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"It doesn't matter what you are!" Explaining social effects of agents and avatars

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ABSTRACT

Empirical studies have repeatedly shown that autonomous artificial entities, so-called embodied conversational agents, elicit social behavior on the part of the human interlocutor. Various theoretical approaches have tried to explain this phenomenon: According to the Threshold Model of Social Influence (Blascovich et al., 2002), the social influence of real persons who are represented by avatars will always be high, whereas the influence of an artificial entity depends on the realism of its behavior. Conversely, the Ethopoeia concept (Nass & Moon, 2000) predicts that automatic social reactions are triggered by situations as soon as they include social cues. The presented study evaluates whether participantś belief in interacting with either an avatar (a virtual representation of a human) or an agent (autonomous virtual person) lead to different social effects. We used a 2 × 2 design with two levels of agency (agent or avatar) and two levels of behavioral realism (showing feedback behavior versus showing no behavior). We found that the belief of interacting with either an avatar or an agent barely resulted in differences with regard to the evaluation of the virtual character or behavioral reactions, whereas higher behavioral realism affected both. It is discussed to what extent the results thus support the Ethopoeia concept.

1. Introduction

Virtual characters: we play and learn with them. We ask them for directions, receive explanations about specific topics. They supervise our fitness program. We communicate through them with our friends or plot with them against our virtual enemies. But what exactly is it that we are interacting with? An interface agent, embodied conversational agent, virtual assistant, autonomous agent, avatar – a variety of labels are used to describe virtual characters, often synonymously. The crux of the matter lies in the control of the virtual figure. An agent is defined as an acting entity, which includes artificial intelligence that renders the control by a human dispensable (Balakrishnan & Honavar, 2001; Erickson, 1997). An avatar, by contrast, is a virtual representation of a human being, which is controlled completely by the human. Good examples of avatars are those in Second Life and World of Warcraft, where the user controls not only the verbal behavior, but also gestures and other body movements. In contrast, the "embodied conversational agent" (ECA) Max (Kopp, Gesellensetter, Krämer, & Wachsmuth, 2005) does not require control by a human; it decides which sentence it is going to say next on the basis of his artificial intelligence. Additionally, his nonverbal behavior is a product of computational algorithms. Consequently, Bailenson and Blascovich (2004) define an avatar as "a perceptible digital representation whose behaviors reflect those executed, typically in real time, by a specific human being", and an agent as "a perceptible digital representation whose behaviors reflect a computational algorithm designed to accomplish a specific goal or set of goals" (Bailenson & Blascovich, 2004, p. 64).

Numerous studies by different research groups show that people react socially towards both forms of representations – agents and avatars (c.f. e.g. Bailenson, Blascovich, Beall, & Loomis, 2003; Bickmore, Gruber, & Picard, 2005; Cassell et al., 2002; Gratch, Wang, Gerten, Fast, & Duffy, 2007; Reeves & Nass, 1996; Nass, Moon, Morkes, Kim, & Fogg, 1997, see Krämer, 2008, for an overview). However, it is still unclear whether people react in the same way towards agents and avatars. This question essentially distils down to gaining an understanding of why people react socially to virtual characters – even if they know that they are conversing with a machine. The current study aims to provide a theoretically and empirically grounded answer to this underlying question.

There are many theories and approaches that attempt to provide an explanation for the occurrence of social effects in human–computer interaction. For example, the innovation hypothesis states that the social reactions towards a computer are a temporal phenomenon due to the novelty of the situation. This novelty effect vanishes once the user becomes accustomed to the interaction with the technology (Kiesler & Sproull, 1997). According to the deficit hypothesis, social effects occur due to

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deficits on the part of the human, such as a lack of knowledge, inexperience of youth, or psychological or social dysfunctions (cf. Barley, 1988; Turkle, 1984; Winograd & Flores, 1987). Other authors claim that the social behavior is not directed to the agent but to the programmer behind the agent (Dennett, 1987; Heidegger, 1977, and Searle, 1981). Besides these approaches there are two more sophisticated and elaborate models regarding the occurrence of social effects in human–agent interaction: the Ethopoeia concept by Nass and colleagues (Nass & Moon, 2000; Nass et al., 1997) and the Threshold Model of Social Influence by Blascovich (2002), Blascovich et al. (2002). The Threshold Model of Social Influence suggests that a human being initially only responds socially to another human being – or, if situated in a virtual reality, to an avatar. An agent, however, would not elicit social responses unless the behavior of the agent is so realistic that the user cannot distinguish the agent from the avatar. The Ethopoeia concept, on the other hand, assumes that it does not matter whether people interact with an avatar or an agent. As long as the situation includes social cues, such as interactivity, natural speech, or the filling of social roles, social scripts are triggered and automatic social behaviors are performed. This so-called mindless behavior is an automatic response to contextual social cues, which does not include active processing of these cues. As these cues are presented by both avatars and agents, social responses should occur in equal measure.

The deficit hypothesis, the innovation effect and the programmer-thought were not addressed in this study for different reasons. The deficit hypothesis, for instance, is an obsolete approach as a lot of studies with healthy adults have been conducted which were able to show social effects. Also, an examination of the innovation hypothesis is not practicable at this stage as most systems are not stable, robust or transportable enough to e.g. be placed three weeks in an ordinary household. And the assumption that people address their social reactions to a programmer behind the computer has already been addressed in a previous study by Nass and Sundar (1994).

Therefore, the latter two theories, namely Ethopoeia and Threshold Model of Social Influence, are considered to provide more potential to contribute to a better understanding of the nature of human–agent-interaction. In this study we aimed to systematically test these competing theories. Therefore, both models will be explained in more detail in the following chapters.

