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A Look at the Roles of Look & Roles in Embodied Pedagogical Agents – A User Preference Perspective

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Abstract. The paper presents a theoretical framework addressing three aspects of embodied pedagogical agents: visual static appearance, pedagogical role, and communicative style. The framework is then applied to a user study where 90 school children (aged 12-15) in a dummy multimedia program were presented with either an instructor or a learning companion condition. They were then to choose between eight visually different embodied pedagogical agents: four more naturalistic (detailed & 3D-rendered) and four more stylized (simplified & cartoonish). Finally the participants were to choose between a strictly task-oriented versus a task- and relation-oriented pedagogical agent.

The goal of the study was to explore possible relations between the three aspects mentioned above with respect to user preferences. Results were: (i) when the agent was introduced as having a pedagogical role, female students displayed a significant tendency to choose a more stylized visual character, (ii) when the agent was introduced as a learning companion, female students displayed a significant tendency to choose a task- and relation-oriented agent, and (iii) in the case when students had chosen a more stylized character, there was a significant tendency to choose a task- and relation-oriented agent.

The paper also discusses limitations and strengths of the study, and advocates careful descriptions in studies of this kind – especially regarding the notion of visual realism.

Keywords. Embodied pedagogical agent, visual style, communicative style, pedagogical role, realism, naturalism, stylization

INTRODUCTION

Embodied pedagogical agents – visually represented, computer generated characters in pedagogical roles, such as virtual instructors, mentors and learning companions – populate the digital society in increasing numbers. They are found in educational programmes from preschool to university, as well as in broader educational contexts in the form of virtual health coaches, information guides, etc.

Behind these embodied pedagogical agents, we find more or less sophisticated computational algorithms that handle communication, behaviour, animation, and so on.

Other aspects of *embodiment*, such as the physical appearance of agents, often fall outside this computational practice. Yet these are the aspects of design that form our first impressions of an agent and they do influence the way humans interact with them (e.g. Baylor & Kim, 2005). Therefore, it is necessary to also address these aspects of embodied pedagogical agents.

One of the more elaborated discussions on the topic can be found in an article by Ruttkay, Dormann, and Noot (2004), where a large number of design features are listed. One of the four main categories in the list is *embodiment* which designates “all low-level aspects which contribute to the physical appearance of the character” (Ruttkay et al., 2004, p. 32). Embodiment is further divided into two sub-categories: *communication modalities* and *look*. Communication modalities can be regarded as the *dynamic* characteristics of face and body that relate to expressivity via facial displays, body and hand gestures, postures, motion generation, etc. Look refers to underlying *static* visual characteristics of the face and body – shapes, colours, attributes, hair, clothes, graphical style, etc. – that convey gender, age, personality, and so forth.

Compared to other properties of embodied agents, such as movements, gestures, facial expressions and speech, their look or, in our terminology, their *visual static appearance* has (as we have already touched upon above) received relatively sparse attention both in embodied agent research in general and in the domain of embodied pedagogical agents, henceforth abbreviated as *EPAs*, (Gulz & Haake, 2006). There are exceptions, of course. Baylor and collaborators are among the (few) research groups that for a long time have approached several aspects of visual appearance, such as visual gender, attractiveness and “coolness” as well as visual realism (Baylor 2005a; Baylor 2005b; Baylor & Kim 2004; Baylor & Plant, 2005; Baylor, Rosenberg-Kima, & Plant, 2006).

Visualizations of gender, attractiveness as well as visual realism have also been examined by Nowak and collaborators (Nowak & Biocca, 2003; Nowak & Rauh, 2005, 2008). Yet another influential researcher is Bailenson, who together with collaborators has investigated user effects of visual realism as well as of height and attractiveness in avatars (Bailenson et al., 2003; Bailenson et al., 2005; Yee & Bailenson, 2007).

In relative terms, static visual appearance is nevertheless an unexplored domain. Furthermore, when visual appearance is researched, it is rather often approached in a simplified manner losing sight of the complexity of the notion. For example “visually realistic” can be used in a sense that mixes up distinctions such as: fantasy or non-fantasy, human-like or non-human-like, 3D or not 3D, detailed or non-detailed, cartoonish or non-cartoonish. This tendency to speak of “visual realism” in a simplified manner easily leads to unwarranted over-generalizations about “visually realistic” agents.

From a pedagogical perspective, the relative lack of detailed research on visual appearance aspects of embodied pedagogical agents is unfortunate since there is reason to believe that the visual appearance of an agent may considerably affect learner expectations, attitudes, understanding and motivation. Such influences are well known and documented in related domains such as theatre, animated film, advertisements, as well as in research on interaction between human beings (Gard, 2000; Haake, 2006; Kalick, 1988; Lassetter, 1987; Schneider, Hastorf, & Ellsworth, 1979).

This is not to say that visual appearance is *more* important than other aspects of embodied agents. For one thing, without the development and refinement of computer hardware, algorithms, and computational models of behaviour, dialogue and intelligence, there would be no embodied agents whatsoever. Nevertheless, even with an ingeniously designed EPA from a computational perspective, an inadequate visual appearance can *decrease* the pedagogical benefits considerably. For instance, Baylor and collaborators have shown that a carefully chosen visual appearance of an EPA can influence both students’ transfer of learning (Baylor & Kim, 2005) and their belief in their own competence in approaching a certain subject matter (Baylor, 2005b).

If one is interested in how learners are affected by different visual appearances of EPAs, this should not be approached as a separate issue in a “vacuum” but in relation to contextual variables

and/or other relevant characteristics of EPAs (as is also generally done in the studies referred to above).

In the present article we will approach aspects of *visual static appearance* of EPAs in relation to aspects of their *communicative style* and *pedagogical role*. First these three aspects will be presented and discussed. Then we discuss in greater detail the sub-aspects of EPAs that were manipulated in the user study presented in the second half of the article: (i) different aspects of graphic expressions (visual static appearance) (ii) strict task-orientation vs. task- and relation-orientation (communicative style), and (iii) authoritative instructor vs. non-authoritative learning companion (pedagogical role). Overall, the topic of visual static appearance is given prominence throughout the article.

Beside from generating results, the study exemplifies how the theoretical framework of the article can be applied. In particular, we go into more detail than is common regarding visual aspects of EPAs, and scrutinize the design choices we have made. Furthermore, in discussing the results of the study that indicate that the three sub-aspects or variables involved are related from the perspective of user/learner responses, we emphasize that this result strictly only applies to these specific design aspects and variables. On the other hand, the projection into the future is that by putting together pieces of evidence from different studies, *that are detailed and specific in what is actually being varied and evaluated*, we will be able to come up with tentative guidelines and generalizations regarding how different aspects of EPA relate to each other from the perspective of learners.

VISUAL STATIC APPEARANCE

Design Considerations for Visual Static Appearance

From a positivistic approach visual static appearance may be regarded as a multidimensional design space that, although immensely complex, could be analytically approached. From the perspective of design practices, visual static appearance is better described as a holistic set of more or less elusive and continuously changing, context-dependent, qualities. But this perspective can hardly be subdued to any analytical deconstruction and, as a consequence, any kind of academic guidance can only hope for high-level *design topics* or *design considerations* to be addressed during the design process.

Following this line of reasoning, we propose an outline with three basic high-level design considerations concerning visual static design in EPAs: basic model, physical properties and graphical style. These design considerations are in line with and elaborated from the discussions around a more integrated design approach for virtual characters reported in Gratch et al. (2004) and further developed in Ruttkay, Dormann and Noot (2004).

Basic model

A first topic to consider concerning the visual static appearance of an EPA is a *basic model* or constitution for the character. The reason to employ an EPA is, in most cases, to add or strengthen social and communicative features in a pedagogical system (Johnson, 2003; Johnson et al., 2005; McQuiggan, Mott, & Lester, 2008; Moreno et al., 2001).

In practice this means that an EPA, as a minimum requirement, will need eye(s) and a mouth.¹ The eye(s) and the mouth will, in the general case, be contextualized within a face, often together with a body or part of a body. To model these features – a face with eye(s) and mouth and a potential body – we can draw upon the basic constitution of: a human, an animal or creature, an inanimate, non-living object, a fantasy concept or a combination of these entities. In Figure 1 the basic model is exemplified by the *MS Agent Package* (included in Microsoft Office until 2003) and the “late” *MS Office Assistant*.

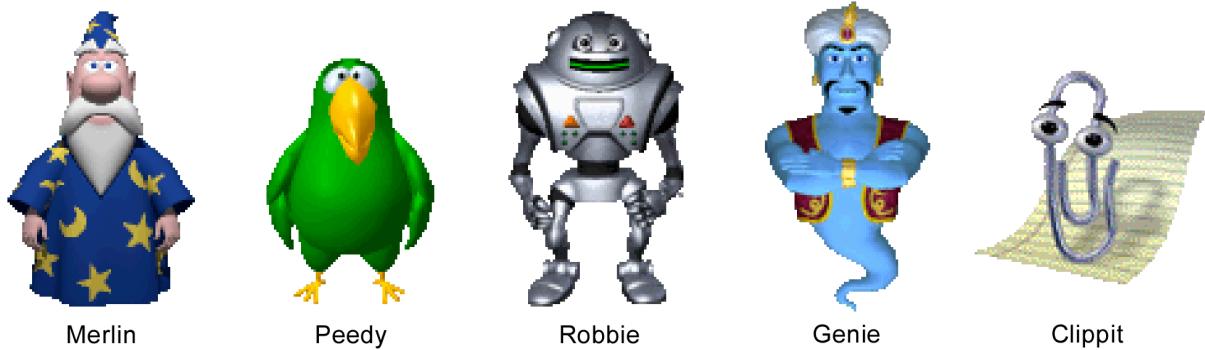


Fig.1. The characters from the *MS Agent Package* and the *MS Office Assistant* are well suited to exemplify the proposed basic model: *Merlin* (a human), *Peedy* (animal/creature), *Robbie* (a combination of a general human constitution, inanimate parts, and the fantasy concept of the robot), *Genie* (a combination of a human and a fantasy concept), *Clippit* (an inanimate object).

