The Influence of Real Human Personality on Social Presence with a Virtual Human in Augmented Reality

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(A) Real-Virtual Human Interaction in AR   **(B) Ignoring/Inconsistency Behavior**   **(C) Requesting/Consistency Behavior**
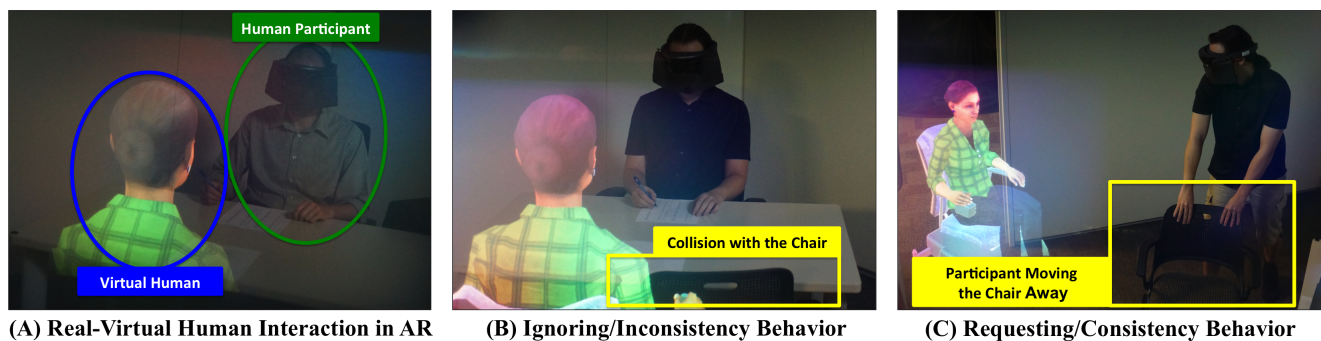
Figure 1: Participant interacting with a virtual human in our experimental augmented reality environment. (A) The participant wears an optical see-through head-mounted display and sees the virtual human in either of two experimental conditions: (B) in the "Ignoring/Inconsistency" behavior condition, the virtual human passes through the physical chair (no occlusion) and does not ask for help from the participant, and (C) in the "Requesting/Consistency" behavior condition, the virtual human is naturally occluded by the physical objects and proactively asks help from the participant, to move the physical chair out of the way.

Abstract

Human responses to an interaction with a Virtual Human (VH) can be influenced by both external factors such as technology-related limitations, and internal factors such as individual differences in personality. While the impacts of external factors have been studied widely, and are typically controlled for in application scenarios, less attention has been devoted to the impacts of internal factors. We present the results of a human-subject experiment where we investigated a particular internal factor: the effects of extraversion–introversion traits of participants on the sense of social presence with a VH in an Augmented Reality (AR) setting. Our results indicate a positive association between a condition where the VH proactively requests help from the participant, and participants indicating higher social presence with the VH, regardless of their personality. However, we also found that extraverted participants tended to report higher social presence with the VH, compared to the introverted participants. In addition, there were differences in the duration of when the participants were looking at the VH during the interaction according to their extraversion–introversion traits. Our results suggest that a real human's personality plays a significant role in interactions with a VH, and thus should be considered when carrying out such experiments that include measures of the effects of controlled manipulations on interactions with a VH. We present the details of our experiment and discuss the findings and potential implications related to human perceptions and behaviors with a VH.

Categories and Subject Descriptors (according to ACM CCS): Information Interfaces and Presentation [H.5.1]: Multimedia Information Systems—Artificial, Augmented, and Virtual Realities; Computer Applications [J.4]: Social and Behavioral Sciences—Psychology

1. Introduction

In Virtual Human (VH) research examining social interactions between real and virtual humans, the human user's personality is often overlooked, despite significant potential effects on the dynamics of social behavior with the VH [LPO15, vdPKG10]. For example, while extraverted people might feel good when they are asked by a VH to assist in a physical task in the middle of an experiment, introverted people might feel uncomfortable because they are aware of the experimental context, and might care about how their behavior is perceived by others. In other words, the personality traits of the real human could influence their perceptions, such as social presence and affect, when interacting with a VH. Thus when carrying out human subject research involving VH interactions in Virtual Reality (VR) or Augmented Reality (AR), one might want to consider the potential role of each participant's personality in their perceptions about and behaviors associated with the interaction.

