The Influence of Users' Personality on the Perception of Intelligent Virtual Agents' Personality and the Trust Within a Collaborative Context

Nader Hanna(✉) and Deborah Richards

Department of Computing, Macquarie University, Sydney, NSW 2109, Australia
{nader.hanna,deborah.richards}@mq.edu.au

Abstract. As Intelligent Virtual Agents (IVAs) have been widely used for applications that require human interaction and collaboration, modeling an IVA that can exhibit personalities is becoming increasingly important. A large body of research has studied variant verbal and non-verbal aspects that are used to deduce an IVA's personality; however, research falls short in showing whether humans' personality influences their perception of the IVA's personality. This paper presents an empirical study that investigated whether human users can perceive the intended personality of an IVA through verbal and/or non-verbal communication, on one hand, and the influence of the user's own personality on their perception, on the other hand. Furthermore, we investigated whether the perceived personality had an impact on the human's level of trust in the IVA teammate. The results showed that similarity in personalities between humans and IVAs tended to significantly influence the humans' correct perception of the IVA's personality and that different perceived personalities influenced the human's level of trust.

Keywords: Personality traits · FFM · Extraversion · Agreeableness · Intelligent Virtual Agent · Human-IVA collaboration · Trust

1 Introduction

An Intelligent Virtual Agent (IVA) is a term used to define an autonomous entity in a virtual environment. This entity should not only look like, but also behave as a living organism (e.g., human, animal, imaginary creature) [1]. Several studies aimed to create believable IVAs and include sophisticated characteristics similar to humans. Among these characteristics, researchers have sought to create unique IVAs with distinct personalities. Personality is a personal aspect that makes it possible to distinguish between different people [2]. Because our personality affects our internal perception and actual behavior [3], personality has been included in multiple aspects of IVAs including their expressive aspect, i.e. non-verbal communication and verbal communication, and their internal aspect, such as planning [4].

A number of psychological theories proposed foundations to understand personality, yet one of the most well-known and widely-accepted theories is Five-Factor Model (FFM) of personality [5]. FFM model is comprised of five-personality dimensions:

F. Koch et al. (Eds.): CARE-MFSC 2015, CCIS 541, pp. 31–47, 2015.
DOI: 10.1007/978-3-319-24804-2_3

openness to experience; conscientiousness; extraversion (antonym-introversion); agreeableness (antonym antagonism); and neuroticism. After its wide success in understanding humans' personalities, numerous studies used the foundations of FFM to personalize the behaviour of IVAs [6]. IVAs with personality according to FFM have been studied in different contexts including interviews, medical treatment, and interactive narrative [7].

Many research papers used FFM to influence the multi-modal behaviour of IVAs and the aim was to investigate whether humans can predict IVAs' personalities based on their expressed behaviour (e.g., [8]), however these papers used a simple simulated environment and basic human-IVA interaction. IVAs are increasingly being used as teammates in heterogeneous teams that combine both IVAs and humans. Studying IVA's personalities in the context of teamwork with humans has become a recent interesting topic to study [7]. A few studies go beyond basic interaction and show more complex scenarios such as interaction in a collaborative environment. Collaborative environments require both human users and IVAs to work as team members to achieve a shared task. Collaborative situations make humans' prediction of IVAs' personalities more difficult as humans tend to focus on achievement of the task.

Among these few studies that investigated IVA's personality in a collaborative context, Negrón et al. [9] stressed the integration of nonverbal communication cues in IVAs as a way to provide human team members with alternatives that may accelerate the communication process and foster collaboration. However, in that work IVAs played the role of facilitator to the human team and were not real teammates. In another study, Prabhala and Gallimore [10] found that people could perceive personality from avatars through their actions, language, and behavior. However, this research falls short in showing whether humans' personality influences their perception of the IVAs' personality.

A further consideration in our study, and gap in existing work, concerned the influence of the IVA's perceived personality on the human's level of trust in the IVA. Trust is widely recognized as an important facilitator of successful relationships and essential in the context of successful collaboration [11]. Trust has been defined as an individual's belief in another person's capabilities and honesty based on his/her own direct experiences [12]. A commonly used classic definition of trust is "*the willingness of a party to be vulnerable to the actions of another party based on the expectation that the other will perform a particular action important to the trustor, irrespective of the ability to monitor or control that other party*" (p. 712) [13]. This definition considers trust as a transient state in any particular situation. Many other definitions of trust exist that offer alternative perspectives (see [14]); nevertheless, the majority of these definitions share the concept of expectation and confidence in the other actors' reliability, fairness and integrity.

The paper is organized as follows. Section 2 presents related work on IVAs and personality. Section 3 presents further background about the FFM personality model and how it has been incorporated in the design of our IVA's verbal and non-verbal behaviour. Section 4 presents the research questions. The methodology used to answer the research questions is presented in Sect. 5. The results will be given in Sect. 6, followed by discussion in Sect. 7. Finally, Sect. 8 presents conclusions and future work.

2 Literature Review

Many researchers have been working on human-IVA relationships [15–18]. Numerous studies have considered whether human participants are able to perceive IVA's personality through communication with IVA. Doce et al. [4] presented a model to create an IVA with distinguishable FFM personality traits. In their model, four cognitive/behavioural processes were identified that were strongly influenced by personality: emotions, coping behaviour, planning and bodily expression. The personality traits were adopted to influence each of these processes. Users were asked to classify different personalities for IVA. Although users' classification correlated with the original values for extraversion, neuroticism, and agreeableness, users failed to identify conscientiousness. Moreover, the model did not introduce personality in IVA's verbal communication.

