ENHANCING BELIEVABILITY: EVALUATING THE APPLICATION OF DELSARTE'S AESTHETIC SYSTEM TO THE DESIGN OF VIRTUAL HUMANS

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Characters play an important role in many interactive entertainment productions, including training simulations and computer and video games. Most current industry methods rely on heavy scripting, where voice acting, cut scene scripting, dialogue scripts, hand-coded animation routines, and hard-coded rules of behaviour are used to portray characters. Procedural animation is less expensive and time-consuming. However, there remains a gap between character models and their portrayal using computer graphics. In order to enhance believability, one must provide a coordinated and consistent expression of body movements.

Delsarte’s system of expression is an artistic aesthetic system that can provide this so I evaluate it in this thesis. In order to compare it to a baseline, I had animators create first their own version, then follow Delsarte’s system. I then had viewers rate the characters’ traits. The results indicate that Delsarte’s system is a promising starting point for the creation of believable characters.

**Keywords:** Believability, Nonverbal Behaviour, Virtual Humans; Procedural animation; Delsarte; Believable Characters
DEDICATION

To my wife, Patricia, for your constant love and support

To my parents, Doug and Susan, for everything
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1: INTRODUCTION

1.1 State of the Art

When people envision the future of virtual environments, they frequently expect virtual humans that seem indistinguishable from actual humans, acting and reacting in intuitive ways. Janet Murray (1998) boldly describes the potential for computerized entertainment using the metaphor of the Star Trek holodeck, complete with engaging storylines, developed characters, and nuanced user agency. While detailing the qualities of digital environments, she makes the important observation that digital environments are procedural, calling the computer “an engine [that was] not designed to carry static information but to embody complex, contingent behaviors” (p. 72). Murray identifies the challenge for the future as being to “invent scripts that are formulaic enough to be easily grasped and responded to but flexible enough to capture a wider range of human behavior than treasure hunting and troll slaughter” (p. 79). While we are currently exploiting these qualities of digital environments to immerse participants in virtual environments such as video games, current practices do not take full advantage of the procedural capabilities of the computer.

Neal Stephenson’s book “Snow Crash” (1993) also raised expectations through his depiction of players’ avatars that inhabit his virtual “Metaverse”. In it, characters gesture at each other and at things around them while they chat and scheme. They fight with swords and race through crowded streets. Characters
act realistically and move naturally, often deriving their mannerisms directly from the person they represent. Unnatural movements remind visitors that they are just in a play world and “people hate to be reminded of this” (p. 102). In short, avatars in “Snow Crash” look and act like real people, and help immerse players as a result.

Contemporary video games present a modern, if less impressive, arena where player avatars interact with each other and computer-controlled agents. Though immersive and exciting, this art form is a young medium fewer than four decades old and remains a byword for “crass, shallow thrills” (“Videogames now outperform Hollywood movies”, 2009). The properties of video games are not fully understood and as a result, user agency competes with authorial control in the creation of engaging and interactive game experiences. For those interested in exploring this new medium’s potential for exhibiting virtual human beings, the developmental challenges include the complex computer code required to drive character behaviour and the animated asset files required to make them look believable.

Assets are the digital components that go into a game, including characters, artwork, sound effects, music, and dialogue. Some games, such as Metal Gear Solid 4, include more than nine hours of cut scenes. Many games also use Hollywood actors to provide voiceovers for character. The screen shot in Figure 1 shows the many models that artists created to make up Metal Gear Solid 4’s extensive environment.
Surprisingly, the current industry practice is to have animators create these assets manually for each new game (Seif El-Nasr & Wei, 2008). This means they model digital characters and environments, and design variations such as emotions based on their intuition and training. Then they hand place objects, vertices, and pixels within the game world. Mateas and Stern (2005) reveal that contemporary games are “pushing against authoring limits caused by an over-reliance on non-procedural, static assets [that] currently contain more media files than lines of code.” Static assets are the rule, not the exception, and Mateas and Stern report that this practice has led to a growing concern among developers that the growing requirement for detailed graphics and larger games is leading to a feedback loop that is unsustainable.
This reliance on static assets is clearly prohibitive and explains why many studios treat games like big-budget movie productions. The cost of making a console game was between $3m and $6m according to a BBC report ("Cost of making games set to soar," 2005), and they predicted it to rise to as high as $10m or $20m. Modern production costs have outstripped that estimate, and now, making a game for Microsoft’s Xbox 360 or Sony’s PlayStation 3 typically costs between $20m and $30m ("The Next Generation of Gaming Consoles", 2009), and the CEO for Ubisoft, a major video game publisher, estimates the next generation will average $60m. In fact, he reports that Ubisoft is integrating assets from a movie into the video game adaptation to try reducing costs.

One of the "short cuts" to creating animated characters in video games that has arisen is the use of motion capture. Using this system, actors or athletes dress in special gear and perform activities against a neutral background. After recording their movement, this allows the systematic production of computerized characters based on their physique and activities. Computer games such as FIFA 07, by Electronic Arts, use motion capture from athletes (see http://www.youtube.com/watch?v=_tiykB5_YwU). Figure 2 shows how an actor’s performance maps to a virtual character (Maraffi, 2009).
Figure 2: An actor provides motion capture data

Motion capture provides a reasonable approach to creating characters, especially for sports games and similar genres where smooth and accurate movement is more important than expressiveness. It is not without its drawbacks, however. Amaya, Bruderlin, and Calvert (1996) point out that motion capture systems require specialized studios and gear and allows for limited editing afterwards. A typical setup might include calibrating between eight and 24 cameras, capturing the movement, and then cleaning and post-processing the data (Naugle, 1999). If the design requires different renditions of a character, the actor will enact them separately. Experts are divided on whether motion capture saves time and money in the end. ILM’s Seth Rosenthal says, “Motion capture is
irreplaceable for some applications and inappropriate for others. When used well, it can be incredibly cost effective, but, in practice, some of those savings are displaced to other parts of the production” (Kenyon, 1999).

Besides artist-rendered computer animation and motion capture, procedural content generation is a solution that takes advantage of the computer’s procedural nature. At the Montreal International Game Summit 2008, Far Cry 2 technical director Dominic Guay called procedural content generation “an increasingly important game development technique, not just to control costs as games get bigger and bigger, but also to retain the crucial ability to make changes throughout the production process” (Remo, 2008). While games in the past have used off-line procedural generation to produce maps of continents (Elder Scrolls II: Daggerfall) and galaxies (Elite), the industry in general “tends to favor brute force approaches” (Remo, 2008).

Procedural content generation has several advantages that help to make it valuable. It allows data compression, which can be useful for sending content over a network and having client machines perform the algorithmic work. It enables user-generated content so long as appropriate tools accompany it. Similarly, programmers become able to generate additional content without as much artist support. Of course, it still involves artists, who help create the original designs and the rules they follow. For them, procedural generation can increase their productivity by multiplying their input into an increased amount of content.

One of the challenges presented by using procedural content is retaining artistry while designing the dynamic processes that produce it. Because
procedural systems rely on a limited number of parameters for control, content can lack expressiveness and suffer from not looking natural. Depending on the environment you wish to depict, this can be more or less important. For a first person shooter such as kkrieger, the results are acceptable and result in an incredibly tiny file size (less than 100kb). This screen shot (© .theprodukkt) shows the player facing an enemy.

Figure 3: kkrieger: an entirely procedurally generated first person shooter game

On the other hand, using procedural animation techniques for characters can limit expressiveness. Integrating realistic behaviour and artistic modelling is a hard problem. Sometimes, the quest for believable behaviour supersedes an artistic agenda. For example, Horswill (2009) built the Twig behaviour solution (Figure 4), which uses techniques from robot control to provide responsive character behaviour. While doing so, however, it intentionally leaves unaddressed the contribution of expressivity to believability.
Depending on the research agenda of a procedural animation project, goal-seeking and realistic behaviour can be more important than character expressivity, as Figure 5 from Lau and Kuffner (2005) demonstrates. For whatever reason, procedurally generated believable graphics and behaviour are seldom produced simultaneously.

Nonetheless, even after transitioning to procedural animation, it is still important to base characters on sound social and psychological models. The result is characters that are better quality and provide a broader appeal to audiences who want socially and emotionally engaging experiences (Isbister,
2006, p. 255). She reminds us that character appeal is broadly composed of social relationships, psychological depth, and social expression. Furthermore, style is an important contributor to character (p. 176) that is reflected even in the way a character moves and helps to capture the personality and mood of a character. As a result, artistic systems of expression can be seen as a way to help connect our design agendas of realism and naturalism with style and broad appeal.

1.2 Challenging Procedure

In describing the present realities of machine autonomy, Badler (1997) provides some useful definitions of terms that will be used throughout this study. He describes virtual humans as computer models of people that can be used “as substitutes for ‘the real thing’ in ergonomic evaluations of computer-based designs … prior to the actual construction of those spaces” and “for embedding real-time representations of ourselves or other live participants into virtual environments.” Badler provides another useful distinction when he defines an agent as a virtual human under computer program control and an avatar as a virtual human controlled by a live participant. He also helps to define my research problem as he provides five basic dimensions for measuring the state of virtual human modelling:

1) Appearance: Cartoon shape — Physiological model

2) Function: Cartoons actions — Human limitations

3) Time: Off-line generation — Real-time production
4) Autonomy: Direct animation — Intelligent

5) Individuality: Specific person — Varying personalities

He locates current research challenges in the final two dimensions, stating that virtual humans with intelligent autonomy and individuality and personality are still in their infancy. Improving the autonomy and individuality of game characters is precisely the potential procedural content generation has. My study speaks to the potential for improving the individuality of characters by using an artistic system for style.

As people strive to create engaging lifelike computer characters, they have taken on a design agenda drawn from the arts, termed “believable characters”. It has come to describe virtual humans that display high fidelity to people by using behaviour motivated by personality and emotion. Of course, the limitations of procedural generation can hinder this artistic agenda. As a result, few projects pursue believable graphics and behaviour simultaneously. One example is Loyall (1997), who brought the “believable character” agenda to the forefront with the demonstration of the work the Oz project has provided in the study and production of these characters. However, it does not propose a system for procedurally generating graphics that meet these goals as well. Many of the other foundational projects in the believable agents discipline also create their own, different, methods for behaviour; the Previous Work chapter demonstrates the variety.

Badler, Allbeck, Zhao, and Byun (2002) call the “creation of effective real-time autonomous embodied agents” one of the “last research frontiers in
computer animation." An important component of embodied agents remains less researched, however. In Seif El-Nasr and Wei’s study of holistic artistic approaches to believable characters (2008), they point out that: “One important gap is the gap between character models (artificial intelligence) and how these characters are portrayed through animation (graphics). While there are models that formalize emotional expression through facial muscles, there is very little work that explores methods of formalizing nonverbal body motions as a function of character characteristics.”

Taken together, this demonstrates the opportunity that exists for finding methods that connect the depiction of character behaviour with their intended psychological state. Such a model would be of great use to the generation of procedural animation. Many cognitive models exist that connect nonverbal behaviour and meaning because behaviourists, psychologists, sociologists, and artists have studied it in depth. In fact, there are still models that have barely been tested at all in a computational setting, in spite of their apparent benefits in their original contexts.

One such model that connects body motion with purpose and meaning is François Delsarte’s system of expression. While there are many artistic systems, some apply only to humans with their innate sense of emotion, while others provide less of an aesthetic grounding. This system, though it “reigned supreme in America” as motivator for human methods of expression (e.g. dance) between 1880 and 1900 (Shawn, 1968, p. 80), has not been thoroughly evaluated for human actors, nor tested significantly as a model for virtual humans. Thoroughly
evaluating it and finding a reliable system of expression would be of great value for those interested in procedural animation. Delsarte’s system has not yet been empirically tested (Marsella, Carnicke, Gratch, Okhmatovskaia & Rizzo, 2006) to see whether it communicates what it intends, nor how has it been evaluated for how well it translates into character animation. If this system were a valid source of inspiration for character behaviour, it would provide a potent foundation for producing procedural animation.

1.3 Delsarte’s System of Expression

François Delsarte was a singer and actor that lived from 1811 to 1871, mainly in Paris, France. After having his voice ruined by bad singing coaches (Shawn, 1968, p. 15), he turned to teaching. In order to train actors well, Delsarte performed systematic observations of human action and interaction. Though he did not publish, he trained a protégé Steele Mackaye (Shawn, 1968, p. 17). Again, Mackaye did not publish, but trained a number of students. His protégé Genevieve Stebbins published an exhaustive volume on Delsarte’s system of expression based on her training and existing notes passed down from Delsarte.

Delsarte’s system inspired dancers who changed the state of their art around the turn of the 20th century, and introduced a completely new technique and vocabulary that ushered in a new era of modern dance (Shawn, 1968, p. 82). Though “couched in a language and terminology from the 1800s that strikes a 21st century reader as perhaps quaint and metaphysical”, “this technique systematically and extensively describes how emotions, attitude and personality are conveyed in dynamic body postures and gestures.” (Marsella et al., 2006).
Delsarte’s system of expression provides several principles of motion, including the meaning of certain zones of the body, and the meaning of different directions of movement. Each part of the body corresponds to a different meaning, and actions are coloured by the zones in which they start and finish. Motions away from the centre (e.g. the body) are termed “excentric” and have relation to the exterior world. Motions towards the centre are termed “concentric” and have relation to the interior. Balanced motion is “normal” and moderates between the two. The system also includes a variety of laws indicating the meaning of parallel motion and successions of movements along the body. Finally, it also describes nine possible poses per body zone (combinations of excentric, normal, and concentric) and their meaning.

1.4 The Study

Since there exists such an opportunity to leverage the procedural nature of the computer to portray characters, it is important to find an aesthetic system that could provide a consistent guide to displaying characteristics. I want to determine how well characters developed using Delsarte’s system of expression can portray personality traits. Since conveying personality is one component of believability, this will indicate whether Delsarte’s system could be a useful tool for procedurally controlling believable characters.

In order to make a high level review of Delsarte’s system, for this study I worked with animators to implement characters using both their normal process and Delsarte’s system of expression using his sets of nine possible poses per body zone. In order to confirm my hypothesis that viewers of these videos would
perceive the characters differently and – more importantly – with a different level of reliability, I then conducted a survey where participants viewed the videos and provided ratings of the character attributes they observed. Working with animators also provides me with an opportunity to derive insight into their process and observe how they integrate a new system of expression into their work.

1.5 Contribution

The main contribution of this thesis is the evaluation of the reliability of Delsarte’s aesthetic theory for animated characters. I am exploring the research gap between procedural animation and the production of expressive characters. An artistic model for behaviour that communicates psychological states accurately would be very valuable for the production of believable character animation, particularly that which is procedurally generated. In doing so I am exploring:

1) The applicability of an artistic model for expression to procedural animation.

2) The process of traditional animation and how animators can incorporate Delsarte’s system of expression.

1.6 Thesis Structure

This introduction provides an overview of the thesis. It introduces the motivation for developing a model based on Delsarte’s system of expression. Chapter 2 describes findings from the social sciences that provide the theoretical
underpinnings for believable characters. Chapter 3 provides details of the previous works that have developed virtual humans. The work I conducted with animators to produce clips based on Delsarte and their own styles is described in Chapter 4. The evaluation study and results are provided in Chapter 5. The future directions I envision based on these results are described in Chapter 6. Finally, Chapter 7 concludes the thesis with a further discussion of the contributions it makes.
2: THEORETICAL GROUNDING

The background of computational behaviour models is grounded in numerous disciplines, including psychology, the visual arts, and computer science. In order to make virtual humans more believable, their creators have based their work on findings from the social sciences, including different ways of representing emotion and personality traits. Designers have derived inspiration from various sources, ranging from psychological models such as the Five Factor Model (FFM or "Big Five") to improvisational theatre and Laban Movement Analysis. While these models provide systematic ways for understanding character attributes, currently, there is no consensus on which model is best used for modelling virtual humans. As a result, each project provides justification for its selection.

The character arts provide a rich set of examples of believable characters and a variety of methods for creating them. Since Disney started animating characters for cartoons and on to the modern day when Pixar produces hit feature films produced using computer animation, the craft has built up a wealth of knowledge about what a lifelike character should look like and how it should act. Of course, even before then actors and observant teachers produced useful insights into how one should move and pose on-stage.

This chapter covers the theories from the social sciences upon which researchers have based believable character research. The creation of lifelike characters involves the study of the fine arts and its representation of characters,
whether stylized or naturalistic; personality, emotion, and nonverbal behaviour are aspects of human behaviour that are incorporated into virtual humans to make them more lifelike. Delsarte’s system of expression is just such a stylized description of human movement and personality, and is described in detail in this chapter.

2.1 Representing Emotions and Personality

“For a character to be that real, he must have a personality, and, preferably, an interesting one” (Thomas & Johnston, 1981, pp. 19–21).

In the depiction of characters in the arts, regardless of how stylized, the focus remains on conveying an interesting and engaging character with a unique personality. Believable character literature (e.g. André et al., 2000) relies on theory and definitions from psychology to come to an understanding of the role that personality and emotion should play. Furthermore, researchers (e.g. Ekman & Friesen, 1969) have linked nonverbal behaviour with the display of emotion and personality traits. When we communicate, our emotional state and personality affect the gestures we make. In order to capture the complex phenomena of personality, I rely on Simon’s definition of personality (1967) as “the complex of characteristics that distinguishes an individual... especially the totality of an individual's behavioural and emotional characteristics” and emotion as an “affect that interrupts and redirects attention (usually with accompanying arousal).”
Modelling personality traits and emotional displays is vital for the creation of virtual humans. Loyall’s PhD thesis (1997) and work on the Oz project provides an example of work that has a deep psychological foundation. He says, “Personality: all of the particular details – especially details of behavior, thought and emotion – that together define the individual”. This section will highlight some of the important theories about emotions and personality that help researchers to design believable characters.

2.1.1 Wallbott's universal emotions

Wallbott (1998) notes that actual lab research connecting body movement to emotion is rare, and as such, he wanted to determine to what degree body movements can be linked to specific emotions. He wanted to show that body movements do not simply indicate the quantity of emotion, but actually the quality of the emotion. To do so, he analysed scenarios involving actors portraying emotions such as joy, happiness, terror, anger, and shame to see whether the viewers perceived the emotions clearly. This study provides me with a pattern for conducting an encoding and decoding study that I follow.

Wallbott asked actors to perform scenarios selected from a cross-cultural study; they were naive to the overall purpose and were given two polyglot “standard sentences” to express their adopted feeling verbally. Actors performed two scenarios for each of the fourteen emotions chosen (elated joy, happiness, sadness, despair, fear, terror, cold anger, hot anger, disgust, contempt, shame, guilt, pride, boredom). Twelve actors repeated this process twice, and ended up with 1344 recordings, which are pared down to a final sample of 224 takes by
selecting only the most consistent two actors of each gender per given sentence/emotion pairing. Naive judges, separate from the expert coders who helped assemble the final sample, assessed the emotion as demonstrated by body movement alone, distinct from face or voice.

After statistically assessing the judges’ overall consistency, Wallbott concludes that there seem to be distinctive features and patterns of movement and postural behaviour associated with emotions. He addresses concerns about posed emotions and actors and uses statistical evaluation to help isolate the contributions of individual idiosyncrasies. In particular, he found that 66% of the movement and posture categories distinguished significantly between emotions. For example, when experiencing shame, sadness, or boredom, actors chose a collapsed body posture. Lifting the shoulders was reserved for elated joy and hot anger. Self-manipulators were frequent during shame and fear experiences. Illustrators dominate during ‘active’ emotions such as hot anger, elated joy, and interest.

This study helps to establish the power of certain body movements to signal specific emotions and strengthens our ability to reliably convey emotions through believable characters when recognizable patterns of behaviour are used. Wallbott’s findings indicate that we can perceive and associate specific emotions with body movement. This leads me to believe that participants can reliably assess the characteristics presented by the characters in my study. Since Wallbott found that actors have distinctive patterns of movement and postural behaviour, this further leads me to believe that Delsarte’s system should be
interpretable in a similar fashion, since it is an artistic system originally intended for acting and dancing.

2.1.2 Big Five personality factors and the Abridged Big Five Dimensional Circumplex

Researchers have identified a need for a taxonomy of personality traits comparable to the periodic table of chemical elements (Goldberg, 1981 as cited in Hofstee, de Raad, and Golberg, 1992). This kind of classification would be of apparent use for social scientists, but accurate personality assessment is useful for the designers of virtual humans who want a basis for distinguishing characters. Two kinds of taxonomic models are apparently popular (Hofstee et al., 1992). The Big Five factor structure subsumes personality traits within five dimensions: (I) Extraversion, (II) Agreeableness, (III) Conscientiousness, (IV) Emotional Stability, and (V) Intellect or Openness. The other is the circumplex model, in which opposed pairs of traits are characterised by their angular position in a two-dimension factor space. The compromise resides in using complete categories or aiding interpretation by providing a positioning tool.

In order to integrate these two systems and resolve the compromise, Hofstee et al. (1992) developed a taxonomy called the Abridged Big Five Dimension Circumplex (AB5C). They used a lexical approach to validate their model by asking participants to describe themselves using adjectives according to a circumplex approach. These adjectives were analysed to determine which adjectives loaded the most meaning and were well defined. The most consistent
and reliable descriptors were then located within the applicable segment of the Big Five dimensions.

This work demonstrates that people can come to a consensus on personality traits and provides an excellent set of labels to constrain participant responses when evaluating characters. The descriptors from sections (I) Extraversion, (II) Agreeableness, and (IV) Neuroticism, are used as scales in my study since they are the most external and observable.

