PUPPET PROJECT

Report on Year Three Activities

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INDEX

PREAMBLE & DOCUMENT ORGANISATION

The development methodology for the PUPPET system involved a cross-referencing of the various partner specialities. At Sussex we took responsibility for the following aspects which form the basis for the three main sections of this report on activities for year 3 of the project.

1 Providing a background framework and grounding for the early learning and developmental competences of 4 to 8 year old children. Example questions here include:
   i. What were the developmental targets for this age group, particularly in a school context (c.f. ESE call)?
   ii. What were the characteristics of existing play which might have importance for a project developing a new form of playing?

   These descriptions are often grounded in observational/experimental studies of children playing or telling stories. Thus, when we have a particular PUPPET-related issue as to whether, say an interface is appropriate, we can begin with observations of children doing 'everyday' play.

In this section we summarise what the major early learning issues might be for the PUPPET project.

2 Developing 'low-tech' and 'mid-tech' prototypes (e.g. in Director or other multimedia tools) which served to guide the development of the 3D system and agent architecture/functionality; using these to carry out experiments on what children found engaging/comprehensible and to discover what was effective in terms of promoting legible expressions for the agents (what are they doing?); helping to define interface and task parameters for the children to interact with the system.

In this section we summarise eight of the major empirical issues we have addressed this year for the project.

3 Performing evaluations of the systems in its various incarnations both in terms of immediate usability and with respect to the system's likely ability to deliver dramaturgical understanding and EL benefits.

In this section we summarise the three major evaluations for the year so far.

All of the work that we do/did is reported on the regularly maintained web page that we have devoted to the PUPPET project and to which all partners have access:

http://puppet.cogs.susx.ac.uk/users/pat/

1. BACKGROUND: EARLY LEARNING (EL) & AND THE PROMISE OF THE TECHNOLOGY

The possibility of having a 3D world populated by agents underpins the potential Early Learning (EL) benefits of the PUPPET project and its construction of a Virtual Puppet Theatre (VPT). Here we summarise the main features of our EL ideas and hypotheses as they relate to the broad features of the VPT. In year 3 of the project we developed the basic rationales advanced in previous years in the light of the greatly accelerated developments in building an engaging, interactive system. The addition of lively animations, avatar functionality, some expressivity on the part of the agents and some record/replay facilities has allowed something like the full potential of a system like PUPPET to be envisaged. This has also allowed a closer integration between the dramaturgical framework developed by the team at Aarhus and the EL framework. In this section we shall summarise the EL considerations and goals, pointing where appropriate to system features that have been developed in year 3 that allow us to make serious judgements about the agent world.

1.1 Improvisation, the VPT and Children's Play

During the normal course of improvisational play the child is dealing with ephemeral actions: they occur and are gone and the child has no time to reflect on them. In addition, they are, by definition, products of the child's own cognition. By contrast, autonomous agents offer the possibility of characters, inside play, which are not of the child's making. These agents are imbued with a 'personality' of lesser or greater complexity, demonstrated/discoverable e.g. through their behaviours. This means that they offer the potential for the child to 'read' the motivations and intentions of the characters in situations, which are still 'playful'. The cognitive benefits of this can be referred to the child's developmental transition to decentred allocentric thought (c.f. Piaget's ideas, e.g. Piaget 1953). Thus, for PUPPET, we hypothesise that reading of agents will be a useful means for exposing the child to situations where decentring skills can be polished. In terms of the development of the VPT this requires a sufficient and understandable expressivity, e.g. expressions, behaviours, vocalisations (speech and non-speech), to allow adequate legibility of internal states. This is one of the goals that we set for the technological developments. At the same time there is a distinction to be drawn, prima facie, between the situation of 'just' observing, as when the child watches agents behave within the 3D world, and interacting with the agents in a more direct fashion. This picks up on the dramaturgical distinctions emphasised by the Aarhus group, between:

- Spectating: the user observes the agents act in the virtual environment
- Acting: the user joins the stage as an avatar and acts together with the agents
- Directing: the user can make choices in terms of the agents characters/numbers/appearances and/or edit elements together in a storyline

1.2 What facilities can the VPT provide to make a difference to EL?

If we think in terms of these modes we can see how these might reflect different kinds of cognitive complexity with differential benefits for the child in terms of his/her reflecting on what is going on. We can 'unpack' this space in terms of key possibilities for providing facilities for the child in the VPT.

(A) The first is that of direct *engagement*, by allowing the child to act through an avatar. We do not claim here that the child 'becomes' the avatar, psychologically, (cf. Bowers), but that such an assumption of character lends itself more naturally to, something like, first person involvement in the ongoing play. Thus we retain the benefit of playfulness, through the situation, but also – we hypothesise – increase the motivation for reading others, ipso facto, because of greater involvement. A central idea here is the dual consciousness of the observer/participant. We know that this is a key component of the move towards cognitive decentring – what might be defined as the difference between the experiencing and cognisance of 'own experience' versus that of 'other experience'. This has important behavioural-cognitive underpinnings. One is in the development of narrative understanding and production, e.g. the 'first' versus 'other' person voice. Another is the ability to read and understand the expressions/postures of others as part of communication. We comment on these at greater length below but the point to be made here is that PUPPET may provide the opportunity for the child to develop these skills in a new context, capturing the essence of improvisational play, but through the device of reconfiguring the potential of a new and powerful technology. Thus the system we build should provide a sufficiently stimulating resource for the child to both be able to engage with the agents but also provoke a need/desire for him/her to think about what the characters in the drama are doing – in short: 'what are they up to'? This in turn sets a target for the agent architecture: it should allow sufficiently complex interactions between the agents for a meaningful narrative to be constructable around what is observed. These interactions need, therefore, to be fast enough and varied enough to allow for continuity between agent-agent encounters. Finally, there is a need to specify/investigate which are going to be effective interactivities for the system. The plans for the year 3 of PUPPET were to include these necessary complexities and interactivities within the system.

