Recognizing Self in Puppet Controlled Virtual Avatars

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ABSTRACT

Recent work in neuroscience suggests that there is a common coding in the brain between perception, imagination and execution of movement. Further, this common coding is considered to allow people to recognize their own movements when presented as abstract representations, and coordinate with these movements better. We are investigating how this 'own movement effect' could be extended to improve the interaction between players and game avatars, and how it might be leveraged to augment players' cognition. To examine this question, we have designed and developed a tangible puppet interface and 3D virtual environment that are tailored to investigate the mapping between player and avatar movements. In a set of two experiments, we show that when the puppet interface is used to transfer players' movements to the avatar, the players are able to recognize their own movements, when presented alongside others' movements. In both experiments, players did not observe their movements being transferred to the avatar, and the recognition occurred after a week of the transfer. Since the recognition effect persisted even with these two handicaps, we conclude that this is a robust effect, and the puppet interface is effective in personalizing an avatar, by transferring a player's own movements to the virtual character.

Categories and Subject Descriptors

H.5.2 [**Information Interfaces and Presentation**]: User Interfaces---*input devices and strategies, interaction styles*; J.4 [**Social and Behavioral Sciences**]: *Psychology*; J.5 [**Arts and Humanities**]: *Performing arts*. K.8 [**Personal Computing**]: *Games*.

General Terms

Design, Experimentation.

Keywords

Puppet, tangible user interface, virtual character, video game, common coding, body memory, creativity.

1. INTRODUCTION

Our research investigates the relationship between the player and the virtual game character they control. Our approach is informed by an interdisciplinary combination of three key research fields as we combine approaches from cognitive science, tangible interfaces, and virtual worlds. Key debates of each area have substantially defined our overall research practice. Within cognitive science, we build on a growing research area that suggests that the execution, perception and imagination of movement share a common representation in the brain [9]. Known as common coding theory, this work suggests that when humans perceive and imagine actions, our motor system is activated implicitly. A common instance of this 'simulation' process is familiar to cinema goers: while watching an actor or car moving along a precipice, viewers move their arms and legs or displace body weight to one side or another, based on what they would like to see happening in the scene [17]. Similar effects have been reported in other audiences such as sports fans as well as novice video game players who react to events in the game world by dodging virtual bullets for their avatar. These gamers simulate their avatars' moves. The common coding theory states that his kind of 'simulation' of others' actions is the basis of our ability to project ourselves into different character roles. We understand the actions of others through our own body memory reservoir, which is 'leveraged' to predict actions and movements in the world. It does not matter whether these actions are performed by a virtual or physical character. However, one central result of work in common coding is that the neural system underlying the simulation may be better activated when watching one's own actions. For example, regarding the use of hands, Knoblich and Sebanz [14] found that people can recognize their own clapping from a set of recordings of clapping. Likewise, pianists can identify their own rendition of a piece from a set of recordings of the same piece. Informed by these findings regarding this 'own-movement effect', our overall research goal is to build a video game that uses tangible interfaces to transfer a player's own and unique movements to a virtual character. Our work is driven by

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two main arguments: 1) The ‘own-movement effect’ suggests that if a game avatar encodes the specific movements of the player, then this player should both identify and coordinate better with the character on the screen. This addresses critical issues such as engagement and coordination that are relevant for the game setting; and 2) Once this projection of own movement is activated it is possible, based on common coding theory, that novel movements executed by the virtual character may be transferred back to the player via the perception-action link. In return, this could lead to an improvement of the player’s ability to execute such movements in imagination, and, perhaps, also in the real world (see also [10]). In combination, we believe this might indicate that virtual characters can ultimately be valuable for teaching movements to players. This effect should be relevant e.g. for physiotherapy and stroke patient recovery.

Our earlier work [16] has focused on self movement recognition in different levels of abstraction up to a tracked hand puppet (see Figure 1). The present paper is based on a new set of experiments for which we designed a tangible game interface to test the transition of self-movement on a virtual character. In the first phase of these experiments, we record a person’s body movements using the tangible puppet interface, and test whether users can identify their own movements. Players will see different digital representations of their own movements, such as walking, tossing a ball, twisting, and drinking from a cup. We then test the extent to which players can identify their own movements in the game character. The second phase of experiments will test one possible effect of such identification with a character: we will examine whether interacting with such a ‘personalized’ game character executing novel body movements improves a player’s imagination of such movements.