<table>
<thead>
<tr>
<th>Big Five Factor</th>
<th>AB5C derived descriptors</th>
</tr>
</thead>
<tbody>
<tr>
<td>I. Extraversion</td>
<td>talkative – silent</td>
</tr>
<tr>
<td></td>
<td>sociable – unsociable</td>
</tr>
<tr>
<td></td>
<td>dominant – submissive</td>
</tr>
<tr>
<td></td>
<td>competitive – uncompetitive</td>
</tr>
<tr>
<td></td>
<td>boisterous – restrained</td>
</tr>
<tr>
<td></td>
<td>courageous – cowardly</td>
</tr>
<tr>
<td></td>
<td>explosive – sedate</td>
</tr>
<tr>
<td></td>
<td>adventurous - unadventurous</td>
</tr>
<tr>
<td>II. Agreeableness</td>
<td>sympathetic – unsympathetic</td>
</tr>
<tr>
<td></td>
<td>friendly – unfriendly</td>
</tr>
<tr>
<td></td>
<td>agreeable – rough</td>
</tr>
<tr>
<td></td>
<td>considerate – inconsiderate</td>
</tr>
<tr>
<td></td>
<td>generous – selfish</td>
</tr>
<tr>
<td></td>
<td>affectionate – unaffectionate</td>
</tr>
<tr>
<td></td>
<td>tactful – tactless</td>
</tr>
<tr>
<td>III. Conscientiousness</td>
<td>organized – disorganized</td>
</tr>
<tr>
<td></td>
<td>ambitious – unambitious</td>
</tr>
<tr>
<td></td>
<td>cautious – reckless</td>
</tr>
<tr>
<td></td>
<td>reliable – unreliable</td>
</tr>
<tr>
<td></td>
<td>consistent – inconsistent</td>
</tr>
<tr>
<td></td>
<td>perfectionist – haphazard</td>
</tr>
<tr>
<td></td>
<td>conventional – unconventional</td>
</tr>
<tr>
<td>IV. Neuroticism</td>
<td>unenvious – jealous</td>
</tr>
<tr>
<td></td>
<td>unselfconscious – insecure</td>
</tr>
<tr>
<td></td>
<td>excitable – unexcitable</td>
</tr>
<tr>
<td></td>
<td>patient – irritable</td>
</tr>
<tr>
<td></td>
<td>emotional – unemotional</td>
</tr>
<tr>
<td>V. Openness</td>
<td>creative – uncreative</td>
</tr>
<tr>
<td></td>
<td>inquisitive – non-inquisitive</td>
</tr>
<tr>
<td></td>
<td>deep – shallow</td>
</tr>
</tbody>
</table>
2.2 Nonverbal Behaviour

Body movements and gestures are an important physical means for demonstrating a character's personality and emotions during communication, as this section will show. This indicates that it is important to coordinate different modalities of communication in virtual humans. In fact, Cassell, Vilhjálmsson, and Bickmore (2001) argue that for the synchronization of speech and gesture, stating that creating dialogue agents that employ appropriate body language leads users' expectations to an appropriate level, away from "unfamiliar interlocutor" that is the computer. Loyall's criteria (1997) for believable agents include following multiple goals concurrently and displaying well-integrated behaviour during communication. Since the display of realistic nonverbal behaviour in virtual humans is so important, this section will review the underlying research and provide grounding for the concepts and terminology used in that literature.

2.2.1 Defining nonverbal communication

One of the fundamental decisions involved when observing human communication is how to measure and understand the role of actions in communication. Harper et al. (1978) provide a definition of verbal communication to start with:
The sending person (source), having an idea to get across, transforms his idea in linguistic forms (source encoding); ... he shapes these linguistic forms by means of his vocal apparatus and articulators into sounds (channel encoding) ... The receiving person hears the sounds through the air between them (channel) and groups them together into linguistic forms (channel decoding), which he finally translates centrally (user decoding) into the idea the sending person had wished to communicate, thus understanding what was said (user).

They diagram this as:

source → source encoder → channel encoder → channel → channel decoder → user decoder → user

Looking at this from the point of view of developing a mathematical theory of communication, there are four important aspects:

a) The information contained in the message.

b) The coding process that takes place on both sides.

c) The channels employed; their capacities and limitations.

d) The effects of noise on accurate transmission.

This theory of verbal communication can be adopted for nonverbal communication, and these four aspects remain relevant concerns.

Measuring the gestures that occur during communication in order to interpret them is an area of dissent among researchers. The two main conflicting views are the structural approach adopted by the early pioneer Birdwhistell and the later external variable approach developed by Ekman and others. Birdwhistell was a linguist, and sought to find in the movement studies he termed "kinesics" the same basic unit of measurement that exists in linguistics, the "morpheme."
He calls this unit "kinemes," the smallest set of body movements with the same
differential meaning, which are in turn composed of “allokines”, similar to
phonemes in speech.

To find these different behaviours, Birdwhistell would observe speakers
and link kinemes with verbal meaning. Because these movements last from just
1/50 of a second to over 3 seconds, it is necessary to use slow-motion
photography to capture certain micro-behaviours. Birdwhistell hypothesizes that
there are 50-60 kinemes, which he groups into kinemorphic classes and
illustrates using a pictorial notation system called kinegraphs which chart motion
using symbols. He stated that all behaviour only had meaning in the context of
verbal communication and could not be separated.

Harper et al. describe several criticisms of the structural approach. Weitz
(1974) believed that there was no way of knowing whether the structure is best
fitting or correct. Performing the microanalyses proved to be very time
consuming, and the kinegraphs can not be used with typewriters or computers.
Dittmann (1971) attacked the entire idea that movements are atomic and
undermined the whole analogy.

What followed was a more descriptive approach. Ekman wanted to map
nonverbal behaviour onto inner feeling states, and to allow others to decode
these states. His approach was psychological rather than structural, and so he
formed his unit of observation at the level of the nonverbal act: a clear movement
observable without special equipment that has a distinct beginning and end. This
approach was followed by others, and resulting in an opening-up of notation. This
kind of mapping approach between emotion and nonverbal behaviour seems very useful for developing believable characters, since computer code can handle character contingencies that arise by relying on them.

2.2.2 Types of nonverbal behaviour

In order to understand the coding process that takes place within nonverbal behaviour, it is important to understand the types of nonverbal behaviour that occur. Ekman and Friesen (1969) describe three characteristics of an act: origin -- how it became part of one's repertoire, usage -- the regular external conditions, and coding -- the type of information being conveyed. These behaviours are said to fulfil one of five general functions in relation to verbal communication: repetition, contradiction, complementing, accenting, or regulating. They further break down into these categories:

1) Emblems - culture specific, learned behaviours that represent meaning.

2) Illustrators - socially learned behaviours that complement or contrast verbal messages.

3) Affect Displays - Ekman and Friesen argue that the facial display of emotion is universal for the seven primary affects: happiness, surprise, fear, sadness, anger, disgust, and interest. They base their argument on the underlying muscles and physical responses in the face. They also describe various culturally obtained display rules that modify displays of emotion within various contexts.

4) Regulators - conversational flow gestures that control turn taking.
5) Adaptors - learned actions based on satisfying bodily needs, based on childhood experience. These are fragmented in adult-hood and experienced in response to buried triggers. These include self-adaptors such as grooming and eating, alter-adaptors such as attacking and flirting, and object-adaptors, which are tool-based, learned behaviours.

These categories and ways of looking at nonverbal behaviour allow the identification and classification of nonverbal acts, as well as helping to clarify their origin and meaning. Subsequent research frequently cites and relies on these classes of nonverbal behaviour.

However, this diversity of behaviour makes Ekman and Friesen conclude that their research "may make it more difficult to conceive of nonverbal behaviour as a simple unified phenomenon, best explained by a single model of behaviour, whether that model be neurophysiological, linguistic, or psychoanalytic." In that case, Ekman and Friesen's work provides an exhaustive description of the types of nonverbal behaviour that people perform, without finding a single underlying cause or model for it. Nonetheless, this helps to provide an understanding of the gestures believable characters should make during communication in order to appear lifelike.

2.2.3 McNeill’s distinctions

McNeill (1992) advances the idea of categories by adopting Kendon’s continuum for language:
Gesticulation → Language-like Gestures → Pantomimes → Emblems → Sign Languages

He states that as we move from left to right: (1) the obligatory presence of speech declines, (2) the presence of language properties increases, and (3) idiosyncratic gestures are replaced by socially regulated signs. These distinctions are important to understand when we try to implement nonverbal behaviour in virtual humans. Often, ‘gesture’ is used interchangeably for any nonverbal behaviour, but it is important to differentiate between fundamentally different types of behaviour. McNeill reserves gestures to refer to ‘gesticulations’ on this continuum and defines them as “idiosyncratic spontaneous movements of the hands and arms accompanying speech” (p. 37). Language-like gestures are similar to gesticulations but are grammatically integrated into the utterance and replace words. In pantomime, the hands depict objects or actions, but speech is not obligatory. Emblems are familiar culturally influenced gestures, with standards of well-formedness since they are usually attempts to control other people’s behaviour. They replace speech, usually as a way of getting around speech taboos.

McNeill observes some useful properties of gestures that could help improve the development of communicative virtual humans. “Spontaneous gestures are global-synthetic, noncombinatoric, context-sensitive, idiosyncratic in form, and timed both to anticipate and to synchronize with speech” (p. 42). Furthermore, “Gestures are integrated into the speech output. They anticipate the speech in their preparation phase, and synchronize with it in the stroke
phase, which is timed to end at or before, but not after, the peak syllable” (p. 42). This provides us with an indication of when gestures should occur, what they should mean, and how they can vary between speakers.

His overall hypothesis also helps to provide a clear model for how gestures are formed. He believes that gesture and speech arise from a single process of utterance formation. The utterance has both an “imagistic” side and a “linguistic” side. The image “arises first and is transformed into a complex structure in which both the gesture and the linguistic structure are integral parts” (p. 30). This helps to explain the crucial role gesture plays in communication and the reason why it should be provided in communicative agents.

2.2.4 Connecting arts and science

Spiegel and Machotka (1974) state their goal is to "build a bridge between arts and behavioral sciences" (p. 351) and demonstrate the relationship by showing the tight links between expressive movement and the arts. In doing so, they explore the same kinds of issues I do in my study of Delsarte's system of expression. Based on what they find in the arts, however, they dispute the existing models of behaviour that hold a strict State → Expression → Impression progression because they fail to find a one to one correspondence between expressive behaviour and inner state, or expressive behaviour and the impression received. They also find fault with trying to discover "inner state variables" and locate meaning in behaviour with linguistic precision. "The assumption that body communication employs the precise terms of a language or the formal categories of linguistic phenomena is itself questionable" (p. 5). The
implication of this is that it will be difficult to interpret an artistic system of expression and map it to underlying states.

They do, however, express support for Darwin's set of three principles, published in his 1872 volume, "The Expression of Emotion in Man and Animals", that find that actions develop from useful, functional behaviours and now lead to expressions or else result from state of mind or high emotion. Ekman and Friesen would classify these as adapter gestures. This leads them to criticize the research strategies of the kinesic/linguistic behaviorists (e.g. Birdwhistell and Scheflen), stating that body language lacks the high level of precision, atomicity, symbolic power, and rule-based structure that language possesses. The study of body movement is broken into four categories, and the authors identify that their work falls into the last category of the following:

1) The study of a variety of different expressive behaviours performed in a standard manner by a sample of "subjects" in order to determine along what inner dimensions individuals actually do vary.

They criticize this method as becoming too occupied with individual style and conflating that with emotion and motivation.

2) Choose a known internal factor and observe its "expression"

3) Use an ontogenetic approach and observe how, in the course of childhood development, internal response pattern is moulded or differs between environmental impact and internal processes.
4) Use an observational approach. By having enough observers judge what is being expressed and how it is being done, arrive at a statistically significant conclusion that reliable describes how expressive behaviour is performed and perceived. The challenge to this method is establishing validity, which Spiegel and Machotka defend by defining outer manifestation as less a product of inner condition than an outwards directed act, whose physical properties can be correlated to an interpretation of meaning in the eyes of the beholder. This shows the value in allowing observers to interpret the meaning of an artistically inspired set of expressions.

They also present a formal system (p. 345) for classifying behaviour. For an interpretation to be made, movements or positions must be placed within:

1) The somatotactical categories of body movement: these categories are a way of classifying motion based on its "somatotaxis" or the arrangement of the body in space. They propose a coding system that is concerned with the formal pattern of movement in body space rather than with the anatomical program of movement that produces the pattern. Patterns of movement are given codes according to their movement within body space, their range in the approach-separation continuum, and their syntropic positioning.

2) An activity series capable of giving the sequence of movements: people learn behaviour in an algorithmic way. Harkening back to Darwin's findings, many body movements seem to be the result of cognitive triggers that meet specific needs, even if the action is not completed fully each time.
3) A set of social roles to provide interpersonal context: a role is a "sequence of acts moving toward a target outcome - the goal - which also describes the function of the role." According to Spiegel and Machotka everyone possesses at least one role, likely more, and these provide cultural context for many behaviours.

4) An event structure or scenario: body motion occurs within a continuous flow of events that has been overlooked in the past. Such a scenario provides valuable contextual information such as a specific social occasion, cultural meaning, and the scale of the event in terms of people and size of location.

In order to find some validation for their formal system, a series of experiments are described which involve showing observers a variety of portrayals of interpersonal activity. These range from a nude and clothed Venus, then Apollo, to sketched figures demonstrating various gazes and arm positions. Another series of experiments asked participants to stage wooden figures in response to a described male-female encounter. These experiments provide some validity for the general concepts described in the first part of this work by providing evidence for the claims about physical body space and context they made earlier.

In all of the art forms they describe, they emphasize the "modifications of natural movement - the representative transformation - occasioned by the process of stylization" (p. 59). This indicates the benefits of basing character behaviour on natural movements and expressions, but also shows the ways a
"representative transformation" into a specific artistic context allows for crucial stylization to take place.

2.3 **Character Arts**

The pursuit of realism in animated characters began with the work of Walt Disney and company around the time of Snow White (1937). Disney strove for a style of realism separate from the surreal humour of Warner animations. "Our work must have a foundation of fact in order to have sincerity. The most hilarious comedy is always based on things actual" (p. 62). Disney’s methods set the standards for the industry and have persisted into the digital age. The animation of Disney and Pixar provide examples in another medium that helps to inform the notion of believability we have adopted for virtual humans.

2.3.1 **The illusion of life**

Johnson and Thomas, two of the main animators from Disney’s early years, went on to write a famous work on animating called “The Illusion of Life” (1981). They based the work on their observations about movement and conveying it realistically and aesthetically. In it, they detail the twelve principles that contributed to realistic character animation:

1) The most important principle is squash and stretch (p. 47). In essence, it states that items preserve their volume, so changes along one dimension (e.g. a squash) produce an effect along the others (e.g. a stretch).

2) Anticipation refers to the energy characters put into preparing for an action (p. 47).
3) Staging maintains its stagecraft meaning and indicates ways to keep characters in focus through placement, the use of light and shadow, and the use of camera (p. 53). In the animation sense, it also means to avoid drawing unnecessary detail.

4) ‘Straight ahead action’ versus ‘pose to pose’ were two different approaches to the actual drawing process. In the first case, one drew out a scene frame by frame; this produced more realistic action sequences. In the second, one drew the ‘key’ frames, and filled in the intervals; this helped to maintain proportions and create more convincing poses that conveyed drama and emotion better (pp. 56-58). Whereas in the practice of hand animation, animators combine the two to balance these effects, computer animation has made ‘pose to pose’ more standard since software can easily ‘fill in the gaps.’

5) Follow through and overlapping action are closely related techniques that produce movement that is more realistic since characters seem to follow the laws of physics. Follow through means that separate parts of the body keep moving, while overlapping action means that when a character changes direction, parts of his body keep moving in the previous direction (p. 59).

6) Slow in and slow out is a principle derived from the time needed for bodies to accelerate and slow down during movement.

7) Most natural actions follow arcs, and so must animated actions (p. 62).

8) Secondary actions are added to a scene to enliven it and support the main action. These emphasize, rather than take attention away from, the main
action. Examples include arms swinging during movement, whistling, or facial expressions (p. 63).

9) Timing is a principle of tension, since it involves two separate concepts that are somewhat at odds with each other: physical timing and theatrical timing. To enforce physical realism, objects must obey physics at the appropriate times and react to impulses and impetuses. On the theatrical side, it is a device to communicate different aspects of a character: emotion, personality, and even pure comic timing (p. 64).

10) Exaggeration refers to the stylistic approach an animator takes to character creation in order to make them unique. Disney used a characteristic amount of exaggeration to create characters that remained true to reality, but in a ‘wilder, more extreme form’ (p. 65).

11) Solid drawing means that the principle of good drawing always applies, and that the basics of anatomy, composition, and weight must be followed (p. 66). Johnston and Thomas warned against creating characters with a mirrored left and right side because the result looked lifeless.

12) Appeal in a character corresponds to charisma in an actor (p. 68). This refers to making characters real and interesting to connect with the audience.

These twelve principles have dominated the field of animation since they were stated, and are the foundation of that craft. They therefore represent reasonable guidelines that any aesthetic system for animated characters must follow.
2.3.2 New practice

John Lasseter has made many important contributions to the field of animation, including being heavily involved in creating the first computer animated feature, *Toy Story*. He reminds computer animators that traditional principles remain important. In 1987, he produced the paper, “The Principles of Traditional Animation Applied to 3D Computer Animation” and detailed how important these twelve principles remained, calling them tools “which are just as important as the computers we work with.” He states: “when defining the character, it is important to make the personality distinct, and at the same time have characteristics that are familiar to the audience. If the actions of a character ring true, the audience will be able to relate to the character, and he will be believable to them.” This informs my work with animators because their training in these methods becomes a lens through which they will filter new styles of animating.

Around the same time, researchers in computer graphics detailed how computational methods can provide compelling animated movement rivalling artist-generated animation. For example, Witkin and Kass (1988) show how spacetime constraints provide animated characters with methods for moving while following physical laws. Their method for producing physically valid motion leads to “what” the character will do, and optimizes “how” they will do it. While solving this problem, they stress the importance of Johnston and Thomas’s twelve principles and use them as criteria for their methods. The development of
procedures such as this led to the widespread adoption of 3D computer animation.

2.4 Delsarte’s system of expression

During the 19th century, François Delsarte spent over thirty years making observations of the human experience in terms of emotions and movement and comparing them to the principles that guided the sculpting of ancient Greek statuary. Stebbins (1902/1977), a student of Delsarte's protégé Steele MacKaye, believes that “the laws and principles underlying true art – whose grandest expression culminated with ancient Greece – and the principles underlying the system of expression formulated by François Delsarte are one and the same; they differ only in the material chosen for their outward manifestation.” (Stebbins, p. 370) Based on this “fixed basis,” he developed an acting style that attempted to connect the inner emotional experience with a systematic set of gestures and movements. The Swedenborgian “Law of Correspondence, in the trinity, applied to the art of human expression” (p. 397) heavily influenced Delsarte's work. It led him to believe that every movement holds meaning.

Beyond his contemporary metaphysics, Delsarte grounded his work in systematic observations, such as his finding that there are three forms of expression for gesture (Stebbins, p. 142):

1) The habitual bearing of the agent
2) The emotional attitudes of the agent
3) The passing inflections of the agent
These forms roughly correspond to personality traits, emotions, and conversational gesticulations. Delsarte ties meaning in his system back to some combination of these forms. He also based several laws on them: the doctrine of special organs, the three great orders of movement, and the nine laws of motion. Delsarte's system divides the body into zones, which he further subdivided into three parts, the mental, moral, and vital subsections (Stebbins, p. 112). The doctrine of special organs indicates that these zones become significant points of arrival or departure for a meaning. For example, the head zone is associated with mental or intellectual meaning, and modifies gestures that start or end near the head accordingly.

Besides this, Delsarte’s observations also led him to identify three sorts of movement: concentric (inwards), excentric (outwards), and normal (balanced) (Stebbins, 1902/1977, p. 113). Delsarte provides meaning for motion made in any combination of these three ways for each zone of the body. The resulting charts of nine-fold combinations became the basis for my study. Appendix 1 contains several examples.

The three orders of movement identified by Delsarte are “Oppositions”, “Parallelisms”, and “Successions”. Oppositions occur when two body parts move in opposite directions simultaneously, indicating strength. Parallelisms occur when two body parts move in the same direction simultaneously and indicate weakness, or possibly stylized movement such as dance. Successions occur when movement passes through the body from an origin through each connecting part in turn. True successions begin at the centre, work outwards,
and indicate good and true motivations. Reverse successions begin at the extremity, work inwards, and indicate evil and false motivations (Shawn pp. 33-35).

The nine laws of motion are attitude, force, motion (expansion and contraction), sequence, direction, form, velocity, reaction, and extension. These laws further modify what each movement means.

Table 2: Delsarte’s nine Laws (Shawn, pp. 47-48)

<table>
<thead>
<tr>
<th>Law</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attitude</td>
<td>The vertical direction of a motion affects the meaning. Positive assertion rises, negative falls. Upwards, or forward motion is constructive or positive. Actions that move down or backwards are destructive or negative.</td>
</tr>
<tr>
<td>Force</td>
<td>Conscious strength assumes weak attitudes. Conscious weakness assumes strong attitudes.</td>
</tr>
<tr>
<td>Motion (expansion &amp; contraction)</td>
<td>Excitement expands, thought contracts, love and affection moderate</td>
</tr>
<tr>
<td>Sequence</td>
<td>Thought leads to facial expression leads to the attitude of the body leads to gesture leads to speech. This is the proper sequence of events and true successions demonstrate them.</td>
</tr>
<tr>
<td>Direction</td>
<td>Movement in heights and depths (up and down) are intellectual. Movement in lengths (front and back) are passional (emotional). Movement in breadths (side to side) are volitional (demonstrate the will). Diagonals are conflicted.</td>
</tr>
<tr>
<td>Form</td>
<td>Straight movement is vital. Circular movement is mental. Spiral movement is moral.</td>
</tr>
<tr>
<td>Velocity</td>
<td>The rhythm and tempo of the movement is proportionate to the mass (including emotion) to be moved.</td>
</tr>
<tr>
<td>Reaction</td>
<td>Everything surprising makes the body recoil. Degree should be proportionate to the degree of emotion.</td>
</tr>
<tr>
<td>Extension</td>
<td>The extension of the gesture is in proportion to the surrender of the will in emotion. Extension beyond the body achieved by holding the body at its culmination, with held breath.</td>
</tr>
</tbody>
</table>

Delsarte’s system for human expression, based as it is upon observation of human interaction as well as ancient art, provides a most intriguing basis for
systematising the movement of believable characters. Being systematic, it lends itself to a rule-based system – in fact, it was criticised as artificial and mechanical by some – and stands in need of further empirical testing to determine its overall validity. So while Stebbins concludes that understanding Delsarte’s metaphysics did not bring her commensurate reward, she finds that “Practical Delsartism” lays “the solid foundations of art in expression on which others can build in safety” (p. 398).