(B) The second key provision reflects our emphasis on *externalisation* as a route to cognitive development. Recalling the emphemeral nature of a lot of real-world play we believe that the child will benefit from 'stepping back' from the action. In the case of PUPPET this would be, for example, by allowing the child access to the product of his/her imagination by allowing some degree of authorial control in addition to his/her direct participation. Thus acting in the world, e.g. by altering the states of characters/settings in a play, allows a reflection on the overall structure. This is a metacognitive skill, a kind of 'learning to learn' since the child has to come to terms with the means (tools) and the ends (what changes are intended). In the case of PUPPET we hypothesised that some provision of authoring/directing tools, in addition to the autonomous agent/avatar provisions, would provide the child with the facility to begin externalising its cognitions about the play it is involved with, in other words acting as a director/editor.

Of particular relevance here, when developing specific tools, is the possible difference in terms of ease of use and cognitive benefits between those for altering (i) external parameters (e.g. appearance/setting) as opposed to (ii) internal ones (e.g.

the happiness levels) of agents. We know from previous work, e.g. Hayes-Roth, that children who use external controls for affective agent states seem to understand the concept of affect better. For PUPPET we have the possibility of extending this to complex interactions over which the child has some control and to see their possible effects on the child's ability to handle improvisational modes. For example, one hypothesis is that tool-provision will vitiate the sense of improvisation, but, again, as the dramaturgues point out, 'improv' is not 'merely' anything-goes, but rather carefully worked in terms of its underlying structure. Will the children see this? The plans for the year 3 of PUPPET were to provide at least some tools which allowed the child to actively edit/intervene in what he/she saw on the screen, something which was part of the initial vision of the system.

1.3 A priori Early Learning Questions for PUPPET

The considerations set out above lead us to a number of empirical questions about the major EL goals which map into the dramaturgical/agent framework. These are:

- *Children's perceptions of virtual characters*
  - Can children understand or 'read' the motives of agents in the VPT?
  - What are the expressivity characteristics of successful readings of internal states, i.e. what agent behaviours does it take for the children to understand what they are up to?
  - Does interaction through avatars help with the above and can children take different avatar roles?
  - Given the above, can children pick up on the basic motifs of the scenarios, such as the persistent aim (project) of the farmer to achieve some order in the farmyard?

Here what we need to know are, for example, what conventions are effective for depicting agent movements and expressions. The simple ones, such as gaze, personal space and speed of movements are obvious starting points. In addition the scenario allows for the provision of a variety of roles, such as 'helper' which are initially defined for the child but which may change as the scenario unfolds. Here it is of major interest to see if the child, firstly, picks up on the basic motif of 'achieving order' and, secondly, begins to construct his/her own narrative around the interactions.

- *Externalisation and promoting metacognition*
  - What kinds of authoring/editing tools are children able to work with easily and what are hard, considered from the point of view of their current level of cognitive development?
  - Will there be different benefits from tools to modify external/internal states of the system?

Here PUPPET allows us some alteration of the affective dispositions of the actors as well as of their appearance. For example setting the happiness levels of particular agents, to allow even more emergent properties for the agent-agent interactions. However even

simple record and replay functions have proved effective for looking at the possibility of externalisation.

1.4 Early Learning Possibilities Summarised

Here is a brief summary of what we expected of EL benefit from year 3 PUPPET:

- An exposure to situations that promote the child's understanding of 'others', i.e. classical decentring. This would come from the reading of agent behaviours and motivations and from role-shifting via the avatars.
- A burgeoning and sophisticated representation of the virtual characters and the 'plot' structures, based on subtle readings of the virtual characters – this corresponds partially to an increased narrative fluency.
- The development of new strategies for externalisation, through the use of tools and talk, pertinent to the kinds of dramatic play the system allows. This could, with time, become generalisable to a variety of other settings, such as organising drama outside of the virtual space.

These aspects are explored further in the next section which reports the results from a range of empirical tests and prototype developments.

2. EMPIRICAL WORK & PROTOTYPE DEVELOPMENT

Introduction

There is little point in gambling on having correct intuitions about how an application should look, how it should behave and so on. The vast majority of software development projects include at some, or even all, stages a degree of user input. This principle should be no different simply because the users are children. However developing software for them, particularly one with at least some implicit educational value, has an additional component that should be heeded. That is the particular developmental state/stage the children will be at when they use the product. For this project this included issues such as: what kinds of conceptual sophistication do they have? how do they understand or produce stories? what cues do they use for reading emotional expressions? Such considerations intersect with more intangible ones, ones that constitute something of a moving target such as: what is their experience with computer-based games? how will this affect their expectations of the PUPPET system? What is the home and school context which might shape their responses?

The background to this is simply stated. It almost goes without saying that a protagonist is central to a story – the content of stories usually chronicle some aspect or dilemma encountered. At its simplest, the story protagonist can try to attain some goal (in the face of an obstacle), or the story can hinge around why the protagonist failed in a given set of circumstances. To achieve this, storytellers have to acknowledge and express their protagonists' feelings and appraisal of consequences that result from goal failure, their desires and motives. Thus, children's skill in making stories of more than one episode has to focus on their protagonists' responses to unfolding events. In short, enabling children to elaborate on characters in terms of their motives, their desires, their goals and how they respond to success and failure is central to story making.

