

# Realistic Simulation of Emotion by Animated Characters

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**Abstract.** A truly realistic virtual environment for simulation would require human characters to display realistic features and behaviours. However, another requirement is believability. These elements would be vital, for example, in order to train students in a medical field by immersing them in scenarios using realistic and believable animated humans. It should provide a concrete experience for effective learning; as defined in Kolb's learning cycle [1].

To facilitate this, animation is reaching a point where animated characters are becoming visually realistic. However, due to the effect of the uncanny valley [2], which is a drop in believability as animated characters approach visual perfection, it may be necessary to display realistic behaviour in order to preserve the credibility of the experience.

Further, realistic human behaviour by definition conveys emotions. Therefore, it is first necessary to define emotion in ways, which could be simulated by animated characters. The display of emotion has been considered previously for facial animation, but 55% of non-verbal communication is conveyed through the body [3] and it is not clear how viewers respond to computer generated body cues, or how such a response could be assessed. In this paper the body is presented as a medium for expressing emotion and the methods that could be used to measure the emotional impact of such characters on the user are discussed.

**Keywords:** Emotion, Animated character, perceived realism, emotional behaviours, simulation

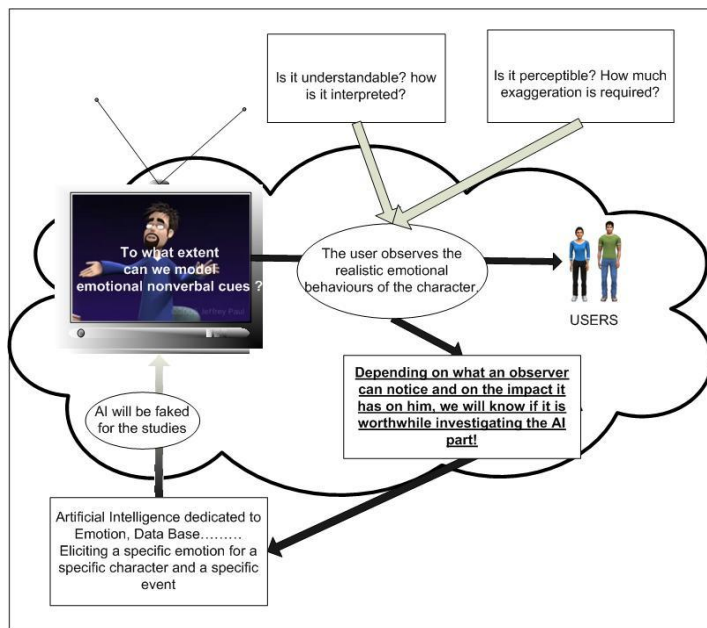
## 1 Introduction

As animation techniques are reaching a point where animated characters are becoming visually highly realistic, animators are likely to be confronted with the issue of the "uncanny valley". The "uncanny valley" models a drop in believability and comfort as characters acquire greater similarity to humans [2].

As displayed realism increases, there is a peak in believability just before the "uncanny valley". While, animation is sensitive to this optimal stage the characters that are required to simulate a medical environment are expected to be highly realistic and hence are more likely to "fall" in the valley. In other words, for animated characters that look more and more realistic (similar to humans) the viewers expect a

higher degree of realism in behaviour and non-verbal expression. Without displaying convincing emotions they tend to look unnatural [4] and hence, cannot avoid the pitfall of the “uncanny valley”. So, finding ways for the character to express emotions, which are interpreted by the user as realistic or near realistic may be one way of avoiding the drop in believability.

This high realism would be needed in order to build a truly realistic virtual environment in order to train students from the medical fields, by immersing them in realistic scenarios. In these scenarios, the character would need the capacity to display non-verbal cues (including body language) from which trainees could assess the inner emotional state of the character. As in real life even though, the user interprets what is communicated both verbally and through body language, the messages conveyed may be contradictory. Simulating the multi-channel communication we naturally use in real life should facilitate a stronger sense of social presence [5]. A higher sense of presence would be beneficial as it should provide a more engaging and hence concrete experience for effective learning [1]. However, before developing applications it is necessary to gain an understanding of the effect that an animated character displaying emotions may have on the observer.



