Human Trials: An Experiment in Intermedia Performance

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Human Trials is simultaneously a public/private and embodied/disembodied performance. One user enters an immersive virtual environment and is led on an absurd quest. The challenges appear to be about control and the choices one makes in using power; but the games are rigged, the characters are duplicitous, the quest is a decoy, and the underlying test is how to cope with disempowerment. Meanwhile the experience is screened for a voyeuristic audience primed by reality TV. The audience members simultaneously watch multiple viewpoints of the virtual world, while live performers, networked into the virtual environment, attempt to entangle the protagonist in their improvisational machinations. The project combines virtual reality, networking, and artificial intelligence technologies.

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1. INTRODUCTION

This article discusses *Human Trials*, a networked, virtual, participatory drama with human actors, intelligent agents, and smart sets. *Human Trials* is a collaboration among the authors of this article. It explores the intersection of virtual reality and embodied performance through an event designed both as an immersive experience for one participant, and as a nonimmersive production for a live audience. The participant enters the virtual world from a projection-based VR system and interacts with a variety of computer-controlled actor-agents and two characters, Filopat and Patofil, played by human actors wearing head-mounted displays (HMDs). The audience watches the actors and three large projections of the virtual action showing the points of view of each of the three main protagonists in the drama.

Rather than involving solely human actors, as in a traditional drama, or entirely computer-driven agents, as in a video game, the performance combines both. This is advantageous as it allows the human actors to improvise and adapt to an unpredictable

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human participant, while letting agents fill out the world and take the roles of several minor characters. We make use of a networked virtual environment to bring the actors and agents together, all of them appearing as avatars in the shared world. We define *Human Trials* as an intermedia performance. The concept of intermediality [Albersmeier and Roloff 1989] is gaining ground in theater and performance studies as the critical intersection of live embodied performance with cinema, television, and digital technology [Auslander1999; Chapple and Kattenbeltr 2006; McKenzie 2001].

After a brief discussion of other work on virtual reality and performance, this article describes the five-act drama *Human Trials*, its enabling technologies, visual design, computer-controlled characters, and human actors.

2. VR AND PERFORMANCE

Research groups and artists have created productions that mix virtual reality and performance in different proportions, for very different purposes, and with very different notions of audience. *Placeholder* (1992) allowed two participants wearing head-mounted displays to share a virtual world with each other and with the disembodied voice of a "goddess" who guided and stimulated their experience [Laurel et al. 1998]. There was no plot or story arc, rather the participants were encouraged to play in a rich virtual world inspired by native American mythology, with three distinct environments and a series of "smart costumes." As they changed costume their avatars also changed, and they could access different abilities: for example, when a participant chose the crow costume, the corresponding avatar could fly. *Desert Rain*, a collaboration between Blast Theory and the Mixed Reality Lab, University of Nottingham, focused critically on the complexities of the 1990 Gulf War [Shaw et al. 2000]. This mixed-reality experience had a narrative plot with a mission for the three participants, who interacted with real actors and real sets, as well as entering a virtual world projected onto the rain curtains of three cubicles. The entire experience implicated the participants in a hi-tech world of spying and counter-intelligence, and pushed them to acknowledge both the seductions and dangers of such a world. Since 1994, the Institute for the Exploration of Virtual Realities and the University Theater at Kansas University have applied virtual reality and related technologies to theater production and performance, including traditional staged versions of *The Magic Flute* (2003) and *Dinosaurus* (2001), with real-time, computer-generated set elements and computer-generated dinosaurs, as well as experiments using head-mounted displays and in cyberspace [University of Kansas University Theatre and Institute for the Exploration of Virtual Realities 2003a; 2003b]. The *Incarnation of a Divine Being* (2001) by The Tools for Creativity Studio of the Interactive Institute (Umea), part of *EVL: Alive on the Grid*, was an intercontinental networked dramatic improvisation. Between four and eight remote avatars sharing a virtual amphitheater were led by an actor at one of the locations in a supported improvisation based on a Greek tragedy [http://w3.tii.se/en/project.asp?project=317. 2007]. Other research groups have focused on using artificial intelligence techniques to build agents that act and improvise in interactive fiction and drama [Burke et al. 2001; Mateas and Stern 2004; Hayes Roth et al. 1995; Sengers 1998].

Like *Desert Rain*, *Placeholder*, and *Incarnation of a Divine Being*, *Human Trials* was created explicitly for a virtual-reality-based performance. It follows the narrative and time-driven style of *Desert Rain* rather than the open-ended play-space structure of *Placeholder*. It incorporates improvisation, but the ratio of two performers to one participant and a more structured script make it a much less open-ended performance than *Incarnation of a Divine Being*. *Human Trials* was designed as a psychological experience for one participant and as a spectacle for a voyeuristic audience. It is a

research project as well as a creative endeavor: our collaboration is interested in building intelligent agents that will act and improvise in a dramatic setting.