While virtual worlds and virtual characters present unique opportunities for exploring interaction between characters, exploring motives, goals and behaviour, cause and effect, it is an empirical issue how that behaviour is expressed in terms of communication of meaning. While there is an obvious mapping between motives, goals, desires and temperament (e.g. personality) and how it is expressed in particular cases, in the context of empirical work reported here we tend to focus on expression, although we also use thought bubbles to try to focus on children's understanding of what motivates that expression (see Andre et al., 2000, for discussion of how they integrate models of personality and emotions into lifelike characters). Although there is little previous work on how young children represent (understand) virtual characters and might use (interpret) meaning, because younger children tend to be more constrained (than adults) by what they can see (e.g. Vygotsky, 1978; Singer, 1994; see George and McIllhagga, 2000 for a discussion in the context of VR), expression is central to the conveyance of meaning. This emphasis is also consistent with current VR systems, where there is a heavy reliance on the visual for interpretation of meaning (than is the likely situation in real life).

In this context we brought to the project a twin approach to helping to specify the design of the PUPPET theatre. The first was to summarise and focus the relevant research literature, providing the contextualisation that the system builders should be taking into account. The second was the development of low/middle tech versions of prototypes which, in some key way, explored an aspect of the child's responses to what we were trying to do with PUPPET. Below we summarise these efforts, noting what was being attempted in year 3 as we go.

2.1 What are the key aspects of children's development and understanding?

As part of our ongoing attempt to brief the developers about the competences of children we have written a number of reviews, as well as giving this information first hand at project meetings. In year 3 the project began to move forward from the complex provision of a 3D world with few characters to one where there was a significant degree of activity to interest the child. In particular the provision of animations that actually engage and interest the viewers was a great leap forward. As part of this we continued to feed through research overviews and our own experiences and discuss these with partners. This has included extensive documentation and summaries of: children's understanding of narrative, speech and thought; story-telling; early forms of play; interface interactions; HCI principles.
An example of this provision is provided in the document: The Communication of Meaningful Visual Information for Children interacting with Virtual Actors [COGS-010410/expressivity.pdf]

2.2 The use of low- and mid-tech methods to explore particular functions and possibilities, resolve problems and test assumptions

The thrust of our empirical work this final year has been concerned with designing interactivity to facilitate children in their understanding of the different roles in narrative construction (e.g. actor, creator, director). Our theoretical reviews and previous empirical work suggested that young children may require support with some aspects of story making, but at the same time, as we saw from our fieldwork in years 1 and 2, they demonstrate during imaginative play that they can excel at other aspects on their own. We saw the main challenge in year 3 as one of trying to get the balance right – creating narrative tools that build on the enjoyment, spontaneity and engaging appeal of play – but in creating an interface that is 'accessible' to young children and flexible enough for child-driven and child-initiated interaction. Specifically, we have spent considerable time and effort with the design and development of tools for Character Expression and Elaboration, Narrative Voice, and Playback and Editing.

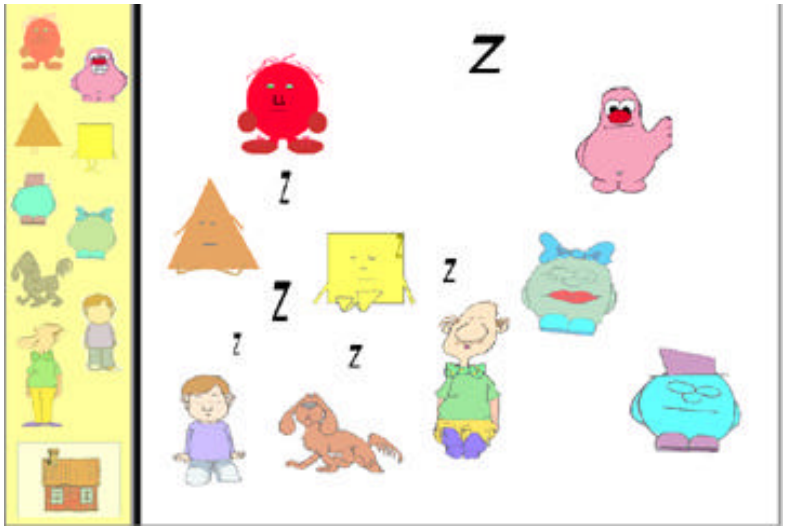
For the convenience of the reader we have organised this work as a series of eight empirical questions which we address individually in sections which are 'top and tailed' by boxes stating the question at issue and the implications for the system developers of the findings.

Empirical Question 1:

To identify the type of characters that young children prefer for story making, in terms of trying to establish if the level of detail makes any difference.

For this we developed a prototype (named "Prototype 3" – see Figure 1 below), which was written in Director software, that was designed to facilitate children being able to play with different styles of characters – in total there were four types ranging from simple (more abstract) to more detailed (cartoon like), each with different types of animations – also ranging in complexity. The children were seen individually and asked to play around with the characters and to comment on and make up characters they thought would facilitate story making.

Figure 1: Screen shot from Prototype 3 showing characters



Our results suggest that this prototype was engaging for children; they spend considerable time playing with the characters and exploring the possible actions/animations. In summary, the type of characters that the children identified as most suitable were those with features that are conspicuous, they thought that the characters with human like limbs were better for story-making. They tended to prefer dramatic (rather than subtle) movements.

