Associations between Interactants' Personality Traits and Their Feelings of Rapport in Interactions with Virtual Humans

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This study explored associations between the personality traits of human subjects and their feelings of rapport when they interacted with either a virtual agent or a real human. The animated graphical agent, the Responsive Agent, responded to real human subjects' storytelling behavior, using appropriately timed nonverbal (contingent) feedback. Interactants' personality factors of Extroversion, Agreeableness, Conscientiousness, and Openness were related to three self-reported components of rapport: Positivity, Attentiveness, and Coordination; and to three behavioral indications of rapport: Meaningful Words, Disfluency, and Prolonged Words. The results revealed that subjects who scored higher on Conscientiousness reported higher rapport when interacting with another human, while subjects who scored higher on Agreeableness reported higher rapport while interacting with a virtual agent. The effects of these personality variables differed significantly across the two experimental groups. The conclusions provide a step toward further development of rapport theory that contributes to enhancing the interactional fidelity of virtual humans.

1. Introduction

Numerous studies have been conducted to explore the impact of personality traits on social interactions between humans and humans or agents. Personality embodies a human's characteristics that represent the consistent and permanent patterns of his/her emotion, thought, and behavior [2,9,35]. Therefore, a human being's dispositional qualities could affect his/her responses to an interaction partner in mediated environments. However, most of those studies have been conducted for human-to-human communication. Those studies focused on the intrapersonal links of global personality dimensions, such as extroversion, neuroticism, associations between personality and nonverbal behavior, interaction quality based on individual attachment in romantic or child/caregiver relationships, or the impact of nonverbal behavior on social interaction [4]. A few studies [22,32,33] for human-to-agent interaction showed contradictory findings on human predisposition to agents' characteristics that embodied some personality traits.

The "Media Equation" perspective [36] proposes that people respond to computer interfaces as if they were communicating with real persons. Hence, human-computer interaction should capture various effects on interactants' sense of being together and connected, that is *rapport,* with agents, depending on the interactants' predisposition. Therefore, we raise the question "what are the various outcomes of social interaction between humans and agents if we examine humans' individual differences in personality?"

Tickle-Degnen and Rosenthal [39] define three components of rapport: positivity as a feeling of "mutual friendliness and caring," mutual attentiveness as a feeling of "intense mutual interest in what the other is saying or doing," and coordination as a feeling of "balance, harmony, and in sync." Hendrick [20] proposes that further theoretical development of construct rapport might reveal the relationship between a person's personality and his/her feeling of

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rapport. In his response to the article of Tickle-Degnen and Rosenthal [39], Izard [23] also suggests exploring the relationships between personality traits and specific elements of rapport. He predicts that more introverted people will perform worse for the mutual attentiveness dimension, more dominant people will perform worse for the coordination dimension, and more aggressive or emotionally negative people will perform worse for the positivity dimension. Izard further proposes the possibility of testing hypotheses of correlations between personality traits and rapport dimensions. No studies have responded these proposals.

In this study, we seek to deepen and generalize our prior findings on the cognitive, emotional, and behavioral impact of rapport and to specifically investigate the role of contingency, which is timely and appropriate feedback, in establishing rapport. The goal is to provide some fundamental data for further development of rapport theory that will contribute to evaluating and enhancing the interactional fidelity of virtual humans for use in social skills training and therapy [26]. In addition to practical insights into building virtual humans, this work illustrates how virtual human technology can provide fundamental insights into open questions in social psychology.

2. Related Work and Research Hypotheses

Contingent Nonverbal Feedback of Responsive Agents

Our research on the Responsive Agent [17] investigates how virtual characters can elicit the harmony, fluidity, synchrony, and flow one feels when achieving rapport.

The Responsive Agent is designed to elicit rapport from human participants within the confines of a dyadic narrative task. In this setting, a speaker (the narrator) retells some previously observed series of events (in this case, the events in a sexual harassment awareness and prevention video) to a graphical character. The speaker is led to believe that the character

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accurately reflects the nonverbal feedback of an actual human listener. In fact, these movements are generated by the Responsive Agent software (see Figure 1).

The central challenge for the Responsive Agent is to provide the nonverbal listening feedback associated with rapportful interactions. Such feedback includes the use of backchannel continuers [38] (nods, elicited by speaker prosodic cues, that signify the communication is working), postural mirroring, and mimicry of certain head gestures (e.g., gaze shifts and head nods). The Responsive Agent generates such feedback by real-time analysis of acoustic properties of speech (detecting backchannel opportunity points, disfluencies, questions, and loudness) and speaker gestures (detecting head nods, shakes, gaze shifts and posture shifts).