To investigate the possible effects, we analyzed the results from an experiment investigating how a particular personality trait— whether they are *extraverted* or *introverted*—could affect their sense of social presence with a VH while interacting in an AR environment (see Figure 1). As an inherent part of the scenario we measured the degree of introversion/extraversion of all participants and divided them into two personality groups while manipulating the VH's behavior in two behavioral conditions to either

- stop and request help from the participant to move a physical object that is in the way of the VH, or
- ignore a physical object that is in the way of the VH, resulting in a real-virtual conflict as the VH collides with the physical object.

While we have examined and describe the effects of both the VH behavior, which we manipulated, and participant personality, which we measured, in this paper we focus on the latter: participant personality. In a future publication we will focus on the former: VH behavior manipulation.

Analysis of the experimental results shows that both the participant's personality and the VH's requesting behavior had main effects on the participant's sense of social presence with the VH. We also found that the extraverted participants tended to be more positively influenced by the VH's requesting behavior, compared to the introverted participants. Here, we present the details of the experiment and the results related to the participants' perceptions and behaviors with the VH, and discuss the findings and potential implications.

This paper is structured as following: Section 2 introduces the concept of social presence and previous research related to the effects of human user's personality in VH experiences. Section 3 describes the details of the experiment that we conducted to evaluate the effects of the participant's personality on social interaction with a VH. Section 4 presents the results, which are discussed in Section 5. Section 6 concludes the paper.

2. Related Work

2.1. Social Presence in Real–Virtual Human Interactions

In research dealing with VHs, the concept of Social Presence is popularly used as a measure of one's perception of the VHs. There is still ongoing debate about precise definitions for Social Presence and a similar concept of Co-Presence, as distinct from yet another broad concept of Presence. Some researchers distinguished them as different but correlated concepts [Bul12, NB03]. In general, while *Presence* could mean one's sense of "*being there*" in a virtual environment, the concepts of *Co-Presence* and *Social Presence* might be described as how one perceives the other's presence as a sense of "*being together*," and how much they feel "*socially connected*," respectively. Blascovich et al. defined Social Presence as "the degree to which one believes that he or she is in the presence of, and interacting with, other veritable human beings" [BLB*02]. In the virtual reality community, it is often to use the terms, Social Presence and Co-Presence, interchangeably [SSRR10].

Previous literature suggests that the sense of Social Presence with a VH can be influenced by the VH's different characteristics such as the fidelity/realism of the VH's appearance and behaviors [Gar03, vdPKG09, KKGK11].

2.2. Personality Effects in Human Perceptions

Each individual has their own ways of perceiving the world and making decisions. However, there are generally accepted personality traits that can influence the behavior [MM95], and given differences of the traits, one's perceptions/feelings in the (social) interactions with agents (e.g., virtual humans) could be very different from another's even if they are exposed to the same interaction.

Previous work has primarily focused on the correlation of a users' personality traits and their perception of interactive agents in human–agent interactions. Von der Pütten et al. [vdPKG10] pointed out the lack of awareness for the human users' personality influence on their perception and behaviors in human–agent interactions, and conducted an experiment varying a virtual human's behavioral realism. They found that some personality traits of participants, e.g., extraversion and agreeableness, were associated with their behavior and could predict the results/outcome of the experiment better than the original manipulation for the virtual human's behavior. In the same sense, Kang et al. [KGWW08a] evaluated the relationship between participants' agreeableness and an interactive virtual human's agreeable behaviors (e.g., nonverbal contingent feedback while listening), and showed that the participants who had more agreeable personalities felt stronger rapport with the virtual human exhibiting agreeable behaviors. Cerekovic et al. [CAGP16] also recently presented that people who had high scores in extraversion and agreeableness reported higher rapport with virtual agents regardless of the agents' emotional expression (i.e., sad or cheerful). Bickmore and Cassell [BC01] suggested that people who were more extraverted tended to build a higher degree of trust in the virtual agent that had social dialogue features, compared to introverted people. Kang et al. [KGWW08b] suggested that shy people felt less rapport with a virtual agent but experienced more embarrassment when they interacted with a non-contingent agent, which did not have responsive behaviors. Wieser et al. [WPG*10] also suggested that people who had high social anxiety tended to show a complex pattern of avoidance behavior, e.g., avoided gaze contact and backward head, while interacting with a virtual agent.

