Embodied Conversational Agents: Effects on Memory Performance and Anthropomorphisation

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Abstract. It is often assumed that the use of Embodied Conversational Agents (ECAs) in human-computer interfaces improves human-computer interaction. Because of their appearance and because they show human-like communicative behaviour, users tend to ascribe human characteristics to ECAs or 'anthropomorphize' them. Since interacting with another human being comes natural to people, anthropomorphisation of agents in an interface is thought to improve the process of communication. As a result, other usability aspects, such as satisfaction and learnability, would probably benefit. This paper describes a study into anthropomorphisation of ECAs and their effect on memory performance. The results of our study show that the presence of an ECA has a positive effect on retainability of information, but that this effect is not necessarily influenced by anthropomorphism.

1 Introduction

An important development in agent design has been the use of so-called Embodied Conversational Agents (ECAs). ECAs are electronic agents that are visually presented in the computer interface with some kind of embodiment – human, animal or fantasy figure. Moreover, they communicate messages to the user by various modalities such as natural language, facial expressions or body postures [1]. ECAs often exhibit human-like behaviour. This results in a certain degree of *anthropomorphisation* of the ECA by the user: the attribution of human characteristics to the agent.

There is some controversy about the effects of ECAs. Advocates of ECAs assume that the efficiency of human-computer interaction would increase with ECAs, because they are anthropomorphised. People do not need to learn an artificial interaction language, but they may avail themselves of the communicative behaviour they effectively use with other people and, therefore, cognitive resources can be spent on the primary task [2]. Opponents to ECAs derive the opposite conclusion and argue that humanizing interface agents might hamper the interaction, since processing all the ECA's visual information and speech takes a lot of cognitive resources away from the primary task [3].

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The goal of this research is to measure the effect of the presence of ECAs in an interface on the retainability of information in relation to the degree to which users anthropomorphise these agents. To this end, an experiment was carried out where different types of ECAs were used in the interaction and where users were set a memory task and questioned about their ascriptions of human characteristics to the agent.

2 Anthropomorphism and User Performance

Various findings suggest that users in interaction with ECAs apply "social heuristics" [4] and behave as they normally do in social intercourse. Underlying this behaviour would be the users' attribution of human characteristics to, or anthropomorphisation of, the ECA. Attributing characteristics such as intentions, goals and feelings to others is part of our psychological *bauplan*. We ascribe mental characteristics to other people without knowing for sure that they have a mind and do the same with ECAs [5].

It is claimed that ECAs could facilitate the learning process in two ways. First, there may be a direct effect of superior knowledge acquisition. Because ECAs can engage users more actively in learning, they may well stimulate the user's reflection and self-explanation, which facilitates integration in existing knowledge [6]. Second, ECAs could facilitate learning through an effect on motivation. A user is not alone facing the task, but accompanied by a helpful supervisor. Because ECAs have such an enchanting presence, they may significantly increase users' positive perceptions of their learning experiences [7].

Another line of reasoning is that ECAs have a positive effect on cognitive functions, because they allow face-to-face communication and multiple communication channels. The human brain is adapted to this style of communication and has developed special circuits to encode facial information [8]. Moreover, delivering redundant information through multiple channels at once makes communication more robust in the sense that a failure of one channel is recovered by another and that a message delivered by one channel can be explained by another channel [9].

From this discussion, it can be concluded that ECAs would improve human-computer interaction, because people anthropomorphize them and consequently feel at ease with them. Also, ECAs would improve user performance because they allow routine social interaction, which more actively engages people and heightens their motivation, and because agents allow multi-channel delivery of information and face to face communication.

3 Effects of ECAs: The Experiment

In the experiment we investigated, first, whether ECAs have an effect on memory performance; second, whether the presence of an ECA in the interface increases the degree of anthropomorphisation; and, finally, whether these two effects are correlated, that is: whether an effect on memory performance might be mediated by anthropomorphisation.

3.1 Design

We had three conditions where the visualisation of the ECA varied between subjects from 'realistic' to 'cartoon' and 'absent'. The ECAs' speech and text were kept constant. We measured the effect of these different presentations on performance on a text comprehension task and their effects on ratings on a questionnaire which measured the degree to which subjects anthropomorphised the ECAs.

The 'realistic' visualisation was a female head, delivered by Desktopmates[1] (Fig.1). It speaks with a Dutch synthetic voice and has a word balloon. The 'cartoon' visualisation was a purple gorilla, from the MsAgent gallery[2], which speaks with the same synthetic voice and also has a word balloon. The ECA with the 'absent' visualisation was presented as text, appearing in a yellow square, very similar to the word balloons used in the other visualisations; it also uses the same synthetic voice. The female character and the gorilla had very basic body language and facial animations.