We first present the necessary background for our work. Then, we discuss the design, development, and implementation of our puppet interface and the 3D virtual environment it manipulates, tailored to optimize the mapping between player and virtual avatar. Then we describe the experimental design, and present the results. We conclude with future directions and implications of this work.

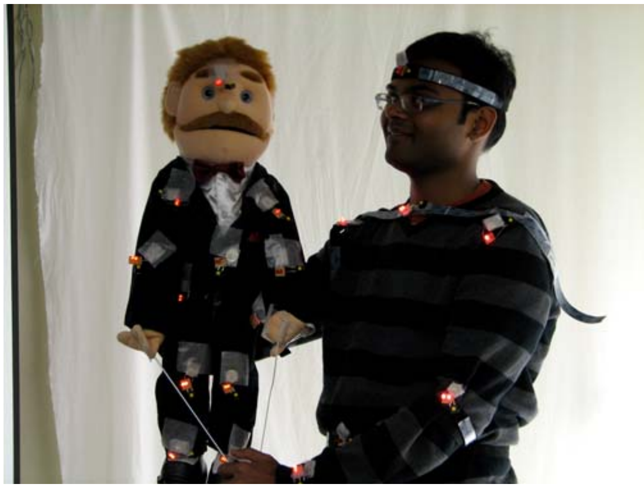


Figure 1. Player controlling a hand puppet. Both the player and puppet are tracked using LEDs.

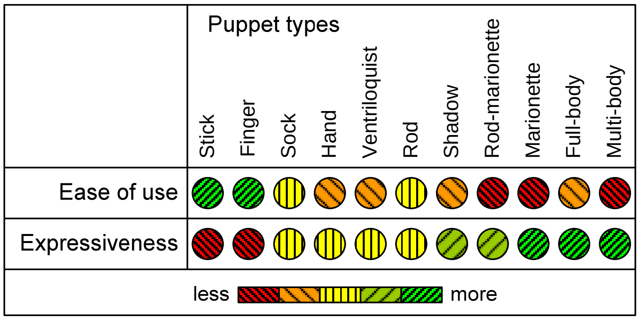
2. BACKGROUND

Our primary research goal is to examine whether transferring a player’s own movements to a virtual character leads to a close connection with the avatar, and whether this leads to improved cognitive performance. The hypothesis is that novel rotation movements executed by a character that encodes the players’ own movements would lead to improvement in the player’s imagination of such movements. This hypothesis is based on the common coding between execution, perception and imagination of movement in the brain, which leads to movement in one modality (say perception), automatically activating the same movement in the other two modalities (imagination and execution). It has been shown that this common coding leads to a better perception of one’s own movement [14]. To pursue this goal in our field of human computer interaction for video games, we had to develop a system that transferred the player’s own movements faithfully to a virtual character, to the extent that the player recognized these movements as her own even when seen offline (i.e. when she was not controlling the character with the puppet).

Our recent experiments [16] show that players can project and identify their own body movements in an abstracted character representation in a 2D video image. Even if the self-representation is reduced to abstracted shapes, players identify their own movements. Moreover, they recognize their own performance even in the abstracted video images of a secondary puppet. That means, if players control a secondary puppet (like a hand puppet, see Figure 1) and we track this puppet’s movements, they are still capable of identifying their personal performance from an abstracted video image of the puppet’s movements. Building on these results, we have designed a tangible puppet interface to encourage a direct means of transferring a player's movement to a virtual 3D character. In comparison to full-body interaction approaches such as motion capture systems, puppets provide a low cost and portable approach for transferring player movements to 3D virtual characters. In fact, puppeteering is a dominating paradigm for current video game control mechanisms. However, in comparison to the level of abstraction in most commercial game controllers (gamepads, joysticks, keyboards), a puppet is tangible and can provide direct access to many degrees of freedom in the physical world, which can be mapped to a high level of granularity in the movements of the virtual characters. Another advantage of the puppeteering approach is that it can open up a space for expressive exaggeration, since puppets can be made to perform actions in the virtual world that would be unachievable with a direct mapping of the human body alone. Puppets can perform actions that are physically impossible to humans; they can take all kinds of forms and appearances that open up control over non-human virtual characters; at times a puppeteer can even control multiple characters at the same time. The abstraction of a puppeteering device thus allows players to execute actions in virtual space impossible in real space, while their body movements still map directly onto the virtual performer. Unfortunately, commercially available control systems (like those used in game consoles) present a disconnect with the player’s own body movement, as even motion-controlled input devices such as the Wii controller or the Sony Move use heavily simplified mappings.