1.1. The Threshold Model of Social Influence

The key factor in the Threshold Model of Social Influence is the so-called "social verification", which is "the extent to which participants in virtual groups experience interactions with virtual others in ways that verify that they are engaging in semantically meaningful communication with virtual others thereby experiencing shared reality" (Blascovich, 2002, p. 26). Social verification is a function of two factors: behavioral realism and agency. Both are considered to be continuous dimensions, ranging from low behavioral realism and low agency (agent), respectively, to high behavioral realism and high agency (avatar), respectively. The authors assume a Threshold of Social Influence, which has to be crossed to evoke social reactions by the user. This is only possible when the level of social verification is sufficiently high. When the factor agency is high (i.e. when the user knows that the virtual character is a representation of a human being), then the factor behavioral realism does not have to be high in order for social verification to take place and for social effects to occur. Conversely, when the factor agency is low (i.e. when the user knows that the virtual character is a mere computer program), the factor behavioral realism has to be very high to compensate for the lack of agency. In sum, it can be derived that according to the Threshold Model of Social Influence, the social influence of real persons will always be high, whereas the influence of an artificial entity depends on the realism of its behavior. The role of agency and behavioral realism in explaining the social influence of virtual characters is still up for discussion. Although some scholars have already conducted studies comparing avatars and agents (agent-avatar paradigm) the Threshold Model of Social Influence was never systematically tested by another research group. In addition, due to inconsistent results in previous studies by Blascovich, Bailenson and colleagues (see below) the Threshold Model of Social Influence requires further investigation (Fig. 1).

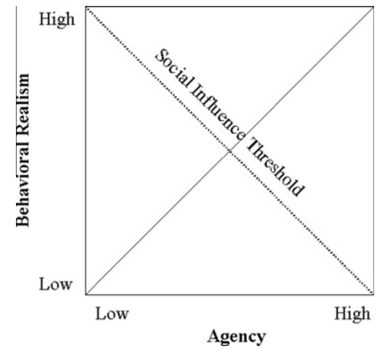

Fig. 1. The Threshold Model of Social Influence (Blascovich, 2002, p.27).

1.2. The Ethopoeia concept

With the term Ethopoeia, Nass and colleagues (c.f. Nass & Moon, 2000, 1997) describe the phenomenon that people automatically and unconsciously react to computers in the same way as they do towards other humans. Nass and colleagues reject the explanation that people consciously anthropomorphize computers, because all participants in their studies consistently denied doing so. The authors show empirically that people do not think of the programmer when they show social reactions. In fact, all participants deny reacting in any social way towards computers and state that this behavior would be inappropriate. Instead, Reeves and Nass (1996) prefer an evolutionary approach to explain this phenomenon. The human brain developed at a time when only human beings were able to show social behavior, and when every person and every place was a real person and a real place. To deal successfully with daily life, the human brain developed automatic responses, which are still in use today. Therefore, people still automatically accept persons and places as real (see also Gilbert, 1991). "When our brains automatically respond socially and naturally because of the characteristics of media or the situations in which they are used, there is often little to remind us that the experience is unreal. Absent a significant warning that we have been fooled, our old brains hold sway and we accept media as real people and places" (Reeves & Nass, 1996, p. 12). Nass and Moon emphasize this point of mindlessly applying social rules and expectations to computers (Nass & Moon, 2000, p. 82). Mindlessness (Langer, 1989, 1992; Langer, & Moldoveanu, 2000) can be best understood as the failure to draw novel distinctions. These automatic responses to contextual social cues trigger scripts and expectations, making active information processing impossible. Moreover, Sundar and Nass (2000) assume that people not only respond mindlessly, but also have the tendency to use cognitive shortcuts and heuristics (Tversky & Kahnemann, 1974), and therefore use the easily accessible social rules from human–human interaction (HHI) and apply them to human–computer interaction – due to the perceived functional similarity between humans and computers. Examples of this functional similarity (or social cues) include the use of natural language (Turkle, 1984), interactivity (Rafaeli, 1990), and the filling of social roles traditionally filled by humans (Nass, Lombard, Henriksen, & Steuer, 1995; Mead & Morris, 1934).

1.3. Empirical results

1.3.1. Ethopoeia and Revised Ethopoeia Model

Reeves and Nass (1996) conducted numerous studies and provide empirical evidence for "How people treat computers, television, and new media like real people and places". All studies were conducted with conventional computers without anthropomorphic interfaces. The Computers Are Social Actors (CASA) paradigm takes findings from HHI and replicates the studies by replacing one communication partner with a computer. The authors were able to successfully replicate findings for many social rules in the areas of person perception, politeness, reciprocal self-disclosure, reciprocal assistance and in-group and out-group stereotypes. With regard to person perception, for instance, Nass, Steuer, and Tauber (1994) report that a computer which criticized the participants was rated as more competent than a computer which praised the participants. Although participants denied having gender stereotypes or being influenced by the voice of the computer, the execution of gender stereotypes was observed: Nass, Moon, and Green (1997) found that computers with a female voice were rated as more competent in the topic of love and relationships, and conversely, the computer with a male voice was rated as more competent with regard to computers and technology. Furthermore, computers which paid a compliment to the participants were rated more positively (Fogg & Nass, 1997), even when the participants knew that the compliments were assigned randomly and not intentionally. Regarding politeness Nass, Moon, and Carney (1999) demonstrate that people use the same politeness rules as we know them from human–human communication. In face-to-face situations, people tend to rate their communication partner more positively and give more polite answers in order not to hurt the other person. In their study, people evaluated the performance of the computer with which they interacted more positively when the same computer inquired about its own performance compared to another computer inquiring about the performance of the interaction computer. With regard to reciprocal self-disclosure Moon (2000) found that participants revealed more intimate information about themselves when the computer revealed information about itself first.

