Effects of simulated gaze on social presence, person perception and personality attribution in avatar-mediated communication.

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Abstract

The paper introduces a platform for experimental analysis of social gaze in avatar-mediated communications and reports on two studies demonstrating the person perception effects of varying durations of directed gaze. The avatar platform allows to transmit nonverbal behaviour in real-time and to replace particular components by simulated data. Study 1, conducted with gender homogeneous female dyads, used two variations of directed gaze (2 vs. 4 seconds). Consistent with the literature the longer gaze duration was found to cause significantly better evaluations of the interaction partner and higher levels of co-presence. Study 2, conducted with mixed-sex dyads, included two more variations of gaze duration (8 and 16 seconds). Prior effects in evaluation and co-presence could not be reproduced. However significant effects occurred with respect to the attribution of personality traits. These effects were nonlinear. Consistent with the literature female observers responded more sensitively to the gaze variations of the male partners.

Keywords **avatars, gaze, person perception, social presence**

1. Introduction

There is ample empirical evidence that nonverbal behaviour is an important component of human communication [1] and an important factor for the creation of social presence in mediated encounters [2-5]. Among the various aspects of nonverbal behaviour, gaze and eye contact have received particular interest in social psychology [6-8] and in virtual reality research as well [9-12]. Research has documented the prominent role of gaze behaviour for the establishment of social relations, the fine tuning of interactions and the mutual attribution of mental states in social encounters [13-17]. The importance of gaze as a social cue finds its correspondence in particular brain areas which are specialised to detect and process gaze behaviour of others. Based on recent results of brain imaging studies Baron-Cohen [18] postulates an eye-detection device (EDD) as a crucial part of the human "mindreading-system". Recent findings from neuro-science indicate the existence of neurons specifically responding to eye-contact [19-21] and to the detection of social attention [22]. Evidence for the existence of "hard-wired" responses to social gaze also comes from psychophysiological research showing elevated systolic and diastolic blood pressure in response to eye contact and cortical arousal [23]. These findings illustrate that we are obviously very sensitive to our interlocutor's gaze and use it as a most relevant social cue [24].

Against this background we should expect a strong impact of perceived gaze on social cognition and evaluation. There is, indeed, evidence that increased gaze has a positive impact on the liking [25]. This effect however is nonlinear, i.e: gaze avoidance leads to similar negative evaluations as staring [26] [see also 27]. Gaze also influences other dimensions of person perception. People who maintain eye contact are perceived as more dominant than those who tend to avert gaze [28, 29]. Gaze aversion can lead to a perception of lower self-esteem [30] and increased state, trait and test anxiety [31]. Moreover, people who avert gaze are perceived as less credible and reliable [32]. Although the reported effects of social gaze depend at least partly on the specific situations, averted gaze seems to be associated with less favourable traits and negative social evaluations [16].

2. Methodological considerations

Existing knowledge on the effects of eye movement on person perception relies on two different research strategies : (1) The first strategy is based on the use of pre-produced or pre-recorded stimuli, i.e. *photos* [24, 33, 34] or *video* [16, 28, 29, 31, 35]. These approaches have in common that they analyse impression effects from a passive observer's vantage point, i.e. they lack interactivity. Contingency aspects of behaviour such as mutual gaze or eye-contact are not covered by these experimental variations. Consequently the generalisability of data derived from mere observation studies is limited [1, 36]. (2) The second strategy is based on the employment of *confederates* [13, 32, 37, 38] who are trained to produce or suppress particular nonverbal cues while interacting with the subjects. The problem here is targeted behaviour control, which is difficult because of the natural confounding of different nonverbal subsystems. For example, Lewis, Derlega, Shankar, Cochard, and Finkel [39] could show that the experimental variation of touch behaviour was involuntarily accompanied by compensatory variations in other nonverbal channels. They reported that: *"Confederates who touched used more nervous gestures and fewer expressive hand gestures compared to those who did not touch*" [39, p.821]. In a manipulation check on gaze variations Kelly and True [40] found the interrater reliability on their confederates' gaze direction to be only .03. Burgoon, Manusov, Mineo and Hale [32] even speculate that their confederates' behaviour may have overridden their experimental manipulation.

