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Design Foundations for Emotional Game Characters

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In both literature and film, richly layered characters contribute greatly to the narrative and increase the audience's enjoyment. Video games and films have very similar interfaces between the narrative and audience, but games have the potential to be more impactful due to their ability to feel more *real* to the player (Rusch 2009). This is achieved via gameplay, the direct mode of interaction between players and a game (Rusch 2008). However, even in story-oriented video games such as Computer Role-Playing Games (CRPGs), Non-Player Characters (NPCs) do not show much character depth. Despite advancements in graphic and audio quality, NPCs have remained relatively unchanged in the interactive mode of the game. We believe that deep, multi-dimensional characters inspired by human behaviour could improve player engagement—perhaps even dramatically so.

Compared to machines, humans are rarely rational automata—they react emotionally to events, something that does not yet arise in digital lifeforms. Emotions provide individuals with motivation—to cope, to begin cognitive processing, and to act (Izard 2010). Whether due to conscious reasoning or adaptive processes for survival, emotions have often been described as a driving force behind behaviour. It is reasonable to posit that players might perceive NPCs as more interesting if they reacted emotionally to circumstances too.

Some games have already integrated NPC emotion and NPC-Player relationships, such as *Persona 5* (P-Studio 2017) and *Danganronpa V3: Killing Harmony* (Spike Chunsoft 2017). However, these are scripted interactions and require heavy authorial control and effort—a luxury that many designers cannot or will not afford. A system that would automatically determine and express an NPC's emotion, especially with respect to the player, would alleviate a portion of the authorial burden while potentially producing similar benefits to their scripted counterparts. CRPGs such as *Fable* (Big Blue Box Studios 2004), *The Elder Scrolls V: Skyrim* (Bethesda Game Studios 2011), and *Black Desert Online* (Pearl Abyss 2016) already incorporate player character attributes like fame and infamy into their social interaction game mechanics. Augmenting these mechanics with emotional reactions to the player outside of direct interactions would add another layer of interest to the NPCs. Adding emotions to NPCs in other types of games, while potentially not as dramatic as for CRPGs, might still increase player interest—the inhabitants of Hyrule going about their business in *The Legend of Zelda: Breath of the Wild* (Nintendo 2017), the mercenaries displaying anger and fear in *Shadow of the Tomb Raider* (Eidos Montréal 2018) as the player picks them off one-by-one. Even arcade and platform games might be more entertaining with the addition of NPC emotion (Broekens, Hudlicka, and Bidarra 2016).

We view *Artificial Intelligence* broadly, encompassing all of the different *kinds* of human intelligence that can be mimicked by a machine. This includes *emotional intelligence*—the perception, use, understanding, and management of emotion for

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adaption and goal achievement (Mayer and Salovey 1997)—amongst the traits that computer simulations should be able to portray, especially when people interact with the simulation directly. Games are perfect sandboxes for emotional intelligence experimentation due to the implicit emotional connection between the game narrative and the player. The expectation of how closely simulated emotions mimic real life is lower than for experimental applications, a sentiment reflected in the animation and acting domains, preventing emotion models from being dismissed for not being true to life. In real life, many characters would be considered *over the top*, but are accepted in movies. This is also a step towards closing the gap between NPC visual and audio quality and their behaviours. The scope of this EE design focuses on the *using* and *managing* aspects of emotional intelligence to produce interesting and narrative-relevant behaviours.

Thus we want to implement an Emotion Engine (EE) to provide NPCs with a wider range of contextually appropriate behaviour. We present the domain and requirements analysis, the high-level design of the engine, and a series of scenarios acting as validation tests. Many different implementations can come out of this work, but the work contained here can be re-used among them all.

