The Potential of Mimetic Emotions for Non-Player Characters with Emergent, Personality-Defined, Behavior

A Thesis

Submitted to the Faculty of the
Interactive Design and Game Development Department

in

Partial Fulfillment of the Requirements for the
Degree of Master of Fine Arts

in

Interactive Design and Game Development
at Savannah College of Art and Design

By

Lucas Craig Stertz

Savannah, GA

SuAnne Fu, Committee Chair
Aram Cookson, Committee Member
Gustavo Delao, Committee Member

Contents

List of Figures

Abstract

This thesis focuses on providing more emergent behavior possibilities through non-player characters in video games. This goal was achieved through the integration of Mimetic Emotions, a variation of artificial emotions that mimic human affects, based on the Big-Five Personality Model, the OCC Model, and PAD Scales. Alternative systems and game AI were considered in their work to achieve similar goals

To provide non-player characters with Mimetic Emotions, a Mimetic Emotion System was developed. This system was used to determine the affects, and indirectly the behavior, of a non-player character in the game 'Trader', which has been developed as part of this thesis. The behavior of this character was analyzed for variations in gameplay possibilities, based on its defined personality across playthroughs. These analyses prove that Mimetic Emotions can be applied to provide emergent behavior through varying personality settings of a game's non-player characters.

1 Introduction

Non-Player Characters (NPCs) can play very important roles in video games. NPCs may serve as an interface to the game's underlying systems, provide support to the player, fulfill the role of an enemy, or merely exist as an element of a world. In any of these cases, the NPC has a role in the story forming within the player's mind. For this story to be meaningful or responsive to the player, the NPC needs to be a mimicry of its real-world equivalent.

Games that attempt to present stories or artificial worlds that are based upon the real world could be said to be attempting to mimic reality; which has been a pasttime of humans for centuries, millenia even. Imitating, but not replicating or simulating, the world as one experiences it can allow for it to be improved upon in a way that may be more fitting for others. The constructed illusionary world that can arise from mimesis is one that can be appropriated, changed, and re-interpreted as needed. Aristotle considered that mimesis is a fundamental expression of our human experiences, and is therefore a means of learning about nature (Puetz).

Something artificial that produces an experience similar to what could be naturally experienced, without simulating the exact complexities of the natural process to achieve the results, could be said to be a product of mimicry. Such mimicry is important for many, but not all, games that attempt to provide a responsive or relatable experience to the player, particularly when considering the behavior of a game's NPCs. The capabilities of mimetic NPCs may lead to other advances in mimcry as well, such as more dynamic narratives or more immersive storytelling in general.

While the appearance, sounds, movements, and possible actions of an NPC are all relevant to producing a mimetic NPC, this thesis focuses on the behavior of NPCs. Mimetic NPCs would require behavior that is too complex to be fully mapped or designed prior to the player's interactions, particularly when considering that every NPC's behavior would have to be tailo-

red to match its unique characteristics. Instead, NPCs could be developed to be capable of expressing unscripted behavior appropriate for a given situation. Such NPCs could be said to have emergent behavior.

For an NPC's behavior to be emergent in a mimetic sense, it must perform actions that are appropriate for their current contexts, in respect to all past actions taken and any defining characteristics of the NPC. Essentially, an NPC needs to have some degree of human-like intelligence. This thesis agrees with Thill and Lowe, in that

> An artificial intelligent agent cannot be expected to attain 'human-like intelligence' if it does not possess at least a subset of the functional abilities provided by emotions, for instance, concerning learning and adaptation or behavior selection (Thill and Lowe) (PageNum)

As such, a mimetic NPC should appear reactive, to have goals, to have emotions, and to have some level of contextual social competence (Bates).

Therefore, a first step towards more mimetic NPCs is to develop NPCs capable of expressing, and/or basing their behavior upon, emotions. Such NPCs could possess Mimetic Emotions; artificial emotions that mimic human affects. This thesis presents Mimetic Emotions as certain psychological concepts integrated into various artificial intelligence techniques. The applied psychological concepts include emotion, mood, personality, and relationships.

This thesis agrees with Plutchik in that emotions are a kind of homeostatic process, the purpose of which is to influence behavior to make progress toward an equilibrium. Emotions are a complex chain of loosely connected events, involving stimuli, feelings, psychological changes, impulses, and behavior aimed at achieving some goal. Social regulation and communication are also guided by emotions, as group extensions to the personal emotion experience. The overall purpose of an emotion is to facilitate interaction between an individual and the

event that caused the rise of the emotion, however this becomes complicated through the possible actions to be taken or the fact that multiple emotions may be experienced at once (Plutchik).

Moods, as summarized by Oliveria and Sarmento, are essentially emotions, but with some defining characteristics that set them apart. A mood's cause may be rather vague. It could have been caused by an intense emotion, a subconsciously perceived event, or the environment, like a rainy day. The length that a mood lasts can also be substantially longer than how long an emotion will last, anywhere from a few hours to a few days. The most striking difference may be that a mood can be subtle, the experiencer may not even be aware of the mood, even though it may be influencing his/her behavior.

For the purposes of Mimetic Emotions, personality is the combined traits and past of an individual. These traits manifest as inherent motivations, common behaviors, methods of thinkings, and emotional tendencies (McCrae and John). Personality defines an NPC's base affective state, which is the greatest influence in determining an NPC's initial and long-term behavior towards a player, with respect to its relationship with the player. Therefore, with an NPC whose behavior is determined purely by Mimetic Emotions, the defined personality will define the general behavior of the NPC.

A relationship could be considered a mental representation of another individual (including the lack of representation by one member of the relationship), forming from the moment when one individual meets another. This representation comes to incorporate all positive and negative information, in the form of beliefs, into one's view of that individual. New feelings, judgements, and experiences constantly update one's view (Ortony et al.). This thesis focuses on the representation of relationships and their use in allowing for believable social transactions to occur between characters, such as those described by Berne. Relationships of NPCs with Mimetic Emotions are modeled by the emotional disposition that one character has for another.

Each of the aformentioned psychological concepts are represented within an NPC's Mimetic Emotions, while being influenced, and influencing, the recorded past and desired goals of the NPC; in response to the events occurring around it and to it. The recorded past represents the memories of an NPC, each instance of which encompasses an event, the actors of the event, and the emotions occurring during and after the event. To evaluate the effects of an event, an NPC must also have outcomes that it wishes to see fulfilled. These are the desired goals of an NPC, however they may also be undesirable by being outcomes which the NPC hopes will never be fulfilled.

The manner in which each aspect is influenced is determined by algorithms, determined through psychological study, and artificial intelligence techniques, some of which were defined by other artificial emotion systems in their work to achieve similar goals. Video games that have made similar efforts are also noted. The culmination of all aspects and their interactions, as outlined by this thesis, are realized by the Mimetic Emotion System. This system is described in terms of how its internal functions and algorithms result in Mimetic Emotions, which are intended to be used in determining the behavior of a game's NPCs.