In order to evaluate Delsarte’s aesthetics, we will consider only what Stebbins called “Practical Delsartism”: Delsarte’s system of expression, “stripped of its theological dogmas and mystical drapery” (p. 399). This system provides several different laws for movement and posing that are supposed to correspond to certain personality traits and affect displays. In this study, I have implemented some of these poses and tested them with human observation to see if they are so.

2.4.1 Marsella’s evaluation

While a variety of research -- especially Ekman and Friesen’s work -- has focused on how emotion is conveyed in the face, Marsella et al. (2006) find the research undertaken for other parts of the body lacking. Using a multidisciplinary approach, they look to the field of acting, choreography, and rhetorical gesture and find the work of Delsarte. This leads to the essential question: “Are the interpretations that people derive from Delsarte’s catalogue of movements consistent with Delsarte’s analysis or at least reliable across observers?” To help isolate the problem, they choose to work specifically with the “attitudes of the
hand,” which Delsarte believed conveyed meaning according to where the palm rests within an imaginary cube. To keep contextual cues to a minimum, animators rendered the hand without text or sound: an un-textured body moves its hand or hands to the given position, using linear interpolation for simplicity.

Fifty participants viewed the animations and selected the meaning they thought it conveyed: the results were considerably consistent with the meaning Delsarte predicted. The study is hard to generalize to the rest of the body, or the rest of Delsarte's system, since it only focused on a single part of the body. Regardless, this study does provide insight into the validity of Delsarte's system and how trials with naive observers could test it by triangulating consistent reports. My study uses similar trials with observers to attempt to triangulate the consistency of their perceptions of the personality traits on display.
3: PREVIOUS WORK

In order to make progress, we must start with an understanding of the different disciplines that provide foundational knowledge to our pursuit of believable characters. This background chapter reviews existing projects that have implemented lifelike computer characters and provides an understanding of the overall context of this work. In adapting the character arts and their associated aesthetics to the animated behaviour of virtual characters, researchers created an agenda for believable character research. As per Loyall and Bates (1997) "'believable' is used in the sense of believable characters in the arts, meaning that a viewer or user can suspend their disbelief and feel that the agent is real." Developing these characters draws on various disciplines by combining the findings of the natural and social sciences with artificial intelligence approaches to controlling characters. The result is characters that display lifelike and goal-seeking behaviour.

It is also important to define what we are discussing. Badler et al. (2002) have quite rightly criticized the use without definition of the term believability. They focus on the psychological and say that a character is believable if “we can infer emotional or mental state by observing its behavior.” Janet Murray (1998) speaks of exercising a creative faculty, saying, “we do not suspend disbelief so much as we actively create belief” (p. 110). Behaviour is also important, and she notes that the “great advantage” of virtual environments is “their capacity to elicit
behavior that endows the imaginary objects with life… Our successful engagement with these enticing objects makes for a little feedback loop that urges us on to more engagement, which leads to more belief” (p. 112). In her vision, computers leverage their rule-based nature to create these “belief-creating virtual objects.”

Researchers have been interested in improving the behaviour of virtual humans for some time. Procedurally generating stories for interactive narrative was an early research agenda. Within these systems, characters acted based on their role in a high-level story. Eventually, characters came to ‘take on a life of their own’ and importance shifted from performing a given role in a story, to displaying an engaging portrayal of a believable character. Some projects focus on improving the artificial intelligence routines of characters to make them more realistic goal seekers; others focus on specific elements of behaviour such as gaze, nonverbal behaviour, or emotional displays. This demonstrates that there is at present no clear best approach to the creation of believable characters and many possible inspirations are worth evaluating. Martinho and Paiva (2006) put it this way: “the quest for believability has sent researchers on two different paths: a pragmatically approach inspired in Arts such as drama and character animation, and another that strives for higher levels of autonomy by providing the synthetic creation with biologically plausible or psychologically sound behaviour. Both paths emphasize the concept of believability as a dimension of synthetic performance closely related to the adequate expression of emotion.”
Hayes-Roth (1998) lays out what an arts-based agenda looks like. Her motivation stems from traditional artistic goals, namely joy, rapture, and enlightenment. Furthermore, she focuses on the importance of characters to their story, and quotes Chuck Jones to say that believability and illusion of life within characters are the goals. She provides seven principles for authoring systems:

1) The participant should be immersed in a first-person experience;

2) A skilful author should create a dramatic arc for the participant to follow;

3) Participant interactions should be meaningful based on the course of events in the story world;

4) The story world should be densely populated by autonomous and semi-autonomous characters to permit many interactions;

5) Sometimes the participant should initiate events, but other characters should sometimes show initiative and offer, suggest, and demand interactions;

6) The participant's choices should feed forward in shaping the story;

7) An adaptive story master should monitor and orchestrate the story experience by modulating the behaviour of the other characters.

These very directed principles are dramatically different from more computational solutions. They capture the value of human artistic input across a broad range of possibilities in order to create an enjoyable experience. While this uses “puppeteering” as a solution to creating expressive characters rather than using procedural methods which give up that kind of control. This provides a vital reminder of the artistic value placed on authorship and choice.
3.1 Animation Techniques

This section includes a description of procedural animation and game techniques for animating characters.

3.1.1 Interactivity and animation

It is important to understand the difference animating for interactive environments such as games and linear animation for films. Tomlinson (2005) locates the differences between linear and interactive works along five axes: intelligence, emotional expressiveness, navigation collision avoidance, transitions, and multi-character interaction. In order, these require animators to specify suites of behaviour to deal with visible decision-making, feelings, the intersection of two characters while moving, the smooth look of animations in between specific states, and those complicated sets of actions such as a fistfight or a romantic scene.

Tomlinson (2005) produced a summary of the five major differences between linear and interactive animation, as shown in Table 3.

<table>
<thead>
<tr>
<th>Topic</th>
<th>Linear animation</th>
<th>Interactive animation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intelligence</td>
<td>The intelligence and behaviour of characters are determined by screenwriters,</td>
<td>The intelligence and behaviour of characters are generated by a computer program in real time</td>
</tr>
<tr>
<td></td>
<td>storyboarders, and animators prior to the audience experiencing the work</td>
<td></td>
</tr>
<tr>
<td>Emotional expressiveness</td>
<td>Animator controls emotional state exhibited by characters in each shot. Each</td>
<td>Animator creates dynamic emotional ranges explored during game play based on a range of factors. Emotions may be layered on top of actions, and controlled independently.</td>
</tr>
<tr>
<td></td>
<td>action a character takes is inextricably tied to an</td>
<td></td>
</tr>
<tr>
<td></td>
<td>emotion.</td>
<td></td>
</tr>
<tr>
<td>--------------------------</td>
<td>--------------------------------------------------------------------------</td>
<td>------------------------------------------------------------------</td>
</tr>
<tr>
<td>Navigation collision avoidance</td>
<td>Characters only run into things when the animator wants them to.</td>
<td>Characters may accidentally collide with others and with objects in their world. Characters need a mechanism for avoiding collisions dynamically and coping if they occur.</td>
</tr>
<tr>
<td>Transitions</td>
<td>Since sequence of events is fixed, transitions between small chunks of animation are controlled by the animator, and may be long or short.</td>
<td>Since the sequence of events is variable, cycles must be kept short or they cause a character to take too long to switch to a different action. (If this is solved by animations not running to completion, characters may exhibit discontinuous motion.)</td>
</tr>
<tr>
<td>Multi-character interaction</td>
<td>Two characters may be animated simultaneously.</td>
<td>Enabling two characters to robustly engage in expressive close contact (fighting, affection, etc.) is an unsolved problem.</td>
</tr>
</tbody>
</table>

The transition to interactive animation involves giving up a certain amount of authorial control, while gaining the ability to use interactive effects. This requires thinking through the situations the characters may encounter and providing animation for these eventualities. This shows the opportunity and complexity involved when procedural animation is introduced to the process. On the one hand, animators no longer have to produce transitions for each behaviour combination and variations for each emotion; on the other, they must produce rules that will do this for them.

Tomlinson provides the AlphaWolf interactive installation he worked on as a demonstration of how emotions can layer on top of action, blending together emotional styles on the fly to provide a continuous emotional range. This still requires the animators to produce different variations but allows them to smoothly transition when the characters interact. He also provides an argument that it is not clear that interactive characters need the same range of emotion that
linear characters do. He believes their core requirements are responsiveness and agency.

3.1.2 Interpolation synthesis

Wiley and Hahn (1997) recognize the difficulty that lies in creating computer-generated characters that display real-time, engaging interaction and realistic motion. They find traditional key framing animation too labour-intensive and not suited to the production of real time characters. Motion capture is more rapid, but still suffers from an overall lack of control. They also reject physical simulation approaches since they are difficult to use and control, and have large computational costs. They detail a technique for moving articulated figures called interpolation synthesis. This technique can be applied to a database of motions from any of these three origins. This also has the potential across networks, since after the initial transmission of the movement database, traffic is just parameters for motion specification.

One of the great advantages this kind of motion synthesis presents is the ability to produce arbitrary cycles and generate poses at different points in time. This greatly helps increase the realism associated with interactivity. It seems that very dense data such as that provided by incorporating motion capture is very important to the system as it stands. Since producing physically possible motions is not guaranteed, it is important to validate intermediate interpolation results. This demonstrates an approach that attempts to provide realism and controllability for real-time motion synthesis. Right now, it operates on a low
number of parameters to require less data, but advances in process technology could open up this technique in the future.

3.1.3 Encapsulated models

May (1998) expands the concept of an “object” and builds a foundation for computer animation systems that consist of representations that are more expressive. His enhanced definition includes the capability to represent procedurally defined and interrelated components. Since he found general purpose programming languages to be inefficient, he proposes a procedural animation language that is specialized for the production of photorealistic computer animation.

Within this system, animated objects are “encapsulated models” with an integrated set of dynamic attributes related to how they must be animated. This includes properties such as shape, motion, materials, light sources, cameras, and user interfaces. This seems to have benefits in terms of code interchange and reuse, it presents the obvious downside that sophisticated user tools are required to avoid the complications of programming animation sequence. Nevertheless, this points out the advantages that can be gained in adapting tools such as programming languages to make them more suitable.

3.1.4 Interactive control

Allowing a user full control over their avatar is called puppetry and is an attempt to leverage their intuitive sense of how they want to move and what gestures they want to make. Giving control over to a user is one way of providing
more agency to them, but also raises questions about what level the user’s control should be at, and what motor control primitives should they have access to.

Laszlo, van de Panne, and Fiume (2000) explore the challenges posed by providing real time control over the movements of a computer character. One issue is that while the controls used in many interactive simulations such as airplanes or automobiles are well defined, the interface between our intentions and muscle actions is complex and harder to understand.

Nonetheless, they propose techniques for building appropriate interfaces for interactively controlled, physically based, animated characters. They map the different actuated joints on a figure to input devices such as mice and keyboards using proportional-derivative controllers in order to allow the motion to be governed by physics. Some solutions for figures with multiple joints with many degrees of freedom of movement include using a continual input device (mouse) or designing a one-to-many mapping from input DOF to output DOF. This relies on symmetry and phase relationships between joints. In general, keys are assigned action semantics and the timing of keystrokes is used to control when actions happen.

Several drawbacks to this approach remain. Designing and learning these interfaces is quite difficult. Furthermore, the authors admit they are far from reproducing the nuanced dynamic motions of 3D human motions. They also feel that haptic devices may be useful interfaces in the future. Regardless of the input
device, they consider that nuanced performances may require years of training, just as in other arts.

3.2 Artificial Intelligence and ALife

3.2.1 Story Generation

The procedural generation of narrative arcs is a starting place for many research projects and set the background for believable character research as autonomous characters within narrative became possible. These approaches reveal the design tension between the goal of coherent narrative and the goal of creating human-like agents.

3.2.2 Augmented reality story engine

When it comes to procedural story generation, many designers have turned to the Russian formalist Vladimir Propp. His work "Morphology of the Folk Tale" (trans. 1968) contains generalized descriptions of the components of fairy tales, broken down into narrative functions. These generalized functions are then available for the generation of new stories. Grasbon and Braun (2001) propose an interactive system based on the work of Propp. His functions become plot abstractions in their system, ensuring that events critical to narrative coherence occur in a logical order by combining according to Propp’s rules.

Their story engine is “designed for a mixed reality scenario in which the user wanders through physical space while wearing augmented reality devices.” They distinguish their work from the very detailed level of Crawford's Erasmatron or Mateas and Stern's beat-based Façade world by using Propp's high level
morphological functions. Grasbon and Braun believe that the particular details of a narrative possesses great value, however, and do not believe that machines are able to create convincing details. For this reason, they have left generating content at scene level and below in the hands of a human author. This requires a great deal of work in the form of content creation and means that scenes cannot be generated on demand using the current system. This demonstrates how valuing particular kinds of authorship can limit the degree to which systems can incorporate procedural generation.

3.2.3 Director agents

In the master's thesis of Swartjes (2006), he describes the Virtual Storyteller project, which is a Multi Agent System that generates stories by simulating a virtual world in which Character Agents pursue their goals. Inspired by improvisational theatre and the Typewriter storytelling system, its architecture was composed of several sub-components: director, narrator, presenter, and characters. This system employs a formal ontology defined in OWL to lay the formal basis for knowledge representation and reasoning. While the semi-autonomous Character Agents have their own emotions, beliefs, and goals, the critical director component limits and influences the Characters in order to achieve coherence. Swartjes' own research extends this Director component in order to better control the plot and apply creativity in these story-changing decisions. This is well-directed research, since achieving cohesion and direction in an interesting fashion is so crucial to the development of stories. Furthermore, something must add those dilemmas that foil the best-laid plans of man and
agent and develop the narrative arc. This extended (and renamed) Plot Agent uses a form of “narrative mediation” to resolve the challenge posed by narrative coherence and character automation. These solutions include: generating events, influencing character perception, changing the setting, and suggesting goals to the characters. However, this new meta-level director still requires a set of goals to be given to the Plot Agent so that it has reasoning for the ways in which it will attempt to motivate the characters.

3.2.4 Player modelling

If most work is focused on the generation of story based on external goals (adherence to a story plan, etc.) “Interactive Storytelling: A Player Modelling Approach” (2007) by Thue et al. presents a distinctly player-centric approach. Their project is called PaSSAGE (Player-Specific Stories via Automatically Generated Events) and models each player to learn their style of play. They distinguish this from Seif El-Nasr’s Mirage project by modelling the player’s style of playing rather than the player’s character, prioritizing other goals (e.g. treasure acquisition, monster slaying) for players who demonstrate a disinterest in drama. The story generation system draws from a library of possible annotated events and keeps track of the choices players make at each branch in the story. Future events are then chosen according to the sum of their indicated preference. In order to maintain a “strong sense of story,” PaSSAGE groups encounters according to Joseph Campbells' Monomyth. Their criteria for success are whether players have more fun and have more agency when the game caters to their interests. According a user study of players using PaSSAGE (implemented
using the Aurora Neverwinter toolset from BioWare), there was a statistically significant correlation of both fun and agency to their adaptive approach. While user modelling seems like a worthwhile and relevant approach, multiplayer games present a unique tension, which may require some sort of balancing module to determine overall story choices. Furthermore, the fundamental tension between player priorities and the construction of overall story formation still seems significant, especially in light of authorial goals and the steep requirements of creating game assets.

3.2.5 Genetic models

Models of evolutionary programming, particularly genetic algorithms, have also influenced the animation of life. According to Ventrella (1995), “new computational techniques such as those practiced in the field of artificial life have begun to contribute techniques to the art of animation for the simulation of life”. He also describes the work of animators as that of refinement, using trial and error by bringing in different techniques and character aspects until they approve of the result. He states that the creative act is often evolutionary, involving evolutionary processes such as “bottom-up emergence, discovery, and serendipity” along with regular design schemes. This understanding helps drive his process of using genetic algorithms to evolve expressive and stylistic animated behaviour.
3.3 Multimodal Agents

The Nonverbal Behaviour section of Chapter 2 illustrates the importance of nonverbal behaviour to human communication. When we try to implement communicative agents, such as embodied conversation (chat) agents, it is important to communicate meaning in the many ways to which we are accustomed. This means using multiple channels for communication, often simultaneously – something we take for granted in human conversations. In order for agents to provide the illusion of life, they must communicate in the multitude of ways with which people are familiar.

In "Embodied Conversation: Integrating Face and Gesture into Automatic Spoken Dialogue Systems", Cassell (1999) makes an argument for linking nonverbal behaviour to dialogue. The essence of this is that normal human communication relies on gestures and so it is normal to us. Besides being “normal”, these gestures help to regulate conversations by providing cueing and turn taking. This leads her to believe that given a chance, humans will attribute ‘social responses, behaviours, and internal states to computers’: something we should encourage with realistic nonverbal behaviour so that user expectation is modulated away from the ‘scary’ computer.

While animators are quite capable of creating linear clips with characters that communicate across a variety of channels, these projects provide examples of how virtual characters can be adapted to do this procedurally while being interactive and responsive.
3.3.1 Generating movement based on invariant laws

In order to control character behaviour, it is important to be familiar with the laws that govern them. Motor control theory is one such explanation for how the physical body organizes itself. Gibert, Kamp, and Poirier (2004) detail how spatio-temporal invariants express general laws underlying the organization of motor control. They find that these laws are satisfied for many gestures, including goal-directed gestures such as pointing and repetitive cyclic gestures.

The laws that Gibert et al. describe as governing this movement include invariance of the velocity profile, Fitt’s law, and the Two-Third Power Law. The velocity profile mirrors the “slow in and out” law of animation by finding that multi-point movements produce bell-shapes. Fitt’s law shows that planar movements over a longer distance reach higher velocities. The Two-Third Power Law decomposes complex movements into smaller units based on velocity gain.

These findings can aid in the automatic animation of virtual characters. Gibert et al. describe how the standard animation technique of Inverse Kinematics can gain increased smoothness by using this law. The authors’ system demonstrates the use of a motor control theory for gesture generation and control of a hand-arm model. Their future work is to determine how expressiveness plays a part in motor control to allow for further parameterization of their system.

Determining how physical laws constraining the body can be incorporated into procedural animation systems is very important for implementing the realistic part of gesture and motion. With a better understanding of constraints and an
ability to parameterize motion that follows them, it becomes possible to allow for a greater range of expressiveness or stylized motion. Gibert et al. believe that a project such as the EMOTE system (Chi et al. 2000) could enhance its transitions between key-postures using invariant laws for interpolation. They believe that adhering more closely to physical body constraints would help improve the naturalness of how the Laban Effort parameter is implemented. These invariant laws therefore provide heuristics regarding certain parts of movement that procedural animation systems can take advantage of to achieve more natural movement.

### 3.3.2 Artificial imperfections

In the 2006 paper “Human Computing, Virtual Humans and Artificial Imperfection,” Ruttkay, Reidsma and Nijholt make the case for endowing virtual humans with the imperfections common to humanity. They consider the question of what we value in “machine humans” -- the precision and deterministic behaviour of a machine, or the adaptable and engaging non-determinism of a human. Rutkay et al. find that it is essential to engage users by exhibiting a coherent personality and getting emotional as they show with examples of a virtual dancer and a virtual trainer. They believe human communications carries two elements that are important to replicate in virtual humans: subtleties that draw attention to our intentions, and imperfections that may be incorrect but demonstrate cognition and error-recovery.

Furthermore, Ruttkay et al. advance the privileging of nonverbal communication against what they see as a natural language privileging research
agenda. This also echoes McNeill’s theory about speech and gesture arising in common during utterance generation. As a result, they explore how different modalities are affected by imperfections. This includes how speech disfluencies and ambiguous wording signal indications of the virtual human’s cognitive and conversational state and attitudes; these can also be communicated (perhaps simultaneously) by irregularities in gaze and body posture. Ultimately, these exist alongside of cognitive imperfections that should be displayed, such as in the case of a chess opponent making a sub-optimal move.

Challenging the definition of what constitutes the appropriate behaviour for a communicative agent, and the meaning of (im)perfection, seems to create room for a research agenda beyond replicating normative human behaviour. After all, if much of our behaviour is suboptimal, shouldn’t virtual humans follow suit? This expanded research agenda could include the kinds of exaggeration and style that animators have applied since Disney. Determining how they could be integrated is part of the question I hope my study answers.

3.3.3 BodyChat

Vilhjálmssson and Cassell (1998) explore the importance of considering embodied conversational agents as more than presence markers in chat by revealing the credibility they can potentially contribute to communication. They propose a method to animate communicative behaviour, based on context analysis and discourse theory. This early project in the field was developed at a time when graphical chat clients were first emerging from text-only environments such as IRC, according to Vilhjálmssson and Cassell. As a result, “emoting” was
entirely manual and ignored many of the autonomous ways of communicating our bodies have.

BodyChat uses a Client-Server architecture to represent each user in a distributed virtual environment. Users are able to navigate their avatars using the cursor keys, give command parameters to their avatars with their mouse, and chat with other users. Command parameters include with whom they want to chat, and whether they are available to chat or whether they want to break off conversation. Figure 6 shows a BodyChat character and its environment.

![Figure 6: BodyChat](image)

While characters interact, the system generates two categories of behaviour: *conversational phenomena* that represent the avatar’s inner state and consist of various *communicative behaviours*. The mapping between these two is based on discourse theory but seems mostly generic best estimates of behaviour. They discuss the ambiguities of mapping indirectly when they refer to the tricky balance between autonomy and direct user control. Their concern is that an overly nuanced system could undermine a user’s intentions and
undermine reliability. This reveals a potential difficulty in making overt style choices in interactive environments: users may feel hindered or want to override it with their own choices. This balance between autonomous and purposeful motion seems tricky but very important.

