Perception of personality through eye gaze of realistic and cartoon models

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Figure 1: *Animation screenshots from the realistic and cartoon female (From left to right: Emotionally Stable, Neurotic, Introverted personalities)*

Abstract

In this paper, we conducted a perceptual experiment to determine if specific personality traits can be portrayed through eye and head movement in the absence of other facial animation cues. We created a collection of eye and head motions captured from three female actors portraying different personalities, while listening to instructional videos. In a between-groups experiment, we tested the perception of personality on a realistic model and a cartoon stylisation in order to determine if stylisation can positively influence the perceived personality or if personality is more easily identified on a realistic face. Our results verify that participants were able to differentiate between personality traits portrayed only through eye gaze, blinks and head movement. The results also show that perception of personality was robust across character realism.

CR Categories: I.3.7 [Computer Graphics]: Three-Dimensional Graphics and Realism—Facial Animation;

Keywords: personality, facial animation, uncanny valley, motion capture, perception

1 Introduction

In everyday life, humans extract information from subtle variations in the eyes' appearance and use changes in eye gaze as cues during social interactions. Eyes can express emotions, communicate our internal states, indicate our level of engagement with our conversational partners and much more. The majority of state-of-the-art eye gaze and head movement models for virtual characters create generic models based on knowledge from a range of disciplines to communicate these behaviours. However, the portrayal of different personality traits through eye gaze, blinks and head movements remains a challenge. Artificial agents in human-computer-interaction equipped with individual personality traits would help users to immerse better and respond more positively. Interpersonal differences may also increase the variety and individuality of agents in groups or crowds. However, it is not only important to let the character convey believable emotions and personality, the motion should also match its appearance. In the entertainment industry, we observe that virtual humans are often stylised for greater appeal, typically with very large eyes and exaggerated motion.

A standard method to describe personality in psychology is the "Big Five" theory, see [Goldberg 1990; John et al. 2008]. In this hierarchical model, the main factors describing human personality are: openness, conscientiousness, extraversion, agreeableness, and neuroticism, each describing specific facets and traits (e.g. an agreeable person is compassionate, cooperative). In our study, we defined parameters for eye and head movement for a subset of these personality traits. We then motion captured three female actors, expressing different personalities. These natural captured motions were applied to two virtual models, a realistic and a cartoon representation on which we conducted a perceptual experiment, to explore if people are able to identify the different personalities. Our experiment verified our main hypothesis on the perception of the personality. Interestingly, we found no difference in the perception of personality on a photorealistic model and a cartoon model with exaggerated facial features.

2 Background

Knowledge from a large number of disciplines, such as psychology, neuroscience and the social sciences, forms the basis for various gaze mechanisms reproducing human behaviour as realistically as possible. State-of-the-art models synthesise high-level aspects of gaze behaviour, such as gaze functions during interactions, attention models, expressing emotions or regulating conversations, see [Ruhland et al. 2014] for an overview.

Research in psychology shows that gaze behaviour is very closely linked to personality. Various studies used eye-tracking and video recordings to analyse the connection between the known personality traits of participants and their eye gaze behaviour. Libby and Yaklevich [1973] tested gaze behaviour for the personality needs - nurturance, intraception and abasement of 35 females and 35 males. People with highly nurturing personalities maintained eye contact more often than their opposite. Frequent gaze behaviour to the left indicated subjects that had more negative traits. Rauthmann et al. [2012] studied the number of fixations, fixation dura-

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	Gaze			**Eye/Head**	**Blink**	**Nods**
	Direction	*Duration*	*Frequency*	*Direction*	*Frequency*	
Extraversion	Toward	Long	Often	Up, Center, Left, Right	Few	Wide, Fast
Introversion	Avoidance	Short	Seldom	Down, Centre	Normal	Small, Slow
Agreeableness	Toward	Medium	Medium	Centre, Left, Right	Normal	Normal
Non-Agreeableness	Toward	Long	Medium	Down/Up	Few	Head-Shake
Neuroticism	Avoidance	Short	Seldom	Left, Right, Down	Often	None
Emotional Stability	Toward	Medium	Medium	Centre, Left, Right	Normal	None