3. A PERFORMANCE IN FIVE ACTS

Human Trials, which is based on an original idea by the first author, networks three protagonists into a virtual world – an audience participant and two actors playing the characters Filopat and Patofil. The ensuing performance plays to a larger audience. Filopat and Patofil can be played by either male or female actors. (In the description that follows, for convenience of reading, we have designated Filopat as "he" and Patofil as "she.")

The feasibility of *Human Trials* rests on the assumption that virtual reality is a medium that fosters first-person psychological experience. In the 1990s, VR applications simulated things that were too big, too small, or too dangerous for direct experience (the cosmos, cell structure, the interior of a gas-turbine), but it has become increasingly clear that VR applications can also create the conditions for the simulation of self. Slater's psychological experiments [Freeman et al. 2005; Pertaub et al. 2002; Slater et al. 2006] and Anstey and Pape's [2002] work on virtual fiction speak to the possibility of self-simulation in immersive VR; many theorists have studied the performance and construction of different and multiple identities in games and online communities [Rehak 2003; Stone 1996]. There is a buffer between real life and VR that suggests that it may be psychologically safer to explore and experiment with the creation and boundaries of self in virtual environments.

We further assume that we can structure and control the user's self-simulation, and, to a degree, direct her internal experience. Every choice that is made in the construction of a VE – sound, visuals, interaction – constrains the user; we believe we can develop constraints that support a particular process of self-simulation. In *Human Trials*, we specifically want to immerse users in situations that exaggerate flaws arising from a failure to successfully negotiate early developmental tasks [Benjamin 1988]. On the surface *Human Trials* is a quest adventure, underneath it is a pseudo-psychological assessment that determines which of two infantile positions the participant is (or tends to be) stuck in: the sadistic and narcissistic position (believing that they are the only thing that exists), or the masochistic and passive position (afraid to exist). The quest adventure serves as a constraining narrative context, with scenarios designed both to stimulate and detect revealing psychological responses. The participant's responses to different scenarios are used to judge whether she is aggressive, bullying, kowtowing, laid back, cynical, eager, or reluctant to engage

The dramatic structure also serves as a constraint – there are five acts which create an arc of rising and falling but ever-increasing dramatic tension and a denouement. The first four acts always occur in the same order. One of the two different versions of act five is presented depending on how the participant has responded. Act five represents the implications of one or other of the two flawed psychological positions. The fixed dramatic structure means that we control the pacing and reversals of the plot, and therefore manage the overall emotional trajectory of the experience. However, within each act the participant can interact much more freely; effectively, the participants can do and say what they like. But we are still interested in managing their interactions, so that they perform activities we have designed to reveal something about their psychological make-up.

As we discuss the five acts of the drama, we will go into more detail about the process of structuring constraints that support the user's self-simulation. We will also discuss the

role of the audience participant and the larger audience in the performance.

3.1 Act One

Human Trials starts on a curtained stage. Avatars of the two networked actors, playing the roles of Filopat and Patofil, enter stage right and left, greet the audience participant, and introduce the quest. The stage is a relatively small space, and the participant's navigation controls are disabled here; it serves as a place without distraction, where the actors can easily attract and keep the attention of the participant. It also serves as an explicit reminder that this is a performance. The three protagonists, Filopat, Patofil, and the audience member are returned here between acts. In the introduction, Filopat proclaims, "Behold, the land of your quest!" and the three are teleported into act one, falling gently to earth amongst reeds, close to a river. The audience sees large projections from the point of view of each protagonist.

The trope of the quest covers the entire drama; it is a narrative constraint designed to structure the participant's and the audience's thinking, and was deliberately designed to be familiar. At the beginning of the experience this is entirely benign: we want the participant to acclimatize rapidly, to feel at home, and perhaps slightly superior to the space he or she is in. As the story develops, the participant should grow more wary, realizing that the challenges are never quite what they seem, and that Filopat and Patofil give conflicting advice and directions. We do not break away from the children's story referent, but it becomes apparent that this piece is more akin to Struwel-Peter or the tales of the Brothers Grimm, containing dangers and warnings, hints that this could be a quest into the unconscious.