Rushforth et al. [19] presented an initial attempt to build a personality framework for virtual characters that allows the domain designer to author different personalities for the same character. The results of two experiments showed that the presented framework had an impact on user perception of several aspects of the personality of the virtual character. Neff et al. exploited the extraversion [20] and neuroticism [21] traits of the Big Five model in multimodal characters evaluating the effects of verbal and nonverbal behavior in personality perception studies. Cafaro et al. [22] conducted a study to investigate how IVA's non-verbal communication influence the first encounters between humans and virtual agents. Each agent exclusively exhibited nonverbal cues (smile, gaze and proximity), and then participants judged IVA's personality (extraversion) and interpersonal attitude (hostility/friendliness) based on the nonverbal cues. The results showed that participants could form an impression about the IVA's personality from the observed non-verbal behaviour. Kang et al. [23] explored associations between the five-factor personality traits of human subjects and their feelings of rapport when they interacted with a virtual agent or real humans.

Despite the large body of research in human perception of IVAs' personality, little research considers personality in a collaborative context. Among these few studies, Aguilar et al. [24] propose a Team Training Strategy whose purpose is to promote social skills. In this training strategy, personality traits have been assigned to appropriate team tasks. However, their study did not investigate the interaction between the personalities of both humans and IVAs.

3 Intelligent Personality Traits: Five-Factor Model

In the last 50 years, the FFM model of personality has become a standard in the field of classifying personalities. FFM [25] claims that personality varies on five factors: Openness, Conscientiousness, Extraversion, Agreeableness and Neuroticism. Openness means being open to experience new things, being imaginative, and intelligent. Conscientiousness indicates responsibility, reliability and tidiness. Extravert personality is outgoing, sociable, assertive and energetic. Agreeableness means a person is trustworthy, kind and cooperative by considering others' goals. A neurotic character is anxious, nervous and prone to depression and lacks emotional stability.

Studies that have explored personality traits and teamwork stress the role of both extraversion and agreeableness to foster inter-relationships between team members. Extraversion and agreeableness were selected in our study because they have been shown to be predominant traits in collaboration and teamwork [26]. The extraversion trait affects interpersonal relations through the quality of social interactions [27, 28]. Extraverts are usually active members in teamwork interactions and often popular among their mates [29].

3.1 Expressing Personality Through Verbal Behaviour

Our personality is likely to influence how we speak [30]. Speaking style can reveal certain personality traits; some traits are easier to detect than others [31]. A number of studies have used verbal capabilities to represent different IVA personalities [32]. Neff et al. [20] determined a number of aspects that demonstrate the impact of the IVA's extravert personality on the IVA's verbal behaviour. Among the list of aspects mentioned in [20], we selected the dominant aspects, see Table 1, as the basis of the design of the IVA in our study. Verbal messages were designed and reviewed by the authors. The messages were designed according to the criteria in Table 1.

Table 1. Verbal aspects used to express introversion/extraversion in IVA's behaviour

Parameter	Description	Introvert	Extravert
Verbosity	Control the number of propositions in the utterance	Low	High
Restatements	Paraphrase an existing proposition	Low	High
Request confirmation	Begin the utterance with a confirmation of the propositions	Low	High
Emphasizer hedges	Insert syntactic elements (really, basically, actually, just) to strengthen a proposition	Low	High
Negation	Negate a verb by replacing its modifier by its antonym	High	Low
Filled pauses	Insert syntactic elements expressing hesitancy	High	Low

3.2 Expressing Personality Through Non-verbal Behaviour

A number of studies addressed how the extraversion personality trait can be represented in an IVA's non-verbal signaling. As verbal behaviours have already been identified that show an IVA's personality, Doce et al. [4] proposed several non-verbal features that could be used to show personality traits in IVA, these features include:

- Spatial extent – the required amount of space to perform an expression - extraverts use a lot of spatial extent, while introverts use a small space.
- Temporal extent - amount of time spent to perform an expression - we assigned a short temporal extent to extraverts.

- Fluidity - smoothness of movements - agents have a high fluidity if they are not extraverted nor neurotic and a low fluidity otherwise.
- Power – intensity of an intention - power is directly proportional to extraversion.
- Repetitiveness -repetition of certain movements - a character with high extraversion will have high repetitivity.

Additionally, the IVA's physical position relative to the human's view or their avatar has been investigated. Argyle's [33] status and affiliation model for animating non-verbal behavior of virtual agents identified two fundamental dimensions for non-verbal behavior: affiliation and status. Affiliation can be characterized as wanting a close relationship and it is associated with non-verbal clues such as close physical position. Other studies suggested that agents approaching the subject's avatar were judged as more extraverted than agents not approaching them, regardless of smile and the amount of gaze they gave [22]. In the design of our agent, we chose the dominant features, shown Table 2.