**Fig.1.** Field of investigation

Therefore, Studies on the perception of emotional behaviour are required before constructing a highly realistic AI dedicated to emotions (Fig.1.). Since emotions have to be displayed by an animated character and will have to be assessed on observers, this paper presents a preliminary working definition derived from the psychology of emotion. Then body-language is presented as a medium to express emotions because

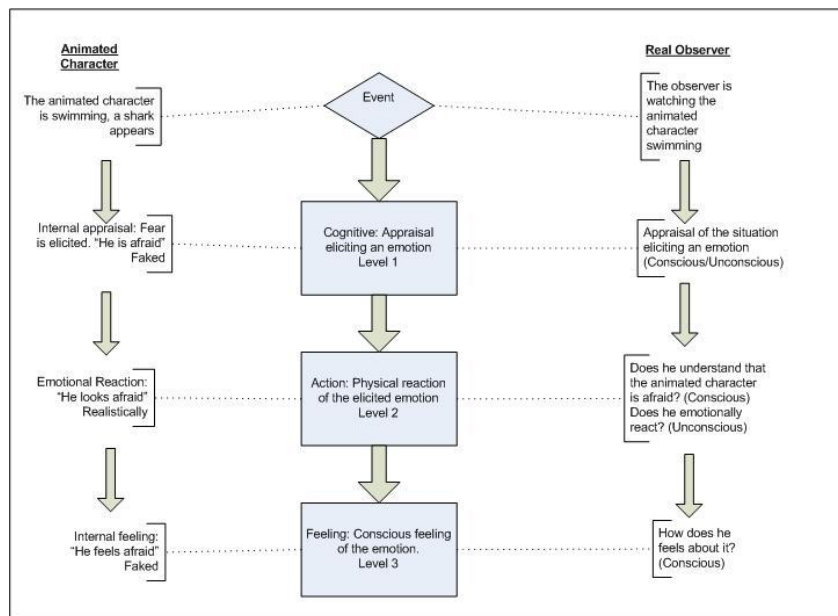
“55% of non-verbal communication is said to be expressed through body language” (Mehrabian and Friar 1969) cited by [3]. Finally methods for measuring the emotional impact caused on the observer by such characters are discussed.

## 2 A Definition and the Project within James-Lang Theory

Defining what an emotion is is problematic, Ledoux (1996) states “one of the most significant things ever said about emotion may be that everyone knows what it is until they are asked to define it” [6]. The problem in defining the term mainly comes from the difficulty of drawing a distinction between what is emotional and what is not. Questions such as when do emotions occur are also very controversial. Moreover, putting such borders in is very subjective.

This paper uses ‘general’ definition proposed by Keltner and Gross (1999) as an emotion as an “episodic, relatively short-term, biologically-based pattern of perception, experience, physiology, action and communication that occur to specific physical and social challenges and opportunities” [7]. In order to use this definition, the elements are grouped into three main components:

- Action: Physical responses to an emotion (including physiological)
- Cognitive: Appraisal of the situation
- Feeling: Consciousness of the emotion, subjective state [6].



**Fig. 2.** Emotional flow (following James-Lang theory) for an animated character and for an observer.

However, a number of theories have been developed to explain how these components articulate together but unfortunately there is no consensus on one theory.