Two things should be emphasized here: First, the possibility to model an embodied agent upon different creatures and inanimate objects relies heavily on the power of anthropomorphism. Second, the qualities of the basic model are only discussed in relation to static visual qualities, and it should be observed that dynamic visual qualities mediated by animation in general reinforce the experience of anthropomorphism by mimicking schemas for human behavioural and communicative strategies.

Physical properties

A second design consideration regards what we chose to denote as *physical properties* of an EPA such as: body type, face shape, skin colour, hair cut and hair colour, clothes and various accessories (Figure 2). Visual representations of gender, age, ethnicity, profession and so on, can emerge through (combinations of) such properties.

The knowledge about different effects of these physical properties is not entirely impenetrable, and there is much empirical data in academic disciplines such as social psychology and behavioural science. In addition there is a large body of experience-based knowledge in areas such as film, theatre, graphic design, and advertising (Gulz & Haake, 2006).

¹ Hypothetically, one could for example imagine a virtual pedagogical agent in the form of a plain cube – but such a case is rather strained and better dismissed as an odd exception.

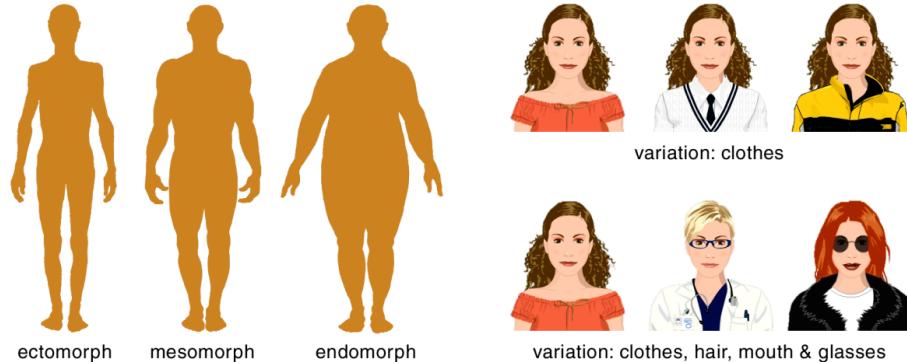


Fig. 2. Examples of *physical properties*. Left: the three body types of ectomorph, mesomorph, and endomorph (Sheldon, Stevens, & Tucker, 1940). Upper right: three different outfits transforming the experience of one and the same character as to age, personality, social position, education, etc. Lower right: variations of the same character by means of outfit, hair cut, hair colour, and use of lipstick and glasses, dramatically changing the experience of the character and characteristics attributed. (The six characters to the right were put together by means of the *SitePal Demo Tool*, www.sitepal.com.)

It is important to be aware that *whatever choices* one makes regarding the physical properties of an EPA, these properties will carry social, cultural, psychological and affective baggage. In other words, there is no such thing as a visually *neutral* character (Gulz, Ahlner, & Haake, 2007; Haake & Gulz, accepted; Isbister, 2006) – and nevertheless, to quote Moreno and Flowerday (2006), “the vast majority of instructional interfaces assign arbitrary animated pedagogical agents assuming that the choice of an agent representation is psychologically neutral” (Moreno & Flowerday, 2006, p. 191). This unawareness may result in non-optimal and restrained pedagogical adequacy and efficiency of EPAs as well as hamper scientific studies. As a general recommendation, one ought to be observant whenever a certain EPA is claimed to have been evaluated against a presumably neutral EPA (taken to be some kind of baseline). Consequently, it is important to pay close attention to all the physical properties of EPAs involved in such comparisons, since all aspects that are *not focused on* need to be *comparable* between the evaluated characters. As an example, it would be a flaw to set up a comparison with a focus on gender that involves a male versus a female character, where one of them is substantially fatter than the other, or where one but not the other wears high-fashion clothing.²

Graphical style

The first two design considerations described above can to some extent be regarded as *conceptual design topics* in the sense that they may be verbally and analytically identified, described, discussed and decided upon in the design process.

² On the other hand, one may have the goal of comparing two distinct and complete *personas* that differ in a large number of aspects. This is of course legitimate and can be highly valuable, yet in this case the comparisons in question are carried out on a more holistic level and should be described, evaluated and discussed as such.

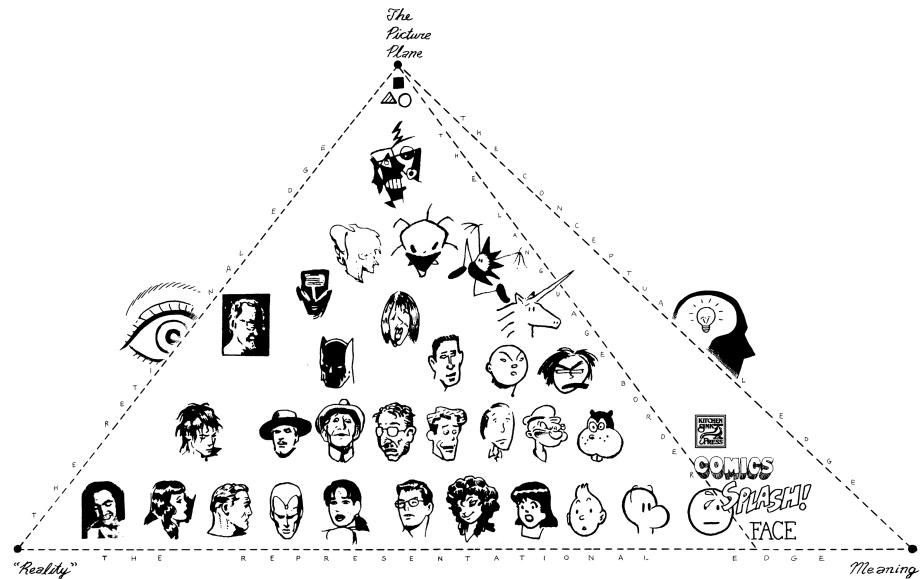


Fig.3. An edited reproduction of the design space of visual iconography (*The Big Triangle*) described by Scott McCloud in his book *Understanding Comics: The Invisible Art* (McCloud, 1993). While this is an ingenious way to set up the design space of graphical style, there is no predictable power to correlate a certain graphical style to a well defined response.

This is not as easy with design considerations concerning graphical style (Figure 3). Here we enter a highly complex design space where, for example, small changes in the qualities of the line (Figure 4), shadings, and proportions – relating to artistic and aesthetical properties of the medium as well as the skill of the graphical designer – may completely change the visual experience in diverse and unpredictable directions (Gulz & Haake, 2006; McCloud, 1993).



Fig.4. The inked line has almost unlimited possibilities with a potential of tremendous visual power (McCloud, 1993, p. 126).

For the purpose of embodied agents, the vast and complex design space of graphical style may seem impossible to navigate (cf. Figure 3). In order to nevertheless relate to this space, one should bear two things in mind: (i) it takes a skilled graphical designer to manoeuvre in (at least) parts of this immense design space, and (ii) the graphical style may have significant but unpredictable effects on

the perceived visual experience. In other words: one should acknowledge and pay attention to the qualities of graphical style.

With this said, some aspects of graphical style may be both possible and worth the effort to explore. With regard to EPAs, *degree of detailedness* and *degree of naturalism* may be possible and meaningful to analyze and evaluate – and since we address these two aspects in our study, we will present them both in some detail.

Graphical style: degree of detailedness

Beginning with a standard greyscale photograph of a face this can be referred to as highly detailed. By reduction, the photo may be converted into a contour line representation or a two level posterized representation of the very same face (Figure 5, left). These two examples illustrate a straightforward algorithm based reduction of the information contained in the original greyscale photo where the different representations can be described as more and less detailed. However, in design practice, a “reduction of detail” normally goes hand in hand with complex changes and deviations as to the graphical expression or style (Figure 5, right).

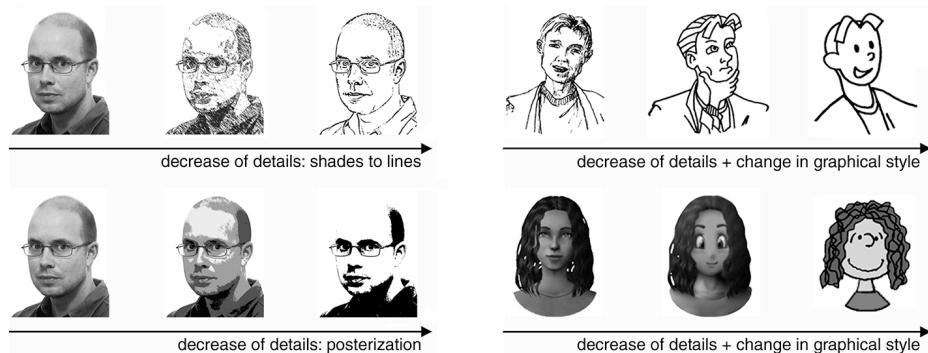


Fig.5. Graphical style: degree of detailedness. Left: two examples of straightforward reduction of detail. Right: two more complex examples where a reduction of detail is combined with divergent, non-linear changes as to graphical style.

