human interviewer than its human counterpart.

While research has yet to establish that virtual human interviewers can increase reporting of PTSD symptoms specifically among service members, some research has considered the potential benefits of using virtual human interviewers and related technology for service members (Lewandowski et al., 2011; Rizzo et al., 2011; Serowik et al., 2014; Bhalla et al., 2016). Rizzo et al. (2011) developed a virtual human to interview service members about their PTSD symptoms. Advances in automation now allow virtual human interviewers to have more interactive conversations with users, in which questions about the PTSD symptoms can be embedded. Having such an interactive conversation is critical because, while anonymity is beneficial, building rapport with respondents can also increase reporting (Burgoon et al., 2016).

Indeed, a second theoretical basis behind the potential effectiveness of virtual human interviewers for increasing report of symptoms is rapport. Psychological theories of rapport (e.g., Tickle-Degnen and Rosenthal, 1990) have outlined verbal and non-verbal behaviors that help to build rapport; and subsequent research has shown that resultant rapport leads interlocutors to disclose more (Miller et al., 1983; Hall et al., 1996; Gratch et al., 2007, 2013; Burgoon et al., 2016). Differences in disclosure between assessment formats have also been found to be mediated by feelings of rapport; rapport leads individuals to disclose more personal information (Dijkstra, 1987; Gratch et al., 2007, 2013).

Because traditional computerized self-assessments and other anonymized forms 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 (Gratch et al., 2007, 2013).

Tickle-Degnen and Rosenthal (1990) suggest several features of “the human element” that are important in increasing rapport, including both verbal and non-verbal behavior. For example, listeners who are naturally more verbally receptive and attentive and who use more follow-up questions, produce greater disclosure from reticent interviewees (Miller et al., 1983). Beyond the words uttered, non-verbal behavior such as positive facial expressions, attentive eye gaze, welcoming gestures and open postures have been reported to influence feelings of rapport (Hall et al., 1996; Burgoon et al., 2016). These features may allow virtual human interviewers to more effectively build rapport, in contrast to

traditional computerized self-assessments and other anonymized forms. Indeed, research suggests that virtual human interviewers have the potential build rapport as well as—or even better than—human interviewers (e.g., DeVault et al., 2014).

Researchers have attempted to translate these psychological theories of rapport into computational systems and studies have indicated that it is possible to capture these behaviors in various automated systems ranging from machine learning-based prediction models (e.g., Morency et al., 2009; Huang et al., 2010) to “chatbots” (e.g., Kerlyl et al., 2007) and virtual humans (e.g., Cassell and Bickmore, 2002; Bickmore et al., 2005; Haylan, 2005; Cassell et al., 2007; Gratch et al., 2007, 2013; Matsuyama et al., 2016; Zhao et al., 2016). For example, some virtual humans have been designed to utilize verbal (e.g., words uttered, prosody, intonation, etc.) and non-verbal behavior (e.g., positive facial expressions, gaze, gestures, and posture) to build rapport (Cassell and Bickmore, 2002; Bickmore et al., 2005; Haylan, 2005; Cassell et al., 2007; Gratch et al., 2007, 2013; Matsuyama et al., 2016; Zhao et al., 2016). Research has also established that virtual humans that employ such rapport-building behaviors are able to induce disclosure (Gratch et al., 2007, 2013).

While rapport-building seems contrary to anonymity, the use of virtual human interviewers may provide a solution that allows for both anonymity as well as rapport-building. Some virtual humans can be used to interview people in a natural way (i.e., *via* conversational speech). Akin to the “Rapport Agents” described above, these virtual human interviewers have been designed to *build rapport with users specifically during interviews* (e.g., Gratch et al., 2013; Qu et al., 2014), including clinical interviews (e.g., Bickmore et al., 2005; DeVault et al., 2014; Lucas et al., 2014; Rizzo et al., 2016). Interspersed *appropriately* during an interview, the virtual human interviewers use verbal and non-verbal backchannels (e.g., utterances of agreement such as “mhm” or head nods) to build rapport with the interviewee. Indeed, virtual human interviewers that employ such backchannels when appropriate to the conversation create greater feelings of rapport than virtual human interviewers that employ them at random during the interview (e.g., Gratch et al., 2013; Qu et al., 2014). As with Rapport Agents, when virtual human interviewers use these rapport-building behaviors in this way, they are able to prompt disclosure from interviewees (Gratch et al., 2013).