Against this background it can be assumed that similar social effects will be found for anthropomorphic interfaces as was shown in the following studies: Sproull, Subramani, Kiesler, Walker, and Waters (1996) showed that participants who interacted with a talking-head filled out a questionnaire in a way that would present them in a better light compared to participants who did not interact with a talking head and thus show a clear tendency to perform impression management. This finding was affirmed by Krämer, Bente, and Piesk (2003) who found that participants who had the choice between a documentary about the life of Albert Einstein, a James Bond movie or the daily TV listings were more likely to choose the socially desirable documentary when they were asked by an anthropomorphic interface agent compared to participants asked by a mere text-based or speech-based interface. With regard to person perception, for instance, Rossen, Johnson, Deladisma, Lind, and Lok (2008) showed that people apply ethnic stereotypes to agents. Caucasian medical students with a prejudice against Afro-Americans were found to show more empathetic verbal and nonverbal behavior towards an agent with a light skin tone than to an agent with a dark skin tone. The results from the politeness study (Nass et al., 1999) were replicated in an experiment with the virtual agent MAX (Hoffmann, Krämer, Lam-chi, & Kopp, 2009). Participants evaluated MAX more positively when it itself asked for the judgment compared to an evaluation via paper-and-pencil questionnaire.

In sum, it can be stated that the results found by Nass and colleagues with regard to conventional computers can also be observed in interactions with virtual agents, and indeed sometimes to an even greater extent. Nass and Moon (2000) note, however, that a direct comparison of HHI with HCI is lacking, and the authors discuss the possibility of meta-analytical comparisons within the agent-avatar paradigm. Their first study within this paradigm showed that "with a few exceptions (see Morkes, Kernal, & Nass, 2000), the "human" conditions in these experiments have *not* elicited stronger social responses than the "computer" conditions" (Nass & Moon, 2000, p. 99). In contrast, the authors concluded on the basis of the empirical findings that agents and avatars with higher behavioral realism provide more social cues and therefore elicit more social responses. They addressed this point in the discussion of their meta-analytical study addressing the avatar-agent paradigm (Morkes et al., 2000). "The results suggest both that humor may enhance likability of an interface and that SRCT [Social Response to Communication Technology] theory should be revised." (Morkes et al., 2000, p. 395). Against this background, Nass and Moon (2000) encourage further research with regard to behavioral realism. They assume that certain characteristics of computers facilitate mindless social reactions: "the more computers present characteristics that are associated with humans, the more likely they are to elicit social behavior [...]" (Nass & Moon, 2000, p. 97). This assumption that we term the *Revised Ethopoeia Concept* would state that is does not matter whether participants are interacting with an agent or an avatar, but rather how many human-like characteristics the systems provides. Although every system elicits social reactions as long as the system provides social cues (Ethopoeia Concept), a system will elicit more or stronger social reactions when it provides more social cues (Revised Ethopoeia Concept). Thus, higher behavioral realism should lead to more social reactions by the user.

1.3.2. Threshold Model of Social Influence

Several studies have compared the effects of agents and avatars, but their results are not consistent and to some extent contradictory. For instance, Guadagno, Blascovich, Bailenson, and McCall (2007) examined the effects of agency and behavioral realism on persuasion and found some supporting results for the importance of agency. Participants in the high behavioral realism group experienced more social presence and, moreover, participants in the avatar group experienced more social presence than subjects in the agent group. However, the lack of interaction effects between behavioral realism and agency suggests that the assumptions of the model cannot be supported. Hoyt, Blascovich, and Swinth (2003) demonstrated classic effects of social inhibition when participants were asked to perform a non-trained task in front of an avatar compared to an agent. Conversely, they did not find effects of social facilitation when participants performed well-trained tasks in front of an avatar. Supporting results for behavioral realism are given by Bailenson, Blascovich, and Beall (2001) who demonstrated that behavior realism with regard to natural proximity behavior is crucial: only when a virtual agent follows the user with its eyes does the user maintain a distance that would also be expected in a human–human interaction. Bailenson et al. (2003) replicated this finding and found additionally that – at least for female participants – the pattern expected by the threshold model emerged.

Also, other research groups varied agency or behavioral realism in their studies. They, however, did not systematically test the Threshold Model of Social Influence as they did not vary both factors but either behavior, or agency in combination with e.g. static aspects such as appearance. Nevertheless, these results relate to the crucial aspects of the Threshold Model of Social influence and shall be reported at this point. With regard to agency the following studies have to be taken into account: Nowak and Biocca (2003) conducted a study about the influence of agency and anthropomorphism. Participants believed that they were interacting either with an agent or an avatar. Additionally, the degree of anthropomorphism was varied from no picture (control group), abstract eyes and mouth (low anthropomorphism) to a realistic picture of a virtual character (high anthropomorphism). Agency showed no effects on the perceived degree of co-presence or social presence, but participants reported increased social presence when confronted with a high anthropomorphic picture compared to a low anthropomorphic picture. In summary, the authors see their results in line with the thesis of Reeves and Nass: "Although no real conclusions can be made with non-significant differences, these results are consistent with several other studies that suggest that participants respond to computers socially, or in ways that are similar to their responses to other humans (Reeves & Nass, 1996)." (Nowak & Biocca, 2003, p. 490). Aharoni and Fridlund (2007) also investigated the influence of the factor agency. Participants in their study interacted with a standard computer with pre-recorded speech output. Participants believed that they were either interacting with a human interviewer or an artificial intelligent computer. The experimenters reported that participants used more silence fillers and smiled more while interacting with the human interviewer compared to the computer. However, the evaluation of the interviewer as well as the subjective emotional state of the participants was not affected by the factor agency. With regard to these experiments and their results, it can be summarized that there is some empirical evidence for the thesis that avatars elicit stronger social effects than agents but that it was not shown consistently. In contrast, the factor behavioral realism seems to be of greater importance.