Table 2. Non-verbal aspects used to express introversion/extraversion in IVA's behaviour

Parameter	Description	Introvert	Extravert
Spatial extent	Amount of space required to perform an expression	Low	High
Temporal extent	Amount of time spent to perform an expression	Long	Short
Repetitivity	Repetition of certain movements	Low	High
Body position	Close physical postures	Far	Close

4 Research Questions

We have proposed the following research questions to investigate the influence of IVAs' personalities on their verbal and non-verbal communication as perceived by humans; in addition, we explored the relation between (mis)match in human-IVA personalities and humans' right perception of IVAs' personality. Finally, we consider how IVA personality and the match with humans was linked with human trust in IVA's decisions and recommendations. Figure 1 shows an overview of the research model that underpins the following research questions:

Q1: Can IVAs' multimodal communication, i.e. verbal and non-verbal communication, distinguish the IVA's extravert/introvert personality?
Q2: Can IVAs' multimodal communication distinguish their agreeableness/antagonism personality?
Q3: Does a match in the human and IVA's extravert/introvert personality traits influence the human's perception of the IVA's extravert-introvert personality trait?
Q4: Does a match in the humans and IVA's agreeableness/antagonism personality traits influence the human's perception of the IVA's agreeableness/antagonism personality trait?
Q5: Does perceiving the IVA's agreeableness/antagonism or extravert/introvert personality traits influence the human's trust in the IVA?

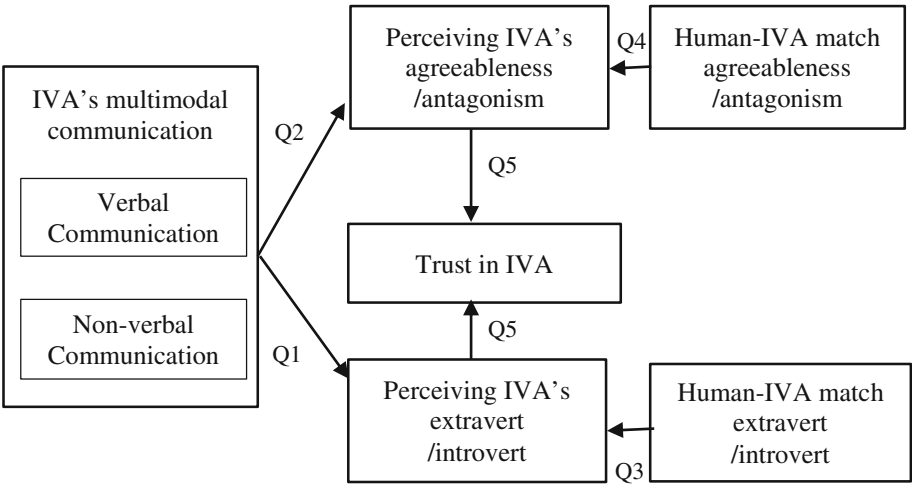

Fig. 1. The proposed research model

5 Materials and Method

An experiment was conducted to answer the five research questions. The design, the participants, the procedure, and the scenario are described below.

5.1 Experimental Design and Procedure

The study was structured as 2 × 2 between-subject experiment and a control group.- Each subject had to take just one treatment. The experiment consisted of five different treatments with the same virtual scenario but the IVA had different personalities, see Table 3. One treatment was a control with a neutral personality IVA. The other four experimental treatments had the four combinations of the two studied personality traits, i.e. extraversion and agreeableness. The four combinations were extraversion-agreeableness, extraversion-antagonism, introversion-agreeableness and introversion-antagonism. Participants had to access a web-based system that contained the five treatments and managed treatment assignment. Each participant was assigned one of the five treatments. The assignment was done by the system sequentially and equally. Participants were divided into five groups each containing 11 students. Participants used the virtual system individually so that the collaboration would be one-to-one between him/herself and the agent. We dedicated 20 min for the study that consisted of four parts, as below, in one session.

- Part 1: sign consent forms and complete biographical information.
- Part 2: Complete 7-item personality test to measure the two personality traits using International Personality Item Pool (IPIP) [34].
- Part 3: Participation in the scenario in the 3D virtual scene. In the beginning of the scenario, the participants were provided with online instructions about the goal of

Table 3. The level of extraversion and agreeableness personality traits in each treatment

Treatment	Extraversion	Agreeableness
Extraversion-agreeableness	High	High
Extraversion-antagonism	High	Low
Introversion-agreeableness	Low	High
Introversion-antagonism	Low	Low
Neutral	Averaged	Averaged

the virtual scenario, the name and the use of each tool in the toolbox and how to select/close the verbal messages.

- Part 4: Complete 5-item survey (5 items each for verbal and non-verbal communication and 5 items for measuring trust) that measures the participant's perception of the communication and collaboration experience. Additionally participants completed a test of the perceived personality of the IVA by answering four items of the Ten-Item Personality Inventory (TIPI) [35].

Both personality tests, i.e. IPIP and TIPI used a 5-item Likert Scale, where 1 corresponded to "Disagree Strongly" and 5 to "Agree Strongly". Additionally, all inputs from the user were logged to allow recreation of navigation paths and record inputs such as responses and selected tools. These inputs included selected regions in the scenario. Analysis of interaction logs to find the most frequently triggered stimuli in the scenario was used before in other studies [32].

5.2 Participants

Fifty-five (55) second-year undergraduate students enrolled in a science unit completed the collaborative task. Participants were aged between 18 and 51 years (mean = 22.56; SD = 6.95). English native speakers were 94.55 % of the participants. The non-native English speakers had been speaking English on a daily basis on average for 13 years. On a scale of 6 levels (level 1 the least experienced and level 6 the highest experience), 23 % of the participants described themselves as having basic computers skills (level 2), 5.45 % as having advanced skills (level 6), while 70.91 % said they have proficient computer skills (level 5). To measure game and 3D application experience, participants answered the question "How many hours a week do you play computer games?" with responses ranging between 0 to 25 h weekly (mean = 2.73, SD = 4.69).

5.3 Case Study

In order to answer the proposed research questions a collaborative scenario need to be designed. This scenario needs to include the common features encompassed in any collaborative scenario. These features are as follows.