From a pedagogical point of view, the degree of detailedness is of interest since the amount of detail may correspond to differences in cognitive processing. For example, the reduction of detail promotes increased distinctness of facial expressions which may support a more rapid and accurate processing and interpretation (Cook, 1979; Isbister, 2006). The simplification may furthermore facilitate subjective self-identification which is a fundamental strategy to engage the reader of comics (Gulz & Haake, 2006; McCloud, 1993).³

³ Herge's Tintin (http://en.wikipedia.org/wiki/The_Adventures_of_Tintin) is maybe one of the most splendid examples of this self-identification phenomenon. The Tintin character is identified by the tuft and the clothes, whereas the face is extraordinarily simple (and the personality diffuse and elusive) – and actually “Tintin” associates with “nothing” in French. Correspondingly, the rest of the characters are more visually detailed and/or have more prominent personalities. Furthermore, Herge uses the *masking effect* contrasting the more simplified and stylized characters against a rather naturalistic background – making further use of the “subject vs. object” phenomenon (Gulz & Haake, 2006; McCloud, 1993).

Graphical style: naturalism – stylization

According to our proposed design space of graphical style, the same conceptual character with respect to a “basic model” and “physical properties” may be visually represented in numerous variations. By manipulating the qualities of line, shape and colour, each single variation (i.e. each graphical style) conveys its own non-linear, complex, dynamic, cultural and context dependent impact on the individual interpretation processes of the receiver.

This may be a disappointing conclusion if the aim is to gain some kind of control or analytical power over aesthetic qualities. However, in the more specific domain of embodied pedagogical agents there is useful knowledge to gain by focussing on certain aspects of the design space of visual iconography (*The Big Triangle*) described by McCloud (1993) (see Figure 3). By collapsing the two dimensions of “meaning” and “picture plane” in the *pictorial plane* into a single (though complex) dimension of “stylization”, we can construct a dichotomy of *naturalism* versus *stylization*. Naturalism will here constitute a well-defined end point of an immense and diverging design space of different stylized graphical expression since a representation cannot be more naturalistic than naturalistic.

In Figure 6, this dichotomy is exemplified by the same conceptual character (a young female) visualized in two more or less “naturalistic” versions and four different “stylized” versions.

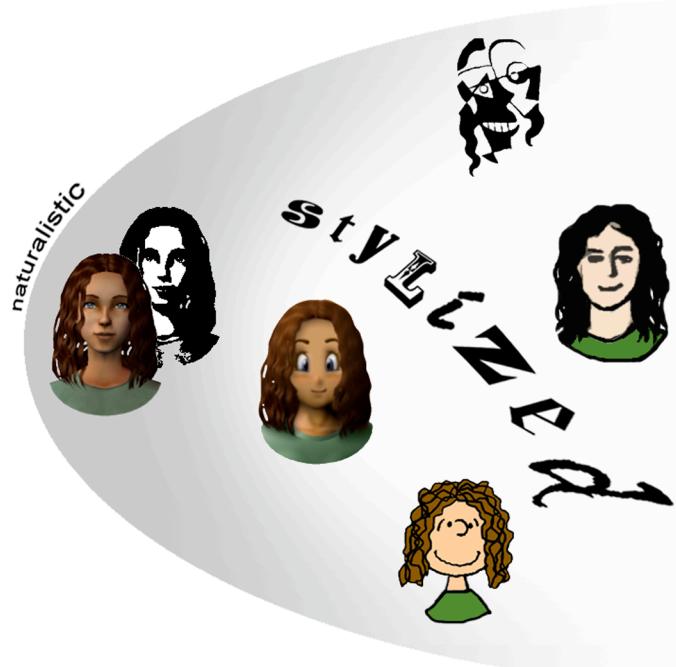


Fig.6. A design space of *naturalism* vs. *stylization*. The two figures to the left (the “naturalistic” corner) differ in degree of detailedness (cf. Figure 5) but both are to be referred to as “naturalistic”. This design space is derived out of the *pictorial plane* by Scott McCloud (1993) but is simplified in order to emphasize the dichotomy of *naturalism* vs. *stylization* (thus ignoring the complexity of different stylized expressions).

As to the two “naturalistic” representations (based upon the style of *The Sims 2*) they differ in degree of detailedness, but are both to be regarded as more or less naturalistic. The leftmost character

corresponds to a standard photo while the other character is reduced as to detailedness (cf. Figure 5); a spotlight will produce the same effect as the rightmost of the two naturalistic representations.

The four “stylized” representations vary in expressive style inspired by: *Peanuts* (simplified, whimsy and humorous), *Manga/Dragonball* (cute, emotional and friendly), *Hernandez* (underground, rebellious) and *Picasso* (abstract and intellectual). Also observe that the design space of “stylization” in Figure 6 does not convey any actual information about the relation between different kinds of stylization. Any attempt to fix coordinates is meaningless since the effects on the user of different graphical styles are everything but well-defined and linear.

It should furthermore be noted that a *3D-rendered* representation does not automatically equal visual naturalism, but is basically an aspect of graphical style that can be more or less detailed as well as more or less stylized.⁴ To exemplify, a 19th century (2-dimensional) black-and-white photo is a far more naturalistic representation than the low polygon 3D-rendering of the embodied agent *REA* (Bickmore, 2003) or 3D-rendered cartoon characters like *Mr Incredibile* in the animated film *The Incredibles* (Walt Disney Pictures & Pixar Animation Studios, 2004).

... And What About “Realism”?

At this stage we are ready to approach the concept of visual “realism” with respect to visual static appearance. Considering the embodied agent literature, the term “visual realism” or “visually realistic” is used in different ways that can be mapped to one or some of the design considerations proposed in this article. In an attempt to grasp a common concept of a “realistic embodied agent”, we propose the following definition: (i) modelled upon some prototypical basic model of a human, (ii) adequate and relevant as to physical properties of the chosen basic model, (iii) detailed, and (iv) naturalistic.

It is problematic that many studies, in presenting their material and their conclusions, lack in specificity as to what is actually meant by the term realism/realistic. Sometimes comparisons regard a character modelled upon a human versus a character modelled upon a fantasy concept, but where both are actually perfectly naturalistic in relation to their basic models and thus equally realistic given a fictive context of e.g. a science fiction movie.

Sometimes the difference is in the degree of detailedness, but combined with a difference as to naturalism-stylization that is not mentioned or problematized, and so on. Nevertheless, results are often generalized in terms of “visual realism” versus “visual non-realism”. An illustrative example is reported by Gustavsson and Czarniawska (2004). At a conference, there was a discussion on the development of the interactive assistant *Olga* (Figure 7). The linguists in the development team opted for a “more realistic” *Olga*, since they insisted that in order for *Olga*’s speech to be understood, *Olga* must be made as humanlike as possible. *Olga*’s lip movements, in particular, had to correspond to those of a living human. The designers in the development team, on the other hand, were of the opinion that the comic styled *Olga* was actually more humanlike as well as attractive than the “more realistic” 3D-*Olga*, who they thought looked like Frankenstein’s monster (an opinion shared by most of the conference audience).

⁴ When it comes to spatial interaction, on the other hand, the 3D experience must be considered a fundamental aspect for the simulation of a “virtual reality”.



Fig.7. The interactive information assistant Olga.

Our point with this example is that none of the Olgas (Figure 7) are “realistic” but instead constitute two different visually “stylized” representations where both could be referred to as: (i) modelled upon the same combination of a human and a fantasy concept of an alien from outer space, (ii) comparable as to physical properties (with the exception of the neck and the tie), (iii) rather comparable as to a low degree of detailedness, (iv) different as to graphical style: 2D rendered, the shapes are a bit squarish/angular, some visual freedom as to postures *versus* 3D-rendered, the shapes are softer/rounder, constrained (stiff) as to postures. This example then indicates that the notion of “realistic” sometimes is more of a non-reflected idea than an actual and explicit visual quality (“If it’s 3D, it’s realistic!”).

Realism and Pedagogical Effects

The number of empirical studies on user responses towards more or less visually realistic EPAs is actually rather limited (Gulz & Haake, 2006). Furthermore, as discussed above, the visual variables in these studies are often not sufficiently controlled and described or even considered. Regardless of this, there is a relatively extensive theory based discussion pro and con visual realism in virtual characters that exposes a number of arguments *for* as well as *against* realism in visual static appearance in EPAs. (For an overview of this, see Haake & Gulz, 2006.)

In view of the study to be presented in this paper, it is relevant to consider the arguments for and against visual realism regarding the potential of virtual characters to establish some kind of (social) relations with learners.

If we start with the pro side, it has been proposed that a high degree of visual realism will increase user/learner *involvement* and sense of presence in a digital environment, and therefore even be a condition for human co-operation with embodied agents (Welch et al., 1996). Another argument states (Wilson, 1997) that a high degree of visual realism is important in order to elicit users’ curiosity about the personality of a character, which in turn can be regarded as an important condition for the development of a relationship between a learner and an EPA. Furthermore it is sometimes argued that visual realism will facilitate learners’ self-identification with an EPA (Baylor & Kim, 2005).

On the other side, we find the approach (mentioned earlier in the section on “degree of detailedness”) arguing that a “non-realistic” representation may facilitate self-identification and involvement. In these arguments “non-realistic” is probably best described as a character with a low degree of visual detailedness in combination with a simplified, stylized graphical representation related to the lower right base of *the design space of visual iconography* (Figure 3), e.g. the graphical style of Charles Schulz’s *Peanuts*.

According to McCloud (1993), people will more easily get *involved* with and also be likely to *project themselves* into a visually simplified character than in a highly detailed and naturalistic character. The highly detailed and naturalistic character is more of a visual and socio-emotional fact, which does not leave much for a user to elaborate on and fill in, whereas a stylized character invites elaboration by the user, who may fill in from his or her own personal and subjective experiences (Haake & Gulz, 2006). In McCloud's wordings, the stylized character is "an empty shell that we inhabit" (McCloud, 1993, p. 36).

We will return to these different framings and arguments in the discussion of our study.