Although these prior studies have demonstrated a social impact of the software agent, it is less clear what aspects of agent behavior are critical and where improvements can be made. One relevant fact is the form of the feedback. People utilize a variety of behavioral movements, posture shifts, and facial expressions, and some research has shown that subtle features of how these behaviors are expressed can influence interpretation. For example, Krumhuber et al. showed that variation in the onset and offset rates of facial expressions would influence interpretations of trust and sincerity [27]. One way to gain insight into such factors is to capture the actual nonverbal feedback displayed by human listeners and use this to drive the behavior of virtual characters [18].

Another relevant factor in the establishment of rapport is the *contingency* of feedback: does listener feedback have to be contingent on speaker behavior? Few empirical studies of embodied agents have specifically controlled for the contingency of feedback behavior.

We have specifically investigated whether contingency of virtual humans' feedback would allow people feel higher rapport in one-on-one social interaction. We measured participants' "rapport (self-report and behavioral measurement)," "disfluency of speech (pause fillers +

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false starts)" and "meaningful words (total number of words produced - pause fillers - false starts)," and mainly found the Responsive Agent creates rapport as real humans do. In a series of studies [17,18,19], we conclude that *contingency,* that is, the timing of nonverbal feedback of listeners, matters when creating rapport. This research suggests that virtual humans can establish something akin to rapport with people by producing rapid nonverbal feedback that is elicited by (i.e., contingent on) behaviors produced by the human interaction partner. Mirroring general findings on rapport, these studies illustrate that the contingency of nonverbal feedback of virtual humans is crucial for interactants' sense of rapport. For example, Gratch and his colleagues [19] created two virtual humans, one that gave contingent feedback to a human storyteller (e.g., head nods and postural mirroring) and the other that provided essentially random feedback, which was generated independent of the storyteller's behavior, and showed a significant impact of contingency on indices of rapport.

Personality, Nonverbal Behavior, and Agents

In studies of personality and agents, researchers [5,6,22,32,33] report the effects personality differences on people's interaction with agents. Isbister [22] found people liked an embodied character which showed a personality complementary of their own, while other researchers [32,33] report that people preferred computer interfaces which embodied a similar type of personality to their own. Bickmore and his colleagues [5,6] explored the effects of personality traits, specifically extro/introversion and trust in an interaction partner, when people interacted with an embodied conversational agent. They found that extroverted people communicated with the agent more significantly than introverted people to constructing their relationships. Most of the Virtual Reality (VR) studies have investigated ways of incorporating personality traits into agents to enhance their believability, or examining the relationship between users' personality traits and agents' traits.

Some previous studies have investigated the associations between personality and nonverbal behaviors in human-to-human interactions. Among these investigations are those that examined the relations between a five-factor model of personality and social interaction by examining both self-report and behavioral measures [3,7,28]. Levesque and Kenny [28] also discovered that extroversion was positively associated with the amount of time participants spent gesturing. Borkenau and Liebler [7] asserted that extroversion was positively related to speed of gestures and frequency of head movements. Berry and Hansen [3] reported that people with greater extroversion and agreeableness were more satisfied with their partners. In their later study, Berry and Hansen [4] explored the effect of nonverbal behavior on social interaction. They specifically investigated the relationships between personality, nonverbal behavior, and the quality of social interaction between females. They found that extroversion and agreeableness were positively associated with participants' self-reported interaction quality as well as independent observers' quality ratings.

Research investigating the impact of personality traits of virtual humans on social interactions has primarily focused on how people respond to agents which represent some set of personality traits. Such research has not investigated virtual humans that are able to respond in meaningful, socially appropriate, ways to human subjects. There is no research that explores the relationship between humans' personality traits and their evaluation of interaction quality when humans interact with agents that specifically embody only nonverbal feedback.

The results of Berry and Hansen [4] show that associations between the measures of the five-factor personality, nonverbal behavior, and social interaction quality show that personality may play an important role in affecting social experience in human-to-human interactions. This finding provides impetus for further studies investigating the relationships between personality, agents' nonverbal behavior, and social interaction between humans and virtual

agents. In the studies of agents, researchers have found contradictory results when they evaluated the relations between agents' personality and users' personality. Therefore, in this study we will examine what type of associations between interactants' personality traits and agents' contingent nonverbal listening feedback associated with rapport-like interactions that embodies rather agreeable responses to interactants' behaviors, as such feedback that uses backchannel continuers, postural mirroring, and mimicry of certain head gestures of a real person who is interacting with the agent.