1.4. Research questions

Taking these considerations on all three models into account, we aimed to systematically test the three models explaining the occurrence of social effects in human–computer interaction. We followed the agent-avatar paradigm and varied the participant's belief of interacting with either an avatar or an agent. In order to provide a systematic test of the Threshold Model, we additionally varied dynamic behavior, namely the listening behavior of the virtual figure. This resulted in a 2×2 between-subjects design. We used the Rapport Agent developed by Gratch et al. (2006), which was designed to create rapport with the user by displaying appropriate listening behavior to a human storyteller. In order to match the abilities of the listening agent, we chose a self-disclosure task for participants. Numerous studies in the field of computer-mediated communication, human–computer interaction and human-agent- interaction suggest that people disclose more personal intimate information when they feel they are in an anonymous situation (e.g. alone in front of a computer) compared to a situation where a another human being is present or mediated (for a review see Weisband & Kiesler, 1996 and Joinson, 2001). Thus, the Threshold Model of Social Influence would predict more self-disclosure in the agent condition especially when there is no behavioral realism. Bailenson, Yee, Merget, and Schroeder (2006) as well as Moon (2000) used a self-disclosure task in previous studies. Thus we chose to use a task on self-disclosure in order to keep the experimental setup comparable. In addition, we opted for dependent variables already used in these studies as well as additional standardized scales to provide a wide range of subjective and objective measurements. According to the above-described models our competing hypotheses are:

- *H0:* There will be no differences with regard to the social effects between the four conditions. (Ethopoeia Concept).
- *H1:* The social effects will be higher in the condition of high behavioral realism than in the condition of low behavioral realism. (Revised Ethopoeia Concept).
- *H2:* The social effects in the condition Agent/Low behavioral realism will be lower than in all other conditions. (Threshold Model of Social Influence).

2. Method

2.1. Experimental design

To test our hypotheses, we used a 2×2 design with two levels of agency (*Agent* or *Avatar*) and two levels of behavioral realism (showing (feedback) behavior versus showing no behavior). Eighty-three persons (42 females and 41 males) participated in the study and were randomly assigned to the conditions (see Table 1). The mean age was 37.27 ($SD = 13.61$), ranging from 18 to 65 years. Participants were recruited via www.craigslist.com from the general Los Angeles area and were compensated $20 for one hour of their participation. During the interaction, the participants were asked three personal questions of increasing intimacy by the animated character.

2.1.1. Factor agency

For the factor agency, we varied the instruction given to the participants by the experimenter. Although, in fact, all participants interacted with the agent, half of them were led to believe that they interacted with an avatar and half of them were instructed that they interacted with an agent. In this way, we were able to guarantee that all participants experienced the same treatment and we avoided biases resulting from different confederates.

Instruction Avatar: The instruction in the avatar condition was: "We invited two participants for this experiment to test this new communication system. You will see an animated character on this screen. The animated character will copy the head and body movements of another participant, who is sitting in another room. For example, if the other person nods his or her head, the animated character will nod its head. The other participant will also see an animated character on the screen, which represents you. Both of you have a red camera in front of you, which tracks your head and body movements. The other participant is instructed to ask you three given questions about your daily life and then listen to your answer. Please only respond to the questions and do not ask questions yourself, because the other participant is instructed not to answer.

Instruction agent: The instruction in the agent condition was: "You will see an animated character on this screen. The animated character is computer-generated. It looks and behaves like a human, but is in fact a software program. The animated character can see your head and body movements via the red camera in front of the screen. It can hear what you are saying via the microphone. And you can hear the animated character through the headset. The animated character will ask you three questions about your daily life and then listen to your answer. Please only respond to the questions and do not ask questions yourself. In this experiment, we are focusing on one-way communication: you are telling a story and the animated character is listening."

Table 1
Distribution of gender over conditions ($N = 83$).

	Agent		Avatar	
	Male	Female	Male	Female
High behavioral realism	11	10	12	10
Low behavioral realism	9	11	10	10

2.1.2. Factor behavioral realism

We used the Rapport Agent, which was developed by Gratch et al. (2006) at the Institute for Creative Technologies. The agent displays listening behaviors that correspond to the verbal and nonverbal behavior of a human speaker. The Rapport Agent has been evaluated in several studies (Gratch, Wang, Gerten, et al., 2007; Gratch, Wang, Okhmatovskaia, et al., 2007; Gratch et al., 2006; Kang, Gratch, Wang, & Watts, 2008a; Kang, Gratch, Wang, & Watts, 2008b) and has proven to be capable of creating the experience of rapport comparable with a face-to-face condition. Tickle-Degnen and Rosenthal (1990) define rapport as conglomerate consisting of three essential factors: mutual attention, positivity and coordination. The experience of rapport is described as follows: "Interactants feeling in rapport with one another feel mutual friendliness and caring." (p. 286). The Rapport Agent concentrates on the factor coordination and tries to establish coordination between the interactants by analysis of the user's nonverbal behavior and in the next step by mapping of the userś and the agent's nonverbal behavior. For this study, we used the Rapport Agent with some adjustments described below in detail.

The Rapport Agent. To produce listening behaviors, the Rapport Agent first collects and analyzes the features from the speaker's voice and upper-body movements via microphone and a Videre Design Small Vision System stereo camera, which was placed in front of the participants to capture their movements. Watson, an image-based tracking library developed by Morency, Sidner, and Darrell (2005), uses images captured by the stereo camera to track the participant's head position and orientation. Watson also incorporates learned motion classifiers that detect head nods and shakes from a vector of head velocities. Acoustic features are derived from properties of the pitch and intensity of the speech signal using a signal processing package, LAUN, developed by Morales (Gratch et al., 2006). The animated agent was displayed on a 30-inch Apple display. A female virtual character was used in all conditions (see Fig. 2).