In Act One, Filopat's task is to get the participant to the river, which marks the true beginning of the quest. Patofil tries to persuade the participant to play about in the reeds which respond dynamically to their movements. Once they reach the river, Filopat stresses the mystical importance of the crossing, while Patofil and the participant acquire water pistols, and Patofil encourages the participant to virtually drench Filopat. In this scene the users are offered a variety of revealing temptations. Will they rush off obedient-

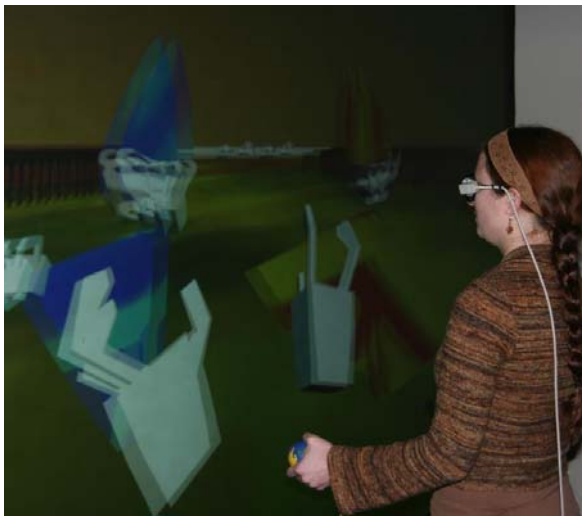

Fig. 1. A participant encounters Filopat and Patofil.

ly after Filopat, intent on the direct path of the quest? Will they dally with Patofil? Will participants relish spraying the protesting Filopat? What does this act reveal about a participant's tendencies to procrastinate and bully?

3.2 Act Two

In Act Two the participant is presented with the challenge of capturing three crowns from animated characters called Monkats. To capture the crowns, the participant must approach the creatures very slowly, and stroke them. At this, their crowns levitate and can be snatched away. Implicit in the activity is a degree of sneakiness, but it also connotes the basic collecting tasks of video games. However, at a certain point in the proceedings, one of the Monkats clings to the participant. It will not let go. If the participant moves away, the Monkat's arms stretch and it cries in pain. The scene ends with the participant having to cope with this frustrating situation. We observe how frustrated participants are with their failure to complete the task, and whether they take this out on the Monkat.

This act demonstrates our approach to constraining activity -- scenes are designed as "snares" for our participant -- and contain the possibility for actions that we believe will be telling. Emotional pressure is applied to the participant by the experience, the story, the characters, and, we believe, it is the participant's emotional response that governs his/her actions/interactions. Snares are specifically designed to provoke emotions and emotional changes. Typically, with these snares we are trying to piggyback on stereotypical responses -- here we first stimulate competition, but the participant who is elated because she/he is "winning" by capturing crowns, is then stymied and disappointed. (For more information on our concept of interactive snares, see Anstey [2005a; 2005b]; Anstey et al. [2004]). The scene also plays with issues of control -- the participant's apparent mastery over the Monkats is abruptly terminated and she/he has to deal with her powerlessness. At the assessment level of *Human Trials*, this scene tests for competitiveness, aggression, and bullying.

3.3 Act Three

We are interested in the simulation and stimulation of social patterns that will constrain the participant to simulate the matching social and emotional response. In *Human Trials*, the characters Filopat and Patofil create social situations for the participant to deal with.

Fig. 2. Collecting the crowns.

They have different personalities and goals, bicker with each other, and press the participant to side with them. Slater's work [Pertaub et al. 2002] in particular shows people responding to avatars as if they are social actors; we assume that the audience participants will automatically respond socially.

In the entre-acte between acts two and three, the two characters assess the participant's performance. Whatever the participant has done, Filopat will condemn and Patofil will praise. Then Filopat announces that the next phase of the quest is an all-night vigil. They are all teleported to a ruined chapel on a grassy mound. Night falls. When Filopat is deep in meditation, Patofil tries to entice the participant to play with wisps that are floating over the mound. This scenario is designed to encourage the participant to subvert authority (Filopat), to feel light-hearted, but possibly with guilty overtones. We observe how willing he/she is to disobey Filopat and the stated rules of the challenge, which are to be still, silent, and to meditate. The entre-acte is designed to prejudice the participant towards Patofil and the subversive path.

Disobedience leads, of course, to swift punishment, and Act Three ends with the participant being bullied by the Red Kings, computer-controlled characters who abduct Patofil. These characters menace and belittle the participant in an insinuating, intimidating, and sexual way. They circumscribe her/his movements, blocking and pushing her/him. The physical intimidation tactics of these characters simulates a delinquent disregard for social norms. This works in terms of our concept as a slippage towards the more infantile behaviors we are exploring – a simulation that may stimulate childish and revealing behavior in the participant. It also works technically as it is easier to model their bullying, which is based on physical reactions and gratuitous insults rather than on more sophisticated social responses. The attack of the Red Kings also baits the next act – the participant should feel irritated, angry, negative towards these characters. Then she/he is offered the chance to be a hero and rescue Patofil from them – is she/he tempted? Is she/he wild to fight? Is she/he cowardly?