The five traits of personality (Five-Factor Model) [16] is a well-accepted model used to differentiate people's personalities [9,15,24,34]. These five factors of personality are: *extroversion* composed of gregariousness, assertiveness, activity, excitement-seeking, positive emotions, and warmth; *agreeableness* which is made up of trust, straightforwardness, altruism, compliance, modesty, and tender-mindedness; *conscientiousness* consisting of competence, order, dutifulness, achievement striving, self-discipline, and deliberation; *neuroticism* as composed of anxiety, angry hostility, depression, self-consciousness, impulsiveness, and vulnerability; and *openness* which is defined by ideas, fantasy, aesthetics, actions, feelings, and values [12,21,30].

Based on the results of our previous research and the literature review, in this study we explore how simple yet contingent nonverbal feedback of an agent affects interactants' sense of rapport as a function of their personality traits. We investigate how these personality traits are related to people's sense of rapport, specifically when they get contingent feedback from the Responsive Agent. In general, we expect the presence of stronger personality traits that are likely associated with more successful communication to produce more rapport. This leads to the hypotheses below:

H1: Extroversion will be positively associated with overall self-report rapport and its individual components of positivity, attentiveness, and coordination.

H2: Agreeableness will be positively associated with overall self-reported rapport and its individual components of positivity, attentiveness, and coordination.

H3: Conscientiousness will be positively associated with overall self-report rapport and its individual components of positivity, attentiveness, and coordination.

H4: Openness will be positively associated with overall self-report and its individual components of positivity, attentiveness, and coordination.

H5: Extroversion will be positively associated with the behavioral rapport variable of meaningful words and negatively associated with the behavioral rapport variables of disfluency and prolonged words.

H6: Agreeableness will be positively associated with the behavioral rapport variable of meaningful words and negatively associated with the behavioral rapport variables of disfluency and prolonged words.

H7: Conscientiousness will be positively associated with the behavioral rapport variable of meaningful words and negatively associated with the behavioral rapport variables of disfluency and prolonged words.

H8: Openness will be positively associated with the behavioral rapport variable of meaningful words and negatively associated with the behavioral rapport variables of disfluency and prolonged words.

In this study, although all five personality traits were measured, we use only four of them to measure participants' personality characteristics because of high collinearity of the trait neuroticism with the other four traits.

Media richness theory [13,14,37] indicates that a medium can be described by its richness in providing affordances for a task. For example, a more equivocal task requires a richer (more information capacity) medium to communicate more efficiently, while a less equivocal task can be carried out efficiently via a leaner medium. This theory claims that richer media can facilitate emotionally arousing tasks that include high equivocality. We consider the communication of a time-sequenced and complex set of events to fall in this class of communication task. Therefore, as face-to-face communication is the richest medium, we propose this hypothesis:

H9: Face-to-face interactions with other humans will produce higher levels of rapport than will interactions with the animated Responsive Agent.

3. Methods

3.1. Experimental Design[1]

To investigate the importance of feedback form and contingency, we used a "good virtual listener" (the Responsive Agent). This is an autonomous computer program that synthesizes head gestures and posture shifts in response to the features of a real human speaker's speech and movements. The impact of this agent on establishing rapport with humans bringing different personality traits to the interaction, is the focus of this research. The performance of the agent is compared to face-to-face interaction with a human as a reference point.

Participants were randomly assigned to one of two experimental conditions using a coin flip:

Responsive Agent Condition (n=24). In this condition, the participant interacted with a virtual character displaying proper listening behaviors. These behaviors were contingent on the

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[1] The experiment with the Responsive Agent condition and the Face-to-Face condition reported in this study were conducted as part of a more extensive design involving four conditions and 64 subjects [18].

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 behavior-mapping rules. For example, certain prosodic contours in the speaker's voice would cause the character to nod. Facial expressions were not generated. A confederate listener was used in the Responsive condition.

Face-to-Face Condition (n=20). In the Face-to-Face condition, the participant talked to a human listener, who was recruited from the same population as the participant and was instructed to simply listen to the speaker without responding verbally. Data was collected from the speaker.

3.1.1. Participants

Participants (70% women, 30% men) from the general Los Angeles area participated in this study. They were recruited using Craigslist.com and were compensated $20 for one hour of their participation. On average, the participants were 38.8 years old.

