Reproducing Personality for Virtual Agent System

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Abstract: With the rapid growth in the cost of human labor and the needs for solving more complicated tasks as well as enhancing user experience, a more functional and believable virtual agent is crucial to the current situation, which requires the agent to convey a convincing personality and a stable emotional state. Although lots of research has investigated how different portraits influence the perceiving of personality, no research has been found that offers a relatively integrated and feasible virtual agent system. Therefore, this research analyzed existing results on conversational functions, facial expressions, and body motions, and integrated them into one virtual agent system. A series of questionnaire studies are first conducted to optimize the effect of characters' facial blend shapes for expressing six basic emotions and to further examine the validity of which. After the implementation of the system, an experiment is conducted to examine the reliability and validity of the developed system. Two virtual agents are built for the experiment, designed to convey an introverted and unconfident personality and an extraverted and confident personality. Participants are instructed to give an interview to these two agents and enroll one afterward. During the experiment, several questionnaires are also filled out, regarding participants' own personalities and agents' personalities. The result shows that the developed agents are successfully perceived with the intended personalities. But on the contrary to the expectations that the participants' preferences depend on the similarity between both parties' personalities, no significative correlations support such expectations.

Keywords: Artificial intelligence, virtual agent, personality, facial expression, body motion

1. Introduction

Within the last couple of decades, significant progress has been made in the field of computer science, leading to increasing demand for more functional artificial intelligence (AI). Take virtual agents for one example. There are more and more applications, websites, and systems using a virtual agent for a medium of user-computer interaction. With the existence of a virtual agent, the user will feel like having an assistant and therefore be more likely to have a higher level of acceptance, efficiency, and enjoyment while using the object. However, it will make the user uncomfortable if the agent's behavior is considered odd or disagreeable [1]. To avoid such circumstances, the virtual agent should be built as convincing as possible, which requires the agent to convey a believable personality and a stable emotional state with high congruency [2]. Plenty of research has been done to study how different portraits influent the way a user perceives a virtual agent's personality, but most research only focuses on one or two portraits of personality such as facial expressions, body gestures, or motions, while no research has been found that presents a relatively integrated and feasible virtual agent system combined with all existing functions. According to which, the purpose of this research is to analyze existing research and to develop an integrated virtual agent system hopefully qualified for all kinds of human-agent interaction tasks.

For the conversational system, Egges et al. present a generic model for personality simulation for conversational virtual agents [3]. Sing, Wong, Fung, and Depickere discussed several conversational agent systems, and due to the recent advances in the field of Natural Language Processing (NLP) and AI, it is more than possible to realize a more humanoid interactive system [4]. In their paper, they concluded several existing embodied conversational agents (ECA), including ALICE (2000, 2001 & 2004 Turing Test Winner), Jabberwacky (2005 Turing Test winner), and AINI.

For the body motion system, the current study has already provided guidelines for hand motion designing to add personality to the virtual agent [5]. They investigated hand pose, hand motion, and finger manipulation and their influence on personality perceiving under the Big Five theory. Based on that, they proposed guidelines for designing a virtual character with a particular personality. As for other body gestures and postures, Peter E. Bull presented various results of a series of studies exploring the effects of posture and gesture in interpersonal communication in his book Posture & Gesture [6]. The author conducted over a dozen of experiments to study the relationship among posture, gesture, speech, and communication. From the results of those experiments, the theoretical and practical significance are examined, and possible implications are discussed in detail. Although the provided results in this book are mostly focusing on interpersonal communication, the author separately summarized the significance for each body part

elaborately. This can also be valid in human-agent interaction and instructive for intelligent virtual agent designing.

For the facial expression system, Sumi and Nagata examined the effect of facial expressions on user persuasion. In this research, the authors concluded that the synchronization of facial expressions of the agent with the user's emotion does not lead to impression on a major level, since the user is likely to expect the agent to ooze synchronized foreseen emotion instead of simply sticking to the present emotion and reaction based on which [7]. Other research reviewed how eye-gaze influent user-agent interactions and provided guidelines for character animation [8].

Based on the existing results from research including but not limited to those mentioned above, the next section introduces the implementation of the integrated virtual agent system developed for further study.