A video game called Trader has been developed featuring a single NPC whose behavior is determined by Mimetic Emotions, as produced by the Mimetic Emotion System. This NPC's behavior is analyzed over several playthroughs for each of several varying personalities of the NPC. The outcomes of the analyses are compared to determine if the NPC expresses emergent behavior for the same personality and if it does even more so across differing personalities. The final conclusion is that an NPC implementing Mimetic Emotions can exhibit emergent behavior that is defined by the NPC's personality. This thesis considers the potential of Mimetic Emotions for further developments that may produce Mimetic Behavior for mimetic NPCs, which can enable more dynamic games and game narratives.

2 Psychological Models

Mimetic Emotions are founded upon certain psychological models. These models provide representations for the emotion, mood, personality, and relationships of Mimetic Emotions. They also guide how world events update these aspects and the relationships between these aspects. As such, an understanding of these models is required for understanding much of the content of this paper.

2.1 Big-Five Personality Model

In recent decades there has been a general consensus that the personality of an individual can be represented through the Five-Factor Personality Model (McCrae and John). This model is a hierarchical organization of personality traits in terms of five basic dimensions:

- **Extraversion** An individual described as active, assertive, energetic, enthusiastic, outgoing, and talkative.
- **Agreeableness** An individual described as appreciative, forgiving, generous, kind, sympathetic, and trusting.
- **Conscientiousness** An individual described as efficient, organized, planful, reliable, responsible, and thorough.
- **Neuroticism** An individual described as anxious, self-pitying, tense, touchy, unstable, and worrying.
- **Openness to Experience** An individual described as artistic, curious, imaginative, insightful, original, and as having wide interests.

Each dimension is most simply repesented as a value between -1 and 1, a positive value indicating that the individual possesses those characteristics and a negative value indicating that the individual possesses opposite characteristics. This representation is used for the personality aspect of Mimetic Emotions.

2.2 OCC Model

There are several methods of determining what emotions an individual should be experiencing in response to a stimuli. Mimetic Emotions follow the OCC model for making such determinations (Ortony et al.). The OCC model defines emotions as:

> Valenced reactions to events, agents, or objects, with their particular nature being determined by the way in which the eliciting situation is construed.(PNr)

For the purposes of Mimetic Emotions, this definition of emotion is considered to be how emotions arise, as opposed to a direct definition of emotions themselves. The reactions described by the OCC model are based upon three basic emotion classes:

- **Pleased vs. Displeased** Reactions to the outcome of an event, independent of the actual or possible causes. These reactions are based upon the desirability that the individual has for the event to occur.

- **Approving vs. Disapproving** Reactions to the behavior of an agent (another individual). This is often considered in terms of the actual or presumed intentions and responsibilities of the agent. These reactions are based upon the praiseworthiness of the actions, with respect to the individual's standards. Such standards are the state of affairs as the individual believes they ought to be, in terms of moral and other judgemental evaluations, as well as attitudes.

- **Liking vs. Disliking** Reactions to objects; whether or not the individual finds certain properties, either real or imagined, of an object to be appealing. Standards of the individual may apply, as they are the basis for appraisals of appealingness.

In combination with several other situational considerations, such as likelihood, desirability-for-other, liking of other, deservingness, expectation-deviation, and familiarity, the model defines how 22 different emotions can be determined. A revised version of the OCC model presents 24 emotions in an inheritance-based hierarchy (Steunebrink et al.). The revised version is more representative of the model used by Mimetic Emotions.

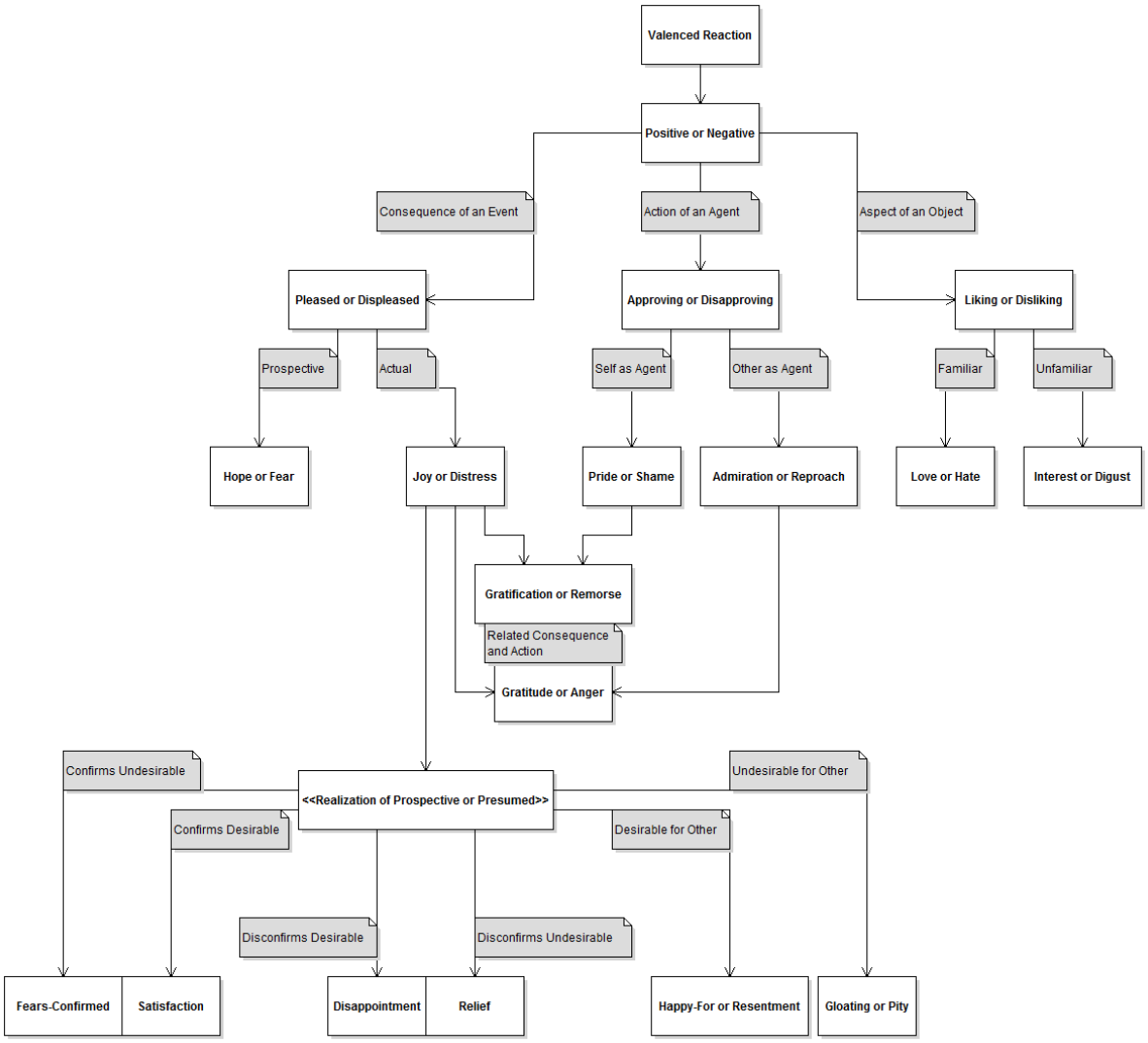

Figure 1: The revised OCC Model.