The Features of Collaborative Scenarios. A number of attempts have been made to define the elements of collaborative activity. In a series of studies, Traum et al. [36] identified the features of collaborative tasks that serve to test out the development of a shared understanding:

- Sharing of the basic facts about the task…sharing the beliefs about the task between collaborators. Traum et al. [36] stressed that it is important to share the basic information not only in an indirect way such as using a whiteboard but also in an intrusive ways such as via dialogues or invitation to perform actions.
- Interferences about the task… the requirement is directly connected to the goal of the collaborative task. The inferences are explicitly negotiated through verbal discussion.
- Problem-solving strategy…As the collaborative activity includes a task to achieve; partners need to have a strategy to accomplish this task. This strategy is individual to each team member, but additionally it should take into account a role to the other partner.
- Sharing information about positions…this element is related to sharing information about the position and progress of each party while achieving the collaborative task. The current position of the partner could be deduced through the partners action, while his/her future position could be communicated though discussion.
- Knowledge representation codes…it is important to use clear notations that represent the required knowledge in the collaborative task. For example, using red label to demonstrate crucial or critical knowledge.
- Interaction rules…the rules the partners agree on to manage the interactions while achieving the task.

In line with these requirements, we proposed a scenario where a human and an IVA should collaborate to achieve a shared task.

The Proposed Collaborative Scenario. The aim of the scenario. In the scenario-based activity, the human and the agent (a virtual scientist called Charlie) needed to pass a sequence of four obstacles.

Aspects should be considered. There are a number of aspects that should be considered to design a scenario to test out the proposed research question including the following.

First, the actions of both humans and IVAs must be dependent or interleaved; that is to say, none of them can do the task alone and the contribution of the other teammate is crucial for the success of the task.

Second, the task should be divided into stages or sequences in order to observe the progress in team behaviour and performance.

Third, humans must have the option either to conform to the IVA's requests or select a different decision.

Fourth, the verbal and non-verbal communication should be bidirectional, that is the human and agent can send and receive messages.

Finally, communication must be task-oriented. That is not to say that social-oriented communication would not be beneficial, however, that was beyond the scope of this study. The collaborative scenario was implemented using the Unity3D game engine (www.unity3d.com). The scenario included a task where both a human user and an IVA, namely Charlie, have to collaborate to achieve a shared goal. The goal is to pass a sequence of four obstacles to reach their target (scientific laboratory). The four

Fig. 2. Snapshots from the third obstacle (the bush) and IVA personality is high extrovert and high agreeableness

obstacles were brick wall, wooden gate, bush and hill (see Fig. 2). In order to get over each one of these obstacles both the human and IVA have to select a pair of tools from a toolbox that contains 12 tools (pruning shears, bush hook, hammer, chisel, ladder, rope, matchsticks, matchbox, screwdriver, nipper, shovel and mattock). These tools were picked so that each pair of tools would be complementary, i.e. a single tool cannot work without the function of the complementary tool. For example, the chisel needs the hammer and matchstick needs the matchbox. In addition, each obstacle could be passed using different tools. For example, the bush obstacle could be chopped, burnt or climbed. Hence, there should be agreement between the human and the IVA concerning the best way to overcome the obstacle and to select which pair of tools is most suitable for the task. The interaction between human and IVA occurs via two means:

- Verbal communication: through exchanging messages that convey both human's and IVA's requests, examples from the scenario can be found in Table 4.
- Non-verbal communication: through the IVA's, hand gestures to represent different personalities.

Table 4. Examples of IVA's verbal messages along with the level of personality traits that is represented in each message

Trait	Set	Example
Extraversion/Agreeableness	Low	Not a bad idea, I will grab " + tools [human_selected_tool == 5?6:5] + " to help.
	Medium	Good idea, it will save effort and time. I will grab " + tools[human_selected_tool == 7?8:7] + " to help you to climb the gate.
	High	Wow, it is an Excellent idea, I was thinking of climbing the gate too. Hmmm, it is also much faster than breaking or burning that gate. I will grab " + tools[human_selected_tool == 5? 6:5] + " to help you in tying a ladder

(*Continued*)

Table 4. (*Continued*)

Trait	Set	Example
Extraversion/Antagonism	Low	I was thinking of opening the wooden gate. Don't you agree?
	Medium	It will be hard to break the gate, would you please think of another way to get over this obstacle? For example, what about opening the gate?
	High	Oh, are you kidding? Do you know how long it is going to take to break that wooden gate? I was thinking of opening the gate. Opening the gate will save lots of time and effort. Don't you think so? Don't you agree with me?

6 Results

To answer Q1, the results, as shown in Table 5, showed that there was a significant difference [$F(2, 52) = 15.014$, $p < 0.01$, $\eta 2 = 0.366$] between the groups of participants, who had introvert, extravert or neutral IVA, in their perception to different personality of IVA as expressed by the verbal messages of IVA. Furthermore, to understand the difference between these groups (introvert, extravert or neutral), the average evaluation of the IVA's verbal communication of each group was calculated. The results, as can be seen in Fig. 3, showed that the average perception of introvert, extravert and neutral IVAs was 3.66, 4.32 and 3.42 out of 5, respectively.

