Memory and the Design of Migrating Virtual Agents (Extended Abstract)

Ruth Aylett
Heriot-Watt University
Riccarton, Edinburgh EH14 4AS, UK
r.s.aylett@hw.ac.uk

Michael Kriegel, Iain Wallace
Heriot-Watt University
Riccarton, Edinburgh EH14 4AS, UK
{m.kriegel i.wallace}@hw.ac.uk

Elena Segura,
Johanna Mercurio,
Stina Nylander
Mobile Life @ SICS
DSV, Forum 100, Kista, Sweden
{elena stny johmerc}@sics.se

ABSTRACT
This paper discusses an experiment examining the impact of interaction memory on user perceptions of a virtual agent with multiple embodiments and migration between them. The outcome showed users perceived agents with memory as more competent, but it had no significant effect on a strong perception of consistent identity across multiple embodiments.

Categories and Subject Descriptors
I.2.11 [**Distributed Artificial Intelligence**]: Intelligent agents

General Terms
Design, Experimentation, Human Factors.

Keywords
Embodiment, agent migration, memory and personality

1. INTRODUCTION
This paper reports an experiment that seeks to establish whether giving a consistent memory to multiple embodiments of 'the same' virtual agent across changes of embodiment impacts the ability of users to perceive multiple embodiments as 'the same' agent.

Specific agent embodiments offer different possibilities for interaction, as well as imposing different limitations. Robots have greater physical presence but also mobility problems and power limits [2]. Graphical characters can be more expressive but do not move in physical space. Characters on handheld devices can accompany their users but are seldom life-size and lack multiple interaction modalities. We have designed an agent that migrates between different embodiments according to the requirements of users [6]. This can be thought of as a 'soul-shell' approach in which 'the agent' inhabits only one body at a time [3, 8, 9].

Recent work suggests that users perceive a single agent across multiple embodiments if a consistency in the perceived personality of the agent is maintained [5]. Various cues have been investigated: appearance; voice [4]; continuous goals and consistent expressive behaviour [3]. This work is the first to investigate a consistent memory as a cue for personality recognition.

In humans, memory is the basis of self-identity, determines who and what is important to us and thus supports long-term relationships. It also underlies consistent behaviour over and above subconscious habits, and was seen as a vital part of a successfully migrating agent [7]. In this paper we investigate whether a migrating agent that remembers events lived in other embodiments contributes to the user's perception of one consistent identity. This is an important tissue for the design of successful social virtual agents.

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2. EXPERIMENT
The experiment was carried out within a showcase called Spirit of the Building, part of the LIREC project [10] examining long-term companionship in both robotic and virtual agents. This showcase focused on a work-place companion called Sarah, developed in three embodiments. The first was a robot companion acting as a Team Buddy for a research group in a specific lab (S_R); the second a large-screen graphical companion able to interact with visitors entering the building (S_G – see Fig. 1 below) and the third, a mobile phone-based companion (S_M – see Fig. 2 below) able to direct visitors round the building using their own smart phone.

All three companions ran a three-level architecture forming a common framework for different platforms [6]. In this framework, level 1 was wholly platform-dependent; level 2 contained platform-specific competencies and a generic competency manager CMION [6]. Level three, common across all platforms, was provided by the FAtiMA affective agent architecture [1]. Migration transfers the FAtiMA instantiated parameter set so that a receiving embodiment is configured exactly as the sending one. Goals, drives and affective state are transferred: if the agent is happy before migration it will still be happy in its new embodiment.

The experiment was carefully designed to isolate the factor being investigated: whether continuous memory across embodiments affected the perception of migration. Cues already known to be important to this perception were held constant. Thus we used the Spirit of the Building interactive screen S_G and mobile companion S_M embodiments shown in Fig.1 below and not the S_R robot embodiment to avoid the known difference in impact of physical v virtual embodiment [3]. S_G and S_M were designed with close-to-identical appearance and animations. Both had text-to-speech output supplied by the same unit-selection based TTS system giving a natural female voice with a noticeable Irish accent. Neither had speech input: interaction used the smart phone touch-screen menus and text entry for S_M, and selection of on-screen options with hand gestures recognised via Microsoft Kinect for S_G as seen in Fig. 1.

Participants carried out a treasure hunt around a local university building. Clues were given by S_G, embodied in a large TV screen, and participants followed the clues by navigating round the building, following directions from S_M, a migration into a mobile phone. Four successive clues were given, causing eight migrations, and considerable dialogue with the agent.

To avoid priming participants, the agent only ever appeared on one device at a time and migration only occurred when the user was in front of the screen with both devices visible. In our other experiments a rising sound at the sender followed by a falling sound at the receiver helped establish the idea of a single agent in transit; in this experiment, no sound was used. The term migration was not used in the experimental protocol, also to avoid biasing the user's expectations.

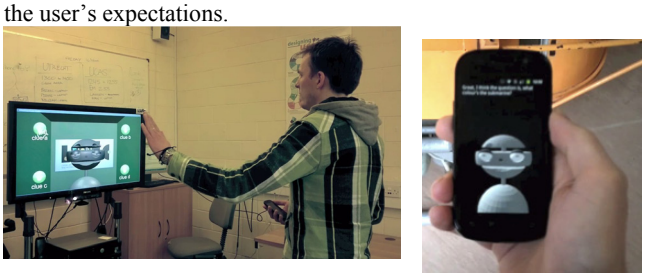

Fig.1 left: S_G - Kinect interaction; right: S_M - in mobile phone

Participants (N=45) were split into three groups, with 15 participants in each:

Group A – Memory migrated every time, except on final migration.

Group B – Memory not migrated, except on final migration when agent remembers events from the prior embodiment.

Group C – Memory migrated on alternating pairs of migrations: on first migration memory is preserved, on second, not; on third it is (earlier memories from the first embodiments were not restored).

Agent speech was used to reveal the presence or absence of continuous memory. Thus, in no-memory migrations, the clue given by S_G was requested from the user by S_M immediately after migration and in the memory conditions, S_M repeated the clue itself. In the memory condition, agent attributes were revealed in one embodiment (such as favourite colour) and referenced in the other.

3. RESULTS AND CONCLUSIONS

Data was collected with a mix of: questions asked by the agent as part of the task (before and after any training effect from exposure to many migrations); pre- and post-questionnaires; and a structured interview. To consider how the participants' attitudes changed with exposure to multiple migrations, questions were asked by the agent during the task to elicit responses indicative of their view on its identity after one, seven and all migrations.

To measure the participants' overall impression, several questions in the post-interview were designed to elicit a response indicating if they thought of it as one or several agents. This culminated with a direct question on this matter as the last question. From 45 participants, all 45 believed there was only one agent. This result suggests that appearance clearly dominates the perception of identity. Additionally, no significant training effect was observed. Participants perceived the agent in the same way at the start of the experiment as at the end.

So does memory have any effect at all on interaction in this experiment? Yes: while not contributing to the perception of identity, there is evidence of a difference in the users' rating of the agent's intelligence. The agent was rated as most intelligent or capable on average by the users in group A (memory), and least by the users in group B (no memory). Short-term memory effects along with a single interaction scenario of about one hour were used here, and it is possible that long-term effects over repeated exposures would give a different result. Intuitively, in the human case one expects memory to play a bigger role in longer relationships. This is however more challenging to study.

Although multiple-embodiment is not found in the natural world, migration seems a remarkably intuitive concept to participants in our experiment and others. If provided with an appropriate set of simple cues (common appearance, no overlap of embodiments), users' default assumption seems to be one agent in multiple bodies.

4. ACKNOWLEDGMENTS

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