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

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Abstract

THE POTENTIAL OF MIMETIC EMOTIONS FOR NON-PLAYER CHARACTERS WITH EMERGENT, PERSONALITY-DEFINED, BEHAVIOR

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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 and player interactions. These analyses prove that Mimetic Emotions can be applied to provide emergent behavior defined through the personality settings of a game's non-player characters.

Keywords: mimetic emotions, Big-Five personality Model, PAD Scales, OCC Model, mimetic emotion system, artificial emotions, Trader, 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 tailored 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 8).

As such, a mimetic NPC should appear reactive, to have goals, to have emotions, and to have some level of contextual social competence (Bates 6).

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 176). 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. Mimetic Emotions follow the OCC model for making such determinations. 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 (Ortony et al.).

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.

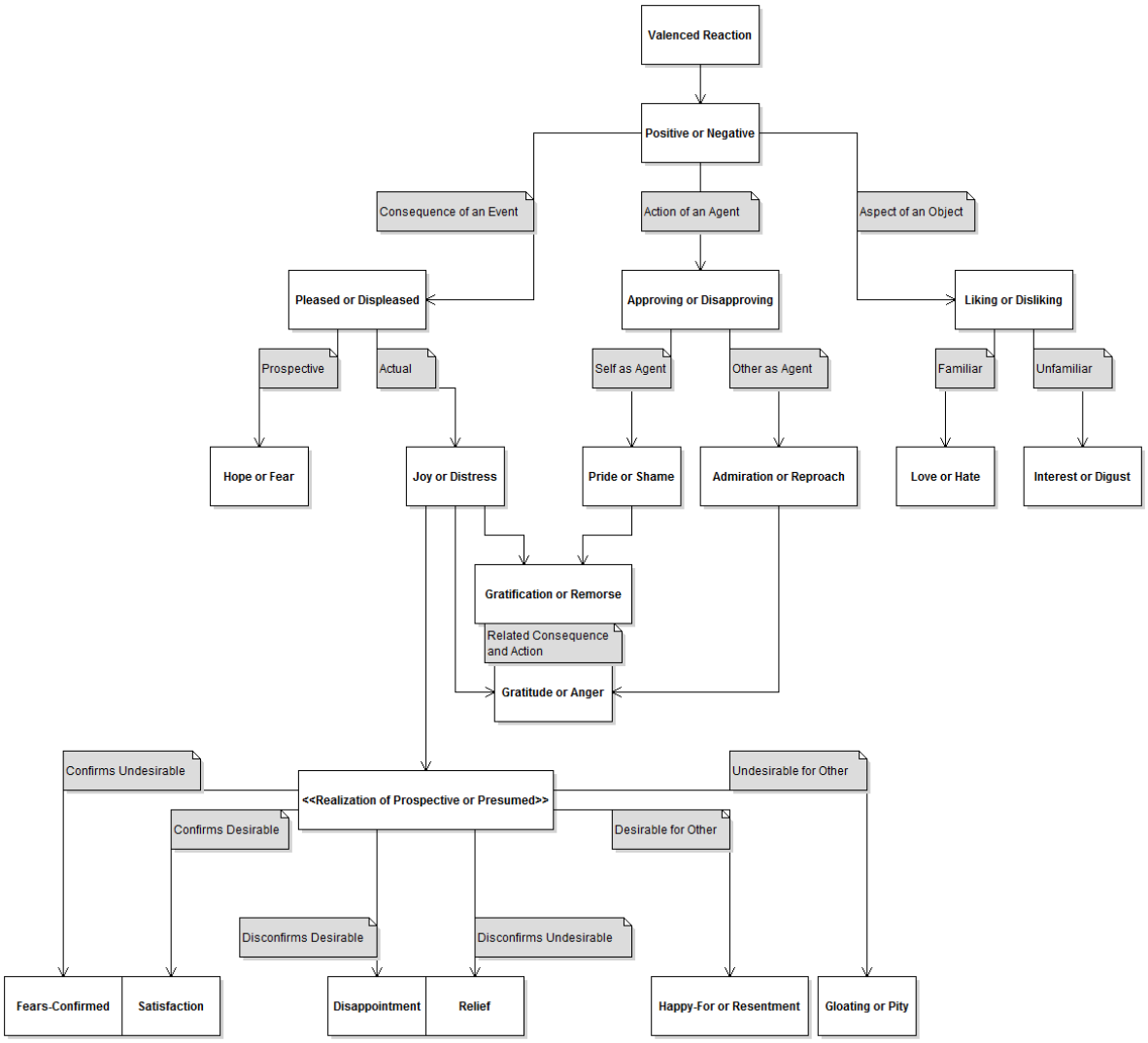

Figure 1: The revised OCC Model.

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"):

- **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.

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

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 620). 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. 403). 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. 402). 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. 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. 286). 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. 289).

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 176). 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. 286), 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); (Sohei) (Condiff).

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 and ending 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 (18 gold), Sell all Herbs (1 gold each), Insult, Threaten, Adventure, Small Talk, Buy Health Potion (14 gold), Adventure, Sell all Apples (2 gold each), Steal, Adventure, Complain, Insult, attempt to Buy Iron Sword (24 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 and ending 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:

- Kind-at-First (in order) - Small Talk, Compliment, Adventure, Sell all Herbs (1 gold each), Adventure, Sell all Apples, (2 gold each), Compliment, Small Talk, Offer Help, Adventure, Buy Gloves (13 gold), Sell all Herbs (1 gold each), Insult, Threaten, Adven-

ture, Complain, Buy Health Potion (6 gold, fail), Insult, Buy Health Potion (12 gold), Adventure, Threaten, Sell Apple (4 gold, fail), Insult, Threaten, Sell Apple (4 gold, fail), Attack, Steal, Adventure, Attack, Threaten, attempt to Buy Iron Sword (22 gold)

- Mean-at-First (in order) - Insult, Complain, Adventure, Sell Herbs (3 gold, fail), Adventure, Sell Apple (5 gold, fail), Threaten, Sell Apple (4 gold, fail), Threaten, Sell Apple (3 gold, fail), Attack, Insult, Adventure, Buy Gloves (6 gold, fail), Attack, Complain, Sell Herbs (3 gold, fail), Sell all Herbs (1 gold each), Buy Gloves (15 gold), Complain, Small Talk, Adventure, Sell all Apples (2 gold each), Compliment, Offer Help, Buy Health Potion (12 gold), Adventure, Sell all Apples (2 gold each), Small Talk, Compliment, Small Talk, Adventure, Small Talk, Offer Help, attempt to Buy Iron Sword (22 gold)

- Kind (in order) - Small Talk, Compliment, Adventure, Sell all Herbs (1 gold each), Adventure, Sell all Apples, (2 gold each), Compliment, Small Talk, Offer Help, Adventure, Buy Gloves (13 gold), Sell all Herbs (1 gold each), 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, attempt to Buy Iron Sword (24 gold)

- Cruel (in order) - Insult, Complain, Adventure, Sell Herbs (3 gold, fail), Threaten, Sell Herbs (3 gold, fail), Attack, Adventure, Sell Apple (5 gold, fail), Threaten, Sell Apple (4 gold, fail), Threaten, Sell Apple (3 gold, fail), Attack, Insult, Adventure, Buy Gloves (6 gold, fail), Attack, Threaten, Adventure, Complain, Buy Health Potion (6 gold, fail), Insult, Buy Health Potion (10 gold, fail), Adventure, Threaten, Sell Apple (4 gold, fail), Insult, Threaten, Sell Apple (4 gold, fail), Attack, Steal, Adventure, Attack, Threaten, attempt to Buy Iron Sword (22 gold)

- Mean-at-First, Extended Time - The same as the Mean-at-First playthrough, but with 5 seconds of inactivity occurring after each interaction listed, 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: 0.5, Conscientiousness: 0.5, Extraversion: 0.25, Neuroticism: 0.25, 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 hard and soft responses to the player's interactions. Hard responses are classified as being purely determined by the NPC's current affective state classification, regardless of the extent that the NPC embodies that classification; e.g., whether the NPC's current mood is barely considered hostile or is substantially hostile, she will provide the same response. All textual responses in Trader are hard responses. Soft responses are classified as being determined by how much the NPC embodies a specified state. All responses to trade attempts, whether the amount offered/requested is acceptable, are soft responses. 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

The outcomes of tests performed for the hypotheses outlined in Chapter 6 are detailed here. These outcomes include graphs, tables, screenshots, and analyses necessary to support or disprove the hypotheses with quantifiable evidence. Section 7.1 covers the outcomes for the hypotheses described by Sections 6.1 and 6.2, while Section 7.2 covers the outcomes for the hypothesis outlined by Section 6.3.

7.1 Affective State Changes

As per the test processes for the hypotheses outlined in Chapter 6, the affective states of each playthough were recorded. The changes in states over time are shown by the following graphs, organized by playthrough. A brief overview of the affective changes is provided for each playthrough, noting the most significant details of that playthrough and its major differences in comparison to other playthroughs.

It should be noted that large 'U'-shaped or 'n'-shaped segments in Mood/Emotion graphs usually occurred when the player went on an adventure. Small spikes are generally associated with interactions that have little individual consequence. Several such spikes in quick succession can appear as cascading lines merged together. This most commonly occurs from the selling/buying of multiple items.

Primarily Social

This playthrough's personality generally welcomed the player's interactions. The NPC was consistently in a pleasurable, aroused, and dominant affective state (an Exuberant mood), with all aspects of her personality being encouraged to remain unchanged or become more positive. However, she was reliant on the player's presence for much of her positive emotion/mood.

Her relationship with the player was generally stable. She liked the player enough that she was able to mostly overlook the negative actions of the player towards the end of the playthrough.

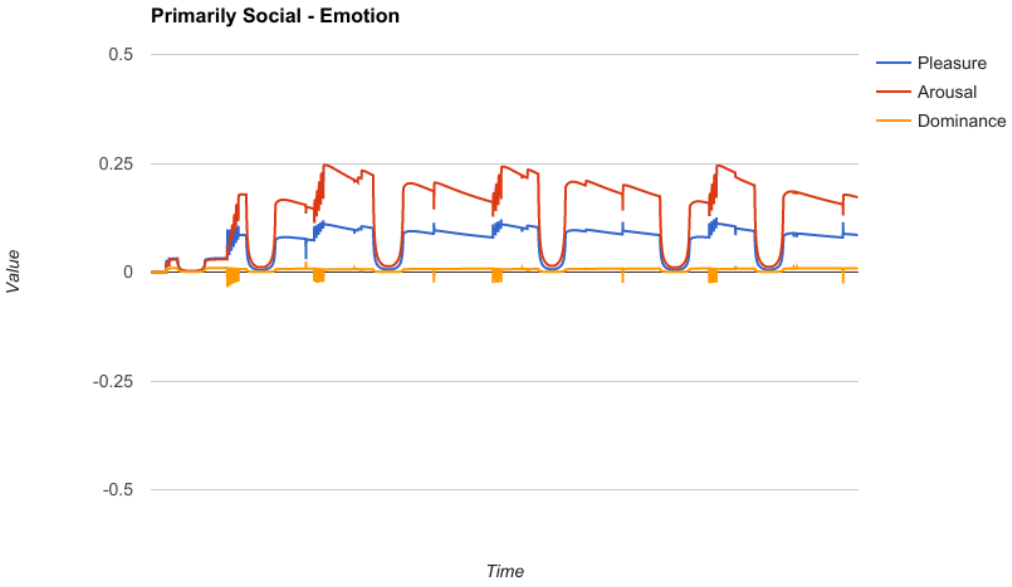

Figure 3: Emotion State Changes of the Primarily Social Playthrough.

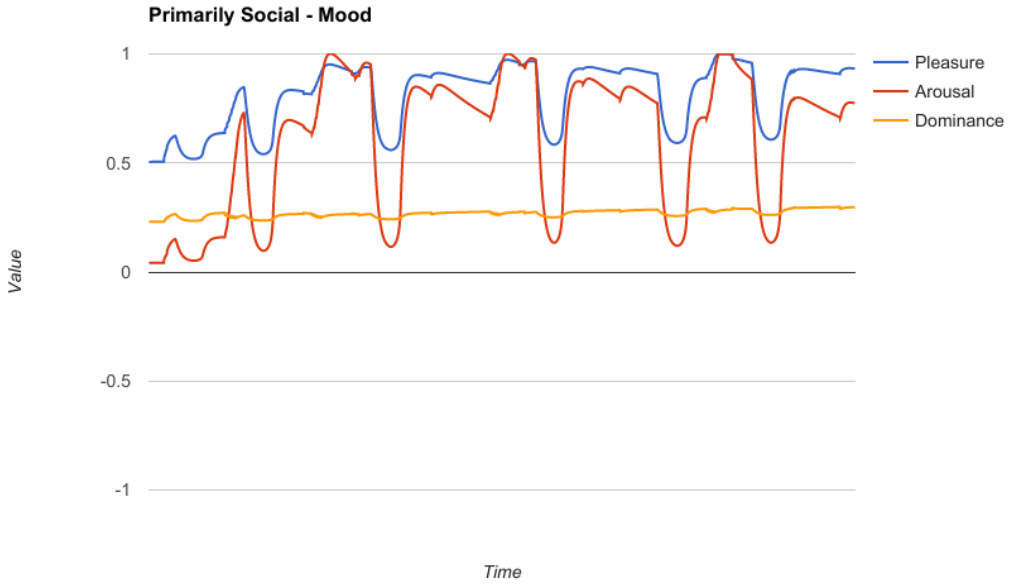

Figure 4: Mood State Changes of the Primarily Social Playthrough.

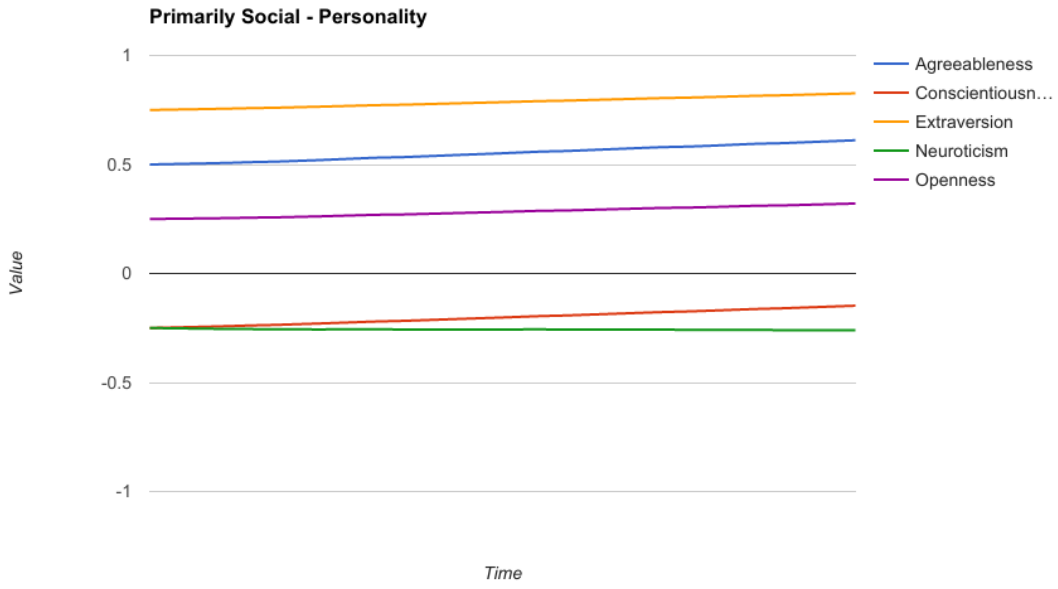

Figure 5: Personality State Changes of the Primarily Social Playthrough.

