

Deliverable	COGS-010410
Task	Achieving Expressivity: WP1
Workpackage	WP1
Title	The Communication of Meaningful Visual Information for Children interacting with Virtual Actors
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Date	1 April 2001

The Communication of Meaningful Visual Information for Children interacting with Virtual Actors

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Introduction

Studies of communication with and between children have shown that the way in which meaning is achieved is a function of several variables, particularly those of age and experience. Particularly for younger children, there may be substantial differences from adults in the ways that they perceive information and the cues that they rely on when making judgements about meaning. This is especially true with regard to visual signals.

This has particular relevance for our attempts to design characters in virtual worlds, which are capable of conveying some degree of meaningful and believable communication. However, given that there are technical constraints in the speed and complexity with which particular systems can produce real-time visualisations of expressions and actions, e.g. due to rendering limitations, means that we need to work with simplifications from the real world. This is not necessarily a limitation, as we know from the effectiveness of cartoons, but the situation is usually more complicated for interactive virtual systems, for example in terms of a very limited capacity for NLP. This means that there is an increased reliance on the visual for interpretation of meaning, (than the likely situation in real life). Thus it is an empirical question as to how system objectives might be realised in particular cases.

Our project (Puppet) aims to give the children the facilities to interact with characters, such as animals on a farm, allowing them the ability to choose one of the characters as their avatar. For the younger children, 4-6 year old, a major goal has been to encourage the child(ren) to explore the environment to discover and interact with the other characters, agents, within the virtual world. They

are first asked to observe and interpret their behaviour with the aim that they will discover that the agents behave in different ways, following different kinds of rules, dependent on their intentions and motivations. Clearly, given this aim, it is essential that we have some principled way of deciding how to visualise not only the affective state and the behaviour of the agents but the meaning of interaction—the principal cue that these children have available to make their judgements.

Although there is little previous research on how young children represent (understand) virtual characters in general and, therefore, might use (interpret) meaning in particular, we have conducted extensive research on this topic encompassing empirical studies using low- and mid-tech prototypes, evaluations of the Puppet platform, and reviewed the research literature on perceptual development, imaginative play, and narrative development.

The sections below have particular relevance for how young children might gather meaning from their observations and interactions with virtual actors and include the following topics: realism v. impressionism; the importance of the eyes; face to face communication; and, recognition of emotion. Although there is a relationship between the two, the emphasis here is towards issues of design for individual characters rather than interactions between characters per se.

1. Realism v Impressionism

An interesting and difficult issue is concerned with trying to determine how realistic the virtual characters should look. At one level, it does not even seem to make sense to talk about ‘realism’ per se since we are not modeling the real world. At another level, addressing ‘realism’ to specific questions provides some suggestions (e.g. how can we engage our users? how can we facilitate creative play and improvisation? what are the learning objectives?).

However, any discussion of how realistic characters should be first involves trying to categorise information into types, such that we might be able to determine what needs to be retained, what can be left out, or presented in a more abstract form. Common terms in the research literature make a distinction between ‘high-realism’ and ‘low-realism’ – because the former are typically miniature copies of ‘real’, it is often argued that they cannot be played with in more than one way. They have therefore been labeled constraining with respect to young children’s imagination (see Almqvist, 1998 for a discussion). However, high-realism objects and characters are obviously more familiar to young children, and therefore easier to identify with. Although, low-realism objects and characters have less distinct counterparts in the real world, and are often ascribed as allowing for a more imaginative type

of play, if taken to an extreme, there is almost certainly a relationship between abstraction and impoverishment of meaning.

A related factor is the level of detail – whereas few details also have less potential to convey meaning, rich details have more potential. Given that the characters in our virtual world have complex minds, it is important to note that our characters therefore *have the potential* to convey that complexity. How that complexity is conveyed leads back to the difficult question of trying to categorise information into types. Our empirical studies using low- and mid-tech prototypes give us some clues here. Although an important issue here is the range of characters and also the level of realism in the 3D world (for example, highly abstract characters might look quite strange in a more realistic 3D environment), young children seem to identify with, and recognise characters by their shape. More specifically, how familiar their shape is to their real life counterparts. For example, if the goal is to have human-type characters then they would probably be easiest to recognize as such by having a human type shape; sheep if they have a sheep shape etc. Other aspects related to realism seem to be more flexible, for example, given the identifiable shape, the colour of the character, or type of paraphernalia does not seem to be an issue. Indeed, making a green pig wearing a funny hat or a purple cow with glasses is seen as fun. Equally, how the characters express behavior does not seem to be related to realism. For example, cows that can express different emotions, are also most appealing to children. These types of ambiguity are not only important for imaginative play, but they allow for flexible expression and ‘playing around’ with meaning and meaning making. Since it is essential that we engage our young users, using these constraints and flexibility, can be turned to our mutual advantage.