3.1.2 Procedure

Participants entered the laboratory and were told they were participating in a study to evaluate a communicative technology. The experimenter informed participants:

The study we are doing here today is to evaluate a communicative technology that is developed here. An example of the communicative technology is a web-camera used to chat with your friends and family.

Participants signed the consent form, and then the experimenter asked both participants "what's your favorite animal?" The participant whose answer came first alphabetically was assigned the speaker role and the other participant was assigned the listener role. In the Responsive condition, the confederate always gave the answer "zebra" to ensure their being assigned to the listener role.

Next, participants were led to two separate side rooms to fill out the pre-questionnaire, which asked for their demographic information and social anxiety related questions, which are not analyzed here.

After both participants completed the pre-questionnaire, participants were led into the computer room. The experimenter then explained the procedure and introduced participants to the equipment used in the experiment.

Next, the speaker remained in the computer room while the listener was led to a separate side room to wait. The speaker then viewed a short segment of a video clip taken from the Edge Training Systems, Inc[2]. Sexual Harassment Awareness video. Two video clips were selected and were merged into one video: The first, "CyberStalker," is about a woman at work who receives unwanted instant messages from a colleague at work, and the second, "That's an Order!", is about a man at work who is confronted by a female business associate, who asks him for a foot massage in return for her business.

After the speaker finished viewing the video, the listener was led back into the computer room, where the speaker was instructed to retell the stories portrayed in the clips to the listener.

Speakers in the Responsive Agent Condition sat in front of a 30-inch computer monitor and approximately 8 feet apart from the listener, who sat in front of a 19-inch computer monitor. They were separated by a screen and could not see each other. The speaker saw an animated character displayed on the 30-inch computer monitor. Speakers in the Responsive Agent Condition were told that the avatar on the screen displayed the actual movements of the confederate human listener. While the speaker spoke, the listener could see a real time

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[2] We have been granted full permission to use these video clips in this study from Paul O'Keefe at Edge Training Systems, the creator of the video.

video image of the speaker retelling the story displayed on the 19-inch computer monitor (see Figure 1). 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 mounted on a headset.

Figure 1. The setup for the experimental conditions

Next, the experimenter led the speaker to a separate side room. The speaker completed the post-questionnaire containing the rapport scales while the listener remained in the computer room.

Finally, participants were debriefed individually and probed for suspicion about the listener using the protocol from Aronson, Ellsworth, Carlsmith, and Gonzales [1]. No participants indicated that they believed the listener was a confederate in the study.

3.1.3 Equipment

To produce nonverbal listening behaviors used in the Responsive Agent condition, the Responsive Agent first collected and analyzed the features from the speaker's voice and upper-body movements (See Figure 2). Two Videre Design Small Vision System stereo cameras were placed in front of the speaker and the listener to capture their movements.

Watson, an image-based tracking library developed by Louis-Phillipe Morency, uses images captured by the stereo cameras to track the participants' head position and orientation [31]. Watson also incorporates learned motion classifiers that detect head nods and shakes from a vector of head velocities. Both the speaker and listener wore a headset with microphone. Acoustic features are derived from properties of the pitch and intensity of the speech signal using a signal processing package, LAUN, developed by Mathieu Morales [17].

Three Panasonic PV-GS180 camcorders were used to videotape the experiment: one was placed in front the speaker, one in front of the listener, and one was attached to the ceiling to record both speaker and listener. The camcorder in front of the speaker was connected to the listener's computer monitor for displaying video images of the speaker to the listener.
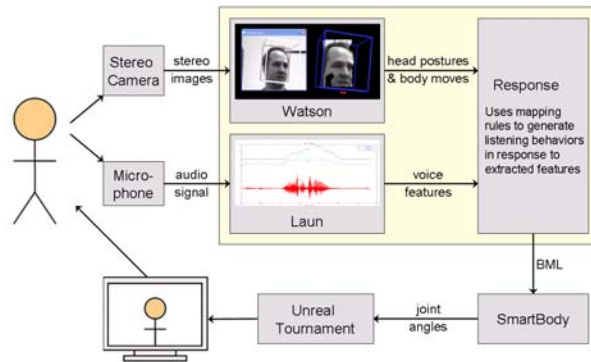
Figure 2. The system architecture of the Responsive Agent

Four desktop computers were used in the experiment: two DELL Precision 670 computers to run Watson and record stereo camera images, one for the speaker and one for the listener; one DELL Precision 690 to run the experiment system; and one DELL Precision 530 to store logs.

