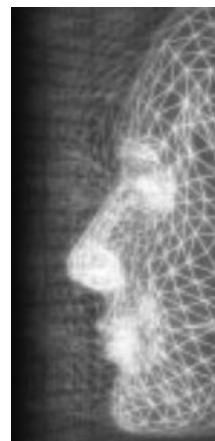


Virtual humans elicit socially anxious interactants' verbal self-disclosure

By Sin-Hwa Kang* and Jonathan Gratch



We explored the relationship between interactants' social anxiety and the interactional fidelity of virtual humans. We specifically addressed whether the contingent non-verbal feedback of virtual humans affects the association between interactants' social anxiety and their verbal self-disclosure. This subject was investigated across three experimental conditions where participants interacted with real human videos and virtual humans in computer-mediated interview interactions. The results demonstrated that socially anxious people revealed more information and greater intimate information about themselves when interacting with a virtual human when compared with real human video interaction, whereas less socially anxious people did not show this difference. We discuss the implication of this association between the interactional fidelity of virtual humans and social anxiety in a human interactant on the design of an embodied virtual agent for social skills' training and psychotherapy. Copyright © 2010 John Wiley & Sons, Ltd.

KEY WORDS: virtual humans; social anxiety; self-disclosure; contingent non-verbal feedback; rapport; virtual agents; anonymity; evaluation

Introduction

There are numerous studies on the application of virtual humans toward the problems of social skills training and psychotherapy. A predominantly interesting application of the technology is in helping people who have problems functioning normally, through a variety of social disorders, in social situations, such as treating social phobias^{1,2} or autism spectrum disorder^{3,4}. In this sense, virtual humans can be proposed to facilitate social interactions among people who have difficulty in shaping social relationships or help improve their social skills via virtual practice.

In existing work, virtual humans and interactive virtual environments have been studied as promising therapeutic approaches for psycho-social disorders, such as social anxiety. Herbelin⁵ reports that virtual reality (VR) exposure therapy has shown empirical success in treating social phobias, although current systems have been facing many technical and theoretical limitations, as well as dealing with restrictive social situations. The studies conducted on such systems have

primarily focused on investigating the effect of interfaces (e.g. head-mounted vs. desktop displays), appearances (photo-real vs. cartoonish characters) and simple motor behaviours (e.g. eye gaze patterns or random body motions) on interactants' feeling of being together and connected (co-presence). Such research has not explored virtual humans that are able to respond to human interactants in evocative social ways.

Earlier studies showed that people were able to better communicate in their social interactions, through feeling greater co-presence, when their interaction partners were represented visually but anonymously^{6,7}. In mediated social interactions, the use of virtual humans has been studied to explore interactants' engagement and self-disclosure, which is critical in shaping stronger social relationships and is a pre-requisite for verbal psychotherapy. The virtual humans, in those interactions, are suggested to secure interactants' identity hiding to allow the revealing of more intimate information about themselves.

In this study, we explored the association between social anxiety in human interactants and their self-disclosure. We assumed that self-disclosure would promote socially anxious people's social skills to form stronger and more intimate relationships in computer-mediated interactions. We specifically considered the

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relationship between interactants' social anxiety and their self-disclosure facilitated by non-verbal feedback associated with rapport—a phenomenon whereby people are inclined to mirror each other's behaviour and provide timely positive feedback over their interaction. We conclude that virtual humans can be more effective in eliciting self-disclosure in socially anxious people than real human interviewers, thereby providing key insights into the design of virtual characters for social skills training and psychotherapy.

Related Work and Research Questions

Social Anxiety and Self-Disclosure in Mediated Interactions with Virtual Humans

Researchers ^{8,9} have been exploring associations between self-disclosure and personality characteristics, such as self-consciousness, which has three subscales: private self-consciousness, public-self-consciousness and social anxiety ⁸. Private self-consciousness is defined as 'dispositional tendency to focus attention on the more private and covert aspects of oneself'. Public self-consciousness refers to 'the awareness of how one appears in the eyes of others' ⁹. Researchers further defined that 'social anxiety resembles public self-consciousness, but while public self-consciousness only refers to the awareness of how one appears to others, social anxiety also implies that one is worried about it and, consequently, inhibited in social interactions' ⁹.