A number of past interaction research efforts have explored the use of physical interfaces for character control and animation. For example, the Monkey Input Device, an 18" tall monkey skeleton equipped with sensors at its joints, allowed for head to toe real-time character manipulation [6]. Johnson's work on "sympathetic interfaces" used a plush toy (a stuffed chicken) to manipulate and control an interactive story character in a 3D virtual world [11]. Similarly, equipped with a variety of sensors in its hands, feet and eye, the ActiMates Barney plush doll acted as a play partner for children, either in a freestanding mode or wirelessly linked to a PC or TV [1]. Additionally, our own past and ongoing research has used paper hand puppets tracked by computer vision [8] and tangible marionettes equipped with accelerometers [15] to control characters in the Unreal game engine.

Although motion capture is dominant in recording real performances in CGI animation, some direct puppeteering controls have been implemented, too. The Character Shop's trademark Waldo devices are telemetric input devices for controlling puppets (such as Jim Henson's Muppets) and animatronics that are designed to fit a puppeteer or performer's body. Waldos allow puppeteers or performers to control multiple axes of movement on a virtual character at once, and are a great improvement over older lever-based systems that required a team of operators to control all the different parts of a single puppet. A limitation of motion capture puppetry is that it typically requires significant clean-up of sensor data during the post processing stage. Its high price point also precludes its use in the consumer space for enhancing the expressive potential of everyday game players. The Henson Company's current real-time puppetry system, used to perform virtual TV puppets, requires two trained puppeteers per puppet. Notably, the dependency on the human puppeteer's performance is seen as the reason for a puppet appearance that is "organic and fun – it never drops into math" [7]. According to Henson, puppets artistically maintain the "organic" reference to the puppeteer's body, a point we aim to prove scientifically in our experiments.



	Puppet types										
	Stick	Finger	Sock	Hand	Ventriloquist	Rod	Shadow	Rod-marionette	Marionette	Full-body	Multi-body
Ease of use	🟢	🟢	🟡	🟠	🟠	🟡	🟠	🔴	🔴	🟠	🔴
Expressiveness	🔴	🔴	🟡	🟡	🟡	🟡	🟩	🟩	🟢	🟢	🟢

less 🔴🟠🟡🟩🟢 more

Figure 2. Our review of different puppetry approaches found an inverse correlation between the ease of use and the expressiveness and articulation of the puppet.

3. PUPPET REVIEW AND DESIGN

We began our puppet design process with a review of existing puppetry approaches and two main goals in mind for our own puppet. First, we wanted to develop a puppet controller that would provide a high-level of articulation and expressiveness in movement. Second, we wanted to develop a puppet that would be relatively easy to use so that it would not require the skill of a professional puppeteer to generate a range of expressions. Various types of the countless techniques in puppet controls were considered (based on [4, 18, 19]):

- *Stick puppet (*also called a *Marotte)*: A puppet often made of fabric, attached to a stick. It has a very simple and accessible interface but also extremely limited articulation and expression in its functionality.
- *Finger puppet*: A puppet usually made of fabric, worn on a finger and articulated by finger movement. Provides a very accessible interface, more ability to move the puppet compared to a stick puppet, but still has quite limited expressive capabilities for the puppeteer.
- *Sock puppet*: A puppet made from a sock or sock-shaped material and manipulated by a single hand. The interface is accessible and the puppet permits a moderate amount of articulation and expression. Moving your arm moves the puppet up and down, side to side, and backward and forward. Moving the fingers on your hand alters the puppet's facial expression and articulates its mouth.
- *Hand & ventriloquist puppet*: A puppet manipulated by the hand, generally more elaborate than a sock puppet. It is often fully formed, having a head, torso and limbs. One hand and arm articulates the puppet's face and moves its body. Additionally the puppet's arm may be manipulated by rods moved by the puppeteer's free hand. It has a moveable jaw that the puppeteer articulates while throwing her voice to make the puppet appear as if it is talking.
- *Rod puppet*: A more developed form of the stick puppet; manipulated by rod extensions often attached to its limbs or torso. The rod controls are fairly accessible, allowing for more expression than stick or finger puppets, but providing less facial expression than a hand or sock puppet. The limbs are generally attached with flexible joints, allowing some secondary motion.
- *Shadow puppet*: A flat, 2D puppet manipulated by rod extensions. The puppet is backlit against a screen, creating a silhouetted shape from the audience's perspective. The rod controls are fairly accessible. The puppet's limbs are often attached with moveable joints, allowing for greater expression than stick or finger puppets but also requiring more skill to manipulate.
- *Rod marionette*: A puppet manipulated with both string and rod controls. This is a hybrid interface that gives some of the expressive abilities provided by strings with the more accessible controls of rods. These puppets tend to be quite large, often over a meter in height. Some strings can be attached to the puppeteer's body.
- *Marionette*: A fully formed puppet manipulated by strings, typically attached to a control bar above. String manipulation is one of the most difficult to use interfaces, but it also permits some of the most expressive movement and gestures. There are many variations of marionettes with different configurations of joints (e.g. two-legged, four-legged) and controls, different numbers of strings, and different shapes, sizes and materials. Some traditional Chinese puppets can have as many as 36 string controls.
- *Full-body puppet*: A fully formed puppet that is manipulated by a puppeteer's body. Full body manipulation creates expressive movement and can be a moderately accessible interface. For example, Kathputli marionettes are often controlled with just