Reeves and Nass [RN96] claimed that people were inclined

to treat media/computers as if they were real people in their studies, and Nass and Lee [NL00] showed a similarity-attraction effect whereby users were attracted by agents—one type of media/computers—that had a similar degree of extraversion. The similarity-attraction effect was generally supported by previous experiments although Isbister and Nass also suggested different findings [IN00]—e.g., people tended to prefer a virtual character whose personality was *complementary* to their own. Lee and Nass explored the similarity-attraction effect in the sense of social presence with computer-generated voices and texts [LN03]. In their experiments, they prepared computer-synthesized voices and texts that revealed human personal traits, specifically extraversion/introversion, and investigated human user's social presence with them along with the computer-synthesized personality and the user's own personality. The results showed that people felt higher social presence with the voice and the text having similar personalities to themselves. Hanna and Richards [HR15] also supported that the similarity in personalities between human users and virtual agents tended to significantly influence the user's correct perception of the agent's personality and level of trust in the agent.

3. Experiment

In this section, we describe the experiment which was the basis for our analysis of the influence of a participant's personality on their perceived social presence with a VH while having a conversational interaction with the VH. In the experiment, we not only measured the participants' personality traits during the real-virtual human interaction, but also manipulated the VH's proactive requesting behavior, which in turn could affect the participant's perception of the VH differently with respect to their personality.

3.1. Material

We performed the experiment in a room with a table, a box-like blocker, and two chairs (see Figure 2). The room had two doors on its opposite sides, and the table was in the middle of the room at a tilted angle (about 45 degrees) with chairs on both sides.

The visual stimulus consisted of a VH designed in Maya and rendered in real time in the Unity3D engine. The VH, called "Katie", was seated in an electric motorized wheelchair and could perform facial expressions, body gestures and speech with spatial audio effects (see Figure 1 and Figure 2). The VH was remotely controlled by a human operator in a *Wizard of Oz* setup to trigger the VH's pre-defined speech and behavioral animations. Throughout the interaction, the VH exhibited neutral or slightly pleasant facial expressions and sometimes looked down at the paper on the table.

We used a Microsoft HoloLens to display the VH in the experiment room (see Figure 2). One problem we encountered with the HoloLens was its narrow field of view. To reduce visual conflicts due to cropping or disappearing virtual content, we covered the periphery with a black polyether foam.

3.2. Methods

In this experiment we used a two-factorial between subjects design. We defined the behavior of the VH as one factor with two levels (Ignoring/Inconsistency or Requesting/Consistency), and we focused
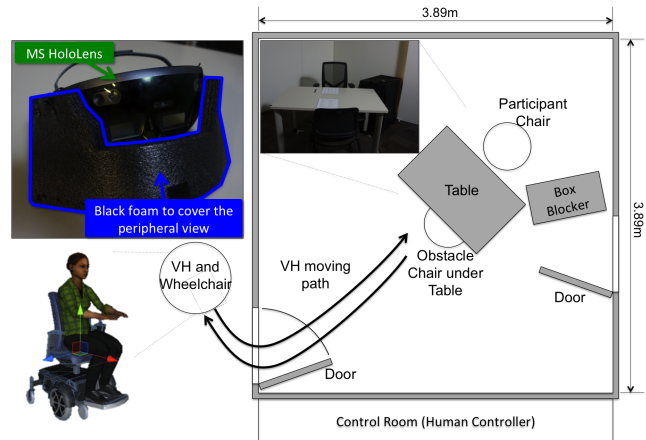

Figure 2: Experiment space and HoloLens with a black cover. A table in the middle of the room, and the VH and the participant have a conversation across the table. When the VH asked the participant to move the chair, he/she had to stand up and move the chair under the table towards the wall so that the VH could slide in the table.

on the personality of the participants as an additional factor with two levels (extraversion or introversion).

3.2.1. Virtual Human Behavior

Regarding the VH's behavior, we established two different conditions: the "Ignoring/Inconsistency" condition and the "Requesting/Consistency" condition, and participants were randomly assigned to one of the two conditions and interacted with a VH across a physical table in an AR environment.