The Current Research

Given that the experience of stigma can limit the reporting of PTSD symptoms, many service members with the disorder are not identified and do not have the opportunity to benefit from the evidence-based treatments that currently exist. By using a virtual human interviewer to increase self-disclosure of more accurate information, service members having such difficulties could be better encouraged to access potentially beneficial mental health care options. Although the prior research is suggestive, it has not sufficiently established that virtual human interviewers can be used to increase service members’ willingness to endorse the presence of PTSD symptoms compared to self-report on the PDHA checklist items. Thus, the current study tested whether virtual human interviewers can encourage reporting of PTSD symptoms compared to the gold-standard PHDA. Accordingly,

we hypothesize that service members will be more willing to disclose PTSD symptoms to a virtual human interviewer than on the official PDHA (H1). The study also examines the role of rapport *in addition to* anonymity for increasing disclosure. While Warner et al. (2011) demonstrated that service members who answered the PDHA symptom checklist anonymously were more willing to report mental health symptoms compared to the official PDHA, virtual human interviewers with the added benefit of rapport-building, may have the capability to evoke higher levels of disclosure of symptoms. If rapport has an impact on self-disclosure in this context above and beyond anonymity, service members will be more willing to report symptoms to a virtual human interviewer than on an anonymized version of the PDHA (even though they are both equally anonymous). Thus, we hypothesized that service members would be more willing to report PTSD symptoms to a virtual human interviewer than on an anonymized version of the PDHA (H2).

In order to address these research questions, we conducted two studies to test whether service members (Studies 1 and 2) and Veterans (in Study 2) would be more willing to report PTSD symptoms when asked by a virtual human interviewer than when asked to report on the PDHA (either official or anonymized).

STUDY 1—MATERIALS AND METHODS

Study 1—Participants

In Study 1, 29 (2 females) active-duty Colorado National Guard service members volunteered to participate in the study during 2013. None of the service members in the unit declined to participate. After returning from a year-long deployment to Afghanistan, they completed the measures described below. The sample was diverse regarding age ($M = 41.46$, Range = 26–56) and previous number of combat deployments ($M = 2.00$, Range = 1–7). Due to technical failures five participants (all male) were excluded from the analysis reported below.

Study 1—Design and Procedure

This study compared reporting of PTSD symptoms in three formats: (1) standard administration of the PDHA upon return from deployment; (2) an anonymized version of the PDHA; and (3) PDHA questions on PTSD symptoms asked by a virtual human interviewer that were embedded in a longer set of general interview questions. All participants completed the official PDHA within 2 days of the other two assessments (either before or after these other two assessments) and signed releases to allow the research team to access their official PDHA responses gathered at post-deployment processing. Three questions on the PDHA assess whether the service member is experiencing the three core Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition, Text Revision (DSM-IV-TR) diagnostic symptoms for PTSD (intrusive recollections; avoidance/numbing; hyperarousal).

On the official PDHA, participants were asked “*Have you ever had any experience that was so frightening, horrible, or upsetting that, in the past month, you:*

- (A) *have had nightmares about it or thought about it when you did not want to?* (intrusive recollection)
- (B) *tried hard not to think about it or went out of your way to avoid situations that remind you of it?* (avoidance/numbing)
- (C) *were constantly on guard, watchful, or easily startled?* (hyperarousal).

Participants selected “yes” or “no” on each of these three items, and their answers were submitted to the US Military as part of their official military health record. At the same time, we were granted access to these official PDHA responses for our study sample.

Next, participants arrived at the study site, gave consent, completed a demographic questionnaire, and rated their mood using items “I am happy” and “I worry too much” on 4-point scales from *almost never* to *almost always*. They then were escorted to a private room and completed the anonymized PDHA PTSD questions on a computer, selecting Yes or No responses to each item. The participants were verbally assured that their responses were confidential as they would be deidentified using a participant number code.

Participants were then engaged by a virtual human interviewer who conducted a semistructured screening interview *via* spoken language. Participants were still alone in the private room and were told they would not be observed by anyone during the interview and that the video recordings of their interview session would not be released to anyone outside the research team. The full interview was structured around a series of agent-initiated questions organized into three phases: Phase 1 was a rapport-building phase where the virtual human interviewer asked participants general introductory questions (e.g., “Where are you from originally?”); Phase 2 was the clinical phase where the virtual human interviewer asked a series of questions about symptoms (e.g., “How easy is it for you to get a good night’s sleep?”), which included the naturally embedded PDHA questions; Phase 3 was the ending section of the interview where the virtual human interviewer asks questions designed to return the patient to a more positive mood (e.g., “What are you most proud of?”). Across the session, the virtual human interviewer built rapport using follow-up questions (e.g., “Can you tell me more about that?”), empathetic feedback (e.g., “I’m sorry to hear that”), and non-verbal behaviors (e.g., nods, expressions).