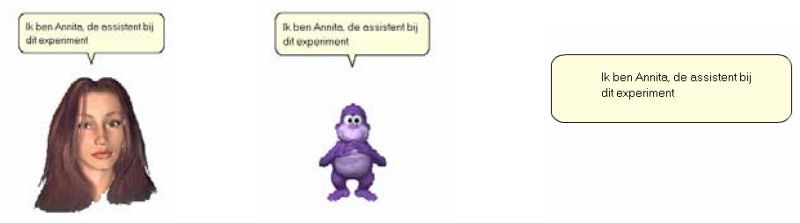

Figure 1. From left to right: the realistic, cartoon and absent visualization**.**

One of the two variables we measured in the experiment was memory performance. Text comprehension can be measured as the percentage of propositions recalled of a text [10]. As a test for text comprehension, the ECA tells the subject two short stories. When the ECA finished the story, subjects were asked to write down everything they remember. Both texts used in the comprehension task were rewritten as propositions by the experimenter. Each subject's reproductions of the texts were scored as a percentage of the correctly reproduced propositions. The 'text score' was calculated for each subject as the mean of the scores on both texts.

The other variable we measured in our experiment was anthropomorphism. To this end, we used a questionnaire that was similar to the one used by McBreen [11]. Subjects were asked to rate twenty statements on a 7-point Likert scale ranging from 'strongly agree' to 'strongly disagree' with a 'neutral' option in the middle. Examples are 'I felt the assistant was sensible' and 'I felt the assistant was helpful'. The degree of anthropomorphisation was established by measuring the absolute distance of the subject's rating from 'neutral' on the 7-point Likert scale over these items.

[1] www.DesktopMates.com (june 2002): 'Annita'
[2] MS Agent 2.0 (1998), Microsoft

3.2 Method

Subjects were 39 men and 22 women, all Dutch native speakers, with an average of 27 years of age, ranging from 18 to 54 years. Of the 61 subjects, 37 were students in cognitive artificial intelligence; the 24 others had various occupations. Groups in the three conditions were of similar size and comparable with respect to gender, age and occupation.

In all three ECA-conditions, the ECA first explained how the interface worked. It introduced itself: 'Hello, I am Annita', and then it had a short conversation with the subjects. In this short conversation users were asked for their name, age, daily activities, computer experience and ECA experience. The purpose of this exchange was to 'get to know each other' which would make it easier for the subject to rate the ECA on different aspects.

Subsequently, subjects were presented with the first small story. They were asked to listen carefully, and afterwards to write down everything they had remembered of the text. After they had finished, the second story was presented, with the same instructions. The ECA then thanked the subject for his/her co-operation and asked him/her to fill in the questionnaire.

3.3 Results

Subjects remembered more in the 'realistic' and 'cartoon' condition than in the 'absent' condition (realistic: 69.48; cartoon: 66.48; absent: 58.18). An ANOVA indicated that the three means differed significantly (F= 3.71, df = 2, p<0,05). T-tests between conditions showed that the subjects in the 'realistic'-condition had a significantly higher score than subjects in the 'absent'-condition (p<0,01). The subjects in the 'cartoon'-condition scored almost significantly higher than subjects in the 'absent'-condition. There were no significant differences between the scores in the 'realistic' and 'cartoon' conditions.

The means of the absolute anthropomorphism scores of the three conditions were 10.24 (realistic), 9.25 (cartoon), and 6.5 (absent). An ANOVA indicated that the three means differed significantly (F=12,75, df=2, p<0.01). The score in the 'realistic'-condition was significantly higher than in the 'absent'-condition (p<0,05). But subjects in the 'cartoon'-condition did not score higher than subjects in the 'absent'-condition. And again, there were no significant differences between the scores in the 'realistic' and 'cartoon' conditions.

To our surprise, we found no correlations between the text scores and the anthropomorphisation scores (r's between –0.14 and 0.13).

4 Discussion

The results of the memory test support the hypothesis that the presence of an ECA has a positive effect on memory performance. The results on the questionnaire indicate that the presence of a realistic, but not a cartoon-like ECA increases anthropomorphisation. But we found no support for the idea that memory performance and anthropomorphisation are correlated. Therefore, we must conclude that embodiment has a

positive effect on memory performance, but that this effect does not depend on social characteristics ascribed to the ECA. Thus, the assumption that ECAs are effective because they are anthropomorphised appears to be untenable. Also, the fact that the information is provided through more channels does not explain the memory effect, since in all conditions the same information was presented both orally and visually. The explanation for the effect of ECA's on memory performance may be along the other line: people are 'calibrated' for processing information provided by talking heads – artificial or real. Another reason for the effect could be that people use the ECA as a marker to access information stored in memory.

It is clear that a lot of studies remain to be done into the reasons for the effectiveness of ECAs. For instance, in order to distinguish between the 'calibration' and the 'marker' hypothesis a simple non-animated object, such as a ball or a flower, could be used instead of an ECA. In any case, anthropomorphisation does not seem to be the answer, as had been tacitly assumed by most ECA-researchers. There is a need for a solid cognitive theory to start from, instead of some assumptions randomly chosen from the fields of communication, psychology or human-computer interaction. But given their beneficial influence on cognitive tasks such as remembering text, ECAs are certainly worth elaborating.

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