2. Approach

As is mentioned before, the first objective of this research is to develop a virtual agent system integrated with sub-functions under the instructions of existing results from various research. To reproduce personality for the developed system, several functions are required to be implemented separately.

2.1 Personality

For personality measurement, it is designed to be conducted under the Big Five theory of personality [9] for that it is widely applied and rich in resources. Although the most commonly used and well-proven Big Five Inventory (BFI) [10] contains only 44 short-phrase items and takes around 5 minutes to respond, multiple inquiries would still take a considerably long time to finish, and since it is not the detailed traits of personality per se that this research is concerned about, an abbreviated version of BFI-10 seems to suit the purpose of this research better. Rammstedt & John provided such measurements in English and German [11]. Oshio, Abe & Cutrone further translated and examined it into Japanese version TIPI-J [12], which will be applied in this research. Besides, there are also open-ended questions [13] appended for more detailed precision [14].

2.2 Conversational system

For the conversational functions, the developed system is currently using several IBM Watson services, including Watson Text-to-Speech Service, Watson Speech-to-Text Service, and Watson Assistant. Through these services and with proper apparatus, the function for users to converse with the agent system has been implemented. In the latest version of the system, users can simply interact with a fully customized chatbot system with a microphone and headset.

For the sake of controllability, the following experiments and system evaluation are designed to be conducted in the form of an interview, in which scenario the contents of the conversation between user and agent would be limited and controllable, therefore avoid being too complicated or unrealistic, yet would not lose sophistication and believability [15]. Built on which, some common questions during an interview are organized into a question set for later use. Then, in order to train the chatbot to recognize these questions, a small preliminary experiment is conducted to collect training data. A number of N = 7 participants helped and provided a total of at least 5 different forms for each question in the question set to meet the minimum quantity for data training.

2.3 Body motion system

For the body motion system, the developed system is currently using Unity Animation and Adobe Mixamo. From the instructive results from existing related research, a body motion can be analyzed by the level of several quantifiable variables, such as direction, velocity, amplitude, frequency, and so on. Through which, what emotion/impression an animation clip will be perceived conveying can be categorized. After this, proper animation clips for conveying certain portraits of personality can be selected from the large database of Adobe Mixamo accordingly. For example, hand animations can be selected under the instructions of the work of Y. Wang, Tree JEF, M. Walker, and M. Neff [5]. While for the torso and other body parts, there are correlations between extraversion and gestural expansiveness, range of movement, gesture direction, smoothness, speed, rate or self-contact [16].

2.4 Facial expression system

For the facial expressions, due to the nature of uncertainty of the 3D character model that is planned to be used in the system, a preliminary experiment was conducted to examine it specifically. The character model uses a mechanism named "blend shape" for configuring facial expressions by adjusting different parts of the model's face individually, such as brows up or down, eyelids up or down, either angulus oris up or down, and so on. In the preliminary experiment, a series of facial expressions configured by different blend shape values are made based on commonly perceivable facial expressions with emotions for Japanese provided by facial expression database JAFFE [17]. A total of N = 13 participants helped to assess these facial expressions. The result shows that most of the facial expressions can convey intended emotions accurately, and the relationship among each blend shape value and emotions are also examined and summarized for further use in later experiments. See Figure 2 for examples.

Table 1. Outline of external behaviors for the two agents to convey intended personalities

Shy	Parameters	Confident
	Intended personality [20]	
Low	Extraversion	High
High	Agreeableness	Low
High	Conscientiousness	Low
High	Neuroticism	Low
Low	Openness	High
	Facial parts	
Mostly sad expression (worried)	Facial expression [18]	Mostly happy expression (smiling)
Avoid eye contacts	Eye movement [8]	Make eye contacts
	Conversational parts	
Apologetic and reserved	Tone [19]	Confident and unreserved.
	Sample Q&A	
Sorry, I'm afraid I don't have any…	… working experience	None. But you can count on me!
Anything you can offer is fine by me.	… salary expectation	The more the better, of course!
It's inevitable. I'll try my best to mend.	… thoughts on making mistakes	I don't make mistakes easily!
	Body parts [5, 16]	
Closed poses	Body poses	Stretched poses
Inward, self-contact	Body movement	Outward, spread
	Other body parts	Head tilt, leg movements, etc.
Small and closed poses	Hand pose	Spread and relaxed poses
Low smoothness	Hand motion	Smooth and fluent
Can be added	Hand manipulation	Shall be avoided
Low	Rate	High
Slow	Speed	Fast
Narrow	Amplitude	Wide