The PDHA questions that were asked by the virtual human interviewer were slightly re-worded in order to embed them in the interview. In place of the three PDHA questions listed above, the virtual human interviewer asked participants these revised versions:

- (A) “*Can you tell me about any bad dreams you’ve had about your experiences, or times when thoughts or memories just keep going through your head when you wish they wouldn’t?*” (intrusive recollection)
- (B) “*Can you tell me about any times you found yourself actively trying to avoid thoughts or situations that remind you of past events?*” (avoidance/numbing)
- (C) “*Can you tell me about any times recently when you felt jumpy or easily startled?*” (hyperarousal).

Participants’ answers to the three PDHA questions during the interview were recorded and later coded by two blind coders as to

whether the participant had this experience in the last month or not. While more nuanced than checking “yes” or “no” on PDHA, our coders dichotomized open-ended responses to parallel the PDHA. For example, one response to the intrusive recollections question that was coded as “no” was “Um... haven’t had any, you know, dreams or nightmares. No.” A response to the avoidance question that was coded as “yes” stated: “Um... I try to leave early. I try to leave a situation. I try not to talk to those people. Um... That’s the only time I really avoid a situation is avoiding those people.” Coders had 100% agreement, and codes served as “yes” or “no” answers.

STUDY 1—RESULTS

In Study 1, three versions of the PDHA (official PDHA, Anonymized PDHA, and virtual human interviewer) were administered to participants to determine whether manner of administration produced differing responses. Scores were created for each version of the PDHA by counting the number of “yes” answers to the three questions that assess the core DSM-IV-TR diagnostic symptoms for PTSD (intrusive recollection, avoidance/numbing, hyperarousal). To compare responding, we conducted a repeated-measures ANOVA using 24 participants from a sample of active-duty Colorado National Guard who completed all three measures. There was a significant effect of assessment type, $F(2,23) = 4.29, p = 0.02$ (Figure 2). Within-subject contrasts revealed that participants reported more symptoms of PTSD (responded “yes” on more questions) when asked by the virtual human interviewer ($M = 0.79, SE = 0.23$) than when reporting on the official PDHA ($M = 0.25, SE = 0.15$), $F(1,23) = 7.38, p = 0.01$, or even when reporting on the anonymized version of the PDHA ($M = 0.33, SE = 0.16$), $F(1,23) = 4.84, p = 0.04$. The difference between official and anonymized versions of the PDHA was not significant [$F(1,23) = 0.19, p = 0.66$].

Study 1 provided an initial test of our research hypotheses with results suggesting that service members are more willing to report PTSD symptoms to a virtual human interviewer than

on the official PDHA (H1). The results also indicate that service members are more willing to report PTSD symptoms to a virtual human interviewer than on an anonymized version of the PDHA (Q2). Indeed, because respondents in this study shared more with virtual human interviewers than an anonymized PDHA—even though both conditions control for stigma and ramifications for service members’ military records—virtual human interviewers that build rapport may provide a superior option for encouraging endorsement of these symptoms. This finding has important implications, suggesting that virtual human interviewers may help service members “open up” and report their psychological symptoms through rapport building. We then conducted a second study to replicate (and extend) this result in a larger, more diverse sample including both active-duty service members and retired military veterans. In this second study, we also ruled out the confound introduced by the wording differences between the virtual human interviewer’s questions and the questions listed on the PDHA. In Study 2, the questions asked by the virtual human interviewer were worded identically to the questions on the anonymized PDHA.

STUDY 2—MATERIALS AND METHODS

Study 2—Participants

In Study 2, 132 (16 female) active duty service members and veterans were recruited (e.g., through *Craigslist*), and paid \$30 for their participation during 2014 and 2015. Only individuals who were enrolled as a part of the US military, either currently or in the past, were invited to participate. As in Study 1, this sample was diverse regarding age ($M = 44.12$, Range = 18–77), but information regarding number of deployments was not taken for this sample.

