Virtual Gaze. A Pilot Study on the Effects of Computer Simulated Gaze in Avatar-Based Conversations

Gary Bente, Felix Eschenburg, and Nicole. C. Krämer

Department of Psychology, University of Cologne, Bernhard-Feilchenfeldstr.11, 50969 Cologne, Germany
{bente, felix.eschenburg, nicole.kraemer}@uni-koeln.de

Abstract. The paper introduces a novel methodology for the computer simulation of gaze behavior in net-based interactions. 38 female participants interacted using a special avatar platform, allowing for the real-time transmission of nonverbal behavior (head and body movement, gestures, gaze) as captured by motion trackers, eye tracking devices and data gloves. During interaction eye movement and gaze direction of one partner was substituted by computer simulated data. Simulated duration of directed gaze (looking into the face of the vis-a-vis) was varied lasting 2 seconds in one condition and 4 seconds in the other. Mutual person perception (impression ratings) and individual experience of social presence (short questionnaire) were measured as dependent variables. The results underline the validity of the computer animation approach. Consistent with the literature the longer gaze duration was found to cause significantly better evaluations of the interaction partners and higher levels of co-presence.

Keywords: Computer mediated communication, nonverbal behavior, social gaze, methodology, person perception, social presence.

1 Introduction

The lack of nonverbal signals has often been conceptualized as a deficit of computer mediated communication (CMC) with particular socio-emotional consequences, on one hand reducing social presence and leading to emotional impoverishment, on the other hand fostering the balance of power and influence and equalize participation through the absence of status signals [1]. Given this discrepancy it is meaningful to ask, under which circumstances the inclusion of nonverbal channels into CMC will enhance the experience of *social presence* [2, 3] and which particular cues lead to beneficial socio-emotional effects and which do not. Among the nonverbal communication phenomena so-called visual behavior [4, 5, 6], i.e. gaze and eye contact has received particular interest in communication research and social psychology. Social gaze serves as an indicator of covert cognitive processes and also constitutes a most powerful overt communicational social cue. Social Psychology has documented the prominent role of gaze behavior for the establishment of social relations, the fine tuning of interactions and the mutual attribution of mental states in social encounters [7, 8, 9, 10, 11] This holds not only for face-to-face interactions but also for virtual encounters with avatars and agents. While a series of studies explored the naturalness

R. Shumaker (Ed.): Virtual Reality, HCII 2007, LNCS 4563, pp. 185–194, 2007.

of simulated gaze in virtual environments [12] or the effects of pronounced social gaze, so-called supergaze [13], little is known yet about the effects of subtle variations in gaze duration, as they occur in real-life interactions [14]. In particular it is unclear in how far avatars can be used to effectively mimic gaze behavior, and whether the temporal thresholds for minimal and maximal exposure to directed gaze are comparable to those in real-life interactions. Against this background the current pilot study investigated the socio-emotional effects of different time patterns of simulated social gaze as embedded in ongoing avatar-mediated net-communications.

1.1 Gaze and Person Perception

There is ample evidence that gaze behavior has a strong impact on person perception and impression formation. It could be demonstrated that visual attention in particular increases liking [15]. Such effects however are nonlinear. Longer durations of directed gaze can be perceived as staring and evaluated as negative as gaze avoidance [16]. Also situational and personal variables seem to mediate the effects of social gaze [17, 18]. In addition to gaze duration also the gaze dynamics have a strong influence on likeability. Mason, Tatkow and Macrae [19] could show that averted gaze followed by directed gaze led to more favorable judgments of faces with respect to liking and attractiveness than did directed gaze followed by gaze aversion.

Besides liking and attractiveness gaze also influences other aspects of person perception and impression formation. For example people who maintain eye contact, especially when talking, are perceived as more dominant and powerful than those who tend to avert gaze [20, 21]. Moreover gaze aversion correlates with the perception of lower self-esteem [22] and increased state, trait and test anxiety, especially in women [23]. Common sense also associates gaze aversion with deception and untrustworthiness. Thus, it is not surprising that people who avert gaze are perceived as less credible and were more unlikely to be hired in an experimental job interview [24]. Although the reported effects of gaze behavior depend at least partly on the specific situations, averted gaze seems to be associated with less favorable traits and negative social evaluations [11].