Adjustments to the system: Usually, the Rapport Agent displays behaviors that show that the animated character is "alive" (eye blinking, breathing), and listening behaviors such as posture shifts and short head nods automatically triggered by the system corresponding to participantś verbal and nonverbal behavior.

For this study, however, we modified the system so that it was possible to conduct a small dialogue. The Rapport Agent still acts as a listener, but prompts the participant's narration through several questions. Before the interaction starts, the animated character is looking to the ground to avoid eye contact with the participant before the system begins. When the system begins, indicated by a ping sound, the animated character looks up and says "Okay, I'm ready." We did not use a text-to-speech system, but instead pre-recorded five sentences with a female voice to create the illusion for the avatar condition that there might really be another participant in another room. The pre-recorded sentences were the following:

- Okay, I'm ready.
- What was the most special experience for you yesterday?
- Which of your characteristics are you most proud of?
- What has been the biggest disappointment in your life?
- Thank you. You are done.

We programmed two different kinds of head nods, a double head nod with higher velocity and smaller amplitude (called back-channel head nod) and a single head nod with lower velocity and larger amplitude (called understanding head nod). The double head nod was used as a back-channeling head nod and replaced the head nods normally used by the Rapport Agent. The single head nod was triggered manually at the end of the participantś verbal contribution to one of the three questions in order to support the impression of an attentive listener. We also programmed a head shake to be able to react to questions appropriately, e.g. "Are you fake?" or "Are you stupid?" Fortunately, no such situations arose and the head shake was not used in the study. The head shake, the single head nods and the five pre-recorded utterances were implemented in an interface through which the experimenter could manually actuate every behavior. We also added the possibility to trigger the back-channeling head nod manually in case the system malfunctioned during interactions in the high behavioral realism condition. In fact, we only used the pre-recorded utterances and the single head nod.

Condition low behavioral realism. For this condition, we chose to use the breathing, eye blinking, and posture shifts, but no head nods, either double head nod or single head nod. In this way, we achieved a rather unrealistic behavior, as the Rapport Agent was simply staring at the participants and did not react to their contributions at all.

Condition high behavioral realism. For this condition, we used breathing, eye blinking, posture shifts and the two kinds of head nods. The back-channeling head nod was triggered automatically by the system according to the nonverbal and verbal behavior of the participants. The understanding head nod was actuated by the experimenter each time the participant finished his or her contribution to one of the three questions. By this the users saw a virtual character which displayed continuous back-channeling behavior during their utterance and a head nod at the end of their contribution indicating the virtual character understood what they said.

Fig. 2. The Rapport Agent – female character.

2.2. Dependent variables

Against the background of the empirical results on the Ethopoeia Model and the Threshold Model of Social Influence we decided to assess a variety of dependent variables to be able to test the two models on a broader basis including self-report measures as well as objective variables which were in part already used in the above presented studies like the self-reported experience of social presence, and self-reported rapport, as well as the participantś emotional state (PANAS) after the interaction and, the person perception of the virtual character. Besides these self-report measures, we also measured the following objective variables: the total number of words the participants used during the interaction and the percentage of pause-fillers and interrupted words. We also carried out a qualitative analysis of the degree of self-disclosure. In the following, all measurements will be described in detail.

2.2.1. Quantitative measurements

In the present study, we used the Positive And Negative Affect Scale (Watson, Tellegen, & Clark, 1988) consisting of 20 items (e.g. strong, guilty, active, ashamed etc.), which are rated on a 5-point Likert scale from "very slightly or not at all" to "extremely". The factorial analysis for the Positive and Negative Affect Scale resulted in three factors, namely *Positive High-Dominance, Negative High-Dominance* and *Negative Low-Dominance* (see Appendix for details).

For the person perception (of the agent), we used a semantic differential with 26 bi-polar pairs of adjectives (e.g. friendly–unfriendly, tense-relaxed), which are rated on a 7-point scale. The factor analysis for the person perception of the virtual character resulted in four factors, namely *Negative Low-Dominance*, *Positive High-Dominance*, *Positive Low-Dominance*, and *Negative High-Dominance* (see Appendix for details).

Social presence (Short, Williams, & Christie, 1976) was measured by two scales: the social presence scale (Bailenson, Blascovich, & Beall, 2001) with five items (e.g. "I perceive that I am in the presence of another person in the room with me") and the Networked Minds Questionnaire (NMQ; Biocca & Harms, 2002; Biocca, Harms, & Burgoon, 2004; Biocca, Harms, & Gregg, 2001). Due to a very long post-questionnaire, we concentrated on the following five aspects of the NMQ: empathy (with 4 items), mutual awareness (with 2 items), attention allocation (with 4 items), mutual understanding (with 3 items) and behavioral interdependence (with 4 items). All items from both scales were rated on a 7-point Likert scale.

To measure perceived rapport, we used a scale that had been developed for previous studies with the Rapport Agent. This scale contains ten items from the rapport construct by Tickle-Degnen and Rosenthal (1990), which were already in use in an experiment on the effects of nonverbal signal delay in tele-psychiatry (see Manning, Goetz, & Street, 2000). Nineteen ad hoc items were added, which proved to measure rapport in several studies (Gratch et al., 2006; Gratch, Wang, Gerten, et al., 2007; Gratch, Wang, Okhmatovskaia, et al., 2007; Kang et al., 2008a; Kang et al., 2008b). The resulting 29 items were measured on an 8-point Likert scale. The factor analysis for the self-reported rapport also revealed four factors, namely *Feelings and Self-Efficiency*, *Rapport and Connection*, *Evaluation of Listener*, and *Attention Allocation* (see Appendix for details).