Study 2—Design and Procedure

Participants completed the same procedures as Study 1 with a few exceptions. First, since this sample included veteran participants who had not just returned from a deployment, we did not collect the official PDHA for this study. Thus, we only compared responses to the anonymized PDHA with the same questions asked by the virtual human interviewer.

Second, after giving consent and completing demographic questions, participants also completed additional screening measures including the PTSD Checklist (PCL; Blanchard et al., 1996). The PCL is a self-report measure that evaluates PTSD using a 5-point Likert scale. It is based on the DSM-IV-TR. Scores range from 17 to 85 and symptom severity is reflected in the size of the score, with larger scores indicating greater severity of PTSD symptoms. The PCL is commonly used in clinical practice and in research studies on PTSD. Participants also completed additional individual difference questionnaires that were not relevant to the current research questions, but described elsewhere (DeVault et al., 2014; Gratch et al., 2014).

Finally, and most importantly, Study 2 rules out the confound of question wording. While in Study 1 our anonymized version of the PDHA used the question wording from the official PHDA, in Study 2 our anonymized version of the PDHA used the exact

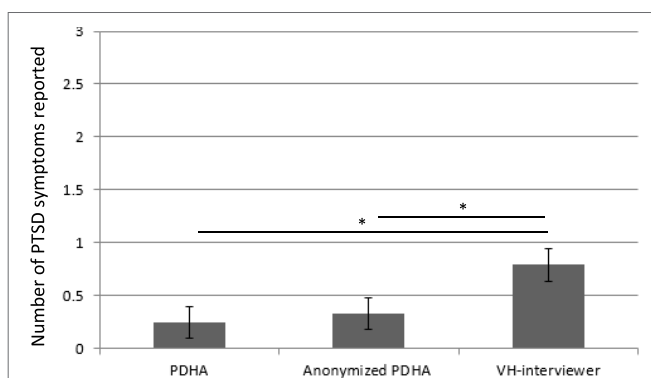


FIGURE 2 | Number of posttraumatic stress disorder (PTSD) symptoms reported out of three questions representing Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition, Text Revision (DSM-IV-TR) categories. Participants reported fewer symptoms (1) on the official Post-Deployment Health Assessment (PDHA) collected by the Joint Forces and (2) on an anonymized version of the PDHA, than (3) to a virtual human interviewer during a postdeployment interview in Study 1. * $p < 0.05$.

wording employed by the virtual human interviewer (see above). Therefore, in this study, any differences observed between answers on the anonymized version of the PDHA and the interview led by a virtual human could not be due to question wording. Coders again dichotomized each response as “yes” or “no” for the PTSD symptom, and had 100% agreement.

STUDY 2—RESULTS

A repeated-measures *t*-test among participants who successfully completed both assessments ($n = 126$) revealed an effect of assessment type that approached statistical significance [$t(125) = 1.76$, $p = 0.08$]; participants reported more PTSD symptoms when asked by the virtual human interviewer ($M = 1.21$, $SE = 0.10$) than on an anonymized version of the PDHA ($M = 1.05$, $SE = 0.11$; **Figure 3A**). There is a significant interaction with PCL score [$F(1,124) = 4.38$, $p = 0.04$] such that among those with subtler subthreshold PTSD symptoms (below median on the PTSD Checklist; PCL; Blanchard et al., 1996), the effect is significant [$M = 0.53$, $SE = 0.10$ vs. $M = 0.17$, $SE = 0.07$; $t(63) = 3.77$, $p < 0.001$; **Figure 3B**]. However, there is no significant difference among those already reporting higher symptoms on the PCL [$M = 1.92$, $SE = 0.12$ vs. $M = 1.95$, $SE = 0.14$; $t(61) = -0.20$,

$p = 0.84$]. Likewise, entering PCL score as a covariate rendered the aforementioned effect of assessment type on number of reported symptoms significant [virtual human interviewer $M = 1.21$, $SE = 0.08$ vs. anonymized PDHA $M = 1.05$, $SE = 0.08$; $F(1,124) = 5.78$, $p = 0.02$]. Finally, while an ANOVA revealed a significant between-subjects main effect of active duty status on number of reported symptoms such that active duty subjects were overall less willing to report symptoms ($M = 0.16$, $SE = 0.25$) than veterans [$M = 1.27$, $SE = 0.10$; $F(1,124) = 17.32$, $p < 0.001$], there was no interaction between assessment type and active duty status [$F(1,124) = 0.34$, $p = 0.56$].