- For the *"Ignoring/Inconsistency"* condition (Figure 1-B), the VH appeared to be unaware of and unaffected by the physical objects in the environment. In other words, the VH was not occluded by foreground physical objects, and passed through any physical objects that were in the way; thus the VH did not ask for help from the participants to move the objects to avoid collisions.
- On the other hand, for the *"Requesting/Consistency"* condition (Figure 1-C), the VH was appropriately occluded by foreground objects, and the VH exhibited awareness of obstructing physical objects such as a chair, asking the participants to move the chair so that the VH could avoid the physical-virtual collision.

3.2.2. Personality Groups

We assessed the participant's personality in the experiment while sitting at the table in the experimental room and interacting with the VH using a form of question-answer conversation. The VH asked the participants twenty questions from the Myer-Briggs Type Indicator (MBTI) personality test [MM95]. The MBTI is widely recognized as a personality type indicator; so, participants seemed to be familiar with it and easily engaged in the interaction. Additionally, the personality test scenario made the dynamics of the verbal interaction relatively constrained in the experiment; so, it enabled the VH's speech to be natural enough keeping the plausibility of the conversational interaction. A short version of the MBTI was used

for this experiment[†]. Each question was a binary choice of A/B, so the participants had to choose either A or B and let the VH know what they chose verbally while marking their answers on a sheet of paper on the table.

The personality types were distinguished by four different dichotomies: extraversion/introversion, sensing/intuition, thinking/feeling, and judging/perceiving. Although all the divided personality groups could be compared to each other in their perceptions and behaviors with the VH, we only focused on the extraversion/introversion dimension because it was considered as an effective factor in previous literature. Thus, the participants were divided into two groups: the *"Extraversion"* group and the *"Introversion"* group.

3.2.3. Procedure

Participants started the experiment by reading an informed consent form and filling out a demographics questionnaire. Next, they were guided to the experimental room and instructed to sit on the chair in the corner of the room while we started the video and audio recording. The experimenter explained that they would be wearing an HMD, a Microsoft HoloLens, and be recorded throughout the experiment. They were informed that they would have an interaction with a VH, Katie, and she would ask twenty questions from the MBTI personality test, which were A/B type binary questions. The experimenter made sure that they understood that they had to answer the questions verbally to the VH while also writing down the answers on the paper in front of them.

The participant was instructed to sit on the chair close to the wall (see Figure 2) and guided to wear the HoloLens. Once the participant had correctly donned the HoloLens, the VH entered the room giving a notice verbally that it was coming in from outside.

The VH behaved depending on the condition as described in Section 3.2.1. In the "Requesting/Consistency" condition, the experimenter opened the physical door for the VH in the wheelchair to get in/out of the room at the beginning/end of the interaction, while in the "Ignoring/Inconsistency" condition the VH drove through the physical door. After entering and without the experimenter in the room, the VH approached the opposite side of the table. While doing this, the presence of the physical chair on the opposite side of the table from the participant presented a conflict and a potential physical-virtual occlusion/collision when the VH approached with the wheelchair. In the "Requesting/Consistency" condition, the VH asked the participant to please move the chair out of its way so that she could move there with her wheelchair. Hence, the participant had to stand up and move the chair away so that the VH could avoid the implausible physical-virtual occlusion/collision. In the "Ignoring/Inconsistency", the VH drove "through" the physical chair without trying to avoid this implausible collision.

Once the participants completed the interaction, the experimenter guided them out of the room and asked them to fill out a post-questionnaire. Afterward, the experimenter had a brief discussion with the participants about their perception and behavior with the VH and finally ended the experiment by giving a monetary compensation to the participants.

3.3. Participants

We had a total of 22 participants from our university community (11 for the "Requesting/Consistency" group and 11 for the "Ignoring/Inconsistency" group; 14 males and 8 females; age $M = 22.82$, $SD = 3.54$), and their subjective responses and behavioral data were used for the analysis. All the participants received $15 USD for their participation. The total duration of the experiment per participant was approximately one hour long including the discussion after the experiment.