Social anxiety disorder (also social phobia) has been reported to be 'one of the most frequent chronic psychological disorders' with a prevalence of up to 16% in western countries ⁵. Researchers ^{10,11} describe social anxiety as a condition in which 'some people, especially those who are shy or easily embarrassed, feel anxious in almost any situation in which they might be evaluated'.

Social psychologists have studied self-disclosure based on the work of Lewin in 1935, who investigated initial self-disclosure to strangers ⁸. Self-disclosure is defined as any private information that can be revealed to be shared knowledge between or among communicators ^{12,13}. Researchers characterized self-disclosure as verbal messages that disclose personal information about the interactant, 'including thoughts, feelings and experiences' ¹⁴.

Reno and Kenny ⁸ found that people high in social anxiety disclosed their personal information less than people low in social anxiety in face-to-face interactions. Schouten *et al.* ⁹ further discovered that people high in social anxiety revealed greater self-disclosure facilitated by reduced non-verbal cues in online social interactions.

Meanwhile, the studies of virtual humans have investigated how the consequence of social interaction occurs when people interact with virtual humans in immersive or non-immersive VRs, measuring interactants' co-presence and performance or anxiety itself if they feel anxiety while being monitored by those virtual humans as well as by real humans. These studies demonstrate that virtual humans affect people's co-presence, regardless of whether they are displayed on a desktop monitor (non-immersive VR) or in head-mounted environments (immersive VR), and the type of feedback determines the degree of interactants' social anxiety. However, those studies investigated non-social interactions ^{15,16} or multiple audience interactions ^{1,2,17}, not one-on-one social interactions.

Bailenson *et al.* ¹⁸ reported that interactants revealed greater self-disclosure in computer-mediated interactions than in face-to-face ones, and more self-disclosure with a text-based interface than a face-based interface. This outcome implies that people disclose their personal information when the other being is less visually identified. They ¹⁸ concluded that self-disclosure could get higher with lean media such as a voice-only condition, which does not support the same conclusion for a virtual human condition.

Rapport, Self-Disclosure and Contingent Non-verbal Feedback of Virtual Humans

Studies in clinical psychology have addressed that rapport-related behaviours would increase patients' self-disclosure which is a critical factor in psychotherapy. Rapport is a feeling of being connected which occurs from timely positive feedback between interactants ¹⁹ and posited to enhance mutual trust, persuasiveness and feelings of connectedness between interactants in social communications. It emphasizes the joint timing of behaviours (one interactant's behaviour educes the other's timely non-verbal feedback such as head nods or postural mirroring) and assumes that such joint behaviours implicitly communicate reciprocal positive evaluations between interactants.

Recent studies suggest that virtual humans can create rapport with human interactants by producing appropriate non-verbal feedback that is facilitated by behaviours generated by a human interaction partner^{20,21}. These studies indicate that the contingency of non-verbal feedback of virtual humans is critical for interactants' feeling of rapport.

In the study by Kang *et al.*²², they explored the associations between interactants' social anxiety and self-reported rapport. They found that the untimely non-verbal feedback of virtual humans elicited interactants' social anxiety more which led to less rapport of interactants, as well as their worse performance and more embarrassment in one-on-one social interactions. The study did not investigate the association between interactants' social anxiety and their self-disclosure yet.

Furthermore, researchers addressed that anonymity could play a critical role in shaping interactants' social ties via co-presence^{6,7}, as securing anonymity entails greater self-disclosure^{18,23}.

Based on the previous outcomes and the literature review, there are no studies to investigate the relationship between interactants' social anxiety and self-disclosure when people interact with virtual humans embodying rapport. Therefore, we propose to explore whether the use of virtual humans could be the best way to secure interactants' anonymity. The virtual humans, in this study, were designed to convey social cues via contingent non-verbal feedback which would elicit interactants' rapport. We will answer the next research question through this study.

What is the relationship between interactants' social anxiety and their verbal self-disclosure as well as behavioural rapport in one-on-one social interactions with virtual humans?