2.3 PAD Scales

Quantifying emotions allows for the emotional states of an individual to be more clearly described, more specifically measured, and more easily used in calculations/conversions. Mimetic Emotions employ the Pleasure-Arousal-Dominance (PAD) scales to achieve such quantification. PAD scales map emotions to 3-dimensional vectors. Each vector consists of the following components, each ranging from the values of -1 to 1 (Mehrabian, "Framework for a Comprehensive Description and Measurement of Emotional States"). The components of the model are based upon three basic emotion classes:

- **Pleasure-Displeasure** The positivity of an affective state; a positive state is considered pleasurable.
- **Arousal-Nonarousal** The amount of physical activity and/or mental alertness required by the affective state.
- **Dominance-Submissiveness** The sense of control and influence over others/situations that an individual is experiencing in the affective state.

Examples of PAD scale representations, where the parantheses indicate the vector given by pleasure-arousal-dominance components, would be: angry (-.51, .59, .25), dignified (.55, .22, .61), loved (.87, .54, -.18), and unconcerned (-.13, -.41, .08). Several other emotions can be mapped to the model as well ("Framework for a Comprehensive Description and Measurement of Emotional States"). Mimetic Emotions have a PAD scale representation for each resultant emotion of the revised OCC Model, described in section 2.2. These representations are a combination of vectors determined by Mehrabian and vectors used by the ALMA team.

Mood Represented by PAD Scales

Just as emotions can be quantified by PAD Scales, so can moods. The interpretation of a mood in PAD scales can be the same as it is with an emotion, as a 3-dimensional vector, or a mood can be represented by an octant of the PAD space. The first interpretation is driven by the idea that a mood is simply an elongated version of an emotion, whereas the second gives a mood a less specific location in the PAD space.

In the case of the latter, which is the interpretation employed by Mimetic Emotions, causes a mood to apply a more general influence on calculations and behavior determinations, instead of a strongly defined effect tied to a given vector. This interpretation gives rise to eight possible moods, including examples such as: Exuberant (+P,+A,+D), Disdainful (-P,-A,+D), and Docile (+P, -A, -D). (Gebhard) However, such regions can also be representative of the personality for an individual, as discussed in the next section ("Analysis of the Big-five Personality in Terms

of the PAD Temperament Model").

Personality Represented by PAD Scales

The Big-Five Personality Model is already quantified, but to make comparisons and perform operations involving the emotion/mood of an individual, it is best to have all three aspects represented by the same mapping. Through the work of Mehrabian (1996), this is possible by mapping the Big-Five into PAD space.

Mimetic Emotions use these equations to convert from the Big-Five into PAD space:

$$Pleasure = .59(A) + .21(E) - .19(N) \tag{1}$$

$$Arousability = .30(A) + .57(N) + .15(O) \tag{2}$$

$$Dominance = -.32(A) + .17(C) + .60(E) + .25(O) \tag{3}$$

It should be noted that Mehrabian's emotional stability variable has been replaced by its opposite, the modern Big-Five's neuroticism, and that the associated factors have had their signs flipped to match the change. Openness to experience has also replaced Mehrabian's defined sophistication, however their meanings are the same so the factors remain unchanged.

The PAD space values for personality can be used to define a personality region or a specific point for an individual to default to when no emotion or mood is being experienced. Being in the same space as the emotions and moods, these values can also be gradually influenced by the strongest emotions or the longest lasting moods over time. Additionally, the PAD space values can be converted back to the more straightforward Big-Five model as needed for other manipulations or for viewing by a developer responsible for a character with Mimetic Emotions.

3 Alternative Systems and Game AI

Several similar systems and relevant game AI implementations were found in the course of researching this topic. Most of them focus on integrating emotions into artificial intelligence systems for improved user interaction or for improved results when an artificial agent (NPC) is representing a human. The effective gameplay experience and notable emergent gameplay advances of the games have been detailed, while the specific approaches of some of the systems have been considered, and in some cases adapted, for Mimetic Emotions. Such approaches are described in Section 4, with references to the appropriate sub-section here.

3.1 ALMA

ALMA, A Layered Model of Affect, is a model to incorporate emotion (short-term), mood (medium-term), and personality (long-term) affect into virtual characters that serve as dialog partners with human-like conversational skills. The affective characteristics are intended to make the characters more lifelike and believable. The emotion and mood of a character implementing the model can be used by a component for determining actions or dialog (Gebhard).

Emotion, mood, and personality are all represented in PAD space. Emotion being a point in space, mood being an octant of the 3-dimensional space, and personality being an octant that represents the default mood of a character. Appraisal rules are defined in accordance to the OCC model to determine how a character appraises events, actions, and objects related to itself, as well as how a character appraises its own acts and those of others. Additional appraisals are defined for appraising a character's emotional/mood displays and the emotional/mood displays of others. All appraisals can be inputs to the model.

The system periodically evaluates recent appraisals and outputs a set of emotion eliciting conditions. These conditions are then used to update a character's emotions and mood. Mood is affected directly by emotion by a push and pull function. If the mood is closer to the default than the current emotion, then the mood value is pulled towards the emotion, however if the mood is past the current emotion's value in the same octant, it is pushed further into that octant.

3.2 ERIC

ERIC is an effective embodied agent for realtime commentary. It uses ALMA to model its emotional component but inputs its own appraisal rules that are determined by comparing events, actions, and objects of the environment against the agent's own goals and desires. Cause and effect relations allow for additional appraisals that are not specified as goals or desires (Strauss and Kipp).

Actions and events are classified as 'leadsto', 'hinders', 'supports', and 'contradicts', so as to be evaluated in terms of their relation to the goals of the agent. The first two classifications model causality, being determined by the change in likelihood of the goal. The second two model logical deduction or belief, being determined by whether the event supports the belief in a goal. Applied recursively, it is presumed that these rules allow for appraisals of all events and actions related to an agent's goals.

3.3 FLAME

FLAME, the Fuzzy Logic Adaptive Model of Emotion, uses fuzzy logic representation to map events and observations to emotional states. It uses Bolles and Fanslow's inhibitions in combination with both the OCC and the Roseman (not featured in this thesis) event-appraisal models (Bolles and Fanselow). It also includes several inductive learning algorithms for learning patterns of events, associations among objects, and expectations (Seif El-Nasr et al.).

Motivational states such as hunger, thirst, pain, and fatigue are able to interrupt cognitive proccesses and block the emotional component of the agent to satisfy their need, but in accordance to Bolles and Fanslow, some situations will allow for a particularly strong emotion to block the motivational states. Emotions are determined by the expectations, desirability, a function of the agent's standards, and previous actions/emotions/expectations in accordance to the appraisal models.