loops of string attached to the top of the head, back of the waist and sometimes the hands of the puppeteer. The intrinsic movements of the puppet and the dexterity of the puppeteer can together produce a great variety of movements [4].

- *Multi-body puppet*: A puppet that requires two or more puppeteers to manipulate. Japanese Bunraku puppet theater is best known for this type of puppeteering.

This list is by no means complete and only offers an introduction into the rich tradition of puppet creation. However, it served as an initial starting point for our design. Since we are interested in the player's identification with the puppet, our design demanded a balance of direct contact and level of expression in the puppet (see Figure 2). But the puppet also needed to be accessible to non-professional performers to be relevant for the kind of game-like performances we targeted. This shifted our focus to full-body puppets, which conform to our body's configuration, and allow expressions similar to body movements. We also found that hybrid puppets can help compensate for the inverse relationship between direct contact and expression. For example, some rod-marionette puppets are attached to the body with strings. The puppeteer's hands move the rods to animate the puppet limbs, and their body moves back and forth to animate the whole puppet, giving a wider sense of control and expression. Inspired by this, we decided to create a hybrid puppet based on a full-body concept, but drawing on a combination of approaches. Based on our earlier experiments on recognition of self-movement in puppet control [16], the hybrid approach provided the required combination of a faithful transfer of own body movements to the avatar, as well as the necessary abstraction between own movement and virtual puppet.

Figure 3. Player interacting with the puppet.

4. SYSTEM DESIGN

The system consists of two main components: the puppet and the 3D engine. The following sections describe these two components and how they work together to translate the puppeteer's movements onto the avatar.

4.1 Physical Interface

Our puppet consists of 10 joints at the knees, hips, waist, shoulders, elbows and neck to provide a wide range of expression and movement. Its feet attach to the player's knees, its head attaches to their neck, and its midsection attaches to their waist. The player's hands also control the hands of the puppet (see Figure 3). In this way, the puppet can be easily controlled by both the hand and full-body movements of the player. The puppet is built out of wooden "bone" pieces and joints that are laser-cut for better durability. They are connected with 16 potentiometers across the 10 joints (see Figure 4). Earlier puppet prototypes experimented with accelerometers but we found potentiometers to be more reliable for our specific needs and the kind of puppet we developed. Puppet joints such as the shoulders, which rotate in two directions, contain two potentiometers oriented 90 degrees from each other, so that the joint can rotate in each direction independently. The potentiometers are connected via a multiplexer to an Arduino Pro microcontroller attached to the chest of the puppet. The microcontroller sends the movement data to the host computer using a Bluetooth connection. A Processing application on the host computer normalizes the values and sends them to the rendering engine via the OSC protocol.