Implications for Puppet:

Children prefer characters with faces that have clearly defined facial features
Children prefer realistic over more abstract characters and movements
Children prefer dramatic (rather than subtle) movements

Empirical Question 2:

To identify how children build up characters within a scene or pre-determined storyline.

This question is mainly concerned with giving children the opportunity to elaborate on a character (using simple speech segments, and simple facial expressions), given a problem situation. For this we used a different prototype (named "Prototype 4" – see Figure 2 below), which was also written using Director software. The children were again seen individually and asked to comment on the scenario (what they thought was happening), and then to elaborate on the character in terms of expression.

Figure 2: Screen shot of Prototype 4 showing a character within a scene

While the limited action in this scenario allowed us to focus on how children build up the expression of one character, after 5 minutes or so the children found this prototype quite boring. However, our results suggest that they did enjoy being able to change the facial expression of a character and also enjoyed playing around with matching/mismatching the speech segments. In summary, our results suggest that even the youngest children (age 4 years), preferred building up characters to just watching a scenario. Building up characters in this way facilitated children in elaborating upon the storyline.

Implications for Puppet:

Young children are able to use speech segments and emotional expression to match the scenario

By giving children the opportunity to have some (even limited) input into character creation, allows for reflection and comment about the storyline.

Empirical Question 3:

- ***To see how children can use external prompts for aspects of character expression in the context of making a story***

Speech and thought bubbles provide a visual cue and prompt for story makers, thus facilitating elaboration of a character's public (speech) and private (thoughts) expression. However, they may also be used as support for 'narrative voice'. For example, many researchers have highlighted developmental differences in the way children present stories – whereas older children tend to support or scaffold the unfolding story for their audience, younger children (under age 8 years) do not spontaneously do this – speech and thought bubbles, therefore also provide a means of facilitating what Engel (1995) has termed 'narrative voice' (e.g. he says "…"; she says "…"), and Auwarter (1986) has termed 'stage voice'. In summary, these depictions provide an external visual representation that acts as a prompt for story makers, and also scaffolds the conveyance of meaning for an audience. Our work in this area has covered three empirical studies, using low- and mid-tech prototypes, and barcode technology. First, our low-and mid-tech work is presented together.

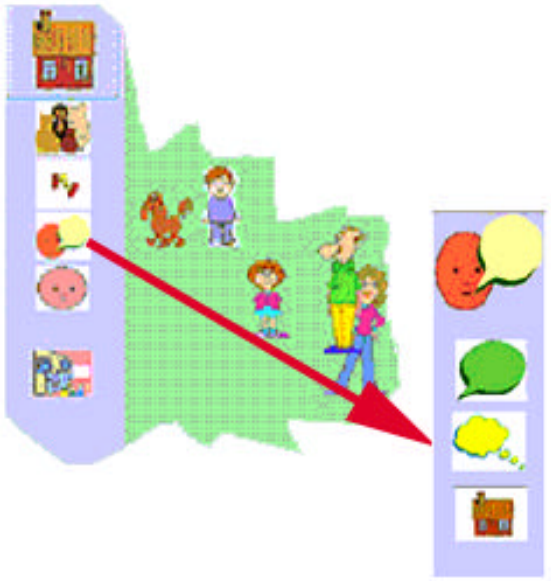
Methodology

In total 20 children took part in Study One (low-tech). Fifteen of these children also participated in Study Two (mid-tech). The mean age of the children was 6 years 5 months.

The method we employed used paper mock-ups (low-tech) and prototype (mid-tech) testing techniques – see Figure 3 and 4 below. Since our aim is to produce flexible tools that could be used across different types and styles of stories, no stem or guidance about what sort of story to make was given. However, to place emphasis on this being a narrative task (rather than 'play'), the children were explicitly asked, "to make a story that they thought someone of a similar age (to themselves) would enjoy". The stimuli used were cartoon type images (printed and laminated for low-tech, and image files for mid-tech), as highlighted by our previous results (see Prototype 3 above). For both story-making sessions the children could select and remove characters as necessary, add character speech after selecting a speech bubble, and add character thoughts after selecting a thought bubble. For mid-tech story making, these tools were presented as a series of windows that were accessible from a 'home window' (e.g. a stacking window system).

Figure 3: Low-tech set up

Figure 4: Prototype for attributing speech and thought to characters



To establish how well these depictions were understood, at the beginning of the first session the children were asked to give their first impressions of the speech and thought bubbles. The images were initially presented with no context. Out of the twenty children seen, all but one identified the speech bubble correctly (e.g. "someone is talking", "talking", "speaking", and "speech bubble"). Only two-thirds of the children (70%) identified the thought bubble as such, specifically that the image related to thinking ("someone is thinking something", "thinking", "…inside the head").The remaining third suggested that this image was "a cloud" or said that they "didn't know". These children were shown the pictures again but this time next to a character's mouth and/or head. When in context, all the children related the pictures correctly – as their intended display. One conclusion is that young children understand the distinction between thinking and speaking, at least as far as giving an appropriate (and different) verbal descriptions of the pictures used to represent them.