Verbal behavior: In addition, we analyzed the participantś verbal behavior. We counted the total amount of words, the amount of pause-fillers ("erm" ", hm") and the amount of broken words (e.g. "I was in the bib ... library"). From the latter two, we calculated the percentage of speech disfluencies in relation to the total amount of words.

2.2.2. Qualitative measurements

We conducted a qualitative analysis of the participantś answers to the questions asked by the virtual character. Questions two and three (see below) were used in previous experiments on self-disclosure (e.g. Moon, 2000). The first question ("What was the most special experience you had yesterday?") was excluded from the analysis because of too much variance due to the weekday on which they participated. When participants took part in the experiment on a Monday, they had more possibilities to report about their activities (i.e. on Sunday) than people who took part on a Thursday.

For the second question ("Which of your characteristics are you most proud of?"), we counted the number of characteristics the participants revealed. For the third question ("What has been the biggest disappointment in your life?"), we used a categorical coding scheme (Mayring, 1996) with three categories:

(1) No answer: the subject gives no answer or uses excuses to avoid an answer.
(2) Low-intimacy answer: the disappointment (or unfulfilled wish) has not sustainably affected the private or business life of the subject.
(3) High-intimacy answers: the disappointment (or unfulfilled wish) has sustainably affected the private or business life of the subject.

The coding was processed by two coders. The inter-rater reliability showed substantial agreement (Cohen's Kappa = .714).

2.3. Procedure

Upon arrival, the participants were asked to read and sign informed consent forms. After completing a web-based questionnaire (Leiner, 2009) about their background including demographic data and the questionnaires of the explanatory variables, participants received a short introduction about the equipment and were given the instructions regarding their interaction partner and the task of the experiment (see above). Then, participants took a seat in front of a 30″ screen, which displayed the Rapport Agent. They were equipped with a headset with microphone. In order to assess the participants' verbal and nonverbal behavior, the whole session was videotaped. The camera was directed towards the participants and situated directly under the screen with the Rapport Agent in combination with the stereovision camera. Participants were instructed to wait until the systems starts, indicating readiness by a ping sound. They were asked three questions by the Rapport Agent with increasing intimacy. After the interaction, the participants completed the second web-based questionnaire. They were fully debriefed, given $20 and thanked for their participation.

3. Results

We calculated MANOVAS with the two independent variables agency and behavioral realism and the dependent variables: three PANAS factors, four person perception factors, four rapport factors, the social presence scale, the constructs empathy, attention allocation, mutual awareness, mutual understanding and behavioral interdependence from the NMQ, the total amount of words, the percentage of speech disfluencies and the number of revealed characteristics.

We identified only one main effect for agency. Participants who thought they were interacting with an artificial agent experienced more negative feelings with *Low-Dominance* (scared, ashamed) than those in the *Avatar condition* ($F(1, 83) = 5.447$; $p = .022$; partial $\eta^2 = .064$; see Table 2).

With regard to the variation of behavior, however, three significant differences emerged. Concerning the person perception, participants rated the animated character higher on *Negative Low-Dominance* (weak, dishonest, naïve, shy) when it showed feedback behavior ($F(1, 83) = 5828$; $p = .018$; partial $\eta^2 = .069$, see Table 3). Moreover, the feeling of mutual awareness (Social Presence) was more intense in the condition with high behavioral realism than in the condition with low behavioral realism ($F(1, 83) = 4.548$;

Table 2
MANOVA with the independent factors agency and behavioral realism and the dependent variable subjective feeling after the interaction ($N = 83$).

	Agent		Avatar				
Negative Low-Dominance	μ	*SD*	μ	*SD*	*F*	η^2	*p*
	.243	1.161	−.254	0.736	5.447	.064	.022

Table 3
MANOVA with the independent factors agency and behavioral realism and the dependent variable evaluation of the agent in terms of person perception ($N = 83$).

	High behavioral realism		Low behavioral realism				
Negative Low-Dominance	μ	*SD*	μ	*SD*	*F*	η^2	*p*
	.249	0.909	−.264	1.037	5.830	.069	.018

Table 4
MANOVA with the independent factors agency and behavioral realism and the dependent variable quantitative verbal behavior ($N = 83$).

	High behavioral realism		Low behavioral realism				
Total amount of words	μ	*SD*	μ	*SD*	*F*	η^2	*p*
	226	221	119	112	7.348	.085	.008

Table 5
MANOVA with the independent factors agency and behavioral realism and the dependent factor mutual awareness ($N = 83$).

	High Behavioral realism	Low Behavioral realism					
Mutual awareness	μ	*SD*	μ	*SD*	*F*	η^2	*p*
	3.670	1.553	4.334	1.242	4.548	.055	.035

Note. Mutual awareness is loaded negatively and a lower mean value is associated with a higher feeling of mutual awareness.

$p = .035$; partial $\eta^2 = .055$, see Table 4, note that mutual awareness is loaded negatively and a lower mean value is associated with a higher feeling of mutual awareness). Additionally, the total amount of words was almost twice as high when there was feedback behavior compared to no behavior ($F(1, 83) = 7.348$; $p = .008$; partial $\eta^2 = .085$, see Table 5). There were no effects with regard to the self-disclosure of information (number of characteristics).

We also found no interaction effects of the factors agency and behavioral realism.

As already mentioned, we carried out a qualitative analysis of the participantś answer to question three ("What has been the biggest disappointment in your life?") using the categorical scheme explained above. We conducted chi-square tests with the factors agency and behavioral realism. No effects were found.