3.4 Act Four

The Red Kings disappear as the sun rises and Filopat emerges from his very deep meditation. Sometimes the participant has already rushed off to Patofil's rescue, at other times Filopat has to drag a guilty confession from the participant in order to discover that

Fig. 3. Confrontation in the dungeon.

the Red King's have abducted her. Either way, the upshot is that Filopat and the participant rush across the plain, enter the Red King's castle, fall into the huge dungeon, and, mounted on flying rocks, engage the Red Kings in battle, while Patofil watches and cries for help. This tends to be the most spectacular scene. Social nuance falls away, and it becomes a shooting match with laser guns and rainbow lighting effects. The participant may feel most empowered or most constrained at this point; able to blast the enemies, liberated even from gravity, but most tightly constrained by the story form, and the demands of the spectacular performance.

As the last King (but one) is vanquished, Filopat falls from his rock and Patofil is dragged away through an exit tunnel. The wounded Filopat urges the participant to follow Patofil alone. As the participant starts along the tunnel, both Filopat and Patofil are moved to a hidden viewpoint above and in front of the participant, so that they, and the watching audience, can see the participant's cautious or reckless approach around a bend. As the participant exits the tunnel, she/he sees large curtains proclaiming, "Heart's Desire." The two characters welcome the participant and assure her/him that neither has "really" been harmed. It has all been a test! Now they have to wait while the results are tabulated and the participant's heart's desire is prepared.

Human Trials has a human stage manager who intervenes in the drama but does not appear in it. The stage manager controls the timing of the entire piece, teleporting the protagonists to the next stage of the drama, changing scenery, cueing entrances by the computer-controlled characters, and cueing the real actors. In our first performances, the stage manager also assessed the participant on the basis of her/his reaction to the scenarios and characters, and determined the ending the participant should receive. In the last performance, the audience, primed with questions about the participant, was required to vote on the participant's behavior. The stage manager tabulated the votes and activated the appropriate ending.

3.5 Act Five

The participant is given the "life" or "death" ending. The life ending is for the participant with sadistic tendencies. This tendency is correlated with a driven, type A personality fixated on mastering the challenges, a person who bullies, an aggressive fighter, a gung

Fig. 4. The stage manager and an actor.

Fig. 5. The "death ending."

ho rescuer. As the participant is dropped back into the world, Filopat and Patofil tell the participant that she/he is in complete control, nothing limits the participant, she/he is the only thing of importance, in fact the only thing. The actors remove their tracking systems and leave the stage, their avatars hang lifelessly. The person stuck in the sadistic position cannot recognize that others are also subjects, and so is ultimately alone.

The death ending is for the participant with masochistic tendencies. This tendency is correlated with a person who procrastinates, is overly sensitive, avoids and refuses responsibility, and appears cynical about the quest. The participant is dropped into a dark space with snowflakes slowly tumbling past. Filopat and Patofil tell him/her to relax, do nothing, cease. They remove their tracking systems, go to the participant, help him/her out of the VR gear, and bring the participant to a couch to sleep. The person stuck in the masochistic position believes that cleaving to a powerful other will keep him/her safe, but in so doing risks losing self entirely.

3.6 Participant and Audience

As a work incorporating first-person experience, *Human Trials* puts a lot of stress on, and is heavily dependent on, the audience participant. If the participant is comfortable handling the technical interface; is confident; and takes cues from the actors, performing within the narrative parameters; the experience is smooth and enjoyable for the larger audience. When things go well, the actors have time to be simultaneously aware of the participant in virtual space and of the audience in real space, and with gestures and body language the actors can respond to the audience as well as play to the participant. They can facilitate feedback between the audience and participant - for example, during one show they encouraged the audience's friendly derision of the participant who was having trouble with the Monkats, provoking the participant to address the audience directly, telling them the task wasn't as easy as it appeared. Under these conditions the narrative makes sense and the point of the last act comes across. For example, one performer offered his own coda to the sadistic ending – saying, “I am everything, I am nothing but I am scared.”

The performance becomes very different if the participant has difficulty navigating and operating in the space and/or is resistant to the flow of the drama. In some cases the actors handled the problems with aplomb, in others they became a impatient and a little hostile, and the audience became increasingly anxious. In these cases the narrative momentum would break down and the ending would not work at all. One participant in particular tended to ignore the actors, had great difficulty operating the joystick, but also seemed to create a unique character for her performance, complete with an assumed voice.