Experimental Design

The basic experimental design was a three-condition between-subjects experiment[†] involving three avatars that differed in visual realism: a raw video ($N=36$), a degraded video ($N=36$) and a virtual human (Rapport Agent, $N=36$). A confederate interviewer was used in the

[†]The experiment with three visual realism avatars reported in this study was conducted as part of a more extensive design involving six conditions involving the manipulation of anticipated future interaction (AFI) which did not show a statistically significant difference between two manipulated conditions: AFI and no AFI. Thus, we collapsed the data across the manipulated AFI conditions.

raw video and degraded video conditions. An experimenter controlled buttons that retrieved pre-recorded voice messages to generate speaking behaviours of an interviewer in the virtual human condition. Each participant was informed that his/her video image would be represented using his/her unmodified face image in the raw video condition, his/her degraded (edge-detector filtered) face image in the degraded video condition and the same gender matched Rapport Agent in the virtual human condition. The participants were informed that the Rapport Agent was an avatar controlled by another participant^{20,21,22}. The participants were further told that their appearance would be presented in the same way as the interviewer to them. Each experimental condition was presented to same gender combinations of dyadic partners: male–male and female–female.

Raw video condition: In the raw video condition, participants responded to the questions asked by a confederate. The participant and the confederate looked at each other's unmodified video.

Degraded video condition: In the degraded video condition, participants responded to the questions asked by a confederate. The participant and the confederate looked at each other's modified video which was degraded using an edge-detector filter.

Virtual human condition: In the virtual human condition, participants responded to the questions asked by the Rapport Agent displaying proper listening behaviours. These behaviours were contingent on the recognition of features of the participant's speech (acquired by a microphone) and head movements (acquired by a stereo camera) and driven according to predefined behaviour-mapping rules.

Participants

One hundred and eight people (50% women, 50% men) from the general Los Angeles area participated in this study. They were recruited using Craigslist.com and were compensated \$30 for 75 minutes of their participation. On average, the participants were 35 years old.

Procedure

First, participants signed the consent form and filled out the pre-questionnaire, which asked for their demographic information and social anxiety related questions. After both participants completed the pre-questionnaire, each participant was paired with someone whom they never met beforehand. The other person was a confederate or

an agent (interviewer) who asked participants 10 questions requiring self-disclosure of the participant¹³ (see Figure 2). The paired participants were randomly assigned to one of three experimental conditions. The interaction took place in two separate rooms where the paired participants were placed at different times, to avoid any initial face-to-face contact.

Second, participants were given a hypothetical conversational scenario where each assumed the role of a person (interviewee) who sought to find out if the other person could be a suitable match with whom an apartment could be shared, and who might possibly become a friend. We propose that this communication situation and the questions could motivate emotional interaction where people need to disclose personal information about themselves to get to know each other. Interactants' anonymity in this kind of self-revealing situation is important. The typical conversation was allowed to last about 30 minutes, but participants were not informed of any specific time limitation.

Participants in all conditions sat in front of a 30-inch computer monitor. They saw the video images of their partners displayed on the 30-inch computer monitor. The monitor was fitted with a stereo camera system and a camcorder. For capturing high-quality audio, the participant wore a lightweight close-talking microphone and spoke into a microphone headset.

After participating in the experiment, participants completed the post-questionnaire and were debriefed individually.

Equipment

Video Avatar Design

Video avatars included an unmodified video-conference image⁶ and its alterations with special video effects in



Figure 1. (a) A raw video, (b) a degraded (edge-detector filtered) video, (c) virtual humans (Rapport Agents: male & female).

the types of avatars. In terms of visual realism, three types of images (raw videos, degraded videos and virtual humans) were provided to represent visual identity. For the degraded videos, we utilized the findings of Zhao and Stasko⁶. They examined four types of video-filtering techniques to express participants' identity masking and reported an edge-detected image (see the image (b) in Figure 1) provided lower actor identification than a pixelized one frequently used for identity hiding. This technique was used to provide interactants' anonymity in previous studies⁶.

To generate the video avatar movement of this degraded video, a web-cam (Logitech QuickCam Orbit MP) captured participants' facial expressions and visual effect software (WebcamMax) degraded the video using an edge-detector filter. To allow video chat conversation, video-conference software (Skype) was used. A hands-free headset connected to the computer was provided to participants for the audio communication.

Virtual Human Design: Rapport Agent

For the virtual humans, we utilized the Rapport Agent (see the images (c) in Figure 1), created by Gratch *et al.*^{20,21}, whose system architecture is presented in Figure 2. They found that the contingent feedback of the Rapport Agent elicited greater social tie of interactants in human-computer interaction between a real human and the agent than in real humans' face-to-face situation.