1.2 Methodological Issues in Gaze Research

A closer look into the relevant literature reveals some basic methodological problems inherent in the experimental control of gaze and the establishment of causal relations between gaze and particular person perception effects. Existing knowledge on the effects of eye movement on person perception is mostly relying on either of two research strategies:

One strategy is based on the use of pre-produced or pre-recorded stimuli, i.e. photos [19, 25, 26] or video [11, 20, 21, 23, 27]. Such approaches have in common that they analyze impression effects from a passive observer's vantage point, i.e. they miss out on the interactive nature of gaze. Observers have no possibility to intervene or change the course of the conversation. Contingency aspects of behavior as e.g. mutual gaze or eye-contact thus are not covered by the experimental variations. Patterson [28, 29] criticizes the artificial separation of production and reception in most observer studies and doubts their generalisability.

The second strategy is based on the employment of confederates [8, 24, 30, 31] who are trained to exhibit a certain nonverbal behavior, e.g. gaze, while interacting with the subjects. Confederates can see the observer and contingently respond to him or her. To control the eye gaze and suppress spontaneous reactions however the confederates have to be trained very thoroughly and even after such training they might have problems to segregate the various nonverbal subsystems and to control particular aspects in a quantitatively predefined way (see [32]). More problems have been reported when using confederates in gaze studies. In a manipulation check of an experiment on the communication of facilitative conditions Kelly and True [33] found the interrater reliability on their confederates' gaze direction to be only .03. Burgoon, Manusov, Mineo and Hale [24] even speculate that their confederates' behaviour may have overridden their experimental manipulation.

Both research strategies suffer from the fact that the various nonverbal subsystems are interdependent not only within communicative acts of the interlocutors but also across interaction partners. To investigate the effects of isolated aspects of nonverbal behavior while preserving the natural contextualization of such cues it is therefore necessary to produce distinct variations of this particular aspect (gaze behavior) while leaving all other aspects of communicative behavior (head movement, gestures, body movement) unaffected. Also it is important that the participants are naïve about this manipulation, i.e. they are not consciously attentive to the cue under investigation. To solve these problems computer animation methodologies have been suggested recently [34, 35]. While early computer animation approaches only allowed for passive observation studies [14, 35, 36, 37] newer developments permit the experimental control of nonverbal cues during the course of an ongoing conversation. Such a methodology will be introduced in the following. Based on this we will report on a pilot study using the novel technology to determine the person perception effects of different levels of social gaze behavior.

2 Method

The pilot study is based on a recent development of an avatar platform, which is capable of transmitting head and body movements as well as hand gestures and gaze behaviors in real-time. Behavior is captured by standard capture devices (Polhemus®, Virtual Technologies Cybergloves®) and a special eye tracker (Mediascore®). Nonverbal communication data is transmitted via TCP-IP and can be buffered for algorithmic transformation or replacement by simulated data. Avatar animation is performed by means of a special AVI Codec transforming translation and rotation data into movements of a virtual character. Figure 1 shows the experimental setup during calibration, displaying a realistic avatar for feedback and adjustment.

To prevent influences of physical appearance the avatar used in our study was a very simplified cartoon-like androgynous character, with enlarged eyes, meant to facilitate the perception of gaze and eye movements (see figure 2).