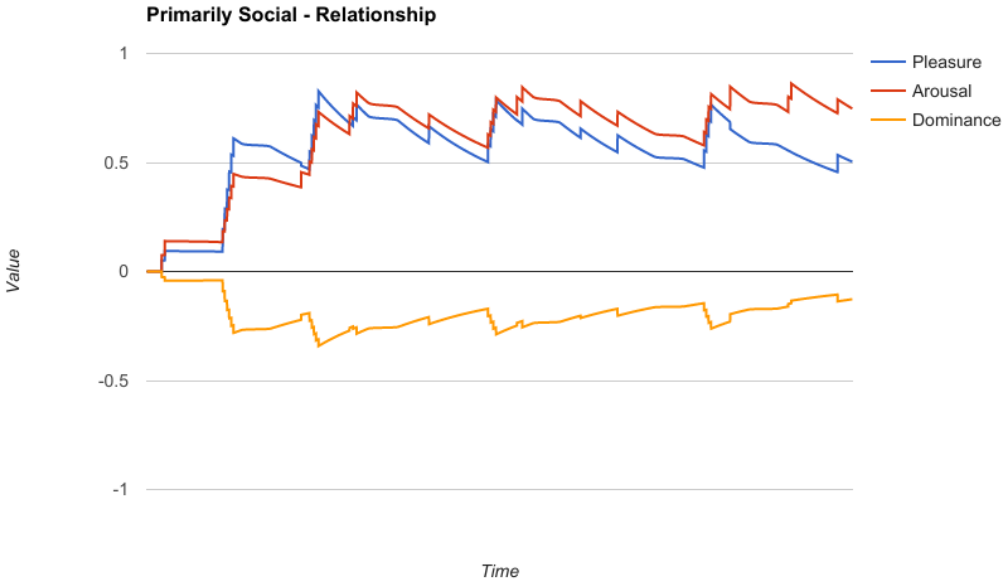

Figure 6: Relationship State Changes of the Primarily Social Playthrough.

Primarily Unsocial

The Primarily Unsocial playthrough's NPC was emotionally balanced with little dependency on the player's presence. The only dimension significantly impacted by the player's presence was arousal. This is further apparent through how little the NPC's personality changed throughout the playthrough.

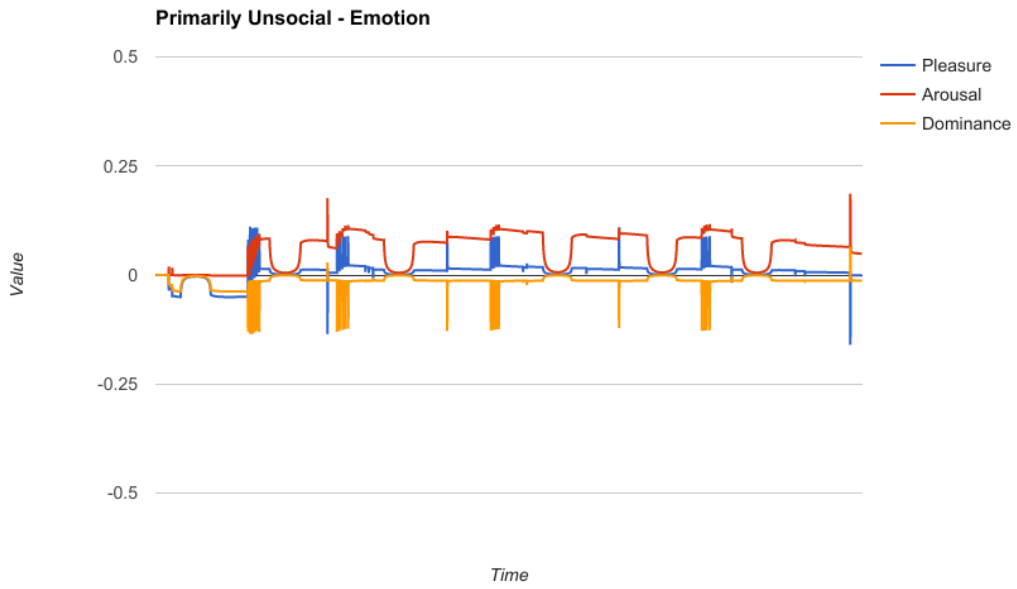

Figure 7: Emotion State Changes of the Primarily Unsocial Playthrough.

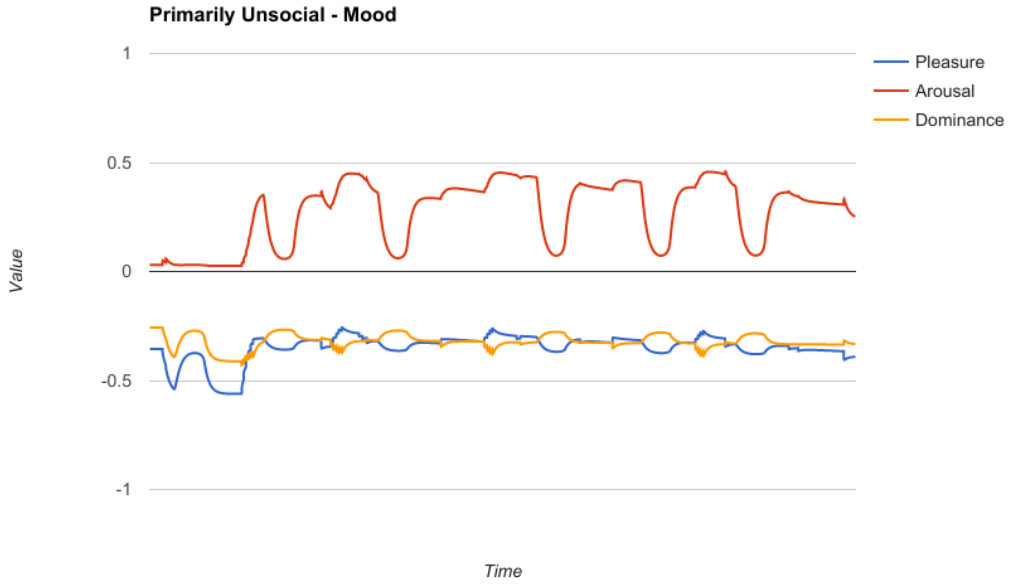

Figure 8: Mood State Changes of the Primarily Unsocial Playthrough.

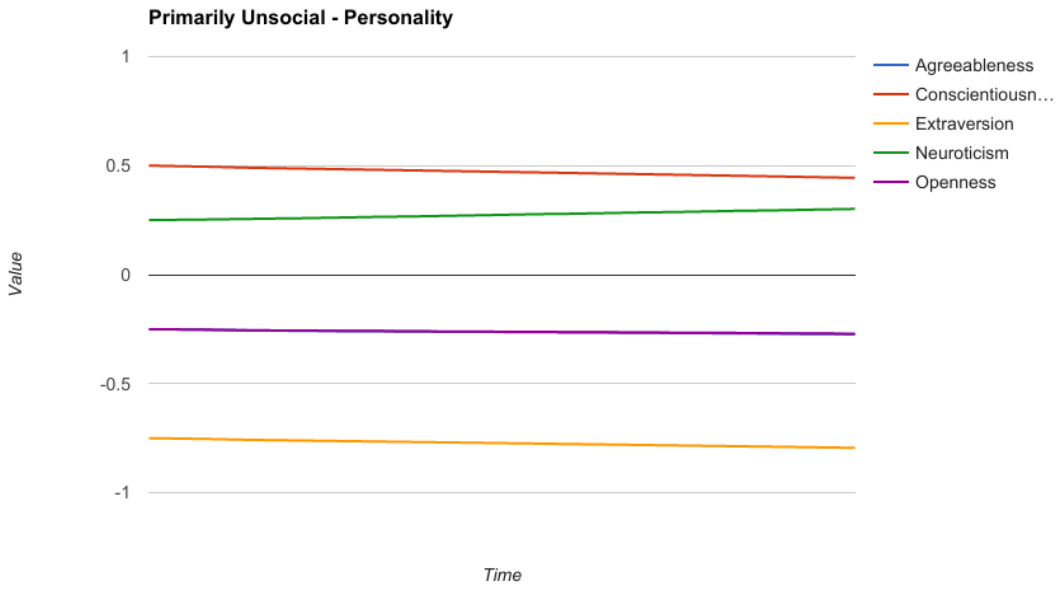

Figure 9: Personality State Changes of the Primarily Unsocial Playthrough. The Agreeableness line is barely visible under the Openness line.

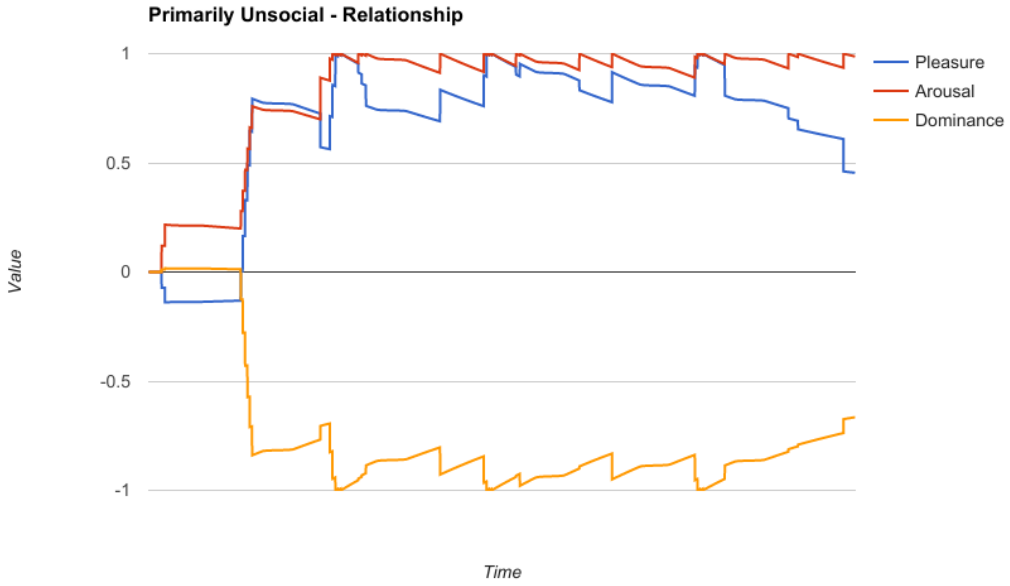

Figure 10: Relationship State Changes of the Primarily Unsocial Playthrough.

Primarily Unselfish

Similar to the Primarily Social playthrough, this playthrough's NPC was highly dependent on the player. This is notable not only through the large swings in state when the player would go on an adventure, but also by the NPC's mood being in the Dependent state for the entirety of the playthrough. This playthrough was generally positive with little change occurring as a result of the player's negative actions. The NPC's personality's Agreeableness dimension was strongly encouraged to grow more positive, due to the highly pleasurable and low dominant affects.

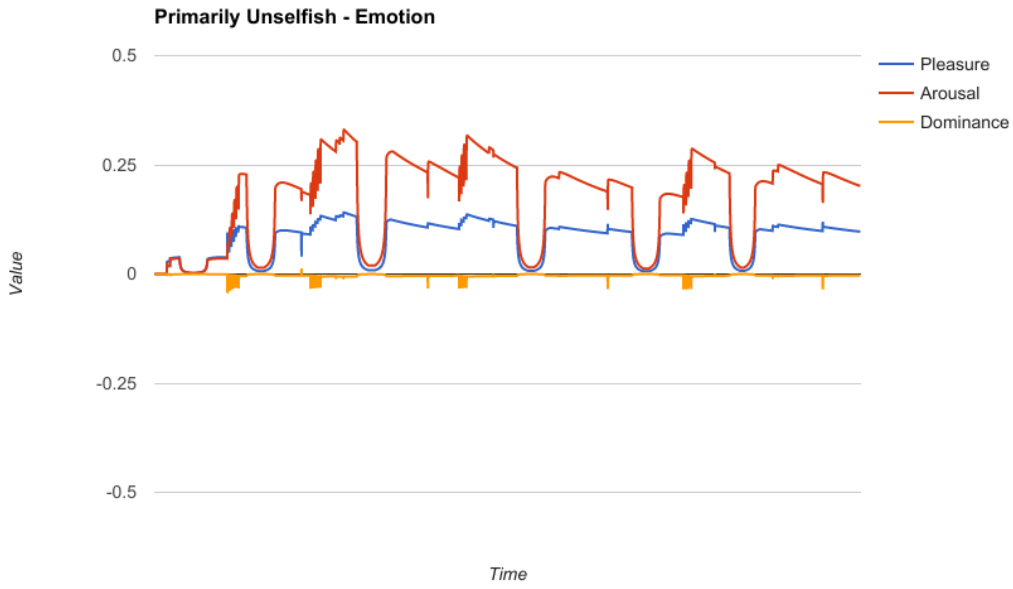

Figure 11: Emotion State Changes of the Primarily Unselfish Playthrough.

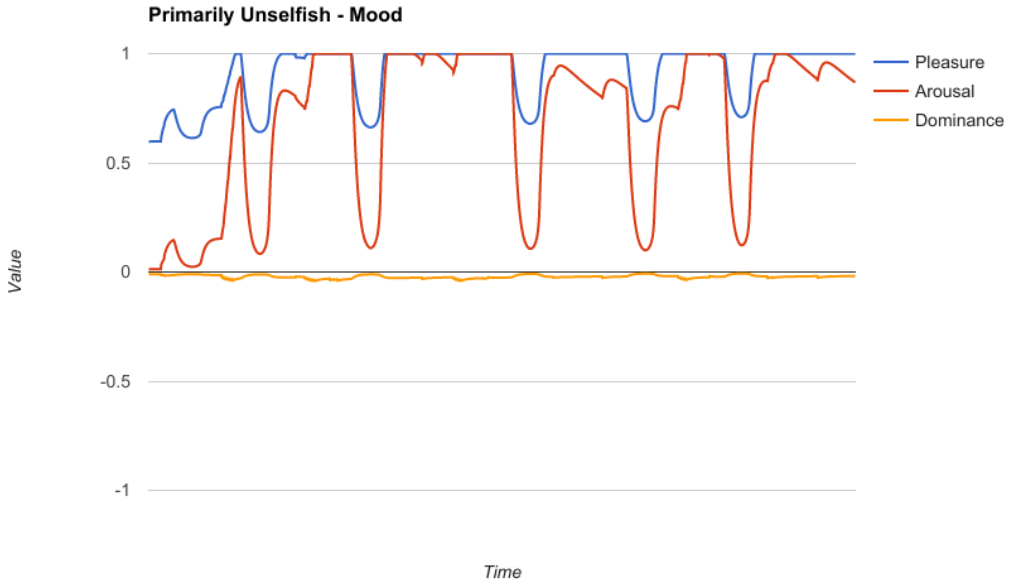

Figure 12: Mood State Changes of the Primarily Unselfish Playthrough.