Another important factor that has been identified from many perspectives (e.g. perceptual development, social psychology, cartoons, as well as being preferred by young children), is the perceived age of the character, with younger characters being preferred over more mature characters. More specifically, this seems to be directly related to the size or proportions of the characters. The proportions of younger (characters) reflect a proportionate increase in head size relative to body size. For example, in humans, the head of a newborn baby represents about one quarter of their overall size, with growth this gradually decreases to about one seventh. Indeed, children find discriminating between younger people easier than adults. One explanation might be that younger heads (being larger) convey more details than older heads, or that younger features (e.g. the eyes) tend to be more conspicuous. This is important for the 3D world, since more information can be conveyed if characters heads are larger than they would be if they had more ‘life-like’ proportions. A central and related factor here that is dealt with in later sections is the importance of the face.

2. The importance of the eyes

The whites of human eyes are unusually prominent, with the consequences that the pupil and iris stand out, making the direction of gaze potentially easy to see. This is likely to be more than a coincidence, because gaze direction is a powerful social signal. Simon Baron-Cohen and his colleagues (Baron-Cohen et al. 1995) have pointed out that adults and young children can use gaze direction to draw conclusions about other people's mental states and make inferences about minds. In social interaction, gaze and eye-contact (looking at another person's eyes) serve a number of different functions (Kleinke, 1986). These include:

- regulating turn-taking, for example, establishing slightly longer than usual eye contact at the end of an utterance is one of the signals that it is the listener's turn to speak.
- expressing intimacy – eye contact increases as a function of positive attraction, and romantic relationships are one of the few circumstances in which prolonged gazing into another person's eyes is considered acceptable.
- exercising social control – through staring to intimidating, or by increasing the amount of eye contact when attempting to persuade or to deceive.
- facilitating goals – such as looking at another person to check their understanding or approval, or looking at them to seek information or clarification

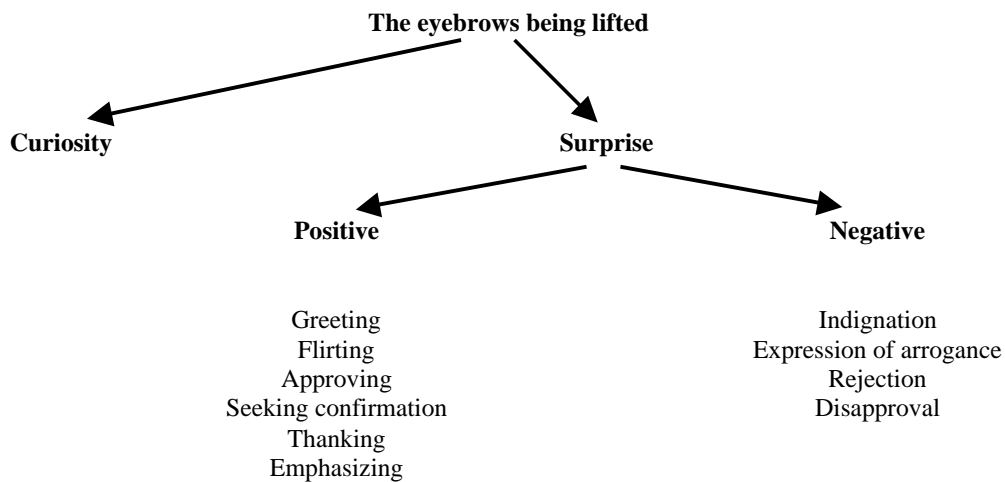
Given that young children are sensitive to the direction of gaze, and that the virtual characters in our world are personality-rich characters with complex minds, using eye gaze provides a flexible way to demonstrate the characters complexity and also will give cues to their behaviour, actions and interactions with others (e.g. joint visual attention).

1. The importance of the face: face to face communication

Face to face communication involves the integrated use of the cues described so far and then some more. Other facial gestures including *nodding* or *shaking the head* to indicate agreement or disagreement, *frowning* for puzzlement, *raised eyebrows* for questioning and so on. Some of these gestures, like positive and negative facial expressions seem to be universally understood by adults and young children, others may vary across cultures. Eibl-Eibesfeldt (1989) has given a thorough analysis

of the functions of the apparently simple gesture of raising the eyebrows, which suggests that this relatively simple perceptual change in information can be used for expression purposes.

Diverse Functions of eyebrow raising, taken from Eibl-Eibesfeldt (1989)



Such gestures are often called ‘paralanguage’, because they supplement and complement the information conveyed by other means (e.g. speech). The linguist David McNeill (1985) has argued by analyzing the speech and facial gestures of people describing cartoon type movies, that gestures modify our interpretation of content.