Table 5. A summary of one-way ANOVA to show difference between participants in perceiving IVA's introversion/extroversion based on IVA's verbal communication

	Sum of squares	df	Mean square	F	Sig.
Between groups	7.599	2	3.800	15.014	0.000
Within groups	13.160	52	0.253		
Total	20.759	54			

Regarding non-verbal communication, Table 6 showed that there was a significant difference $p < 0.01$ [$F(2, 52) = 11.424$, $p < 0.01$, $\eta 2 = 0.30$] between the groups of participants, who got introvert, extravert or neutral IVA, in their perception to different personality of IVA due to the non-verbal messages of IVA. Furthermore, to understand the difference between these groups (introvert, extravert or neutral), the average evaluation of the IVA's non-verbal communication was calculated. Figure 3 showed that average perception of introvert, extravert and neutral IVA was 3.72, 4.30 and 3.78 out of 5, respectively.

To answer Q2, the results, see Table 7, showed that there was a significant difference $p < 0.01$ [$F(2, 52) = 6.086$, $p < 0.01$, $\eta^2 = 0.189$] between the groups of participants, who got agreeableness, antagonism or neutral IVA, in their perception to

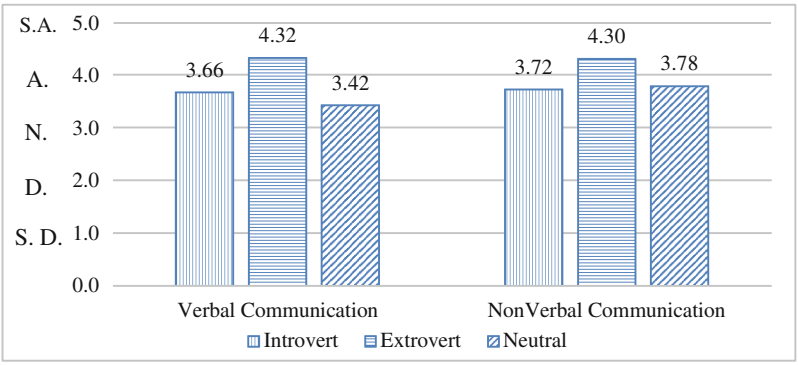

Fig. 3. Average evaluation of verbal and non-verbal communication of Introvert, Extrovert and neutral IVA (S.A. = Strongly Agree, A. = Agree, N. = Neutral, D. = Disagree, S.D. = Strongly Disagree)

Table 6. A summary of one-way ANOVA to show difference between participants in perceiving IVA's introversion/extroversion based on IVA's non-verbal communication

	Sum of squares	df	Mean square	F	Sig.
Between groups	4.178	2	2.089	11.424	0.000
Within groups	9.509	52	0.183		
Total	13.687	54			

IVA's agreeableness-antagonism as represented in verbal messages. To further understand the difference between these groups (agreeableness, antagonism or neutral), the average evaluation to IVA's non-verbal clues of each group was calculated. The results, as can be seen Fig. 4, showed that average perception of agreeableness, antagonism or neutral IVA was 4.15, 3.84 and 3.42 out of 5, respectively. Additionally, the results showed that there was no significant difference between the five groups of participants' in their perception to IVA's agreeableness-antagonism as represented in non-verbal clues.

Table 7. A summary of one-way ANOVA to show difference between participants in perceiving IVA's agreeableness/antagonism based on IVA's verbal communication

	Sum of squares	df	Mean square	F	Sig.
Between groups	3.937	2	1.969	6.086	0.004
Within groups	16.822	52	0.323		
Total	20.759	54			

In answer to Q3, whether the match in extravert/introvert personality trait correlates with humans' perception of IVA's extraversion, the results of Chi-square test, $\chi^2(1, N = 55) = 6.04$, and $p < 0.05$, showed a significant difference between actual match between human and IVA and the correct perception of humans to IVA's extraversion trait.

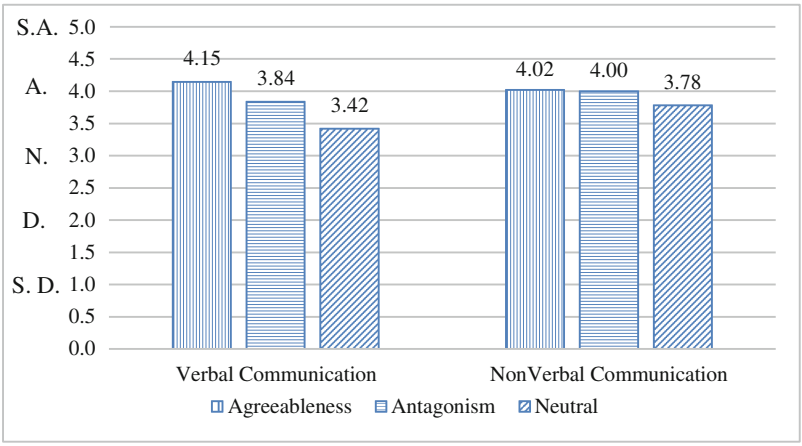

Fig. 4. Average evaluation of verbal and non-verbal communication of Agreeableness, Antagonism and neutral IVA (S.A = Strongly Agree, A. = Agree, N. = Neutral, D. = Disagree, S.D. = Strongly Disagree)

Question four inquired whether the match in agreeableness/antagonism personality trait correlates with humans' perception of IVA's agreeableness. The results of Chi-square test between real match between human and IVA and the correct perception of humans to IVA's agreeableness trait $\chi^2(1, N = 55) = 4.035$, and $p < 0.05$ showed significant difference in the accuracy of the guess of IVA's agreeableness/antagonism personality trait by human users whose agreeableness/antagonism personality match IVA.