3.3.4 Emotional agents

In "Integrating Models of Personality and Emotions into Lifelike Characters", André et al. (2000) describe the Presence project which “uses an internal model of the agent's ... affective state to guide the conversation dialogue between agent and user.” The lifelike agents in this project are used as infotainers and virtual receptionists to help visitors. It develops a high-level descriptive language for character description and combines computational models of personality and emotion with planning techniques to guide the characters. This system incorporates both the Five Factor Model for personality and the Cognitive Structure of Emotions models (OCC). The FFM provides a descriptive model that can be used to express those traits and they are focusing on extraversion, agreeableness, and neuroticism as the most applicable traits in social situations. The OCC model provides causation, so it will be used to determine characters responses to events. This model is then used in different projects to drive a custom output system for graphics or even the Microsoft Agent API system.
3.3.5 Articulated communicator

Wachsmuth and Kopp (2001) present their work on an articulator communicator in a paper entitled “Lifelike Gesture Synthesis and Timing for Conversational Agents.” Since responding to natural gestures and generating such gestures is such an important part of communication, implementing this within a virtual environment equally important. Their stated goals again demonstrate the difficulty of implementing multimodal communication:

1. To measure gestures as articulated hand and body movements in the context of speech

2. Interpreting them by way of classifying features and transducing them into symbolic meaning

3. Timing gestures in the context of speech

Within the system, gesture templates are constructed and then triggered during communication. Emphasis is given to the issue of “peak timing, that is to produce accented parts of the gesture stroke at precise points in time that can be synchronized with external events such as stressed syllables.” Their “articulator communicator” has a “kinematic skeleton of a highly articulated figure comprising 43 degrees of freedom in 29 joints for the main body and 20 DOF for each hand.” Their system uses a combination of key-framed animation and procedural animation that follows motor control theory to generate actions.
To control movements, this work introduces a gesture lexicon that provides abstract frame-based descriptions of gestures along with their communicative intent. The lexicon contains entries that define a mapping from communicative function to movement description. Figure 7 shows their articulated communicator following a template of instructions to make a pointing gesture. In co-verbal gestures, the most important part of the gesture is tightly coupled with the accompanying speech to enforce the meaning. The gesture unit provides successive rests for the limbs by enforcing preparation and retraction for the main part of the gesture phrase.

This work demonstrates how the framework for an embodied conversational agent can be constructed. It combines symbolic descriptions with an articulated virtual figure and synthesizes lifelike gestures as a result. Its design features also make allowances for adapting to the signal from a text-to-speech tool in order to achieve synchronicity. Its primary difference from other systems is conceptual: it takes an action from its gestionary and calculates an image of the movement by arranging constraints representing mandatory spatial and temporal features of the gesture. However, it relies on "common sense
knowledge” and spatiotemporal references so it also reveals the potential for using a psychological or aesthetic model for influencing how it moves.

3.3.6 The BEAT toolkit

Cassell, Vilhjálmsson, and Bickmore (2001) describe “BEAT: the Behavior Expression Animation Toolkit”, a system that allows animators to input typed text and produces synchronized nonverbal behaviours and synthesized speech. They identify the need to produce procedural animation for embodied conversational agents as interfaces to web content, animated non-player characters, and animated avatars in online chat environment. Their system therefore extracts linguistic and contextual information from the text to control the avatar gestures based on a mapping system derived from behavioural research.

The architecture of the system contains several modules that coordinate their efforts by passing XML tree representations of the text and behaviour. The modules, including language tagging, discourse model, knowledge base, behaviour generation, behaviour scheduling, and translator, reveal the complexity behind language synchronization. In particular, the behaviour generator module takes a tagged phrase and applies generator rules to provide appropriate behaviours. Potential conflicting gestures must be filtered out, as are redundant and unnatural gestures. Adding high quality rules to this generator module are particularly important in creating lifelike or stylized characters. In Figure 8, a BEAT toolkit character talks about typing. Many factors of expressivity and personality go into how the gesture will be formed.
Figure 8: A character talks about typing

BEAT provides an example of an animation tool that can take care of choosing and scheduling nonverbal behaviours while allowing the author to concentrate on other levels of concern such as personality or motion characteristics. However, as BEAT makes certain choices about communicating meaning, it does make a subtle influence on the aesthetics of the motion. As noted, it is at the behaviour generator level that gestures are proposed for selection. Creating this repertoire of gestures becomes critical in influencing what characters look like, and demonstrates that an overlaid control mechanism might be needed if choices need to be made between “regular” natural movements and “stylized” versions to avoid awkward mix-and-match effects. In the case of my work, this demonstrates how Delsarte’s system of expression will have to be integrated into natural and autonomic gestures to create cohesive characters.

Given the limitations inherent in using a lexicon of gesture shapes, or “estionary”, finding a way to generate gestures in real time is very useful. Tepper, Kopp, and Cassell (2004) rely on the study of spontaneous gesture and models of natural language generation to produce their computational
architecture. Their system uses a common pipeline architecture composed of content planning, microplanning and surface realization. Content planning requires a rich knowledge base of domain knowledge and organizes it into a rhetorically structured plan. Then, the grammar-based microplanner builds utterances using a greedy search algorithm. The last stage generates and executes planned behaviour using a graphical avatar’s body and synthetic speech. They have enhanced the BEAT system with a module for calculating required animations. This is instead of relying on static libraries of predefined motion elements (e.g. Cassell et al., 2001), or applying procedural animation to adjust them (Chi, Costa, Zhao & Badler, 2000) or combine them (e.g. Perlin & Golberg, 1996).

This important step in gesture generation leaves many open questions, such as the ways in which context can be interlinked with gesture, or how precisely a gesture needs to be specified to facilitate motor planning of the movement. Nonetheless, it is a promising step towards the future of procedurally generated character motion.

3.3.7 Greta

In their creation of an embodied conversational agent, Pelachaud and Bilvi (2003) describe the importance of the face not only for expression of emotion, but also for a variety of essential communicative functions. Their agent ‘Greta’ uses a taxonomy of communicative behaviour to guide its actions. These categories include information about beliefs, intentions, emotions, and even meta-cognitive actions such as thinking activities. To ensure portability, the facial
model is compliant with MPEG-4, and to ensure independence between the specification of facial expressions and the facial models they use an XML markup language called Affective Presentation Markup Language (APML) whose tags reflect the communicative functions they have identified. Table 4 provides an example of instructions that provides some brief small talk accompanied by meta information indicating what kind of statements are being made.

<table>
<thead>
<tr>
<th>Table 4: Example of APML instructions</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;APML&gt;</td>
</tr>
<tr>
<td>&lt;turn-allocation type=&quot;take turn&quot;&gt;</td>
</tr>
<tr>
<td>&lt;performative type=&quot;greet&quot;&gt;</td>
</tr>
<tr>
<td>Good Morning, Angela.</td>
</tr>
<tr>
<td>&lt;/performative&gt;</td>
</tr>
<tr>
<td>&lt;/turn-allocation&gt;</td>
</tr>
<tr>
<td>&lt;affective type=&quot;happy&quot;&gt;</td>
</tr>
<tr>
<td>It is so &lt;topic-comment type=&quot;comment&quot;&gt;wonderful&lt;/topic-comment&gt; to see you again.</td>
</tr>
<tr>
<td>&lt;/affective&gt;</td>
</tr>
<tr>
<td>&lt;certainty type=&quot;certain&quot;&gt;</td>
</tr>
<tr>
<td>I was &lt;topic-comment type=&quot;comment&quot;&gt;sure&lt;/topic-comment&gt; we would do so, one day!</td>
</tr>
<tr>
<td>&lt;/certainty&gt;</td>
</tr>
<tr>
<td>&lt;/APML&gt;</td>
</tr>
</tbody>
</table>

The Greta architecture consists of the following modules: APML Parser, Expr2Signal Converter, TTS Festival, Conflicts Resolver, Face Generator, and Viseme Generator. Once text is parsed, it is turned into facial signals, which are resolved for conflicts, and then converted into facial animation parameters for animation. The lips are separately and synchronously animated and speech is synthesis to go with the words. To help keep the facial expressions tightly synchronized, onset and offsets are provided for timing purposes.
Greta differs from other systems such as BEAT (Cassell et al. 2001) through the use of Belief Networks to resolve conflicts and create complex expressions. These networks include nodes for communicative functions, facial parts, performative dimensions, and emotion dimensions. This allows combinations such as ‘satisfaction’ and ‘certain’ by cutting off only parts of the conflicting signals. After this, the face is procedurally generated according to the appropriate facial animation parameters. The end result is a somewhat more sophisticated agent that demonstrates how belief networks can be used to manage conflicting emotions.

3.3.8 Style in gesture

While the various physical laws governing human movement can be explored, it is also important to determine the contribution made by style. Furthermore, it is also important to find a way to parameterize and control expressivity in agents. Noot and Ruttkay (2004) describe GESTYLE, a new XML markup language for controlling embodied conversational agents (ECAs). ECAs are virtual assistants for complex devices or systems. They could be used as expert systems to help guide a user through a difficult process, or they could introduce someone to an unfamiliar university campus. Since conversation is the primary goal of this kind of agent, it becomes important to support this goal with the meaningful use of gestures and body language. This work is representative of a number of projects that focus on developing markup languages to synchronize speech and gesture.
One way for controlling the actions of an ECA is the use of a markup language that annotates text to provide gestural and synchronization cues. GESTYLE provides these details with a focused theme of applying style to gesture. This approach relies on a thoroughly defined style dictionary with meaning mappings. A gesture dictionary then maps the marked up text with the chosen style. The result is a set of low-level parameters for use in a chosen animation system. Table 5 shows a relevant snippet from an example that Noot and Ruttkay (2004) provide of how text can be marked up in their system. In this case, there are cues about when the character will pause to think or point at his subject.

Table 5: GESTYLE markup example

```
<StyledText>
  <StyleDeclaration>
    <weighted elements>
      <style aspect="social status" dict="simple person" weight = "2"/>
      <style aspect="culture" dict="Brazilian" weight = "2"/>
      <style aspect="gender" dict ="male" weight="1"/>
    </weighted elements>
  </StyleDeclaration>
  <TextBody>
    <Meaning Name="sad">
      <Meaning Name="start_turn"> Well, </Meaning>
      <Meaning Name="thinking">I would like to live in a </Meaning>
      <Meaning Name="empasis"> hot </Meaning> country. I need the
      <Meaning Name="space">space, </Meaning> with
      <Meaning Name="wide_location_above"> blue skies, </Meaning>
      <Meaning Name="remembering">... that I can see
      <Meaning Name="point_location_above"> the sun </Meaning>
      every day,
    </Meaning>
  </TextBody>
</StyledText>
```
GESTYLE shows the complexity of using a markup language to define gestures. This system uses atomic basic gestures that can be combined into composite gestures by gesture expressions. At the next level of this hierarchy, meanings denote the communicative act that can be expressed by some gestures. Entries within style dictionaries provide the mapping between one or more gesture expressions and meaning. Style dictionaries are “at the core of GESTYLE” (Noot & Ruttkay, 2004). Table 6 shows an example of a style dictionary.

Table 6: Style dictionary example

```
<StyleDictionary Name = "extrovert">
  <Meaning Name = "emphasize" CombinationMode = "DOMINANT">
    <GestureSpec>
      <MannerDefinition intensity="intense"/>
      <UseGest Name="nod_and_beat"/>
      <UseGest Name="LookAtPerson"/>
      <Probability P="0.7"/>
    </GestureSpec>
    <GestureSpec>
      <MannerDefinition motion_manner="sudden_on"/>
      <UseGest Name="beat"/>
      <Probability P="0.3"/>
    </GestureSpec>
  </Meaning>
  <Meaning...
</StyleDictionary>
```
This defines a set of meanings that apply to an extrovert. It shows how an extroverted ECA would emphasize speech and make more eye contact. Weights within these dictionary help to provide priority in the case of an overlap.

GESTYLE also supports manner definition to encode characteristics of motion and modality usage specifying preferences on the part of an ECA. This allows you to control the shape and frequency of the gestures an ECA makes (smooth or angular, more or less hand gestures). The ECA finally has a style declaration, which is normally static but can change dynamically in certain situations. The example in Table 5 demonstrates a “Brazilian male” who is a “simple person.” This will affect the style dictionaries the ECA relies on.

GESTYLE also has a speech style component with a similar structure, which introduces another level for complexity for a potential author to create. The authors also recognize the difficulty of competing style dictionaries and of using probabilistic gesture generation. These levels of complexity seem inherent with a markup language approach and show the potential for good authoring tools to reduce some of this complexity. Furthermore, there has been an abundance of markup languages created, probably since there are so many ways to interpret body language.

3.3.9 SmartBody

SmartBody is an “open source modular framework for animating ECAs in real time, based on the notion of hierarchically connected animation controllers” (Thiebaux, Marsella, Marshall & Kallmann, 2008). The research goals it is
created around are the needs for a virtual human to be responsive, believable, and interpretable in social contexts. In order to combine the flexibility of procedural animation and the expressive power of motion capture and hand-animation, SmartBody can employ arbitrary animation algorithms. To further assist in the accessibility of this system, it is designed around the SAIBA framework and Behavior Markup Language (BML). This means that performance descriptions are encoded in BML and then transformed into character animation and synchronized audio.

The process of generating behaviour is realized by scheduling and blending multiple controllers, each of which uses specific methods for different body parts. These controllers are scheduled to work together by meta-controllers to create a workable pipeline for graphic generation. Some of the motion controllers include Post, KeyFrame, HeadTilt/Nod/Shake, StepTurn, and Gaze. Pose provides the base animation to which a character returns when it is at rest. KeyFrame controllers provide pre-defined poses that can be interpolated between. StepTurn uses a pre-defined animation of the lower body along with joint angles to complete a turn. Gaze is tuned procedurally. These are some examples of how different kinds of animation are combined to produce expressive characters.

SmartBody demonstrates a research effort that makes practical use of the “best tool for the job” approach to accomplish its goals. It makes use of motion generators that rely on simple primitives, which means that animators can leverage their artistry and create 3d characters in traditional ways. SmartBody
represents a system in which I could create interactive characters that use Delsarte’s system of expression in their communication. It is noncommittal as to how its BML instructions are generated, so a modular approach could work here.

3.4 Embedding Emotions and Style

In “The Role of Emotion in Believable Agents,” Bates (1994) takes cues from animators and argues that the realism of the work is dependant largely on the “agents’” ability to demonstrate true-to-life emotional responses. Their work uses a three-pronged method of showing emotional responses by defining the emotions clearly though a system of emotional classification, demonstrating a thought process to determine emotional state, and determining the appropriate timing and volume of the emotion to duplicate recognizable and realistic emotional responses. These three methods are integral parts of a computational system for representing emotions and the works covered in this section will demonstrate the variety of approaches that have been used.
Jon Gratch (2009) demonstrates the history of computational models of emotion in Figure 9. This shows how different psychological theories of emotion have led to a diversity of approaches to instantiate them computationally. These systems and the others I will describe in this chapter can also be categorized by how they dynamically adapt characters to display these emotions. First, characters have a graphical origin: either hand-created by animators, adapted from motion capture data of people, or procedurally created. Secondly, these graphics must be manipulated to create transitions between affect displays. The original method of animator keyframing and blending to produce entirely linear effects is no longer suitable, so the graphics must be changed procedurally. Of course, as demonstrated by Gratch’s diagram, each system still has an underlying system that it uses to provide expressivity – even if it is an ad-hoc, or
open, author-defined system. Table 7: Procedural animation systems demonstrates the variety of systems that this chapter will discuss.

Table 7: Procedural animation systems

<table>
<thead>
<tr>
<th>System</th>
<th>Researchers</th>
<th>Graphical System</th>
<th>Behaviour System</th>
</tr>
</thead>
<tbody>
<tr>
<td>IFace</td>
<td>DiPaola et al.</td>
<td>Mocap + Procedural</td>
<td>AB5C – personality</td>
</tr>
<tr>
<td>Emotional</td>
<td>Amaya et al.</td>
<td>Mocap deltas</td>
<td>n/a</td>
</tr>
<tr>
<td>Transforms</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Em</td>
<td>Reilly</td>
<td>n/a</td>
<td>OCC – emotion</td>
</tr>
<tr>
<td>Façade</td>
<td>Mateas &amp; Stern</td>
<td>Hybrid (Hand-animated + procedural)</td>
<td>ABL</td>
</tr>
<tr>
<td>EMA</td>
<td>Marsella &amp; Gratch</td>
<td>n/a</td>
<td>OCC - emotion</td>
</tr>
<tr>
<td>FearNot!</td>
<td>Aylett et al.</td>
<td>VICTEC synthetic characters</td>
<td>OCC – emotion</td>
</tr>
<tr>
<td>Improv</td>
<td>Perlin &amp; Goldberg</td>
<td>Procedural</td>
<td>Ad-hoc</td>
</tr>
<tr>
<td>Jack</td>
<td>Badler et al.</td>
<td>Procedural motion synthesis</td>
<td>Laban Motion Analysis</td>
</tr>
<tr>
<td>EMOTE</td>
<td>Chi et al.</td>
<td>Procedural from keyposes (Jack + LMA layer)</td>
<td>Laban Motion Analysis</td>
</tr>
</tbody>
</table>

3.4.1 Adapting improv acting techniques

Seif El-Nasr and Wei (2008) identify a gap between the developments of computer models within the AI field and their portrayal via computer graphics. They want to find an alternative to what they call the “current industry methods” for portraying character in interactive narratives: heavy scripting, voice acting, dialogue scripts, hand-coded animation and behaviour. Their goal is to identify nonverbal behaviour patterns (which they define as a list of two or more movements linked with specific timing and pacing constraints) and their relation to the essence of a character: their attributes parameters such as age, physique, personality, habits, etc. Since they consider the popular Five-Factor Model too
general, and previous trait models under-described, they turn to improvisational acting teacher Johnstone's “Fast-Food Stanislavsky,” a system which identifies several parameters of character representation. In order to test out the ability of artists to understand and implement this system, three animators were given a scenario describing an office firing, ten variations, and the appropriate digital props. They produced traditional keyframed clips that demonstrate the effects of different improv parameters on the scene.

Seif El-Nasr and Wei found “considerable consistency” in the portrayal of specific characters, which they believe indicates a coherent understanding of the attributes they were asked to portray. There were inconsistencies in some of the portrayals, particularly those whose instructions were framed in the jargon of improvisational acting. They also frame a number of lessons learned regarding animator interactions. For example, the animators frequently portrayed a trait by using character interaction, showing how they did not keep the characters separate and independent as the researchers did.

This work contributes much in terms of identifying the problem domain and progress made, while revealing how collaboration with animators could improve research projects. They identify the trend towards using very detailed motion-captured characters, and cite the examples of Assassins’ Creed, Prince of Persia (both from Unisoft), and Façade (Mateas and Stern) as games that rely on artists to diligently craft culturally and emotionally applicable body motion. This motivates my search for an aesthetic model that could drive the procedural generation of body movement. Furthermore, their method of working with
animators and testing character depiction provides examples for my work with animators. Their success with Jonestone’s scenario also motivated my use of the same basic scenario.

### 3.4.2 Personality models and parameterization

Zammitto, DiPaola and Arya (2008) provide another motivating example. According to their work, “strong human personality models exist but are not easy [sic] implemented within current gaming systems.” They believe the main obstacle to such implementation is a standardized way of tying “low level 3D movements to semantic gestures, through to emotion and time based personality sequences.” This work establishes the need for connections to be made between movement and semantic gesture, which is a current research goal.

They focus on developing a parameterized face system called iFace that can convey meaning while making it easy to generate many unique faces. Its basis for facial patterns is motion capture data from live actors. This data is divided into feature points that are rendered using MP4 and modified using mesh vertices. Its psychological basis is two components: mood and personality. Personality is defined, while mood can change and temporarily overwrite the personality. A variety of visual cues for personality are described, which are added into speech. In order to control speech, a new markup language for facial animation, Face Modelling Language, is defined. The ability to create many unique and expressive faces has applications in producing believable characters that preserve expressivity.
iFace is a system that works from motion capture and creates variations based on parameters. After this, dynamic changes are introduced depending on personality and mood. These procedural changes work from a list of possible connections, which they are using research to help improve. Developing the quality of these connections will help improve both the quality and quantity of expressions that are possible. The parameterization approach also represents a flexibility that allows for stylized or naturalistic motion, which also helps increase the number of systems that could use it.

3.4.3 Emotional transforms of mocap data

Another way to look at adapting animation to the display of emotion is to use a system of “emotional transforms” as proposed by Amaya, Bruderlin, and Calvert (1996). Their approach “modifies existing animation data of articulated figures and therefore makes the use of motion capture, procedural, physical-based and keyframe techniques more meaningful and useful.” First, human participants embody different emotions and the results are motion-captured. Then, for each emotion, an emotional transform is calculated using the “difference” between it and the neutral movement. This emotional transform is then applied to new neutral movements. The authors used signal processing techniques to analyze the emotional motions demonstrated two main axis of difference: speed (timing) and spatial amplitude (range). To determine the accuracy of their transforms, they compared the results to the actual motion captured examples of each emotion. The results were successful and seem promising for facilitating the reuse and adaptation of existing motion libraries.
However, authors admit that the large unknown is how well this can be extended to personalities across ages, cultures and genders.

### 3.4.4 The Oz project

The Oz project demonstrates how researchers at one institute can collaborate their research efforts over time to improve the quality of believable characters. This work starts with adaptations of theoretical models that will help motivate the actions and expressions of agents that are later built on top of this framework.

Reilly and Bates (1994) present a logical method of determining a “broad agent’s” emotional range. The resulting emotional system is called Em and is based on the OCC cognitive model of appraisal. This means that agents develop emotional responses based on events that occur around them. By integrating emotional responses and the environment, they have created predictable emotional outcomes through "sense-think-act" cycles of evaluation. Every action or lack of action must have an emotional response, whether it is from their Em "sense-think-act" model or from the Hap "goal tree of ... current active goals."

The emotions of an agent are also tightly linked to the goals they have been assigned. For example, if an agent was assigned the goal of being hungry and placed in an environment where food was accessible, the agent would be pleased; if the agent was placed in an environment where food was scarce, they would be displeased. However, their goals only make sense in an environment that has appropriate characteristics. If the environment has nothing integrated
regarding the quantity or accessibility of food, the goal is moot because there is nothing for the agent to react to. They have also integrated a system of emotional "decay" as well as emotional caps so that satisfaction levels can drop as time progresses to safeguard against stockpiling positive emotions to balance negative emotions. As well, they have created an integration of personality traits that affect the reactions of an agent. One of example is passivity/aggressiveness. This also ties into the social awareness of an agent, which creates expectations for the agents that they can follow or challenge depending on their personality.