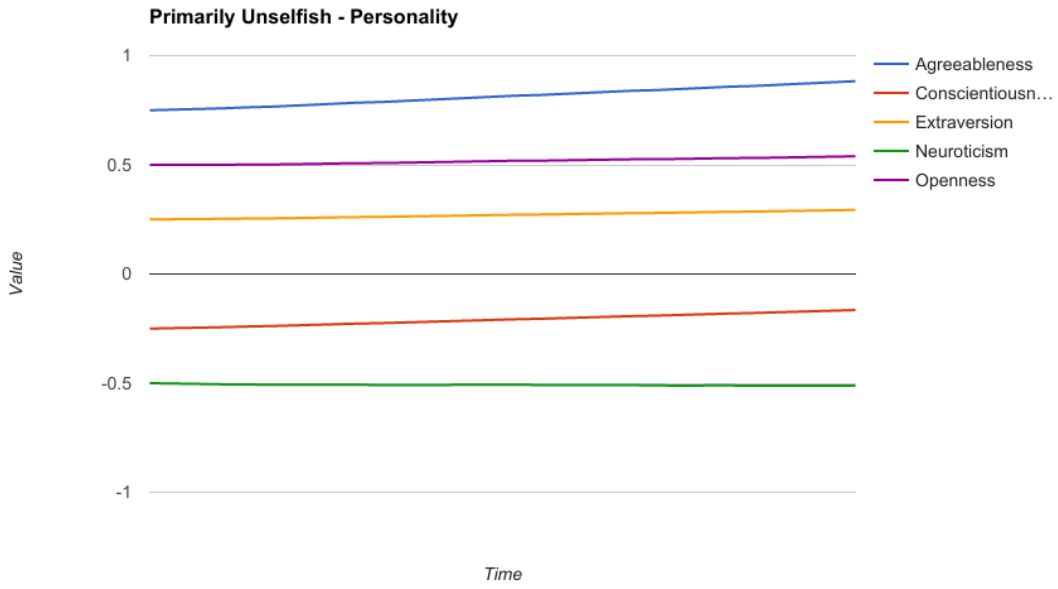

Figure 13: Personality State Changes of the Primarily Unselfish Playthrough.

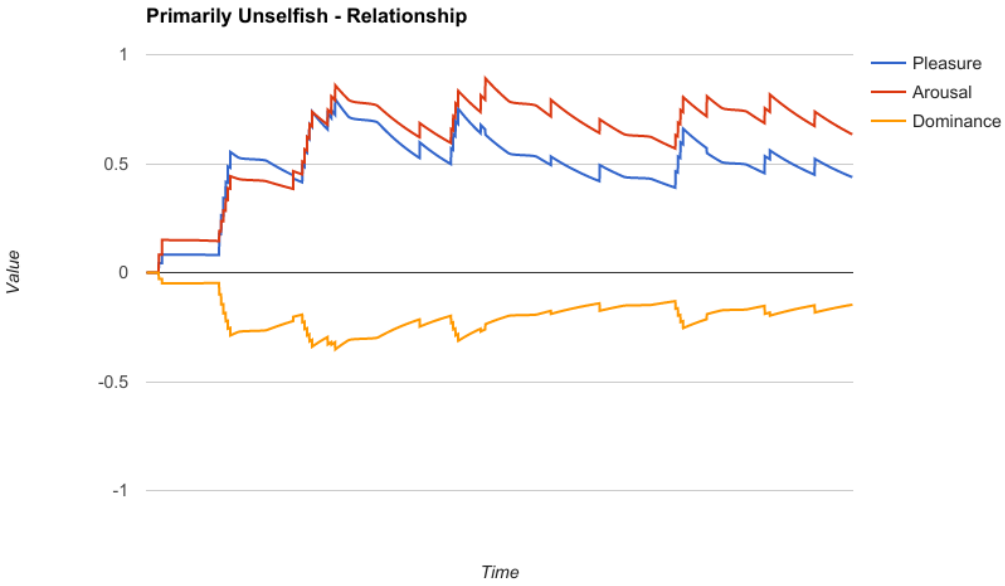

Figure 14: Relationship State Changes of the Primarily Unselfish Playthrough.

Primarily Selfish

This playthrough was similar to the Primarily Unsocial playthrough, but the NPC had a far more dominant mood. This resulted in her mood being in the Hostile state for almost the entire playthrough. Her personality reflected this state by steadily decreasing in Conscientiousness and Agreeableness, with a persistent increase in Neuroticism.

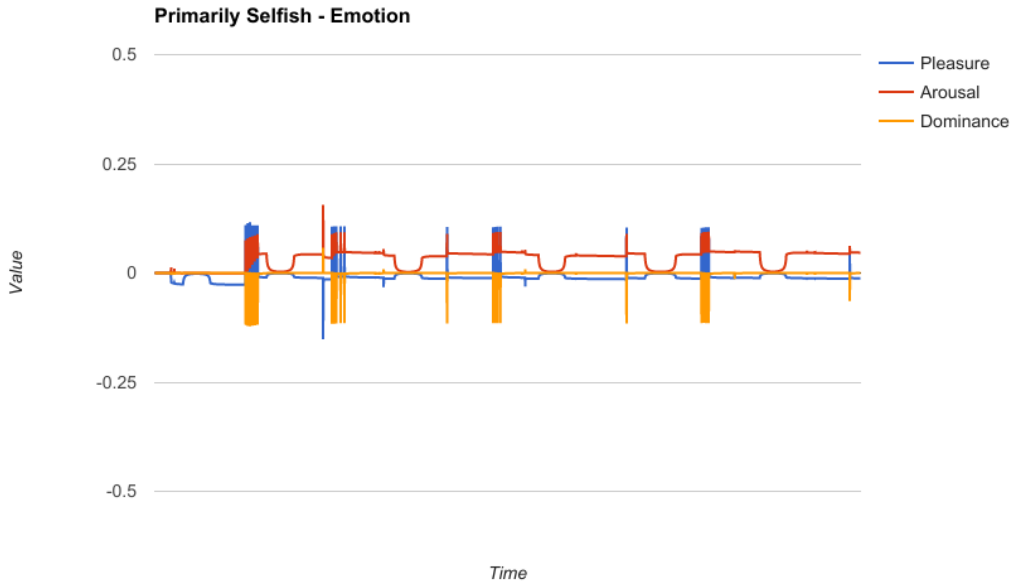

Figure 15: Emotion State Changes of the Primarily Selfish Playthrough.

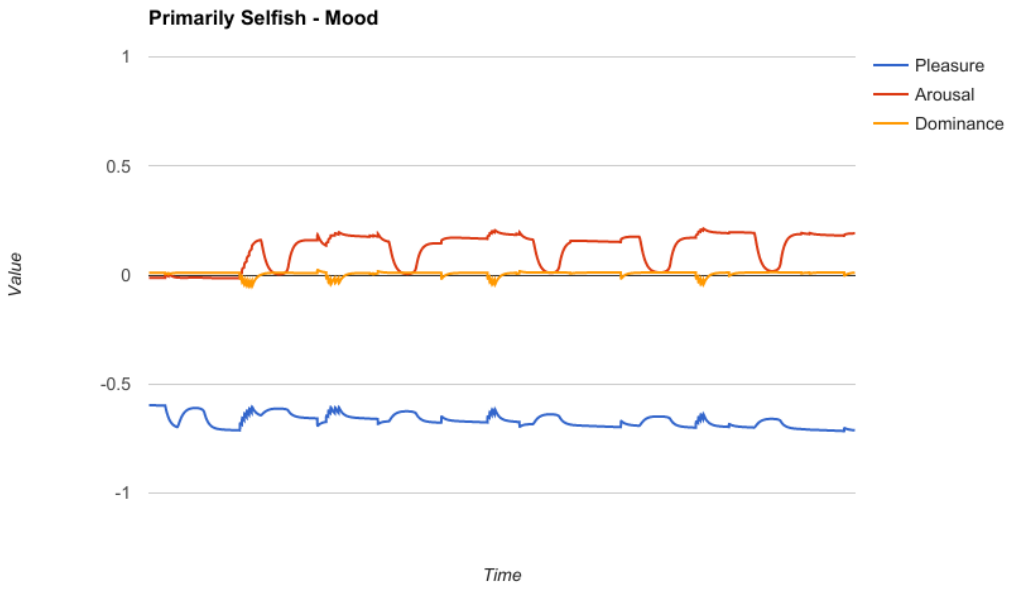

Figure 16: Mood State Changes of the Primarily Selfish Playthrough.

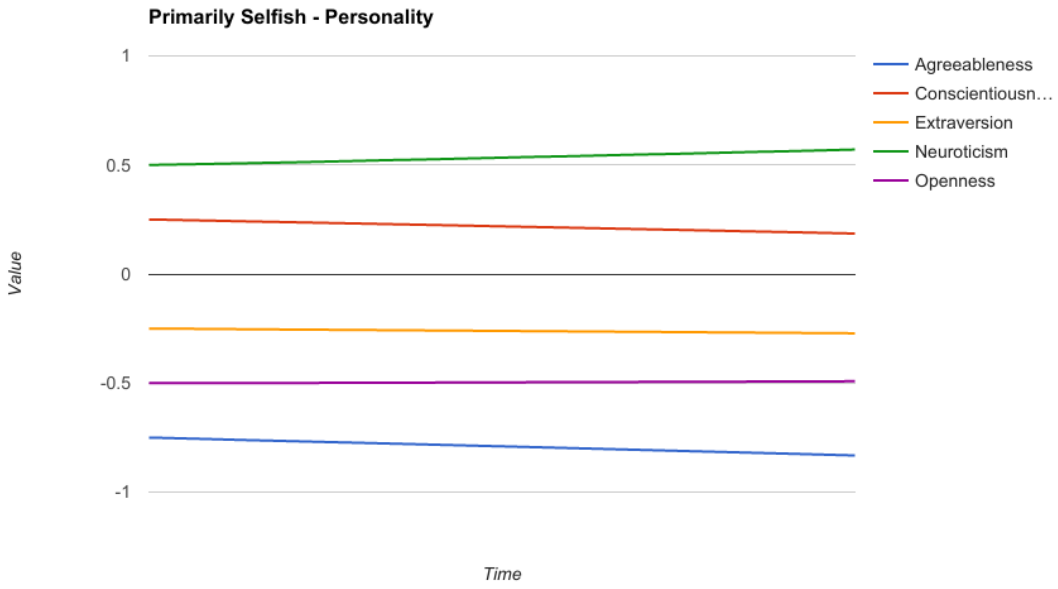

Figure 17: Personality State Changes of the Primarily Selfish Playthrough.

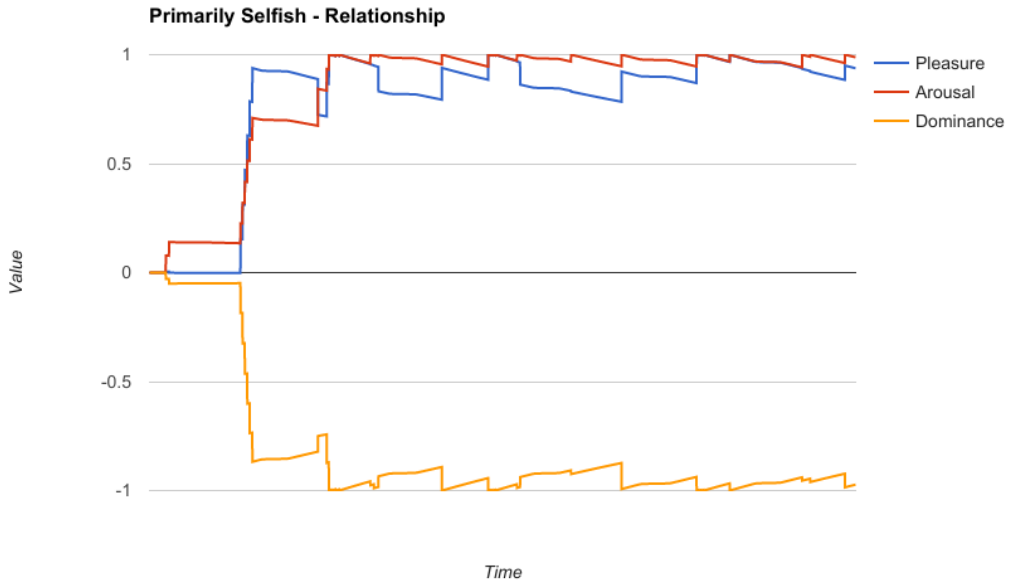

Figure 18: Relationship State Changes of the Primarily Selfish Playthrough.

Kind-at-First

The NPC enjoyed the interactions of the player during the 'kind' stage of the playthrough and only reflected the negative interactions through a slowly decreasing pleasure/dominance in their relationship, until the player attacked her. Once attacked, all affects had a sharp drop in pleasure, which was repeated to greater effect after the second attack. The second attack caused her sense of dominance to cross over the x-axis for all affects. This resulted in her being in a Dependent state at the end of the playthrough. The negative interactions were not meaningful enough, for the length of this playthrough, to significantly alter the steady positive climb of her personality's values.