3.1. Discussion

The main goal of this research was to empirically test three models which explain the occurrence of social effects in human–computer interaction: the *Threshold Model of Social Influence* (Blascovich, 2002; Blascovich et al., 2002), the *Ethopoeia Concept* (Nass & Sundar, 1994; Nass et al., 1997; Reeves & Nass, 1996) and the *Revised Ethopoeia Concept*. To empirically test the models, we varied on the one hand the factor agency and made participants believe they were interacting with either an avatar or an agent. On the other hand, we varied the factor behavioral realism and created an agent with unrealistic behavior and an agent with higher behavioral realism. We used a wide range of dependent variables, including quantitative and qualitative behavioral data, scales previously used within the paradigm and standardized psychological measures used for face-to-face interactions.

According to the Ethopoeia Concept, it can be assumed that there will be no differences with regard to the social effects between the four conditions (H0). In actual fact, 14 of the dependent variables showed no effects (two PANAS factors, three person perception factors, four social presence factors, four rapport factors and also the qualitative self-disclosure). Although the Ethopoeia concept equals the null hypothesis and thus technically cannot be verified, this lack of significant differences suggests that it does not make a difference for either social reactions or social evaluations whether people believe they are interacting with another person or an artificial entity.

According to the Revised Ethopoeia Concept, a more realistic agent behavior provides more social cues and hence elicits more social effects on the part of the user. Thus, H1 stated that there will be a main effect of the factor behavioral realism, resulting in increased social effects when behavioral realism is high. Indeed, we identified three significant effects with regard to the variation of the behavior. In the high behavioral realism condition, participants rated the animated character higher on *Negative Low-Dominance*, they experienced more feelings of mutual awareness, and they used more words during the interaction. In sum, H1 was supported by three main effects. The virtual character's behavior significantly influenced participantś subjective experience as well as their actual behavior. Although these effects did not emerge for all dependent variables, the behavioral realism seems to play an important role in human–agent interaction. The assumption that "the more computers present characteristics that are associated with humans, the more likely they are to elicit social behavior" (Nass & Moon, 2000, p. 97) is confirmed in our experiment. Furthermore, the effects we observed are very plausible: The presence of the back-channeling behavior in the high behavioral realism condition encouraged the participants to tell longer stories and supported the feeling of mutual awareness. More surprisingly, the presence of nodding behavior caused a more negative perception of the virtual character – it was rated as rather weak and naive. However, if we take into account that the character was nodding to everything the participants said during the interaction, this result can also be explained and can be classified as a social effect. By showing only nodding behavior – which can also be interpreted as approval – the agent appeared to be very submissive. In sum, it was once more shown that the behavior of the virtual character matters (see Rickenberg & Reeves, 2000). Like in face-to-face interactions, the evaluation of people is first and foremost dependent on what people do – even if it is merely subtle differences in nonverbal behavior. As has been stated previously (Krämer, Simons, & Kopp, 2007), we suggest that further research is required in the field of behavioral realism. With regard to the focus of the present study, it would be interesting to ascertain whether different levels of behavioral realism elicit more or fewer social effects. It has to be noted that the behavior shown by the agent in our experiment is clearly not the most elaborate and therefore realistic behavior imaginable. The fact that main effects were still found therefore suggests the power of even subtle behavioral variations. Apart from this, another important point is what this finding implies for designing virtual agents. Although the nodding behavior encourages people to keep going within the conversation it did not contribute to a positive evaluation of the agent itself. Thus, "just adding" behavior cannot be a solution to design more engaging and more believable agents. Every additional behavior may cause side effects and therefore the positive and negative interactions of different behaviors should be evaluated carefully during an iterative design process.

What emerged most clearly from our results is that the Threshold Model of Social Influence cannot be supported. According to the model, the social influence of real persons will always be high, whereas the influence of an artificial entity depends on the realism of its behavior. Thus, H2 stated that the condition Agent/Low behavioral realism will differ from all other conditions with regard to the occurrence of social effects. Although we identified one main effect for agency, which is that participants in the agent condition experienced more negative feelings with *Low-Dominance* than those in the avatar condition, we could not find any interaction effects of the factors agency and behavioral realism. Therefore, H2 has to be rejected, as we did not find evidence for the Threshold Model of Social Influence. It might be criticized that effects that are in line with the threshold model did not emerge since the behavior in the high behavioral realism condition was not sufficiently realistic. However, even if this had been the case, the pattern that should have been observable to support the threshold model would be a strong main effect of the agency factor. On the other hand, the pattern we found would – given the correctness of the model – merely be able to show when participants had perceived high behavioral realism not only in the "high behavioral realism" condition but also in the "low behavioral realism" condition – which seems highly unlikely given that there was no behavior at all.

3.2. Conclusions

Contributing beyond the current knowledge on explanations for social reactions towards embodied agents the present study systematically tested two elaborate models explaining social effects. By this we contribute to the ongoing discussion on this highly relevant topic in HAI. Moreover, we looked at social effects on a broader basis and did not address merely one behavior or one self-reported measure, respectively. To sum up our conclusions, the Ethopoeia concept by Nass and Colleagues is more suitable as an approach to explain the social effects we found than the Threshold Model of Social Influences by Blascovich and colleagues. However, as Nass himself has already suggested, the concept should be amended by the claim that for both agents and avatars, the behavior is crucial for the emergence and quality of social effects. Additional studies should concentrate on these aspects and systematically vary the level of behavioral realism. These studies also have to target what behavioral realism includes and what increases the perceived realism and what does not. In this way, data will also be gained that are relevant for fundamental research on human communication and the perception of verbal and nonverbal behavior.

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Appendix A. Factor analyses

The factor analysis for the Positive and Negative Affect Scale resulted in three factors. (see Table 6). The first factor, *Positive High-Dominance*, explains 28.24% of the variance (Cronbach's $\alpha = .838$). The second factor, *Negative High-Dominance*, explains 23.09% of the variance (Cronbach's $\alpha = .819$), and the third factor, Negative Low-Dominance, explains 7.57% of the variance (Cronbach's $\alpha = .712$).