One of FLAME's primary features is its fuzzy logic representation. Emotions are fuzzified and referenced in terms of a fuzzy value to determine behavior selection, such as:

IF Anger is High AND dish-was-taken-away, THEN behavior is bark-at-user

Emotions in FLAME are also used to anticipate how an action may affect other individuals. Values are assigned to an agent's actions based on the action immediately performed by the user after the agent has completed an action. These values are used to determine how useful or desirable the agent's action might be to the user, thus learning the user's preferences. Another version of learning is the anticipation of an event based on recent events. Counters are used to assign probability of event sequences to a user's action. This probability is applied to an agent's expectations of an event occurring. In cases where a behavior has been conditioned to occur, the emotional components of the model may be skipped.

3.4 iCat

iCat is a social robot with an implemented emotion model. It uses chess as a game scenario while trying to help users better understand the game state. Emotion is determined through an anticipatory mechanism, in which the system creates a predictive model of itself and/or of the environment. iCat uses a heuristic evaluation of the game state as the anticipated value. Emotion is the result of the (mis)matching of the expected and actual values. Mood is a variable that determines the emotional affect when no other emotion is being triggered (Pereira et al.).

An animation module is used to display the emotions to the user. Testing results found that added emotional behavior helped users to better perceive the game's state.

3.5 NES

NES, the Newtonian Emotion System, is a scalable emotion representation and evaluation model. It features attention narrowing, emotional effects on memory, and motivation consideration. Emotion is represented as a four-dimensional vector that is bound to Newtonian Interaction laws. These laws follow the concepts of Netwonian phsyics, in which emotions have qualities of position, distance, velocity, acceleration, mass, and force within the emotion space. The laws for interacting with an emotional state are essentially the same as the Newtonian phy-

sics laws for interacting with a mass. Emotions also gravitate towards a defined neutral state (Lungu).

The first stage of the system is to appraise events for a character. The appraisal returns a list of forces, descending in order of magnitude, to be applied to the character's emotional state. In cases where attention narrowing is necessary, only a certain number of forces at the top of the list are applied. A separate behavior module selects a set of possible actions based on the inputted events. The chosen action is the behavior that most closely aligns with the agent's current emotional state. Feedback is provided as another emotion force that affects the character's emotional state and is processed by the appraisal, conflict set, and behavior modules. The appraisal module attempts to predict coming feedback based on the current event and previous feedback, while the conflict set module settles conflicts between competing actions by selecting the action that has the greatest gain-risk ratio.

A personality filter, another four-dimensional vector, skews the character's perception of events by scaling the character's emotional feedback. Feedback is distributed to previous actions based on a geometric progression. A character that has obtained an item by unlocking a chest would be given a joyful feedback to the actions of opening the chest, unlocking the chest, and approaching the chest; with lessening feedback value applied to the actions performed further in the past. This would encourage this successful sequence of events in the future.

3.6 SIMPLEX

SIMPLEX models goals, emotions, mood, personality, memory, and relationships between characters in an attempt to improve the user's experience. Emotions are determined through the appraisal of events in accordance to the OCC model. This appraisal is altered through a personality scale based on the Big-Five personality model. The closer an emotion is to the current mood, the more likely that the emotion will be considered the active emotion (Kessler et al.).

Mood is represented as an octant in PAD space. It influences emotions and represents the relationship between two characters. Emotions caused by another agent are applied to the

relationship that the effected agent has with the performing agent, thus recording the action's results as a part of their relationship. An agent's mood slowly decays back to a default defined by the agent's personality. How quickly a character's mood will change is dependent upon the character's neuroticism, a factor of the character's personality. Personality is also used to influence a charcter's decisions on multiple levels.

Events are evaluated at several levels involving the personality of the character. The output is an emotion that depends on the kind of prospective outcomes and the sign of the qualitative value. An emotion that is active, and is therefore close to the mood the character, is more likely to influence the character in performing a certain behavior over others.

3.7 Lionhead Studios' Black & White

The Creature of Lionhead Studios' Black & White (2001) features advanced learning AI. The Creature can reproduce any action that the player can perform, including sequences of actions. These actions can then be encouraged or discouraged by the player. Ultimately, the Creature develops personality based on the actions that it performs regularly. (**Molyneux**)

The learning process somewhat emulates the learning process that a child progresses through, but deviates from that process in that the Creature learns the most between the ages of three and eight. The Creature's ability to learn is advanced enough to allow complex interactions to occur between Creatures, of different players, as they express their personality through their learned actions; as in this case recalled by Molyneux,

> My creature enjoyed playing many games of catch with Andy Robson's creature, but this may have been because he was better at catch. After a while Andy's creature was getting fed up, and he did the most amazing thing when my creature wasn't looking. He placed a rock in the fire so that it got hot and then maneuvered it into my creature's pile of rocks with his feet. My creature picked up the hot rock and badly burned his hands. (**GameSpot**)

3.8 Maxis' The Sims 4

Maxis' The Sims series has always focused on simulated persons with varying degrees of resemblance to actual humans. The latest iteration, The Sims 4 (2014), has had its NPCs upgraded so that their emotional states are largely expressed through their responses to events, based on their personality. The personality of a Sim determines the activities it likes/dislikes, while the emotional state of a Sim may influence how effective it is at performing a task. (**Rose**)

3.9 Monolith Productions' Middle Earth: Shadow of Mordor

Through their Nemesis System, Monolith Productions enabled the NPCs of Middle Earth: Shadow of Mordor (2014) to remember their encounters with the player's character. The NPCs may also take advantage of the situations that arise from each others' encounters with the player's character. This permits NPCs to rise through their group's ranks of the game, to taunt the player, or to be more challenging in a later encounter. Furthermore, these encounters form a relationship between the player's character and those that have been encountered. This relationship is reflected back to the player in later encounters, through the NPCs' actions and through what they say. (**Monolith**)

4 Mimetic Emotions

Mimetic Emotions can be defined by various artificial emotion aspects and artificial intelligence operations that produce results mimicking human affects. The Mimetic Emotion System was developed as the underlying system that realizes Mimetic Emotions for the NPC of this thesis' accompanying game, Trader. This system defines the primary technical aspects and operations required to produce Mimetic Emotions.

The goal of the Mimetic Emotion System is to provide a working example of the conceptual foundation that could be applied for further developments in creating more emergent behavior in NPCs. As such, this paper outlines the conceptual purpose of each component of Mimetic Emotions, as well as the Mimetic Emotion System's technical implementations of those components. Communications with an external system, such as Trader's NPC's system, are noted throughout the technical implementations.

4.1 Concepts

These concepts are components that define the 'what' of Mimetic Emotions. They are the aspects of Mimetic Emotions, which may be used individually or collectively by an NPC. Each aspect is almost a direct representation of an aspect of human affects or mental processes.

4.1.1 Emotion

Emotion plays several vital roles in humans. In recent years one of the most important discoveries regarding emotions has been their influence in decision making. Emotions that are expected to occur in the future strongly influence the choice of an action, while emotions experienced at the time of making a choice can indirectly impact the perceived probabilities of certain outcomes and directly affect which actions are considered to be options (Loewenstein and Lerner). Generally, the brain makes a choice among alternatives by choosing the more emotionally prominent option, thereby acting as a filtering method to enhance decision making (Damasio). Oliveira and Sarmento considered emotion to be a short-lived affect that usually

has a clear pre-condition, is intense and distinguishable, is consciously recognized by the experiencer, and may influence mood.