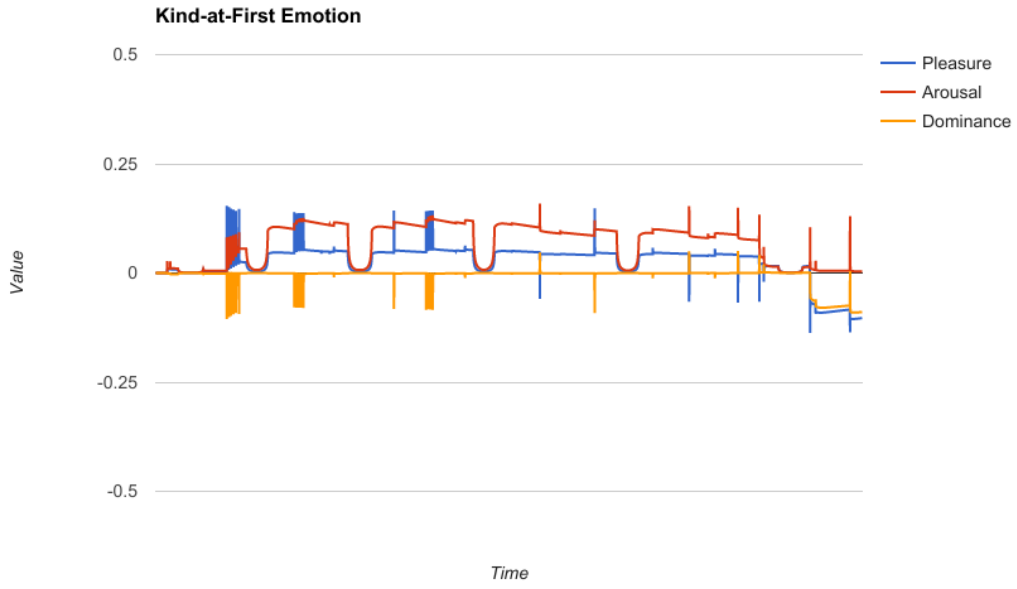

Figure 19: Emotion State Changes of the Kind-at-First Playthrough.

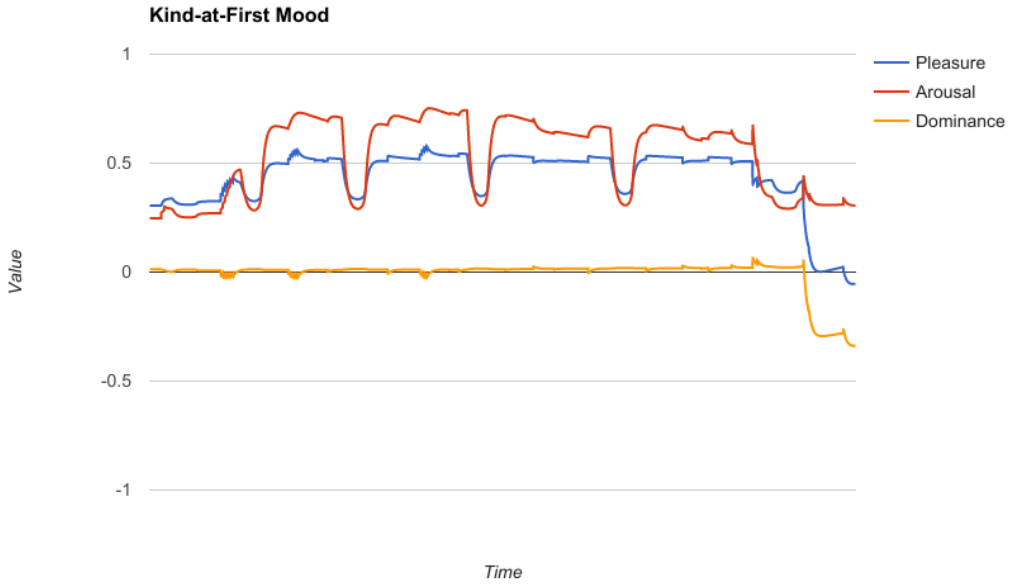

Figure 20: Mood State Changes of the Kind-at-First Playthrough.

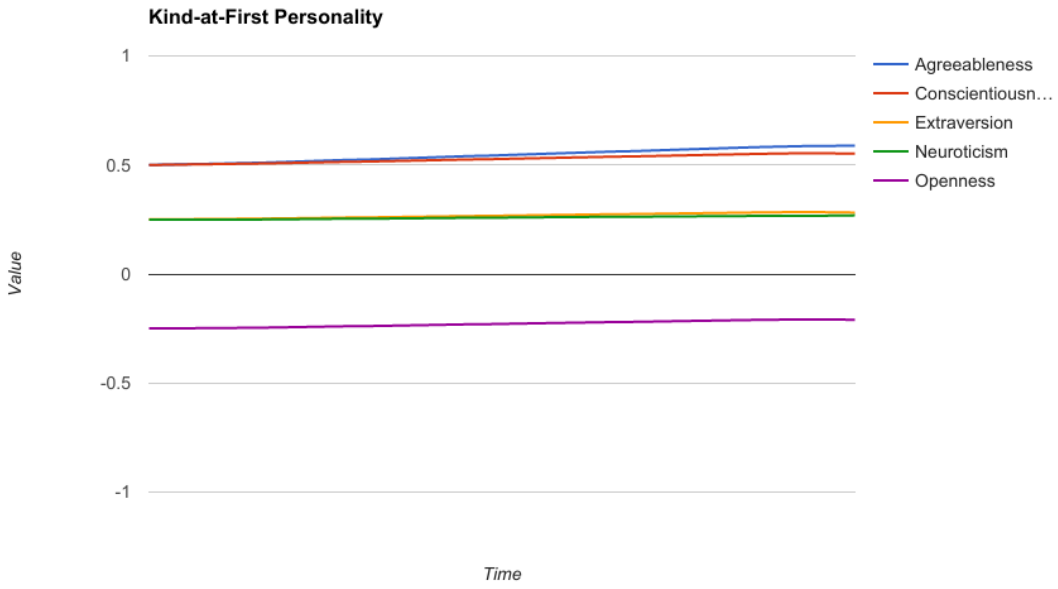

Figure 21: Personality State Changes of the Kind-at-First Playthrough.

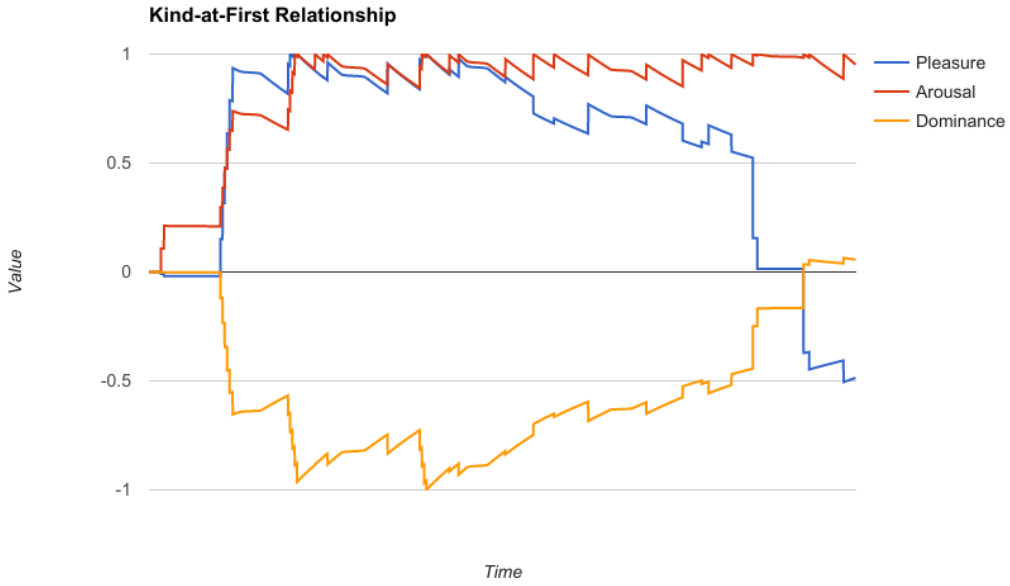

Figure 22: Relationship State Changes of the Kind-at-First Playthrough.

Mean-at-First

Unlike the Kind-at-First playthrough, this playthrough shows much more responsiveness to the player's shift from being mean to being kind. The NPC quickly shifted from her default Exuberant mood to a Dependent mood and then to an Anxious mood, with a short reprieve while the player was on the second adventure. However, with the selling/buying of multiple goods, an adventure, and a couple of kinder interactions, all of the NPC's affects showed an immediately shift in pleasure and dominance. This shift was also strong enough to create a noticeable change in direction for all values of the NPC's personality. The NPC's dominance remained negative for her emotion and mood, resulting in Dependent mood state for the remainder of the playthrough.

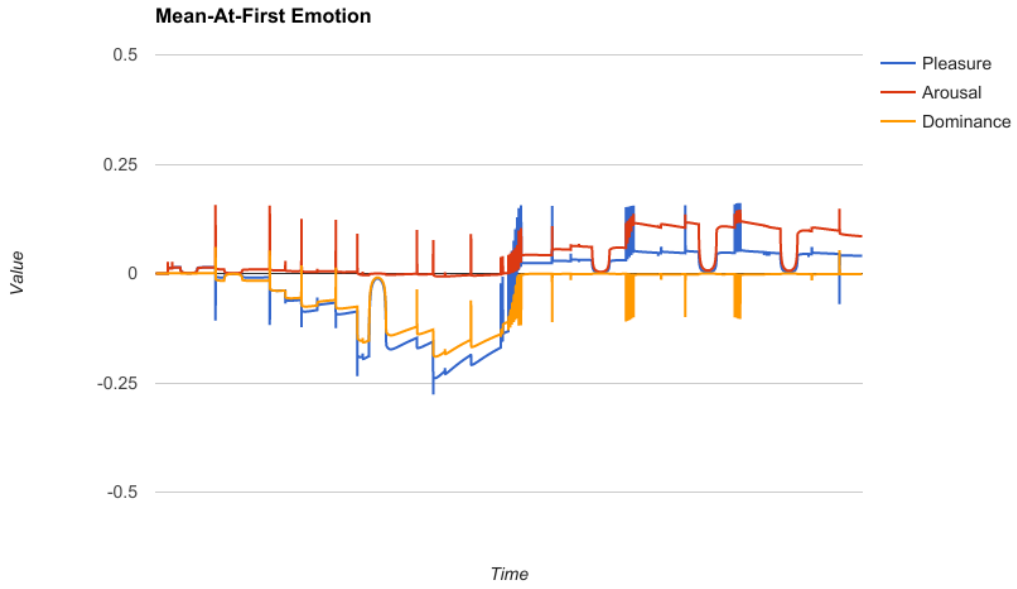

Figure 23: Emotion State Changes of the Mean-at-First Playthrough.

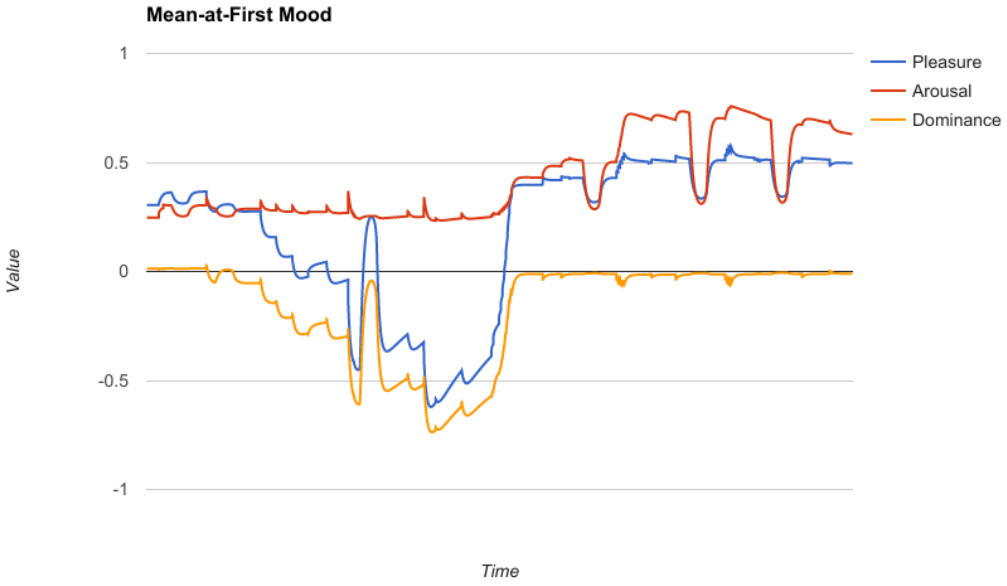

Figure 24: Mood State Changes of the Mean-at-First Playthrough.

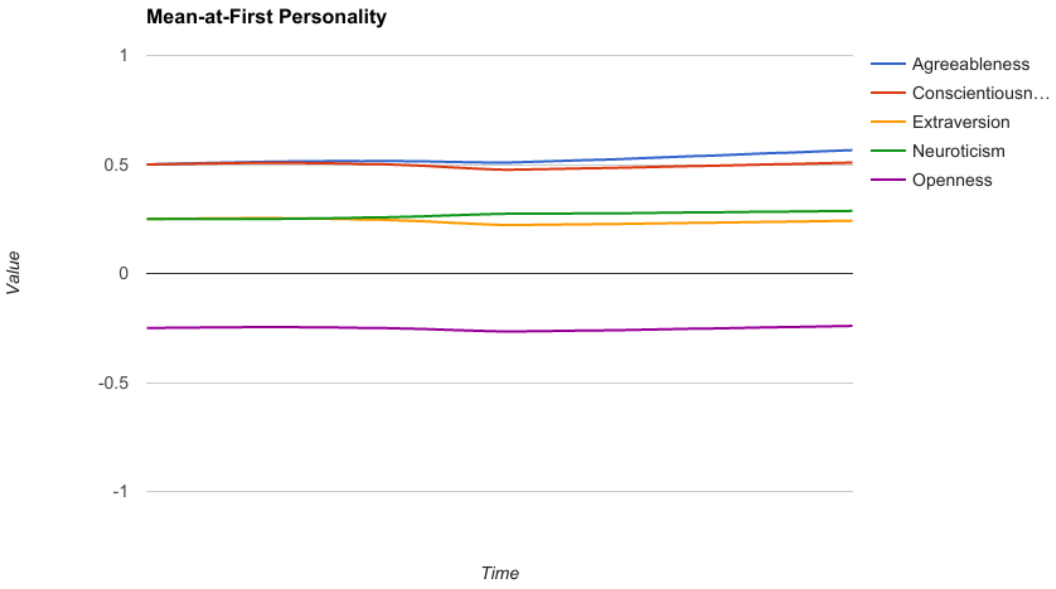

Figure 25: Personality State Changes of the Mean-at-First Playthrough.

