Who's in Control?
Exploring human-agent interaction in the McPie Interactive Theater project

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ABSTRACT
The McPie Interactive Theater project explores an unusual style of interaction between human users and visual software agents. Unlike direct manipulation or intelligent agents, McPie explicitly creates a co-adaptive interaction, in which both the human user and the agent modify their behavior according to a changing set of criteria with respect to the other's behavior. The final implementation was tested at an Interactive Theater exhibition in front of a live audience over three days. Volunteers wearing motion detection equipment, interacted with McPie, an animated 3d character back-projected on a wall-sized screen. The setting offered a rich environment for trying out otherwise-controversial interaction styles and suggests new directions for human-agent interaction.

Keywords: Co-adaptive systems, Human-Agent interaction, Intelligent agents, Motion Capture

INTRODUCTION
HCI researchers debate the advantages and disadvantages of different human-computer interaction strategies. Should we use direct manipulation, in which the user directly controls an on-line agent's behavior? Or should intelligent agents act on their own, based on their assessment of user needs? Or should the initiative be mixed between users and agents [1]?

The McPie project was designed to create a thought-provoking interactive theater exhibit that explored novel types of human-agent interaction, particularly the shift of control between users and agents. We created a 3d animated character projected onto a wall-sized screen, in the spirit of Krueger's *Critter* [2]. We decided to twist the human-agent relationship, to see what would happen if the character tried to control the user's behavior, while the user was trying to control the character's behavior, as part of a co-adaptive environment [3].

DESIGN PROCESS
We began by video-brainstorming interaction ideas, with one person manipulating images, hand-drawn on transparencies, that were projected onto the wall and ceiling in response to another person's actions (fig.1). The 3d McPie character (fig.2) was created with Alias|Wavefront Maya. Our initial Wizard-of-Oz tests, in which a programmer controlled McPie's actions as a volunteer interacted with its image projected onto a wall, let us test McPie's facial expressions and actions, to ensure that it produced sufficiently interesting and entertaining actions in real time.

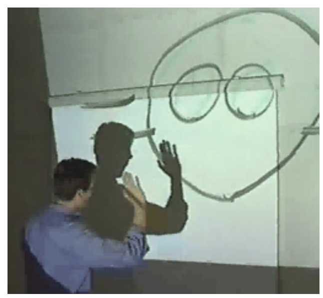

Fig. 1: Video brainstorming

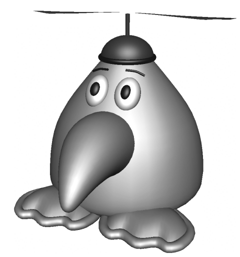

Fig. 2: McPie Character

Motion detection was implemented with an Ascension Technology *Flock of Birds* motion capture system. The user wears a backpack and three sensors: one in a cap to detect head position and one on each wrist to detect arm positions. A receiver detects the sensors' positions in 3d space and transfers them to the Maya software. Gesture-recognition was implemented as a C++ Maya plug-in. We used Rubine's algorithm, but extended to handle 3d gestures. We user-tested the motion-detection algorithms with a simple 2d character and then integrated the Maya 3d character.

Three sets of rules determined responses to the user's movements and were activated in succession. The goal was to "shape" users' behavior [4], with the ultimate goal of having them to tap their heads with their arms. In stage 1, McPie produced "interesting" behavior in response to any arm movement. In stage 2, McPie would start to "act bored" and walk away, unless the user moved their arms to their shoulders or above. (Most users responded to McPie's boredom with a variety of random movements, usually including the above.) In stage 3, McPie only responded "enthusiastically" when the user tapped his/her head. McPie thus responded to successively closer approximations to the desired head-tapping behavior of the user.

INTERACTING WITH MCPIE

McPie was presented to the general public during a 3-day Interactive Theater exhibition (*Kasernescenen*) in Denmark. Audience members waiting to see another performance watched McPie moving around a large screen. Images were projected from behind, using mirrors to reduce the depth of the stage. Figure 3 shows a young Irish woman who decided to try a Riverdance. She jumped up and down and ran from side to side, causing McPie to jump along with her. The audience laughed and clapped; it seemed as though she and McPie were dancing together. (In fact, McPie responded only to her horizontal position and the vertical movement of her head sensor.) Later, as these movements "bored" McPie, he turned away, almost disappearing from the screen. She rushed over to stroke his nose and spoke softly to him. McPie reemerged and tipped his nose toward her. Someone shouted "He's flirting with you!". So she waved shyly at McPie, who responded by "happily" flipping in the air.

Fig. 3 Interacting with McPie

RESULTS

We videotaped and interviewed a number of users, and recorded data of all users' and McPie's movements. We identified three basic interaction strategies:

• *Direct manipulation:* Computer scientists were most likely to try to manipulate McPie directly, persisting in their efforts to scale or move him, even when McPie did not respond as expected. (Some said he must be buggy...!)

• *Identification:* A few users, mostly children, assumed that McPie represented themselves (as in a computer game). One child kept asking "Who am I"? and never understood that McPie was a character separate from himself.

• *Communication:* Most users assumed that their role was to communicate with McPie, experimenting with various movements and poses to establish a connection. They viewed the sensors as points of contact with McPie. (However, many users quickly forgot where the sensors were, moving their fingers or legs to get McPie to react.)

We interviewed users and found that most had stories or theories about how McPie worked, some very complex. None identified the exact relationship between McPie's actions and their own, but most assumed a connection. Stories varied widely: one person thought keeping his hands over his head while jumping was necessary for a reaction; another thought McPie got angry if he looked at him through the hole in the tree. Interestingly, *all* users believed that, with a little extra time, they would understand McPie's rules. Constant generation and adjustment of rules meant there was always a "most recent rule" that had not yet been proven wrong and was thus probably right. This maintained interest in McPie for both users and the watching audience .

We hoped that McPie would "shape" some users into tapping their heads, by rewarding appropriate actions with interesting behavior. Although some *did* tap their heads, the interactions were more complex. Users experimented with social gestures, such as waving or stroking McPie, and random movements, such as flapping their arms, clapping or spinning around. Some stood relatively still, but most moved around the stage and explored movement tempo, size and speed.

Since some users became bored if they could not quickly get McPie to respond, we updated the software after the first day to include a direct relationship, e.g., McPie would always jump (although not necessarily enthusiastically) whenever the user jumped. This positive 1:1 feedback maintained the user's (and audience's) interest and most users returned to jumping when they felt other strategies were not working. Thus McPie was more successful "controlling" users who also controlled McPie, that is to say, users learned better when they shared control.

CONCLUSION AND FUTURE RESEARCH

The McPie project experimented with the shift of control between human users and a visual computer agent. Ultimately, human users and McPie shared control of each other's behavior, while each produced a wide variety of independent actions, which maintained the user's interest. The techniques used in McPie are well-known in animal training and in coaching sports, but are rarely used in software agents. (The exception, programmed instruction, attempts to fully control the user's behavior.) Our experiences with McPie suggest that environments that let users and agents share control of each other's behavior may produce new and more effective teaching strategies.

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