However, performances that go badly also engage the audience in interesting ways, fostering exploration of the kind of complicated and contradictory responses that are also evoked by reality TV shows. Audience members may sympathize, laugh, cringe, identify with the participants, want to act for them or influence their response. At the show in which the participant had so much trouble driving, audience members criticized the production team for not rescuing her from her predicament sooner. Fictional issues of coping with the discomforts of power and control were suddenly displaced by normative social responses. Whether the performance succeeded or failed, it was always dramatic!

4. ENABLING TECHNOLOGY

The production of *Human Trials* involved combining VR, networking, and AI technologies and techniques. The virtual environment was created in Ygdrasil, a scripting framework for networked VR developed by Pape [Pape et al. 2003]; Ygdrasil was first used to build *EVL: Alive on the Grid* and the *Incarnation of a Divine Being* improvisation application. Our AI technology is SNePS, a KRR system developed by Shapiro, which has been used in the construction of virtual and real robot agents.

Our multiuser environment has four stations – three VR systems for the actors and the participant, plus one for the stage manager. A networked database server runs on an additional processor. When we use the SNePS actor-agents we need yet another machine to run them. The VR stations consist of either a rear-projection, passive stereo display or an HMD (along with projectors for the audience); a graphics computer; and a tracking computer. We use an electromagnetic tracking system with three sensors, one for the head and one for each hand. One of the hand sensors is attached to a controller with a joystick and buttons. Sound effects and prerecorded agent voices are mixed with sound from microphones worn by the actors and participant. The participant is given a station, separated from the main performance area, to allow some privacy. The actors and the stage manager, meanwhile, perform in front of the audience. Large projections behind the actors provide views of the virtual world, including the avatar of the hidden participant.

The virtual world of the drama is built in Ygdrasil, which is based on the OpenGL Performer scene graph, and provides a framework for extension; application-specific modules (plug-ins) are added to define behaviors for objects or characters [Pape et al. 2003]. Scripting involves defining messages sent between scene nodes in response to events. *Human Trials* is a large and complex virtual world with five major and many minor scene changes, three networked participants, and nine computer-controlled characters. As the participant moves through the experience, objects; entire scenes; and time-based, event-based, and location-based triggers; must be turned on or off appropriately. Ambient sound and lighting must also be changed; smart set elements and intelligent agents must be cued and managed. As much as possible this is handled automatically by triggers preset in the environment; the human stage manager controls the rest from a desktop interface.

Fig. 6. An actor with HMD, trackers, and controller.

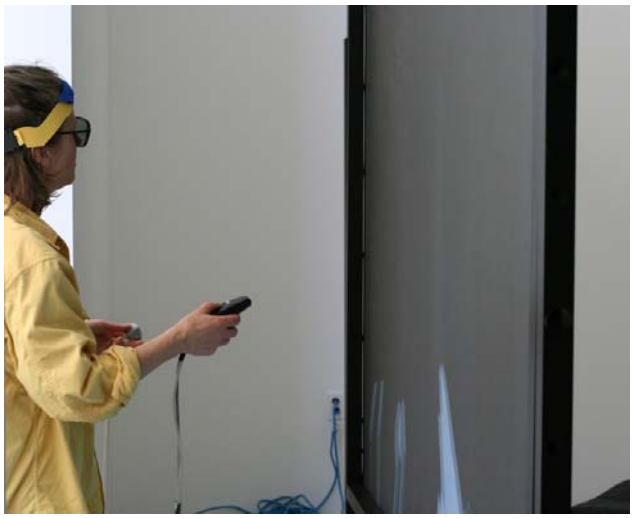

Fig. 7. Projection-based VR system for the participant.

In *Human Trials*, the Red Kings and the Monkats are computer-controlled characters, which must be animated, navigate autonomously about the environment, possess independent behaviors, and yet act within the structure of the narrative. The Monkats are entirely scripted within Ygdrasil. *Human Trials* has both a simpler, scripted version of the Red Kings and a more flexible and nuanced version that is a multiactor-agent SNePS/Ygdrasil hybrid (see Section 6). In this case, the minds of the actor-agents run on separate computers connected via TCP/IP sockets to the VR embodiment. We have also been working on a computer-controlled version of Patofil and a sister project, *The Trial The Trail*, which has the ambitious agenda of making a version of the drama entirely operated by actor-agents [Shapiro et al. 2005].