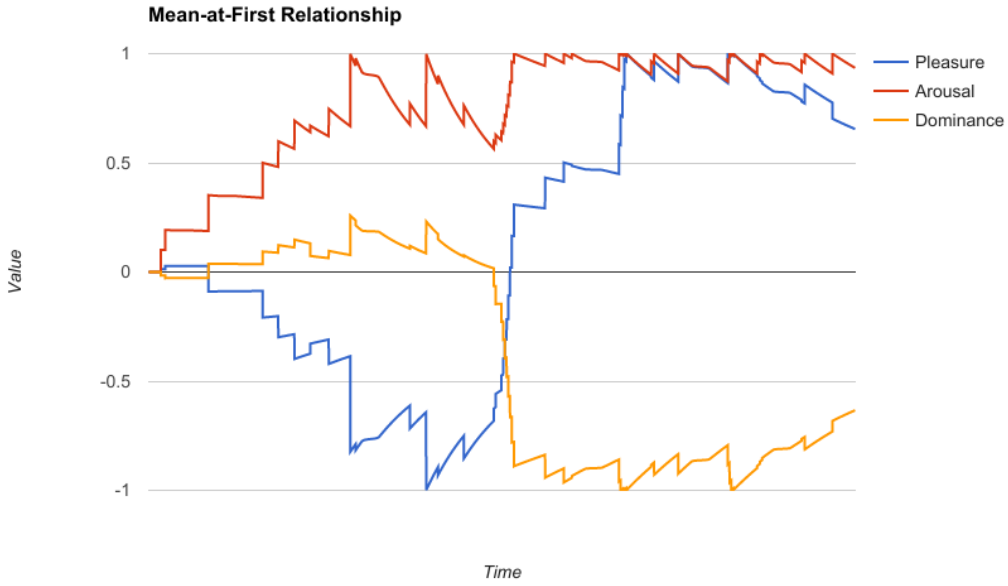

Figure 26: Relationship State Changes of the Mean-at-First Playthrough.

Kind

This playthrough includes only positive interactions, which aligned with the NPC's initial Exuberant mood state and encouraged that state for the entirety of the playthrough. All affects seem to reflect the Kind-at-First playthrough's affects, had the player continued with only positive interactions.

Figure 27: Emotion State Changes of the Kind Playthrough.

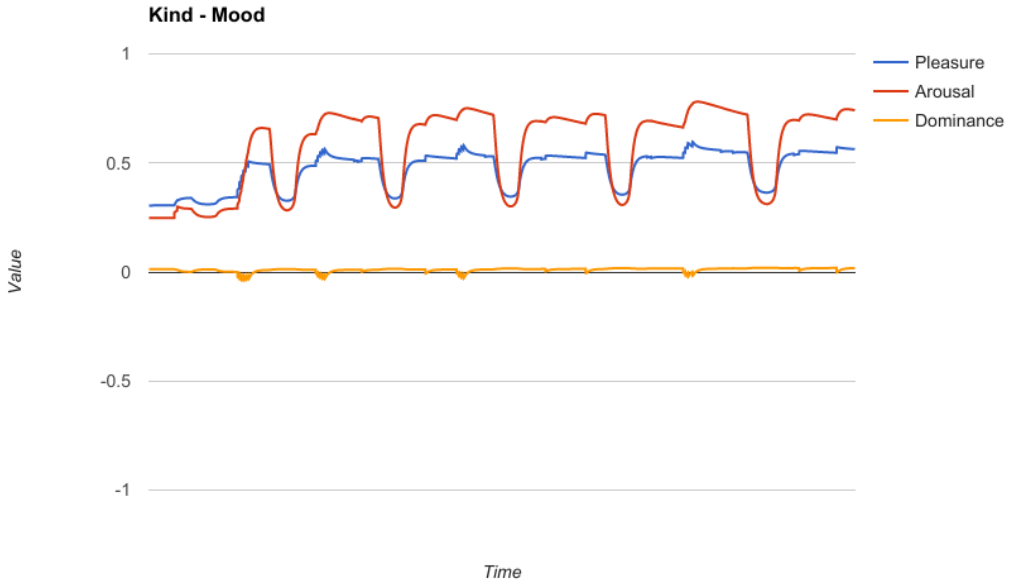

Figure 28: Mood State Changes of the Kind Playthrough.

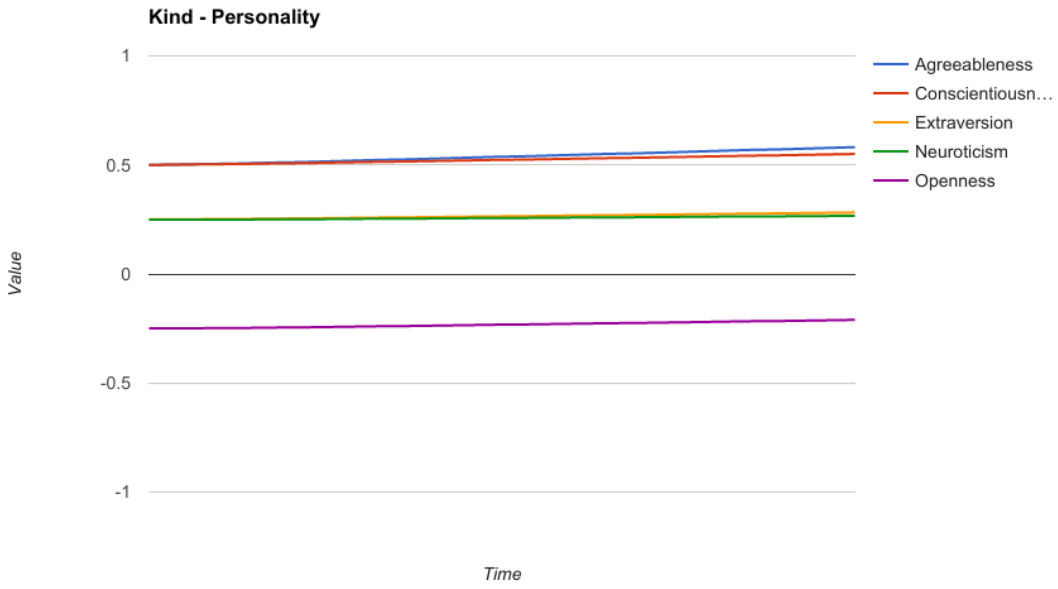

Figure 29: Personality State Changes of the Kind Playthrough.

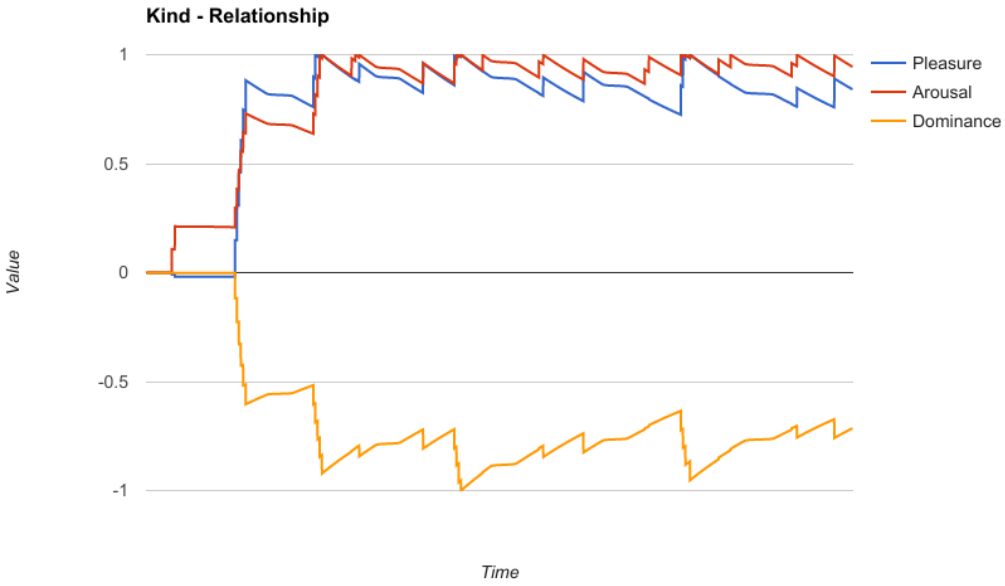

Figure 30: Relationship State Changes of the Kind Playthrough.

Cruel

Like the Mean-at-First playthrough, this playthrough quickly shifts the NPC's default Exuberant mood to a Dependent mood and then to an Anxious mood. The Anxious mood is reinforced with the player's interactions, particularly by attacks that regularly occur shortly before adventures. The NPC's mood and emotion jump closer towards her default state while the player is adventuring, but returns to an Anxious state upon the player's return; although her mood remains slightly closer to her default mood than it was before the player went on the adventure.

The NPC's sense of arousal remains close to her default throughout the playthrough, so there is little shift in its values whether the player is adventuring or performing interactions. This playthrough affects all values of the NPC's personality negatively, except for her Neuroticism, which increases. Perhaps most interesting was that the dominance value of the NPC's relationship affect slowly shifted towards the negative, indicating some sense of wearing down to the negative interactions over time.

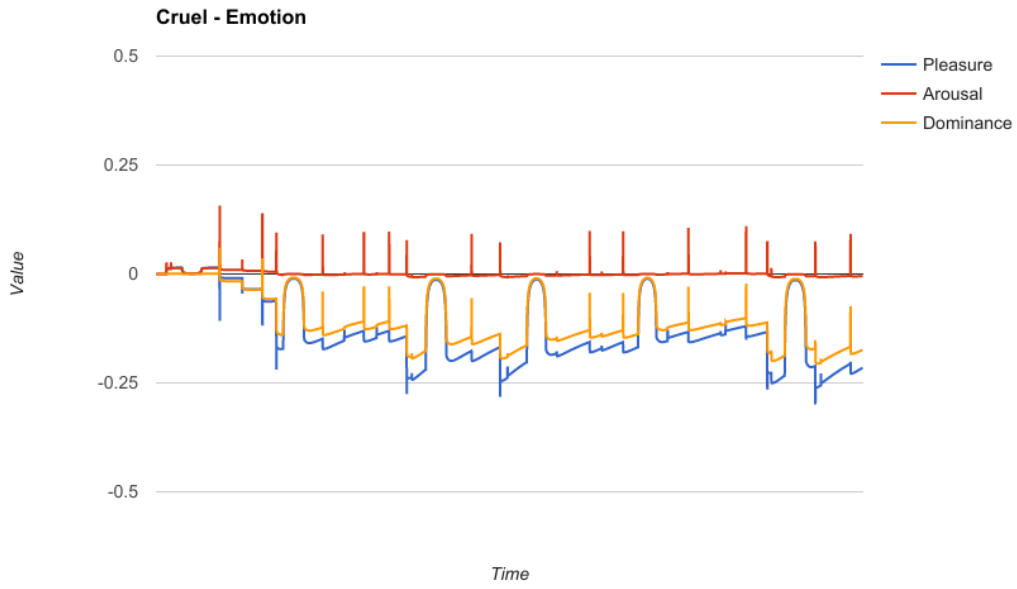

Figure 31: Emotion State Changes of the Cruel Playthrough.

Figure 32: Mood State Changes of the Cruel Playthrough.

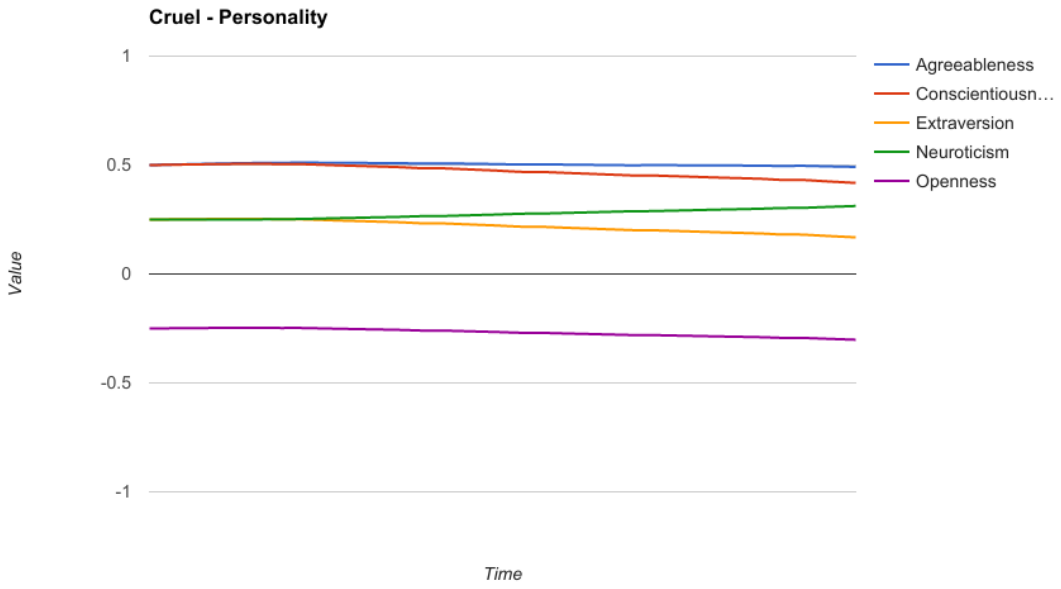

Figure 33: Personality State Changes of the Cruel Playthrough.

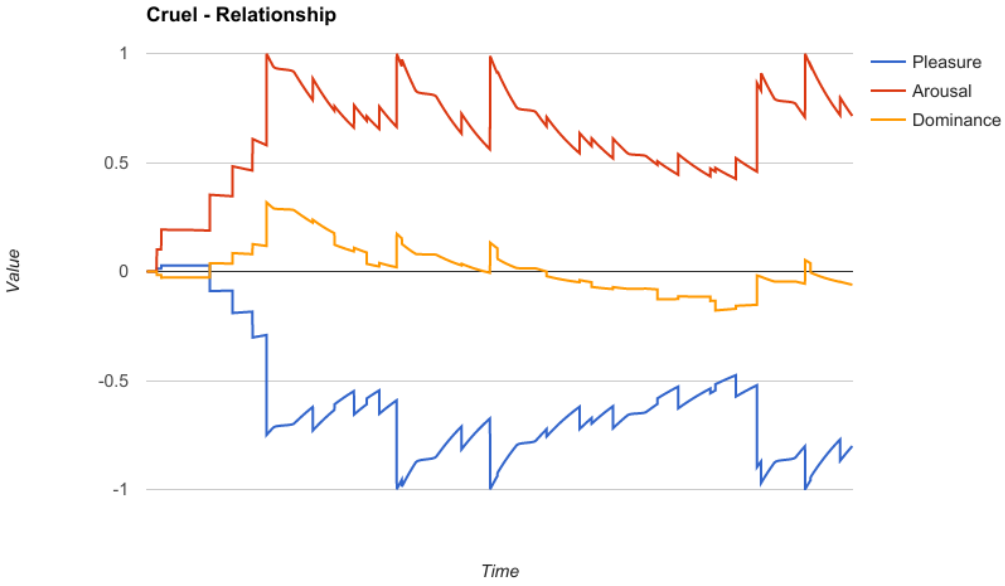

Figure 34: Relationship State Changes of the Cruel Playthrough.

Extended Mean-at-First

This playthrough maintained a strong similarity to the original Mean-at-First playthrough, except with the affect value changes being more emphasized and drawn-out. This had little effect until the near-end of the playthrough, at which point the player selling recently found apples seemed to be received far more pleasurably than it had in the original Mean-at-First playthrough. Reinforced by additional positive interactions, the NPC's mood maxed out on pleasure and plummeted in dominance. The NPC's ending mood was far more Dependent than it had been for the original Mean-at-First playthrough, due to having less dominance and more pleasure. These differences were also reflected in her personality, which saw a much more significant shift in Agreeableness towards the end of the playthrough.