PEDAGOGICAL ROLES

In our everyday world, we can find a large variety of pedagogical roles. The following list, as well as the overall categories of more and less authoritative roles, is based on a paper by Chou and collaborators (Chou, Chan, & Lin, 2003), to which we have added some pedagogical roles as well as some examples of EPA correspondences for certain roles.⁵

More authoritative roles:

- the tutor, e.g. the agent Autotutor (D'Mello et al., 2006)
- the coach, e.g. the agent Laura (Bickmore, 2003)
- the guide, e.g. the agent PPP Persona (André, Rist, & Müller, 1998)
- the instructor, e.g. the agents Steve (Shaw, Johnson, & Ganeshan, 1999) and Adele (Johnson, Rickel, & Lester, 2000)
- the mentor (e.g. Baylor & Kim, 2005)
- the expert (e.g. Baylor & Kim, 2005)

Less authoritative roles:

- the competing co-learner (e.g. Chan et al., 1992)
- the collaborating learning companion, e.g. the agent Sam (Ryokai, Vaucelle, & Cassell, 2003)
- the tutee, e.g. the teachable agents Bill and Betty (Biswas et al., 2005)
- the peer tutor that can alternate in the role of being a tutor and a tutee (e.g. Chan & Chou, 1997)
- the troublemaker (e.g. Aimeur & Frasson, 1996)
- the critic, the criticizing co-learner (e.g. Hietala & Niemirepo, 1998)
- the clone (e.g. Chang et al., 1999)

We believe that this classification into more and less authoritative roles together with the listed examples gives a satisfying overview of the different pedagogical roles of interest for EPAs. Focusing on the individual specified pedagogical roles, it is not obvious that another kind of classification would add much of interest. Nonetheless, in parallel to our arguments on the visual static appearances of EPAs, we argue that pedagogical roles, when they are involved in user evaluations of EPAs, should also be spelled out in detail. The reason is simply that these role concepts listed above are not clearly defined. The boundaries between them are often diffuse and change between cultures and sub-cultures. A notion such as authoritativeness certainly varies between cultures, and also within cultures we find

⁵ Note that Chou et al.'s (2003) classification also applies to pedagogical agents that are not visually embodied, e.g. classical intelligent tutoring systems.

variations. For instance, many of us have experienced mentors, coaches and teachers that have varied more or less with regard to their authoritative style.

As an instructive example of a study that provides this specificity, we would like to hold forth the paper *Simulating Instructional Roles* by Baylor and Kim (2005). The study presented in this paper involved the three pedagogical roles of *Expert*, *Mentor* and *Motivator*.⁶ For each of the roles the following was designed and specified: (i) a script where the relation between information and encouragement is varied between roles (primarily informative for the Expert, primarily encouraging for the Motivator, and both informative and encouraging for the Mentor), (ii) an emotional or affective style varying between the roles (no emotional expressions in the Expert versus a variety of emotional expressions for the two other roles), (iii) animation gesture schemes (deictic gestures in the Expert, emotional expressive and highly-animated gestures in the Motivator, and a mixture of these gestures in the Mentor), and (iv) visual static appearances (older, serious looking, formally dressed Expert, a young, smiling, casually dressed Motivator, and the Mentor being in between).

In the study, these particular role instantiations of EPAs were empirically validated in the sense that it was established that learners perceived the embodied agents as having these intended pedagogical roles. Furthermore, it was confirmed that the three agents had divergent effects on learning and motivation according to their roles. The Expert agent led to increased information acquisition, the Motivator led to increased self-efficacy, and the Mentor led to overall improved learning and motivation (Baylor & Kim, 2005). The possible effect of visual appearance on these results was not addressed in this particular study.

COMMUNICATIVE STYLE

The notion communicative style is used to refer to a number of different dimensions such as degree of argumentativeness (Myers, 1998); degree of assertiveness (Myers, 1998), descriptive vs. narrative (Kemper et al., 1990; Berman & Slobin, 1994), extrovert vs. introvert (Janvier & Ghaoui, 2003), separate vs. connected (Galotti et al., 2001).

It is probably evident to all who have been to school or received education of some kind that human pedagogues differ on such aspects of communicative style. Given that most EPAs also communicate verbally, in text and/or speech, it can be relevant to consider dimensions of communicative style in the development and evaluation of EPAs. Here again, the most important issue for an evaluation is, in our view, that the communicative style dimension used and evaluated is described in sufficient detail. The work of Bickmore and MIT Media Lab provides exemplary specificity on the aspects of communicative style implemented and studied in the embodied agents *REA* and *Laura*, where the former is a virtual real estate agent who interviews potential home buyers and shows them around houses and the latter a virtual coach or advisor for individuals who want to increase their physical activity.

The communicative style aspect used in our study is largely inspired from Bickmore's work. The definitions we provide below of *strict task-orientation* vs. *task- and relation-orientation* is largely based on Bickmore's categories: (i) *task condition* vs. *social condition* (Bickmore, 2003), and (ii) *relational* vs. *non-relational* (Bickmore, 2003).

⁶ Note that motivator is not included in the list above, but is close to a collaborative learning companion.

Given a pedagogical context, our definition of *strict task-orientation* vs. *task- and relation-orientation* is as follows:

- A pedagogue (instructor, mentor, collaborative learning companion, etc.) who is *strictly task-oriented* sticks closely to the learning task, provides information in a succinct and objective way and focuses on matters of fact. He or she is strictly professional and does not bring in additional elaborative issues that are not clearly related to the knowledge domain and learning task at hand.
- A pedagogue (instructor, mentor, collaborative learning companion, etc.) who is *task- and relation-oriented* does, apart from contributing to the solving of the learning task, also focus on the developing of a social relationship with the learner; he/she is more subjective, personalizes the task and focuses less strictly on the task in the dialogue. The dialogue may also contain small-talk, conversational storytelling, getting-acquainted-talk, joke-telling, sharing of personal experiences, preferences and opinions, etc.

Returning to REA and Laura, both agents have been developed in two versions that can be mapped on the two communicative styles just described, even though the pedagogical context is more prominent in the case of Laura. The task condition REA can be mapped on a strictly task-oriented virtual estate agent, and the social condition REA on a task- and relation-oriented virtual estate agent. The non-relational condition Laura can be mapped on a strictly task-oriented virtual coach, and the relational condition Laura on a task- and relation-oriented virtual coach.

Additionally the two Lauras also differ in non-verbal aspects. In the relational version there is more of forward lean, body and facial orientation towards the partner, and more smiling, nodding, gazing, gesturing, etc. Certain voice features are also more often present such as greater warmth and expressiveness, reinforcing interjections and more variation in pitch, amplitude, duration and tempo (cf. Bickmore, 2003). We have not included these non-verbal aspects in our definition above, primarily since the possibilities and resources for implementation in our study set-up were limited, and to only describe them would hardly be meaningful. In a fuller developed implementation of strict task-orientation vs. task- and relation-orientation, they should be included since there is empirical support for this from studies of communicative styles in human beings (Bickmore, 2003).

Also Baylor and Kim (2005) made use of a similar pair of communicative styles when implementing their *Expert* and *Mentor* agents mentioned previously. The *Expert* agent was task-oriented in the sense of (only) providing accurate information in a succinct way. He also spoke in a formal and professional manner with authoritative speech, showed no affect and was limited to deictic gestures with little expressiveness in the animation. The *Mentor* agent was task- and relation-oriented in the sense of working more closely together with the learner and with the goal of demonstrating competence to the learner while simultaneously developing a social relationship to motivate the learner. Gestures incorporated both deictic and emotional expressions, and the agent showed various affects such as confusion, approval, excitement and pleasure.

VARIABLES OF THE STUDY

After this exposition of visual style, pedagogical role, and communicative style, we now provide a description of the variables used in our empirical study.

Visual Appearance: Detailed & 3D-Rendered vs. Simplified & Cartoonish

The initial approach to the design of the characters used in the study was to vary “degree of visual realism” by using two sets of characters. Character set 1 made use of a “detailed” and “naturalistic” representational form (e.g. the style of *The Sims 2*), and character set 2 made use of a “semi-detailed” and “semi-naturalistic/semi-stylized” representational form (e.g. the style of *Marwin Comics*), (Figure 8).

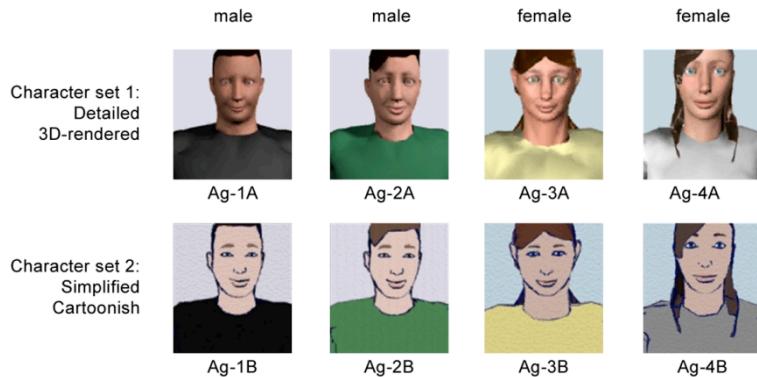


Fig.8. The two sets of characters (top row and bottom row respectively) used in the study.

Based upon our proposed approach to visual static appearance, we will describe below the two sets of characters used in the study in more detail. The notion “neutral” should here be interpreted as: not visually deviating and/or conspicuous for the group of people in the study.

Character Set 1

- a) Basic model: A human.
- b) Physical properties: Age 20-25, average/neutral body related aspects, neutral hairstyles, neutral clothes (t-shirts), Caucasian ethnicity, overall similarity except for gender.
- c) Graphical style: Striving for “realism”, the characters can be described as detailed and naturalistic with a 3D-shading effect (cf. *The Sims 2*). Henceforth the graphical style of character set 1 will be referred to as “naturalistic” and/or “detailed & 3D-rendered”.