The factor analysis for the person perception of the virtual character resulted in four factors. The first factor, *Negative Low-Domi-*

Table 6
Factor loadings and communalities based on a principal components analysis with varimax rotation for the 20 items of the Positive And Negative Affect Scale (*N* = 83).

	Positive High-Dominance	*Negative High-Dominance*	*Negative Low-Dominance*
Enthusiastic	.852		
Inspired	.808		
Active	.786		
Proud	.786		
Determined	.766		
Excited	.739		
Strong	.687		
Alert	.676		
Attentive	.620		
Interested	.566		
Hostile		.804	
Irritable		.780	
Upset		.778	
Guilty		.655	
Jittery		.575	
Nervous		.547	
Afraid			.829
Scared			.666
Ashamed		.517	.557
Distressed			.524

Note. Factor loadings <.4 are suppressed.

Table 7
Factor loadings and communalities based on a principal components analysis with varimax rotation for 26 items regarding person perception of the agent (*N* = 83).

	Negative Low-Dominance	*Positive High-Dominance*	*Positive Low-Dominance*	*Negative High-Dominance*
Weak	.817			
Dishonest	.749			
Naïve	.726			
Mature	−.713			
Shy	.649			
Unintelligent	.617	−.507		
Acquiescent	.539			
Nervous	.507			.476
Compassionate		.695		
Noisy		.650		
Involved		.596	.509	
Inviting		.592	.426	
Passive		−.583		
Unsympathetic		−.581		
Cheerful		.468	.465	
Modest			.753	
Soft			.666	
Permissive			.602	
Callous			−.527	
Non-conceited			.464	−.407
Non-threatening				−.768
Relaxed				−.691
Unpleasant				.573
Sleepy				.542
Unfriendly			−.426	.540
Proud				.509

Note. Factor loadings <.4 are suppressed.

Table 8
Factor loadings and communalities based on a principal components analysis with varimax rotation for 29 items regarding the perceived rapport ($N = 83$).

	Feelings and self-efficiency	Rapport and Connection	Evaluation of Listener	Attention allocation
I felt awkward telling the story to the listener.	.873			
I felt uncomfortable telling the story to the listener.	.836			
I found it easy to tell the story.	−.761			
As I told the story, I felt embarrassed.	.733			
I found it hard to tell the story.	.723			
I think I did a bad job telling the story.	.718			
I had difficulty explaining the story.	.692			
I think I did a good job telling the story.	−.671			
Seeing the listener distracted me from telling the story.	.479			
I felt that the listener was bored with what I was saying.	.451			
I felt comfortable telling the story to the listener.	−.425			
I felt I had a connection with the listener.		.846		
I felt I was able to engage the listener with my story.		.828		
I think the listener and I established a rapport.		.804		
I felt that the listener was interested in what I was saying.		.797	,221	
I felt I had no connection with the listener.		−.797		
I think that the listener and I understood each other.		.688		
The listener's body language encouraged me to continue talking.		.662		
I felt I was unable to engage the listener with my story.		−.623		
The listener was warm and caring.		.610		
Seeing the listener helped me focus on telling the story.		.508	.422	
The listener was respectful to me.			.771	
The interaction was frustrating.			−.639	
I was able to say everything that I wanted to say.			.616	
The listener's body language discouraged me from continuing talking.			−.538	.408
I was more focused on myself than on the listener as I told the story.				−.795
I was more focused on the listener than myself as I told the story.				.760
I watched the listener as I told the story.				.639
I ignored the listener as I told the story.				−.326

Note. Factor loadings <.4 are suppressed.

nance, explains 32.60% of the variance (Cronbach's $\alpha = .852$). The second factor, *Positive High-Dominance*, explains 11.20% of the variance (Cronbach's $\alpha = .816$). The third factor, *Positive Low-Dominance*, explains 8.21% of the variance (Cronbach's $\alpha = .748$), and the fourth factor, *Negative High-Dominance*, explains 5.65% of the variance (Cronbach's $\alpha = .792$) (see Table 7).

The factor analysis for the self-reported rapport also revealed four factors. The first factor, *Feelings and Self-Efficiency*, explains 33.30 % of the variance (Cronbach's $\alpha = .850$), the second factor, *Rapport and Connection*, 11.73% (Cronbach's $\alpha = .919$), the third, *Evaluation of Listener*, 8.38% (Cronbach's $\alpha = .735$), and the fourth factor, *Attention Allocation*, explains 5.89% of the variance (Cronbach's $\alpha = .689$) (see Table 8).

Appendix B. Examples for the self-disclosure categorical coding scheme

(1) *no answer:* the subject gives no answer or uses excuses to avoid an answer (e.g. "-um-... I dońt know. Ith + I don't think I've had anything horrible happen to me yet. Ím lucky");
(2) *low-intimacy answer:* the disappointment (or unfulfilled wish) has not sustainably affected the private or business life of the subject (e.g. "I'd like to be wealthy so I think that's my biggest disappointment." or "-um- Not finishing tasks that I start or not following through with things I want to follow through with.");
(3) *high-intimacy answers:* the disappointment (or unfulfilled wish) has sustainably affected the private or business life of the subject (e.g. "hm. e- if Ím really looking at my entire life, I would say -would probably be- that my sister was diagnosed with juvenile diabetes when she was four years old. [...] So we went through a lot during her childhood. A lot of pain. Of me not being able to share candy or things with her. [...], but I would say that that had pro + probably impacted my life -um- almost more than anything else." or "-um- I would say the death of -um- an older brother -um- several years ago -um- this was related to -um- his suicide").

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