Like Study 1, Study 2 demonstrates that service members are more willing to report PTSD symptoms to a virtual human interviewer than on an anonymized version of the PDHA (Q2). Indeed, even though both conditions control for stigma and ramifications for service members' military records, participants are more willing to report PTSD symptoms to virtual human interviewer than an anonymous version of the PDHA.

DISCUSSION

Across both studies, participants reported more PTSD symptoms when asked by a virtual human interviewer. Study 1 showed the effectiveness of virtual human interviewers in a sample of active duty service members reporting symptoms of mental distress. Supporting H1, service members reported more symptoms during a conversation with a virtual human interviewer than on the official PDHA. Our analysis of the small sample in Study 1 did not reveal differences between official and anonymized versions of the PDHA as was reported in Warner et al. (2011). However, in Warner et al., within-group results were not assessed and instead mean group differences between those who volunteered to fill out the anonymous version were compared with the mean of the larger official PDHA sample (1,712 out of 3,502). Service members in Study 1 also reported more PTSD symptoms to a virtual human interviewer than on an anonymized PDHA. In Study 2, we found a similar effect that approached statistical significance using a larger sample of active-duty service members and veterans. As in Study 1, participants in this study tended to report more symptoms when asked by a virtual human interviewer than on an anonymized PDHA. Thus, both reported studies support H2. Furthermore, the second study suggests that individuals falling under the radar in traditional assessments and scoring low on questionnaires like the PCL (e.g., possibly due to impression management, fear of stigmatization) could be detected by virtual human interviewers. Indeed, in this second study (where the sample has a broader range of distress), without taking into account PCL, the effect of assessment type on reporting of PTSD symptoms only approached statistical significance.

Although we showed that virtual human interviewers can increase service members' disclosure of mental health symptoms, further research is required to rule out alternative explanations concerning the mechanism behind this disclosure. For example, the open-ended nature of the questions asked by the virtual human interviewer could have contributed to encouraging service members to disclose. To see the extent to which this factor

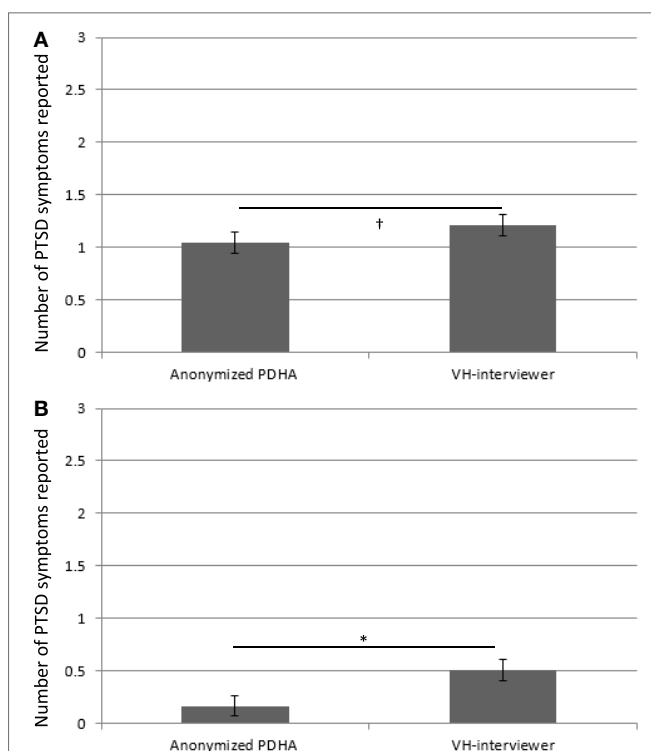


FIGURE 3 | Number of posttraumatic stress disorder (PTSD) symptoms reported out of three questions representing Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition, Text Revision (DSM-IV-TR) categories. Participants reported fewer symptoms (1) on an anonymized version of the Post-Deployment Health Assessment (PDHA), than (2) to a virtual human interviewer in Study 2 **(A)** across all participants and **(B)** among those with subtler PTSD symptoms [below median on PTSD Checklist; PTSD Checklist (PCL); Blanchard et al., 1996]. * $p < 0.05$; † $p < 0.09$.