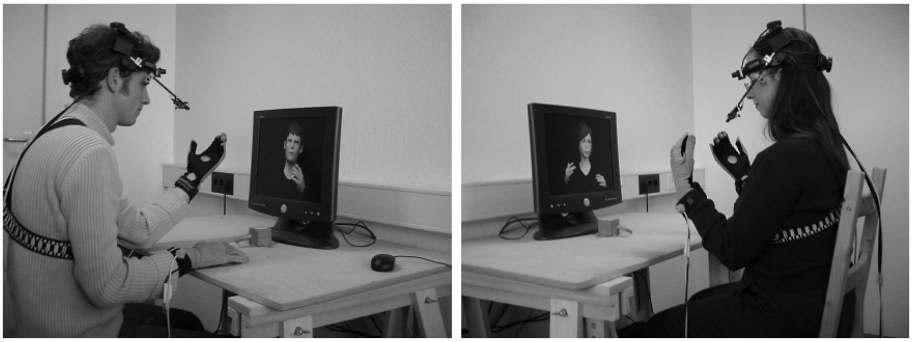

Fig. 1. Experimental setup of the avatar platform

2.1 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 an incentive of 10 Euros.

2.2 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 at 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 explained that the participants should get acquainted with each other by using avatar-mediated communication. As soon as the connection between the participants had been established, the experimenter started the recording of the interaction and left the room for ten minutes. After that, each participant was asked to fill out a questionnaire, was detached from the sensor equipment and paid for participating in the study.

2.3 Independent Variables

The experiment had a single-factor (short gaze vs. long gaze vs. real gaze) design. In each of the 38 dyads one participant saw the other's avatar with real eye data, whereas the other one saw an 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. Figure 2 shows three examples of different gaze directions.

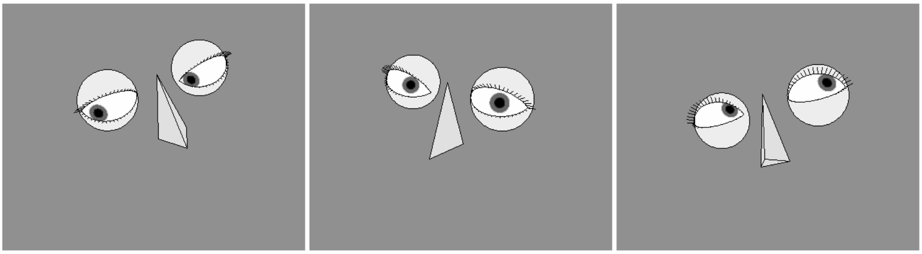

Fig. 2. Examples of averted gaze (left and right) and directed gaze (middle)

2.4 Dependent Variables

Person perception was assessed via a semantic differential on person perception developed by Krämer [38] and social presence was assessed with an instrument developed in a former study on social presence [39]. Specific items were added asking for technical problems or inconvenience in using the sensor technology. These items used a 5-point-Likert-scale of acceptance reaching from 1 (not at all) to 5 (extremely). Finally, the questionnaire included an item asking for the estimation of being looked at in percentage of time the conversation lasted.

3 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 (df=2; F= 4.345; p =.017; $\eta 2 = 0.109$), but not on activity and potency. Bonferroni corrected post-hoc tests revealed significant differences between the long-gaze and the other two conditions (both $p < 0.05$).

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 behavior did often influence my own behavior”; factor loading: .763). These factors were submitted to a single-factor ANOVA, which revealed a significant effect on co-presence (df= 2; F= 3.583; p = .033; $\eta 2 = .092$), 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.

Figure 3 summarizes the results for person perception and social presence factors across the three treatment conditions.