Table 1: *Personality definitions derived and adapted from previous research on eye gaze in psychology and computer science [Matsumoto et al. 2010; Franks 1963; Fukayama et al. 2002, etc.]*

tion and dwell time for gaze behaviour of the Big Five model. For neuroticism, they detected a longer fixation duration and dwelling time; extraversion revealed short dwelling times and high number of fixations and openness showed a longer mean fixation and dwelling time. Test results by Matsumoto et al. [2010] also showed the relationship between eye movement and personality using the Big Five model for openness. Openness was found to influence the eye fixation point, while other factors, such as eye movement range or speed, were found to show no significant relationship. Franks [1963] found that spontaneous blinking and eye movements were related to extraversion.

Research in the field of Computer Graphics aims to artificially construct different personalities using predefined parameters for eye gaze based on these psychological studies. Fukayama [2002] tested the relationship between changes in gaze parameters and the perceived impression. In their experiment, predefined eye gaze parameters, for amount, duration and fixation were altered to express different impressions. From eye movement alone, looking-up was rated more dominant and friendly than looking-down, a low mean duration of gaze was seen as more friendly and high amount of gaze scored high on the dominance scale. Building on this, Veldhuis [2006] investigated the influence of head nods and eye gaze behaviour on the perceived personality of an artificial agent. They found that different eye gaze patterns did not change the perceived impression. The computational model by Bevacqua et al. [2012] generates different types of behaviour, such as head movement, facial expressions and acoustic cues, for a listening virtual agent depending on the agents personality and in accordance to the user's visual and acoustic input. The agents behaviour was predefined for the personality traits extraversion and neuroticism. In their perception study, it was shown that participants reacted more positively toward agents driven by the computational model than a random behaviour and that the frequency of backchannels corresponded with the personality trait the agent portrayed.

Our study differs in the sense that we constructed a set of guidelines for gaze, head, blinks and nods behaviour of three different personality traits, based on reports from previous research. Actors portraying these personalities were recorded to gather realistic movement, which we then applied to two virtual models.

We chose two different virtual models to represent our recorded motions and to study the effect of appearance on the perceived personality and appeal. Studies have shown that appearance of the model affects the perceived pleasantness [Mori 1970; MacDorman et al. 2009] and other subjective opinions about the model [Carter et al. 2013; Hyde et al. 2013], and can also affect the perception of personality, specifically on the agreeableness trait of the Big Five [Zibrek and McDonnell 2014]. However, the mentioned studies varied the visual characteristic of the model mostly by changing the render style, whereas we also introduced a change in facial geometry, making the cartoon style match a typical cartoon model (bigger eyes, simplified geometry of the face) and choosing a highly realistic appearance for the second model, see Figure 1. We expect that the model will have an affect on the perceived personality, especially because the cartoon model has bigger eyes and since they are portraying personality characteristics mainly through gaze, this could facilitate the recognition of the personality. Also, small imperfections in the realistic model could produce uncanny effects [MacDorman et al. 2009], which could reflect in more negative assessments of personality for this model as opposed to the cartoon one. Additionally, we recorded appeal ratings for both models, in order to determine whether the realistic or the cartoon model is favoured by the participants.

3 Stimuli Creation

Based on previous research, we defined guidelines for the personality traits extraversion, agreeableness, emotional stability and their polar opposites (6 different scenarios in total), as a subset of the Big Five model with the most noticeable differences in gaze direction, duration and frequency, see table 1 for more details. These guidelines provided the range in which the actor had to express each of the six personalities while listening to instructional videos.

We chose to portray the character's personality through the listening behaviour, since this type of behaviour is known to convey personality traits through non-verbal communication [Bevacqua et al. 2012] and also because the listener's motion is mainly expressed through gaze and at the same time gives information about the attitude towards the speaker [Vinayagamoorthy et al. 2006].