Different types of emotion produce different affects, many of which optimize choice-making or some other mental faculty in a manner that is appropriate to maintain or reach a specified emotional state. Negative emotions lead to choice making where a single attribute of several alternatives is considered at a time. This often results in more extensive processing of the alternatives or the simple choice of the status quo (Luce et al.). The justification here would be that negative emotions, such as sadness and fear, are occurring as a result of poor past choices. In these situations, more careful planning may be the solution (Oliveira and Sarmento).

However, in emotional situations of high arousal, decision makers are likely to be less accurate, presumably due to the (perceived) lack of time (Luce et al.). Fear and anger will also alter an individual's risk estimates. Those experiencing fear will be more pessimistic in their estimates, attempting to avoid risky choices, while those feeling anger will be more optimistic, basically becoming risk seekers (Lerner and Keltner).

On the other hand, positive emotions indicate that an individual has recently been successful in achieving his/her goals. This leads to a more heuristic processing strategy, where pre-existing knowledge is used to estimate the overall benefit of an alternative which is then used in direct comparison with other alternatives. This tends to lead to faster decision making that favors those that were recently used or were known to be beneficial when last used.

As an expected beneficial choice is already known, the decision maker is free to fulfill other tasks or consider additional options (Oliveira and Sarmento). This mental freedom allows for improved performance on tasks that require some form of creative ingenuity, including problem solving (Isen). Overall, the cognitive processes of positive emotions are more flexible, innovative, and creative, as well as thorough and efficient (Isen).

Memories are altered by the emotion felt at the time of the memory. If the event that took place was highly emotional, then the details around the central activity in the event are enhanced, while other details are undermined. This loss in non-central details is greater than the enhancement of central details. The addition of emotion also seems to slow the process of

forgetting (Burke et al.). When considering these emotional events, the emotional peaks and ends of the event are most easily recalled with the overall timespan of the event being neglected (Hsee and Hastie). The memories that are most easily remembered are those that match the current feeling of the individual, leading to the possibility of additional bias in decision making (Marreiros et al.).

In summary, emotions are short-lived, highly influential affects that guide immediate decisions through active mental processes, mid-term decisions through shifts in mood, and long-term decisions through associations with memories. The primary purpose of emotion is to optimize choice-making and encourage behavior that makes progress toward an equilibrium (Plutchik). Emotions may also cause attention narrowing (in the moment and in memory) and can affect the accessibility of memories associated with a specific emotion (Burke et al.).

4.1.2 Mood

Moods generally seem to affect risk/reward evaluation and probabilities. Bower and Wright found that a sad (mood) individual is more pessimistic, reporting less favorable probabilities for the occurrance of a desired event and a higher probability for the occurrance of a negative event. Sadness can also cause an individual to look towards high-risk/high-reward options, seeking an implicit goal of reward replacement, while anxious individuals favor low-risk/low-reward options to reduce uncertainty (Raghunathan and Pham). Happy individuals report the opposite of sad individuals for the probability of an event occurring (Wright and Bower).

Oliveria and Sarmento considered that moods may not have a clear pre-condition, may remain unconscious to the experiencer, may be caused by an intense emotion or vaguely perceived environmental factors, and may last anywhere from a few hours to a few days. These details present moods as the primary influencers of behavior when there is no extremely strong emotion active. Given that mood can change rapidly in response to a strong emotion, it could be argued that most decision making can be based off of the current state of the mood alone.

4.1.3 Personality

Personality, as it will be considered for Mimetic Emotions, is the combined traits of an individual. These traits manifest as inherent motivations, common behaviors, methods of thinkings, and emotional tendencies (McCrae and John). For example, an individual described as highly anxious will, when no emotions or direct influences are in effect, gravitate towards a train of thought that promotes some amount of anxiety.

Personality can also influence the change of emotion or the choice of behavior at a given time. An individual considered to be trusting might choose a behavior that places faith in a less reliable person more often than the average individual would. The dimensions of personality are described in section 2.1. For Mimetic Emotions, personalities are formed and altered over the lifetime of an individual, generally moving towards the most commonly experienced mood.

4.1.4 Relationships

One of the goals of Mimetic Emotions is to allow for emergent social situations, a pre-requisite of which may be the ability for various social transactions to occur between characters (Berne). To do so, an NPC must have a sense of its relationships with other characters. A relationship could be considered a mental representation of another individual, forming from the moment when one individual meets another, and includes the lack of representation by one member of the relationship (one-sided relationships). This representation comes to incorporate all positive and negative information, in the form of beliefs, into one's view of that individual. New feelings, judgements, and experiences constantly update one's view (Ortony et al.).

These mental representations can be realized as an emotion that one character attributes to the existence of another. For Mimetic Emotions, such an emotional disposition is represented by a point in PAD space and is determined by a function that combines the emotional value of abstract memories associated with the individual's current emotional state. This is currently assumed to be a novel approach to the representation of artificial agent relationships.

Such relationships also include a sense of familiarity. This familiarity is determined by how long characters have been around one another. Its purpose is to enable a character's impression

of another character to be formed primarily by interactions that occur when familiarity is low, while also enabling corrections in impression when mid-term or long-term interactions differ from the initial interactions. Essentially, familiarity exists to permit concepts such as a bad or good first impression, where mostly insignificant interactions are interpreted as significant in a new relationship, but are retrospectively considered less significant as familiarity increases.

4.1.5 Past

The past of an individual, in terms of Mimetic Emotions, consists of all recallable memories of that individual. A memory consists of an event that happened to or around the individual, how the individual felt prior to, during, and after that event, as well as who/what was involved in that event. Given that a strong emotion can slow the process of forgetting a memory (Burke et al.), and that the most accessible memories are those with emotions similar to an individual's current emotion (Marreiros et al.), it follows that memories themselves may be strongly associated to the emotions experienced when they occurred.

The most easily recalled memories can thereby be filtered by an individual's current emotion and memories of weak emotions can be forgotten more quickly than those of strong emotions. This strategy is applied to an NPC with Mimetic Emotions. Such an NPC's past will consist of memories pruned by time with consideration of their associated emotion's strength, with those memories associated with emotions most similar to the NPC's current emotion being the first to be analyzed for emotional dispositions and emotional heuristics.

4.1.6 Progression

Several emotions of the OCC Model can only be the result of a valenced reaction's evaluation if the evaluator has a set of outcomes that it considers desirable or undesirable (section 2.2). As such, an NPC should possess such outcomes to best evaluate valenced reactions. These outcomes should have success, fail, and in-progress states, in addition to a value of desirability/undesirability. They should be modeled after the goals that humans, in the position of the NPC, might strive towards.

Examples of such outcomes may be a desire to not die, a desire to make money, or a desire to help or hurt another character. The progression of an NPC consists of all such outcomes as well as the relations between those outcomes. ERIC (section 3.2) evaluated such relations with classifications of 'leadsto', 'hinders', 'supports', and 'contradicts'. Mimetic Emotions support such classifications, in addition to parent/child relationships, however, for simplicity, this thesis' implementation does not take advantage of doing so.