The Rapport Agent is functioned using a vision-based tracking system and a life-sized animated character with the image of the character's head and upper body presented on a computer monitor. The agent is equipped with an open modular architecture that incorporates different feature detectors and animation systems, as well as an easily authored mapping between features and behaviour. The behaviour mapping language integrates contextual features, probabilistic responses

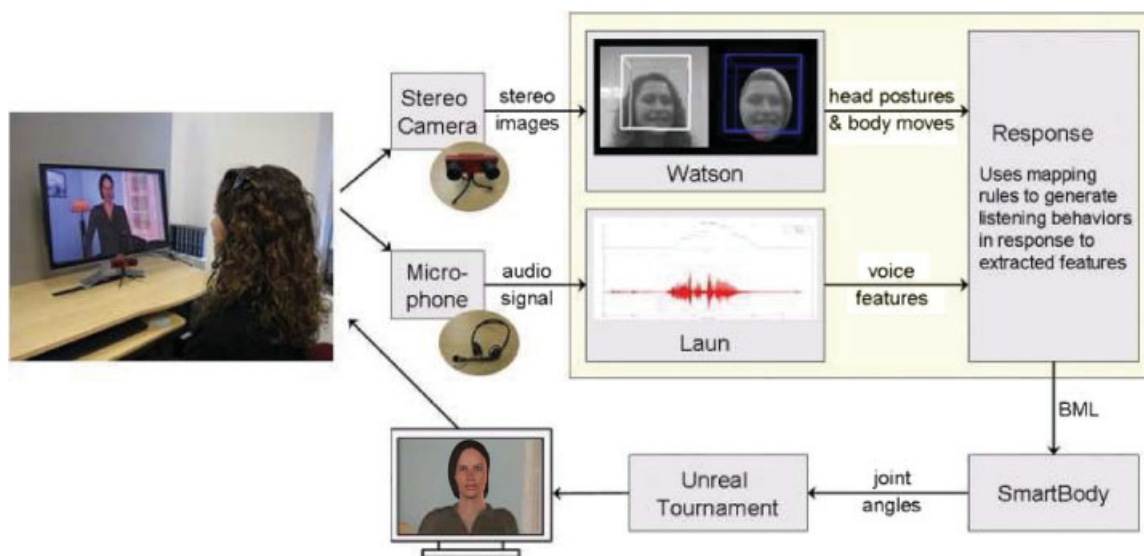


Figure 2. The setup for interactions and the system architecture of Rapport Agent.

and some control over the temporal dynamics of behaviour. For example, particular prosodic contours in a human interactant’s voice can elude the agent to nod and mirror posture shifts. The animation commands of the agent are passed to the SmartBody animation system²⁴, which is a virtual human animation system created to seamlessly combine animations and procedural behaviours. These animations are rendered in the Unreal Tournament™ game engine and displayed to an interaction partner.

To generate listening behaviours of an interviewer used in the virtual human condition, the Rapport Agent first collected and analyzed the attributes from the interviewee (participant)’s voice and upper-body movements.

Two Videre Design Small Vision System stereo cameras were placed in front of the interviewee. The interviewee’s head orientation and position were tracked by the Watson image-based tracking library using a stereo camera^{20,21}. Watson also incorporated learned motion classifiers that detected head nods and shakes from a vector of head velocities. Acoustic features were derived from properties of the pitch and intensity of the speech signal using a signal processing package, LAUN^{20,21}. To generate speaking behaviours of the interviewer in the virtual human condition, the experimenter controlled the buttons that retrieved pre-recorded voice messages.

Four desktop computers were used in the experiment: two DELL Precision 670 computers to run Watson and record stereo camera images, one for an interviewee and

one for an interviewer; one DELL Precision 690 to run the experiment system; and one DELL Precision 530 to store logs. The video avatars and Rapport Agent were displayed on a 30-inch Apple display to approximate the size of a real human sitting 4 feet away. The Rapport Agent conditions used the same male and female virtual characters (see the images (c) in Figure 1).

Measurements

Response Variables

The response variables were composed of two measurements: (i) behavioural measures of self-disclosure¹³ and (ii) behavioural measures of rapport²¹.

We videotaped participants’ verbal responses to answer 10 questions, which were supposed to stimulate interactants’ intimate self-disclosure and given by their partners including confederates and a virtual human. Sample questions include: ‘What characteristics of yourself are you most proud of?’, ‘What have you done in your life that you feel most guilty about?’ and ‘What is your most common sexual fantasy?’ The verbal responses of all interactions were transcribed and coded by two coders in order to evaluate the quantity and quality of interactants’ self-disclosure as well as behavioural rapport.