The markerless motion capture system *Faceshift* [Weise et al. 2011] was used to capture the performance of three professional female actors, recording eye and head movement. The actors were instructed to respond as a listener to two different instructional videos with neutral content, by taking into account our definitions for the various personalities, see table 1. For example, the actor was told to portray an extraverted personality while listening to one of the videos. In this case, she was instructed to gaze toward the speaker frequently, for long periods, keeping her eyes and head up, centred, left or right, with a low blink frequency and wide and fast head nods. The presented videos were approximately two minutes each, containing advice on acting and gardening. During the video presentation the actor was free to portray the personality in the defined range.

For the experiment, 36 animation clips per virtual model were created (3 actors x 6 personalities x 2 examples). The length of each clip was limited to eight seconds. From the recordings, eight seconds of the best interpretation according to our guidelines with the most expressive cues of the personality portrayed by the actor were chosen as stimuli, e.g. agreeableness had to show increased head nods, while introversion avoided gaze.

Different render styles in Autodesk 3ds Max 2015 were used to ensure the correct appearance of the virtual models. For the realistic

model, a photorealistic depiction was achieved using sub surface scattering with photometric lights to create reflections and shadows. Eye reflections result from using physically accurate reflections with a Fresnel falloff. Our cartoon model was rendered with sub surface scattering and painted textures to create a style similar to that used in the computer graphics cartoon industry. Spot lights placed in strategic positions in the scene added depth to the model.

4 Experiment

For the experiment, a between-groups design was used, where participants in the first group viewed the 36 animations displayed on the cartoon model and the participants of the second group rated the 36 animation clips on the realistic model. This setup allows us to indirectly measure if there is an effect of realism on the perceived personality. University ethical approval was granted for the experiment. Twenty-four participants (13 and 11 per group, 12 female and 12 male), aged between 19-54 took part in the experiment. Participants were recruited mainly via university student and staff mailing lists with different disciplinary backgrounds. They had normal or corrected to normal vision and were all unaware of the intention of the experiment. As a reward for participation, they were given a €5 book voucher. The experiment lasted approximately 30 minutes.

After the participants read and signed the consent form, their first task was to rate their own personality on the Ten-Item Personality Inventory (TIPI) [Gosling et al. 2003]. Defined to capture the Big Five personality traits [Norman 1963], TIPI describes the human personalities: openness, conscientiousness, extraversion, agreeableness and neuroticism.

After the self-rating, each group was shown a still image of the virtual model they were about to see in the animation clip, for three seconds, and asked "How appealing do you find this virtual character?". On a scale from 1 (Extremely Unappealing) to 7 (Extremely Appealing) the participants rated by pressing the number keys on the keyboard. The main part of the experiment consisted of the playback of the 36 animation clips of one of the virtual models in random order, with the participants informed that each clip contained different personality traits. The participants rated the character's personality on a subset of the TIPI. As in Neff et al. [2010], only the questions for "extraverted, enthusiastic", "sympathetic, warm", "calm, emotional stable" and their polar opposites were asked, since we only created animations for this specific subset of the Big Five model, see section 3. On a scale from 1 (Disagree strongly) to 7 (Agree strongly), the participants reported their agreement or disagreement as to what extent the pair of traits applied to the viewed animation clip.

5 Results

For the analysis of the perceived personality of the animations, we used the subset of the scales that were applied to the virtual model: extraversion, agreeableness and emotional stability, and their polar opposites: introversion, non-agreeableness and neuroticism. As is common practice for interpreting the TIPI ratings [Gosling et al. 2003], we further collapsed the 6 scales down to 3 by averaging the scores for the positive poles (e.g., extraversion) with the reverse scores for the opposite pole (e.g., introversion). We treated these final scales (Extraversion, Agreeableness and Emotional Stability) as independent variables, and a repeated measures ANalysis Of VAriance (ANOVA) was conducted for each scale with within-subjects factor Acted Personality (6 different personalities that the actors were portraying). We chose the name Acted Personality (AP) to describe the personality that was portrayed by the actor to avoid confusion with personality ratings by the participants. All data was averaged across the actors and videos they were reacting to, since we treated these conditions as different instances of the same personality. We also included between-groups factors Participant Sex and Model (2, cartoon and realistic) on all our data. Where main or interaction effects were found, we conducted Newman-Keuls tests for comparison of means to further explore the results.