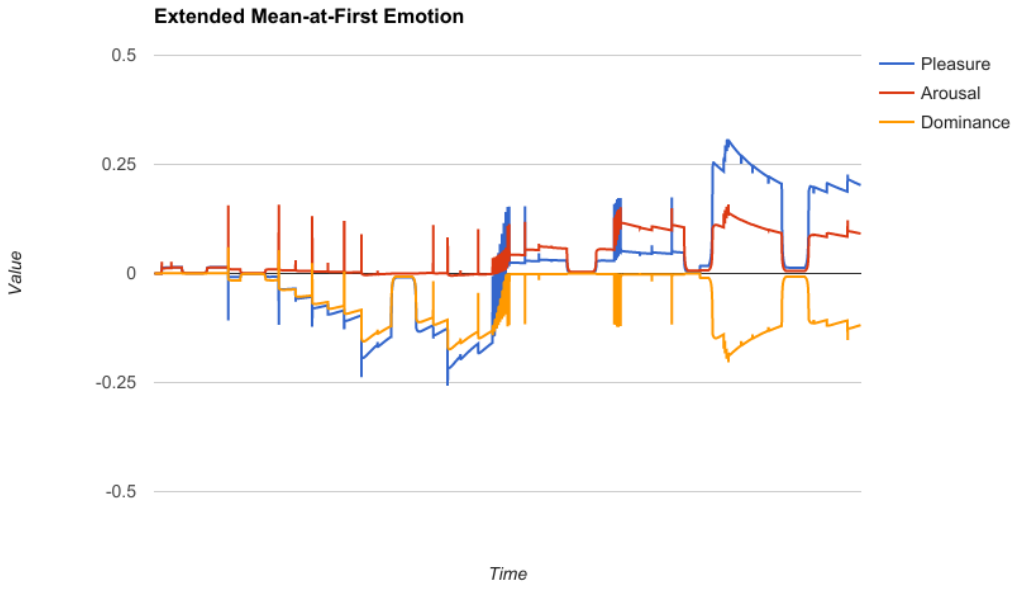

Figure 35: Emotion State Changes of the Extended Mean-at-First Playthrough.

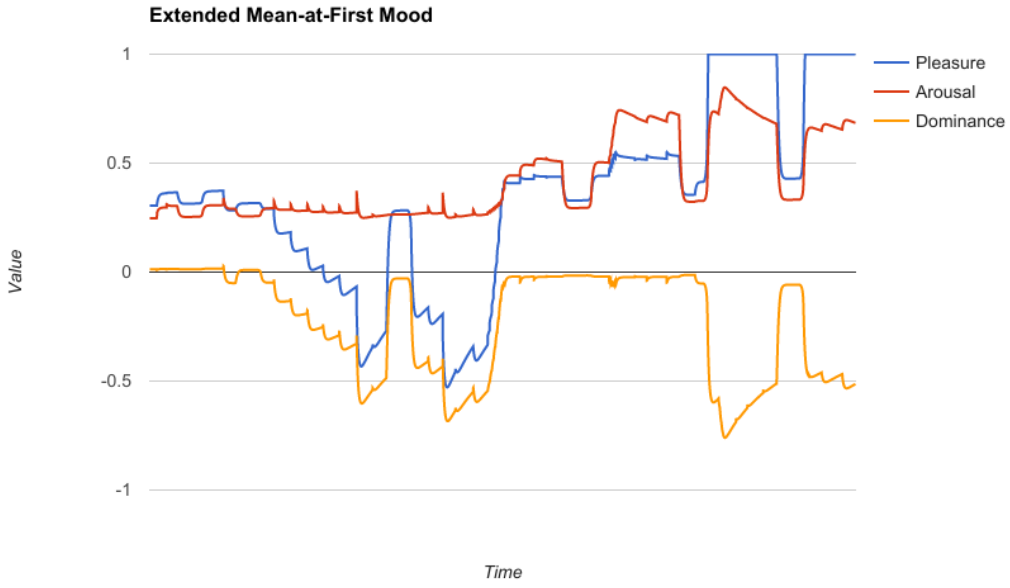

Figure 36: Mood State Changes of the Extended Mean-at-First Playthrough.

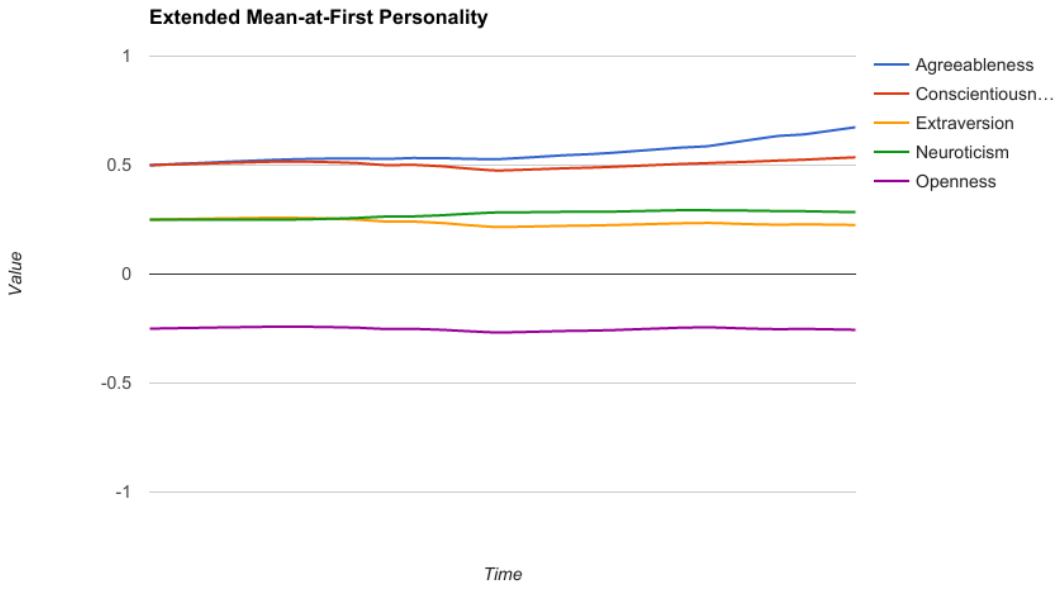

Figure 37: Personality State Changes of the Extended Mean-at-First Playthrough.

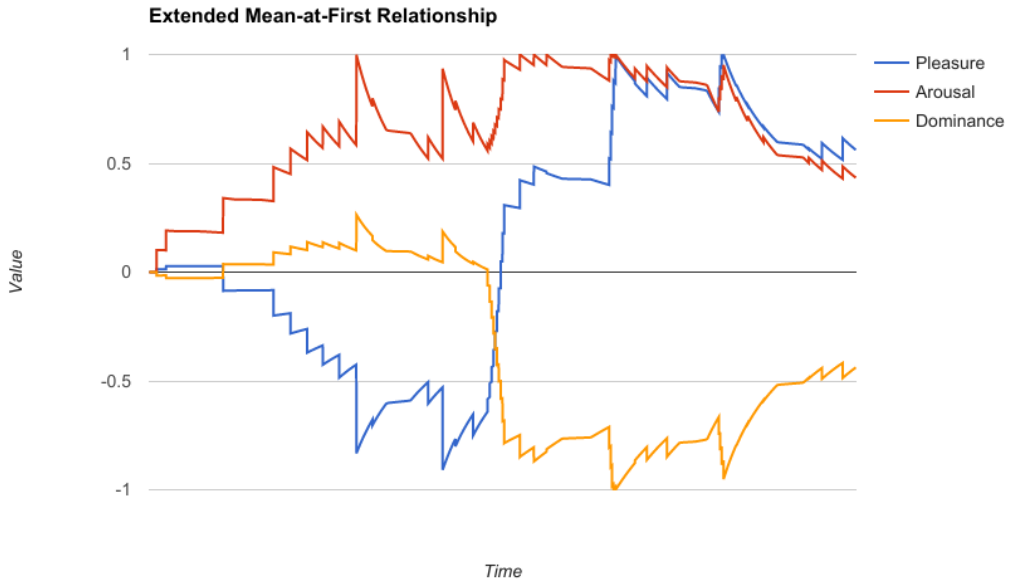

Figure 38: Relationship State Changes of the Extended Mean-at-First Playthrough.

7.2 Behavior Tracking and Observations

As per the test process for the hypothesis outlined in section 6.3, the NPC's responses in each playthrough of the other hypotheses were recorded, categorized as either positive, somewhat positive, somewhat negative, or negative, and mapped to the mood being experienced by the NPC at the time of the response. These response-by-mood mappings have been organized by playthrough and are analyzed here, with respect to their playthrough, while being compared to the mappings of other playthroughs. Screenshots from the start and end of each playthrough are also presented. The only definitive 'soft' response present in each playthrough, the player's attempt to buy the iron sword, is considered in these analyses as well.

Interaction Keys		Response Mapping			
Interaction	Key	Positive	Somewhat Positive	Somewhat Negative	Negative
Small Talk	ST	enjoyed	replied	-	pointless
Compliment	CT	laughed	smiled	ignored	-
Complain	CN	agreed	listened	ignored	useless
Offer Help	OH	accepted	allowed	no help needed	rejected
Insult	IT	listened	questioned	ignored	foolish
Threaten	TN	shrugged	questioned	recoiled	threatened
Steal	SL	-	look away	scolded	attacked
Attack	AK	-	cowered	threatened	-

Table 1: Interaction Keys and their mapping to response categories; as observed across all playthroughs.

Primarily Social

The Primarily Social NPC maintained an Exuberant mood throughout the playthrough. As such, all responses were able to be mapped directly as Exuberant responses. Attack's response was not available as the player did not attack the NPC in this playthrough. The player was able to obtain the iron sword for 24 gold.

Exuberant Responses	ST	CT	CN	OH	IT	TN	SL	AK
Positive	X	X		X		X		
Somewhat Positive							X	
Somewhat Negative			X		X			
Negative								

Table 2: Primarily Social - Exuberant Responses

Figure 39: Starting/Ending screenshots of the Primarily Social Playthrough (Sohei) (Condiff).

Primarily Unsocial

The Primarily Unsocial NPC expressed an Anxious mood throughout the playthrough, so all responses were able to be mapped directly as Anxious responses. Attack's response was not available as the player did not attack the NPC in this playthrough. Every player interaction was met with a different response when compared to the Primarily Social playthrough. The player was not able to obtain the iron sword, despite offering 24 gold; another difference when compared to the Primarily Social playthrough.

Anxious Responses	ST	CT	CN	OH	IT	TN	SL	AK
Positive								
Somewhat Positive	X	X	X		X	X		
Somewhat Negative				X			X	
Negative								

Table 3: Primarily Unsocial - Anxious Responses

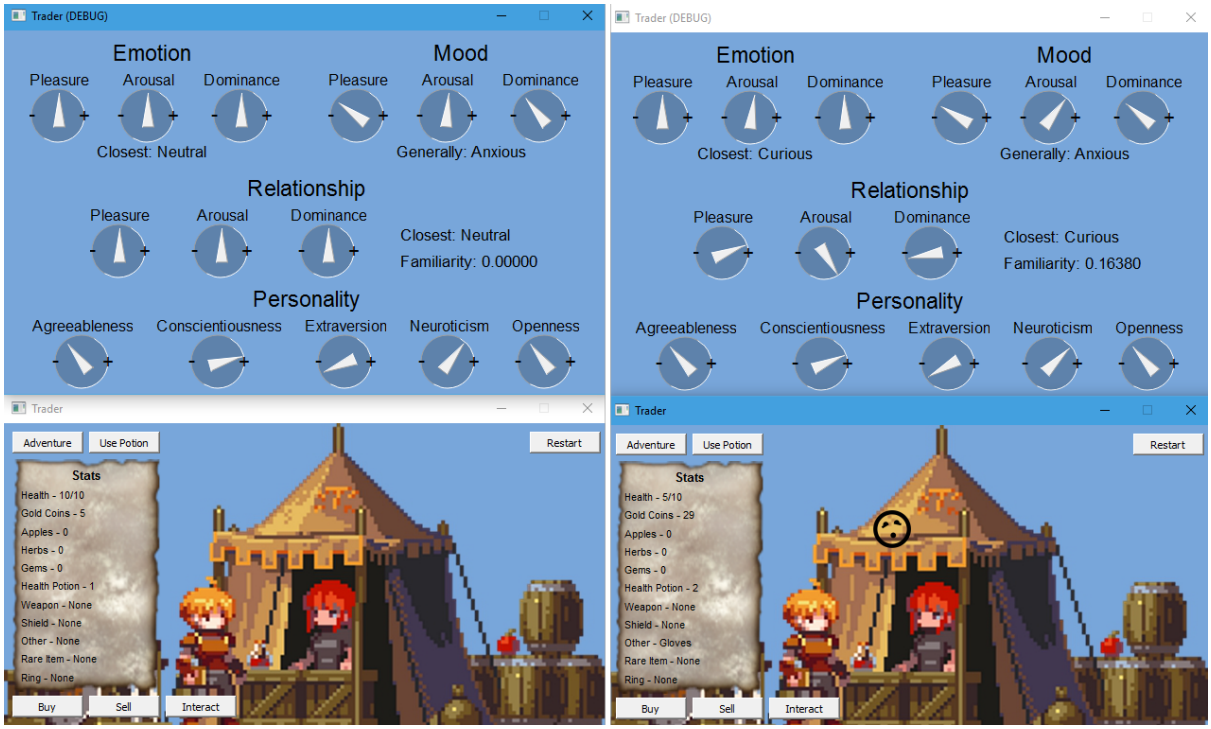

Figure 40: Starting/Ending screenshots of the Primarily Unsocial Playthrough (Sohei) (Condiff).

Primarily Unselfish

The Primarily Unselfish NPC maintained a Dependent mood throughout the playthrough. All responses were able to be mapped directly as Dependent responses. Attack's response was not available as the player did not attack the NPC in this playthrough. The small talk and compliment responses were the same as they were for the Primarily Unsocial playthrough, and the steal response was the same as it was for the Primarily Social playthrough. The player was able to obtain the iron sword for 24 gold, an outcome shared with the Primarily Social playthrough.

Dependent Responses	ST	CT	CN	OH	IT	TN	SL	AK
Positive			X		X			
Somewhat Positive	X	X		X			X	
Somewhat Negative						X		
Negative								

Table 4: Primarily Unselfish - Dependent Responses

Figure 41: Starting/Ending screenshots of the Primarily Unselfish Playthrough (Sohei).

Primarily Selfish

The Primarily Selfish NPC started with a Disdainful mood and shifted to a Hostile mood early in the playthrough. As such, responses are split between the two moods, with most responses being associated with the Hostile mood. These moods are generally more negative than the other moods, resulting in the NPC providing responses that had not been seen in the aforementioned playthroughs, including the NPC attacking the player in response to an attempted steal. Attack's response was not available as the player did not attack the NPC in this playthrough. The player was not able to obtain the iron sword, despite offering 24 gold for it, an outcome shared with the Primarily Unsocial playthrough.