By exploring the way in which they were used for character elaboration, it may be possible to determine if they are facilitative for different and meaningful aspects of character expression in the context of making a story. Since, speech refers to 'public', and thought to 'private' expression, we might predict that if children differentiate

between them for character elaboration there would be difference involving communicative utterances. The data showed that the majority of speech events were indeed communicative (e.g. “do you want to play football”), in contrast to the thought events, which were mostly statements (e.g. “he hates walking”). Another aspect is the perspective or voice that was used. For example, an utterance could be from different points of view, e.g. from the perspective of the character – 1st person voice (“I”, “we”), or from a more objective perspective – 3rd person voice (“he said”, “she said”). A large proportion of character speech was voiced from the 1st person perspective (e.g. “I want to watch TV”), this suggests that children use speech bubbles to speak as the character. Thus, speech bubbles promote and facilitate character identification. However, this was not the case with character thoughts, which were mostly voiced in the 3rd person (e.g. “he hates walking”). A large proportion of the thought bubbles were used to express a character’s wishes, desires, aims and goals (60%) – in short, they were used for communication of the private world of the character. However, a significant number of thought events were used to elaborate on the story itself.

Implications for Puppet:

Young children make a distinction between how they use speech and thought bubbles – they are facilitative for different and meaningful aspects of character expression in the context of a story

While speech bubbles tend to be used for communication between characters, thought bubbles tend to be used for expression of character wishes and goals

Speech bubbles facilitate children in the role of the character – majority were in the 1st person voice

Thought bubbles can be used as a vehicle to facilitate and reflect on the internal state of the character (wishes/desires, and aims/goals).

Speech and thought bubbles provide an external and visual cue for story-makers as well as encouraging a more sophisticated narrative style “he says/she says”

Empirical Question 4:

To determine the optimal range of speech and thoughts to encourage improvisation and novelty in story-making

Barcode Technology:
This third empirical study was aimed at building upon pilot work that specifically explored the development of tools that support story making and construction. In summary, our pilot studies demonstrated that young children not only enjoy using the barcode technology, but they have no problems using it – all children seen were able to use it with little practice. Putting the scanner across speech bubbles containing barcodes activates sound files. The difficult issue that we have to consider is in determining how many speech bubbles to provide and what should the content be – there should be enough to allow flexible story making without overwhelming the children. The way we got around this was to categorise the sounds into positive, negative and neutral by matching sounds to three types of speech bubbles (round yellow = positive; jagged red = negative; square while = neutral). The advantage of this is two fold: first the sounds are chunked into categories; and second, measures of ambiguity or consistency with the facial expressions can be made.

Figure 5: Using barcode technology to activate speech and thoughts

Implications for Puppet:

Giving children a selection of 'types' of sounds encourages creativity and improvisation

Providing some ambiguous speech and thoughts allows for diversity of expression

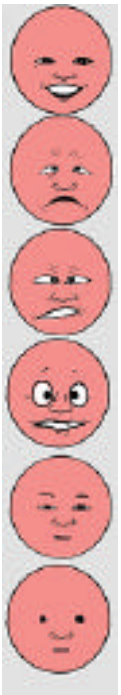
Empirical Question 5:

To determine how children build-up characters in the context of story making, using the emotional expressions provided and to determine if they facilitate story making

In previous years of the puppet project, we have conducted a number of empirical studies that have directly explored young children's perception of emotion within the context of story making. Our findings suggest that: young children can discriminate between cartoon-like faces in a similar way to (real) human faces; that they really enjoyed changing the facial expressions of characters and that the process stimulated character involvement, identification and elaboration and, crucially, for PUPPET, they support the expression of a protagonist's emotional state, which in turn facilitates the elaboration of intentions, goals etc. The emotions that we have identified as salient in this respect are those that express happiness, sadness, anger and fear. To provide flexibility we also tried to include categories of emotion that could be perceived as neutral or ambiguous – a face displaying a neutral and a calm expression tended to be best, and were interpreted and used by some children to express mixed emotion.

Methodology

In total 20 children (10 male, 10 female) took part in this study. The mean age of the children was 6 years 5 months. The method we employed used paper mock-ups (low-tech) and prototype (mid-tech) testing techniques – as above, see Figure 3 and 4 above.



The emotional expression tools that were available were represented as cartoon caricatures of facial expressions (see icons on the left – these are replications of stimuli used in previous studies, see George and MacIllhagga, 2000). They represent happy, sad, angry, frightened, calm and neutral emotional expressions [1]. In this study, the facial expression of characters was initially set to neutral, and the children were free to change the expression at any point. In the low-tech situation, the children changed the characters face by pointing to the icon that matched how they wanted their character to look, and for mid-tech story making, selection of an icon changed the face of the character.

A first point to note, was that the children really enjoyed playing with the different facial expression – this was particularly noticeable in the mid-tech situation when the children frequently changed the faces of their characters, at least 5 times more than the actual number of faces that were eventually selected for storylines.

[1] Although these categories of emotion are labelled here, no explicit labels were given to the children.

Overall, using the happy icon was most popular (54%), followed by sad (19%), then angry (14%) and then frightened (9%). The more ambivalent and subtle facial icons (calm, and neutral) were used relatively little (3% and 2% respectively). Overall, there were over 6 facial expression changes per story, although the emotions of a character were not always cited explicitly in the story. The results showed a number of very relevant points for the project.

A first point to note is that when a facial expression was selected for a character without verbal reference to the emotion of a character, the children tended to say something like, "*[the character now]* looks like this", while pointing to a particular facial expression. The difference between selecting visual emotions for characters and using this information verbally is particularly interesting since there was a relationship between using emotion tools and the complexity of the story produced – significantly more emotion tools were used for complex than simple stories. An interesting question is whether there was a relationship between using emotion terms verbally and story complexity. The data suggest that there is.