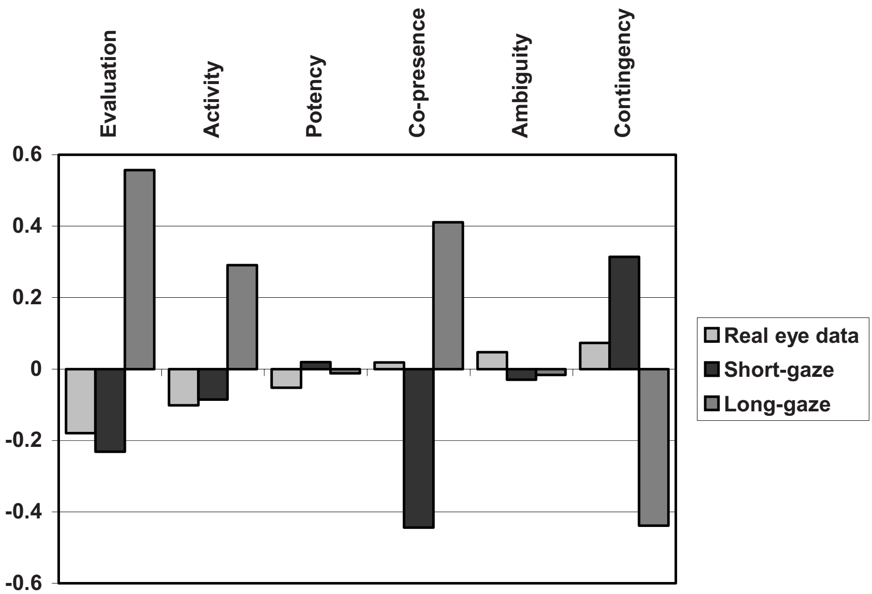

Fig. 3. Overview over the differences in the person perception and social presence factors

The questions on problems with the technology were analyzed on a single item basis. Each item's mean value was investigated and tested against the scale's mean value of 3 to decide whether there is a specific problem with the technology or not. Table 3 shows that all items scored significantly below the mean value of the scale. Thus, the technology was neither experienced as obtrusive nor as distracting during the interaction.

Table 1. Mean values and results of one-sample T-tests for the items on technological problems and obtrusiveness

Items	*Mean*	*SD*	*t*	*df*	*p*
Did the headset limit your visual field?	2.01	1.09	-7.90	75	.000
Have you felt distracted due to the equipment?	1.88	.89	-10.91	75	.000
Did you think a lot about the equipment during the interaction?	1.82	.83	-12.47	75	.000
Did you feel alienated due to the equipment?	1.92	.86	-10.93	75	.000
Did you worry about damaging the equipment during the interaction?	1.21	.52	-29.74	75	.000
Did you feel limited in your freedom of movement?	2.32	1.19	-5.017	75	.000

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). Surprisingly in all conditions the amount of perceived eye contact was estimated to cover around 50% of the interaction time. Thus the experimental variation did not pass the threshold of conscious registration but nevertheless induced significant person perception effects.

4 Discussion

Major advantages of using avatars in nonverbal communication studies could be demonstrated: (1) avatars allow to filter out the influence of physical appearance and thus help to establish direct causal relation between behavioral cues and impression formation (2) the relevant aspects of nonverbal behavior can be directly and reliably controlled, (3) uncontrolled aspects of nonverbal behavior keep their dynamic properties, leading to 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. The results of our avatar study are consistent with the literature [11]. Longer phases of directed gaze, i.e. looking in direction of the partner for four seconds consecutively, produced more favorable 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. A number of questions however stay unanswered and have to be addressed in the next studies. As there is a confounding between the duration and the number of directed gazes as well as the overall percentage of directed gaze 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. Furthermore it remains unclear, how the duration of averted gaze is influencing the impression and how this aspect is interacting with duration of directed gaze. Another open problem concerns the type of relationship between gaze and evaluation. The identified differences can represent a segment of a linear relation as well as 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 ones own behavior. Future studies will have to clarify this relation more precisely and will aim at identifying possible thresholds for attention to and positive evaluation of directed gaze. The mentioned problems and open issues can well be addressed using the introduced platform within a programmatic research approach. Further improvements of the technology as under development will include ease of use in eye movement calibration and the provision of non-obtrusive remote eye-tracking and head tracking.

Acknowledgements. The presented research has benefited by funding from the German Science Foundation (DFG) within the project "Interaction, identity and subjective experience in virtual communication environments" (FK/SFB 427-B3) as well as from the European Commission as part of the Integrated Project "Psychologically Augmented Social Interaction Over Networks" (PASION, IST-FET Project no. 27654).