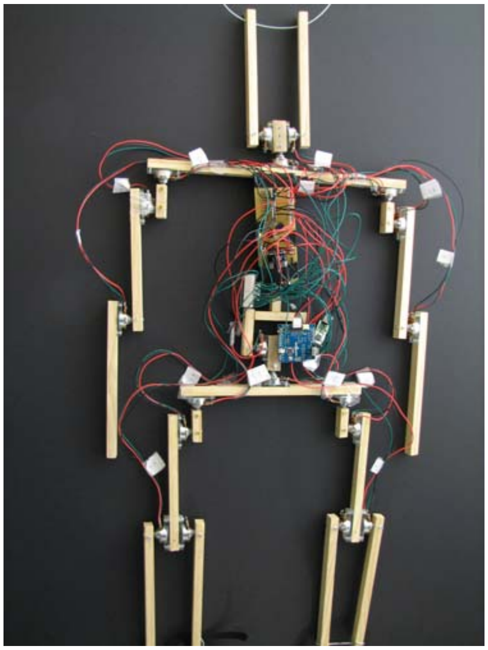


Figure 4. Tangible interface puppet with 10 joints for the knees, hips, waist, shoulders, elbows and neck.

4.2 3D Engine

In contrast to our first series of experiments, which tracked the player and puppet's movements in 2D video imagery, we represented the virtual puppet as a fully functional 3D character in this set (see Figure 5). The 3D renderer allows the puppet device to steer a virtual puppet in real-time. It is based on the Moviesandbox (MSB) application, an open-source, OpenGL-based, machinima tool written in C++ by Friedrich Kirschner. It uses XML files to store the scenes and the settings for the characters. This allows for a very flexible usage of the renderer.

MSB receives the OSC message from the Processing application, and provides their mapping onto the virtual avatar. Based on the settings for the joint rotations in the currently loaded XML character file, positions the bones are set by MSB relative to one another using forward kinematics. In addition to character control, MSB currently supports camera placement, panning and tilting. The 3D renderer also includes advanced import functions and has basic animation recording options. Both are valuable for experimenting with different virtual puppets and comparing the animations our puppeteers create with them.

The system provides us with a basic but highly flexible virtual puppetry engine that mimics the functionality of video game systems – in fact, its first installment used the Unreal game engine as renderer but to provide better flexibility, we moved on to an Open GL approach. At the same time, it allowed us to adjust necessary control mechanisms to the interfaces we were designing.

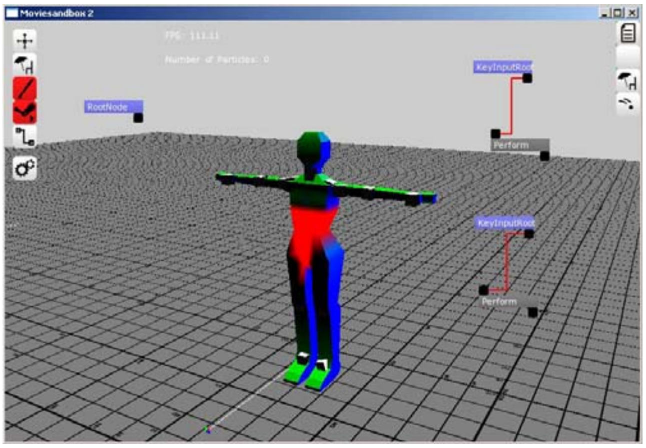


Figure 5. 3D Renderer with avatar in initial state.

5. EXPERIMENTAL DESIGN

The overall goal of our research is to investigate whether we can transfer novel movements executed by a virtual character on screen back to a player. A number of basic conditions have to be tested before we can address this final question. The work presented here on the first stage of the project investigates the extent of the connection between the player's own movement and that of a virtual entity in a 3D environment.

5.1 Experiment Overview

We conducted two experiments to assess the hypothesis that a person can identify her own movement even when the movement is instantiated by an avatar. A series of previous studies of biological movement [2, 5, 12, 13] have shown that when a person sees a visually abstract representation of their movement (something as simple as a light-point animation, see [16]), they can recognize the image's movements as their own. Unlike the highly abstracted video image in these previous experiments, the virtual representation here is a clear virtual body. Like most other virtual characters, this virtual body's size and shape remain uniform for all users. Also, it does not display any recognizable gender specifics.