To build the computer-controlled characters, our team has created animations using both motion-capture and physically-based procedural methods. We have also focused on navigation methods for the agents, especially on having characters stage their activities where the user will see them. These behaviors are extension modules for Ygdrasil. Spatial triggers, which are standard Ygdrasil modules, are used as a sensory system to detect the participant's approach to the entire creature or to parts of the creature. For example, a series of triggers detects if a participant is approaching a Monkat too quickly, or whether a participant is hitting a Red King. These triggers allow us to script simple behaviors very quickly.

5. VISUAL DESIGN

There is a tight interrelationship between the exigencies of our story and the affordances of our technology, which is most apparent in the visual design of the piece. We opt for simple visuals and stress movement and character. This bias arises from our prior work with networked virtual reality projects, which has convinced us that abstract avatars or agents, simply animated with motion capture, read better as living entities than do more complexly articulated, photorealistic representations. The simple, abstract, visual style also supports the psychological substrate of *Human Trials*. The virtual world recalls painted and artificial theatrical sets (a notion which is underlined by the recurrence of the literal stage environment) rather than a film set or a photorealistic video game environment. This style indicates that the space is not real: it is a symbolic play-space. The colors are bright, the objects have a flat quality. The environment looks like a children's book, a fairy-tale. The behavior of the set and creatures is in support of the narrative and interactive strategy, which deliberately tries to subvert a reasoned, adult response and push the participant into childish, id-like, preverbal reactions.

The hybridity of the entities in *Human Trials* also references fairy tales, weirdness, things not being quite what they seem, shifty, untrustworthy, liminal. Patofil and Filopat have cone-shaped heads with masks (no faces), that change to represent their moods. Their bodies consist of cloth-like panels that stretch from their heads out to their hands and down to the ground. The Monkats combine elements of monkeys and cats, but also have black limbs with a spidery quality. Their body parts are separate elements connected only by the eyes of the audience following and interpreting their concerted movements. The Red Kings are identical, slightly warped chess pieces – they suggest the dream-like world of Alice in Wonderland. Although the land of *Human Trials* is abstract, we do want the participant and audience to believe that it is inhabited by living creatures, so lifelike movement is stressed. Filopat and Patofil's robes flutter; the Red Kings wobble lasciviously; the Monkats' bodies are springy. The avatars of the human actors are animated in real-time, taking data from the tracking systems; while precaptured motion data is played back to animate the intelligent agents.

We also want the participant to feel copresent and colocated with these beings; to feel a physical tie to the land and its occupants. So the participant can trample reeds and play with water; the Monkats run away from participant if he/she approaches too quickly, but stay still and croon if the participant strokes them gently; the Red Kings harass the participant by getting in his/her way, pushing, talking dirty. We are in agreement with the approach to the interactive story that extends the user's engagement with a storyline by introducing virtual guides, characters, or agents [Ibanez et al. 2003]. Companion characters that are "copresent" with the user in a virtual environment are shown to increase the user's sense of presence [Fencott 2003].

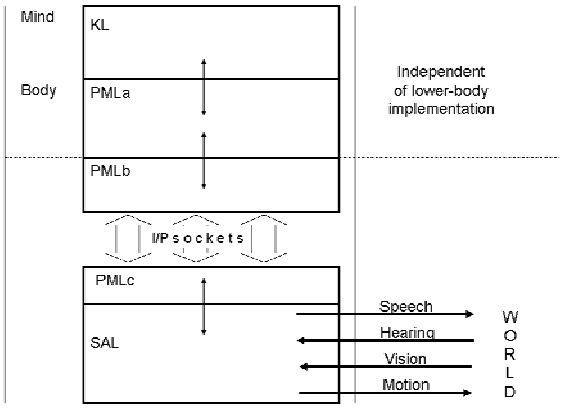

Fig. 8. GLAIR architecture.

6. SNePS AGENTS

In the case of the more complex SNePS/Ygdrasil characters, the minds of the actor-agents run on separate computers connected via TCP/IP sockets to the VR embodiment. The actor-agents are implemented according to the MGLAIR architecture [Shapiro et al. 2005a], which is a modification of GLAIR (grounded layered architecture with integrated reasoning) [Hexmoor et al. 1993]. GLAIR is organized into several layers (see Fig. 8) that can be summarized as follows:

> The knowledge layer (KL) is where conscious reasoning takes place. It is implemented by the SNePS knowledge representation and reasoning system [Shapiro et al.1987; 1992; 2002], and its acting subsystem SNeRE (the SNePS Rational Engine) [Kumar 1994; 1996; Kumar and. Shapiro 1994a; 1994b; [Shapiro and the SNePS Implementation Group.2002, Ch. 4]. SNePS, in turn, is implemented in Common Lisp.
> The perceptual-motor layer, sublayer a (PMLa), contains the implementation of the actions that are primitive at the KL layer.
> The sensori-actuator layer (SAL) contains the low-level implementations of the agent's sensors and effectors.
> The perceptual-motor sublayers b and c (PMLb and PMLc) handle communication between the PMLa and the SAL.
> The world is built using Ygdrasil [Pape et al. 2003].