Behavioural measures of self-disclosure. Two coders defined utterances as disclosure or other. The utterance

is 'an idea unit, which is an expression of one whole idea or proposition'¹⁴. They further rated intimacy level of each 'disclosure' utterance using the three layer categorization scheme of Altman and Taylor²⁵ which is composed of the peripheral, intermediate and core layers: 'The peripheral layer is concerned with biographic data; the intermediate layer deals with attitudes, values, prejudices, opinions, aspirations, dreams and desires; the core layer is comprised of highly personal aspects related to basic values, beliefs, needs, fears, self-concept, emotions, feelings and things people are ashamed of'²³.

The utterances of each layer included: 'I am 30 years old (peripheral layer)', 'I like to go shopping (intermediate layer)' and 'I feel most guilty about cheating on my girlfriend (core layer)'.

After the utterances were defined as self-disclosure and intimacy levels were judged, the inter-coder reliability was measured. The depth of self-disclosure was calculated using the mean of two rating scores. Big rating disagreements were resolved through discussion between two coders, if the sum of each coder's rating score had a difference gap over 10, which ranged between 0 and 18.

*Behavioural measures of rapport.*²¹ Behavioural measures of rapport included word count (total number of words an interviewee said), number of disfluencies (summed numbers of an interviewee's pause fillers, incomplete words and prolonged words) and number of meaningful words (number of words after excluding the disfluencies in all words an interviewee said). The examples of pause fillers are 'um' and 'er'. The example of incomplete words is 'universe-'. The example of prolonged words are 'I li::ke it', in which ':' signifies a lengthened vow 'i'.

Explanatory Variables

Social anxiety. The pre-questionnaire packet included questions about one's shyness[‡] as a dispositional personality trait²⁷. Scales ranged from 1 (disagree strongly) to 5 (agree strongly). Sample items include: 'I

[‡]Researchers^{10,26} introduced shyness as a concept correlated with social anxiety (or social phobia). According to this definition, social anxiety and shyness could be used to identify the same concept. Hopko *et al.*²⁶ found that the revised Cheek and Buss shyness scale is a reliable and stable measurement to measure social anxiety, such as inhibition and discomfort in the presence of others. We used this scale to measure participants' social anxiety in this study.

feel tense when I'm with people I don't know well' and 'I feel inhibited in social situations'.

Private self-consciousness. The pre-questionnaire packet contained questions about one's private self-consciousness²⁸. Sample items include: 'I'm always trying to figure myself out' and 'I generally pay attention to my inner feelings'. Scales ranged from 1 (disagree strongly) to 5 (agree strongly).

Public self-consciousness. The pre-questionnaire packet contained questions about one's public self-consciousness²⁸. Sample items include: 'I care a lot about how I present myself to others' and 'I'm usually aware of my appearance'. Scales ranged from 1 (disagree strongly) to 5 (agree strongly).

Scheier and Carver²⁸ investigated the measures of self-consciousness and found a positive association with social anxiety. Myers¹⁰ addressed 'shyness is a form of social anxiety characterized by self-consciousness and worry about what others think', thus social anxiety includes some features of self-consciousness. In this study, we assessed the two constructs separately. Social anxiety contained items indicating some form of aversion to the communication situation that might impede communication and other behaviours, while self-consciousness included items specifying merely awareness of oneself without direct implications to behaviour. Therefore, we controlled for the effect of self-consciousness variables (both private and public) while measuring the association between people's social anxiety and their behavioural (verbal) self-disclosure and rapport after their participation in the experiment²².

Results

We conducted a hierarchical multiple regression[§] relating social anxiety to self-disclosure and behavioural rapport in each condition, controlling for the potential effect of private self-consciousness and public self-consciousness by introducing them first in the hierarchy.

Inter-Coder Reliability

Two coders independently rated the intimacy of self-disclosure in 108 files. The reliability compares those two ratings per file.

[§]We explored social anxiety as a dispositional trait of the individual, not an outcome of the experimental manipulation, and thus simple ANOVA does not control for this additional variable.

We performed Krippendorff's alpha[#] 29. The results of Krippendorff's alpha showed good inter-coder reliability: $\alpha = 0.84$; Do (Observed Disagreement) = 232.37; De (Expected Disagreement) = 1483.14.