The fifth question inquired if the perceived agreeableness/antagonism or extravert/introvert influence humans' trust in IVAs. The results of ANOVA test showed that there was a significant difference between agreeableness/antagonism treatments in human trust in the IVA $p < 0.001$ [$F(1, 53) = 10.93$, $p < 0.001$, $\eta 2 = 0.17$]. However, the results of ANOVA test showed that there was no significance difference between extravert/introvert treatments in human trust in the IVA.

7 Discussion

The aim of this paper was to study whether the (mis)match in personality between humans and IVAs influences the humans' perception of the IVAs' personality. To answer this question, we studied the impact of two personality traits, i.e. extraversion and agreeableness, on the perceived multimodal communication, i.e. verbal and non-verbal communication.

The results of the first research question showed that there was a significant difference between the participants in the five treatments in the perception of IVA's extraversion expressed by IVA's verbal and non-verbal behaviour. This finding demonstrated that both verbal and non-verbal communication contribute toward participants' perception of IVA's personality. This result is consistent with the other studies,

e.g. [37, 38], that showed the impact of IVA's verbal and non-verbal communication aspects on human users' prediction of IVA's personality.

Regarding the results of perceiving neutral personality, participants did not get different treatments that would allow them to compare between the personalities of IVAs. They were assigned a single treatment and so based on that single experience they perceived the personality of the IVA teammate. Although the neutral personality was meant to be midway between extravert and introvert, participants tended to classify the neutral IVA as either an introvert or extravert. Previous research work has identified the problem of erroneous perception of the neutral emotion and personality, where neutral emotion and personality could be confused with other traits, or other traits could be confused with neutral. In one study, the neutral emotion was easily confused with other emotions such as sadness [39]. In another study, where pictures of an IVA (Alfred) with different head postures and eye gazes were shown, participants were likely to recognize different head posture and eye gaze as neutral [37].

The result of the second research question showed that there was a significant difference between the participants in the five treatments in the perception of IVA's agreeableness as expressed by IVA's verbal behaviour. However, the result did not reveal any significance between participants in differentiating IVA's agreeableness personality because of the non-verbal behaviour of the IVA. The impact of non-verbal behaviour on humans' perception of IVA's personality has been a debated topic. Burgoon [40] suggests that overall approximately 60-65 % of social meaning is derived from nonverbal behaviors. Vinciarelli et al. [41] reported that nonverbal behaviour influences our perception of others. Arellano et al. [37] studied the influence of some visual cues of non-verbal communication, head orientation and eye gaze, on human users' perception of certain IVA personality traits: extraversion, agreeableness and emotional stability. The results showed that non-verbal communication visual clues affected significantly the users' perception of the IVA's personality traits. However, in their study about varying personality in spoken dialogue, Rushforth et al. [19] reported that feedback from the participants suggested that the non-verbal behavior may have been a confounding factor in their perception of IVA's personality.

The results of questions three and four suggested that in the collaborative context the similarity in personality traits between IVAs and humans is likely to impact on humans' perception of IVAs' personality. Numerous studies reported different points of views; while Isbister [42] found people liked virtual agents which showed a different personality to their own, other researchers [43, 44] report that people preferred computer interfaces (including IVA) that embodied a similar type of personality to their own. These differences in findings are probably due to the differences in goals and designs of each of the studies and highlights the complexity of the personality dimension and its effects.

Relating to question five, the results showed that the humans trusted in the agreeable IVA and not the antagonistic or the neutral IVA. Additionally, the results showed that the humans trusted in the extravert IVA rather than introvert or the neutral IVA. Probably agreeableness is the personality trait that can be identified as the most associated with trust. The reason for this strong association is due to the nature of agreeableness that makes the individual willing to conform to the needs of others. Some researchers have claimed that the propensity to trust is a facet or component of

agreeableness [45]. Many studies showed that agreeable IVAs can more easily build a sense of rapport with a human [45, 46]. In their study, Kang et al. [23] investigated the association between personality traits of human subjects and their feelings when they interacted with an IVA that is incorporated with personality. Their result indicated that agreeable IVAs create stronger rapport especially with agreeable people.

8 Conclusion and Future Work

This study investigated whether the (mis)match in personality between humans and their IVA teammate tends to influence the humans' perception of the IVA's personality. Additionally, this paper studied whether IVA's personality as perceived by humans influenced humans' trust in IVA decisions. While human preference for a particular IVA personality has been previously explored [42, 43], our study went beyond preferences to investigate the influence of (mis)match between the human's and IVA's personalities on the human's perception of the IVAs' personality. Our findings supported the idea that humans are more likely to perceive correctly the personality of the IVA when the personality of their IVA teammate matches their own. Moreover, the humans who perceived the personality of the IVA teammate as agreeable tended to report greater trust in that IVA. As future work, the impact of a (mis)match between humans and IVA teammates on team performance needs to be studied.