Character Set 2

Same as character set 1, except for:

- d) Graphical style: These characters are simplified (semi-detailed) and less naturalistic (semi-naturalistic/semi-stylized) with a cartoonish style (cf. *Marwin Comics*). Henceforth the graphical style of character set 2 will be referred to as “stylized” and/or “simplified & cartoonish”.

Additional design comments

The facial forms of all the characters were modelled to be as similar as possible given the condition that one should perceive them as different individuals. Age related features were held constant. Body shape and eye colour on the male agents were identical. The female agents had small differences in body shape, the same hair length, and the same eye colour. Clothing (t-shirts) was simple and discrete in all agents. The underlying design rationale was to make all characters relatively “neutral” with

respect to the actual group of participants, as well as comparable between the four characters. By this we mean that we strived to avoid extremes and avoid any character(s) sticking out with respect to visual stereotypes (attractiveness stereotypes, personality stereotypes, gender stereotypes, etc.). Pre-tests of the characters confirmed/validated this goal. However, we are not suggesting that the visual characters are neutral in any absolute sense. They certainly carry social and cultural connotations as to gender, age, ethnicity, etc. (Gulz, Ahlner, & Haake, 2007).

Another rationale behind the visual static design decisions was to adhere to the association of “computer characters” as being “realistic” (naturalistic, relatively detailed and 3D-rendered) and the association of “comic characters” as being simplified, cartoonish and “flat”.⁷

Summing up, the visual variation between the two character sets can be described as differences in graphical style: detailed & 3D-rendered vs. simplified & cartoonish.

Pedagogical Role: Expert/Instructor vs. Learning Companion

The two pedagogical roles varied in the study were an authoritative *instructor* versus a non-authoritative, collaborating *learning companion*.

More specifically the pedagogical roles were presented in the form of *a chief editor at a magazine* and *a companion journalist*, with the student being herself a journalist who is going to be sent to various European countries to do article research on different topics.

These roles were not implemented in any actual interaction between learners and agents but were provided within the multimedia program in the form of verbal scenarios. (These scenarios had been developed together with teachers who work with students of the actual age group, in order to ensure that the linguistic style would be adequate and easy to understand.)

In the *instructor version* of the program, the student was presented with the narrative that there was a chief editor in London who would be her or his instructor. The chief editor would formulate the missions, orient the journalist (the student) and provide necessary information at critical stages. The journalist (the student) should continuously report back to the chief editor who would evaluate the reports and describe what is well done and what should be improved and further worked on. Furthermore, it was implied that the chief in question had high standards and demanded much from the journalists.

In the *companion version* of the program the student was presented with the narrative that there would be a companion journalist with whom s/he would conduct the missions. The student was also told that it would be important to co-operate with the companion, who might not be completely reliable when it comes to knowledge but would provide some of the keys necessary to complete the missions.

Communicative Style: Strictly Task-oriented vs. Task- and Relation-oriented

The two styles we chose to include in our study are based on the definitions given above in the section “Communicative Style”: (i) a *strictly task-oriented* communicative style versus (ii) a combined *task- and relation-oriented* communicative style.

As in the case of pedagogical role, these were not implemented in the form of an interactive session between user and agent, but were provided by an experimental leader in the form of two verbal

⁷ This association was also confirmed in interviews.

scenarios. (Again, the scenarios had been developed together with teachers who work with students of the actual age group in order to ensure that the linguistic style would be adequate and easy to understand. The exact wordings of the two scenarios also varied somewhat depending upon the pedagogical version of instructor or companion.)

- (i) One scenario described an instructor/companion who focuses on the mission and sticks to this, deals with matters of fact in an efficient way, is strictly professional and does not invest time in establishing a more personal relationship with the user (the student).
- (ii) The other scenario described an instructor/companion who is more social and apart from working on the professional tasks also supplies information about him or herself, tells about former missions, her/his family and friends, interests, etc. and seeks to share stories, opinions on various things and personal experiences with the user.

METHOD

Goal of the Study

The goal of the study was to explore users' choices of EPAs as to their *static visual appearance* (detailed & 3D-rendered vs. simplified & cartoonish) and communicative style (task-oriented vs. task- and relation-oriented), in relation to their pedagogical role (instructor vs. learning companion). In particular, we wanted to explore possible relations between these variables as to user responses.

Experimental Design

The participants were presented with one of two alternative versions of a pedagogical multimedia program with regard to the *pedagogical role* of the embodied agent: an *instructor* version or a *companion* version. The participants were then to make two choices.

- (i) First regarding the *static visual appearance* of the pedagogical agent: two male and two female characters, each presented in two *graphical styles*: detailed & 3D-rendered vs. simplified & cartoonish (cf. Figure 5), altogether eight alternatives (Figure 8).
- (ii) Second regarding the *communicative style* of the agent (*task-oriented* vs. *task- and relation-oriented*).

This yields an experimental set-up, where *pedagogical role* is the independent variable, and *static visual appearance* and *communicative style* are the dependent variables (Figure 9).

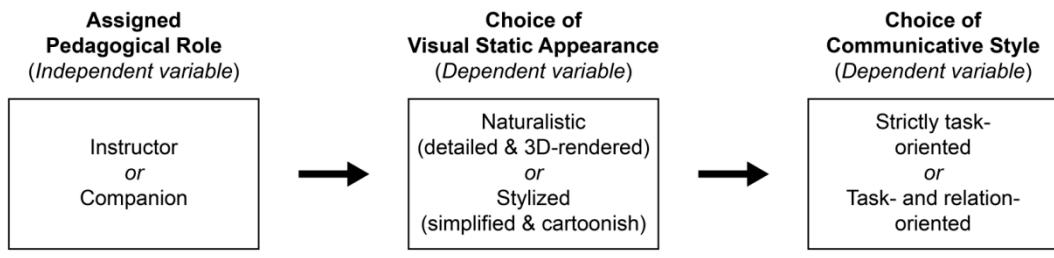


Fig.9. Experiment flow.

Hypotheses

Three hypotheses were formulated.

Hypothesis 1: The *visual style* preference will depend on the assigned *pedagogical role* of the embodied agent in the following manner: the *instructor* version will yield a preference for a *detailed & 3D-rendered (naturalistic)* agent, and the *companion* version will yield a preference for a *simplified & cartoonish (stylized)* embodied agent.

Hypothesis 2: The *communicative style* preference will depend on the assigned *pedagogical role* of the embodied agent in the following manner: the *instructor* version will yield a preference for a *strictly task-oriented* embodied agent, and the *companion* version will yield a preference for a *task- and relation-oriented* embodied agent.

Hypothesis 3: The *communicative style* preference will depend on the *visual style* preference in the following manner: a preference for a *detailed & 3D-rendered (naturalistic)* embodied agent will yield a preference for a *task-oriented* agent, and a preference for a *simplified & cartoonish (stylized)* embodied agent will yield a preference for a *task- and relation-oriented* embodied agent.

Comments on the hypotheses

Thus, the first and third hypotheses concern the choice of visual style in relation to the pedagogical role of the agent, and in relation to the choice of communicative style. These hypotheses are based on pilot studies (described in Gulz & Haake, 2005) as well as on theoretical considerations (Gulz & Haake, 2005; McCloud, 1993).

According to the theoretical framework proposed by McCloud (1993) cartooning and simplifying is framed as a way to *amplify the meaning* of an image. For instance, the meaning of facial expressions may be amplified, and thereby afford more powerful socio-emotional communication. This, in turn, is a fundamental element in companionships and friendships but not so in boss-subordinate relationships. Similarly socio-emotional communication is integral to relation-oriented but not to strictly task-oriented communication.

Another theoretical consideration presented by McCloud (1993) is the *universality* of stylized and simplified representations. Whereas a photorealistic picture represents only one individual, an abstract cartoon image might represent millions of people. An abstract cartoon image is therefore more likely to afford feelings of “being related to” and of identification. These, again, are fundamental and inherent aspects in companionships and friendships, but not in boss-subordinate relations. Likewise they are aspects integral for relation-oriented but not for strictly task-oriented communication.

It should be observed, however, that there are *other theoretical considerations* that do not lead to the hypotheses formulated in this article, but rather to their reverse. *Media richness theory* instead predicts that emotionally engaged communication, in contrast to strictly task-oriented communication, is facilitated by *visual realism* in the representation of actors (Daft & Lengel, 1986; Dennis & Kinney, 1998; Kang, Watt, & Ala, 2008). It predicts, that it is more likely that a more visually naturalistic character compared to a more stylized one will evoke associations such as: “this could be a friend of mine”, “this is someone I can imagine having a friendly chat with”, and “this is someone that I could feel close to”, etc. (Kang, Watt, & Ala, 2008). The naturalistic representation, being richer in visual cues and providing higher visual fidelity, increases social presence, which involves emotionally engaged communication and feelings of closeness and relatedness to one’s communicative partner. In

other words, more naturalistic character representations facilitate aspects integral to companionships (in contrast to relations with a more authoritative and distanced person) as well as aspects integral to relation-oriented communication (in contrast to strictly task-oriented communication).

Since there are, thus, divergent predictions related to different theoretical considerations, hypothesis 1 and hypothesis 3 correspond to open research questions.

The second hypothesis regards pedagogical role and communicative style and is derived from “real world” experiences and conceptions, where an instructor or boss is more readily associated with a task-oriented communicative style, and a companion is more readily associated with a task- and relation-oriented communicative style.

Participants

Ninety 12-15 year-old adolescents (48 girls and 42 boys) from a Swedish secondary school participated in the study, which was organized in the context of their regular arts lessons. The students came from nine different teaching groups. Nearly all students in all groups participated. An overall observation was that the students seemed enthusiastic to participate and a couple of times the students spontaneously organized a queuing system among themselves. All students had at least some familiarity with pedagogical programs making use of embodied computer characters.