5.1 Model

The ANOVA showed no main effect of Model, which implies that the perception of personality was robust across our two models. This is contrary to our hypothesis that eye gaze would appear more exaggerated on the cartoon model and thus would make the personality traits easier to recognise. Furthermore, we expected that the photorealistic model would trigger more negative judgements about the acted personality, as previous research has indicated that an uncanny reaction to realistic appearance is common [Mori 1970].

5.2 Acted Personality

We found a main effect of AP for all the measured scales (Extraversion: $F(5, 100) = 37.919, p \approx 0$, Agreeableness: $F(5, 100) = 21.033, p \approx 0$, Emotional Stability: $F(5, 100) = 22.151, p \approx 0$) signifying that participants were able to distinguish differences in personality.

More importantly, post-hoc analysis shows that most personalities were recognised by the participants, signified by the higher values of the corresponding traits (red bars in Figure 2) and lower values on their polar opposites (green bars in Figure 2). The highest values for Extraversion were found for agreeable AP and extraverted AP ($p < 0.005$ for all). The lowest ratings on Extraversion were expected for the introverted AP and we found this to be the case, however the emotionally stable AP was rated equally low on Extraversion ($p < 0.02$ for all). The agreeable AP was rated the highest for Agreeableness, but the extraverted and emotionally stable AP received equally high ratings for Agreeableness as well ($p < 0.005$ for all). As expected, the lowest Agreeableness ratings were made for the non-agreeable AP ($p < 0.05$ for all). Lastly, participants rated Emotional Stability highest for emotionally stable, agreeable and extraverted AP ($p < 0.01$ for all) and lowest for the neurotic AP, as expected ($p < 0.001$). We conclude that the created personalities were sufficiently well recognised but some motions elicited traits which we did not specifically intended to be present. In particular, the extraverted, agreeable and emotionally stable characters seemed to be perceived to have similar traits, whereas introverted, non-agreeable and neurotic were more discernible and their intended personality was recognised more successfully.

In order to measure accuracy of personality identification, we conducted one sample *t*-tests with the constant 4, which would indicate if the scores were significantly different from the middle of the rating scale. Extraverted AP was rated significantly higher from the constant on Extraversion ($t(23) = 5.272, p \approx 0$) and introverted AP significantly lower on Extraversion ($t(23) = -5.468, p \approx 0$). Agreeable AP was rated higher on Agreeableness ($t(23) = 4.784, p \approx 0$) and non-agreeable AP significantly lower on the same trait ($t(23) = -4.616, p \approx 0$). Similarly, emotionally stable AP received higher ratings on Emotional Stability ($t(23) = 7.128, p \approx 0$) and neurotic AP lower ratings on this trait ($t(23) = -6.324, p \approx 0$). This implies that all expected traits, portrayed only with eye and head motions, were faithfully recognised on the virtual models.