References

1. Vosinakis, S., Panayiotopoulos, T.: SimHuman: a platform for real-time virtual agents with planning capabilities. In: de Antonio, A., Aylett, R.S., Ballin, D. (eds.) IVA 2001. LNCS (LNAI), vol. 2190, pp. 210–223. Springer, Heidelberg (2001)
2. Kasap, Z., Magnenat-Thalmann, N.: Intelligent virtual humans with autonomy and personality: state-of-the-art. In: Magnenat-Thalmann, N., Jain, L., Ichalkaranje, N. (eds.) New Advances in Virtual Humans, vol. 140, pp. 43–84. Springer, Berlin (2008)
3. von der Pütten, A.M., Krämer, N.C., Gratch, J.: How our personality shapes our interactions with virtual characters - implications for research and development. In: Allbeck, J., Badler, N., Bickmore, T., Pelachaud, C., Safonova, A. (eds.) IVA 2010. LNCS, vol. 6356, pp. 208–221. Springer, Heidelberg (2010)
4. Doce, T., Dias, J., Prada, R., Paiva, A.: Creating individual agents through personality traits. In: Allbeck, J., Badler, N., Bickmore, T., Pelachaud, C., Safonova, A. (eds.) IVA 2010. LNCS, vol. 6356, pp. 257–264. Springer, Heidelberg (2010)
5. John, O., Srivastava, S.: The Big Five Trait Taxonomy: History, Measurement, and Theoretical Perspectives. Guilford Press, New York (1999)
6. Neto, A.F.B., da Silva, F.S.C.: A computer architecture for intelligent agents with personality and emotions. In: Zacarias, M., de Oliveira, J.V. (eds.) Human-Computer Interaction. SCI, vol. 396, pp. 263–286. Springer, Heidelberg (2012)
7. Bahamón, J.C., Young, R.M.: Toward a computational model for the automatic generation of character personality in interactive narrative. In: Nakano, Y., Neff, M., Paiva, A., Walker, M. (eds.) IVA 2012. LNCS, vol. 7502, pp. 520–522. Springer, Heidelberg (2012)

8. Robison, J., Rowe, J., McQuiggan, S., Lester, J.: Predicting user psychological characteristics from interactions with empathetic virtual agents. In: Ruttkay, Z., Kipp, M., Nijholt, A., Vilhjálmsson, H.H. (eds.) IVA 2009. LNCS, vol. 5773, pp. 330–336. Springer, Heidelberg (2009)
9. Negron, A.P.P., Vera, R.A.A., Jiménez, A.d.A.: Collaborative interaction analysis in virtual environments based on verbal and nonverbal interaction. In: Ninth Mexican International Conference on Artificial Intelligence (MICAI), pp. 129–133 (2010)
10. Prabhala, S.V., Gallimore, J.J.: Designing computer agents with personality to improve human-machine collaboration in complex systems. Wright State University (2007)
11. El-Kassrawy, Y.A.: The impact of trust on virtual team effectiveness. Int. J. Online Mark. **4**, 11–28 (2014)
12. Wang, Y., Vassileva, J.: Trust and reputation model in peer-to-peer networks. In: Proceedings of the 3rd International Conference on Peer-to-Peer Computing, p. 150. IEEE Computer Society (2003)
13. Mayer, R.C., Davis, J.H., Schoorman, F.D.: An integrative model of organizational trust. Acad. Manage. Rev. **20**, 709–734 (1995)
14. Mitchell, A., Zigurs, I.: Trust in virtual teams: solved or still a mystery? SIGMIS Database **40**, 61–83 (2009)
15. Hanna, N., Richards, D.: The impact of communication on a human-agent shared mental model and team performance. In: The 13th International Conference on Autonomous Agents and multi-agent Systems (AAMAS 2014), pp. 1485–1486, Paris, France (2014)
16. Zhao, R., Papangelis, A., Cassell, J.: Towards a dyadic computational model of rapport management for human-virtual agent interaction. In: Bickmore, T., Marsella, S., Sidner, C. (eds.) IVA 2014. LNCS, vol. 8637, pp. 514–527. Springer, Heidelberg (2014)
17. Stanković, I., Popović, B., Focone, F.: Influence of agent behaviour on human-virtual agent body interaction. In: Ronzhin, A., Potapova, R., Delic, V. (eds.) SPECOM 2014. LNCS, vol. 8773, pp. 292–299. Springer, Heidelberg (2014)
18. Bevacqua, E., Stanković, I., Maatallaoui, A., Nédélec, A., De Loor, P.: Effects of coupling in human-virtual agent body interaction. In: Bickmore, T., Marsella, S., Sidner, C. (eds.) IVA 2014. LNCS, vol. 8637, pp. 54–63. Springer, Heidelberg (2014)
19. Rushforth, M., Gandhe, S., Artstein, R., Roque, A., Ali, S., Whitman, N., Traum, D.: Varying personality in spoken dialogue with a virtual human. In: Ruttkay, Z., Kipp, M., Nijholt, A., Vilhjálmsson, H.H. (eds.) IVA 2009. LNCS, vol. 5773, pp. 541–542. Springer, Heidelberg (2009)
20. Neff, M., Wang, Y., Abbott, R., Walker, M.: Evaluating the effect of gesture and language on personality perception in conversational agents. In: Allbeck, J., Badler, N., Bickmore, T., Pelachaud, C., Safonova, A. (eds.) IVA 2010. LNCS, vol. 6356, pp. 222–235. Springer, Heidelberg (2010)
21. Neff, M., Toothman, N., Bowmani, R., Fox Tree, J.E., Walker, M.A.: Don't scratch! Self-adaptors reflect emotional stability. In: Vilhjálmsson, H.H., Kopp, S., Marsella, S., Thórisson, K.R. (eds.) IVA 2011. LNCS, vol. 6895, pp. 398–411. Springer, Heidelberg (2011)
22. Cafaro, A., Vilhjálmsson, H.H., Bickmore, T., Heylen, D., Jóhannsdóttir, K.R., Valgarðsson, G.S.: First impressions: users' judgments of virtual agents' personality and interpersonal attitude in first encounters. In: Nakano, Y., Neff, M., Paiva, A., Walker, M. (eds.) IVA 2012. LNCS, vol. 7502, pp. 67–80. Springer, Heidelberg (2012)
23. Kang, S.-H., Gratch, J., Wang, N., Watt, J.H.: Agreeable people like agreeable virtual humans. In: Prendinger, H., Lester, J.C., Ishizuka, M. (eds.) IVA 2008. LNCS (LNAI), vol. 5208, pp. 253–261. Springer, Heidelberg (2008)