The animated agent was displayed on a 30-inch Apple display to approximate the size of a real life listener sitting 8 feet away. The video of the speaker was displayed on a 19-inch Dell

monitor to the listener. A male virtual character was used in the Responsive Agent condition (See Figure 1).

3.1.4 Measurements

3.1.4.1. Response Variables

Self-Reported Rapport. We constructed a 10-item Overall Rapport scale (Cronbach's alpha = .89), presented to speakers in the post-questionnaire. Sample items included: "I think the listener and I established a rapport" and "I felt I was able to engage the listener with my story." Scales ranged from 0 (disagree strongly) to 8 (agree strongly). The self-reported rapport scales contained three components [39]: positivity, mutual attentiveness, and coordination. The items for each component included: "I felt I had a connection with the listener. (Positivity)" "I felt that the listener was interested in what I was saying. (Mutual Attentiveness)" and "I think that the listener and I understood each other. (Coordination)" In this study, the positivity is defined as connection rather than friendliness and caring, as the agent did not provide facial expressions or deliver speech to create interactants' feelings of mutual caring and friendliness.

Behavioral Measures of Rapport. We videotaped participants' verbal outcomes, such as the number of meaningful words and prolonged words, as well as disfluency of their storytelling. Behavioral measures of rapport included number of pausefillers, number of prolonged words, number of incomplete words, number of disfluencies (pausefillers + incomplete words), and number of meaningful words (wordcount - pausefillers - incomplete words) [18, 19].

3.1.4.2. Explanatory Variable

Personality. The pre-questionnaire packet included questions about participant's personality traits. The personality traits are composed of the Big Five Scales [16]. Scale measurement ranged from 1 (disagree strongly) to 5 (agree strongly): extroversion, agreeableness, conscien-

tiousness, neuroticism, and openness. Sample items included: "Is talkative. (Extroversion)" "Has a forgiving nature. (Agreeableness)" "Does a thorough job. (Conscientiousness)" "Can be tense. (Neuroticism)" and "Values artistic, aesthetic experiences. (Openness)" Neuroticism was found to be highly collinear with the other four personality variables, and consequently was dropped from analyses, as its presence as a predictor in the regressions resulted in little additional predictive power, but large increases in the standard error of the estimates of partial regression coefficients for the other personality variables.

4. Results

4.1. Power of Statistical Tests

The statistical power of the tests in this study is fairly low due to the small number of subjects in each experimental condition. For example, the power to detect mean differences of 1.0 in the self-report scales, based on a standard deviation of 1.5 for the scale (typical of that actually found in this study) is only .58 when the alpha (Type I) error probability is set at the conventional $p < .05$, indicating that almost half of the mean differences this large will not be detected. To better balance this error (beta error, or Type II error) with the alpha error, the alpha probability was increased to .10 in this study. This increases the power of a t-test to .70, at the expense of allowing 10% Type I error. Power calculations were done with the PASS power analysis software produced by NCSS Statistical Software, Kaysville, Utah, which uses the methods of Machin, Campbell, Fayers, and Pinol [29] as well as Zar [40] to estimate the power of t-tests of mean differences.

Likewise, the power to detect even moderately high R^2 values in regression models that predict rapport variables with the personality variables is low. Power to detect R^2 of .33 in the Face-to-Face group is only .49 when the alpha error probability is set to .05, but increases to

.64 when alpha is increased to .10 (PASS results, based on Cohen [10]). The alpha error level for regression results was also increased to .10 for this reason, again to balance Type I and Type II error.

4.2. Results and Conclusions

4.2.1. Self-Report Rapport Variables

In general, H1 finds little support in the data, as shown in Table 1. Only one personality factor, Extroversion, predicts the rapport variable Positivity in the hypothesized direction in Responsive Agent condition. No other rapport variable is predicted by this personality factor in the Responsive Agent condition, and none of the rapport variables are associated with Extroversion in the Face-to-Face condition.

H2 predicts a positive relationship between Agreeableness and the rapport variables. It is strongly supported in the Responsive Agent condition, but not in the Face-to-Face condition. The personality variable Agreeableness significantly predicts Overall Rapport, as well as each of the individual items of this measure (Positivity, Attentiveness, and Coordination) in the Responsive Agent condition. However, Agreeableness does not predict any of the self-report items in the Face-to-Face condition.