Em and Hap provide examples of the "heart and brains" of a believable character. They take a psychological model of emotion and personality, and adapt them into methods of goal-seeking and expressive communication. As a result, they indicate no particular graphic output system or method for synchronizing speech. Instead, other systems rely on them, or their own version of them, to motivate their characters.

Loyall's doctoral dissertation (1997) comes out of his work within the Oz project, and is on the topics of believability, agent architecture, and natural language generation. By drawing on believability principles in the character-based arts, Loyall builds the case for the design decisions he makes about his agent system, as well as the need for speech generation. He wants to make language generation more realistic because "action and language are used together to accomplish communication goals and language generation occurs in parallel with other goals such as perception and action." This theme of parallel goal seeking is
important to Loyall’s dissertation, and demonstrates the animation principle of secondary action among others.

The Hap architecture he presents supports an artistically chosen personality and emotional expression, automatic control of real-time interactive animation, and pattern-recognition ability. His work on natural language generation is less developed. It includes an analysis of requirements and an approach to a solution by integrating natural language generation within Hap.

Apart from the specific details on how to build an agent architecture, which provide a well-developed groundwork for understanding the problem and creating one’s own system, some of the more interesting insights come from the lessons Loyall shares. He has come to believe that some of the traditional computer science conventions do not help with the problem of believable agents: namely, generalizable solutions (which undermine artistic uniqueness of expression), modularity (which treats speech, graphics, behaviour as separate systems), and the tendency to build high-level tools (which undermines the ability of artists to create). Since Loyall rejects a high-level approach, Hap contains a specification language that is used to provide instructions for each agent. While he is specifically aware of the traditional difficulties for artists to learn programming languages and simplifies Hap to accommodate, learning this system would remain the most difficult task. Nonetheless, Hap remains an innovative and groundbreaking instance of a virtual human system, while presenting a compelling argument for its design basis in the character-based arts.
In Loyall's work, he develops a useful definition of believability which demonstrates the variety of disciplines that come to bear on this nominally computational problem: believable agents must concurrently pursue parallel actions, be appropriately reactive and responsive, be situated, be resource bounded, exist in a social context, be broadly capable, and have well integrated modes of communication.

These criteria for believability in believable agents provide a guideline for creating character control systems. This outlines the requirements for procedural systems with which I might want to integrate Delsarte's system. In particular, it demonstrates the importance of personality and emotion as ingredients into the composition of believability. This means that if Delsarte's system produces characters that convey these traits better, they can be said to be more believable. These requirements provide the confidence that the reliable display of emotion and personality traits is a vital part of believability and is worth exploring on its own merits. Table 8: Loyall’s requirements for believability outlines the breadth of these requirements.

<table>
<thead>
<tr>
<th>Requirements</th>
<th>Illusion of Life Sub-requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Personality</td>
<td>Appearance of Goals</td>
</tr>
<tr>
<td>Emotion</td>
<td>Concurrent pursuit of Goals</td>
</tr>
<tr>
<td>Self Motivation</td>
<td>Parallel Action</td>
</tr>
<tr>
<td>Change</td>
<td>Reactive and Responsive</td>
</tr>
<tr>
<td>Social relationships</td>
<td>Situated</td>
</tr>
<tr>
<td>Consistency</td>
<td>Resource Bounded – body and mind</td>
</tr>
<tr>
<td>Illusion of Life</td>
<td>Exist in a Social context</td>
</tr>
<tr>
<td></td>
<td>Broadly Capable</td>
</tr>
<tr>
<td></td>
<td>Well integrated (capabilities and behaviors)</td>
</tr>
</tbody>
</table>
3.4.5 Façade

Mateas' 2002 PhD Dissertation “Interactive Drama, Art and Artificial Intelligence” describes the interactive drama system called Façade. This system is based on the smallest unit of dramatic action, the dramatic beat. This is the unit of plot/character integration and consists of a short dialogue exchange or a small amount of physical action. The architecture also includes ABL (A Behaviour Language), a reactive language for authoring characters based on Hap. A drama manager with its own language for authoring declarative knowledge and a runtime system that dynamically sequences beats is also included. Mateas creates a theory of Neo-Aristotelian narrative poetics that integrates player agency and drives the plotting of the story within Façade.

Façade’s character animation is achieved through a mixture of procedural animation and layered keyframe animation data. It uses a simple scripting language to sequence together individual frames of keyframe body animation, and annotate pre-recorded lines of audio dialog with lip sync, timing and emphasis cues (p. 12). This demonstrates a practical hybrid approach to providing expressive characters.

In “Procedural Authorship: A Case-Study Of the Interactive Drama Façade”, Mateas and Stern (2005) review their Façade system and describe the tension between interactivity and procedural content. In their system, the tension is between well-structured plot and agency. The solution presented by Façade is to “recast” player interactions in terms of abstract “social games.” These
procedural games lead to event variability and player agency. They also reveal a critical change in role for the author:

As the granularity of the atomic pieces of story content (e.g. dialog, emotion and gestural expression) becomes very small, and the procedures to sequence and combine them into a coherent narrative performance become primary to the realization of the experience for the player, the author’s activity shifts from that of a writer of prose into a writer of procedures, that is, into becoming a programmer.

The creator of any procedural system experiences this. It is reflected in how the animator’s role changes in the transition between traditional and interactive animation (Tomlinson, 2005). This transition to rule-based systems leverages the power of computers and explains the need for good psychological models but also creates the need for different ways of thinking about authorship. As a result, Façade makes a powerful argument for the importance of procedural content creation and its potential for resolving the tensions caused by interactivity.

3.4.6 EMA

Marsella and Gratch (2009) describe a model for agent emotions based on appraisal theory, which they call EMA (Emotion and Adaptation). Since emotions are inherently dynamic and “linked to both the world’s dynamics and the dynamics of the individual’s physiological, cognitive and behavioural processes” they identify capturing this as a key challenge of any theory of emotion. They recognize that creating a computational model is a “powerful approach to concretizing and exploring the dynamic properties of appraisal” since it forces specific commitments about relationships and how appraisals are
performed. In turn, EMA is used as the emotional basis for other projects (see 3.4.7 FearNot!) and demonstrates how emotional models such as OCC can be transformed into computational models.

The Soar cognitive architecture provides the basis for this system, and each agent is given an explicit representation of its beliefs, desires, intentions, plans, and probabilities to allow for fast appraisal processes. These can change dynamically with observation or inferences about events. Each event that occurs in the environment is evaluated across a number of categories, including: perspective, desirability, likelihood, causal attribution, temporal status, controllability, and changeability. Each appraised event maps to an emotion instance with a certain intensity following a structural scheme. For example, if an agent is faced with certain damage that will make it unhealthy, this will cause it to feel anger or fear depending on whether it can control or change the outcome.

Agents also receive coping strategies for dealing with their emotions, including taking actions, planning, seeking support, procrastinating, positive reinterpretation, acceptance, denial, mental disengagement, shifting blame, and seeking or suppressing information. These coping strategies affect the category-based appraisal of an event and therefore change the produced emotion.

Marsella and Gratch provide a strong argument for the value of creating computational models for emotional processes. Their implementation also demonstrates the complexity that arises, but also the strength of handling these appraisals computationally. This is a foundational example of how adapting a psychological model for computational use can provide value to both disciplines
involved as specific commitments are made and obstacles are faced and overcome.

3.4.7 FearNot!

FearNot! is described by Aylett, Vala, Sequeira and Paiva (2007) as a story-telling application in the domain of education against bullying. This system prioritizes believability as a means for engaging its child audience in discussion of various responses to bullying. It is composed of dramatic episodes generated by the bullying behaviour of one of its characters against another. Between episodes, the victimized character seeks advice from the child user, who enters free-text input. This leads to changes in the character’s internal state.

The character agents are based on an emotion-driven architecture, FAtiMA, which uses OCC-based cognitive appraisal combined with coping behaviour. Within specific episodes, stories emerge from character interaction, producing an emergent narrative. A narrative facilitator agent sets up the episodes by choosing and placing the characters. This demonstrates some of the possibilities presented by basing a system purely around characters, with only minor involvement from a top-level director agent. The result seems to be more psychologically sound characters, but less coherent narrative.

3.4.8 Improv

Perlin and Goldberg (1996) present Improv, a system for scripting real-time behaviour-based animated actors. This system demonstrates how complex the agent approach to believable characters can be as it takes time and effort to
create scripts for behaviour and movement. It also demonstrates how a system can produce animations entirely procedurally. At the same time, however, it shows how without a consistent system for linking behaviours and style, personality must be handled in an entirely ad-hoc, author-defined way.

*Improv* contains two main subsystems: the first is an animation engine that uses procedural techniques to create layered, continuous motions with transitions. The animation engine relies on atomic actions that are defined. These can also be blended and layered procedurally to create smooth transitions. The second is a behaviour engine that enables authors to create rules governing actor communication and decision-making. These two correspond to “mind” and “body” and produce visible characters by sending their output to the Geometry sub-system.

*Figure 10: A deformable mesh allows procedural expression*

While the system for dictating possible actions is a “plain English” scripting system designed to be easy for non-programmers, authors must provide detailed specifications for each character, including degrees of freedom in order to facilitate interpolation via deforming meshes (see Figure 10). Authors must also define scripts for behaviour rules, including animation details down to the second and the behaviour or belief implications that may result. The use of decision rules
and randomization provides a degree of unpredictability to characters, as they inhabit an environment with many possible external triggers. *Improv* also uses an action buffering system to restrain character gestures and avoid graphical jerkiness or stuttering.

*Improv* provides an example of a system built around the constraints of procedural animation. Characters must be accompanied with details about how they can move and behaviour rules that guide how they *will* move. Animation and behaviour modules must be coordinated in order to provide smooth transitions. This system opts to avoid influencing the subtle nuances of behaviour by not providing it: artists creating characters in the system can define them with as stylized or realistic of motion as they desire.

### 3.4.9 Jack

Badler (1997) describes the University of Pennsylvania’s *Jack* system. The Jack figure has a “polygonal model with rigid segments and joint motions and limits accurate enough for ergonomics evaluations”. There is also a smooth body to help portray a visually appealing virtual human. In detailing developments in motion synthesis, Badler considers the relative merits of pre-stored and synthesized motions. While pre-stored motions are faster to execute and computationally safer, synthesis requires a reduced parameter set size and provides greater generality and extensibility. In order to parameterize *Jack*’s motion, they have implemented an interpretation of Laban’s effort notation, which characterizes the qualitative rather than the quantitative aspects of movement. The danger in synthesis is that natural-looking motions can be difficult to
produce, and failing to find a solution or providing a poor result is a distinct possibility. He concludes that building adequate human motion synthesis models is “wide open and complex”.

Badler also addresses the issue of interacting with your avatar. He identifies the possibilities as “direct sensor tracking (where each joint is driven by a corresponding sensor input), end effector tracking (where inverse kinematics or other behaviors generate the ‘missing’ joint data), or external invocation via menu, speech, or button selection of the actions (whether then synthesized or interpreted from pre-stored data)”. Badler promotes a language-centric view of action triggering and finds a requirement for agent architectures to include semantic interpretation of instructions and a “lower reactive level within the movement generators for generality and environmental context-sensitivity”. He presents a two level architecture built on Parallel Transition Networks following this requirement to execute parameterized scripts and optimize reactivity to the environment. This architecture allows experimentation with the generation of appropriate gestural responses, appropriate visual attention, locomotion tasks, and multi-agent activity scheduling.

This project provides an example of the many design challenges faced in the creation of realistic virtual humans who must act somewhat autonomously in their environment and respond to human control. The issues with procedural motion synthesis and interactivity are only starting to be resolved and much work remains. Jack also has no built-in aesthetic guidelines, so only human figure constraints and human control guide his movements.
EMOTE

Chi et al. (2000) present a method for procedurally generating gestures, the EMOTE (Expressive MOTion Engine) 3D character animation system. This system is based on Laban Movement Analysis (LMA), which is an artistic system of expression that developed from Rudolf Laban’s study of movement. As LMA has evolved, it has been applied in many different fields, according to Chi et al. Within this system are five major components, Body, Space, Shape, Effort, and Relationship, and EMOTE encapsulates the Effort and Shape components. These components provide a way of describing and notating movement, and can be adopted to parameterize motion. The LMA provides a theoretical framework for defining the duration, flow, direction and strength of various motions and the causes of them. EMOTE uses gestures across McNeill’s categories (1992), ranging from gestures made spontaneously during speech to 'emblems' with culturally understood meanings.

The EMOTE system, based on the Jack flexible human body model, provides a parameterized implementation that attempts to build on the LMA so that it has a consistent basis for translating emotion into action. In order to produce gestures, underlying movements are specified through key time and pose information defined for the arms and torso. This can be extracted from an external process such as a motion library, a procedurally generated motion, or motion captured from live performance. Regardless of the source, the EMOTE parameters are then used to vary the original performance.
As well as providing me with a parallel example of adopting an artistic system into a computational one, Chi et al. also provide an example of how to evaluate the output that results. By using “Certified Movement Analysts” trained in LMA, Chi et al. have access to well trained to provide motion capture. They also rely on CMAs to provide an expert review of the system in order to determine their success in capturing the principles of LMA. Specifically, four CMAs evaluated a video of animations and coded it to determine whether they recognized the LMA attributes as being present. This validated whether or not their behaviour system was capturing LMA appropriately.

This work shows how a parameterized character system can employ a nonverbal behavioural system (in this case, LMA) by modifying its algorithms and overcoming specific challenges associated with getting the motions working. EMOTE provides a very useful example of a believable character system built on an artistic system for expression through collaboration with trained artists. It also provides an example of how it can be evaluated after implementation. It also demonstrates how an artistic system can “produce a new layer in the motion control process in which expressiveness is represented by a small number of parameters” (Chi et al. 2000). This demonstrates the solution to bridging the gap between manually and procedurally animated characters that I am also researching.

A later review of the EMOTE project by Badler, Allbeck, Zhao, and Byun (2002) stresses the importance of their approach to believability through “coordinated and consistent expression of body movements in all possible
channels.” They cite studies showing that isolated expressions of emotion look artificial or insincere. Their examples are: arm gestures without facial expressions look odd (citing Chi et al. 2000), facial expressions with neutral gestures look artificial (citing Ananova), arm gestures without torso involvement look insincere (citing Badler et al. 2000), attempts at emotions in gait variations look funny without concomitant body and facial affect (citing Ashida et al., 2001), and otherwise carefully timed gestures and speech fail to register with gesture performance and facial expression (citing Cassell et al. 2001).

Their adoption of LMA into EMOTE provides the use of a relatively small number of parameters that control many aspects of manifest behaviour across the agent’s body in a consistent and reliable method. This model of parameterizing behaviour is very useful for an agent-based approach to the creation of virtual humans. Their conclusion that isolated expressions of emotion look odd motivates my holistic approach to testing Delsarte’s system of expression by working with animators to produce example clips.

3.4.11 A component-based approach

Martinho and Paiva (2006) show an approach to enhancing believability that complements other agent architectures for life-like characters. They tout the importance of anticipation for creating believable behaviour; surprise is given as a beneficial addition that results in these kinds of systems as opposed to purely reactive systems. Their approach attaches an anticipatory mechanism to each sensor called an “emotivector”. These are managed in a salience module. Besides surprise, anticipation can also help to focus attention and create
precursor emotional responses. This is an example of a modular approach to believability and the benefit that can be gained from implementing a “feature” possessed by regular humans.

Due to the number of elements that compose human expression, this approach makes sense. Demonstrating the importance of a particular factor – such as anticipation – to establishing believability creates the potential for helping other researchers without creating an entire system. Delsarte’s system of expression could similarly be implemented as a component that guides the procedural production of gestures.

3.5 Immersive Environments

In the introduction to this thesis, I invoked the vision of the holodeck as the future of believable characters. Some researchers share that vision and work with large-scale, physically-immerse virtual environments in order to see its effects. Cavazza (2000) describes their ongoing project as “the convergence of VR, cinema and computer games”. These projects demonstrate how many factors for establishing believability come together and require support in these novel systems.

3.5.1 Prototyping the ‘holodeck’

The CAVE-style immersive projection display involved in the system described by Cavazza (2000) allows a user to interact with a cast of virtual actors, and address them in natural language. Users can participate in story generation through “physical” interactions with virtual objects, through on-stage
conversations, or off-stage interjections. The narrative theory underlying this work is a refinement of Propp's narrative functions and relies on the branching points that Barthes called dispatchers – plot zones of risk where causality is at stake. AI planning drives virtual actor behaviour, influenced by participant interaction. Since physical presence becomes so important, the users are directed to be aware of how they interact with agents and how they enter and leave the stage.

The paper also lays out the importance of story telling as key to creating a believable world “in order to allow a human to be socially immerse and being able to understand this world.” They must also be social environments that support a user’s “social presence” since relationships between the agents and the human player is so important. Some basic social requirements for the agents are laid out:

1) The ability to recognize and identify other agents,

2) The ability to establish and memorise direct relationships with other agents

3) The ability to monitor and memorise third-party relationships that exist between other agents

The “Holodeck” also demonstrates the possibilities of a “story-in-actions” in conjunction with the normal “story-in-words.” Physical presence leads to social immersion that helps to reinforce believability for the player. The interactive story generation follows rules to create different sorts of causality: “physical causality”,

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“psychological causality”, and “narrative causality.” Following Raskin, causality is said to “serve the interest of the story” because it is “necessary for the coherence and inner logic of a story”.

### 3.5.2 Mission Rehearsal Exercise project

Swartout et al. (2001) present the Mission Rehearsal Exercise Project in “Toward the Holodeck: Integrating Graphics, Sound, Character, and Story”. An immersive system set-up with large screens and surround sound, the participant becomes a military officer undergoing an in-country stressful experience. At the heart of the system is the MRE StoryNet, a hybrid solution. It allows free-play within certain nodes of activity, while certain "hook" actions lead down links to other nodes. A Director agent that can take action at various control points to move the story along further manages this mix of linear and non-linear story elements.

This system provides an example of adopting a hybrid approach to controlling virtual humans. The characters are either: scripted with a limited range of behaviours, controlled by an AI reasoner, or controlled by a combination of an emotion model and AI reasoner. Speech generation was likewise either pre-recorded or dynamically produced using text-to-speech synthesis. The role of the character and the perceived requirements of believability for that character determine which system controls it. Visually, character bodies, heads, and scene models are stored as files for loading at run-time. This allows some flexibility in creating scenarios.
The Mission Rehearsal Exercise Project demonstrates a large-scale project that relies on motion capture and artist manipulation to create believable characters. As a result, expanding the number of available scenarios is limited by the possible recombination of existing models or the “expensive” addition of more models. This demonstrates the potential value for based character behaviour on the procedural generation of aesthetically coherent and meaningful gestures.
4: DESIGN METHODOLOGY

4.1 Introduction

I wanted to explore how well Delsarte’s system of expression would lend itself to the reliable creation of animated characters that portrayed emotions and personalities. In order to run the study to determine how reliably viewers can interpret these characters, clips of characters were produced for comparison purposes. First, I examined the written descriptions of Delsarte’s system by Shawn (1954) and Stebbins (1902/1977) and produced a model that guided my production of character poses. In order to constrain the number of poses required, I chose a simple scene from improvisational theatre. I then reviewed this work with experts in Delsarte’s system of acting and animation. After making appropriate changes, I forwarded the scene descriptions to the artists. After they completed their work, I uploaded their videos to YouTube for use in the decoding study.

4.2 The Process

Based on Delsarte’s rules and nine-fold divisions (see Chapter 2 for more details), I created a simplified process for deriving character poses. An iterative design process involving expert review led to the following:

1) Identify the corresponding meaning for the gesture.

This should be rooted in some combination of:
1. The agent's habitual bearing

2. The agent's emotional state

3. The agent's communicative intent

2) Decide whether the agent is expressing itself sincerely and the strength with which it should express it

If sincere: Start the movement from the centre and move towards the extremity [movement group]

If insincere: Start the movement from an extremity and move towards the centre

If strong: Move two body parts in opposition simultaneously

If weak (or stylized movement like dance): Move two body parts in the same direction simultaneously

3) Decide whether the agent is expressing itself positively or negatively.

The direction of motion should be as follows: Positive assertion expands, negative contracts.