24. Aguilar, R.A., de Antonio, A., Imbert, R.: Searching pancho's soul: an intelligent virtual agent for human teams. In: Electronics, Robotics and Automotive Mechanics Conference (CERMA 2007), pp. 568–571 (2007)
25. Goldberg, L.R.: An alternative description of personality: the big-five factor structure. J. Pers. Soc. Psychol. **59**, 1216–1229 (1990)
26. Van den Bosch, K., Brandenburgh, A., Muller, T.J., Heuvelink, A.: Characters with personality! In: Nakano, Y., Neff, M., Paiva, A., Walker, M. (eds.) IVA 2012. LNCS, vol. 7502, pp. 426–439. Springer, Heidelberg (2012)
27. Barry, B., Stewart, G.L.: Composition, process and performance in self-managed groups: the role of personality. J. Appl. Psychol. **82**, 62–78 (1997)
28. McCrae, R.R., John, O.P.: An introduction to the five-factor model and its applications. J. Pers. **60**, 175–215 (1992)
29. Mann, R.D.: A review of the relationships between personality and performance in small groups. Psychol. Bull. **56**, 241–270 (1959)
30. Scherer, K.R.: Personality Markers in Speech. Cambridge University Press, London (1979)
31. Scherer, K.R.: Personality inference from voice quality: the loud voice of extroversion. Eur. J. Soc. Psychol. **8**, 467–487 (1978)
32. Krishnan, V., Foster, A., Kopper, R., Lok, B.: Virtual human personality masks: a human computation approach to modeling verbal personalities in virtual humans. In: Nakano, Y., Neff, M., Paiva, A., Walker, M. (eds.) IVA 2012. LNCS, vol. 7502, pp. 146–152. Springer, Heidelberg (2012)
33. Argyle, M.: Bodily Communication. Routledge, London (1988)
34. Goldberg, L.R., Johnson, J.A., Eber, H.W., Hogan, R., Ashton, M.C., Cloninger, C.R., Gough, H.G.: The international personality item pool and the future of public-domain personality measures. J. Res. Pers. **40**, 84–96 (2006)
35. Gosling, S.D., Rentfrow, P.J., Swann, W.B.: A very brief measure of the big-five personality domains. J. Res. Pers. **37**, 504–528 (2003)
36. Dillenbourg, P., Traum, D.R., Schneider, D.: Grounding in multi-modal task-oriented collaboration. In: The European Conference on Artificial Intelligence in Education, pp. 401–407 (1996)
37. Arellano, D., Varona, J., Perales, F.J., Bee, N., Janowski, K., André, E.: Influence of head orientation in perception of personality traits in virtual agents. In: The 10th International Conference on Autonomous Agents and Multiagent Systems, vol. 3, pp. 1093–1094. IFAAMAS, Taipei, Taiwan (2011)
38. de Sevin, E., Hyniewska, S.J., Pelachaud, C.: Influence of personality traits on backchannel selection. In: Allbeck, J., Badler, N., Bickmore, T., Pelachaud, C., Safonova, A. (eds.) IVA 2010. LNCS, vol. 6356, pp. 187–193. Springer, Heidelberg (2010)
39. Deng, Z., Bailenson, J.N., Lewis, J.P., Neumann, U.: Perceiving visual emotions with speech. In: Gratch, J., Young, M., Aylett, R.S., Ballin, D., Olivier, P. (eds.) IVA 2006. LNCS (LNAI), vol. 4133, pp. 107–120. Springer, Heidelberg (2006)
40. Burgoon, J.K.: Nonverbal signals. In: Knapp, M.L., Miller, G.R. (eds.) Handbook of Interpersonal Communication, 2nd edn. SAGE Publications, Thousand Oaks (1994)
41. Vinciarelli, A., Salamin, H., Polychroniou, A., Mohammadi, G., Origlia, A.: From nonverbal cues to perception: personality and social attractiveness. In: Esposito, A., Esposito, A.M., Vinciarelli, A., Hoffmann, R., Müller, V.C. (eds.) COST 2102. LNCS, vol. 7403, pp. 60–72. Springer, Heidelberg (2012)
42. Isbister, K., Nass, C.: Consistency of personality in interactive characters: verbal cues, non-verbal cues, and user characteristics. Int. J. Hum Comput Stud. **53**, 251–267 (2000)
43. Nass, C., Moon, Y., Fogg, B.J., Reeves, B., Dryer, D.C.: Can computer personalities be human personalities? Int. J. Hum Comput Stud. **43**, 223–239 (1995)

44. Nass, C., Fogg, B.J., Moon, Y.: Can computers be teammates? Int. J. Hum Comput Stud. **45**, 669–678 (1996)
45. Mooradian, T., Renzl, B., Matzler, K.: Who trusts? Personality trust and knowledge sharing. Manage. Learn. **37**, 523–540 (2006)
46. Hanna, N., Richards, D.: "Building a Bridge": communication, trust and commitment in human-intelligent virtual agent teams. In: The Third International Workshop on Human-Agent Interaction Design and Models (HAIDM 2014) at AAMAS2014, Paris, France (2014)