Materials

For the study, two dummy versions of a scenario based multimedia program for elementary school were developed (Figure 10a). In both versions the student is to take the role of a journalist at a magazine, being sent to various European countries to do article research. In the *instructor version* the student is presented with the scenario that she is to be guided by a virtual *chief editor*, and in the *companion version* accompanied by a virtual *journalist companion*. The multimedia presentation dummies were created in *Macromedia Director* and include: (i) an introduction where the program and a first mission is presented, and (ii) a module where the student is asked to choose one out of eight animated characters presented as their virtual instructor (in the instructor version) or as their virtual companion (in the companion version), see Figure 10.

The presentation of the mission includes illustrations from Istanbul and traditional Turkish music (Figure 10c). A male speaker’s voice tells about the mission and presents the student with her or his role as a journalist. As described in the section “Variables of the study” the student also gets information about the role of the chief editor (in the instructor version) or the companion journalist (in the companion version). All the material had been pre-validated by teachers who work with the age group in question.

The eight embodied agents are the same in the instructor and companion versions: two males and two females with two different visual representations (detailed & 3D-rendered and simplified & cartoonish respectively). They are presented in an elliptical layout on the page (Figure 10d), where the individual positions of the agents are determined from a predefined randomized table. The layout was also pre-tested to minimize experimental artefacts of position effects.

The agents

The eight embodied agents were developed from four basic figures, two males and two females. They were created as 3D-models in the program *3d Studio Max 5* and their faces created with the plug-in module *FacialStudio*. The four basic figures were then rendered into: (i) a detailed & 3D-rendered character set using the *3d Studio Max 5* default renderer, and (ii) a simplified & cartoonish character set using the *finalToon* rendering tool.



Fig.10. The dummy multimedia program used in the study: a) Data collection of participants and setting for instructor/companion version, b) Start page, c) Introduction page, d) Preference choice page.

The agents were furthermore slightly animated. The animation was parsimonious and included only subtle eye blinks and breathing – there were no sudden movements that would attract attention. The movement patterns were similar between agents but with a displacement in time between the different agents in order to avoid movements from different agents from coinciding. Each animation lasted a few seconds and was repeated in a loop so that the agents seemed to move continuously.

Had the animations been more extensive and explicit, the animation patterns ought to have been randomized between trials and agents, but for the present study there was no indication that the animation patterns had any effect on the choice patterns.

Study Procedure

During the experiment, three experimental leaders alternated between the following roles: *Experimenter A* initializing the study program and entering participant data into the computer (Figure 10a), *Experimenter B* conducting the interviews including taking interview notes,

Experimenter C making back-up notes about the participant, double-checking the experiment, and assisting in various ways when needed. The interview scripts had been developed in collaboration with a teacher who works with the age group in question. The procedure of the experiment was as follows.

- (1) The three experimental leaders presented themselves to the class as coming from the university and doing research on educational media. Students were told they were welcome to participate in a study. The students went, one at a time, to a small room behind the classroom. In most cases all students in the class participated. It was emphasized that the main purpose was to listen to students' opinions on various aspects of a program that they would be asked to try out and that they were fully anonymous. (The experimental leaders did not mention who created the program.)
- (2) Before each new student, Experimenter A initialized the next experiment session by entering the session number and program version (instructor/companion) according to a random scheme. Each student was randomly assigned to one of two conditions: (i) the companion version, or (ii) the instructor version. There were 45 participants in each condition.
- (3) After welcoming a student, Experimenter A asked what grade she was in, whereupon she was asked to sit down at the computer. Meanwhile Experimenter A entered codes for grade and gender into the computer (Figure 10a) and initiated the session.
- (4) The student was told to press "start" (Figure 10b) and then listen to further instructions provided by the program (Figure 10c).
- (5) After the program introduction, the student reached the module for the choice of visual representation (Figure 10d) and was instructed by the text on the screen to choose one of the eight embodied agents. Right after the choice, the chosen agent was enlarged and centred on the screen, with the other agents simultaneously disappearing.
- (6) Experimenter B then asked the student the open-ended question: "Why did you choose the instructor/companion you did?"
- (7) Upon answering, Experimenter A reran the program to bring forth all eight embodied agents again. Experimenter B asked the student whether there were any that she would definitely not have chosen as her instructor/companion. Thereafter Experimenter B asked the student what she thought to be the important differences, if any, between the agents.
- (8) Experimenter B then verbally presented the student with the two scenarios on: (i) a strictly task-oriented agent (chief editor/journalist companion) and (ii) a task- and relation-oriented agent (chief editor/journalist companion). The student was then asked by Experimenter B which of the two agents she would prefer and asked to motivate her choice. The scenarios as well as the questions were based on a standard script. When required they were rephrased or clarified in order to secure that all students had an adequate understanding of the tasks.
- (9) Finally, two cognitive style inventories were completed by Experimenter B (Gulz & Haake, 2006). After the completion of this, the student was offered refreshment, was debriefed and thanked for valuable help.

For each participant the following was logged by the program: the program version (instructor/companion), the positions of the embodied agents, the time it took for the participant to choose an agent, the chosen agent and its position. The qualitative data, that is the participant's arguments for and articulations of their choices were noted down manually during the session and transferred to a computer transcript within a few hours.

RESULTS

The test data can be presented as frequencies in a three dimensional contingency table categorized by the variables: pedagogical role (P), visual style (V), and communicative style (C) as shown in Table 1.

Table 1
The test data categorized by the three variables: Pedagogical Role (P), Visual Style (V), and Communicative Style (C)

Pedagogical Role	Visual Style	Communicative Style		Total
		Task	Relation	
<i>Instructor</i>	<i>Naturalistic</i>	12	6	18
	<i>Stylized</i>	9	20	29
	Total	21	26	47
<i>Companion</i>	<i>Naturalistic</i>	7	8	15
	<i>Stylized</i>	7	21	28
	Total	14	29	43
Column Total		35	55	90

To control for higher order interactions in multi-dimensional contingency tables, interactions can be evaluated using a log-linear analysis. In our case, the experimental data were evaluated by log-linear analyses (using *R for Windows*) in the saturated model:

$$\ln(F_{ijk}) = \lambda + \lambda^P + \lambda^V + \lambda^C + \lambda^{PV} + \lambda^{PC} + \lambda^{VC} + \lambda^{PVC}$$

The log-linear analyses used were (cf. Howell, 2002):

1. Simultaneous test of: model effects + marginal and partial tests of association.
2. Test of all possible models.
3. Stepwise solution for an optimal model.

All analyses suggested that the distribution of frequencies can be explained by the final model:

$$\ln(F_{ijk}) = \lambda + \lambda^V + \lambda^C + \lambda^{VC}$$

The final model (VC) is nonsignificant at $p = 0,755$ and is nonsignificantly different from more complex models. The model does not take pedagogical role (P) into account and consequently excludes the two-way interactions λ^{PV} and λ^{PC} (Pedagogical Role \times Visual Style and Pedagogical Role \times Visual Style) as well as the three-way interaction λ^{PVC} (Pedagogical Role \times Visual Style \times Communicative Style).

Knowing that the three-way interaction (λ^{PVC}) could be excluded from the model, the three hypotheses can be evaluated as they correspond to the two-way interactions λ^{PV} , λ^{PC} , and λ^{VC} .

From the log-linear analysis above we have seen that the contribution of the two-way interactions λ^{PV} and λ^{PC} can be excluded, i.e. hypotheses 1 and 2 can be rejected. Likewise the contribution of the two-way interaction λ^{VC} cannot be excluded, i.e. hypothesis 3 cannot be rejected.

Even if the hypotheses 1 and 2 are rejected, a separation of pedagogical role into the two different pedagogical roles of instructor and learning companion, together with a separation of the data

according to participant gender, may provide a more detailed understanding. Thus we will set out to examine the three hypotheses one by one by evaluating their corresponding 2×2 contingency tables in three steps:

Step 1: Standard Pearson chi-square test on the 2×2 contingency table (corresponding to the tests of the two-way interactions in log-linear analyses above).

Step 2: Standard Pearson chi-square tests on the separated levels of the “independent variable” (Pedagogical Role: Instructor / Companion, Visual Style: Naturalistic / Stylized).

Step 3: Repetition of the standard Pearson chi-square tests in Steps 1 and 2 above separated as to participant gender (Male / Female).

In addition, all the standard Pearson chi-square tests in Steps 1 to 3 have been paralleled with Yates’ correction for continuity (in the cases of 2×2 contingency tables) and likelihood ratio tests. In all cases the different tests agreed on the results.

Choice of Visual Style as Dependent on Pedagogical Role (Hypothesis 1)

To evaluate hypothesis 1, the data were initially collapsed across participant gender and communicative style.

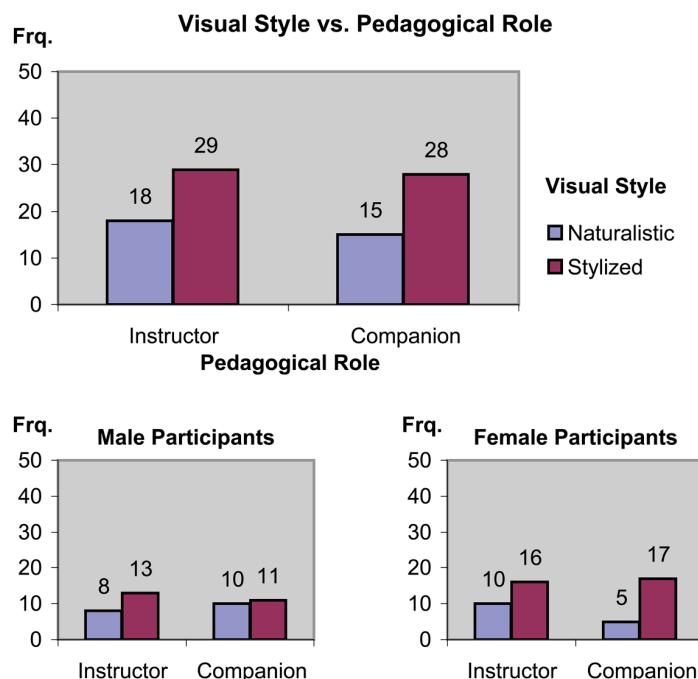


Fig.11. Frequency distributions of the visual style choice against the pedagogical role (of the embodied pedagogical agent). “Naturalistic” stands for the detailed & 3D-rendered visual expression, “Stylized” stands for the simplified & cartoonish visual expression.