Similarly, H3 predicts a positive relationship between Conscientiousness and the rapport variables. It is supported in the Face-to-Face condition, but not in the Responsive Agent condition. In the Face-to-Face condition Conscientiousness predicts the Overall rapport variable, as well as two of the three individual rapport variables (Attentiveness and Coordination). Conscientiousness does not predict any of the rapport variables in the hypothesized direction in the Responsive Agent experimental condition, although it does significantly predict Positivity in a direction opposite of that hypothesized.

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H4 is not supported by the data. The only significant prediction of the personality factor Openness is a negative one with the rapport variable Coordination. This is in a direction the reverse of that predicted by H4.

Table 1. Self-report rapport variables predicted by personality variables

Rapport Variable	Inter-actant	Full Model	Extro-version	Agreeable-ness	Conscientious-ness	Openness
Overall Rap-port (sum of Positivity, Attentiveness, Coordination)	Responsive agent	R^2 = .42 F(4,19) = 3.41 p = .03		β = .51 t(22) = 2.42 p =.01	β = .04 t(22)= .19 p = n.s.	
	Face-to-Face	R^2 = .33 F(4,15) = 1.86 p = n.s.		β = .01 t(18) = .05 p = n.s.	β = .63 t(18) = 2.12 p =.05	
Sig. of β difference				p = .06	p = .06	
Positivity	Responsive agent	R^2 = .40 F(4,19) = 3.10 p = .04	β = .37 t(22) = 2.42 p =.05	β = .56 t(22) = 2.62 p = .01	β = -.33 t(22) = -1.46 p =.08 (wrong direction)	
	Face-to-Face	R^2 = .27 F(4,15) = 1.42 p = n.s.	β = .10 t(18) = .44 p = n.s.	β = .22 t(18) = .81 p = n.s.	β = .39 t(18) = 1.27 p = n.s.	
Sig. of β difference			p = n.s.	p = .08	p = .04	
Attentiveness	Responsive agent	R^2 = .24 F(4,19) = 1.45 p = n.s.		β = .316 t(22) = 1.33 p = .10	β = .19 t(18) = .75 p = n.s.	
	Face-to-Face	R^2 = .23 F(4,15) = 1.14 p = n.s.		β = -.09 t(18) = -.28 p = n.s.	β = .54 t(18) = 1.68 p = .06	
Sig. of β difference				p = n.s.		
Coordination	Responsive agent	R^2 = .49 F(4,15) = 4.53 p = .01		β = .53 t(22) = 2.73 p = .005	β = .17 t(22) = .94 p = n.s.	β = -.44 t(22) = -2.18 p = .02 (wrong direction)
	Face-to-Face	R^2 = .35 F(4,15) = 2.06 p = n.s.		β = .02 t(18) = .07 p = n.s.	β = .56 t(18) = 1.92 p = .04	β = -.24 t(18) = -1.08 p = n.s.
Sig. of β difference				p = .09	p = .10	p = n.s.

p values for personality variable beta weights are one-tailed, as Hypotheses 1-4 are directional.

Blank cells indicate nonsignificant regression coefficients in both interactant conditions.

The test for significant differences between independent group regression coefficients was conducted using the Cohen, Cohen, and West [11] procedure. The test for differences is a directional, one-tailed t-test based on H9's prediction.

4.2.2. Behavioral Rapport Variables.

H5 received only weak support, as shown in Table 2. None of the personality factors predicted the number of meaningful words in the Responsive Agent condition. Extroversion was significantly negatively associated only with Disfluencies as predicted by H5 in the Responsive Agent condition.

H6 was partially supported in the Responsive Agent condition, with higher levels of Agreeableness marginally significantly associated with less disfluency in the Responsive Agent condition and significantly with fewer Prolonged Words in the Face-to-Face condition. Agreeableness predicted the behavioral rapport variable of Meaningful Words in the Face-to-Face condition, but in the opposite direction proposed by H6.

H7 also received weak support, with Conscientiousness predicting an increase in Meaningful Words in the Face-to-Face condition only. This personality factor also predicted Prolonged Words in the Face-to-Face condition, but in the opposite direction proposed by the hypothesis.

H8 was not supported, as Openness did not significantly predict any of the behavioral rapport variables in the hypothesized direction in either experimental condition.