Avatar-technologies may provide a solution to both problems inherent in the traditional research strategies as they allow for perfectly targeted experimental variations of particular nonverbal cues during the course of ongoing social interactions [11, 12, 41, 42].

3. The avatar research platform

A typical setup of our current avatar platform is shown in figure 1. To guarantee a most natural nonverbal performance of the avatars the system makes use of state of the art capture technology for behaviour tracking.

Figure 1. Avatar-mediated conversation with fully equipped participants

The head, torso and arm movement is assessed with Polhemus® motion capture sensors attached to the relevant body parts. The sensors are measuring movement with 6 degrees of freedom and are able to determine rotational and translational information with high accuracy.

Data gloves (Virtual Technologies Cybergloves®) are used to measure hand curvature and finger movement in great detail. Gaze and eye-movements are captured with a head-mounted video based eye-tracker at a temporal resolution of 25 Hz.

An integrated software routine is provided to calibrate motion capture and eye tracking devices as well as data gloves in one path. A client-server architecture is used for the synchronisation, storage and distribution of the nonverbal data as collected via the sensors. Data is transmitted to the receiving client where a front-end animation tool translates it into the movement of the avatars. A gender-neutral, cartoon-like low-resolution avatar (see Figure 2) and a high-resolution avatar (male, female and androgynous version) are available for display.

Figure 2. Low-resolution avatar looking

For experimental purposes any aspect of the transmitted behaviour records can be algorithmically modified on the server side or replaced by predefined records. In the current study sequences of simulated gaze data replaced the original eye movement data while all other aspects of nonverbal behaviour remain untouched, thus generating a most realistically looking avatar activity with the real head, hand, torso and finger movement, but with experimentally controlled eye movement.

4. Study 1: Socio-emotional effects of simulated gaze in female dyads

Study 1 has been conducted as a proof of concept, targeting to establish significant effects of different durations of directed social gaze on person perception. The primary goal was to replicate findings from the literature, showing that longer gaze produced positive social evaluations [16]. Findings from previous research show that, on an average, females offer eye contact for approximately 7 sec during informal conversation, while males offer eye contact for approximately 4sec [43]. Both genders, however, averted gaze for the same time of approximately 2 sec. Given these results, a gaze pattern of offering eye contact for 4sec on an average seems to be the minimum occurring in informal conversations. A gaze pattern offering eye contact significantly below 4 sec on an average could therefore be called a reduced gaze and should result in lower evaluations of the person showing this pattern. Given the fact that communication was mediated via a virtual communication environment, we were particularly interested in the effects of the gaze patterns on the experience of social presence [see 11].

4.1. Participants

Seventy-six female undergraduates (between 19 and 55 years of age; m= 25.76; sd = 6.91) from University of Cologne participated in the experiment in return for course-credit or 10€.

4.2. Procedure

Two participants were invited for each time slot of the experiment. To avoid the participants meeting each other before the experiment they were invited to different floors of the laboratory building. Each participant was greeted by a female experimenter and led into the laboratory. While helping the participants into the sensor equipment the experimenter explained that the study involved avatar-mediated communication. After completing the calibration process, the experimenter instructed the participants asking them to chat and get acquainted with each other using a new medium.

The experiment had a single-factor design (short gaze vs. long gaze vs. real gaze). In each of the 38 dyads one participant saw an avatar with her interlocutor's real eye data, whereas the other one saw her interlocutor's avatar with simulated eye data. Head, hand, torso and finger movement were directly mapped onto the avatar. There were two conditions of simulated gaze patterns. In the short-gaze condition the avatar offered eye contact (i.e. looked towards the participant) on an average of two seconds and looked away on an average of two seconds. In the long-gaze condition the avatar offered eye-contact on an average of four seconds and also looked away on an average of two seconds.