Figure 1. Example external behaviors of designed personalities of agents (left: Shy, right: Confident)

3. Method

After developing the integrated virtual agent system, an experiment is conducted to examine the validity and reliability of its ability to convey intended personalities.

3.1 Participants

A total of N = 27 participants' data were collected. One participant did not finish the experiment due to system failure and thus deleted, leaving a total of 26 data (8 females and 18 males). All participants are college students, aged from 19 to 26 years.

3.2 Materials

Apparatus The experiment was presented with a desktop computer. Participants were instructed to wear a headset with a microphone attached to interact with the agent program that appeared on the monitor before them and respond to questionnaires that appeared on another monitor on their right hands.

Scenario Participants were asked to play the role of an interviewer and give an interview to two virtual characters. After the interviews, they were asked to choose one to enroll in and give their reasons.

Agents Two agents were built for the experiment, intended to convey opposite personalities. One was designed to convey an introverted, agreeable, conscientious, nervous, and conservative personality (future referred to as the Shy agent, or Shy), and the other to convey an extraverted, disagreeable, unconscientious, non-nervous, and open personality (future referred to as the Confident agent, or Con). See Table 1 for an outline and Figure 1 for examples of external behaviors.

3.3 Design

Within-subject 2 (agents' personality) factorial design, pseudo-randomly ordered.

Participants' personal preferences would be measured by the time length they are willing to wait for an agent.

3.4 Procedure

Firstly, the participant is asked to read and sign an informed consent, including information on this research and rights as a participant. After that, the experiment starts. The participant will first be asked to respond to a personality questionnaire about him/herself for later comparison. Since the experiment will take the form of a simulation of interviews, the participant will take the role of the interviewer while the agents take the role of the interviewees. In order to manipulate the contents of the conversation, the participant can only ask questions from a questions sheet provided in advance in any preferable order. During the interview, the mobile phone of the agent will ring. After apologizing, the agent will ask for an absence to take the phone call. The participant is instructed to wait for the agent or call the agent back by ringing the bell on the desk any time he/she likes. Once the participant chooses to call the agent back, or the waiting time reaches the maximum (4 minutes), the agent will come back and continue the interview. After all of the questions considered necessary by the participant are covered, the interviewee will give the participant a questionnaire and request for an evaluation of its performance. After that, the participant can call in the next interviewee and repeat the above process. After responding to the evaluation questionnaire for the second time, the participant needs to respond to a final questionnaire and make the decision of enrollment.

Figure 2. Example facial expressions and corresponding sources in JAFFE database

4. Results

4.1 Personality

Analysis of personality measurement shows that both agents succeed to convey the intended personalities to the participants, as one was designed to convey an introverted, agreeable, conscientious, nervous, and conservative personality and the other to convey an extraverted, disagreeable, unconscientious, non-nervous, and open personality (future referred as the Confident agent, or Con) as is shown in Table 3. Paired t-test results prove that two agents significantly differ in four out of five factors of personality: 1) Extraversion $t(25)=-8.299$, $p<.001$, 2) Agreeableness $t(25)=4.426$, $p<.001$, 3) Neuroticism $t(25)=3.381$, $p=.002$, 4)Openness $t(25)=-2.984$, $p=.006$, while 5)Conscientiousness $t(25)=1.773$, $p=.088$. Participants' impressions over two agents are also significantly different, $t(25)=7.083$, $p<.001$.

4.2 Final decision

Out of N = 26 participants, 18 of which chose Shy (69.23%) to enroll at last. And since participants' impression of the shy agent is significantly higher than that of the confident agent, it could be easily assumed that participants tend to choose based on personal preference. Further examining using Mann-Whitney U Test did not support such assumption, with a significance $p=.978$. Other attempts to find differences between two decisions all failed except for the openness score of the confident agent, with a Mann-Whitney U Test significance $p=.016$.