Table 2
The standard Pearson chi-square tests on the data in Figure 11, evaluating whether the visual style choice depends on the assigned pedagogical role

	χ^2_{total}	χ^2_{instr}	χ^2_{comp}
Both gender	0.113	2.574	3.930 *
Males	0.389	1.190	0.048
Females	1.373	1.385	6.545 *

* $p < 0.05$

Step 1: The standard Pearson chi-square test on the two dimensional contingency table of pedagogical role and visual style gave no support for the rejection of H_0 ($\chi^2_{\text{total}} = 0.113$, $p = 0.737$), i.e. it could not be concluded that the chosen visual style is dependent on the assigned pedagogical role (Figure 11 & Table 2).

Step 2: With the data separated in consistence with the two different pedagogical roles of instructor and learning companion, the standard Pearson chi-square tests showed a dependency of the visual style choice in the learning companion condition with $\chi^2_{\text{comp}} = 3.930$ significant at $\alpha = 0.05$ (Figure 11 & Table 2).

Step 3: With the data separated according to participant gender and collapsed across communicative style, the standard Pearson chi-square tests yielded the conclusion that the dependence found above originates from the female group, i.e. for the female group, the choice of visual style depends on the assigned pedagogical role in the learning companion condition with $\chi^2_{\text{comp}} = 6.545$ significant at $\alpha = 0.05$ (Figure 11 & Table 2).

Choice of Communicative Style as Dependent on Pedagogical Role (Hypothesis 2)

Following the same procedure as above in the evaluation of hypothesis 2, the data which were in this condition initially collapsed across participant gender and visual style.

Step 1: The standard Pearson chi-square test on the two dimensional contingency table of pedagogical role and communicative style showed no support for the rejection of H_0 ($\chi^2_{\text{total}} = 1.389$, $p = 0.239$), i.e. it could not be concluded that the chosen communicative style is dependent on the assigned pedagogical role (Figure 12 & Table 3).

Step 2: With the data separated in consistence with the two different pedagogical roles of instructor and learning companion, the standard Pearson chi-square tests showed a dependency of the choice of communicative style in the learning companion condition with $\chi^2_{\text{comp}} = 5.233$ significant at $\alpha = 0.05$ (Figure 12 & Table 3).

Step 3: With the data separated according to participant gender and collapsed across visual style, the standard Pearson chi-square tests yielded the conclusion that the dependence found above in "Step 2" originates from the female group, i.e. for the female group, the choice of communicative style depends on the assigned pedagogical role in the learning companion condition with $\chi^2_{\text{comp}} = 6.545$ significant at $\alpha = 0.05$ (Figure 12 & Table 3).

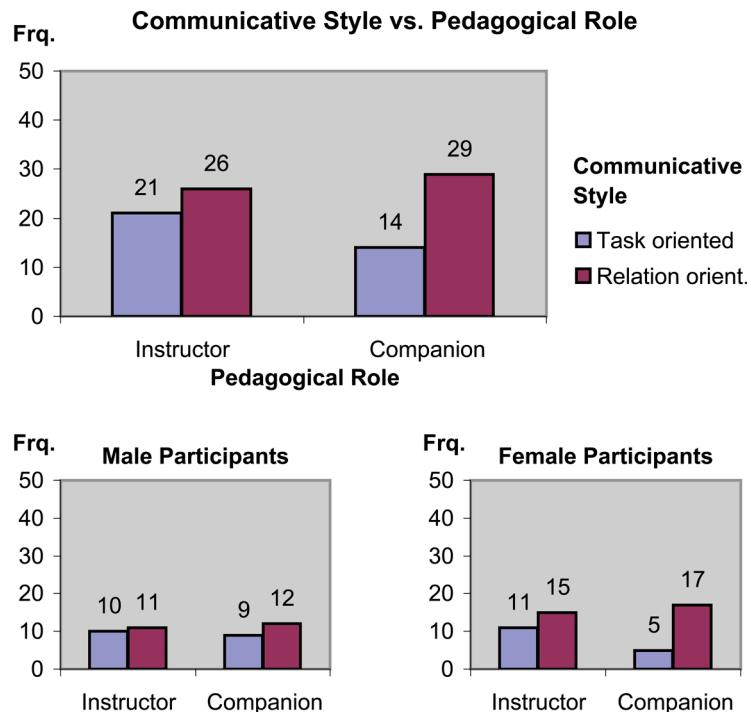


Fig.12. Frequency distributions of the communicative style choice against the pedagogical role (of the pedagogical agent).

Table 3

The standard Pearson chi-square tests on the data in Figure 12, evaluating whether the communicative style choice depends on the pedagogical role assigned to the agent

	χ^2_{total}	χ^2_{instr}	χ^2_{comp}
Both gender	1.389	0.532	5.233 *
Males	0.096	0.048	0.429
Females	2.056	0.615	6.545 *

* $p < 0.05$

Relations between Visual Style and Communicative Style (Hypothesis 3)

For an evaluation of hypothesis 3, the same procedure as in the two previous evaluations was once again performed. In this evaluation the data were initially collapsed across participant gender and pedagogical role.

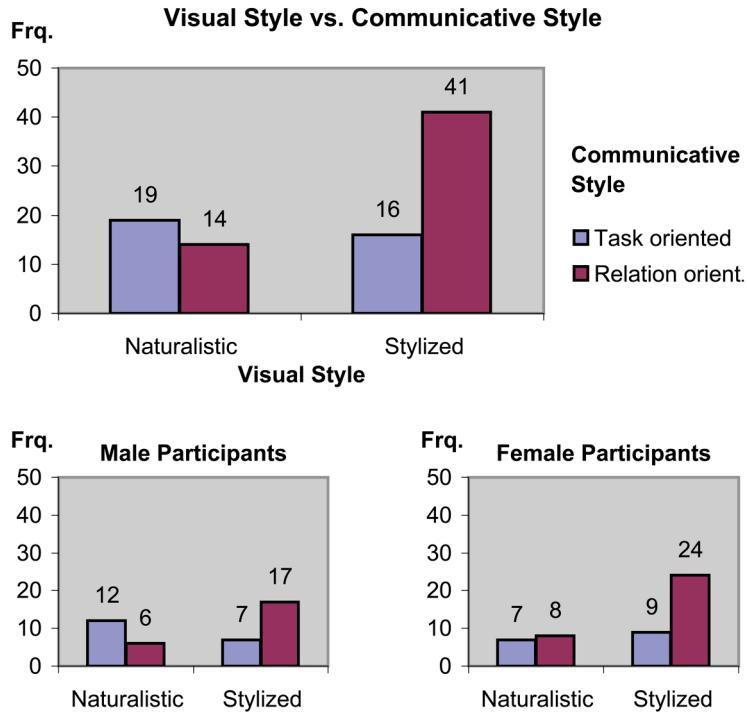


Fig.13. Frequency distributions of the visual style choice against the communicative style choice (of the pedagogical agent). “Naturalistic” stands for the detailed & 3D-rendered visual expression, “Stylized” stands for the simplified & cartoonish visual expression.

Table 4
The standard Pearson chi-square tests on the data in Figure 13, evaluating whether the visual style choice is related to the communicative style choice

	χ^2	χ^2_{natur}	χ^2_{style}
Both gender	7.656 **	0.758	10.965 ***
Males	5.839 *	2.000	4.167 *
Females	1.745	0.067	6.818 **

* $p < 0.05$ ** $p < 0.01$ *** $p < 0.001$

Step 1: The standard Pearson chi-square test on the two dimensional contingency table of visual style and communicative style supports the rejection of H_0 ($\chi^2_{\text{total}} = 7.656$, $p = 0.006$), i.e. there is a significant dependence at $\alpha = 0.01$ between the chosen visual style and the chosen communicative style (Figure 13 & Table 4). This result is also in accordance with the model suggested by the log-linear analysis above.

Step 2: With the data separated in consistence with the two different visual variables of naturalistic (detailed & 3D-rendered) and stylized (simplified & cartoonish), the standard Pearson chi-square tests gave support for the conclusion that the dependence between visual style and communicative style can be attributed to the stylized condition, i.e. there is a very strong support for the conclusion that a

person who chose a stylized embodied agent will also choose a task- and relation-oriented agent with $\chi^2_{\text{style}} = 10.965$ significant at (Figure 13 & Table 4).

Step 3: With the data separated according to participant gender and collapsed across pedagogical role, the standard Pearson chi-square tests in this condition provide a more complex picture than in the two previous evaluations. A possible conclusion is that the strong support for the result of Step 2 can be attributable to both the male and the female group with $\chi^2_{\text{style}} = 4.167$ significant at $\alpha = 0.05$ and $\chi^2_{\text{style}} = 6.818$ significant at $\alpha = 0.01$ respectively (Figure 13 & Table 4).

Summing up, the results are as follows:

- Participants who chose a naturalistic representation of the embodied pedagogical agent, showed no specific preference in the choice between a strictly task-oriented agent and a task- and relation-oriented agent.
- Participants who chose a stylized representation of the embodied pedagogical agent, showed a very strong preference for a task- and relation-oriented agent (Figure 13 and Table 4).