Results for Behavioural Self-Disclosure

The results indicated that interacting with virtual humans promoted more self-disclosure in more socially anxious individuals.

In the virtual human condition, addition of social anxiety to the equation significantly raised the prediction of self-disclosure ($sr^2 = 0.19$). The ANOVA result indicated that the model as a whole (which includes both blocks of variables) was significant [$F(3, 32) = 5.00, p < 0.01$]. The variable of social anxiety ($\beta = 0.48, p < 0.01$) made a statistically significant contribution to the increase in self-disclosure, when the overlapping effects of the controlled variables (private self-consciousness, public self-consciousness) were statistically eliminated.

In the other conditions (raw videos and degraded videos), there were no statistically significant associations between social anxiety and self-disclosure, when private self-consciousness and public self-consciousness were statistically controlled.

Results for Behavioural Rapport

Results for total words. The results demonstrated interacting with virtual humans fostered more total words in more socially anxious individuals.

In the virtual human condition, addition of social anxiety to the equation significantly increased the prediction of the number of total words ($sr^2 = 0.13$). The ANOVA result indicated that the model as a whole (which includes both blocks of variables) was significant [$F(3, 32) = 4.21, p < 0.05$]. The variable of social anxiety ($\beta = 0.40, p < 0.05$) made a statistically significant contribution to the increase in the number of total words, when the overlapping effects of the controlled variables (private self-consciousness, public self-consciousness) were statistically removed.

Results for meaningful words. The results demonstrated that interacting with virtual humans promoted

more meaningful words in more socially anxious individuals.

In the virtual human condition, addition of social anxiety to the equation significantly raised the prediction of the number of total words ($sr^2 = 0.17$). The ANOVA result indicated that the model as a whole (which includes both blocks of variables) was significant [$F(3, 32) = 4.87, p < 0.01$]. The variable of social anxiety ($\beta = 0.45, p < 0.01$) made a statistically significant contribution to the increase in the number of meaningful words, when the overlapping effects of the controlled variables (private self-consciousness, public self-consciousness) were statistically eliminated.

In the other conditions (raw videos, degraded videos), there were no statistically significant associations between social anxiety and total words, as well as between social anxiety and meaningful words, when private self-consciousness and public self-consciousness were statistically controlled.

Results for disfluencies. The results did not show that there were any statistically significant associations between social anxiety and disfluencies across all three conditions.

Discussion and Future Directions

Summary of Results

This study demonstrated that virtual humans caused a significant improvement in the behaviour of socially anxious interactants. Interactants with a disposition to be anxious in social situations exhibited more speech (total words), more information (meaningful words) and disclosed more intimate information about themselves (self-disclosure) in an interview task when interacting with virtual humans than with real human video avatars (see Figure 3).

The results for the virtual humans condition in Figure 3 show that the β weight for social anxiety on verbal self-disclosure is positive. This suggests that people with more social anxiety reveal intimate information about themselves more than people with less social anxiety when they interact with virtual humans.

This implication lends support to the contention that virtual humans and virtual environments can facilitate social interactions among people with social anxiety disorders.

[#]Krippendorff's alpha is more sensitive than Cohen's kappa and recommended to use for assessing inter-coder reliability of quantitative ratings by two coders.

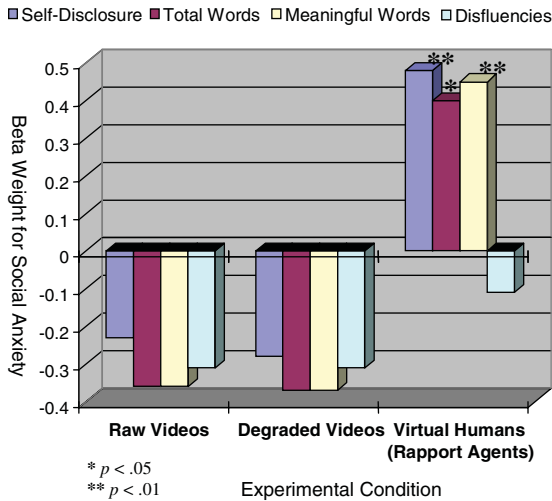


Figure 3. Associations between social anxiety and dependent variables (self-disclosure, total words, meaningful words and disfluencies) in each of three experimental conditions.