4.3 Waiting time

Analysis of waiting time shows that participants waited significantly longer for the first interviewee than the second, $t(25)=3.704$, $p=.001$, while waiting time differed neither between agents with different personalities with a $t(25)=.960$, $p=.342$, nor between chosen-or-not, $t(25)=-.367$, $p=.715$

Table 3. Results of personality evaluation

	Self		Shy		Con	
	Mean	SD	Mean	SD	Mean	SD
Extraversion	7.96	2.96	5.27	3.09	11.58	2.02
Agreeableness	9.85	2.07	7.96	2.82	5.00	2.21
Conscientiousness	5.69	2.73	7.42	2.73	5.85	3.07
Neuroticism	9.85	2.80	9.31	2.84	6.77	2.12
Openness	9.12	2.40	6.35	2.67	8.46	2.67
Impression	/	/	37.92	9.74	24.12	6.96

*The score of each factor of personality ranges from 2 to 14 with a neutral score of 8, while impression score ranges from 9 to 63, with a neutral score of 36

Table 4. Results of waiting time

	Order		Personality		Decision	
	1st	2nd	Shy	Con	Chosen	Not-chosen
Mean	93.96	75.35	87.35	81.96	83.62	85.69
SD	71.18	78.21	75.07	75.59	76.24	74.50

5. Discussion

In this research, an integrated virtual agent system is developed based on existing results of how different portraits influent the way a user perceives a virtual agent's personality under the Big Five personality framework. To examine the validity of which, an experiment is conducted, with two agents designed to convey opposite personalities. and further examines participants' preferences over these two agents. The results show that most factors of personalities are successfully perceived as they are intended to be, except for conscientiousness, which might because conscientiousness is a relatively long-term factor of personality and is harder to be detected and distinguished within short notice.

Two extra variables, final decision and waiting time, are measured for further examination. Although the results show that most of the participants chose the Shy agent, the reason why they made such decisions remains unclear. Several neglected factors may have caused such results. For example, a cross-legged posture is included in the confident agent's animation database, while such posture can be considered offensive to Japanese participants during an interview, therefore induces certain bias. Since social research suggests that extraversion and conscientiousness are positively correlated with success in interviews [20], and since the agents are designed to disclose as little information about

themselves as possible to avoid any possible bias, personality should be the only factor on the agents' side that affects participants' decisions and preferences. But contrary to expectation, none of the personality factors (shy agent's personality score, separately or overall; confident agent's personality, separately or overall; differences between two agents' personality scores, separately or overall; impressions of two agents, separately or overall) or participants' own characteristics [21] (participants' own personality, separately or overall; differences between participants and either agent's personality, separately or overall; participants' age; participants' gender) is statistically significant to support it, except for the openness score of the confident agent. Existing research indicates that the matching between the user and the agent in extraversion does not have an impact on collaborating, the matching in agreeableness shall have a positive influence [22]. This might be because of the characteristics of Japanese participants, who prefer more conservative candidates in the scenario of an interview since the more open-minded candidates use a lot of wide and spread gestures and postures that can be considered as rude and impolite under this kind of circumstance. Another possible reason is that this is simply a Type I error outcome, as 32 possible factors are examined in the analysis, making it have a possibility of over 80% to include at least one false significance. Waiting time also seems to be a flawed variable in this experiment. Due to the restricted length of idle time, waiting time has a limited maximum of 4 minutes, which is not an amount sufficient enough, as multiple participants have exceeded that length of time, causing the ceiling effect to take place. Along with shown learning effect between two rounds of interviews, the data was thus compromised.

As for the reason for the failure of factorial analysis, there are several possible causes. One is that participants are not instructed clearly enough about making decisions, thus making their decision criteria varies. Through self-report, it can be seen that some of the participants made their choices based on personal preferences, while others made their choices based on their predictions of how the two agents with different personalities would perform in a longer time span. This kind of divergence might cause the mixed results and lead to such results. Besides, the acquired data might be insufficient in this experiment and need further examination.

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