MGLAIR (modal Glair) differs from GLAIR in that the KL and PMLa are organized into modalities. A modality is a hardware or software resource utilized by an intelligent agent for either sensing or acting. A single modality can support only a small number of behaviors at a time, but behaviors that occupy different modalities can be simultaneous. The modalities used by our actor-agents are animation, hearing, mood, navigation, speech, and vision. When *Human Trials* is utilizing actor-agents, the KL, PMLa, and PMLb of each agent run on one computer; the PMLc, SAL, and the world run on another. Communication is via IP sockets, one for each modality. The sockets provide the mind-body connection, with the "mind" running on one computer, and most of the "body" on

Fig. 9. Harassed by the Red Kings.

another. Several modalities provide feedback about what the agent itself says or does. This prevents it from starting another action while still performing the previous one.

The Red Kings constitute a multi-agent system, each controlled by an independent program perceiving its own and the others' utterances and actions via its sensory modalities. They cooperate in harassing the human participant, and are sensitive to actions that might interfere with each other. Each actor-agent has a script, which constitutes a set of beliefs in the KL specifying how and when it should say its lines and perform its actions. Some actions are strictly sequential; some involve arbitrary choices among several possibilities; and some are event-driven. Just as a stage actor uses various cues to know when to take some actions or deliver some lines, the agent-actors of our drama make use of triggers in the world-model to identify the actions and locations of the virtual objects, the agents, and the participant during their interaction in the world. For example, when one jostles or pushes the user, the others perceive that behavior, and don't also move in until they perceive that the jostling or pushing has finished. Another example occurs at the beginning of the scene. Each Red King believes *whendo(Said(Patofil, HelpMe), do(surroundUser1))*, which means that when Patofil has said "Help me", the agent-actor should perform part 1 of the surroundUser action. RedKing1 believes *ActPlan(do(surroundUser1), performAct(LookAnotherOne, Fierce, Surround_User))*, which means that the way to perform part 1 of the surroundUser action is to say the line denoted LookAnotherOne, adopt a fierce body posture, and go to the "Surround User" position. RedKing2 and RedKing3, however, believe *ActPlan (do(surroundUser1), performAct(Silent, Fierce, Surround_User))*. So they don't say anything at first, but RedKing2 also believes *whendo(Said(RedKing1,LookAnother One), performAct(HalloLittleOne, Menacing, Surround_User))*, while RedKing3 believes *whendo(Said(RedKing2, HalloLittleOne), performAct(WereYouLookingFo, Menacing, Surround_User))*. The net effect is that after Patofil says "Help me," the three Red Kings surround the user, RedKing1 says "Look another one," and then RedKing2 says "Hallo little one," and then RedKing3 says "Were you looking for me?" and each waits to say his line until he hears the previous line.

7. HUMAN ACTORS/AVATARS

Our technology allows us to combine human actors and actor-agents in the virtual environment, so we can exploit the flexibility and improvisation skills of a few actors in

Fig. 10. The actors, with projections of different views.

major roles, yet people the drama with a larger cast of minor characters without having to incur the overhead of more and more VR and tracking systems. In the virtual world, the similar visual design and motion-based animation of agent- or human-driven avatars means that the two are not obviously distinguishable.

The human actors wear head mounted displays (HMDs) and tracking sensors on their heads and hands. The heads and arms of the avatars move as they move. The actors hold controllers with joysticks for driving about the environment, and have three buttons that are programmed for a variety of functions. In the case of Filopat and Patofil, the buttons are used to change the face mask - they can be happy, sad/mad, or neutral. The functionality of the buttons is overloaded for Filopat when they are trapped in the dungeon of the Red Kings. The actor can use one button to kill off the Red Kings if the participant is particularly ineffective in the fight, and another to cause his own demise when the plot demands it.