As soon as the data connection between the participants was established, the experimenter started the recording of the interaction and left the room for 10 minutes. After completion of the task the participants were detached from the sensor equipment and asked to fill out the questionnaire. Then they were paid for their participation.

4.3. Dependent measures

Person perception was assessed with an adjective list on person perception developed by Krämer [44] and social presence was assessed using a slight modification of the scale Rüggenberg and her colleagues [2] used in a former study on social presence. This scale, in turn, is a modified German version of thee "networked minds" questionnaire presented by Biocca and his colleagues [45] with some additional items that have been used by Nowak [46]. Finally, as a treatment check, we included an item asking for the estimation of being looked at in percentage of time the conversation lasted.

4.4. Results

Factor analysis of the semantic differential for person perception revealed a three factor solution explaining 60.509% of the variance after Varimax rotation. The resulting factors could sensibly be named as ***evaluation*** (marker variable: "*friendly-unfriendly";* factor loading: -.763), ***activity*** (marker variable: "*active-passive*"; factor loading: .920) and ***potency*** (marker variable: "*dominant-compliant*"; factor loading: .804). These were submitted to a single factor analysis of variance (ANOVA), which revealed a medium effect of gaze condition only on evaluation ($F(2,77) = 4.345$; $p = .017$; $\eta^2 = 0.109$), but not on activity and potency (see Table 1 for an overview of the results). Bonferroni corrected post-hoc tests revealed significant differences between the long-gaze and the other two conditions (both $p < 0.05$).

Table 1. Effects of gaze duration on the three dimensions of person perception

Gaze	Evaluation		Activity		Potency	
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**
real	$-.17_a$	1.13	-.10	1.05	-.05	.88
short	$-.21_a$	.81	-.09	.88	.11	1.38
long	$.56_b$	.69	.29	1.00	-.01	.78

Note: Different subsets indicate significant differences

Factor analyses on the social presence scale resulted into a three factor solution, explaining 51.27% of variance after Varimax rotation. The resulting factors were ***co-presence*** (marker variable: *"I was often aware that we were at different places"*; factor loading: -.841), ***ambiguity*** (marker variable: "*My interlocutor was able to communicate his/her intentions*"; factor loading: -.745) and ***contingency*** (marker variable: "*My interlocutor's behaviour did often influence my own behaviour*"; factor loading: .763). These factors were submitted to a single-factor ANOVA, which revealed a significant effect on co-presence ($F(2,77) = 3.583$; $p = .033$; $\eta_p^2 = .092$), but not on the other two factors. Bonferroni corrected post-hoc tests revealed a significant difference only between the long-gaze condition and the short-gaze condition ($p= .027$) on social presence. See Table 2 for an overview over the results.

The last item under investigation was an estimation of the frequency of eye contact during the interaction given in percentage values. There were no significant differences between the real gaze condition (m = 51.38; sd = 19.78), the short-gaze condition (m = 49.02; sd = 27.32) and the long-gaze condition (m = 49.73 sd = 26.62).

Table 2. Effects of gaze duration on the three dimensions of social presence

Gaze	Co-presence		Ambiguity		Contingency	
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**
real	0.01_{ab}	0.96	0.02	1.08	0.07	0.83
short	-0.44_a	1.20	-0.03	0.96	0.31	1.25
long	0.41_b	0.69	-0.02	0.92	-0.44	0.96

Note: Different subsets indicate significant differences

4.5. Discussion

The study was considered as a first platform test and should give a first answer to the question whether different durations of directed gaze lead to different impressions and social evaluations. Consistent with the literature [e.g. 16] we found that longer phases of directed gaze, i.e.

looking in the direction of the partners gaze for four seconds consecutively, produced more favourable results than shorter gaze periods (2 seconds). This significant result can also be interpreted as a successful treatment check, as the computer simulated gaze induced the expected impression effects. Interestingly the remarkable quantitative differences in gaze duration, though leading to different evaluations of the partners, did not pass the threshold of conscious registration. Eye contact in both conditions was estimated as covering about 50% of the interaction time. Given the distinct advantages of controlling single aspects of nonverbal behaviour and the successful treatment check, the proposed approach can be regarded as particularly useful to further enhance our understanding of the effects of nonverbal behaviour in social interactions.