4) Decide whether the agent is expressing passion, intellect, or the will and adapt the direction of the motion as follows:

- Passion = Lengths (directly toward/away from the audience)
- Intellect = Heights and depths (up and down in elevation)
- Breadths = will (side to side)
(Diagonals are conflicted)

5) If hand gestures are involved, consider the following:

(Remember that both starting and ending point modify the action)

Actions with an emotional or moral component should involve the torso

- If gesture seeks the chest, self-respect predominates
- If gesture seeks the heart-region, affection predominate
- If gesture seeks the abdomen, the appetites predominate

Actions with a mental or intellectual component should involve the head

- If hand seeks the chin, appetites and passions predominate
- If hand seeks forehead, mental instincts predominate
- If hand touches the cheeks, affections predominate

Actions with a physical or sensual component should involve the legs

6) Decide whether the nature of the motion is expansion or contraction or balanced: Excitement expands, thought contracts, love and affection moderate

   For each body part involved, determine which of the three predominates and which is secondary. Consult the Delsarte charts and notes for the given combination.
Table 9: Delsarte’s poses: legs (Stebbins)

<table>
<thead>
<tr>
<th>Motion</th>
<th>Description</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nor-Nor</td>
<td>Both legs strong and wide apart; standing in the breadths, knees straight</td>
<td>Condition of fatigue, vertigo, intoxication; sentiment of familiarity or vulgar boorishness</td>
</tr>
<tr>
<td>Con-Nor</td>
<td>Standing in the breadths; both legs are strong and together; knees straight and unbent, heels together, toes turned out</td>
<td>Condition of feebleness or sentiment of respect</td>
</tr>
<tr>
<td>Ex-Nor</td>
<td>Standing in the lengths; both legs are strong and apart, one directly in front of the other, knees are straight</td>
<td>Condition of indecision, sentiment of deliberation</td>
</tr>
<tr>
<td>Nor-Con</td>
<td>Standing in the lengths; the back leg is strong, the knee of that leg is straight; the forward leg is free, while its knee is bent, thus bringing the foot in front near to the foot behind</td>
<td>Calm strength, reserved force, reflection, controlled emotions</td>
</tr>
<tr>
<td>Con-Con</td>
<td>Standing in the lengths; the strong leg is back, its knee bent, the free leg is in front, the knee straight</td>
<td>Condition of prostration or sentiment of despondent passion</td>
</tr>
<tr>
<td>Ex-Con</td>
<td>Standing in the lengths; the strong leg is back, its knee straight; the free leg in front, the knee also straight</td>
<td>Condition of antagonism or the sentiment of defiance, irritation, self-assertion</td>
</tr>
<tr>
<td>Nor-Ex</td>
<td>Standing in the lengths; strong leg is in front. Weight entirely on forward leg Knee is straight, free leg is behind, knee bent, ball of the foot rests on the ground; the heel should be raised</td>
<td>Condition of vigor, animation, intention, or attention. sentiment of ardent or passional tendency; no introspection</td>
</tr>
<tr>
<td>Con-Ex</td>
<td>Standing in the breadths; the free leg is slightly in the rear of the strong leg; the knee of the strong leg is straight; the free knee is bent; the toe of the free leg is on a line with the instep-arch of the strong leg; the foot of the free leg is very much turned out; the heel of the free leg is raised a little from the ground, while the ball rests on the ground</td>
<td>Suspensive condition; neutral, transitive sentiments</td>
</tr>
</tbody>
</table>

Table 10: Delsarte’s poses: arms (Stebbins)

<table>
<thead>
<tr>
<th>Motion</th>
<th>Description</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nor-Nor</td>
<td>elbows bent and pressed to sides brings wrists to level of chest, hands fall limp</td>
<td>suspense of will in its attention or intention</td>
</tr>
</tbody>
</table>
### Table 11: Delsarte's poses: head (Stebbins)

<table>
<thead>
<tr>
<th>Motion</th>
<th>Description</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nor-Nor</td>
<td>head level between the shoulders</td>
<td>calm repose, indifference</td>
</tr>
<tr>
<td>Con-Nor</td>
<td>head leans toward object, must not be raised, depressed, or rotated</td>
<td>trust, tenderness, sympathy, affection, esteem from the soul</td>
</tr>
<tr>
<td>Ex-Nor</td>
<td>head leans from object, must not be raised, depressed, or rotated</td>
<td>distrust, esteem from the senses</td>
</tr>
<tr>
<td>Nor-Con</td>
<td>head sinks on chest midway between the shoulders</td>
<td>reflection, concentration, scrutiny, humility</td>
</tr>
<tr>
<td>Con-Con</td>
<td>head depressed and toward object, not rotated</td>
<td>humility plus trust and affection = veneration, adoration</td>
</tr>
<tr>
<td>Ex-Con</td>
<td>head depressed and from object, not rotated</td>
<td>scrutiny plus distrust = suspicion, hate, envy, jealousy</td>
</tr>
<tr>
<td>Nor-Ex</td>
<td>head thrown back midway between the shoulders</td>
<td>exaltation, explosion from self as centre, a lifting to the universal</td>
</tr>
<tr>
<td>Con-Ex</td>
<td>head thrown back and toward object</td>
<td>exaltation plus trust, abandonment plus trust = resignation or abandonment to sense or soul</td>
</tr>
</tbody>
</table>
4.3 The Scenario

The scenario for animation is set in an office environment with fixed
dialogue between two male characters (see Table 12: Simple scenario ). I chose
to use this scenario, because several authors have successfully used it to show
variations in nonverbal behaviours, including Seif El-Nasr and Wei (2008). The
scene describes the firing of an employee with a criminal record and was chosen
from Keith Johnstone's work (1987) with improvisational theatre. It provides a
simple scene with the ability to easily vary the character types involved. It
constrains a number of factors including the length of the exchange, the number
of actions that occur, and the personality traits and emotions on display.

Table 12: Simple scenario

<table>
<thead>
<tr>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>- Officer (male): Come in, Smith. Sit down. I suppose you know why I've sent for you?</td>
</tr>
<tr>
<td>- Smith (male): No, Sir.</td>
</tr>
<tr>
<td>[Officer slides a newspaper over to Smith.]</td>
</tr>
<tr>
<td>- Smith: I was hoping you wouldn’t see that.</td>
</tr>
<tr>
<td>- Officer: You know we can’t employ anyone with a criminal record.</td>
</tr>
<tr>
<td>- Smith: Won’t you reconsider?</td>
</tr>
<tr>
<td>- Officer: Good-bye, Smith.</td>
</tr>
<tr>
<td>- Smith: I never wanted your bloody job anyway. [Exit.]</td>
</tr>
</tbody>
</table>

While I want to evaluate the effectiveness of Delsarte's system in
conveying character traits such as emotion and personality, I want to avoid
confounding the impressions provided by the body language of the characters
with too much or overly obvious dialogue or an extended timeline. Because of
this, the emotional range and relevant personality traits on display will be smaller. I expect the emotions to range from boredom to contempt and disgust on the part of the boss to fear, guilt, shame, and anger on the part of the employee.

4.4 Scene Descriptions

To provide the animators with background information in a familiar format, I identified the personality traits I wanted the characters to show, and then described them in a short story about each character. After choosing the traits sociable, dominant, restrained, unsympathetic, tactful, and unexcitable, I provided this prose for the manager (see Appendix 2 and 3 for further details):

The Manager is a 45 year old man and works for a banking firm in Toronto in 2004. He is a white Anglo-Saxon protestant. He was raised in the Metro Toronto area, and after getting his MBA, he joined this firm where he was hired because his father’s friend is a Vice-President. He is married but doesn’t see his wife much during the week.

He’s benefited a lot from his family’s wealth and connections, but he feels that his success in the “dog-eat-dog world of finance” is due to his determination and sharp analytical ability and as a result, feels a lot of pride and accomplishment in his position.

The Manager has spent his life climbing the social and business ladder, and knows its politics very well. As a result, he smoothly handles social relationships to “get along with everyone.” To his subordinates, however, he is dominating and demanding. He worked hard to get where he is, and by golly, so will they!

He takes the long view in most things. Given time, he’ll be a Vice-President, and from there it’s only a few stock options to the Bahamas. Besides his underlings’ incompetence, nothing gets him very excited.

This incident barely registers on his daily schedule and it sits on his BlackBerry to-do list between setting up a bankruptcy auction and a
working lunch with his secretary. Smith might have made a nice new assistant, but now he’s headed for the Manager’s black-list.

For the second scene, I needed the animators to work from Delsarte’s system of expression. However, I could not expect them to learn such a detailed system in a reasonable length of time. As a result, I acted as animation director and provided the artists with line-by-line posing. This is an example of the manager’s movements:

Manager (male):

Legs: standing one leg in front of the other; the back leg is strong, the knee of that leg is straight; the forward leg is free, while its knee is bent, thus bringing the foot in front near to the foot behind

Arms: hanging from shoulders at side

Head: level between the shoulders

Gaze: straight ahead

Mouth: lips slightly parted

Manager: Come in, Smith. Sit down. I suppose you know why I’ve sent for you?

Legs: standing one leg in front of the other; the strong leg is back, its knee straight; the free leg in front, the knee also straight

Arms: hang full length in front of body

Head: turned away from Smith

Gaze: looking at Smith

Mouth: lips closely shut (when not speaking)
4.5 Expert Review

In order to help improve the faithfulness of my system to Delsarte’s ideas and the applicability of my instructions to animators, I communicated with Leslie Bishko, Associate Professor of Animation at the Emily Carr University of Art and Design, and Juilliard dance instructor Joe Williams. Joe is an experienced dancer who specializes in Delsarte’s system and has been providing seminars and workshops about it since 1997. The process I followed is displayed in Figure 11.

Figure 11: Expert review process
I communicated with Joe Williams after he reviewed my model for obtaining Delsarte poses, and he helped me understand Delsarte’s system and the relative importance of his laws. Leslie reviewed my instructions to the animators, including the Delsarte poses I chose.

I worked with Leslie Bishko first in the production of scene descriptions and instructions for the animators. Much of this process involved developing better filters between technical psychology and Delsarte language and a format understandable to animators. This led to the development of character backgrounds and history as a way of encoding the desired characters traits. I then updated the language used to describe Delsarte’s poses: for example, I changed “decomposed” to relaxed and changed the stage directions “lengths and breadths” so they related to the characters’ motions. Her evaluation also helped me realize the importance of gaze and focus in the Delsarte descriptions.

In order to confirm that I was implementing Delsarte’s system with validity, Leslie advised that I contact Joe Williams. He reviewed my Delsarte poses and we discussed what it means to follow the Delsarte system. This led to subtle improvements to my model for posing characters. He noted the importance of following the Law of Extension (Magnitude) whereby it takes passion to overcome restraint and reach extremes. Even after taking this into account, a review of the final animations reveals that the animators interpreted the poses relatively extremely, and the final poses show abrupt transitions as a result. Joe helped me to understand the nature of Delsarte’s main three principles of motion (excentric, concentric and normal) and how they relate to actual motion and
Delsarte’s other laws. This contact with an actual expert in dancing according to Delsarte’s system provided me with important examples of movement and a disciple’s vision for implementing his system.

4.6 The Animators

I recruited the animators who produced work for this study via industry and academic contacts. The two animators were of different skills levels: one had newly finished a design school credential and had previous personal experience with animation; the other works for a video game company and thus had industry experience producing characters in that context. The first animator described their style as heavily influenced by Disney’s style of cartoon animation and preferred doing work for audiences of children. The second was more influenced by his work experience with video games. Throughout the work, the first animator will be called Animator1 and the second animator will be called Animator2.

The animators were paid $450 for producing this work for me.

4.7 The Process

I met with the animators to describe the project and answer questions. I was also available via phone and email. At the beginning, I described the first stage as using their own intuition after reading the character backgrounds and dialogue. I initially described the second stage as requiring them to “follow specific instructions” without mentioning the specifics or Delsarte. The animators were directed to a specific basic character model to use in the study and were given a set of models and textures for the office room.
I made this restriction to a simple character model to help constrain the set of body parts for animation. For example, Delsarte's system for eyeball, eyelid and eyebrow movement was omitted in favour of simple gaze since it seems likely that such specific, small areas of the body would have to be studied by themselves in order to make any claims about their contribution. As well, the amount of extra work required to animate such small, specific parts would have required too much time and effort on the part of the animators. This also follows a similar level of attention as displayed by Badler, Allbeck, Zhao, and Byun (2002) in the EMOTE project, where their main focus is the arms and torso, facial expressions, and eye movements. They show the importance of working at the higher level of holistic body movement: since we are used to seeing coordinated displays of emotion, it becomes unusual to see them isolated and studies have found the effects range from artificial, to “wrong”, to insincere.

After completing the first stage of the process, I was in contact with the animators to provide them with the Delsarte version of the scene. This included specific poses as described previously and as seen in Appendix 1. I also provided a brief description of Delsarte and some of the extant hand-drawn examples of his poses.

Once both stages were completed, I asked the animators about their experience and personal approach to animation.
4.8 Final Product

The finished videos were rendered from the 3dMax software where they were created and provided in 640x480 QuickTime MOV files. These files were then uploaded to YouTube. They are available on my YouTube Channel at http://www.youtube.com/meinleapen.

4.8.1 Bodies

Animator1’s videos use the untextured “Max” body for both characters. The untextured body is a free rig available for either 3dMax or Maya at http://www.11secondclub.com/resources/max_for_maya/ or http://www.11secondclub.com/resources/max_and_lowmax/

Figure 12: Untextured 3dMax figures in Animator1’s animation
Animator2 decided to use a different cartoon rig called Sergio for the Manager. This character is a barrel-chested man wearing a visor. Smith is animated using the untextured “Max” body. These animations were produced in Maya.

Figure 13: Animator2’s Manager character

“Good-bye, Smith.”
4.8.2 Camera

Animator1’s videos do not move the camera throughout. The camera angle is almost side-on to both characters, but it rotated slightly so more of Smith’s face is visible, and the Manager’s back is towards the camera more often.

Figure 14: Animator1’s intuitive version

Animator2’s videos make use of dynamic camera angles and the two characters are never in view at the same time. The camera is also in motion, and pushes in and pulls out on the character in view.

4.8.3 “Delsarte” versions

Comparing Animator1’s two versions shows one of the common changes that marked both artists’ interpretations. The Delsarte poses described extreme
extensions of the body and the resulting poses created some dramatic transitions between stances that did not flow as naturally as their intuitive approach. On the other hand, it did help to create more involvement in limbs such as the legs where the stances of the two characters parallel each other.

Figure 15: Animator1’s Delsarte version

In Animator2’s work, the characters are more often in motion and the camera always is, giving the work a dynamic feel. In this example, the Delsarte version provides Smith with the body language of defiance rather than accusation.
Figure 16: Animator2’s intuitive Smith

“I never wanted your bloody job anyway.”

Figure 17: Animator2’s Delsarte Smith

“I never wanted your bloody job anyway.”
Unfortunately, the final rendering added some strange artefacts to one section of the Delsarte version of the manager. In this case, hardware rendering has left the wire frame of the view frame and camera in part of the scene.

Figure 18: Rendering artefacts
5: STUDY AND RESULTS

5.1 Study Overview

This study explores the reliability of the Delsarte system of expression to portray personality traits and emotions in animated characters. Such a system would be useful to game designers seeking to implement believable characters, particularly those using procedural animation techniques. Furthermore, it is valuable to examine how we can adapt models from the arts into the computational world. This research uses the research method employed by Marsella et al. (2006) as they pursued the goal of determining whether “the interpretations that people derive from Delsarte’s catalogue of movements [are] consistent with Delsarte’s analysis or at least reliable across observers?” This method maps to what Argyle (1975) refers to as a decoding experiment wherein participants’ perceptions about personality are recorded using multiple scales (p. 14).

This research was designed as a two-phase, sequential, mixed-methods approach. The first stage is described in the previous chapter and led to the production of animation clips. The first phase was a qualitative exploration of how to implement Delsarte’s system of expression using animated characters. Through interviews with certain experts, portions of a model for doing this were improved and finally used to produce the animation of a standard improvisational scenario by a number of animators. This iterative review helps me to be confident that I am adapting Delsarte’s system properly.
The second phase is the decoding stage, wherein participants watch the animations and rate the characters’ personality traits. In order to provide a baseline for comparison, the animators first produced a clip based on their intuitive understanding of the character descriptions. In this quantitative phase of the study, naive participants evaluate the characters involved in these scenarios. The differences in how participants rate the characters provide an estimate of the contribution of Delsarte’s system.

Participants accessed the survey using their web browser at the URL they were provided with and completed the survey.

5.1.1 Hypothesis

The overall hypothesis for this study is that the animated characters produced based on Delsarte’s system of expression will receive similar and more consistent ratings among observers than those produced “naively” by the animators. This meant that I expected to see the Delsarte versions of the videos produce similar mean ratings and have less dispersion in their ratings.

The particular statistical test that I did used a “two tailed” approach that explored differences in either direction, so a formal null hypothesis describing these two elements would be written as:

\[ H_0 = \text{there is no difference between the mean ratings for characters animated using the animators’ naïve interpretation versus the animators using the Delsarte style of expression} \]
H₀ = there is no difference between the dispersion in the mean ratings for characters animated using the animators' naïve interpretation versus the animators using the Delsarte style of expression.

5.2 Participants

I obtained participants through two different convenience methods. Firstly, I recruited undergraduates in the School of Interactive Arts and Technology (SIAT) undergraduate classes. Secondly, I used the SIAT graduate student email list and my Facebook contacts to recruit participants. One characteristic of students shared by both the undergraduate and graduate level of SIAT is a familiarity with new media and design principles. As a result, the main desirable characteristic of being familiar with animated characters through movies and video games is likely to be possessed.

Participants in this study were volunteer respondents, however, the undergraduate students received a token of additional 2% credit in their classes for completing the surveys. My primary goal was to obtain a constrained age group with similar characteristics of media awareness. While this is a form of convenience sampling, I expect that the participants are representative of a general audience of young adults who are familiar with video games and animated characters. However, any cultural influences on interpretation will be hard to detect by this study, which was not set up to detect or analyze those kinds of interpretative differences.
I received 124 responses to the survey, however, of them, only 94 completed ratings for at least one video. Of all the participants, 53% were male, 37% were female, and 10% did not reply to the gender question. The majority were in their twenties: 69% were aged 20-24, 18% were aged 25-29. Almost half of the participants, 48%, indicated they were taking Dr. Magy Seif El-Nasr’s SIAT undergraduate classes and thus would receive credit for the study. All of these respondents would go on to provide answers for each video.

5.3 Instrument

I used a survey method for collecting observations, since I wanted to collect the data in a highly structured and efficient way, similarly across observers. Since observing the videos was the only requirement of the study, it made sense to make it accessible across the Internet to increase the number of people who could access it without coming in to a lab setting. The use of automation has also been noted (Martin, 1991, p. 81) to help reduce demand characteristics and help participants feel less pressure. Questionnaires have historically been useful for measuring attitude and opinion, in particular using Likert or semantic differential scales similar to the ones I use (Martin, 1991, p. 23).


The first section of the survey is the informed consent section, which informs participants of the terms of their involvement. After this, the participant
provides basic demographic information, and preferences related to their gaming habits. Again, this helps to get a sense of the representativeness of my sample.

The rest of the survey uses a counterbalanced approach and presents four sections in a random order by using embedded clips of both animators’ “naïve” and “Delsarte” styles of animation. In order to try help reduce any order effects (such as training or fatigue) from seeing one of the versions for first, the order of “naïve” or “Delsarte” conditions were randomized. Since the survey displayed these videos to the participant in random order, only one such ordering is reproduced in Appendix 4.

After viewing each segment, the participant indicated the personality descriptors they observed using the semantic differential scales. Each clip was accompanied by semantic differential scales generated from the Abridged Big Five Dimension Circumplex I, II, and IV sections (extraversion, agreeableness, and neuroticism). A semantic differential scale is similar to a Likert scale, except that it labels both ends with opposed pairs of adjectives to record what a participant’s believes about themselves, others, or something they have observed. Using Likert scales for detecting perception of emotions and personality traits is quite common in psychological research (e.g. Tracy & Robins, 2004). The AB5C descriptors have been lexically validated and checked to ensure they are maximally unique and well defined (Hofstee, de Raad & Goldberg, 1992). The responses to these scales are averaged and the mean values used for analysis.
Table 13: The twenty semantic differential scales

<table>
<thead>
<tr>
<th>Scale</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>silent</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>submissive</td>
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<td></td>
<td>√</td>
</tr>
<tr>
<td>restrained</td>
<td>√</td>
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<td></td>
<td></td>
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<td></td>
<td>√</td>
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<td>√</td>
</tr>
<tr>
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<td></td>
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<tr>
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<td></td>
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</tr>
<tr>
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</tr>
<tr>
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</tr>
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<td></td>
<td></td>
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</tr>
<tr>
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<td>√</td>
<td></td>
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<td></td>
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</tr>
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<td></td>
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</tr>
<tr>
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<td>√</td>
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<td></td>
<td>√</td>
</tr>
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<td></td>
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</tr>
<tr>
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<td>√</td>
<td></td>
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</tr>
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<td></td>
<td></td>
<td></td>
<td></td>
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<td>√</td>
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<tr>
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<td></td>
<td>√</td>
</tr>
<tr>
<td>restrained</td>
<td>√</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>√</td>
</tr>
</tbody>
</table>

Table 13 demonstrates the twenty semantic differential scales presented in a random order, as they were for the questions.

I chose to show both the “naïve” and “Delsarte” conditions to each participant in a within-subject manner for a number of reasons. Besides practical advantages such as reducing the number of participants required, this provides the statistical advantage of minimizing the individual differences between participant groups, helping to increase confidence in the results.
5.4 Results

The collected results from the questionnaires were analyzed. The questions, shown in Appendix 4, were designed to evaluate the personalities of the different character displays. In this section, we will analyze the participants’ answers and determine the consistency with which they responded.

5.4.1 Open answers

When asked to provide overall feedback on the survey and the characters, several themes emerged in participant responses. In some cases, they reflected the difficulty in reflecting on character attributes. In others, they reveal possible refinements that could assist future work in this area.

One participant reflected on the interaction between the dialogue and the video, stating that it was difficult to read and required careful watching, involving pausing andrewinding the video to understand. Once the dialogue was understood not to differ, the character-judging portion could commence. In the same way, another participant stated that it was tough to separate the content from the body language when evaluating the attributes.

Another theme reflected change over time. One participant felt that it was difficult to provide an “overall” measure of the character attributes, since they would reveal different characteristics throughout the clip. On the other hand, another participant felt that differences were not obvious enough, and the characters acted too similarly, and that subsequent clips made it difficult to change one’s interpretations.
5.4.2 Mean ratings

To begin with, the ratings for each character on each scale were averaged and can be seen in Table 14: Smith average ratings and Table 15: Manager average ratings. This allows us to compare how each character was perceived in the different clips.