Beginning in January 2006, *Human Trials* has appeared first as a work in progress and then as a finished piece. Anstey and Bay-Cheng initially played the roles of Patofil and Filopat, and were later replaced by several actors. In the latter performances, Bay-Cheng served as the director, integrating the embodied performance with the virtual environment. Bay-Cheng has a background in puppetry, mask, and performance theory. Her approach to the virtual environment was to assume the technology of the avatar as if it were a human-sized puppet. Her first task was to become accustomed to the way her arm and head movements affected the wing-like bodies of her avatar. The avatars look best if the actors hands are held horizontally away from the body, so that the robe-like cloth spreads out and flutters. Bay-Cheng quickly acclimatized to the VR environment and interface, and formalized and verbalized her discoveries for the other actors. For example, she advised them to move slightly at all times so that they would continue to seem “alive,” and to clarify their speech with deliberate head movements. Central among the physical discoveries of the piece was the effectiveness of combining movement of the joystick and body movement into dramatically interesting turns and approaches. The goal of these movement studies was and is to create believable gestures within the virtual environment.

Since the audience sees large projections of the actors' viewpoints, these also serve as cameras into the virtual world. One of the hardest tasks for the actors is to try to keep the participant and other actor in view as much as possible, and to stage their own activities in front of the participant so that their activities show up on the screens. Driving with a joystick is not as nimble as regular motion, Bay-Cheng instructed the actors to drive in large curving motions and to remember that they could move their heads to look around and locate the other protagonists. The actors also have the difficult task of keeping the drama moving, so that it remains an engaging spectacle for the audience, while also paying attention to the particular participant and her/his effect on the entire process.

Rehearsals for *Human Trials* took place in networked VR. Anstey had initially developed a script for the two human actors based on the project's storyboard and the virtual environment. The script was further revised in rehearsal with actors and director. The script describes each scene and any computer-generated action taking place in the scene. Specific lines are given to the actors which: explain the quest in general, introduce a particular activity, and reveal the characters' temperaments and attitudes. These lines are interspersed with suggestions for improvisation. For example, when the participant is caught by the Monkat, who cries if she tries to pull away, Filopat is directed to simultaneously object to the participant hurting the Monkat, and to hassle her because she isn't completing the task. Patofil minimizes the pain being caused to the Monkat, but suggests that it doesn't really matter if she collects the crowns or not. In addition, the actors are required to improvise responses to anything unexpected the participant may say or do.

The script also describes the characters' personalities. Patofil is reckless and insouciant, believes the journey is more important than the arrival, and is dubious whether the heart's desire exists. Filopat follows rules, adheres to duty, and fervently believes in the quest. Patofil stimulates the user to disobey and to be a little cruel. Filopat provokes defiance to authority, yet also urges humanity and caring. Their different personalities explain why they give different advice to the participant and encourage the participant to reveal her/his attitude as the participant sides with Filopat or Patofil. They are important elements supporting the psychological storyline.

During rehearsals and performances, the script has been revised to clarify the dramatic arc, more clearly articulate the key plot points, and to accentuate the characters' distinct attributes, e.g., Filopat's speech has become more pedantic and florid.

8. CONCLUSION AND FUTURE WORK

Our assessment of *Human Trials* lies in observation of and feedback from participants and audience members. We feel that the process for the participant and the spectacle for the audience is engaging and interesting. In about ten performances the participants largely became accustomed to the virtual interface and virtual world, appeared comfortable with Filopat and Patofil, and engaged with the story and activities they were presented with. Based on watching and listening to participants, our snares do seem to provoke emotional response: anxiety/irritation/helplessness as the Monkat clings; a response of anger to the Red Kings; an understanding that Patofil needs rescuing and a desire to help; and some concern when Filopat is killed.

Informal questioning suggests that the audiences get used to and enjoy seeing the virtual world from three perspectives. Depending on the behavior of the participant, the audiences did seem to be inclined to laugh at them or to empathize with them. In some situations the participant would address remarks to the audience on hearing their reaction.

This indicated that participants, as well as the performers, tend to be aware of their dual role as protagonists and performers.

The main problem of this project is the stress put on the participant. Part of the diegesis is stress generated by the driving force of the narrative and by the interventions and bickering of Filopat and Patofil, however the extra-diegetic stress from the technology and the audience tends to work against the grain of the piece. *The Trial The Trail*, a version of the same story that involves only the participant and computer-controlled characters, will address the problem in one way, by creating a personal dramatic space where there is no onus on the participant to perform for anyone but herself.

However, *Human Trials* has been a great learning environment and represents the first engagement of our collaboration with the field of intermedia performance. As we go forward, our agenda is to focus specifically on the integration of live actors, virtual avatars, intelligent actor-agents, dynamic sets, and live, mobile audience members. As a next step we are becoming involved in projects that are less invested in a central audience participant, but that use projections, virtual reality, mixed reality, real, avatar, and computer-controlled performers for scripted or semi-scripted dramatic events.

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