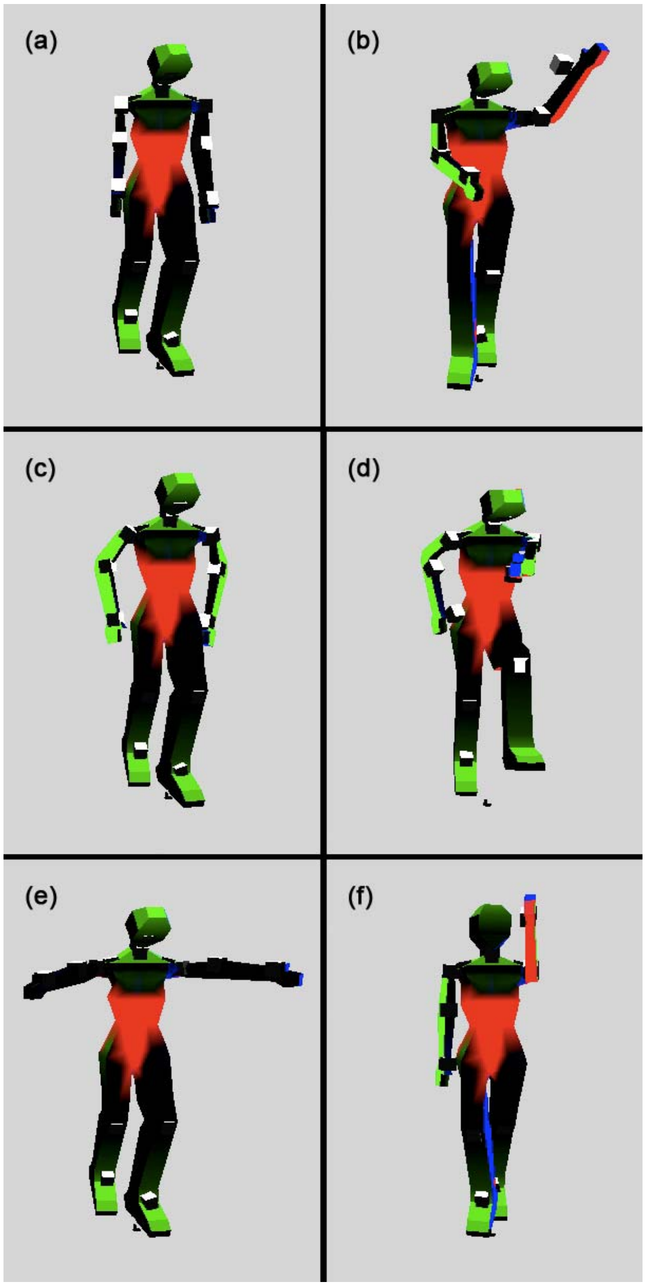


Figure 6. Stills of the 3D avatar in the walking movements (walk (a), hip-walk (c), arm-out-walk (e)) and in the fixed position movements (toss (b), twist (d), drink (f)).

Our first experiment analyzed participants' ability to recognize their body movement in different types of walking: normal walk, hip-walk and arm-out-walk. The second experiment analyzed participants' ability to recognize their movements when they performed while standing in a fixed location. Movements here were: tossing an item, twisting and drinking an imaginary beverage. In both experiments, the participants used the puppet controller we designed and that was described above.

We were interested in discovering whether participants were able to recognize the movements they make while using such a control interface even after some time had passed after the original performance. This can allow us to establish whether a user will perceive the movements of a virtual character controlled by a tangible user interface as their own movement. In turn, this determines whether it is possible to use an external interface (e.g. puppet rather than body motion capture) as the basis for extending a user's body memory.

For each prototypical movement, participants did 5 trials during which their movements were translated into the 3D render program where they animated a virtual avatar. However, during the first part of the experiment participants were not able to see the animated avatar on screen. Instead, we recorded the animations for later use. There were a total of twenty four participants in this study: twelve participants (6 male, 6 female) participated in the walking experiments; and twelve participants (6 male, 6 female) in the standing movement experiments. None of them was an experienced puppeteer.

5.2 Animation Recording and Recognition

Each experiment involved a recording session and a recognition session. In the recording session, the puppet interface was attached to a participant, and she was then asked to execute the series of six different movements. The puppet transferred the participant's movements to the avatar on screen, but the avatar's movements were only visible to the experimenter, and never to the participant. Once the participant had executed the movements, she was asked to return after a week for the second "recognition" session. In this session, she was presented a series of videos, and she had to identify her own movements in these videos.

For the recording session in the first experiment, each participant was asked to perform three types of walks (Walk, Hip-walk, Arm-out-walk). The Walk involved walking in the natural walking style of the participant. In Hip-walk, participants were asked to walk with their hands on their hips. For Arm-out-walk, participants walked with their hands outstretched (see Figure 6a, c & e). For each participant, 5 Walk, 5 Hip-walk, and 5 Arm-out-walk trials were captured.