3.4. Dependent Variables

Social Presence (Questionnaire): We used the Social Presence (SP) questionnaire from Bailenson et al. [BBBL03]. The SP questionnaire consists of five questions, covering the VH's authenticity and realism as well as the sense of "being together". All questions were on 7-point Likert scales, and we used the averaged score as a representative score for the sense of SP with the VH. We established the following three hypotheses for SP based on the assumptions that the VH's requesting behavior in this experiment might be positively perceived by the participants, and the participants' personality (extraversion-introversion) might influence their perception of the VH:

- **SP-H1**: The level of SP will be higher in the "Requesting/Consistency" condition than in the "Ignoring/Inconsistency" condition.
- **SP-H2**: The level of SP will be higher for the "Extraversion" group than in the "Introversion" group.
- **SP-H3**: There will be an interaction effect similar to the *similarity-attraction* effect in SP between the VH's behavior conditions and the personality groups (refer to Section 2).
  - **SP-H3-1**: I.e., the "Extraversion" group will have higher SP in the "Requesting/Consistency" condition than the "Introversion" group,
  - **SP-H3-2**: whereas the "Introversion" group will have higher SP in the "Ignoring/Inconsistency" condition than the "Extraversion" group.

Positive/Negative Affect (Questionnaire): Affect could be an important measure to understand how the VH was perceived by the participants. We assessed affect with the Positive and Negative Affect Schedule (PANAS) questionnaire [WCT88]. The PANAS questionnaire consists of 20 words describing different feelings and emotions (e.g., interested, distressed, and excited), and participants evaluated the words based on what they felt during the interaction with the VH in 5-point scales (1: very slightly or not at all, and 5: extremely). The words are divided into two categories: positive and negative terms, and the positive/negative affect is evaluated as the average score of each category. An additional open-ended question at the end of the questionnaire asked how the participants felt during the interaction with the VH and requested that they wrote at least three sentences as detailed as possible. The open-ended responses were analyzed using the Linguistic Inquiry and Word

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[†] https://www.quia.com/sv/522966.html (2016-11-02)

Count (LIWC)—a program that can analyze one's emotion or feelings based on the words they use [PBBF15]. Among many variables from the LIWC, we only focused on the affect category—the higher score the more (positive) affect. We expected that people would more likely exhibit positive affect than negative affect due to the novel experience interacting with the VH in AR; thus, we hypothesized:

- **PN-H1**: The level of positive affect will be higher in the "Requesting/Consistency" condition than in the "Ignoring/Inconsistency" condition.
- **PN-H2**: There will be an interaction effect in affect between the personality groups and the VH's behavior conditions.

Mutual Gaze (Behavior): Inter-personal mutual gaze (i.e., eye-contact) correlates with one's perceived SP and the engagement to the interaction [BBB02]. Although we were not able to integrate a professional eye tracker with the HoloLens to compare gaze behavior directly, we used an approximation of this measure by evaluating how long the VH's face appeared in the HoloLens view during the interaction. Since the HoloLens has a very small FoV, we expect these measures to be sufficiently similar, although they were technically not the same. To analyze the gaze, one reviewer evaluated the videos of the participants' HoloLens views and checked the time stamps when the VH's face appeared/disappeared in the videos. In a second pass, another reviewer confirmed the time stamps reviewing the videos again while correcting them if needed. For the gaze analysis, we did not include the period when the VH was exploring in the room, but only consider the period when the VH arrived the table and had a conversational interaction with the participants. Finally, we extracted the duration while looking at the VH's face and also counted the number of times the gaze shifted. We hypothesize:

- **MG-H1**: There will be longer mutual gaze in the "Requesting/Consistency" condition than in the "Ignoring/Inconsistency" condition.
- **MG-H2**: There will be longer mutual gaze for the "Extraversion" group than for the "Introversion" group.
- **MG-H3**: The number of gaze shifts will be lesser in the "Requesting/Consistency" condition than in the "Ignoring/Inconsistency" condition.
- **MG-H4**: The number of gaze shifts will be lesser in the "Extraversion" group than in the "Introversion" group.

4. Analysis and Results

Among the total of 22 participants, the participants' personality responses divided them into two personality group: the "Extraversion" group and the "Introversion" group—7 and 15, respectively. The distribution of the participants is shown in Table 1. Non-parametric Kruskal-Wallis H tests are conducted to determine whether there are statistically significant differences in each of our measures among the groups. Also, we examine whether there is any interaction effect between the VH's behavior conditions and the participant's personality groups.