Table 2. Behavioral rapport variables predicted by personality variables

Rapport Variable	Inter-actant	Full Model	Extro-version	Agreeable-ness	Conscien-tious-ness	Openness
Meaningful Words	Responsive Agent	$R^2 = .06$ $F(4,19) = .31$ p = n.s.		β = .00 t(22) = .00 p =n.s.	β = -.23 t(22)= -.80 p = n.s.	
	Face-to-Face	$R^2 = .23$ $F(4,15) = 1.10$ p = n.s.		β = -.61 t(18) = -1.98 p = .03 (wrong direc-tion)	β = .47 t(18) = 1.46 p =.08	
Sig. of β difference				p = .09	p = .04	
Disfluency	Responsive Agent	$R^2 = .48$ $F(4,19) = 3.84$ p = .02	β = -.60 t(22) = -2.88 p =.005	β = -.33 t(22) = -1.60 p = .07		
	Face-to-Face	$R^2 = .24$ $F(4,15) = .23$ p = n.s.	β = .12 t(18) = .47 p = n.s.	β = -.26 t(18) = -.76 p = n.s.		
Sig. of β difference			p = .02	p = n.s.		
Prolonged Words	Responsive Agent	$R^2 = .27$ $F(4,19) = .38$ p = n.s.		β = .03 t(22) = -.09 p = n.s.	β = -.14 t(18) = -.49 p = n.s.	
	Face-to-Face	$R^2 = .40$ $F(4,15) = 2.53$ p = .08		β = -.84 t(18) = -3.10 p = .004	β = .52 t(18) = 1.83 p = .04 (wrong direction)	
Sig. of β difference				p = .01	p = .04	

H9 predicted that Face-to-Face interaction would produce higher rapport in general than would Responsive Agent interaction. Table 3 shows the results of simple tests for differences between the means of the rapport variables in the two conditions.

Table 3. T-tests contrasting Responsive Agent and Face-to-Face interactants on rapport variables

Rapport Variable	Responsive Agent Mean (s.e.)	Face-to-Face Mean	t(df)	Sig.
Overall Rapport	5.04 (.28)	5.53 (.32)	1.17(42)	p = .13
Positivity	4.71 (.41)	5.60 (.39)	1.57(42)	p = .06
Attentiveness	5.25 (.34)	5.70 (.35)	.92(42)	p = .18
Coordination	5.38 (.28)	5.55 (.39)	.37(42)	p = .36
Meaningful words	333.17 (25.82)	307.60 (28.23)	.67(42)	p = .26
Disfluency	16.92 (2.66)	11.30 (1.73)	1.77(38.25)*	p = .04
Prolonged words	3.17 (.52)	4.60 (1.00)	1.28(29.00)*	p = .11

* adjusted for unequal group variance

There were few significant differences in the means for rapport variables between the groups that interacted with the Responsive Agent and those who interacted with another human face-to-face, providing only marginal support for H9. The results showed less Disfluency by the subjects in the Face-to-Face group, indicating better rapport with the human than with the Responsive Agent, as predicted by H9. Likewise, the self-report rapport variable Positivity was significantly higher in the Face-to-Face condition.

The relatively low power of this study precludes any strong statement of null differences between the two experimental groups. It is not appropriate to conclude that the lack of significant differences between the experimental groups for most rapport variables is a confident finding of the similarity of both another human and the Responsive Agent in producing rapport in the interactant. However, the data makes it reasonable to infer that any true differences, if they exist, are relatively small when considering a full range of personality traits.

But finer analysis shows that there are differences in rapport responses to humans and virtual agents as a function of personality traits. This is made clearer by examining the differences between the predictive ability (beta weights) of personality variables that are shown in Tables 1 and 2. There are significant differences between the Responsive Agent and Face-to-Face groups in the predictive ability of all personality variables except Openness. A general pattern emerges in which subjects with higher Agreeableness scores tend to report more rapport in the Responsive Agent condition, which is counter to the effect predicted by H9, while subjects with higher Conscientiousness scores tended to report higher rapport in the Face-to-Face condition, which is consistent with H9.

A similar set of mixed results is seen in Table 2, where three of the significant differences between the Responsive Agent and Face-to-Face group are in the predicted direction, while two are in the reverse direction. Overall, a slim majority of the tests support H9, but the num-

ber of contradictory results leads to the conclusion that Face-to-Face interaction is not clearly superior to interaction with the Responsive Agent in producing rapport. Rather, the richness of the medium is interacting with personality traits to produce rapport.

5. Discussion and Future Work

The tests for significant difference between the individual regression coefficients in the self-report rapport variables provide some context for the lack difference in the mean rapport variables found across the two experimental groups. Rather than concluding that both animated Responsive Agents and humans produce similar levels of rapport in interactants, one must examine the personality type of the interactant in conjunction with the kind of entity with which they are interacting.