References

[1] Kiesler, S., Siegel, J., McGuire, T.W.: Social psychological aspects of computer-mediated communication. American Psychologist 39(10), 1123–1134 (1984)
[2] Biocca, F., Harms, C., Gregg, J.: The Networked Minds Measure of Social Presence: Pilot Test Factor Structure and Concurrent Validity. In: Presence 2001. Philadelphia, PA (2001)
[3] Biocca, F.C., Harms, C., Burgoon, J.K.: Toward a more robust theory and measure of social presence: Review and suggested criteria. Presence-Teleoperators and Virtual Environments 12(5), 456–480 (2003)
[4] Exline, R.V., Gray, D., Schuette, D.: Visual behavior in a dyad as affected by interview content and sex of respondent. Journal of Personality and Social Psychology 1(3), 201–209 (1965)
[5] Exline, R.V.: Visual interaction: The glances of power and preference (1971)
[6] Fehr, B.J., Exline, R.V.: Social visual interaction: A conceptual and literature review, In: Siegman, A.W., Feldstein, S., (eds): Nonverbal behavior and communication 2nd ed. pp. 225–325 1987 Lawrence Erlbaum Associates, Inc 640 Hillsdale, NJ, England (1987)
[7] Argyle, M., Cook, M.: Gaze and mutual gaze, p. 210. Cambridge University Press, Oxford, England (1976)
[8] Abele, A.: Functions of gaze in social interaction: Communication and monitoring. Journal of Nonverbal Behavior 10(2), 83–101 (1986)
[9] Bavelas, J.B., Coates, L., Johnson, T.: Listener responses as a collaborative process: The role of gaze. Journal of Communication 52(3), 566–580 (2002)
[10] Kleinke, C.L.: Gaze and eye contact: A research review. Psychological Bulletin 100(1), 78–100 (1986)
[11] Larsen, R.J., Shackelford, T.K.: Gaze avoidance: Personality and social judgments of people who avoid direct face-to-face contact. Personality and Individual Differences 21(6), 907–917 (1996)
[12] Garau, M., Slater, M., Bee, S., Sasse, M.A.: The impact of eye gaze on communication using humanoid avatars. In: Proceedings of the SIGCHI conference on Human factors in computing systems, pp. 309–316. ACM Press, Seattle, Washington, United States (2001)
[13] Bailenson, J.N. Beall, A.C., Loomis, J., Blascovich, J., Turk, M.: Transformed Social Interaction, Augmented Gaze, and Social Influence in Immersive Virtual Environments. Human Communication Research 31(4), 511–537 (2005)
[14] Bente, G., Donaghy, W.C., Suwelack, D.: Sex differences in body movement and visual attention: An integrated analysis of movement and gaze in mixed-sex dyads. Journal of Nonverbal Behavior 22(1), 31–58 (1998)
[15] Mehrabian, A.: Relationship of attitude to seated posture, orientation, and distance. Journal of Personality and Social Psychology 10(1), 26–30 (1968)
[16] Argyle, M., Lefebvre, L., Cook, M.: The meaning of five patterns of gaze. European Journal of Social Psychology 4(2), 125–136 (1974)

[17] Ellsworth, P.C.: The Meaningful Look (Review of Argyle & Cook). Semiotica 24, 341–351 (1978)

[18] Williams, G.P., Kleinke, C.L.: Effects of mutual gaze and touch on attraction, mood, and cardiovascular reactivity. Journal of Research in Personality 27(2), 170–183 (1993)

[19] Mason, M.F., Tatkow, E.P., Macrae, C.N.: The Look of Love: Gaze Shifts and Person Perception. Psychological Science 16(3), 236–239 (2005)

[20] Brooks, C.I., Church, M.A., Fraser, L.: Effects of duration of eye contact on judgments of personality characteristics. Journal of Social Psychology 126(1), 71–78 (1986)