An open issue is the type of relationship between gaze and person perception. The identified differences can represent a segment of a linear relation as well as that of a curvilinear one. It is most likely that a further prolongation of the directed gaze periods can lead to negative results as it is perceived as staring, or as non-contingent to one's own behaviour. Also it is hard to interpret why the "real gaze" performed as bad as or even worse than the short gaze. An error analysis of the eye tracking data, however, pointed to frequent calibration problems and instable data flow. As drop outs in gaze data were displayed as "frozen gaze" (last valid position - which is more likely not to be in the eye centre) the likelihood for averted gaze was probably higher than normal, which could explain this effect.

5. Study 2: Effects of prolonged gaze in mixed-sex dyads

The second study picks up on the open issues identified in study 1 and extends the approach to cross-gender interactions. Furthermore it focuses on a new set of dependent variables which more directly tie in to the concept of "mind reading". In particular we aimed at the question whether systematic variations of gaze duration lead to the attribution of particular personality traits in the vis-a-vis as measured on the basis of a standardised personality questionnaire (NEO-PI-R). Two variations of prolonged gaze duration (8 and 16 seconds) were included into the treatment factor to identify possible nonlinearities in the interlocutors' responses. To avoid problems of bad calibration gaze data was simulated for both interlocutors.

5.1. Participants

82 male and female students (between 19 and 39 years of age; mean= 24,12; sd= 4,74) participated in the experiment and received payment of 15 € or course-credit for each experimental session. The participants were randomly assigned to 41 mixed-gender-dyads.

5.2. Procedure

Procedure was identical to study one with only one exception. To focus the participants on the task of personality trait attribution the instruction was given to use the next ten minutes of chat to form a detailed impression of the personality of the partner.

5.3. Dependent measures

Dependent measures for social presence and person perception were identical to study one. In addition we applied a short version of the NEO-PI-R [47] adapted for observer judgment instead of self-reports. The questionnaire covers the "big five" personality factors extraversion (assertiveness, activity), openness (feelings, actions), agreeableness (trust, compliance), conscientiousness (competence, deliberation) and neuroticism (anxiety, impulsiveness). As indicated in the brackets two subscales were used for each factor, represented by 8 items each.

5.4. Results

A first analysis of the data was performed using a 2 (gaze condition) by 2 (gender) ANOVA. This yielded significant results for the factor "gaze condition" on the presence factor "contingency" ($F(3,74) = 7.025$, $p<.001$, $\eta_p^2=.222$) and on two of the NEO-PI-R scales. These were "extraversion: assertiveness" ($F(3,73) = 4.902$, $p<.01$, $\eta_p^2=.166$) and "extraversion: activity" ($F(3,73) = 4.982$, $p<.01$, $\eta_p^2=.168$). For the factor "gender" two significant main effects emerged. One significant effect showed on the factor "Neuroticism: Anxiety" ($F(1,73) = 12.864$, $p<.01$, $\eta_p^2=.148$). Here, females perceived their male interlocutors less anxious ($M = 2.63$, $SD = .44$) than males did perceive their female interlocutors ($M = 2.98$, $SD = .43$). The second significant main effect for gender was on the NEO-PI-R scale "openness to experiences: feeling" ($F(1,73) = 4.003$, $p<.05$, $\eta_p^2=.051$). Females perceived their interlocutors as less open concerning feelings ($M = 3.41$, $SD = .45$) than males did ($M = 3.61$, $SD = .472$). The third significant effect was found for the factor "extraversion: activity" ($F(1,73) = 12.829$, $p<.01$, $\eta_p^2=.148$). Males were perceived from their female interlocutors as less active ($M = 2.90$, $SD = .57$) than females from their male interlocutors ($M = 3.26$, $SD = .43$). No significant interaction effects were found. Because gender differences in person perception are not subject to this article, the results on gender will not be elaborated further and were only given for sake of completeness.