Implications for Puppet:

These results highlight the salience of facial expressions in terms of an effective expression of the emotion of characters

Facial expressions support and scaffold character elaboration on two levels – visual expression of emotion and verbal expression of emotion

The contribution of facial expressions and elaborating of characters in this fashion is highlighted by the significant relationship between the complexity of the story produced and emotion of characters – more emotions (both visual and verbal) were used in complex than simple stories.

Empirical Question 6:

To determine if providing simple character actions constrains or facilitates story making

Do children expect more complex actions when animations are available?

When story characters are virtual actors, the actions that are made available need to be designed and specified before they can be implemented as behaviours. Given that unlimited actions are not possible, this raises difficulties in trying to determine what character actions might be salient and meaningful. To a certain extent the meaningfulness of character actions in a story will probably be specifically related to the context and the design of the characters themselves, so it is particularly difficult to be prescriptive with respect to what types of actions might be meaningful for young children. Using previous prototypes of our 3D world, the children commented that they wanted to have dramatic actions and reactions that would have a clear cause and effect (the Farmer demonstrating that he didn't like the cow by kicking him, for example). However, the most important factor with regard to action (and reaction) seemed to be the speed of the action – if the action/reaction was at the 'wrong' speed then the children tended to get bored or missed interaction between characters. In this sense the timing is crucial.

Although trying to establish the type and range of character actions that will facilitate character elaboration and story making is a rather ambitious goal, if the aim is to give children some authorial control over what their protagonists do, some decisions about which character actions and/or animations to make available needs to be made. Two approaches to this problem are adopted here. First by exploring the spontaneous actions that children ascribe to their protagonists, we might be able to make some design decisions about which actions are meaningful for young children. A second approach is to explore the influence (upon character actions) of providing a simple and restricted range of animations.

(i) Spontaneous character actions

Verbal references to action made up 36% of the events recorded over all stories. On average, each story involved protagonists engaging in 6 actions. To get some insight into the range and type of spontaneous actions that were ascribed to characters, they have been very simply categorised by their relationship to the protagonist into three types [2]: (1) *physical* – those mainly involving physical movement; (2) *active* – those involving an activity; (3) *interactive* – those involving (inter)actions between characters.

Physical movement action words include the following: bend, climb, fall, fly, go, jump, lay down, move, run, sit, sleep, slip, trip and walk. Those that are categorised as an

[2] There are some obvious difficulties in categorising actions in such a fashion, for example, some words may overlap categories or their meaning may be ambiguous, however, within these limitations we aim to highlight the *type* of words that are commonly used by the children, and also to make generalisation of their function.

activity included: bang, buy, dig, catch, cut, dream, eat, find, get, hide, knock, kick, laugh, look, make, put, ride, smack, smash, take, throw and watch. Since the following generally involved two characters engaging in some activity together, actions categorised as *interactive* included the following: chase, come, fight, follow, give, meet, play and tell.

Over the 34 stories, 54% of spontaneous action words relate to the type of physical movements that protagonist do. The second most popular category highlights the activities that protagonists engage in, which was 29%. This data suggests that children used relatively few spontaneous actions for their protagonists that directly involved another character (17%). While this may paint a picture of protagonists that are (physically but) not socially active, this may, or may not, be misleading since what is being measured here ignores actions (that may have been) influenced by the tools that were provided – for example, references to thinking, speaking [3] and moving were not included in this data.

(ii) The influence that providing a simple and restricted range of animations had upon storytelling

A second approach to the difficult problem of how to determine what character actions will be facilitative for story making, was to provide a restricted range of simple character actions with a view to trying to determine how they influence story making. In addition to the character elaboration tools that were available in the first session, Session 2 also had 'action' buttons that could be used to make the characters do simple animated movements from a standing position, for example, 'walk', 'run', 'bend', 'sit' and 'stand upright'.

A first point to note is that the children spend a great deal of time moving the characters around the screen, as with the facial expression changes, many more times than those that contributed to a storyline. Although the average number of times they were used as part of a storyline was 12, some children used the movement buttons up to 10 times more.

Since no action tools were available in the first session, it is possible to determine if the animations had an influence upon the stories produced, by comparing the verbal references to actions used in both contexts.

Making action tools available significantly increased the number of actions related to protagonists' physical movements (by 18%`). It would seem that simply having action buttons and animations to allow characters to walk, run, bend down etc. had an influence upon the type of character actions the children used in their stories – for example, "move", "bend", "climb", "kick" were used in the second (but not the first) session.

Overall, the number of interactive actions remained approximately the same across both contexts (19% and 17% respectively); there were less activity-based actions (20% compared to 36%). This suggests that the type of animations available for characters biases the actions that are verbalised over and above those that directly relate to the animations themselves.

In summary, the problem as we see it, is in trying to determine the type and range of character actions that might best facilitate children's story making. From looking at the type of actions that children ascribe to their characters, the large majority of verbal references to actions referred to the physical movement of characters (54% overall). Only 17% of actions were obviously interactive with the remaining actions involving activities or objects. While this might give the impression of protagonists engaging in physical and not social activities, this does not consider the references to thinking and/or speaking, which the tools might have inspired for that purpose. When action tools for simple physical animations were provided, they had a strong influence upon the range of character action words that were subsequently used for story making – with a significant increase in the number of verbal references to the type of action that the animations portrayed.