4.2 Implementations

These implementations are modules of the Mimetic Emotion System that define the 'how' of Mimetic Emotions, fulfilling many of the details outlined in the concepts. They define the operations of Mimetic Emotions; performing tasks that update the realized concepts with respect to world events and the concepts' internal relationships. Each module encapsulates a part of the human psyche that contributes to affective processes. An NPC's Mimetic Emotions are completely updated for one calculation frame once all of the following modules, processing in the order listed, have finished their operations.

4.2.1 Awareness

The Awareness module handles the transferring of world events into the consciousness of a character with Mimetic Emotions. For this to occur, the system utilizing the Mimetic Emotion System must first register world events as occurring with a cause (a character) and its affected characters/objects. Awareness evaluates such events, adds them to the appropriate characters' sense of personal reality, and converts them to percepts.

Each percept is an event with personalized information for the experiencer of the event. A percept includes the event and an evaluated affect strength, which is based on how far away the event occurred from the experiencer. Percepts are the input analyzed by the next module, Analysis.

4.2.2 Analysis

The Analysis module analyzes provided percepts of a character to determine how that character should be affected by recent world events. The first step in this process is for percepts to be filtered through attention narrowing, which is based on to what extent the character's current emotion is pleasurable. The reasoning for this filtering is based on negative emotions requiring additional processing in making a decision, leaving fewer mental resources available for incoming perceptions. The Newtonian Emotion System employed attention narrowing as well (section 3.5).

Once the percepts have been filtered, each of the remaining is considered for the effect it may have upon the desired/undesired outcomes of the character. These considerations produce valenced reactions, which consist of the event and the anticipated effects upon the character's outcomes. Such effects include expected changes to an outcome's desirability and probability. These effects are calculated heuristically, or precisely if possible, based on the character's most relevant and strongest memories, as filtered by the character's current emotion. The resulting valenced reactions are used for emotion calculations by the next module, Affect.

4.2.3 Affect

The Affect module is responsible for progressing all affects of an NPC, based on the valenced reactions provided to it. This responsibility breaks down into several main tasks: calculate the resulting emotion for the provided valenced reactions, update the NPC's emotion, update the NPC's mood, update the NPC's personality, and update the NPC's relationships.

Calculating the resulting emotion for provided valenced reactions is accomplished in five steps. The first step is calculating emotions that are based upon the NPCs (if there are any) that caused the valenced reactions. This step will produce one of the following emotions for each valenced reaction: Gratitude, Anger, Gratification, Remorse, Admiration, Reproach, Pride, Shame, or Neutral; as determined through calculations reproducing the logic of the OCC Model, while being influenced by the NPC's emotion and mood.

The second step is to produce emotions that are based on the effects, or anticipated effects,

of each valenced reaction's event. This step will produce, for each valenced reaction, one of the following emotions: Joy, Satisfaction, Disappointment, Distress, Fears-Confirmed, Relief, Hope, Fear, or Neutral. This resulting emotion is determined through calculations reproducing the logic of the OCC Model, while being influenced by the NPC's emotion and mood.

The third step is to produce emotions that are based on the presumed emotions of others that the NPC has a relationship with. Each one of the NPC's relationships results in one of following emotions: Happy-For, Pity, Resentment, Gloating, or Neutral. These emotions are also determined through calculations reproducing the logic of the OCC Model, while being influenced by the NPC's emotion and mood.

The fourth step is to produce emotions for each object/character (other) present near the NPC. Stronger emotions are produced for others with which the NPC is more familiar. Each other results in one of the following emotions: Curious, Inhibited, Liking, Disliking, Love, Hating, or Neutral. These emotions are determined through calculations reproducing the logic of the OCC Model, while being influenced by the NPC's emotion and mood.

The last of the calculation steps is to condense all of the previously produced emotions into a single emotion. This calculation uses a weight associated with each emotion to give stronger emotions more influence. The resulting condensed emotion directly replaces the NPC's previous emotion. The new emotion only resembles the previous emotion through the influences that the previous emotion had upon the calculations in determining the new emotion. This ensures an emotion is short-lived, although perhaps too much so.

The new emotion is considered in updating the NPC's mood. The mood is first decayed from its current state. It is then shifted by the NPC's personality to provide influence in moving towards the stable personality state. Finally, it is influenced by the NPC's new emotion with a push/pull strategy, as was also implemented by ALMA (section 3.1). The new mood is then used to shift the personality of the NPC by a small factor, also through a push/pull strategy.

The final main task of the Affect module is to update the NPC's relationships. An NPC has a relationship with every object and character that it has been near, including itself. Each relationship is represented by an emotion and a value for how familiar the NPC is with the

other.

This task accepts all of the uncondensed emotions, groups them by their relevant other, and produces a condensed emotion for each group (one for each other). When condensing, the influence of each emotion is determined by weight. Each condensed emotion is then used to update the relationship of its associated other, with the influence of the new emotion being determined by how familiar the NPC is with the other; less familiarity creates a greater influence. The last operation of the Affect module is to update the familiarity that the NPC has with each other that was present near the NPC.

4.2.4 Acquisition

The Acquisition module is responsible for acquiring new memories. For each NPC, it is provided all of the emotions calculated by the Affect module, as well as the valenced reactions that evoked those emotions. This module first updates the status of all existing memories; it strengthens memories that were recalled during the processes of the Analysis module and decays the strength of all other memories. Memories whose strength falls below a certain threshold are removed from the NPC's past, thereby being forgotten.

For each valenced reaction, a new memory is formed. The memory is associated with the emotion evoked by its valenced reaction and the resulting emotion of the NPC, which is its active emotion when this processing occurs. The strength of the evoked emotion determines the initial strength of the memory.

4.2.5 Aspiration

The last module of the Mimetic Emotion System is the Aspiration module, which is responsible for updating an NPC's progression. This module updates the perceived, or actual when possible, probability of each outcome being fulfilled. It also updates the measurable completion of each outcome. This module's last step is to update each outcome with a newly calculated desirability/undesirability. The specifics of each of these steps is delegated to the NPC's specific implementation.

5 Trader

To analyze the potential of Mimetic Emotions, the Mimetic Emotion System was implemented in a video game called Trader. Trader features a single NPC, the trader, with Mimetic Emotions. The personality of the trader can be set on a setup screen before the game begins. The trader's personality influences the base state of her mood and emotion, as well as the desirability of most of her outcomes; therefore it is the primary factor in causing variations in the emergent behavior of the trader.

The objective of the game is for the player to successfully buy the 'priceless amulet' from the trader. The game includes gold as a currency and several items that can be bought from and sold to the trader. The player can find a limited number of items and gold by going on adventures.

A secondary goal is for the player to not lose all of their health, which can occur during adventuring or when interacting with the trader. Health can be restored through the use of health potions, and damage from adventuring can be mitigated by having better weapons, armor, and magic items. Adventuring can change the trader's mood, as the trader will lack the player's emotional influence while the player's avatar is not near the trader.