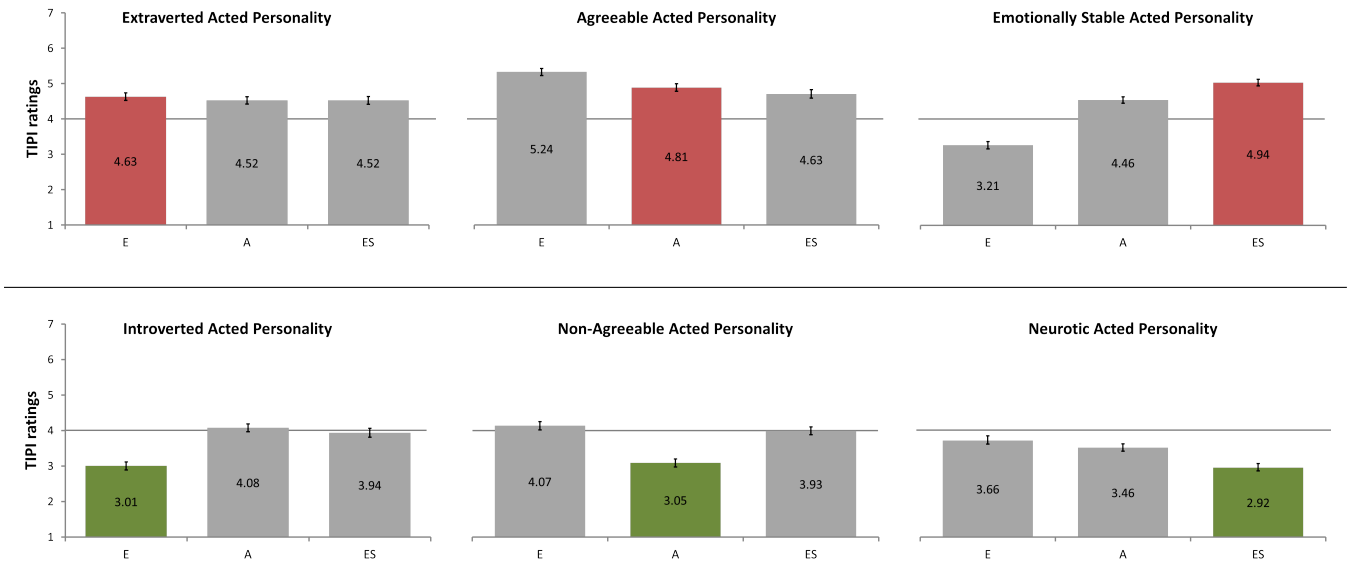

Figure 2: *TIPI ratings on scales: Extraversion, Agreeableness, Emotional Stability, averaged over model and participant sex, for the 6 personalities which portray positive (upper top graphs) and negative (lower bottom graphs) poles of the Big Five traits. Coloured bars represent the average ratings of the intended trait, for each situation (e.g., red bar shows an average rating of 4.63 for the extraverted trait in the extraverted acted personality). Each bar is labelled with the average mean value and standard error bars.*

5.3 Participant Personality

One-way ANOVA on the TIPI self-ratings of participants showed that there were differences between how they rated themselves on the personality traits ($F(4, 80) = 4.940, p = 0.001$) and our post-hoc showed that the sample consisted of participants who rated themselves lower on Extraversion and Conscientiousness ($p < 0.02$) than on other traits of the Big Five. Our sample of participants was not balanced in personality traits, which could have an effect on the ratings of the observed acted personality.

5.4 Appeal of the Model

We conducted a *t*-test to analyse if one of our models was perceived to be more appealing than the other. No significant difference between the models in the ratings of Appeal was found. We conclude that the realistic and cartoon model were perceived to have a similar level of appeal, unlike previous research that showed that cartoon characters are more appealing than realistic characters [MacDorman et al. 2009].

6 Conclusion

In this paper, we presented a workflow for creating different personalities using minimal motion cues. The results of our experiment positively confirm that participants were able to recognise the portrayed personality from eye and head movement alone. Extraverted, agreeable and emotionally stable personalities seemed to convey similar traits, which could be attributed to similar definitions of the eye gaze, head and blink parameters (see table 1 for the description of motion for the mentioned traits). This could also explain why their polar opposites were more precisely identified, since the motion was more distinctive for each trait. Further studies with more participants balanced in personality traits, will also show if participant personality influences the ratings of the virtual model, when used as a covariate. In deviation to our hypothesis, there was no difference in the perception of the personality between the two virtual models and no significant difference in the ratings of appeal. This could suggest that appeal of the character influences personality assessments to a greater extent than realism. In future work this presumption will need to be investigated systematically by presenting more virtual models of different stylisations and levels of appeal.

Our study only investigated the perception of personality through eye gaze, blinks and head movement alone. The effect of full facial animation on the perceived personality will need to be explored in order to determine the relevant importance of the eye and head motion. Also, we limited our study to the investigation of female listening behaviour. It is possible that different cues could be used for males, which is something we will investigate in future work. An alternative approach to acting out personalities would be to record real scenarios from a range of people with different personalities to determine if our definitions match the real human behaviour.

Overall, our results show that with the parameter set we defined for eye and head movement alone, the participants were able to recognise the intended personality traits for a subset of the Big Five. In future work, we plan to use these eye and head movements to enhance virtual conversations with the intended personalities.

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