People react differently to events and which behaviours are chosen depends on their personality (Revelle and Scherer 2009), values (Tappolet 2009), biases (Ahn and Picard 2006; Fiske, Cuddy, and Glick 2007), and goals (Smith and Kirby 2009). There is even evidence that emotion processing is universal, with individual and cultural differences only influencing perception and behaviour regulation (Ekman, Sorenson, and Friesen 1969; Scherer and Wallbott 1994). NPCs in CRPGs already possess character and status attributes, and may display personality and biases in the game's narrative. However, *agency attributes*—personality, values, biases, and goals—are typically not part of the gameplay mechanics. These attributes should alter NPC behaviours as events unfold within the game world, increasing their believability within their assigned narrative role. For example, the most reasonable option for a Level 1 character who encounters a combative Level 40 character is to run away because they have a low probability of survival. Emotion presents an opportunity to incorporate new mechanics whereby an NPC is given more agency for their own behaviour planning process so that they can be directly influenced by in-game scenarios. This integration of NPC emotions and the gameplay has the potential to create an emotional rapport with the player. This increases the game's association with reality—and consequently the player's emotional connection to the game—due to the player's real actions affecting the fictional world (Rusch and König 2007).

Defining *emotion* is difficult because there is little agreement, even within the field of psychology, on what emotion *is* (Barrett 2006). It is generally accepted that "an emotion is a psychological state or process that mediates between our concerns (or goals) and events of our world" (Keltner, Oatley, and Jenkins 2014, pp.4). However, the questions of *how* and *why* this happens are subject to debate. There are three broad, but not incompatible, categories of emotion theory: *physiological*, where emotions are elicited by or occur simultaneously with physiological and neurological changes; *expressive*, where emotion are adaptive survival functions and cause observable and measurable behaviour changes; and *cognitive*, where emotions arise from an appraisal process rooted in cognitive processes (Carlson and Hatfield 1992).

At present, no one theory has been accepted over all others and psychologists are still determining how the known aspects of emotion fit together. For the purposes of a game, any coherent emotion model can be used, as long as it satisfies the designer's needs for creating the player experience. Here we pursue *psychoevolutionary synthesis* (PES) to represent the internal emotion state, and *cognitive appraisal* (CA) to design an evaluation process for generating emotions from game world state data.

Examining these two coherent, complementary models highlights a number of issues, such as the difference between *affect*—any influence on the mind, including reflexes and drives, which originates from the body—and *emotion*—specific affect categories comprised of multiple cognitive elements such as a subjective feeling state (Barrett and Bliss-Moreau 2009)—and identifies requirements that a game engine must fulfill. For video game purposes, designers have more design flexibility because the purpose is not necessarily to achieve *correct behaviours* so much as *interesting behaviours*. However, interesting behaviours should still be *psychologically valid*—grounded in human psychology—to make them plausible and more likely to be accepted by players (Broekens, Hudlicka, and Bidarra 2016). Some of the requirements are: NPCs should have prioritized goals, possess a world model that includes knowledge of events, characters and objects of the world, understand how the model affects their ability to achieve and maintain their goals, and know what actions they can take and their effects on the world.

Our goals are to build a portable, efficient, and testable EE, where the design decisions underlying the engine's architecture can be justified from the adopted emotion models. Lastly, we are more interested in a blueprint for a family of engines than a single engine that *does it all*.

We first review cognitive architectures and EEs, noting which emotion theory they use and some reasons why. We then describe PES and CA, and draw out the *induced requirements* for an EE, as well as what we need from the larger game engine in which our EE is embedded, and what services our EE can offer to the game in return. Then we can dive in to the more detailed design of the EE itself—not just what inputs and outputs it provides, but also the internal architecture and computations. Lastly, any implementation of this design must be *validated* with respect to the expected emotional response of the NPC. For this purpose, we outline emotion-eliciting scenarios of known characters and events in popular animated films which result in the display of specific emotions. These scenarios are specified with respect to PES and CA with the understanding that the proposed design might need to be refined.