Social Presence (Questionnaire): The Kruskal-Wallis H tests show that there is a statistically significant difference in social presence both for the VH's behavior conditions and for the participant's personality (see Table 2). The tendency of the reported scores for

Table 1: 2×2 participant distribution for the VH's behavior conditions and the personality groups.

Personality	VH Behavior		Total
	Ignoring/ Inconsistency	Requesting/ Consistency	
Introversion	9	6	15
Extraversion	2	5	7
Total	11	11	22

Table 2: The results of Kruskal-Wallis H tests for social presence (* $p < .05$) and group descriptives.

Comparison by VH Behavior Conditions
("Ignoring/Inconsistency" vs. "Requesting/Consistency")

	χ^2	df	p	η^2
Social Presence	5.620	1	**0.018***	0.268

Comparison by Participant Personality Groups
("Introversion" vs. "Extraversion")

	χ^2	df	p	η^2
Social Presence	4.203	1	**0.040***	0.200

Mean and SE for Each Group

VH Behavior	Participant Personality	Mean	SE
Ignoring/ Inconsistency	Introversion	3.444	0.369
	Extraversion	3.300	0.783
Requesting/ Consistency	Introversion	3.967	0.452
	Extraversion	5.480	0.495

social presence support our hypotheses **SP-H1** and **SP-H2** that the "Requesting/Consistency" condition (the "Extraversion" group) has higher social presence than the "Ignoring/Inconsistency" condition (the "Introversion" group) (see Table 2 and Figure 3).

For **SP-H3**, we could not find a statistical interaction (crossing) effect between the VH's behavior and the participant's personality because the levels of social presence for the "Introversion" group and the "Extraversion" group were similar to each other for the "Ignoring/Inconsistency" condition. Interestingly, however, we could see that the "Requesting/Consistency" condition increased the sense of social presence for the "Extraversion" group dramatically compared to the "Introversion" group (see Figure 3). This suggests that the same behavior of VH can be perceived differently depending on the participant's personality, specifically in the extraversion-introversion domain; this could support the **SP-H3-1**.

Postive/Negative Affect (Questionnaire): The Kruskal-Wallis H tests did not show any statistically significant differences in both PANAS and LIWC affect measures (see Table 3); thus, we could not find any supportive evidence for **PN-H1** and **PN-H2**. However, we found an interesting observation on the LIWC affect measure—linguistic analysis based on what participants wrote in the open-ended question asking about how they felt during the interaction. The affect score dropped down when the extraverted participants interacted with the VH not requesting help but ignoring the physical-virtual consistency compared to the introverted participants (Figure 4).
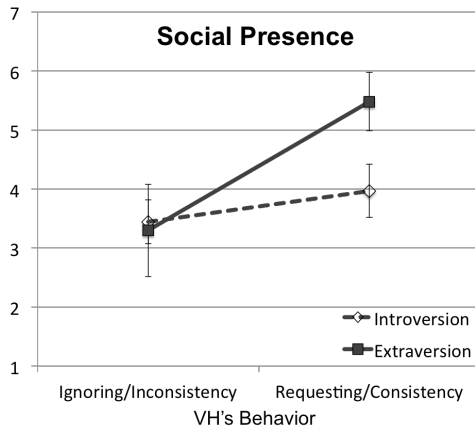
Figure 3: Influence of participants' personality in social presence. The extraverted participants tend to experience much higher social presence with the VH requesting help compared to the introverted participants although the introverted participants' social presence is also increased by the VH's requesting/consistency behavior.

Table 3: The results of Kruskal-Wallis H tests for affect.

Comparison by VH Behavior Conditions
("Ignoring/Inconsistency" vs. "Requesting/Consistency")

	χ^2	df	p	η^2
PANAS				
Positive Affect	2.284	1	0.131	0.109
Negative Affect	2.187	1	0.139	0.104
LIWC				
Affect	0.571	1	0.450	0.027

Comparison by Participant Personality Groups
("Introversion" vs. "Extraversion")

	χ^2	df	p	η^2
PANAS				
Positive Affect	2.865	1	0.091	0.136
Negative Affect	0.012	1	0.912	0.001
LIWC				
Affect	0.061	1	0.805	0.003

Mutual Gaze (Behavior): Regarding the total interaction time, there is not a statistically significant difference among the VH's behavior conditions and the participant's personality groups. However, there are statistically significant differences in the mutual gaze ratio both for the comparison among the VH's behaviors and for the comparison among the participant's personality groups (see Table 4). These are supportive evidence for **MG-H1** that participants exhibit longer mutual gaze for the "Requesting/Consistency" condition than the "Ignoring/Inconsistency" condition, and for **MG-H2** that the participants for the "Extraversion" group exhibit longer mutual gaze with the VH than the "Introversion" group (see Figure 5). Considering the simple dyadic interaction scenario, the high ratio of mutual gaze over the total interaction time (more than 60% for all groups) seems reasonable.