[21] Knackstedt, G., Kleinke, C.L.: Eye contact, gender, and personality judgments. Journal of Social Psychology 131(2), 303–304 (1991)

[22] Droney, J.M., Brooks, C.I.: Attributions of self-esteem as a function of duration of eye contact. Journal of Social Psychology 133(5), 715–722 (1993)

[23] Napieralski, L.P., Brooks, C.I., Droney, J.M.: The effect of duration of eye contact on American college students' attributions of state, trait, and test anxiety. Journal of Social Psychology 135(3), 273–280 (1995)

[24] Burgoon, J.K., Manusov, V., Mineo, P., Hale, J.L.: Effects of gaze on hiring, credibility, attraction and relational message interpretation. Journal of Nonverbal Behavior 9(3), 133–146 (1985)

[25] Baron Cohen, S., Wheelwright, S., Jolliffe, T.: Is there a language of the eyes? Evidence from normal adults, and adults with autism or Asperger syndrome. Visual Cognition 4(3), 311–331 (1997)

[26] Macrae, C.N., Hood, B.M., Milne, A.B., Rowe, A.C., Mason, M.F.: Are you looking at me? Eye gaze and person perception. Psychological Science 13(5), 460–464 (2002)

[27] Naiman, T.H., Breed, G.: Gaze duration as a cue for judging conversational tone. Representative Research in Social Psychology 5(2), 115–122 (1974)

[28] Patterson, M.L.: Functions of non-verbal behavior in social interaction. In: Giles, H., Robinson, W.P. (eds.) in Handbook of language and social psychology, pp. 101–120. John Wiley & Sons, Oxford, England (1990)

[29] Patterson, M.L.: Strategic functions of nonverbal exchange. In: Daly, J.A., Wiemann, J.M. (eds.) in Strategic interpersonal communication, pp. 273–293. Lawrence Erlbaum Associates, Inc, Hillsdale, NJ, England (1994)

[30] Iizuka, Y.: Gaze during speaking as related to shyness. Perceptual and Motor Skills, 78(3, Pt 2), pp. 1259–1264 (1994)

[31] Kleinke, C.L., Staneski, R.A., Berger, D.E.: Evaluation of an interviewer as a function of interviewer gaze, reinforcement of subject gaze, and interviewer attractiveness. Journal of Personality and Social Psychology 31(1), 115–122 (1975)

[32] Lewis, R.J. Derlega, V.J., Shankar, A., Cochard, E., Finkel, L.: Nonverbal correlates confederates' touch: Confounds in touch research. Journal of Social Behavior and Personality 12(3), 821–830 (1997)

[33] Kelly, E.W., True, J.H.: Eye contact and communication of faciliative conditions. Perceptual and Motor Skills 51(3), 815–820 (1980)

[34] Blascovich, J., et al.: Immersive virtual environment technology as a methodological tool for social psychology. Psychological Inquiry 13(2), 103–124 (2002)

[35] Bente, G., Krämer, N.C., Petersen, A., de Ruiter, J.P.: Computer animated movement and person perception: Methodological advances in nonverbal behavior research. Journal of Nonverbal Behavior 25(3), 151–166 (2001)

[36] Bente, G., Feist, A., Elder, S.: Person perception effects of computer-simulated male and female head movement. Journal of Nonverbal Behavior 20(4), 213–228 (1996)

[37] Bente, G., Petersen, A., Krämer, N.C., de Ruiter, J.P.: Transcript-based computer animation of movement: Evaluating a new tool for nonverbal behavior research. Behavior Research Methods, Instruments and Computers 33(3), 303–310 (2001)
[38] Krämer, N.C.: Bewegende Bewegung. Sozio-emotionale Wirkungen nonverbalen Verhaltens und deren experimentelle Untersuchung mittels Computeranimation. Pabst Science Publishers (2001)
[39] Rüggenberg, S., Bente, G., Krämer, N.: Virtual encounters. Creating social presence in net-based collaborations. In: Presence 2005, London, UK (2005)