Implications for Puppet:

Categorising the type and number of animations that are available may be particularly important, since the type of character actions that are made available have important implications with respect to the overall narrative experience.

Actions that are 'interactive' promote character elaboration and involvement

Empirical Question 7:

Do children use 'playback' to help create storylines?

One clear advantage of using IT over more traditional story making is the potential of developing some kind of editing facility. The possibility of viewing what has been created is most appealing, since a playback tool can bring the role of audience more immediately into the story making process – the process of creation. For example, by allowing children to play back their story lines, an interesting question is whether they use insights from this perspective to make 'on-line' changes to their story. However, how this facility might be designed is by no means an easy question.

As a starting place a playback tool was made available in the 2D prototype. It was designed to record which characters were selected throughout, and any changes that are made to them (e.g. when they are moved to another location, their facial expression changed, speech or thought bubbles and contents are added). The idea is that the data will continue to accumulate until the playback tool is selected (e.g. the child would like to view their storylines so far). At this stage, the data file containing the character events recorded so far are written as a movie, which repeats each event in sequence. This movie can be stopped, the behaviour and/or expression of the characters can be changed as before, and replayed at any point.

To enable us to begin to address some of issues involved, a tool was designed for viewing and editing of storylines. This tool was designed to record in a data file the characters used, their location and any events that were ascribed to them in sequence. When 'playback' is selected, the data file is used to create a movie of the action recorded. When the movie is written, the playback widow provided buttons to, move backwards, forwards, and to stop the movie. Editing the movie (e.g. changing the storyline) involves stopping the action at the desired point, and then returning to the story-making window. Apart from determining how useful children thought this facility might be for story making, we also wanted to determine how often children used 'playback', and, any changes they wanted to make when viewing storylines.

How often and when the children used the playback

The children were explicitly shown how playback worked by a demonstration: a few events were selected, and then they were played back. Then they were asked to change

one event, after which the new storyline was played back. From this simple demonstration, the children seemed to understand what this tool could do. Asking the children to make one storyline, and then play it back before moving on to making their own story confirmed that they had no difficulty understanding and using this tool.

All the children followed the same pattern of using this function – none of the children spontaneously viewed storylines or 'parts' of their story. They only selected playback once, when they had 'finished their story'. However, at this stage all the children expressed great excitement at the prospect of being able to replay their story. Unfortunately, due to the design of this tool, none of the children were able to see their stories. As a result, it is not possible to determine what their reactions would have been, or how and if they might have changed their stories as a result. The next section briefly presents a re-iteration of the design in terms of the main problems with its implementation.

Implications for Puppet:

Children understand what playback is, but they do not spontaneously use it to view and/or edit their storylines – it is not enough to simple provide this facility, more interventions and/or structure would be required

Empirical Question 8:

How do children segment their stories?

Problems with the design and implementation of playback and editing

As noted above, the children did not use the playback tool until they had completed their story. Although the average events associated with each story were between 16 and 20, the actual number of tools selected during story making was many times more. As noted in previous sections, the process of making storylines with the character elaboration tools provided involved exploring and playing around with potential and possible characters, in different and possible locations, with potential and possible poses, expressions, thoughts and speech prior to selecting those that were going to be used for a storyline. The algorithm used recorded the data for every character (location plus move details if any, pose, facial expression, public or private expression) at time period 1, time period 2, and so on until 'playback' was selected. As a starting place, each time period was initially set to occupy five frames of a movie, with the movie initially set to play one frame per second [4]. Since this algorithm did not discriminate between, playing around with possibilities, and the completed storyline, even the shortest story involved a considerable amount of data. When playback was selected (at the end of the story), the data file containing the events was written as a movie file. The actual time taken to write a movie was too long for children to wait to see their stories, so editing did not take place.

To reiterate, the idea of providing a playback and editing tool is to facilitate the story maker in 'standing back' from the activity, to view their storylines from a different perspective and by providing editing tools this allows insights from this perspective to be incorporated within the story making process – perhaps changing the storyline as a result. Because the children did not spontaneously use playback for storylines, simply providing this facility was arguably insufficient in itself. Although, it was clear that the children were very keen to see their 'completed' stories, it is not possible to know what insights they might have gained from this, or if they would have liked to change their story. In some ways the provision of this tool has raised many more questions than it has addressed, however, we suggest that a playback tools needs to first take into account, how children segment their stories, and how to differentiate between 'playing and exploring' and 'story making', *before* issues concerned with editing can be addressed. Segmentation presumes and imposes some kind of temporal sequence or logic upon the stories, which may enable us to understand the issues involved more directly with how to develop an editing facility.

[4] Although these parameters are easily changed, the implications for how the rate is perceived or how long the recording takes in practice are probably very important for how the story is perceived. However, these issues are beyond the boundaries of this study.

We have conducted two empirical studies for this purpose, For the first study, nine children were asked to produce a comic strip of their stories. They were provided with an A3 sheet of paper, pens and pencils, cut-outs of the characters (each with six emotional expressions), and speech and thought bubbles. The children were free to use any of these to produce the comic strip. The first task involved the children deciding how many pictures they needed for their stories, the page was then segmented into these, and the child was encouraged to complete each segment. A first issue that can be addressed is concerned with the number of segments – is there a relationship between story length and the number of segments? A more problematic issue is concerned with whether it is possible to categorise each segment. Since the comic strips were produced immediately after the story, another issue is concerned with how difficult it might be to make a comparison between the comic strips and the stories from which they were derived.