Disdainful Responses	ST	CT	CN	OH	IT	TN	SL	AK
Positive								
Somewhat Positive								
Somewhat Negative		X						
Negative	X							

Table 5: Primarily Selfish - Disdainful Responses

Hostile Responses	ST	CT	CN	OH	IT	TN	SL	AK
Positive								
Somewhat Positive								
Somewhat Negative								
Negative	X		X	X	X	X	X	

Table 6: Primarily Selfish - Hostile Responses

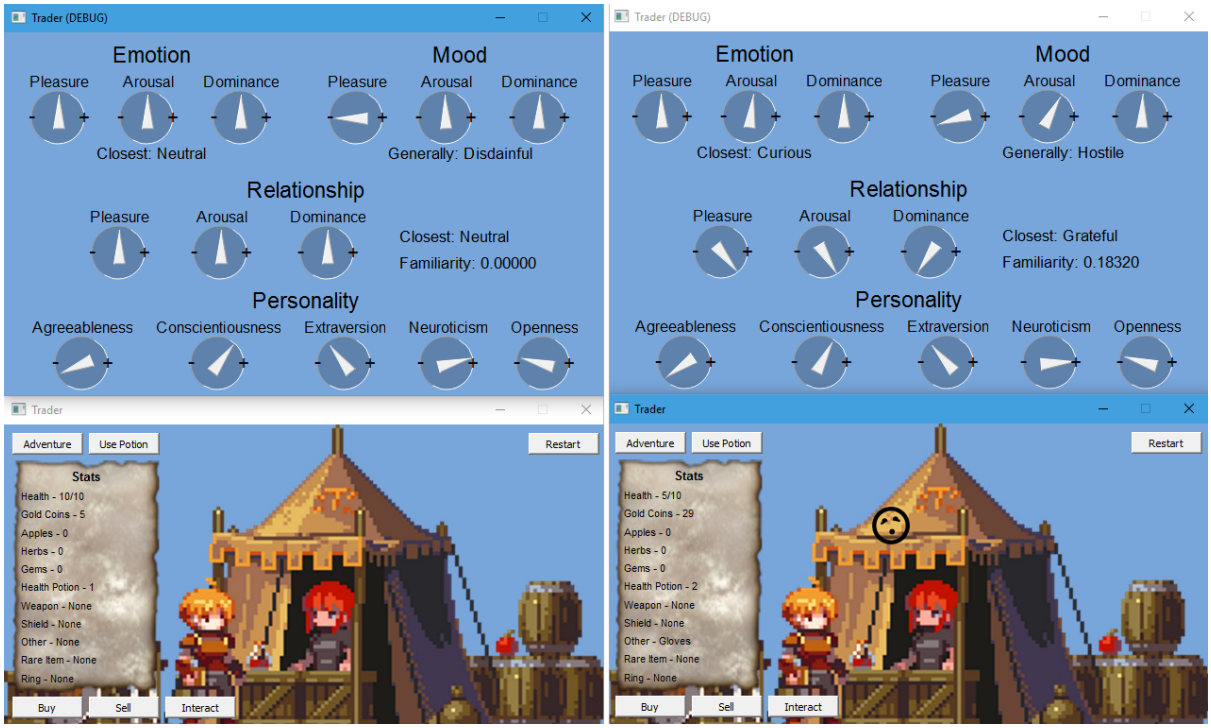

Figure 42: Starting/Ending screenshots of the Primarily Selfish Playthrough (Sohei) (Condiff).

Kind-at-First

The Kind-at-First playthrough's interactions kept the NPC in an Exuberant mood up until the end, when her mood became Dependent. For both moods, the responses matched Exuberant and Dependent responses seen from the Primarily Social and Primarily Unselfish playthroughs, respectively, with the addition of an Attack response for the Exuberant mood set. However, the player was not able to obtain the iron sword for 22 gold. This could have been due to the lower price offered in combination with the NPC's Dependent mood's strength being much less than it was for the Primarily Unselfish playthrough.

Dependent Responses	ST	CT	CN	OH	IT	TN	SL	AK
Positive								
Somewhat Positive								
Somewhat Negative						X		
Negative								

Table 7: Kind-at-First - Dependent Responses

Exuberant Responses	ST	CT	CN	OH	IT	TN	SL	AK
Positive	X	X		X		X		
Somewhat Positive							X	
Somewhat Negative			X		X			X
Negative								

Table 8: Kind-at-First - Exuberant Responses

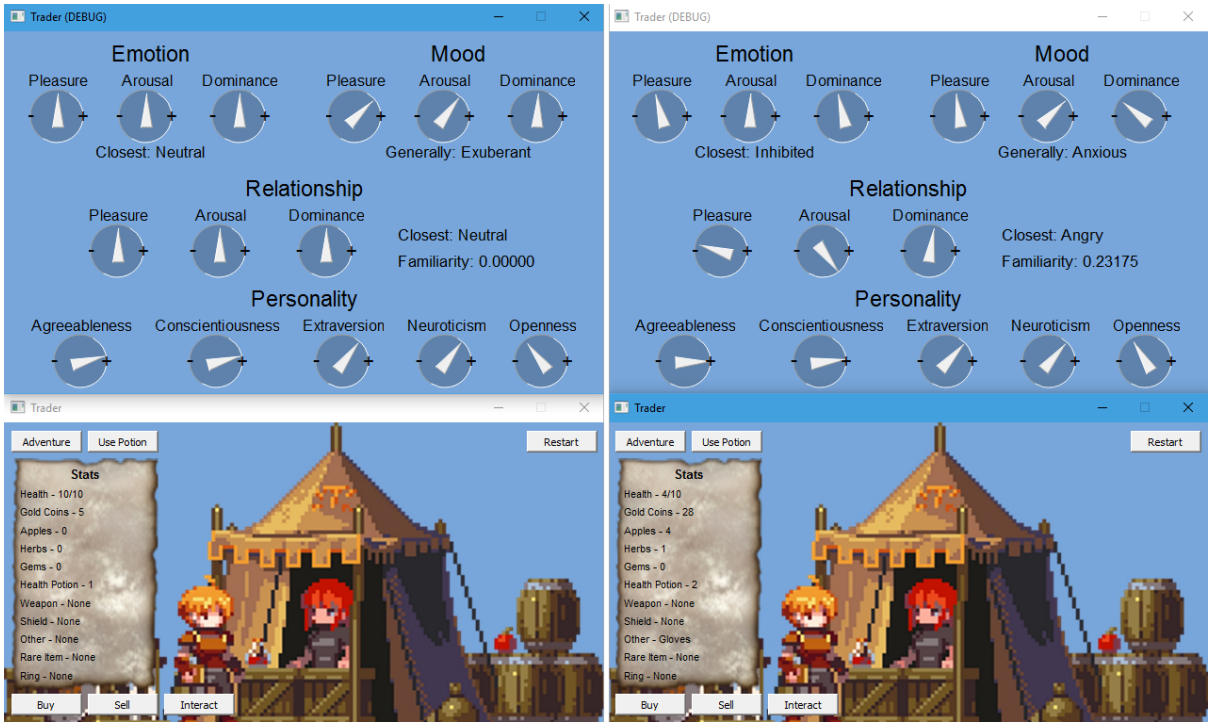

Figure 43: Starting/Ending screenshots of the Kind-at-First Playthrough (Sohei).

Mean-at-First

The Mean-at-First playthrough's interactions quickly shifted the NPC's mood from Exuberant to Dependent to Anxious, and finally back to Dependent. All three moods' responses match the responses seen for those moods in the aforementioned playthroughs, with the addition of an Attack response for the Anxious mood set. The player was not able to obtain the iron sword for 22 gold. This could have been due to the lower price offered in combination with the NPC's Dependent mood's strength being much less than it was for the Primarily Unselfish playthrough.

Anxious Responses	ST	CT	CN	OH	IT	TN	SL	AK
Positive								
Somewhat Positive			X		X	X		
Somewhat Negative								X
Negative								

Table 9: Mean-at-First - Anxious Responses

Dependent Responses	ST	CT	CN	OH	IT	TN	SL	AK
Positive			X					
Somewhat Positive	X	X		X				
Somewhat Negative						X		
Negative								

Table 10: Mean-at-First - Dependent Responses

Exuberant Responses	ST	CT	CN	OH	IT	TN	SL	AK
Positive								
Somewhat Positive								
Somewhat Negative			X		X			
Negative								

Table 11: Mean-at-First - Exuberant Responses

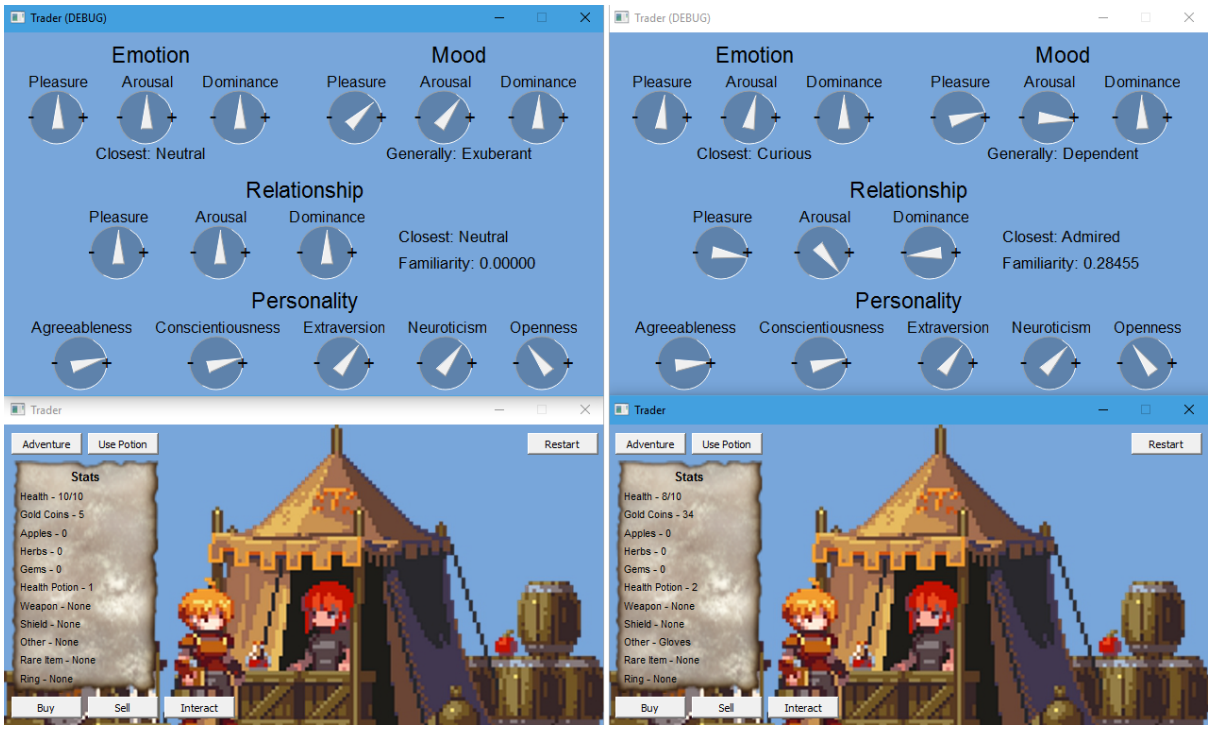

Figure 44: Starting/Ending screenshots of the Mean-at-First Playthrough (Sohei).

Kind

The Kind playthrough's interactions kept the NPC in an Exuberant state throughout the playthrough. The player only performed three interactions that resulted in hard responses, each of which provided responses that matched previous Exuberant mood responses. The player was able to purchase the iron sword for 24 gold, which reflects the outcome of the Primarily Social playthrough, despite the strength of the Exuberant mood having been less for this playthrough.

Exuberant Responses	ST	CT	CN	OH	IT	TN	SL	AK
Positive	X	X		X				
Somewhat Positive								
Somewhat Negative								
Negative								

Table 12: Kind - Exuberant Responses

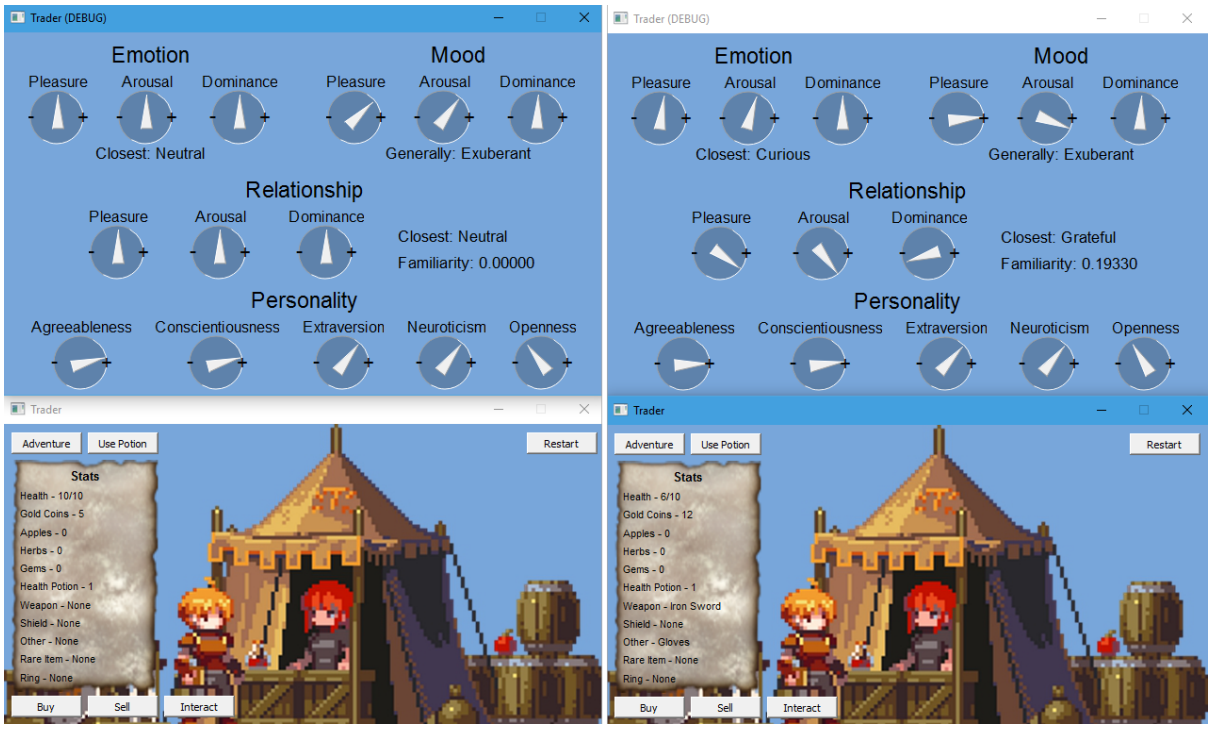

Figure 45: Starting/Ending screenshots of the Kind Playthrough (Sohei).