contributes, future research could—for example—compare an open-ended paper-and-pencil version of the PDHA questions to the official forced-choice version in the absence of rapport building. Likewise, in both studies, all participants completed the anonymized PDHA before the interview with the virtual human, leaving order as another possible alternative explanation. However, this is unlikely to explain our results because, in Study 1, some participants completed the official PDHA before the anonymized PDHA and the virtual human interview, whereas others completed the official PDHA *after* these other two assessments. Although we do not have access to the dates when specific service members in our study completed the official PDHA to further test this, if order made a significant contribution, we would not have found the strongest effect of assessment (1) in this study and (2) when comparing to this (official) assessment, which was completed last for some participants. While this may help to rule out order as an alternative explanation for the difference between the virtual human interviewer and the official PDHA, it does not preclude the possibility that an order effect contributed to the difference between the virtual human interviewer and the anonymized PDHA.

In line with previous studies (Slack and Van Cura, 1968; Lucas et al., 2014; Pickard et al., 2016), these results support the view that virtual human interviewers provide a safe, reduced-stigma context where users may reveal more honest information. However, our results also go beyond prior work in that the current study focused specifically on service members and veterans, rather than a general civilian population. Also, where other clinical interviews led by virtual humans are more general, the clinical interview in this work assessed responses to specific questions about symptoms of PTSD. Thus, the results of this study add to previous work on use of such technologies for service members by demonstrating that virtual human interviewers may have a role to play in enhancing military mental health assessment by encouraging service members to report more PTSD symptoms than the gold-standard PDHA.

Moreover, beyond effects of anonymity found previously (e.g., Warner et al., 2011), virtual human interviewers may help soldiers “open up” and report their psychological symptoms through rapport building. Given that service members were more willing to report symptoms to a virtual human interviewer than on an anonymized version of the PDHA—even though these assessments were equally anonymous, this work establishes the idea that rapport has an impact on self-disclosure *above and beyond anonymity*. Pragmatically, this finding makes the case for taking advantage of the value that rapport-building holds for honest reporting rather than just relying on anonymity. For example, just having an anonymous online form appears not to be a sufficient “technological leap” to maximize self-disclosure. Honest reporting of such symptoms can better inform accurate diagnosis and help service members and civilians to break down barriers to care and receive evidence-based interventions that could mitigate the serious consequences of having a chronic untreated health condition. As such, the benefits of virtual human administrated mental health assessments could be substantial.

Finding that there is an impact of rapport for increasing disclosure *in addition to* anonymity has implications beyond

just reporting of psychological symptoms. Building upon the established effect of anonymity on disclosure (Sebestik et al., 1988; Thornberry et al., 1990; Baker, 1992; Beckenbach, 1995; Joinson, 2001; Warner et al., 2011), rapport-building could be beneficial for honest disclosure of any kind of sensitive information. As reviewed by Weisband and Kiesler (1996), anonymous assessments are especially helpful for eliciting information that is illegal (such as crimes like sexual assault) or is largely considered unethical or at least taboo (like risky sexual activity); our work implies that adding the second technique to elicit disclosure of rapport-building would further increase honest reporting of such information. Because virtual humans can build rapport while maintaining anonymity, they could be particularly useful for encouraging these kinds of disclosures.

Future work should investigate the impact of virtual human interviewers on promoting honest disclosure in other such sensitive clinical domains (Rizzo and Koenig, *in press*). Additionally, virtual human interviewers could be considered as an assessment strategy in other areas (e.g., financial planning) where people may perceive at least *some* stigma, and therefore may be tempted to under-report certain values (such as debt) even though honest information is essential for practitioners to give clients sound advice. Virtual human interviewers might also be useful for gaining honest information that—while not particularly stigmatizing—is still uncomfortable to disclose. For example, in organizational contexts, virtual humans could be helpful in eliciting honest performance evaluations.

ETHICS STATEMENT

The study was approved by University of Southern California's Institutional Review Board. Prior to participating, every participant consented by signing a written informed consent. No vulnerable populations were involved.

AUTHOR CONTRIBUTIONS

GL made substantial contributions to the conception and design of the work as well as the analysis or interpretation of data. AR and JG made substantial contributions to the conception and design of the work as well as interpretation of data. SS and GS made substantial contributions to the conception of the work as well as analysis and interpretation of data. JB made substantial contributions to the acquisition, analysis, or interpretation of data. L-PM made substantial contributions to the conception and design of the work.

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Conflict of Interest Statement: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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