Buying and selling is accomplished through bartering. The value of any item that the player wishes to buy or sell is not listed, but must be anticipated based on the the current mood of the trader. For example, a health potion may have a base price of 10 gold. The player may be able to purchase the potion for 8 gold if the trader's mood is very docile, relaxed, dependent, or exuberant. The player may have to pay as much as 12 gold if the trader's mood is very anxious, bored, disdainful, or hostile.

The trader's emotions can be influenced through failed/successful trades and through interactions. The player's available interactions include: Compliment, Offer Help, Small Talk, Complain, Insult, Threaten, Steal, and Attack. Each interaction influences the trader's sense of accomplishment in its outcomes. The interactions of Steal and Attack have additional effects. Steal attempts to take an item, which the trader can either allow or reject, by taking the item

back, possibly attacking the player in response. Attack damages the trader's health; an injured trader may attack the player back. The responses of the trader are determined by her mood immediately after the player's action is completed. As such, the trader's behavior is defined by the results of the Mimetic Emotion System.

Figure 2: The video game, Trader; the main screen after the player chose to 'Offer Help' (top) and the adventure screen (bottom). Background pixel art used with the permission of the artist, 'Sohei' (http://pixeljoint.com/p/12873.htm). Original emoticons created by Austin Condiff from the Noun Project.

The trader has four outcomes. She desires to improve her financial standing, she desires to be effective at her job, she desires to be effective socially, and she finds it undeseriable to lose all of her health. The desirability of the first three varies by the trader's personality, updating for any changes in personality that occur during play-time, as per the Mimetic Emotion System. Change in the trader's sense of accomplishment for these outcomes produces affective changes, as determined by the Mimetic Emotion System.

For every interaction and failed/successful trade, an emoticon is shown to display the trader's new emotion. When the player returns from an adventure, an emoticon is shown to display the trader's current mood. These emoticons, paired with response messages, provide feedback to the player, so that they may know the current/changing state of the trader.

It is vital that the player know the state of the trader and be able to manipulate it through trading and interactions. The base price of the priceless amulet is greater than all gold achievable in the game, but it is affordable if the trader's mood is very dependent, docile, exuberant, or relaxed. These game mechanics and the setup of Trader have been designed to provide a simple, but fully functional, game that features an NPC with Mimetic Emotions.

6 Hypotheses and Tests

The intended potential of Mimetic Emotions is defined through the following hypotheses. Each hypothesis covers scenarios that must be proved to declare that emergent behavior can be enabled through the implementation of Mimetic Emotions. The tests and each test's playthroughs, in Trader, are described for each hypothesis.

6.1 Personality-Based, Emergent Affective States

Hypothesis

Based on her initial personality, the NPC of Trader will exhibit emergent affective states in response to the same set of player interactions.

Test Process

Multiple playthroughs were performed, with different initial personality settings and in which the player performs the same set of interactions in as close to the same elapsed time as possible. Each playthrough's affectives state changes over time were recorded. The starting states, ending states, and average states were compared across playthroughs; along with graphs showing the affective state changes over singular playthroughs.

Playthrough Details

The various personality settings used across this hypothesis' four playthroughs are:

- Primarily Social - Agreeableness: 0.5, Conscientiousness: -0.25, Extraversion: 0.75, Neuroticism: -0.25, Openness: 0.25
- Primarily Unsocial - Agreeableness: -0.25, Conscientiousness: 0.5, Extraversion: -0.75, Neuroticism: 0.25, Openness: -0.25
- Primarily Unselfish - Agreeableness: 0.75, Conscientiousness: -0.25, Extraversion: 0.25, Neuroticism: -0.5, Openness: 0.5

- Primarily Selfish - Agreeableness: -0.75, Conscientiousness: 0.25, Extraversion: -0.25, Neuroticism: 0.5, Openness: -0.5

The interactions to be used for the four playthroughs are, in order: Small Talk, Compliment, Adventure, Sell all Herbs (1 gold each), Adventure, Sell first Apple (4 gold, fail), Sell all Apples, (2 gold each), Complain, Small Talk, Offer Help, Adventure, Buy Gloves (11 gold), Sell all Herbs (1 gold each), Insult, Threaten, Adventure, Small Talk, Buy Health Potion (12 gold), Adventure, Sell all Apples (2 gold each), Steal, Adventure, Complain, Insult, Buy Iron Sword (22 gold)

6.2 Interaction-Based, Emergent Affective States

Hypothesis

Based on the variance in the player's interactions throughout a playthrough, the NPC of Trader will exhibit emergent affective states despite the same initial personality setting.

Test Process

Multiple playthroughs were performed, with the player performing a different set of interactions, or the same set with a different amount of time elapsing between interactions, and in which the initial personality setting was always the same. Each playthrough's affective state changes were recorded. The starting states, ending states, and average states were compared across playthroughs; along with graphs showing the changes over singular playthroughs.

Playthrough Details

The various sets of interactions (excluding health potions, which are used as needed) across this hypothesis' five playthroughs are:

- Composite, Kind-at-First (in order) - Small Talk, Compliment, Adventure, Sell all Herbs (1 gold each), Adventure, Sell first Apple (4 gold, fail), Sell all Apples, (2 gold each), Complain, Small Talk, Offer Help, Adventure, Buy Gloves (11 gold), Sell all Herbs

(1 gold each), Insult, Threaten, Adventure, Small Talk, Buy Health Potion (12 gold), Adventure, Sell all Apples (2 gold each), Steal, Adventure, Complain, Insult, Buy Iron Sword (22 gold)

- Composite, Mean-at-First (in order) - Insult, Complain, Adventure, Sell all Herbs (1 gold each), Adventure, Sell first Apple (4 gold, fail), Sell all Apples, (2 gold each), Complain, Threaten, Insult, Adventure, Buy Gloves (6 gold, fail), Buy Gloves (11 gold), Sell First Herb (2 gold, fail), Sell all Herbs (1 gold each), Complain, Small Talk, Adventure, Compliment, Offer Help, Buy Health Potion (12 gold), Adventure, Small Talk, Compliment, Sell all Apples (2 gold each), Compliment, Small Talk, Adventure, Small Talk, Offer Help, Buy Iron Sword (22 gold)

- Kind (in order) - Small Talk, Compliment, Offer Help, Adventure, Sell all Herbs (1 gold each), Adventure, Sell all Apples (3 gold each), Compliment, Small Talk, Offer Help, Adventure, Buy Gloves (12 gold), Sell all Herbs (1 gold each), Small Talk, Compliment, Adventure, Small Talk, Buy Health Potion (13 gold), Adventure, Sell all Apples (3 gold each), Compliment, Adventure, Small Talk, Offer Help, Buy Iron Sword (24 gold)

- Cruel (in order) - Insult, Complain, Adventure, Sell all Herbs (1 gold each), Adventure, Sell first Apple (4 gold, fail), Sell all Apples, (2 gold each), Threaten, Attack, Insult, Adventure, Buy Gloves (6 gold, fail), Steal, Buy Gloves (11 gold), Sell Herbs (2 gold each, fail), Attack, Threaten, Adventure, Threaten, Insult, Buy Health Potion (9 gold, fail), Threaten, Buy Health Potion (9 gold, fail), Adventure, Complain, Threaten, Sell all Apples (3 gold each), Insult, Adventure, Insult, Threaten, Buy Iron Sword (15 gold, fail)

- Kind, Extended Time - The same as the Kind playthrough, but with 5 seconds of inactivity occurring after each interaction, and 10 seconds of inactivity occurring when items are found during each adventure.