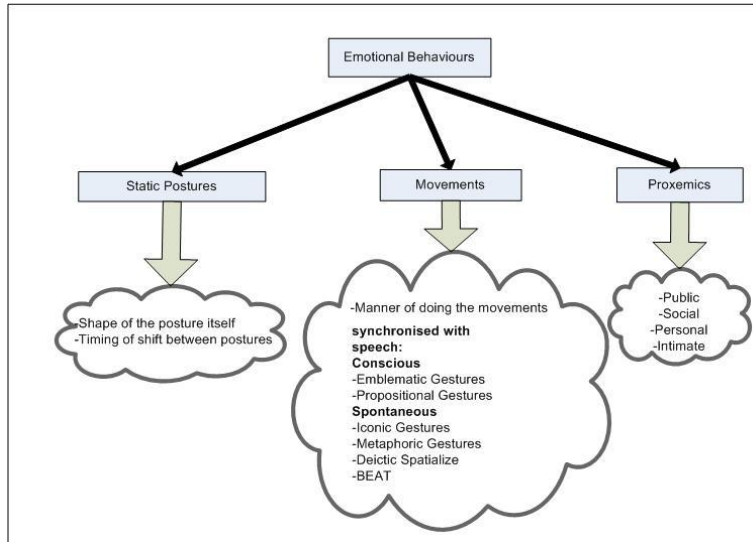
In order to focus on the display of emotion and the effect it has on an observer, a theoretical model is needed for situating the project in a fluent emotional event. To do that, the James-Lang theory [8] was chosen which orders the component by Event → Cognition → Action → Feeling (Fig.2.). This theory has been chosen here to highlight the PhD objectives efficiently: even if it is quite disputed today, ordering the components in a fluent process helps differentiate the ones that are important to the project. Moreover, the order in which they occur was not identified as an issue at this stage.

For the animated character the studies will only focus on how to represent the action component (Level 2), whilst the rest of the system can be simulated. However, when it comes to assessing the observer's understanding and emotional inner state, all the components are required (Fig.2.).

### **3 Body-Language as a Modality to Display Emotions Realistically**

Focusing on the display of emotion through the body seems to be an appropriate approach. However, psychology has mainly focused on understanding facial expressions [3]. Nevertheless, in order to bridge the uncanny valley it is necessary to consider emotions throughout the whole body, as an animated character displaying emotion realistically through the face and not through the rest of the body will probably still look unnatural to a viewer. This has been codified as a rule in 'classical' animations as "the expression must be captured throughout the whole body as well as in the face" [9]. Theatre also does so, by asking actors to become, in Artaud's words, "athletes of the emotions" and a large part of an actor's training concerns the non-verbal expression of emotions, see [10] for example. Emotions such as fear, anger, happiness, stress... are likely to be expressed through the whole body and should be readable.

Researchers have started to categorise different types of body language, depending on how it occurs. The categorisation created from [11] and from [12] can be separated into three different areas (Fig.3.).



**Fig.3.** Emotional Gestures Classification created from [11, 12].

**Postures:** Postures are specific positioning that the body takes during a timeframe. It is commonly acknowledged that postures are a medium to express emotion. For example, educationalists commonly take their students' postures as an indication of their inner state [13]. Thus, a human character displaying realistic emotion will have to take up postures appropriate to the emotion. Some researchers in Human-Computer Interaction have started to study and classify postures. For example, De Silva & Bianchi-Berthouze's study of cross-cultural recognition of four emotions (anger, fear, happiness, sadness) through interpretations of postures. They built a set using actors to perform emotional postures and analysed the interpretations of the emotion represented [13]. Their study is useful to this project as provides a method to collect and classify emotional postures.

**Movement:** "The consensus is now that many emotions are indeed differentiated both by characteristic body movements and by static postures, and that these are effective cues for judging the emotional states of other people in the absence of facial and vocal cues" [14]. Hence, an animated character displaying emotions realistically should also do so during, and via, motion. Research in the perception of emotion has shown that it was possible for observers to recognise emotions from body expression alone, even in very short dynamic scenes [14].

The movement category is the widest as it includes the manner of performing a movement as well as the gestures made in interaction with speech. In this study conversational gestures are separated into two categories the ones that are done being fully aware of the movement (Here called conscious gestures) and the ones done in an 'automatic' way (here called spontaneous gestures).

#### Conscious Gestures

- Emblematic: For example the American ‘V’ gesture for victory. “These gestures are culturally specified in the sense that one single gesture may differ in interpretation from culture to culture”. [12]
- Propositional: For example the use of the hands to measure a symbolic space.

#### Spontaneous Gestures

- Iconic: depict by the form of the gesture some feature of the action or event being described [12].
- Metaphoric: Represent concept without a physical form.
- Deictic spatialize: Represent entities, or idea or events in space [12].
- BEAT: they are “small baton like movements that do not change in form with the content of the accompanying speech... They convey information that is not conveyed by speech”[12].