Given, however, the pronounced gender differences in sensitivity towards nonverbal cues as reported in the literature [e.g., 48] the results on the "gaze condition" factor was analysed in more detail by separately analysing female and male participants.

ANOVA on the five presence factors revealed only one significant main effect on the factor contingency for ***female*** participants ($F(3,73) = 14.133$, $p<.01$, $\eta_p^2=.275$). Bonferroni corrected Post-Hoc tests revealed a significant difference between the 16second directed gaze condition and the 4-second and 8-second conditions (all $p<.05$), but no other significant effects. ANOVA on the presence factors revealed no significant effects for ***male*** participants, although the effect on contingency barely failed to reach statistical significance ($F(3,73) = 5.250$, $p=.063$, $\eta_p^2=.177$). Table 3 gives an overview on the condition's mean values and standard deviations respectively.

Table 3. Influence of gaze duration on the social presence factor "contingency"

Gaze	female		male		N
	Mean	SD	Mean	SD	
2 secs	-0.010_{ab}	0.978	0.12	0.75	10
4 secs	0.454_a	0.817	0.39	0.89	11
8 secs	0.481_a	1.281	0.04	0.69	10
16 secs	-0.977_b	0.890	-0.58	0.89	10

Note: Different subsets indicate significant differences

Figure 3 further illustrates the results showing different patterns for male and female observers. Although the differences between the 2,4 and 8-sec gaze conditions are not statistically significant, female observers perceived the male gaze lasting 8 seconds as most contingent, while male observers reported a decline in this dimension.

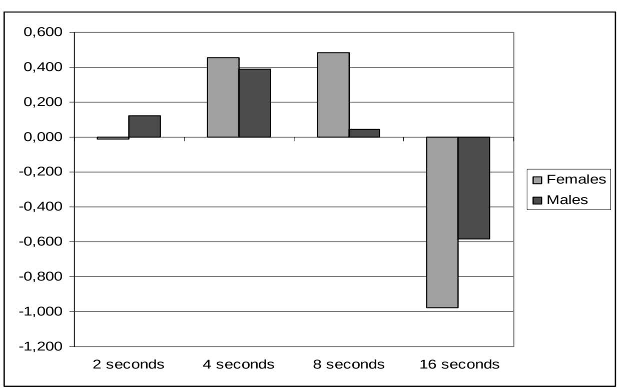

Figure 3. Illustration of the results in the social presence factor "contingency"

ANOVA on the ten personality facets measured by the NEO-PI-R revealed two significant main effects for ***female*** participants. Both significant main effects for experimental condition were on the two facets of extraversion, that is assertiveness ($F(3,37) = 3.663$; $p < .05$; $\eta_p^2=.207$) and activity ($F(3,37) = 2.835$; $p < .05$; $\eta_p^2=.221$).

Bonferroni corrected post-hoc tests on assertiveness and activity showed a significant difference for both dependent variables between the 4sec condition and the 8sec condition (both $p<.05$), but no other significant effects. ANOVA on the personality facets revealed no significant main effects for ***male*** participants, although the effect on assertiveness barely failed to reach statistical significance ($F(3,37) = 2.320$; $p = .053$; $\eta_p^2=.186$). Table 4 gives an overview on the mean values and standard deviations for both, female and male participants.