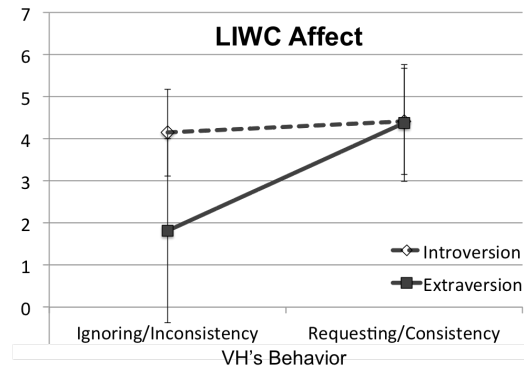For participant's gaze shifting behavior, we could not find any

Figure 4: Participant-reported affect analyzed by the LIWC. The level of affect for the "Extraversion" group decreases in the "Ignoring/Inconsistency" condition.

statistically significant effects, but observed the tendency opposite to our hypothesis **MG-H3**. The results show that the number of gaze shifts is lesser in the "Ignoring/Inconsistency" condition than in the "Requesting/Consistency" group. This phenomenon seemed to result from the experimental interaction scenario—participants had to write their answers on the paper at the table during the interaction with the VH. We noticed that the participants for the "Requesting/Consistency" condition more dynamically changed their gaze between the paper and the VH whereas the "Ignoring/Inconsistency" condition tended to spend more time attending/staring at the paper instead of the VH. That could explain why we had longer mutual gaze time, but more gaze shiftings for the "Requesting/Consistency" group.

For **MG-H4**, we could not find a statistically significant effect of the participant's personality in the number of gaze shiftings, but we observed the positive tendency along with our expectation (see Figure 6). The "Extraversion" group tended to have fewer gaze shiftings than the "Introversion" group, which could be interpreted as they were more engaged in the VH itself.

Table 4: The results of Kruskal-Wallis H tests for interaction time and gaze (* p < .05).

Comparison by VH Behavior Conditions
("Ignoring/Inconsistency" vs. "Requesting/Consistency")

	χ^2	df	p	η^2
Interaction Time (s)	0.183	1	0.669	0.009
Mutual Gaze Time (s)	1.175	1	0.278	0.056
Mutual Gaze Ratio (%)	4.011	1	**0.045***	0.191
Gaze Shift (count)	0.351	1	0.554	0.017

Comparison by Participant Personality Groups
("Introversion" vs. "Extraversion")

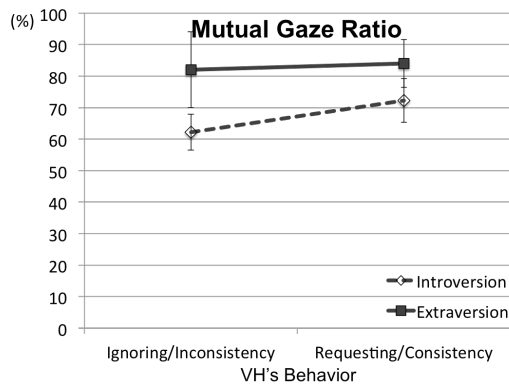|	χ^2	df	p	η^2
Interaction Time (s)	0.151	1	0.698	0.007
Mutual Gaze Time (s)	4.628	1	**0.031***	0.220
Mutual Gaze Ratio (%)	6.988	1	**0.008***	0.333
Gaze Shift (count)	1.995	1	0.158	0.095