Another complementary methodology that we have used involves providing the children with blank storyboards (and of physical props). The idea of using story boards is not only to provide a framework for the story making, but also to provide an explicit means of segmentation (e.g. beginning, middle and ending), so that we can gain more understanding of how children might segment their stories, in the long term this will enable us to develop an editing tool for story making in other story making environments (e.g. virtual). Although four story boards was a starting place only, it has proven to be sufficient for change and flexibility in the characters and props that we provide and seems to take the right length of time to complete – about half an hour (any more story-boards would probably take too long and we might need more characters etc.). We have considerable data on this, and are currently doing an analysis of the data.

Implications for Puppet:
No conclusions yet since we are currently doing an analysis of the data.

3. EVALUATION AND FEEDBACK

As the system was developed versions of it were installed at Sussex for trials. The goals were to give feedback to partners on (i) usability issues and (ii) design issues relevant to the EL goals and perceived child competence. Three comprehensive evaluations were performed in year 3, which are appended separately (give filenames) as well as a series of ongoing usability feedback sessions between these dates. We do not wish here to repeat the detailed findings and recommendations within the detailed reports, but rather to summarise some of the generic issues.

3.1 The evaluation methodology

The setting/context of testing with children

We decided that the best way to evaluate was by inserting the prototype into a range of other activities, for example playing with toy farm animals and constructing stories about them. This had advantages because:

- It did not make the system the only focus, which was useful for testing systems with only limited prototype functionality
- This also better corresponded to possible uses as a school activity, i.e. as embedded within others
- It allowed children time to adjust to the setting, strange adults etc
- It provided a more comfortable setting for eliciting responses, which could be children's comments on the system afterwards or during the sessions, their drawings or other reports they made

The specific goals for the evaluations were:

- To analyse children's interactions with the system in terms of usability, particularly to assess the capability of young children to navigate in, interact with and understand the virtual environment.
- To discover what children thought about the characters visually and the animations and the system as a whole – their engagement, comprehension and evaluation
- To solicit children's own ideas for improvements to the system

The outcomes of the evaluation, supplied to partners, were:

- Specific recommendations about usability issues, e.g. interface/input device
- Flagging issues to do with where the design was not working well, e.g. animations not correctly read by the children
- Design suggestions by the researchers for the 'look and feel' of the system, e.g. reducing the area of interaction
- Suggestions from the children about the system and their likes/dislikes, e.g. navigation

3.2 Summary of the main evaluations

3.2.1 Month 25: (Evaluation1.pdf attached)

System features:

- This was on a version of the system that had a well-developed 3D farm world with complete navigability, a set of agents (farm animals) with simple greeting behaviours and movements and some capacity for changing perceptual viewpoints.

General reception for system:

- The system showed promise in that the agents aroused interest and the children liked moving around the 3D world once the y understood the navigation paradigm.

The main recommendations from analysing the videotapes included:

- Consider different input devices to the mouse
- Reduce the size of the world to give children a better mental model of the farm
- Put more landmarks into the world for the same reason
- Make changes to the cursor & navigation mode
- Make the interactions between agents faster and more readable (better expressivity)
- Make the system more interactive and allow the children more scope for authoring/editing, i.e. less passive

3.2.2 Month 30: (Evaluation2.pdf attached)

System features:

- This was a version of the system that instantiated a version of the Black Sheep Scenario with the child in spectating mode. It involved a limited set of agents (farmer, cow)

General reception for system:

- The system was essentially a first working prototype for the black sheep scenario. The agent behaviour needed some fine-tuning

The main recommendations from analysing the system included:

- To increase the speed and stability of the system
- To make the system more interactive and give the agents more complexity and better animations to increase interest

3.2.3 Month 34: (Evaluation3.pdf attached)

System features:

- Following the first PUPPET Research Atelier in Aalborg from 30th April to 4th May, 2001, it was decided to implement an improvisational scenario in which there were two virtual actors: a Farmer and a Cow. While the Farmer is always trying to create order on his farm, the Cow is constantly trying to run away thus challenging the (will and) order that the Farmer is trying to create. The two virtual actors (agents) can change their status (high or low respectively), and their behaviour (positive or negative). The animations

used in this version of the system are aimed at : (1) the expression of personality; (2) the expression of the different combinations of status and behaviour available for the characters , as above, and also, (3) the various encounters of the Farmer and the Cow. The overall goal of the scenario is to provide a storyline that is interesting: the storyline itself is intended to have a cyclical quality, which means it can be repeated with variations.

General reception for system:

- The system with animations is far more engaging to the children than any of the instantiations they had seen previously. There was a far higher degree of attention and it was easier to get the children involved with what they saw. The animations are highly visually effective and, with minor glitches, the pace of the action sustains interest. The higher levels of engagement mean that the scenarios the children watch are of definite potential in terms of involving them in situations where learning can occur. For example, there was strong evidence of the children trying to work out the motives and intentions of the agents. This is one of the goals that the PUPPET theatre was trying to achieve and demonstrates the potential of this sort of system.

The main recommendations from analysing the system included:

- To increase the clarity of expressiveness for the agents, since not all of the behaviours (e.g. status postures) were correctly interpreted
- One possibility here is that, with far more explicit prompting/scaffolding of the idea of status, they would perceive these changes in the way intended. This in turn, would allow a better reading of the projects of the cow/farmer.
- As another suggestion, the use of more explicit facial expressions (or more readable ones) could have a similar effect.
- The system tested here also still had a limited interactivity but the advent of the 'recording' facility should be a big step forward.

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