More agreeable individuals react to responsive graphical agents with more rapport [25], but show no similar increase when interacting with a human; but more conscientious individuals react to other humans with increases in rapport, but show no similar increase when interacting with a nonverbally responsive animated agent. In fact, the impact of the two personality factors seems to be operating in an inverse fashion in some cases, as in the Face-to-Face condition where higher levels of Agreeableness are associated with fewer Meaningful Words (a reduction in rapport), while Conscientiousness is associated with an increase in this variable. Similarly, in the Face-to-Face condition, Agreeableness reduces the number of Prolonged Words (an increase in rapport), while Conscientiousness increases the number (a decrease in rapport).

In human-to-human interactions, previous studies demonstrated that more agreeable people showed greater satisfaction about their interaction partners as well as self-reported interaction quality [4]. This implies that people feel greater satisfaction in their interactions when they feel more comfortable or get along easily with other people. The outcome of our study shows

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this effect when more agreeable people feel greater rapport with animated Responsive Agents than do lesser agreeable people, but the subjects in this study show no such tendency when interacting with real humans. This is a curious and unexplained outcome. Likewise the finding that conscientious subjects experienced more rapport when talking to humans but not to the animated agent needs further investigation and explanation.

Although Agreeableness and Conscientiousness effects are clear in many of the rapport variables, the personality trait Openness has only a weak relationship to rapport, with only one of the six rapport variables being predicted by this factor. Extroversion is only slightly better, with two of the rapport variables predicted by this personality factor. Clearly Agreeableness and Conscientiousness are more intimately involved with the process of establishing rapport with humans and virtual agents.

This outcome is consistent with the study by Berry and Hansen [4] that found a positive association between Agreeableness (as well as Extroversion) and independent observers' ratings for interaction quality in human-to-human interaction. Furthermore, when interacting with the Responsive Agent, greater Agreeableness of interactants was associated with the greater feelings of rapport in the Positivity dimension among the three dimensions of rapport as proposed by Izard [23]. The findings indirectly support the idea that people respond to the contingent feedback of the Responsive Agent as if they were interacting with a human being as proposed by the "Media Equation" perspective in a series of studies by Nass and his colleagues [22,32,33,36].

In conclusion, some researchers [4,24] assert that Extroversion and Agreeableness are the most important dimensions for interpersonal communication among the five-factor personality traits. In this study, the results for both self-reported and behavioral-measured rapport support the idea that agreeableness is important in establishing rapport, but also indicate the

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conscientiousness is equally important. There is much less evidence for the importance of Extroversion. This leads to the prediction that virtual agents that embody appropriate nonverbal feedback will be effective when communicating with persons who are high on the personality trait of Agreeableness. If we assume that appropriate contingent nonverbal feedback is an expression of agreeableness by the Responsive Agent, this may also be consistent with prior findings that indicated people preferred a computer interface representing a type of personality similar to their own [32,33].

There were limitations in this study that beg questions of future studies. The three elements of rapport, as proposed by Tickle-Degnen and Rosenthal [39], were constructed using only one item for each dimension. And as mentioned above, the item for the positivity dimension does not fully embody the original definition by Tickle-Degnen and Rosenthal. This is rooted in the current agent's response abilities, which is limited to nonverbal feedback that excludes facial expressions as well as verbal feedback that could better support the appearance of feelings of mutual friendliness and caring by the agent. Consequently, the measures of the three elements of rapport should be further developed to more fully represent the definitions of the components, and the Responsive Agent should be extended to provide expression of nonverbal facial expressions.

Also, the behavioral measurements of rapport in this study were limited to the measures of verbal behaviors such as pause fillers, incomplete words, and so forth. Other kinds of nonverbal behaviors of interactants (speakers) should be considered as objective indicators of interactants' rapport that can be perceived by independent observers.

Personality traits may affect different types of social interactions, involving different intensity of relationships, in unknown ways. Therefore, the associations between the personality traits and interactants' sense of rapport should be further studied using different kinds of

communication tasks. The conclusions of this study contribute to a growing body of knowledge about the conceptualization and measurement of rapport, when applied to humans' social interaction with virtual agents. Furthermore, our conclusions hold promise that incorporating appropriate behaviors into agents that might respond to a human's individual personality features could improve the quality of real humans' interaction with the virtual humans.

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