Figure 5: *Participant's mutual gaze ratios. The extraverted participants tend to have more mutual gaze with the VH compared to the introverted participants throughout the VH's behavior conditions. Slight increases of mutual gaze with the VH's requesting/consistency behavior are observed for both the "Extraversion" group and the "Introversion" group.*
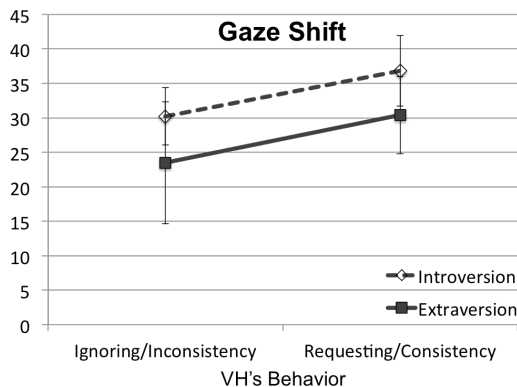

Figure 6: *Participant's gaze shiftings. More gaze shiftings are observed in the "Requesting/Consistency" condition. The introverted participants tend to have more gaze shiftings than the extraverted participants throughout the VH's behavior conditions.*

5. Discussion

We found that the participant's sense of social presence was higher when the VH was exhibiting the help-requesting behavior with plausible physical-virtual occlusions than not. Also, the sense of social presence was higher for the extraverted participants than for the introverted participants; the extraverts benefited more from the help-requesting behavior of the VH in terms of social presence than the introverts. This seems to be associated with the findings in social psychology, for example, it has been reported that extraverted people tend to perceive interactions with others as more natural and relaxed [CI09]. In other words, extraverts who are asked for help by the VH, and help by getting up and moving the chair, might feel the circumstances are both natural and rewarding, increasing their sense of social connection with the VH. The decrease of affect for the extraverted participants in the "Ignoring/Inconsistency" condition could also support this interpretation—those circumstances are not natural and do not actively involve the participant.

In terms of gaze behaviors, compared to introverted participants

the extraverted participants tended to spend more time looking at the VH. In (social) psychology, Berlyne claimed that individuals spent significantly more "gaze time" in examining novel, complex, or ambiguous stimuli [Ber58], and also the amount of gaze could differ according to the individual differences, such as personality traits and cultural differences [HPH02], for example, Mobbs stated that an extravert might gaze more than an introvert [Mob68]. Such previous findings could explain our current findings of increased mutual gaze for the VH's "Requesting/Consistency" behavior and for the "Extraversion" group in the experiment.

For the "Ignoring/Inconsistency" condition, the absence of a request for help resulted in the participants staying in their seated position—not moving during the experiment other than small movements related to the conversation with the VH. In contrast, in the "Requesting/Consistency" condition the request for help resulted in the participants moving more actively, i.e., they had to stand up and move the chair for the VH during the interaction in the experimental room. It is possible that the physical exertion on behalf of (to help) the VH in some way affected the "Requesting/Consistency" participant perceptions.

With respect to personality traits, our experimental results related to VHs seem to agree with the results of prior studies looking at human perceptions and behaviors during interactions with another (real) human. This suggests that at least from the standpoint of participant personalities, a VH appears to elicit similar extravert/introvert perceptions and behaviors to that of a real human interlocutor. As such, researchers should be aware that participant personalities can have a hidden effect on participant perceptions and behaviors, and can therefore affect measures of perceptions and behaviors in an unseen way.

Our results support the notion that in future work it would be desirable to detect personality traits through an automated measurement process, such that one might be able to devise methods for adapting VH behavior to each specific human user, potentially improving the effectiveness of the VH.

6. Conclusions

In this paper we analyzed how a human user's personality traits could affect perceptions and behaviors with a VH in AR. We described an experiment, in which we measured the participant's personality—specifically in the extraversion-introversion domain—and their sense of social presence and affect with the VH, while we manipulated the VH's behavior. For example, in one condition the VH proactively asked for help from the participants to move a physical chair out of the way. The results showed that both the participant's extraversion and the VH's requesting behavior had main effects on the participant's sense of social presence with the VH. Also, we found that the extraverts tended to be more positively influenced by the requesting behavior compared to the introverts. This could emphasize that understanding of human user's personality is important when attempting to measure/predict the effectiveness of a VH. In the future we plan to investigate the effects of other personality traits in real-virtual human interactions, while refining the experimental design to tease out which of the VH's behaviors induce perceptual differences with respect to the personality differences with a larger number of participants—for example whether

it is the acknowledgement of the physical environment, the help-requesting, or the participant's active physical involvement in the interaction.

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