ANALYSIS AND DISCUSSION

In what follows we first reflect on some limitations of the study. Then we analyze and discuss the three hypotheses and corresponding results. We conclude with a general discussion.

Limitations of the Study

Implementation

One obvious limitation of the study is that the variables *pedagogical role* and *communicative style* of the agents were not implemented as actual algorithm driven agent behaviour and encountered and evaluated as such by the students.

Here we share the goal and desire of many other EPA researchers to develop and work with fully developed educational programs where learners can act and interact over time in order to increase the ecological validity of the studies. At the same time, it is not always the case that an exploratory study with a focus on certain variables and their relation is best carried out in a fully implemented running program. In the present case we may gain additional knowledge on a more generalized conceptual and articulated level concerning preferences and relations with regard to pedagogical role, visual style, and communicative style. This kind of information would be blurred and even inaccessible in an actual implementation where the information certainly would be of higher ecological value, but at the same time more case specific.

Continuing this line of argument, a desirable and logical follow-up on the present study would be to use brief implementations with interactive human-agent scenarios, systematically varying the communicative styles in relation to the pedagogical role.

It is furthermore possible to look on the limitation constituted by our “meagre” stimuli material (as to pedagogical role and communicative style), from still another angle. Given that these stimuli could be considered “quite weak”, results in terms of relations between the variables may be even more notable.

The context of study and participant motivation

Another ecological validity issue relating to the context of this study is the question of whether the results would have been different if the test was embedded into a history or social science lesson, in which case the participants' need or motivation to use the program might have been more obvious.

It is possible that participants would have paid even more attention to and cared about their choices in such a case. Note, however, our use of the notion "even more". A common observation made by all three experimenters was that in the present study participants also showed commitment, focus and engagement in the tasks. We may speculate that this has to do with the fact that their regular arts teacher expressed a commitment and engagement in what was going on.

Another open question is whether students might have been somewhat more inclined to choose a strictly task-oriented pedagogical agent than in our study if the context had been a more regularly scheduled activity that they wanted to "get over and done with" in order to continue with the next activity.

The age group

One should furthermore be careful not to generalize from the actual group of participants to users or learners in general. The participants were 12-15 year old Swedish adolescents. A replication of the study in a group of younger school children or in a group of university students, and/or in another culture might – or might not – produce different results. We simply cannot tell.

Pedagogical Role and Visual Style (Hypothesis 1)

The evaluation of hypothesis 1 indicated that for the female group the pedagogical role of the agent in the "learning companion condition" conveyed a preference for a visually stylized embodied agent. For the male group there were no results indicating any form of relation between pedagogical roles and visual style preferences.

As already observed the pedagogical role of the agent was quite a weak stimulus in the sense that participants were simply being *told* that they were to interact with either a chief editor (instructor condition) or a companion journalist (learning companion condition) together with a description of what this involved. This method can be criticized for low ecological validity, but the fact that such a weak stimulus could still yield a strong (even if partial) effect is notable.

Furthermore, although this is not a straightforward and unambiguous support for hypothesis 1, one can note the shift from a non-significant distribution (instructor condition) to a significant distribution (learning companion condition) regarding the choice of visual style. In the learning companion condition, a stylized character is clearly preferred, in coherence with hypothesis 1.

Why would participants prefer a simplified and cartoonish learning companion agent? Based on previous discussions in this article, a possible explanation relates to the long tradition in comics to use simplified and stylized characters to emphasize socio-emotional expression and facilitate subjective identification and immersion into the characters and the story (McCloud, 1993). If participants associate a learning companion with a "friend" with whom they can have a personal relationship (in contrast to a strictly task-oriented, authoritative boss or instructor) it may then be close at hand for them to select a more simplified and cartoonish (stylized) character rather than a more detailed and naturalistic one (Gulz & Haake, 2005).

But it should be emphasized that such a choice pattern, of course, can be overturned if other important visual aspects of the alternative characters are not equivalent, for instance age, clothing and friendliness, since such variables may affect the choice as well. For the characters in our study we explicitly sought to keep such aspects equivalent (see section “Additional design comments”), and pre-tests in the age-group in question were conducted to ensure that none of the characters would “stand out” in relation to the others. Of particular importance for the present study was that no characters in their appearance would stand out with regard to the aspect of “friend” v. “boss”. Thus the visual aspect of “friendliness” vs. “non-friendliness” was of particular importance. In retrospect, we believe it would have been a good idea to have an additional and more targeted focus on this in the pre-tests. However, the pre-tests as carried out gave no indication of deviations with respect to “friendliness” vs. “non-friendliness”.

To illustrate why choice patterns like the one we have described cannot be generalized in an unqualified way, consider the following hypothetical situation: Your task is to assign two given visual characters – a naturalistic version of Calvin (in Calvin and Hobbes) and a cartoon character in Dick Tracy style (cf. Figure 4) – to two different given roles, namely your young companion/pal and a tough boss of a criminal gang. In such a case we would not predict that people would choose the Dick Tracy style character to be the companion and the naturalistic version of Calvin to be the criminal boss.

Pedagogical Role and Communicative Style (Hypothesis 2)

Also here the move from the “instructor condition” to the “learning companion condition” brings about a change in the preference distribution in favour of a task- and relation-oriented agent, and significantly so for the female participants. Thus, the results may be interpreted as partially in coherence with hypothesis 2.

Again one should consider the relatively weak stimuli as to the “pedagogical roles” in combination with the same weakness in the stimuli of the “communicative roles”. This makes the interpretation of the results more intriguing and at the same time the strong partial significant dependence even more conspicuous.

One interpretation of the results – in line with *the Media Equation* of Reeves and Nass (1996) – is that social strategies and responses that we apply in the real world are being transferred into the virtual world, in this case real world relational strategies. This interpretation is supported by the observation that when the pedagogical agent in our study shifts from a more *formal* social role (instructor) to a more *relational* social role (learning companion), the tendency to turn to real life relational strategies and transfer them into the virtual world becomes more distinct.

If we also pay attention to the fact that the significance of the result arises from the female group, we can speculate on gender-specific behaviours and social strategies. In the real world girls/females are considered more competent in using subjective relational strategies, whereas boys/males rely more on formal, objective strategies for social interaction (Walker, 2005). Perhaps this pattern is seen reproduced here in a virtual setting.

Visual Style and Communicative Style (Hypothesis 3)

The results concerning the relation between the choices of visual style and of communicative style were statistically more distinct than for the two previous hypotheses. Given that a participant had

chosen a stylized (simplified & cartoonish) embodied agent, he or she showed a significant tendency to choose a “task- and relation-oriented” agent. The significance persisted both when collapsed across gender and when separated as to gender. For the male group, furthermore, there was also a tendency for a participant who had chosen a naturalistic (detailed & 3D-rendered) embodied agent to choose a strictly task-oriented agent.

Our interpretations of these relations between preferences for visual appearance and preferences for communicative style of the embodied agent, as presented in the section “Realism and pedagogical effects”, propose that *subjective identification* may be facilitated with simplified and cartoonish (stylized) characters. A visually realistic embodied agent, on the other hand, promotes objectivity. Consequently a stylized character is more easily associated with a subjective and personal relation, as expressed in relation-oriented communication, and a realistic character is more easily associated with strictly task-oriented communication. Support in this direction comes from Nowak and Biocca’s (2003) study, involving relatively realistic versus heavily stylized characters in VR-environments. Here users rated the stylized characters significantly higher than the naturalistic ones as to their experience of a psychological connection with the character, in terms of co-presence and social presence.

As a rule of thumb or design consideration to reflect upon, we propose that an embodied non-authoritative learning companion agent can in many cases be favourably designed to be visually simplified and cartoonish (stylized) as well as to be communicatively task- and relation-oriented.

General Discussion

There is an overall need for more studies in order to assemble evidence from which guidelines about different aspects of EPAs can be developed. To accomplish this, it is of importance that studies are detailed and specific in the description of the variables they examine.

In this article, we have proposed a theoretical framework and a method to specifically address different aspects or variables of *visual static appearance* in evaluations of EPAs. The purpose is to augment the granularity in discussions and evaluations of characteristics of embodied agents in general, and EPAs specifically.

From a broader perspective the article may be seen as a contribution to a “visual design guidelines project” in the sense suggested above. It should be emphasized that we are not referring to generalized step-by-step recipes (guidelines) on “how to visually design an EPA”. We believe this would be a futile objective since the adequacy of a visual design depends on such a complex set of variables including the learning context, the learning goals, and the group of learners, in combination with – as indicated by the study presented in this article – the pedagogical role and communicative style of an EPA. What we believe is desirable and possible, though, is to delimit and encompass the visual design space by means of guidelines in the form of high-level *design topics* or *design considerations*: “These variables may relate to each other in the following ways...”, “Given equivalence in other relevant visual design aspects, these different design alternatives can have the following consequences...” and “This is a topic that ought to be reflected upon before making a choice on a certain visual parameter”. We are not implying that designers of EPAs could thereby refrain from user evaluations, but believe that these kinds of guidelines can be a support for designers and developers, as well as researchers, in order to navigate in the immense visual design space that is there at the outset, and as a support through the design process.

Such a “visual design guidelines project” would also be a useful counterbalance to the seeming elusiveness of visual appearance aspects in the area of embodied agents. Even though there are, admittedly, important ingredients of subjective evaluation regarding visual aspects, this is not all there is to it. The visual appearance of EPAs is a topic that should *not* be neglected by scientific and pedagogical perspectives and left to the opinions and gut feelings of individual designers or “the market”. For this, it is far too important and influential.

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Fig. 7. The interactive information assistant Olga was developed by: CID NADA KTH, TMH KTH, Lingvistik SU, SICS & Nordvis AB. <http://www.nada.kth.se/~osu/olga/>

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