The personality setting to be used for this hypothesis' five playthroughs is: Agreeableness: 0.25, Conscientiousness: -0.25, Extraversion: 0.5, Neuroticism: 0, Openness: 0.25

6.3 Affective-Based, Game-Defined, Emergent Behavior

Hypothesis

Based on game-specific logic, and in response to player interaction, the NPC of Trader will exhibit emergent behavior that reflects her emergent affective states. As per Trader's game logic, the affective state that will primarily determine the NPC's responses will be mood.

Test Process

The records of all previously defined playthroughs were examined, with the primary affective state (mood) of Trader's NPC being mapped to her responses to the player's interactions. The response-to-state mapping was analyzed for the logical relations between the two.

Playthrough Details

This hypothesis uses the records of the playthroughs for all other hypotheses.

7 Outcomes

8 Conclusions

Works Cited

Bates, Joseph. "The Role of Emotion in Believable Agents." *Communications of the ACM*, 1994, pp. 122–125.

Berne, Eric. *Games People Play: The Psychology of Human Relationships*. Penguin Life London, 2016.

Bolles, Robert C. and Michael S. Fanselow. "A Perceptual-Defensive-Recuperative Model of Fear and Pain." *Behavioral and Brain Sciences*, vol. 3, no. 2, 1980, pp. 291–301.

Burke, Alafair, et al. "Remembering Emotional Events." *Memory & Cognition*, vol. 20, no. 3, May 1992, pp. 277–290.

Damasio, Antonio. *Descartes' Error: Emotion, Reason, and the Human Brain*. Putnam Publishing, 1994.

Gebhard, Patrick. "ALMA." *Proceedings of the Fourth International Joint Conference on Autonomous Agents and Multiagent Systems - AAMAS '05*, 2005.

Hsee, Christopher and Reid Hastie. "Decision and Experience, Why Don't We Choose What Makes Us Happy?" *Trends in Cognitive Science*, vol. 10, no. 1, Jan. 2006, pp. 31–37.

Isen, Alice M. "An Influence of Positive Affect on Decision Making in Complex Situation: Theoretical IUssues with Practical Implications." *Journal of Consumer Psychology*, 2001.

Kessler, Henrik, et al. "Simulation of Personal Emotion Experience." *Affective Computing*, edited by Jimmy Or, I-Tech Education and Publishing, May 2008, chap. 13, pp. 255–270.

Lerner, Jennifer S. and Dacher Keltner. "Fear, Anger, and Risk." *Journal of Personality and Social Psychology*, vol. 81, no. 1, 2001, pp. 146–159.

Loewenstein, George and Jennifer S. Lerner. "The Role of Affect in Decision Making." *Handbook of Affective Sciences*, edited by R.J. Davidson, et al., Oxford University Press, 2003, chap. 31, pp. 619–642.

Luce, Mary Frances, et al. "Choice Processing in Emotionally Difficult Decisions." *Journal of Experimental Psychology: Learning, Memory, and Cognition*, vol. 23, no. 2, 1997, pp. 384–405.

Lungu, Valentin. *Artificial Emotion Simulation Techniques for Intelligent Virtual Characters: A Model of Affective Behaviour*. Rep. no. 2. Polytechnics University of Bucharest, Jan. 2012.

Marreiros, Goreti, et al. "Emotion and Group Decision Making in Artificial Intelligence, Cognitive, Emotive and Ethical Aspects of Decision-Making." *in Humans and in AI vol IV.* Edited by Iva Smit, et al., The International Institute for Advanced Studies in Systems Research/Cybernetics, 2005.

McCrae, Robert and Oliver John. "An Introduction to the Five-Factor Model and Its Applications." *Personality*, vol. 60, 1992, pp. 175–215.

Mehrabian, Albert. "Analysis of the Big-five Personality in Terms of the PAD Temperament Model." *Australian Journal of Psychology*, vol. 48, no. 2, 1996, pp. 86–92.

---. "Framework for a Comprehensive Description and Measurement of Emotional States." *Genetic, Social & General Psychology Monographs*, vol. 121, no. 3, Aug. 1995, pp. 341–362.

Oliveira, Eugénio and Luís Sarmento. "Emotional Advantage for Adaptability and Autonomy." *In Proceedings of the Second International Joint Conference on Autonomous Agents and Multiagent Systems*, ACM, 2003, pp. 305–312.

Ortony, Andrew, et al. *The Cognitive Structure of Emotions*. Cambridge University Press, 1990.

Pereira, Andrea, et al. "iCat: an Affective Game Buddy Based on Anticipatory Mechanisms." *In AAMAS '08: Proceedings of the 7th International Joint Conference on Autonomous Agents and Multiagent Systems - Volume 3*, International Foundation for Autonomous Agents and Multiagent Systems, 2008, pp. 1253–1256.

Plutchik, Robert. "The Nature of Emotions." *American Scientist*, vol. 89, no. 4, 2001, pp. 344–350.

Puetz, Michelle. "Mimesis (1)." *The Chicago School of Media Theory*, The Chicago School of Media Theory, 2002. Web. 20 Feb. 2017. https://lucian.uchicago.edu/blogs/mediatheory/keywords/mimesis/.

Raghunathan, Rajagopal and Michel Tuan Pham. "All Negative Moods Are Not Equal: Motivational Influences of Anxiety and Sadness on Decision Making." *Organizational Behavior and Human Decision Processes*, 1999.

Seif El-Nasr, Magy, et al. “FLAME - Fuzzy Logic Adaptive Model of Emotion.” *Autonomous Agents and Multi-Agent Systems*, vol. 3, no. 3, Sept. 2000, pp. 219–257.

Steunebrink, Bas R., et al. “The OCC Model Revisited.” *The 4th Workshop on Emotion and Computing*, 2009.

Strauss, Martin and Michael Kipp. “ERIC: A Generic Rule-based Framework for an Affective Embodied Commentary Agent.” *In AAMAS ’08: Proceedings of the 7th International Joint Conference on Autonomous Agents and Multiagent Systems*, International Foundation for Autonomous Agents and Multiagent Systems, 2008, pp. 97–104.

Thill, Serge and Robert Lowe. “On the Functional Contributions of Emotion Mechanisms to (Artificial) Cognition and Intelligence.” *Artificial General Intelligence Lecture Notes in Computer Science*, 2012.

Wright, William and Gordon Bower. “Mood Effects on Subjective Probability Assessment.” *Organizational Behavior and Human Decision Processes*, vol. 52.2, 1992, pp. 276–291.