Modeling Emotion

The notion of *believable characters*, central in literature and film, refers to a character that displays the *illusion of life* and helps audiences' suspension of disbelief (Bates 1994). Well-timed and clearly expressed emotion, credited as key to the illusion of life in animated Disney characters, gives them the appearance of having desires and caring about what happens in their world. Rather than realistic portrayals, emotions are often exaggerated, staged with respect to other characters in the scene, and expressed through their actions. Many cognitive architectures have focused on realism, but some have been designed to create this illusion of life for use in games.

Cognitive Architectures

Considerable effort has been spent creating intelligent agents for real-world tasks, but the focus has been almost exclusively on the rational components of the mind. Affect and emotion have been given much less consideration despite arguably being what make us human. LIDA, a cognitive model for computer agents, is based on the idea that any autonomous agent must continuously sense their environment, interpret the gathered information, and then act (Franklin et al. 2014). Particular to LIDA is the use of the *principle of grounded cognition* from psychology: internal representations of sensory inputs are based on primitive sensors and actuators. However, the overwhelming amount of information available from the environment would make it difficult for an agent to select information from raw input data, requiring an attention mechanism to identify *relevant* information. In an open world where the environment is too complex to model outright, agents must be able to update their world model via learning. However, video games are a closed world, so believable NPCs could be built from hard-coded models; of course, for long-term play, more realism might be achieved if NPCs used learning too. With LIDA, it is possible to use more appraisal factors affecting emotion intensity than other models. The emotion model is based on work by Marsella, Gratch, and Petta (2010) and the appraisal factors are taken from the work of Scherer (2001).

SOAR is an architecture designed to handle cognitive tasks in a goal-driven way that uses a subset of the appraisal dimensions from Scherer divided into three main types—attention directing, future consequences, and action selection (Laird 2012). Multiple processes are used in appraisals and past appraisals inform subsequent ones. Perhaps uniquely, emotions are not used to influence behaviour and learning—the appraisal values are used directly. Intensity and valence are derived from appraisal values, which are then used to calculate a reward signal for reinforcement learning algorithms. Care must be taken to prevent the agent from entering a reward loop due to appraisal feedback.

ACT-R is a cognitive architecture for investigating the organization of knowledge and how it produces intelligent behaviours (ACT-R 2002). It does not natively handle emotion or affect but its modular design allows it to be so extended (Dancy 2013). A modification that changes goal and confidence values for ACT-R’s learning and problem solving capabilities could be viewed as implicit emotion effects (Belavkin 2001).

CLARION is a cognitive architecture incorporating action decision-making, memory and inference, motivational processes, and meta-cognition (Sun 2007). While CLARION does fully-integrate motivational drives into its cognitive processes to create system goals, it fails to acknowledge the role of affect and emotion on goal formation.

The Hourglass of Emotions is a model of affect organization inspired by Plutchik (1980) to objectively assess affective states and their natural language associations

(Cambria, Livingstone, and Hussain 2012). The central idea is that an actor's capabilities can be activated independently by emotional states. Plutchik's eight primary emotions (joy, sadness, disgust, trust, fear, anger, surprise, and anticipation) are arranged around four independent affect dimensions, whose collective activation levels contribute to the total emotional state. They suggest a transition function for moving along an affect dimension that rises quickly to a unit value, inspired by *strong* emotions, which tend to be felt in isolation.

The Fuzzy Logic Adaptive Model of Emotions, FLAME (El-Nasr, Yen, and Ioerger 2000), and the Emotion Model for Intelligent Agent, EMIA (Jain and Asawa 2015), are two computational models of emotion that use fuzzy logic and rules to map appraisal values to emotions. A combination of OCC (Ortony, Clore, and Collins 1988) and Roseman's (Roseman, Spindel, and Jose 1990) models of emotion (EMIA also uses Scherer's work) are used for appraisals and emotion definitions. After an emotional state is calculated, FLAME sends it through a filtering process where emotions can impact each other's intensity before being used for action selection. EMIA passes the emotional state to a decoder to translate the domain-independent emotion into domain-specific text which can then be used to select actions. Emotions in EMIA are regulated by reappraisals and suppression after predicting what the next event will be. Both models include emotion decay mechanisms. FLAME also uses event predictions based on past interactions with the user, modelled using a probabilistic approach, such that the likelihood of event occurrence and their desirability are learned dynamically.