Further investigation is required in order to gain a deeper understanding of which role emotion plays in human conversational behaviour and which gestures are perceptible and identifiable on an animated character by observers.

**Proxemics:** It is the distance between persons during a social interaction. However, it can also be indicative of emotional states, for example, angry people have a tendency to reduce the distance during social interaction, but this is also the case between intimate people. Hence, proxemics cannot be considered as an emotional expression in itself but is required to complete a representation of realistic emotional behaviour.

In order to build a set of animated characters displaying emotions through the body realistically, the same method used by researchers in perception to build emotional stimuli could be reused: actors could display a specific emotion whilst it is recorded using motion capture technology instead of video recording [13, 14]. Then the ‘best’ stimuli could be used to animate a character display of emotion realistically, considering that there are evidences suggesting that the posed emotional expressions represent an approximation of really felt emotional expressions [15]. However, this will have to consider the observer’s ability to understand and react to the expressive cues displayed.

## 4 Methods for Measuring the Emotional Impact on an Observer

Measuring emotion is a key field of investigation because it provides the methods that could be used to assess the emotional impact such characters have on an observer and also indicates which elements might be used to display an emotion. Psychologists use three types of methods to measure emotion [6, 7]:

Self-reports are probably the most used, the participants are asked to report their own feelings, directly or using scale questions. Unfortunately, it is not possible to know if two subjects rate equally what their inner emotional states are, or feel an emotion equally. Thus it seems to be more useful to assess the evolution of the emotional state (Fig.2. right part of level 3) of a subject [6]. Such an approach could be modified in

order to assess how an observer interprets an animated character expressing emotion instead of assessing the inner state of the participants themselves. An issue with such an approach is the transparency of the research question: If the subject can guess the tested hypothesis by reading the questionnaire she might answer differently. Furthermore, a forced choice question on emotions cannot be used as it would assume that an observer is able to perceive what is emotional, avoiding other possible types of perceptual responses such as “it is just an algorithmic loop”. Hence, a questionnaire would have to be carefully built in order to avoid bias towards specific answers.

An alternative is physiological measurement, which can reveal an unconscious reaction to an emotion. Physical body reactions such as blood pressure, heart rate or sweating can be measured, partially revealing the experience of emotion by an observer. Such measures are interesting because they are partially visible and hence should also be taken in account when displaying a specific emotion. For example, an animated character displaying fear could (depending on the level of arousal) breathe more quickly and even sweat. In other words, the animated character should display the cues associated with the emotion (Fig.2. left part of level 2). The main problem with this approach is to ensure that specific measurements reveal a specific emotion and hence that a specific set of physiological changes represent the right emotions, which is not possible.

Lastly, behavioural observations of people’s reactions are widely used. Unfortunately, when it comes to assessing emotion through behaviours, psychologists tend to focus on facial expression, using standardised methods such as the Facial Action Coding System (FACS) [16]. The FACS provides researchers with a very precise description of facial muscle movements. A very careful observer can often detect “micro-expressions”. These are very difficult to simulate and “micro-expressions” are not currently presentable via an animated character. However FACS has the potential to articulate the impact a displayed emotion has on an observer (Fig.2. right part of level 2), although it is also “extremely time intensive” [6] as it requires the study of recordings of the participants’ face.

Unfortunately, these three standard types of measurements are not well-suited to assessing the emotional understanding and impact that the display of emotion would have on an observer. Hence it appears necessary to develop new methods from these approaches, which are specifically adapted to animation.

## **5 Conclusion**

This paper reviews the basic definition of emotion in psychology, and considers issues with animating the body as a modality to express emotions as well as the methods used by psychologists for measuring its impact.

Classical animation and theatre have been suggested as ‘expert’ fields in understanding the expression of emotions through the body: animating a character using theatrical techniques for expressing emotions and constraining it within

classical animation rules could be an effective approach, to create simulated emotional experience.

However, the project will have two different outputs:

Theoretical:

- Understanding how an observer interprets an animated character expressing emotion through nonverbal cues.
- Knowledge of the impact that such behaviours have on an observer's own state.

Practical:

- Potentially reusable methodology to assess the impact of emotional animated characters.
- Recommendations for a display framework for an AI dedicated to emotions.

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