Table 14: Smith average ratings

<table>
<thead>
<tr>
<th>Scale</th>
<th>A1 Naïve</th>
<th>A1 Dels</th>
<th>A2 Naïve</th>
<th>A2 Dels</th>
</tr>
</thead>
<tbody>
<tr>
<td>silent</td>
<td>talkative</td>
<td>4.54</td>
<td>4.46</td>
<td>3.99</td>
</tr>
<tr>
<td>unsociable</td>
<td>sociable</td>
<td>3.89</td>
<td>4.07</td>
<td>3.89</td>
</tr>
<tr>
<td>submissive</td>
<td>dominant</td>
<td>4.33</td>
<td>4.53</td>
<td>3.57</td>
</tr>
<tr>
<td>noncompetitive</td>
<td>competitive</td>
<td>4.3</td>
<td>4.59</td>
<td>4</td>
</tr>
<tr>
<td>restrained</td>
<td>boisterous</td>
<td>4.34</td>
<td>4.54</td>
<td>4.23</td>
</tr>
<tr>
<td>cowardly</td>
<td>courageous</td>
<td>4.19</td>
<td>4.31</td>
<td>3.87</td>
</tr>
<tr>
<td>sedate</td>
<td>explosive</td>
<td>5.02</td>
<td>4.88</td>
<td>4.67</td>
</tr>
<tr>
<td>unadventerous</td>
<td>adventurous</td>
<td>4.02</td>
<td>4.39</td>
<td>3.88</td>
</tr>
<tr>
<td>unsympathetic</td>
<td>sympathetic</td>
<td>3.91</td>
<td>3.64</td>
<td>3.91</td>
</tr>
<tr>
<td>unfriendly</td>
<td>friendly</td>
<td>3.57</td>
<td>3.4</td>
<td>3.66</td>
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<tr>
<td>rough</td>
<td>agreeable</td>
<td>3.29</td>
<td>3.27</td>
<td>3.55</td>
</tr>
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<td>inconsiderate</td>
<td>considerate</td>
<td>3.58</td>
<td>3.39</td>
<td>3.62</td>
</tr>
<tr>
<td>selfish</td>
<td>generous</td>
<td>3.4</td>
<td>3.32</td>
<td>3.55</td>
</tr>
<tr>
<td>unaffectionate</td>
<td>affectionate</td>
<td>3.88</td>
<td>3.69</td>
<td>3.9</td>
</tr>
<tr>
<td>tactless</td>
<td>tactful</td>
<td>3.63</td>
<td>3.48</td>
<td>3.69</td>
</tr>
<tr>
<td>jealous</td>
<td>unenvious</td>
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<td>3.71</td>
<td>3.89</td>
</tr>
<tr>
<td>insecure</td>
<td>unsconscious</td>
<td>3.64</td>
<td>3.69</td>
<td>2.93</td>
</tr>
<tr>
<td>unexcitable</td>
<td>excitable</td>
<td>4.43</td>
<td>4.38</td>
<td>3.96</td>
</tr>
<tr>
<td>irritable</td>
<td>patient</td>
<td>3.01</td>
<td>3.02</td>
<td>3.61</td>
</tr>
<tr>
<td>unemotional</td>
<td>emotional</td>
<td>5.23</td>
<td>5.13</td>
<td>5.24</td>
</tr>
</tbody>
</table>

In terms of the ten personality traits I factored into Smith’s character description, under the Delsarte system he was perceived as: more sociable, less submissive, less cowardly, less insecure, and less explosive (although he was
stil perceived as decidedly explosive). However, on the axes of talkative, boisterous, friendly, tactless, and excitable the trend depended on the artist. However, in terms of which side of the axis these perceptions were on, Smith was talkative, tactless, and excitable.

Table 15: Manager average ratings

<table>
<thead>
<tr>
<th>Scale</th>
<th>A1 Naive</th>
<th>A1 Dels</th>
<th>A2 Naive</th>
<th>A2 Dels</th>
</tr>
</thead>
<tbody>
<tr>
<td>silent</td>
<td>talkative</td>
<td>4.09</td>
<td>4.56</td>
<td>4.13</td>
</tr>
<tr>
<td>unsociable</td>
<td>sociable</td>
<td>3.58</td>
<td>3.91</td>
<td>4.63</td>
</tr>
<tr>
<td>submissive</td>
<td>dominant</td>
<td>4.88</td>
<td>5.23</td>
<td>4.79</td>
</tr>
<tr>
<td>noncompetitive</td>
<td>competitive</td>
<td>4.43</td>
<td>4.52</td>
<td>3.9</td>
</tr>
<tr>
<td>restrained</td>
<td>boisterous</td>
<td>3.66</td>
<td>4.33</td>
<td>3.42</td>
</tr>
<tr>
<td>cowardly</td>
<td>courageous</td>
<td>4.37</td>
<td>4.46</td>
<td>4.58</td>
</tr>
<tr>
<td>sedate</td>
<td>explosive</td>
<td>3.91</td>
<td>4.26</td>
<td>3.15</td>
</tr>
<tr>
<td>unadventurous</td>
<td>adventurous</td>
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<td>3.83</td>
<td>3.78</td>
</tr>
<tr>
<td>unsympathetic</td>
<td>sympathetic</td>
<td>2.82</td>
<td>3.14</td>
<td>4.63</td>
</tr>
<tr>
<td>unfriendly</td>
<td>friendly</td>
<td>3.03</td>
<td>3.16</td>
<td>4.56</td>
</tr>
<tr>
<td>rough</td>
<td>agreeable</td>
<td>3.04</td>
<td>3.16</td>
<td>4.4</td>
</tr>
<tr>
<td>inconsiderate</td>
<td>considerate</td>
<td>3.02</td>
<td>3.53</td>
<td>4.74</td>
</tr>
<tr>
<td>selfish</td>
<td>generous</td>
<td>3.2</td>
<td>3.69</td>
<td>4.26</td>
</tr>
<tr>
<td>unaffectionate</td>
<td>affectionate</td>
<td>3.34</td>
<td>3.47</td>
<td>4.42</td>
</tr>
<tr>
<td>tactless</td>
<td>tactful</td>
<td>3.65</td>
<td>3.92</td>
<td>4.65</td>
</tr>
<tr>
<td>jealous</td>
<td>unenvious</td>
<td>4.19</td>
<td>4.17</td>
<td>4.48</td>
</tr>
<tr>
<td>insecure</td>
<td>unselfconscious</td>
<td>4.35</td>
<td>4.38</td>
<td>4.48</td>
</tr>
<tr>
<td>unexcitable</td>
<td>excitable</td>
<td>3.51</td>
<td>4.12</td>
<td>3.53</td>
</tr>
<tr>
<td>irritable</td>
<td>patient</td>
<td>3.47</td>
<td>3.27</td>
<td>5.18</td>
</tr>
<tr>
<td>unemotional</td>
<td>emotional</td>
<td>3.66</td>
<td>4.4</td>
<td>4.1</td>
</tr>
</tbody>
</table>

In terms of the six personality traits I factored into the Manager’s character description, under the Delsarte system he was perceived as more dominant and less restrained. The artists’ renditions were divided on how Delsarte affected the axes of sociable and tactful. The artists’ renditions were conflicted in trend for
unsympathetic and unexcitable, but still provided an interpretation that was in the direction I called for in my description.

Since the personality ratings varied so much, I felt it was important to determine what conditions made a significant impact on these ratings in order to properly address my hypothesis. When there is more than one independent variable affecting means and there are more than two groups to compare, the statistical tool used to compare these means is called a “factorial Analysis of Variance” (Reinard, 2006, p. 213). This test helps isolate main effects and interactions effects that cause differences in means.

In this case, a four factor (2x2x2x20) factorial Analysis of Variance (ANOVA) was conducted. The model fitted includes terms for:

- **ARTIST** (A1, A2)
- **STYLE** (naïve, Delsarte)
- **CHAR** (Smith, Manager)
- **SCALE** (20 different bipolar descriptor pairs)

The ARTIST, STYLE, and CHAR terms represent independent variables, with SCALE being the dependent variable.
Table 16: Tests of fixed effects on means

<table>
<thead>
<tr>
<th>Effect</th>
<th>F Value</th>
<th>Pr &gt; F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Style</td>
<td>0.08</td>
<td>0.7778</td>
</tr>
<tr>
<td>Artist</td>
<td>24.53</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Artist*style</td>
<td>42.19</td>
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</tr>
<tr>
<td>Char</td>
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</tr>
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</tr>
<tr>
<td>Scale</td>
<td>48.65</td>
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</tr>
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<td>Style*scale</td>
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<td>Artist*scale</td>
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<td>&lt;0.0001</td>
</tr>
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</tr>
<tr>
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<td>&lt;0.0001</td>
</tr>
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<td>Artist<em>scale</em>char</td>
<td>2.10</td>
<td>0.0035</td>
</tr>
<tr>
<td>Artist<em>style</em>scale*char</td>
<td>4.66</td>
<td>&lt;0.0001</td>
</tr>
</tbody>
</table>

Table 16: Tests of fixed effects on means shows the results of this ANOVA procedure. This indicates that a number of interactions are significant. First, notice that the STYLE term alone does not account for significant differences (P=0.7778). The ARTIST term, however, does produce significant differences (P<0.0001). In most cases, the interactions involve the artist, except for the obvious scale differences. While we will examine the effects of different means later, we have already noted that the scales received different ratings. The artist main effect continues in the artist by character and artist by style by character interactions.

Following our exploratory analysis, a full least squares analysis is now undertaken to investigate the influence of each of the fixed effects. In order to determine which are most valuable to explore further, the test of effect slices is
presented. To maintain the overall experiment error rate at an acceptable level, during post-hoc testing, Bonferroni’s Correction is applied (0.05 / 40 = 0.00125) and the statistically significant rows are bolded in Table 17: Test of effect slices.
Table 17: Test of effect slices

<table>
<thead>
<tr>
<th>Effect</th>
<th>Artist</th>
<th>Scale</th>
<th>Character</th>
<th>F Value</th>
<th>Pr &gt; F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Artist<em>style</em>scale*char</td>
<td>Cowardly</td>
<td>Mgr</td>
<td>0.80</td>
<td>0.4913</td>
<td></td>
</tr>
<tr>
<td>Artist<em>style</em>scale*char</td>
<td>Cowardly</td>
<td>Smith</td>
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<td>0.1221</td>
<td></td>
</tr>
<tr>
<td><strong>Artist<em>style</em>scale*char</strong></td>
<td>Inconsiderate</td>
<td>Mgr</td>
<td><strong>30.82</strong></td>
<td><strong>&lt;0.0001</strong></td>
<td></td>
</tr>
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<td>Artist<em>style</em>scale*char</td>
<td>Inconsiderate</td>
<td>Smith</td>
<td>2.11</td>
<td>0.0965</td>
<td></td>
</tr>
<tr>
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<td>Mgr</td>
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<td>0.1196</td>
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<td>Smith</td>
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</tr>
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<td>Mgr</td>
<td>40.31</td>
<td><strong>&lt;0.0001</strong></td>
<td></td>
</tr>
<tr>
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<td>Irritable</td>
<td>Smith</td>
<td>7.07</td>
<td><strong>&lt;0.0001</strong></td>
<td></td>
</tr>
<tr>
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<td>Jealous</td>
<td>Mgr</td>
<td>1.35</td>
<td>0.2570</td>
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<td>Smith</td>
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<tr>
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<td>Mgr</td>
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<td>0.0057</td>
<td></td>
</tr>
<tr>
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<td>Smith</td>
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<td>0.0154</td>
<td></td>
</tr>
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<td>Restrained</td>
<td>Mgr</td>
<td>8.31</td>
<td><strong>&lt;0.0001</strong></td>
<td></td>
</tr>
<tr>
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<td>Restrained</td>
<td>Smith</td>
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<td>Mgr</td>
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<td>Smith</td>
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<td>Mgr</td>
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<td>Mgr</td>
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</table>
The following graph breaks down the Artist by Style by Character interaction and explores how the two artists’ different renditions of the Manager are affected by style.
The overall effect on Smith is not statistically significant under the filtering effect of Bonferroni’s Correction, but a similar trend is observed.

Figure 20: Synchronization effect on Smith

As an example of how these effects are composed of individual attributes, consider the Inconsiderate Manager shown in Figure 21.
The manager showed convergence for the follow significant descriptor axes: irritable, inconsiderate, rough, sedate, selfish, unsympathetic, unsociable, tactless, unaffectionate, and unfriendly. He showed divergence on the restrained and unemotional axes. The average difference in mean rating between artists among the significant descriptor axes under the naïve condition was 1.03. This changed to 0.27 under the Delsarte condition.

Smith shows a slightly different effect. He shows convergence only on the Insecure axis. He diverges on the Irritable, Sedate, Submissive, and Unfriendly axes. However, the average change was smaller than with the Manager. The average difference in mean rating between artists among the significant descriptor axes under the naïve condition was 0.40. This changed to 0.56 under the Delsarte condition. To see the effect on an individual characteristic, consider Unfriendly Smith.
Between styles, A1’s Smith shows an average difference of 0.12 among significant descriptor axes. A1’s Manager shows an average difference of 0.31. A2’s Smith shows an average difference of 0.43, and A2’s Manager shows an average difference of 0.83. This indicates that the Manager tended to be affected more by the change than Smith, and A2 likewise.

5.4.3 Dispersion of the ratings

As well as examining the differences in means, it is important to determine whether there are any differences in variance. This is because the ability to constrain interpretations (mean ratings) is also valuable. In order to determine how much variance was involved in the rating of characters, the data was first transformed using the Mean Absolute Deviation (MAD) of each score. In other words, this transformation involves calculating the mean for each rating, and then
changing each rating into its difference from that mean, disregarding the sign. This helps to preserve the interpretability of the results.

After performing the MAD transformation, a four factor (2x2x2x20) Factorial Analysis of Variance (ANOVA) was conducted similar to that used for the means. The model fitted includes terms for:

- **ARTIST** (A1, A2)
- **STYLE** (naïve, Delsarte)
- **CHAR** (Smith, Manager)
- **SCALE** (20 different bipolar descriptor pairs)

Again, ARTIST, STYLE, and CHAR are the independent variables, with SCALE being the dependent variable.
Table 18: Type 3 Tests of fixed effects on variation

<table>
<thead>
<tr>
<th>Effect</th>
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<th>Pr &gt; F</th>
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</thead>
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</table>

Table 18: Type 3 Tests of fixed effects on variation shows the results of this ANOVA procedure. This indicates that a number of interactions are relevant.

In contrast to the situation with the means, the STYLE term (P=0.0265), not the ARTIST term, accounts for a significant difference in variation. From looking at the other significant interactions, Artist by Style and Artist by Style by Character will likely develop this finding.

Following our exploratory analysis, a full least squares analysis is now undertaken to investigate the influence of each of the fixed effects. In order to determine which are most valuable to explore further, the test of effect slices is presented. To maintain the overall experiment error rate at an acceptable level during post-hoc testing, Bonferroni’s Correction is applied (0.05 / 40 = 0.00125)
and the statistically significant rows are bolded in Table 19: Test of effect slices with variation.
Table 19: Test of effect slices with variation

<table>
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<tr>
<th>Effect</th>
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<th>Style</th>
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The differences in variation start at the character level. Comparing Manager and Smith, we find that the Manager has an average variation of 1.22, while Smith has 1.17. The impact of the STYLE and ARTIST are seen here.

**Figure 23: Manager variation**
The remaining interaction that is not shown on these two graphs is the difference between the artists across all their work. Animator1 produced ratings with a variation of 1.20 which Animator2 produced ratings with a variation of 1.22.

5.5 Discussion

Based on these findings, I can reject my formal null hypotheses that held that there was no difference in means or variation between clips produced using Delsarte’s system and the animators’ own style. However, no obvious alternative hypothesis presents itself through this data. It seems that Delsarte’s system played some role in constraining interpretations and causing animators with different styles to produce similar meanings. However, there was also a significant effect on variation where one of the Delsarte versions caused greater variation. It important to understand these findings in context and so lessons learned from both phases of this study are now discussed.
5.5.1 Character interpretation

In evaluating the mean ratings, the factorial ANOVA found that Artist was a main effect in determining rating. This showed up in the other significant interactions that are not simply scale differences: Artist by Style, Artist by Character, Artist by Style by Character and Artist by Style by Scale by Character. This seems to indicate that what the artists and their personal style contribute to the final product is a major factor in determining how they are interpreted. Section 4.8 Final Product describes some of the differences that occurred, including different use of camera angles and a cartoon-style model for the Manager in one case. However, in spite of these differences, the manager showed significant convergence in mean ratings under the Delsarte condition. In particular, he converged on ten out of twelve significant scales, which seems to indicate that the Delsarte style produced similarities of interpretation across artist renditions, while the naïve style produced more varying characters. There may be a consistency of interpretation provided by following the Delsarte system.

Furthermore, the character descriptors that I designed for resulted in scales with significant interactions. The Manager’s scales of difference include four out of the six I incorporated into his design: unsociable, restrained, unsympathetic, and tactless. Of these four, three of them converged in the Delsarte case, while only one – restrained – diverged. Smith’s scales of difference include four of the ten I included in his design. However, his case is reversed, with only one converging in the Delsarte case. This seems to indicate
that my scenarios caused differences along the axes I expected. This is a valuable finding for the design process.

The dispersion results complicate the understanding of style however. In this case, the Style interaction is significant and can be broken down into Artist by Style and Artist by Style by Character. However, while Style makes a difference, it affects the two artists differently. In the case of the Manager, they switch places from their naïve interpretation: in the Delsarte case, A1’s character experiences less variation while A2’s character experiences more variation. Therefore, while the mean ratings converged under Delsarte, the participants experienced more uncertainly in understanding A2’s Delsarte Manager. It is possible that Delsarte’s system conflicts slightly with people’s expectations of cartoon figures, or that the technical artefacts that are present in that video caused greater variation. Regardless of the cause, there was a split between the animators in how using Delsarte’s system affected them.

5.5.2 Evaluating character personality

A factor that may have affected participants’ ratings is reflected in a theme that emerged in 5.4.1 Open answers where participants stated it was difficult to judge characters’ personalities since they revealed different characteristics even over short periods. This raises the question of how people construct models of others’ personalities. It would take further study to determine how much time and what kinds of interactions it takes to change people’s impressions. Isbister points out that traits in the neuroticism, openness, and conscientiousness factors “manifest themselves over longer interactions” (2006, p. 35). For this reason,
using descriptor traits from these factors should be reserved for longer interactions.

Due to the participant response surrounding the rating process, it seems as though observers construct personality in different ways. This study seems to indicate that the process is complex and not easily broken down into component scales. This suggests that rating characters should be approached differently. Rating them at time intervals may help to isolate additive factors. Furthermore, it may be necessary to provide simpler methods for rating characteristics to gather ratings that are more reliable.

This factor arose in the study as one quarter of participants did not fill out video ratings and some of the remaining participants only filled out partial responses. While this is partially an obvious side effect of using a web survey, it may indicate what some participantsanedotally reported: filling out minor gradations of personality across so many axes is difficult. For this reason, finding ways of reducing the number of descriptor pairs could be valuable for future studies. Principal component analysis could indicate which traits were more central to character ratings, and could indicate which ones are best to continue using.

5.5.3 Reading smith

It is difficult to know what to make of Smith. While some of his ratings resulted in significant results, there was no overall significant interaction in terms of Artist by Style by Character. Furthermore, the changes in mean ratings are
much smaller for this character. This may indicate that the animators portrayed him in ways similar to each other and similar to Delsarte’s system to begin with. However, an examination of Smith’s mean ratings reveals that many participants’ considered him to be an unsympathetic character. The traits his mean ratings assign to him are: talkative, dominant, boisterous, very explosive, unfriendly, inconsiderate, tactless, insecure, excitable, and emotional.

While this was surprising to me, since I was sympathetic to the Smith character, there are two main possibilities that seem to explain this. One possibility is described by a theme that is found in 5.4.1 Open answers: some participants found it difficult to consolidate an overall impression of the characters separate from specific actions. In this case, Smith’s last, dramatic outburst may have made the most impact, which could have given the impression of an excitable boor.

Another possibility that arose upon post-hoc analysis is the impact of the participants’ cultural backgrounds. While analyzing this was not part of my research, Smith’s ratings may result from the impressions formed by participants from cultures that place more value on respecting authority. There is evidence that many of the students in Dr. Magy Seif El-Nasr’s undergraduate classes (which constituted 48% of the participants) have non-Western cultural backgrounds. In class assignments and personal discussion, many related high levels of respect for authority. This indicates it would be valuable to determine the impact of cultural background on reading character personality. This could help create more nuanced interactions and displays of personality traits.
5.5.4 Working with animators

It may seem unsurprising that artist interpretation of characters and methods of animating them cause differences in perception. Perhaps more surprisingly then, it appears that working from instructions based on the consistent influence of the Delsarte system of expression causes coherence in interpretation and perception of those characters. At the same time, it is important to recognize that this system may conflict with the expectations introduced by certain styles of character animation, and remember the overall influence of individual artistry.

In the case of the two animators involved in this study, animator one, a new graduate, received more benefit from using Delsarte than the experienced video game animator. This may indicate that the over time, animators develop styles and processes that are resistant to external influences. This reveals a dilemma that needs to be resolved for future work: animators who newer to the field may prove more receptive to new styles; however, more experienced animators may be more capable of capturing the nuances of Delsarte’s system. It seems that if the animators standing in as naïve substitutions for a procedural animation system, as in this study, less experienced animators might be best. On the other hand, if one desires an animator to produce content that will then be procedurally animated using Delsarte’s system, a more experienced animator might be more helpful.

Along the same lines, the process of involving animators in research studies is worth examining. In this case, two out of four animators initially
contracted to produce clips stopped work part way through. One of the remaining animators produced work that has technical defects. It seems that if the work seems like a job, it will be treated as such, with fewer opportunities to interact with the animators and learn from their process. If there is not enough money available, then individuals may lose interest. On the other hand, working with animators during their training may help to find individuals more interested in the educational process and produce opportunities for collaborative learning.
6: FUTURE WORK

6.1 Applications

A system of expression provides both benefits and challenges to the process of animation. On the one hand, it provides consistency and guidance to the animation process. On the other hand, that very fact means animators must go through a learning process and follow it quite strictly. For this reason, it seems likely that Delsarte’s system of expression will provide less use to animators using traditional key frame animation and more use for those basing character animations on procedural affects. Nonetheless, animators who learn and apply the Delsarte system of expression could benefit from the laws it provides.

When it comes to the procedural generation of animation, or affecting motion captured models procedurally, Delsarte’s system provides more likely guidance. This seems especially likely given that those who implement procedural animation often do not possess the same background and artistic training. The potential for Delsarte’s system is to provide rules of movement that are layered above the physical restraints of a human model. A model for character movement could be adapted that would inform both regular movement and meaningful gestures such as affect displays. This would provide the benefit of consistent and stylized motion.
6.2 Future Directions

Given some of the ambiguity that remains surrounding Delsarte’s system and how it affects perceptions, it seems worthwhile to continue experimentation at the theoretical level. Section 5.5 Discussion mentioned several areas that were problematic and could be refined for future work. This includes interactions between Delsarte’s system (grounded in Western artistic ideals) and other cultures with different value systems; as well, it may be that we have developed expectations for certain animation styles (e.g. cartoons) and these conflict with Delsarte’s system – this should also be studied.