Cruel

The Cruel playthrough's responses are similar to the Mean-at-First playthrough by shifting the NPC's mood from Exuberant to Dependent to Anxious, but without returning back to Dependent, so most of the playthrough's responses occurred while the NPC was in an Anxious state. All three moods' responses match the responses seen for those moods in the aforementioned playthroughs. The player was not able to obtain the iron sword for 22 gold. This reflects the outcome of the Primarily Unsocial playthrough, which ended with the NPC having a weaker Anxious mood than she did in this playthrough.

Anxious Responses	ST	CT	CN	OH	IT	TN	SL	AK
Positive								
Somewhat Positive			X		X	X		
Somewhat Negative							X	X
Negative								

Table 13: Cruel - Anxious Responses

Dependent Responses	ST	CT	CN	OH	IT	TN	SL	AK
Positive								
Somewhat Positive								X
Somewhat Negative						X		
Negative								

Table 14: Cruel - Dependent Responses

Exuberant Responses	ST	CT	CN	OH	IT	TN	SL	AK
Positive								
Somewhat Positive								
Somewhat Negative			X		X			
Negative								

Table 15: Cruel - Exuberant Responses

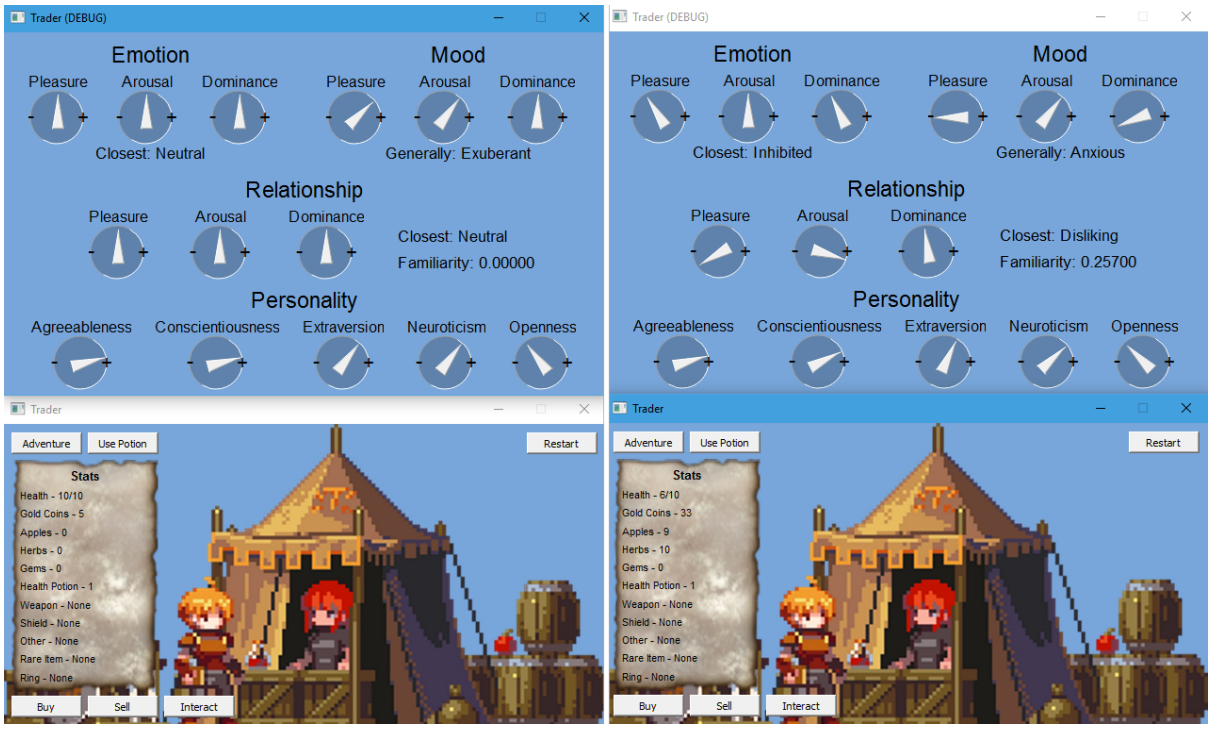

Figure 46: Starting/Ending screenshots of the Cruel Playthrough (Sohei).

Extended Mean-at-First

The Extended Mean-at-First playthrough's hard responses were almost the same as the Mean-at-First playthrough's except that a Threaten interaction that occurred while the NPC's mood was Anxious in that playthrough occurred while the NPC's mood was Dependent in this playthrough. However, unlike in the Mean-at-First playthrough, in this playthrough the player was able to obtain the iron sword for the same 22 gold. This is likely due to the NPC's Dependent mood being far stronger in this playthrough, more closely matching the Primarily Unselfish playthrough's NPC's Dependent mood that also allowed the player to buy the sword.

Anxious Responses	ST	CT	CN	OH	IT	TN	SL	AK
Positive								
Somewhat Positive			X		X			
Somewhat Negative								X
Negative								

Table 16: Extended Mean-at-First - Anxious Responses

Dependent Responses	ST	CT	CN	OH	IT	TN	SL	AK
Positive			X					
Somewhat Positive	X	X		X				
Somewhat Negative						X		
Negative								

Table 17: Extended Mean-at-First - Dependent Responses

Exuberant Responses	ST	CT	CN	OH	IT	TN	SL	AK
Positive								
Somewhat Positive								
Somewhat Negative			X		X			
Negative								

Table 18: Extended Mean-at-First - Exuberant Responses

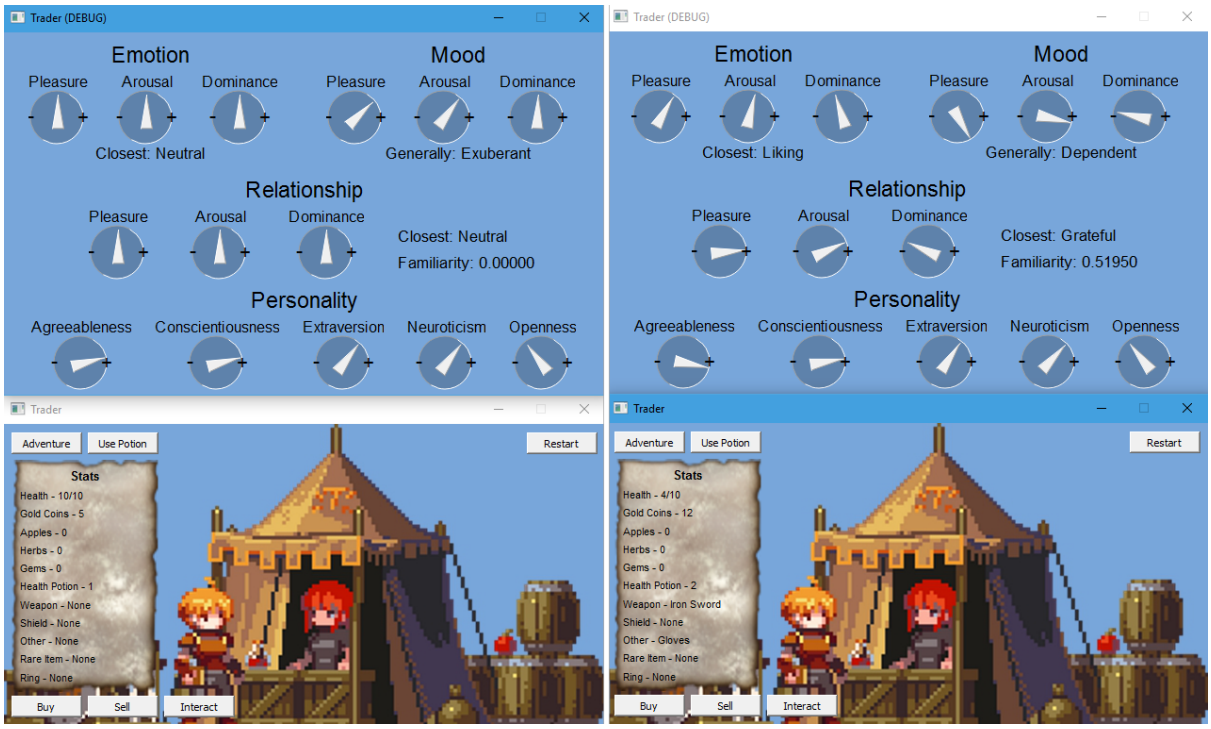

Figure 47: Starting/Ending screenshots of the Extended Mean-at-First Playthrough (Sohei).

8 Conclusions

Based on the outcomes (Chapter 7), each hypothesis (Chapter 6) can be concluded as follows:

The Personality-Based, Emergent Affective States hypothesis (section 6.1) is proven by the NPC's varying affective states across playthroughs that defined varying initial personality settings for their respective NPC. Not only were the initial affective states, and their associated responses, different for the initial personality setting, they also varied in how they were changing over the course of the playthroughs. This indicates that the NPC's affective states were unlikely to eventually converge to the same state, thereby guaranteeing different and emergent responses over the long-term, based on the initial personality settings. These results should be valid, with some variation, across all implementations that use the Mimetic Emotion System, as the entire evaluation of affective states and their results are contained within the Mimetic Emotion System.

The Interaction-Based, Emergent Affective States hypothesis (section 6.2) is proven by the NPC's varying affective states across playthroughs that differed by the player's interactions. This included a variation in the NPC's states in response to the same player interactions being performed with a different amount of time elapsing between each interaction. Furthermore, the responses of the NPC could require the player to perform different interactions later in the playthrough, which could cause the NPC's responses to branch further apart. The varying affective states of the NPC in these playthroughs were also shown to change the NPC's personality, which, in accordance with the Personality-Based hypothesis and as evidenced by this hypothesis' outcomes, could result in different responses, even across playthroughs in which the player began to perform the same interactions partway through. The validity of these results are dependent upon the implementation's handling of interactions through the Mimetic Emotion System.

The Affective-Based, Game-Defined, Emergent Behavior (section 6.3) is proven by the same hard responses of all varying NPCs matching to the same mood being experienced when the response was performed. This claim is reinforced by soft responses matching to similar

affective states, i.e., the strength/weakness of a mood. The proving of this hypothesis allows this thesis to conclude that a given affective state can be equated to an associated behavior, and that a given change in affective state can be equated to an associated change in behavior. The validity of these results are dependent upon the implementation's association of NPC behavior to the outputs of the Mimetic Emotion System.

In consideration of all hypotheses being proven, with respect to the implementation of Trader, this thesis concludes that Mimetic Emotions, as provided by the Mimetic Emotion System developed by this thesis or an equivalent that realizes the essence of Mimetic Emotions, have the potential to provide NPCs with emergent, personality-defined and interaction-based, behavior. The behavior of such NPCs are emergent through both the initial personality settings that they are provided with and as a result of how the player interacts with them. However, the personality-defined emergence is slightly less dependent upon the implementation, and therefore has the greater potential in producing definitive emergent behavior.

The resulting Mimetic Emotion System is an example system that achieves Mimetic Emotions for non-player characters. As it is an example, it would require updating and additional developments to be usable in real use case implementations, e.g., commercial video games. The essence of Mimetic Emotions, as detailed conceptually in section 4.1 and described through a proven implementation in section 4.2, is considered the successful outcome of this thesis; it is entirely applicable to future developments and should be the primary take-away of this thesis.

8.1 Future Work

The author of this thesis originally intended to find solutions for developing truly dynamic narratives within video games. However, that task was too monumental for any single thesis and required a multitude of lower-level developments to be completed before any over-arching development could begin. Mimetic Emotions were the result of drilling down to the lowest-level development that was necessary to make progress towards dynamic narratives.

The future work described here is in consideration of further testing and improving the essence of Mimetic Emotions, not necessarily this thesis' developed Mimetic Emotion System.

These future works detail the next step towards the author's intent of developing dynamic narratives. Specifically, this next step would be to produce Mimetic Behaviors for NPCs, through a Mimetic Behavior System. Such a step is anticipated to include the following:

- A full implementation with multiple NPCs in a single game instance, each influencing one another independent of the player. This would allow the interactions between multiple NPCs with Mimetic Emotions to be evaluated for emergent affective state changes self-contained within the system, as may result from situations that the player creates for the NPCs. Such an implementation would require the NPCs to be able to initiate actions, instead of just respond to an interaction.

- The Mimetic Emotion System of Trader considered all actions as immediate. Providing an in-progress stage for actions could provide greater emotional effect and allow an NPC to recognize an action that it may want to prevent or assist before it completes. This would not only advance the abilities of NPCs with Mimetic Emotions, but also allow for games using Mimetic Emotions to have additional game mechanics based on the capabilities of the NPCs.

- Sequences of actions could be remembered, as well as their collective effect. This would let an NPC determine a sequence beneficial for it to perform or for it to evaluate when others may be beginning to perform the sequence. This could open a possibility for NPCs to learn action combinations from the player or other NPCs.

- An NPC could develop plans, which would be collections/sequences of actions that would allow it to achieve a desired outcome, or prevent an undesirable outcome. These plans could take the form of behavior trees that are generated by a genetic algorithm that uses the estimated change in outcome probabilities as its fitness function. Being able to develop plans would allow an NPC to take the initiative in altering one of its, or another NPC's, outcome's probability. Such a development would move NPCs out of the common responsive/passive role to an active actor and contextual instigator of game events.

- The progression of an NPC could be automatically updated as outcomes are satisfied or determined to be impossible, with new outcomes created to reflect the state of the game world. This improved progression could be managed by a behavior network that would also determine a primary outcome for an NPC to pursue. This development would further enhance NPCs with plans, permitting them to more strategically determine their next steps and to re-assess the situation to add, remove, or insert new steps to reach their ultimate goals.

- The results of Mimetic Emotions could be used to influence the choice of plans/actions, but not determine them directly; as is done with Trader. More specifically, the emotion, mood, and personality of an NPC could be factored in to the NPC's genetic algorithm when building plan behavior trees. Those affects could also be factored into the evaluation of the NPC's behavior network when choosing the NPC's primary outcome. This would likely give a more realistic representation of how decision making is influenced by affects, particularly since it would be in-line with research stating that affects primarily influence behavior indirectly (subsection 4.1.1).

Were these works to be completed, Mimetic Emotions would be refined and extended, no longer determining affective states, but also behavior in general, thereby being re-defined as Mimetic Behaviors. An NPC with Mimetic Behaviors would have affective decision making, situation analysis, a minimal form of behavior learning, and strategic planning, all of which would be applied to achieve the character's goals and to respond to the player with contextual awareness. This would likely permit NPCs to achieve an even greater level of emergent behavior, possibly being more similar to the behavior that may be expected of player characters; the applications of which could include more immersive games and, with additional developments, dynamic narratives.

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