Table 4. Influence of gaze duration on the NEO-PI-R facets assertiveness, activity and impulsivity

	Gaze	female		male		N
		Mean	SD	Mean	SD	
Assertiveness	2 secs	3.14_{ab}	0.64	3.23	0.44	10
	4 secs	3.24_a	0.86	3.10	0.53	11
	8 secs	2.47_b	0.42	2.71	0.57	10
	16 secs	3.08_{ab}	0.39	2.68	0.54	10
Avtivity	2 secs	2.86_{ab}	0.55	3.44	0.41	10
	4 secs	3.18_a	0.68	3.39	0.32	11
	8 secs	2.49_b	0.42	3.01	0.50	10
	16 secs	3.05_{ab}	0.32	3.23	0.40	10

Note: Different subsets indicate significant differences

5.5. Discussion

Strikingly changes in experimental design as reflected in the use of cross-gender dyads and in the slightly different instruction ("make up your mind about the personality of the partner") led to results divergent from study 1. No differences were found in the evaluation factor of the adjective scales. Only the presence factor "contingency" revealed highly significant differences, indication that prolonged gaze (16 seconds, i.e. staring) resulted in unfavourable effects. Significant differences were found in the attribution of personality traits for the two extraversion dimensions assertiveness and activity. Although male and female observers showed comparable responses to the different gaze conditions only the female partners' judgements reached the level of significance. In general the 2 second and 4 seconds gaze was perceived as more active and assertive than 8 seconds gaze. The drop from the 4-sec gaze condition to the 8-sec gaze condition in activity scores seems plausible. The drop in assertiveness scores could be explained by the perception of higher levels of social attention, which in turn could be related to the perception of submissiveness. As these interrelations described in the literature are dependent on the speaker-listener roles [see 6], further analyses should include data from the voice channel. The fact that the 16-second condition did not show any significant differences to either one of the other conditions might be interpreted as fall back to a default mode in person perception. Showing little variation the extremely prolonged directed gaze might be no longer perceived as a salient cue but as a possible technology artefact and filtered out in impression formation. The result that interpersonal contingency was perceived as low in this condition also underpins this interpretation.

6. General discussion

An avatar-based computer-platform for the real time simulation of nonverbal behaviour has been introduced, which allows for the experimental variation of particular nonverbal cues during ongoing dyadic interactions. By means of this platform it was possible to systematically vary the duration of directed and averted gaze of avatars while all other nonverbal activities reflected the original behaviour of the human interlocutors. On the example of gaze behaviour the implemented “dimensional control technique” has been illustrated to be a powerful methodological principle, which can be applied to any aspect of nonverbal communication. Four major advantages of the methodology could be demonstrated: (1) avatars allow for the standardisation, respectively for the masking of the physical appearance and thus help to establish direct causal relation between behavioural cues and person perception, (2) the relevant aspects of nonverbal behaviour can be directly and reliably influenced, without risking a confound with other aspects while (3) other aspects of nonverbal behaviour keep their dynamic properties and thus create a realistic overall impression and (4) the experimental variation can be overlaid to real-time interactions, thus placing the person perception and impression formation into an interactive process and not in a passive observer task.

A number of questions and problems however remain unanswered and have to be addressed in the next studies. Firstly, we could not find any effect on potency as reported in the literature [28, 29] in our first study. We can only speculate about this lack of effect. In a thorough literature review on gaze and eye contact Kleinke [15] illustrated that the specific effects of gaze on person perception at least partly depend on the specific situation. In the first study the subject’s were instructed to get acquainted to each other. They did not know each other and had neither a specific task to fulfil nor a conflict of interests. In such a situation potency might possibly not play an important role which might explain the lack of effect.

Another issue is a more methodological one: Since the duration of single gazes, the number of gazes in a certain time interval and the overall percentage of directed gaze are confounded, it is not possible to identify which parameter best reflects the psychological variance in person perception. This problem can be solved in future studies by applying systematic variation to all three aspects, which will also imply a control of total interaction time. The mentioned problems and open issues can well be addressed by using the introduced platform within a programmatic research approach. Further developments of the technology include improvements in eye movement calibration and the provision of non-obtrusive remote eye-tracking and head tracking devices.

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