A week after the recording session, participants returned for recognition sessions during which they watched a series of trials, each with two video clips of a movement (see Figure 6a, c & e). One clip showed the participant's own action (say, Hip-walk) and the adjacent one showed the same action performed by another participant. The participant was asked to identify which video displayed her own action. There were 33 trials for each movement type (Walk, Hip-walk, Arm-out-walk), making a total of 99 trials. The 99 trials were presented together, but in blocks of three trials – the videos from Walk were shown first, followed by those from Hip-Walk, and then Arm-out-Walk. This sequence of 3 trials was repeated 33 times, so that participants never saw the same movement in succession.

To avoid any patterning during the individual video trial, the program picked a random video clip of the participant from a list, and another random video clip from a list of others making the same movement. The location on the screen where these two animations were presented (left, right) was also random. Participants were asked to press "P" if they thought their video clip was on the right, and "Q" if they thought it was on the left. The videos looped until the participant made a choice. The video presentation program kept track of the randomizations of files and locations, the key press responses of participants, and the time it took for a participant to respond.

The second experiment followed the same design, except that the participant stood in a fixed position and made movements in the recording session. The movements were Toss, Twist and Drink (see Figure 6b, d & f). Toss involved the participants tossing a ball in the air and trying to catch it. Twist involved doing a twisting movement at the hip. Drink involved picking up a cup from the table and making a drinking motion. The recognition session followed the same pattern as the Walk experiment. All the 99 trials were presented together. The order of presentation of the video trials were Toss, Twist and Drink, with this pattern repeating 33 times.

6. RESULTS

For each participant, we computed the proportion of correct self-identifications (see Figure 7). Since the guessing probability is .5, values significantly greater than .5 indicate that participants recognized their own movement.

	Percent Correct	SD
Walk	71.21	22.55
Hip Walk	68.43	20.20
Arm Walk	76.01	24.36
Toss	67.17	23.29
Twist	82.32	18.04
Drink	74.75	21.48

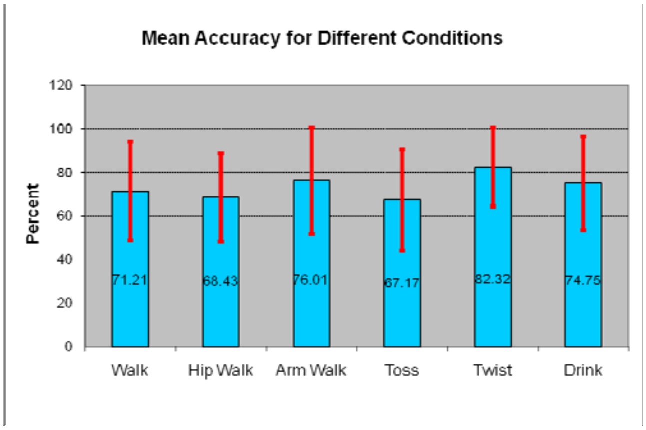


Figure 7. The average percentage of correct results across all six study trials.

Accuracy: Participants showed high levels of identification in both experiments. All accuracy measures were significantly above chance level. The mean proportions of correct identifications for the Walk experiment were as follows: Walk: 71.21 (SD=22.54, χ^2 = 72.54, p<.001); Hip-walk: 68.43 (SD=20.20, χ^2 = 56.54, p<.001); Arm-out-walk: 76.01 (SD=24.36, χ^2 = 96.66, p<.001); The mean proportions of correct identifications for the No-Walk experiment were as follows: Toss: 67.17 (SD=23.28, χ^2 = 62.72, p<.001); Twist: 82.32 (SD=18.03, χ^2 = 106.36, p<.001); Drink:

74.74 (SD=21.47, χ^2 = 82.00, $p<.001$). The high standard deviations suggest significant individual differences, and follow the pattern in our previous experiment [16] and other studies in the literature.

Gender: Previous experiments have shown that people can accurately recognize the gender of a point-walker [5]. Therefore, it is possible that in trials where the two videos showed participants with different gender, people made the recognition decision by recognizing the other person's gender, and then eliminating that video. To check whether this occurred, we analyzed the data based on the same/different gender in the video. The proportion of correct identifications for same gender trials and different gender trials were extracted for each condition (see Figure 8). Performance for different gender was higher only in the Walk experiment; in the No-Walk experiment, same gender scored higher. Even in the Walk condition, the differences were not very high. For Walk we noticed less than 5% and for Arm-out-walk less than 3%. For hip-walk, there was an 8.33% rise in performance. It is possible that this difference is based on the above proposed logical mode of recognition. However, the lack of a pattern across the two experiments, and the absence of a performance advantage in the other two walk conditions, suggest that the self-identification was based on a simulation of the movements seen on video, rather than a logic-based elimination process. Further supporting this view, our previous study showed no effect of gender in recognition decisions [16].