Besides these, Delsarte’s system also needs to be empirically tested and evaluated at different levels. It seems that there is a difficult-to-resolve tension between the findings that body language is difficult to read on isolated body parts (Badler et al., 2002) and the complications of character interactions during extended scenes. Marsella et al. (2006) tested Delsarte’s system for hand gestures and a similar approach could be used for other parts of the system. This could be used to both determine whether actions mean what Delsarte thought they did (as in the case of Marsella et al.’s study) and whether they correspond to specific emotions or traits from psychology research (as in my study).

As indicated by Joe Williams, one of the most important parts of Delsarte’s system is the set of nine laws that govern movement. These laws could help to address the transitions between poses that must invariably occur. Since I was primarily studying the meaning behind the poses in Delsarte’s system, the unnaturalness of certain transitions in this study’s animation clips was identified
as a weakness. Movement is an important part of animation, and so Delsarte’s rules governing it should be analyzed as well. In particular, the law of extension dictates that it requires extremes of emotion to reach the extremes of movement, and so moderating poses based on degrees of emotion could prove useful.

Finally, this study raised for me larger issues surrounding aesthetics and game characters. It seems as though the computer animation field is largely concerned with the physical constraints of human motion – an important issue in portraying lifelike computer characters, to be sure! However, as the many approaches to conveying believability (i.e. an overriding artistic agenda) seem to demonstrate, there are fruitful avenues of inquiry surrounding how style interacts with game characters. Aesthetics is largely resolved in some of the component areas of game design such as drama writing, but the involvement of important game principles such as reactivity, interaction, and rule-based game play in constructed a sense of style are not fully understood.
7: CONCLUSION

The production of animation for virtual humans is a process in need of change. The current industry practice involves a lot of time-consuming traditional animation. As a result, games involving sophisticated characters take large teams years and tens of millions of dollars to produce (“The Next Generation of Gaming Consoles”, 2009). This is creating an unsustainable feedback loop (Mateas & Stern, 2005). Leveraging the procedural nature of the computer more fully provides a natural solution. However, doing so is an unsolved problem, and effective heuristics could greatly assist the process.

As character designs grow more sophisticated, especially in view of the challenges faced in displaying them with procedural animation, it is important to remember the importance of character believability. Primarily, this is a cognition-action mapping, as Badler et al. (2002) say that a character is believable if “we can infer emotional or mental state by observing its behavior.” Furthermore, characters have been animated successfully using a variety of artist methods that remain relevant to computer animation. These principles even apply to simple objects such as desk lamps (e.g. Pixar’s Luxo Jr.). Some researchers, such as Mori (1970), believe that people experience negative emotions when presented by human likenesses that are too realistic. However, Hanson et al. (2005) find evidence to reject the theory of the uncanny valley, and believe better design can help people see realistic robots and figures in a better light. For
example, behaviour should match appearance to avoid disturbing expectations. Delsarte’s system provides just such a mechanism for providing realistic behaviour.

As has been demonstrated, the transition to interactivity requires a change in content creation: animators must adapt to new approaches (Tomlinson, 2005) and authors must take on a “programmer mentality” and learn how to write in a rule-based way (Mateas & Stern, 2005). Researchers adapting to these new non-linear methods have created systems for representing virtual humans in a variety of environments, from avatars in games to embodied conversational agents in chat forums. These systems must all create systems of graphical representation; some start from traditional key-framed animation, some go directly to the source and capture motion data from people, while others keep the whole system procedural and generate bodies in real time. After incorporating this original graphic, these systems must function procedurally to generate the expressiveness that leads to believable characters.

One heuristic that could be used to guide procedural animation is the use of a consistent and thorough artistic system of expression. We have seen how Laban Motion Analysis (Chi et al. 2000) can be incorporated to successfully design a character system. Delsarte’s system of expression provides us with one that has been adopted by actors and dancers, and revolutionized the production of modern dance (Shawn, 1968, p. 82). His system is observation-based, and does not rely on an intuitive understanding that computers lack. It also provides
an aesthetic sense of style. Nevertheless, it has not been scientifically validated and few studies exist (Marsella et al. 2006).

My study examines the application of Delsarte’s system of expression. In an iterative process with experts familiar with animation and Delsarte, I constructed a model for posing characters. In order to determine whether this would produce results that differ from and (hopefully) have advantages over an intuitive process, I had two animators produce their own version and my Delsarte version of a scene derived from improvisational acting (Johnstone, 1987).

To find out the differences in how people “decoded” each character, I embedded the videos with twenty semantic differential scales labelled with bipolar personality descriptors. 124 respondents filled out the online survey, of which 94 rated at least one video. A statistical analysis called factorial Analysis of Variance allows comparison between the average ratings and degree of dispersion and shows significant interactions and effects. The Delsarte versions of the clips seemed to cause both animators to be perceived in the same way, particularly in the Manager character. At the same time, the Delsarte style caused different effects in the dispersion of ratings of the Manager character. Most significantly, the cartoon version yielded greater variation. This may reveal that some styles of animation are at odds with the style of expression contained in Delsarte’s system. Overall, this lends some support to my hypothesis that Delsarte’s system of expression helps to improve the presentation of personality traits within characters.
This study also revealed several findings separate from the main evaluation. The process of working with animators yielded several lessons. In particular, it seems that collaborating with animators in the educational process could provide greater insights. Furthermore, the resulting clips point out the importance of applying Delsarte’s laws of movement. Transitions between poses are a crucial component of displaying motion and should be studied further. It also appears that people construct personality in complex way over time, which future studies should take into consideration. As well, participants felt that there were too many ratings required, and so a simpler method should be used.

For now, it seems that the aesthetics of character creation for virtual worlds are not fully understood. Some principles and processes for improving the believability of characters have been found, and Delsarte’s system of expression seems to hold promise and be worthy of further study. This is especially valuable, as it could be a guide for the production of procedural animation systems, which themselves greatly aid the scaleable production of virtual humans.
Appendix 1

Delsarte’s nine-fold divisions

These are examples of Delsarte’s nine-fold divisions based on the combinations of concentric (inward), excentric (outward) and normal (balanced) motion. These scans are taken from Stebbins (1902/1977).

Figure 25: Chart VI - Attitudes of the Head (p. 223)
Figure 26: Chart II - Attitudes of the Legs (pp. 152-153)
THE HAND.

CHART III.

CONDITIONAL ATTITUDES OF THE HAND.


Appendix 2

Basic Scene Description

Instructions

Thank you for participating in my study.

Please read the following carefully, as it will impact your ability to create the desired scene.

Using the accompanying animation assets containing the scene with the characters and props, animate the characters according to the following dialogue. Dialogue should be provided by on-screen “balloons”. Please consult the following character descriptions to inform your animation.


Manager (male): Come in, Smith. Sit down. I suppose you know why I’ve sent for you?

Smith (male): No, Sir. [Manager slides a paper over to Smith.]

Smith: I was hoping you wouldn’t see that.

Manager: You know we can’t employ anyone with a criminal record.

Smith: Won’t you reconsider?

Manager: Good-bye, Smith.

Smith: I never wanted your bloody job anyway. [Exit.]

Manager

The Manager is a 45 year old man and works for a banking firm in Toronto in 2004. He is a white Anglo-Saxon protestant. He was raised in the Metro Toronto area, and after getting his MBA, he joined this firm where he was hired because his father’s friend is a Vice-President. He is married but doesn’t see his wife much during the week.

He’s benefited a lot from his family’s wealth and connections, but he feels that his success in the “dog-eat-dog world of finance” is due to his determination and sharp analytical ability and as a result, feels a lot of pride and accomplishment in his position.
The Manager has spent his life climbing the social and business ladder, and knows its politics very well. As a result, he smoothly handles social relationships to “get along with everyone.” To his subordinates, however, he is dominating and demanding. He worked hard to get where he is, and by golly, so will they!

He takes the long view in most things. Given time, he’ll be a Vice-President, and from there it’s only a few stock options to the Bahamas. Besides his underlings’ incompetence, nothing gets him very excited.

This incident barely registers on his daily schedule and it sits on his BlackBerry to-do list between setting up a bankruptcy auction and a working lunch with his secretary. Smith might have made a nice new assistant, but now he’s headed for the Manager’s black-list.

**Smith**

Smith is a 25-year-old man. He completed his Commerce degree and some Chartered Accounting training, and now he’s looking for work to pay off his student loans. He wasn’t top of his class and feels uncertain about his ability to succeed. His mother is a strongly Catholic woman from Montreal who fell for his dad, an Anglo from Toronto who worked as a mechanic there for a while. They raised four children, of whom Smith is the second. His parents are both proud and a little confused by his career choice.

Smith had a lot of fun in school when he wasn’t studying hard, and got along well with his class-mates. Back then, he had a girlfriend who was very politically active and they both got arrested when a protest got violent. Ultimately, he ended up doing some community service. Due to the tension this caused in the family, the relationship didn’t last. He takes his parent’s advice pretty strongly in these matters. On the other hand, it caused a number of dramatic confrontations, since Smith has quite a temper himself.

This job would be an important step in starting his career. He has gotten through a number of interview stages, and thinks he’s about to get the job. He is a little scared about the possibility of his past coming up but hopes for the best.
Appendix 3

Delsarte Scene Description

Instructions

Thank you for participating in my study.

Please read the following carefully, as it will impact your ability to create the desired scene.

Using the accompanying animation file containing the scene with the characters and props, animate the characters according to the provided action descriptions. Dialogue should be provided by on-screen “balloons”. Please follow the action descriptions as closely as possible. When something is not noted in a subsequent pose, it is unchanged.


Manager (male):

Legs: standing one leg in front of the other; the back leg is strong, the knee of that leg is straight; the forward leg is free, while its knee is bent, thus bringing the foot in front near to the foot behind

Arms: hanging from shoulders at side

Head: level between the shoulders

Gaze: straight ahead

Mouth: lips slightly parted

Manager:  Come in, Smith. Sit down. I suppose you know why I've sent for you?

Legs: standing one leg in front of the other; the strong leg is back, its knee straight; the free leg in front, the knee also straight

Arms: hang full length in front of body, hands

Head: turned away from Smith

Gaze: looking at Smith

Mouth: lips closely shut (when not speaking)

Smith (male):

[Walks into room normally]

Smith (male):  No, Sir.
Legs: standing with legs side by side; both legs are strong and together; knees straight and unbent, heels together, toes turned out
Arms: hands loosely covering each other on his chest; elbows at his sides
Head: tilted down slightly, but toward Manager
Gaze: downcast
Mouth: lips closely shut

[Manager slides a paper over to Smith.]

Legs: standing one leg in front of the other; strong leg is in front. Weight entirely on forward leg; Knee is straight, free leg is behind, knee bent, ball of the foot rests on the ground; the heel should be raised
Gaze: towards Smith
Head: depressed and from object, not rotated

Smith: I was hoping you wouldn’t see that.
Legs: both legs strong and wide apart; knees straight
Arms: arms crossed on breast
Head: tilted down and toward paper
Gaze: at paper
Mouth: lips closely shut, corners depressed

Manager: You know we can’t employ anyone with a criminal record.
Legs: standing one leg in front of the other; strong leg is in front. Weight entirely on forward leg; Knee is straight, free leg is behind, knee bent, ball of the foot rests on the ground; the heel should be raised
Arm: extended their full length in front, a little above shoulder level. animated hand gesture such as pointing at Smith.

Smith: Won’t you reconsider?
Legs: standing one leg in front of the other; both legs are strong and apart, one directly in front of the other, knees are straight
Arms: beseeching, extended their full length in front, level with shoulders
Head: sinks on chest
Gaze: watching Manager
Mouth: lips slightly apart, corners of mouth depressed

Manager: Good-bye, Smith.
Legs: (leans forward) standing one leg in front of the other; both knees should be
wide apart; strong leg in front, the knee bent; free leg behind, the knee straight; the heel
of the foot is raised, the ball resting on the ground

Arms: extended from shoulders, thrust slightly behind him so his hands could
meet behind his back

Smith: I never wanted your bloody job anyway. [Exit.]

Legs: standing one leg in front of the other; the strong leg is back, its knee
straight; the free leg in front, the knee also straight
Arms: elbows bent, hands on hips, eye of elbow toward front
Head: thrown back
Gaze: at Manager

[Walks out]
Expresses defiance, vital force flowing to toes before moving rigid knee,
heel strikes hard, torso dragged after
Appendix 4

Following is the printable view of the survey as produced by the Lime Survey software. The four video questions are presented here in one possible ordering – keep in mind they were randomized for counterbalancing purposes.

Character Interpretation Survey

Thanks for your interest. In this survey you will be watching 4 short videos (<35s ea) and reporting on the personality traits you saw.

This survey should take less than 20 minutes for you to complete.

There are 28 questions in this survey

Informed Consent

1 [consent]

SIMON FRASER UNIVERSITY

INFORMED CONSENT BY PARTICIPANTS IN A RESEARCH STUDY

Title: Enhancing believability: evaluating the application of Delsarte's aesthetic system to the design of virtual humans

Principal Investigator: Michael Nixon (mna32@sfu.ca)

Investigator Department: School of Interactive Arts & Technology

Place: Simon Fraser University Surrey Campus

Purpose and Goals of Study: The animation evaluation activity in which you have been asked to participate in is part of a Master's thesis study on believable virtual characters by Michael Nixon.

Ethical Conduct: The University and those conducting this study subscribe to the ethical conduct of research and to the protection at all times of the interests, comfort, and safety of participants. This form and the information it contains are given to you for your own protection and to ensure your full understanding of the procedures and benefits described below.

Risks to the participant, third parties or society: There are no expected risks outside of what you might experience in day to day physical activity. Participation is voluntary and you may withdraw at any time.

Benefits of study to the development of new knowledge: This research program will
provide insight into the stylistic animation of emotion and personality by determining the consistency with which it can be accomplished and the underlying aesthetic principles which inform it.

What the participants will be required to do: Participants will watch short animated videos displaying a scene involving two characters in an office setting and compare them by periodically assessing the traits being displayed.

Data Collected: The data gathered in this study will be used to understand more about how to design believable characters. The results from this study will be shared with the faculty and graduate students at Simon Fraser University. It will also be included in graduate student thesis work and may be in one or more published research papers. Personally identifiable information such as first and last name will never be used to reference the participant under any circumstances. All information will be kept in a secure location for up to ten years, at which time it will be destroyed.

2 [consent2]What signing means: Completing this survey will signify that you have received this document which describes the possible risks, benefits and procedures of this research study, that you have received an adequate opportunity to consider the information in the document, and that you voluntarily agree to participate in the study.

I understand the procedures to be used in this study. I know that I have the right to withdraw from the study at any time, and that any complaints about the study may be brought to Dr. Hal Weinberg, Director, Office of Research Ethics at hal_weinberg@sfu.ca or 778-782-6593, 8888 University Drive, Simon Fraser University, Burnaby, BC, Canada V5A 1S6.

I may obtain copies of the results of this study, upon its completion by contacting the investigator named above.

I certify that I understand the procedures to be used and that I have been able to receive clarification of any aspects of this study about which I have had questions. I have read, understand and agree with the above, and understand that I can request a copy of this document for my records.

Demographics
3 [gender]What is your gender? *

Please choose only one of the following:

○ Female ○ Male

4 [age]What is your age? *

Please choose only one of the following:
5 [consoles]Which game systems do you have? *

Please choose all that apply:

〇 GameCube 〇 Wii
〇 Nintendo DS 〇 Xbox
〇 PlayStation Portable 〇 Xbox 360
〇 PlayStation 2 〇 Gaming PC
〇 PlayStation 3 〇 Other:

6 [genre]What are your preferred game genres? *

Please choose all that apply:

〇 Action-adventure (e.g. Resident Evil, Prince of Persia)
〇 Casual (e.g. Flash games on Facebook)
〇 Construction Simulation (e.g. SimCity)
〇 Fighting (e.g. Street Fighter, Super Smash Bros.)
〇 Life Simulation (e.g. The Sims, SimLife, Petz)
〇 Music (e.g. Rock Band, Guitar Hero)
〇 Platformers (e.g. Super Mario Bros., Super Metroid)
Role-playing (e.g. Diablo, Dungeons & Dragons)

Shooter (e.g. Doom, Counterstrike)

Strategy (e.g. Civilization, Command & Conquer)

Vehicle simulation (e.g. Flight Simulator, NASCAR)

Massively Multiplayer RPG (e.g. World of Warcraft, EVE Online)

Other:

7 [favorite] What is your favorite video game?

Please write your answer here:

8 [position] Please order the following statements as they apply to you: *

Please number each box in order of preference from 1 to 3

I like the sensory pleasure of playing games; the quality of a game's visuals, soundtrack and audio effects motivate me to play it.

I like a game that challenges me; games should provide me with problems with solve, adversaries to overcome, and recognize me when I win.

I like it when games let me use my imagination; fleshed-out environments with engaging characters and storylines allow me to enjoy a game.

9 [timeforgames] How many hours per week do you spend playing video games on any platform? *

Please choose only one of the following:

○ 1-9
○ 10-19
○ 20-29
○ 30-39
○ 40-49
○ 50+

10 [timeforpc] How many hours per week do you spend using the computer besides playing games? *

Please choose only one of the following:
11 [timefortv] How many hours per week do you spend watching tv shows (including alternative methods of tv viewing)? *
Please choose only one of the following:

- 0
- 0-9
- 10-19
- 20-29
- 30-39
- 40-49
- 50+

12 [social] Do you actively blog or twitter? *
Please choose only one of the following:

- Yes
- No

Instructions

13 [instr] You will now be watching four short clips of animation. Each scene has the same dialogue and same two characters. Each version differs in how it portrays the characters, however, and after each one you will be rating the attributes they displayed.

**Artist-JP-Condition1_rand()**

The following video shows one 'take' on a short scene showing the confrontation between a manager and an employee in an office. The dialogue and premise is the same as the other videos you will see, but the way the characters act is different.

After watching the video, you will be asked to rate the attributes of the characters as displayed in this scene alone.
Please watch the following animation that shows the confrontation between two characters in an office setting.

You will then be asked about the attributes of the two characters, MANAGER and SMITH.

Feel free to replay it.

15 [smith-rating] Please rate the character attributes displayed by the character SMITH. Feel free to review the video. *

Please choose the appropriate response for each item:

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SMITH is on the RIGHT

16 [mgr-rating] Please rate the character attributes displayed by the MANAGER character. Feel free to review the video. *

Please choose the appropriate response for each item:

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Artist-RW-Condition1_rand()

The following video shows one 'take' on a short scene showing the confrontation between a manager and an employee in an office. The dialogue and premise is the same as the other videos you will see, but the way the characters act is different.

After watching the video, you will be asked to rate the attributes of the characters as displayed in this scene alone.

17 [intro-rw1]Please watch the following animation that shows the confrontation between two characters in an office setting.

You will then be asked about the attributes of the two characters, MANAGER and SMITH. Feel free to replay it.

18 [smith-rw1-rate]Please rate the character attributes displayed by the character SMITH. Feel free to review the video. *
Please choose the appropriate response for each item:
Smith is the employee character on the LEFT side.

19 [mgr-rw1-rate]Please rate the character attributes displayed by the MANAGER character. Feel free to review the video. *

Please choose the appropriate response for each item:

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The MANAGER is on the RIGHT.

Artist-JP-Condition2_rand()

The following video shows one 'take' on a short scene showing the confrontation between a manager and an employee in an office. The dialogue and premise is the same as the other videos you will see, but the way the characters act is different.

After watching the video, you will be asked to rate the attributes of the characters as displayed in this scene alone.

20 [intro-jp2] Please watch the following animation that shows the confrontation between two characters in an office setting.

You will then be asked about the attributes of the two characters, MANAGER and SMITH. Feel free to replay it.

21 [smith-jp2-rate] Please rate the character attributes displayed by the character SMITH. Feel free to review the video. *

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Please rate the character attributes displayed by the MANAGER character. Feel free to review the video.*
Please choose the appropriate response for each item:

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- silent
- unsociable
- submissive
- noncompetitive
- restrained
- cowardly
- sedate
- unadventerous
- unsympathetic
- unfriendly
- rough
- inconsiderate
- selfish
- unaffectionate
- tactless
- jealous
- insecure

Unadventurous  Unadventurous  Unadventurous  Unadventurous  Unadventurous  Unadventurous  Unadventurous
Unsympathetic  Unsympathetic  Unsympathetic  Unsympathetic  Unsympathetic  Unsympathetic  Unsympathetic
Unfriendly  Unfriendly  Unfriendly  Unfriendly  Unfriendly  Unfriendly  Unfriendly
Rough
Inconsiderate
Selfish
Unaffectionate
Tactless
Jealous
Insecure

Adventurous  Sympathetic  Friendly  Agreeable  Considerate  Generous  Affectionate  Tactful  Unenvious  Unselfconscious

SMITH is on the RIGHT

22 [mgr-jp2-rate]
The MANAGER is on the LEFT.

**Artist-RW-Condition2_rand()**

The following video shows one 'take' on a short scene showing the confrontation between a manager and an employee in an office. The dialogue and premise is the same as the other videos you will see, but the way the characters act is different. After watching the video, you will be asked to rate the attributes of the characters as displayed in this scene alone.

23 [intro-rw2]Please watch the following animation that shows the confrontation between two characters in an office setting.

You will then be asked about the attributes of the two characters, MANAGER and SMITH.

Feel free to replay it.

24 [smith-rw2-rate]Please rate the character attributes displayed by the character SMITH. Feel free to review the video. *

Please choose the appropriate response for each item:

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Smith is the character on the LEFT side.

25 [mgr-rw2-rate] Please rate the character attributes displayed by the MANAGER character. Feel free to review the video. *
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The MANAGER is on the RIGHT.

Conclusion
26 [other] If you have other comments on the animations or this survey, please enter them here.
Please write your answer here:

27 [thank-you]Thank you for participating in my study. Remember to email me if you're interested in finding out the results of this study.
Michael Nixon: mna32@sfu.ca

28 [iat]If you are in Dr. Magy Seif El-Nasr's under-graduate class this semester, please check this box. The email you send to me reporting that you have finished this survey should have the following word in the subject line: tetelestai.
Please choose **only one** of the following:

- Yes
- No

Submit your survey.
Thank you for completing this survey.
REFERENCES