4. Recognition of emotion

Human emotional state can be categorised by (i) the subjective experience of the emotion—happiness, sadness etc.; (ii) the physiological changes which occur—butterflies in the stomach, goosebumps, sweating etc.; (iii) the behaviour associated with a particular emotion—smiling, crying, frowning, running away, being frozen to the spot etc. From the point of view of the perceiver, any behaviour can be used to infer emotion—perhaps the most obvious would be something like crying, running, stamping of feet or blushing. However, recognising an emotion can depend upon the salience of many factors including the context of the behaviour. While adults tend to make complex inferences, which take into account the *beliefs* and *desires* of the individual concerned, the research specifically concerned with young children suggests that they may not normally utilise as many factors as adults when they gather emotional information.

Generally, young children tend to be more constrained (than adults) by what they can see (e.g. Vygotsky, 1978; Singer, 1994). With specific reference to making inferences about emotion, when children are gathering emotional information, they tend to be particularly influenced (and biased) by emotional expressions (e.g. Venden, 1999, Reichenbach and Masters [21]). Indeed, research suggests that young children tend to rely on facial expressions to read emotions even when they are in conflict with contextual cues (e.g. Gnepp [14] and Iannotti [15]).

We have conducted a number of empirical studies that have directly explored young children's perception of emotion and have found that they can discriminate between the different cartoon-like faces in a similar way to previous research using human faces. The emotions that we have found to be most salient for the large majority of children are those faces that display a happy a sad, an angry, and a frightened expression. However, to provide flexibility we also found that we needed to include some categories of emotion that were more neutral or ambiguous for children (e.g might be interpreted as displaying a face with mixed emotion), and those that were most effective were faces displaying a neutral and a calm expression. Not only do the children find facial expression changes fascinating but they seem to stimulate interest and enjoyment. We found that young children were able to build up character actions, faces and action modifiers, and were able to use facial expressions within a story telling context. Generally, our empirical work demonstrates that children can use facial expressions creatively: facial expressions can be used to elaborate the protagonists intentions, goals and emotion.

5. Character Actions

The type of actions that young children seem to enjoy is in some ways paradoxical – in their spontaneous stories, they tend to be biased towards individual character actions, whereas when they viewed the puppet platform they wanted to have more 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).

The most important factor with regard to action then reaction seems to be the speed at which this occurs. Although this raises difficult issues, if the reaction is too slow then the children tend to get bored or might miss the interaction between characters. In this sense the timing is crucial.

To a certain extent the meaningfulness of character actions will probably be related to the context so it is particularly difficult to be prescriptive with respect to what types of actions will be meaningful for

our users. However, if one of our characters is to beckon and shoo (e.g. the Farmer) then how that is portrayed will be intimately related to the design of the character. Again, it seems that techniques of exaggeration are probably one design solution, since this would not only make the action more obvious, but would allow for such an action to be conveyed from a more diverse vantage point.

Conclusions

Children are primarily influenced by visual cues, and there are a number of factors that seem to be most important. First, creating believable characters does not seem to be related to their level of realism *per se.*, but characters can be identified and categorized by their shape, should they have specific roles (e.g. in the Black Sheep Scenario.). This being the case, shape-based information can be seen as being directly related to a character's perceived believability. Other factors like colour, clothing, texture or paraphernalia are much more flexible and do not need to be realistic. Indeed, characters with ambiguous or flexible characteristics are intriguing for young children – which is an essential goal of our puppet theatre – building a system that will sustain interest, be engaging and enjoyable for our young users.

Another aspect of the characters that young children are particularly influenced and attracted by is their proportions. Characters that have proportions that appear 'youthful' are more attractive and convey more information, perhaps because the heads of younger (humans or animals) tend to be larger than the heads of older (humans or animals). Generally, child-like faces are not only seen to be easier to process for children, but the implied exaggerated size of head (relative to adult proportions) in which the features (eyes) are easier to see and also convey more information. The eyes are a particularly useful part of the face – not only can the eye gaze be used to draw inferences about a character's mind, but the eyebrows can be used to convey a variety of emotions and actions.

A related and central issue concerns the primary importance of the face – faces displaying diverse facial expressions are not only appealing to young children, but provide a means of conveying the emotional state of the characters. Emotions that are sometimes described as 'basic', are easy for most young children to discriminate between (e.g. happy, sad, angry and frightened), but having more neutral facial expressions are also important (neutral as a base and/or faces that can be imputed with more complex emotional states) since they provide flexibility from which more complex inferences can be made. Our findings indicate that children are biased towards faces when gathering meaningful information. Indeed, using facial expressions may *even* better enable children to identify with a

character, and help them to elaborate on a character's intentions, goals and emotion. With respect to character actions, young children tend to use less complex character actions when they tell spontaneous stories, but expect more complex interactions between characters in the virtual world.

We suggest that in order to empower the user with a richer model of the characters that they interact with, attention should be focused on mechanisms, such as shape, proportion, facial expression, conspicuity of the eye region, and exaggeration, which better communicate meaningful information about virtual characters.

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