	Same Gender	SD	Different Gender	SD
Walk	68.89	25.95	73.15	22.58
Hip Walk	63.89	23.86	72.22	19.82
Arm Walk	74.44	28.69	77.31	21.38
Toss	67.22	25.66	67.13	22.41
Twist	83.89	16.44	81.02	21.12
Drink	77.22	20.98	72.69	23.86

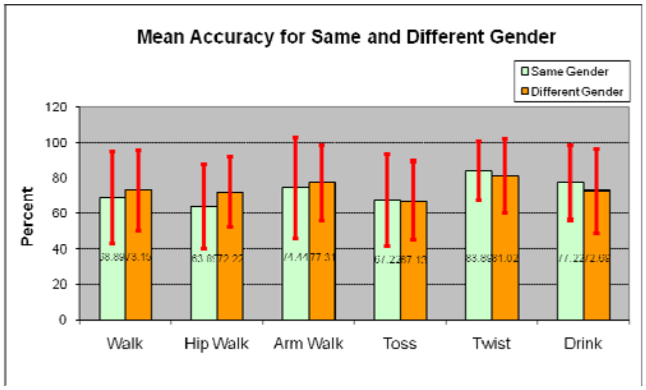


Figure 8. The average percentage of correct results for same and different gender tests across all six study trials. The recognition of walking movements is slightly higher when the genders are different.

7. DISCUSSION

Overall, the results show that player/ puppeteers can recognize their own movements if they are transferred to an avatar using a puppet interface. The recognition rate is not as high as the recognition of own body movements in a point-light-walker video (~95%) but comparable to the self-recognition of a point-light-animation recorded from the movements of a hand puppet operated by a non-professional puppeteer (~80%) [16]. The difference between the hand puppet movement recognition and the more complex hybrid marionette recognition presented in this paper could be explained by the unfamiliarity with the interface. Both the hybrid puppet and the avatar are currently at a prototype stage and still limited in their expressive range. In contrast, the hand puppet (see Figure 1) appeared to be more familiar to most participants. The avatar we used is androgynous, and cannot really display walking in space. Point-light walkers display walking in space, and they also display smoother movements. We believe the recognition levels could be raised further by improving the avatar's visual presentation and movement patterns. We are also working on optimizing the puppet further. Even though the puppet is very accessible, the interface for a point-light walker experiment is usually visual and thus less restrictive to users.

The results show an effective translation of self to the avatar using the puppet interface, suggesting that we indeed project ourselves to the movements of 3D virtual characters whose movements derive in second order from our own body memory; probably through a common coding system. We believe these results could be exploited to develop new media, new interfaces, and also new applications for video game and digital media, particularly in the medical field. For a broader discussion of the use of common coding theory to derive novel interfaces, see [3].

8. CONCLUSION AND FUTURE WORK

The research presented here illustrates ongoing work at the interface between basic science and technology development in the application of common coding theory to virtual character control through tangible interfaces. It is part of our larger and ongoing project investigating the value of tangible user interfaces and virtual characters to augment a user's body memory gradually, by exploiting the common coding and self-recognition effect. We have presented our implementation of a tangible puppet interface and 3D virtual environment tailored to optimize the mapping between player and virtual avatar, and a set of experiments which demonstrate that the underlying connection between own body memory and virtual character through this puppet interface stays intact. Players were able to recognize their own movements when presented alongside others' movements, even though they did not observe their movements being transferred to the avatar and the recognition occurred after a week of the transfer. We have, thus, demonstrated that our puppet interface design supports players' self-recognition in a 3D virtual character. Based on these results, we are conducting a new set of experiments to examine whether controlling the avatar using our puppet interface leads to better cognitive performance of the player in comparison to other interfaces (such as game controllers and keyboards). One of these experiments tests whether participants' mental rotation abilities improve after interacting with the avatar using the puppet interface. Future experiments will examine whether perceiving a 'personalized' video game character executing novel body movements can augment a player's body memory and 'teach' a player in that way.

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