The results also demonstrate that the β weights for social anxiety on both total words and meaningful words are positive in the virtual humans condition, while showing no statistically significant difference for disfluencies across three conditions. This indicates that people with more social anxiety feel greater rapport with virtual humans than people with less social anxiety.

Implications and Future Work

The studies of virtual humans have been exploring the ways that virtual agents embody social resonance, so interactants could interact with the agents as if they were communicating with real humans in some sense. The work of Bickmore *et al.*³⁰ or McRorie *et al.*³¹ has investigated interactants' responses to the personality traits of virtual humans. Gratch *et al.*^{20,21} have been exploring interactants' feeling of rapport through embodying contingent non-verbal feedback of virtual humans. Maat and Heylen³² also have studied social interactions between real humans and virtual humans utilizing a turn-taking scheme.

In our study, we aimed at exploring this subject through investigating the associations between interactants' personality characteristics (i.e. social anxiety) and their social responses, specifically verbal self-disclosure as well as behavioural rapport by variation of anonymity, which was facilitated by the contingent non-verbal feedback of virtual humans and not manipulated in previous studies. We found that people

high in social anxiety felt greater behavioural rapport by exhibiting more speech and information than people low in social anxiety when they experienced the contingent non-verbal feedback of virtual humans (Rapport Agents). This upshot suggests that interactants' feeling of rapport could mediate their intimate self-disclosure if they are high in social anxiety, which needs to be explored in future studies.

Existing psychotherapy-related studies find that self-disclosure, even mutual self-disclosure between patients and therapists, is a pre-requisite for verbal psychotherapy. Researchers³³ in clinical psychology reported that people revealed their personal information more when they communicated with others in face-to-face interactions, as it is critical to disclose intimate information about patients based on therapeutic alliance between the patients and therapists. Meanwhile, other researchers⁸ discovered that more socially anxious people revealed less personal information than less socially anxious people in face-to-face interactions, since more socially anxious people needed more time to overcome their nervousness until they get to an actual conversation. Schouten *et al.*⁹ also stated that more socially anxious people disclosed greater self-disclosure via reduced non-verbal cues in computer-mediated interactions. In their study, the amount of self-disclosure was reported by interaction partners. The researchers suggested that further studies would need to investigate interactants' self-disclosure reported by a third person's observation. In our study, we hired two coders to rate interactants' behavioural self-disclosure.

The outcome of our study somewhat mirrors the conclusions of the studies in online interactions mentioned above. The conclusions of other previous work are inconsistent based on the type of media, specifically arguing that socially anxious people revealed greater self-disclosure facilitated by reduced non-verbal cues in online social interactions. We argue that virtual humans could generate about the same behaviour as a real human listener by timely non-verbal feedback yet reduced non-verbal cues, which has been supported in previous studies and could contribute to promoting interactants' self-disclosure. We further suggest that virtual humans could provide high anonymity which is critical to elicit interactants' self-disclosure. Therefore, our conclusion contributes to helping socially anxious people better communicate with new acquaintances when they interact with virtual humans securing anonymity and conveying contingent non-verbal feedback, which embodies social cues. The conclusion of our study also implies that socially anxious patients could reveal more personal information

in initial interactions with psychotherapists using virtual humans.

There are several issues which could be explored in future studies. We suggest elaborating the experimental design to further investigate how social influence affects social interactions with virtual humans by measuring people's situational anxiety through their interaction. The results of this study can be limited to a single emotionally engaged situation in which two strangers communicated in the study. It also involved role-playing, and this may have caused the type of engagement which is different from the one a real situation would entail. In actual interactions with virtual humans, a virtual human asked the questions using a pre-recorded voice that was operated by an experimenter, which might not allow the interaction in a natural way. Confederates were also instructed to behave in a similar way to the virtual human which is potential confound. Furthermore, the animation technology used in this experiment was not able to reproduce facial expressions for virtual humans, which is considered a key to convey emotional signals in social interactions. It has been studied that reciprocity is a critical concept in psychological interventions where therapists often initiate disclosure; this increases intimacy and promotes self disclosure in the patient³⁴. Therefore, the communication outcomes of this study need to be explored in more elaborated experimental designs that include a more affective and reciprocal communication situation.

Overall, the study illustrated here adds to our understanding of the relationship between the non-verbal feedback of virtual humans, interactants' social anxiety and self-disclosure. We highlight that the contingent non-verbal feedback of a virtual human could improve socially anxious people's self-disclosure more than real humans' rich social cues could.

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