The Emotion and Adaption model, EMA (Marsella and Gratch 2009), uses CA (Smith and Lazarus 1990) and models both the quick reactionary appraisals and slow deliberate appraisals of events that give rise to different emotions. Mood accounts for some of the indirect effects of emotion, biasing individual appraisals and coping responses. Coping strategies are implemented as control signals, enabling or suppressing cognitive processes influencing attention, goal utility, and action selection.

The Emotion-Belief-Desire-Intention architecture (EBDI) allows designers to implement an emotion theory of their choice to influence the reasoning of the BDI architecture (Jiang, Vidal, and Huhns 2007). Its design was motivated by an individual's inability to make decisions under emotional impairment, emphasizing the role of emotion in human reasoning. EDBI's flexibility lets designers decide how to measure and present emotions, how emotions affect decision-making, and how to update the emotion state.

The Generic Robotic Architecture to Create Emotions, GRACE, was built for the EmotiRob project, a robot companion for impaired or hospitalized children (Dang and Duhaut 2009). The affect system in companion robots was found to directly impact the psychological comfort of the human users, emphasizing the need for machines to have emotional reactions to improve their usability. GRACE uses OCC's appraisals for evaluation, CA's appraisal and coping strategies for stabilizing the individual-environment relationship, and Scherer's emotional processes. The robots were also given personalities that are noticeable to human observers.

Modeling Emotion in Games

The most frequently used model in emotion engine designs for games are the Ortony, Clore, and Collins (1988), or OCC, model of emotion which defines a set number of emotion types with a three stage appraisal process. This model is often supplemented with the Pleasure-Arousal-Dominance (PAD) space model (Mehrabian 1996) to enable emotional variations, intensities, and moods.

The emotion and social relationship component—Em—in the Oz project's Tok agent architecture uses the techniques for conveying emotion in animation, such as the illusion of life (Thomas and Johnston 1981), to design believable agents in simulated worlds (Bates, Loyall, and Reilly 1992). Goals, which have an *importance* value for Em processes, are abstracted away from the emotion system such that action selection can also be influenced by other architecture processes. Em uses the OCC model to evaluate emotional states based on an agent's goals, but not all goals result in emotional reactions. Em also models the decay of emotions over time.

A Layered Model of Affect (ALMA) integrates emotions via the OCC model, moods via PAD space, and personality via the Five Factor model of personality (De Raad 2000) and addresses the duration of each of these affects (Gebhard 2005). The temporal attributes of each affect are used to influence specific tasks or functions which impact human behaviour. Emotions affect short-term behaviours, such as gestures, facial expressions, and verbal expressions, and are associated with a specific object or event. Emotion-eliciting conditions are identified by appraisal tags assigned at design time and used to calculate emotions along the dimensions of *desirability*, *praiseworthiness*, *appealingness*, and *likelihood* (Gebhard et al. 2003). Moods affect medium-term cognitive behaviours, such as attention, and are not related to a specific object or event. An initial mood is determined from personality values and is altered by experienced emotions, which are each mapped to PAD space values. Personality affects long-term behaviours, and is used to influence the intensity of emotional reactions and emotion decay rate (Gebhard, Klesen, and Rist 2004).

GAMYGDALA is an EE designed specifically for video game NPCs based on the OCC model with the option to derive PAD space values as an alternative emotion state representation (Popescu, Broekens, and van Someren 2013). The goal was to make a modular, black-box engine grounded in psychological theory while remaining efficient and easy to use for non-experts. Developers can design goals for their NPCs and annotate game events with information which affects those goals. The engine scales reasonably well and has been shown to be game independent (Broekens 2015). The OCC model was chosen because it is well-known and accepted emotion theory, easily translates to a computational framework, allows for a variety of emotions, accounts for both internal emotions and social relationships, and has been successfully used before.

JBdiEmo (Korecko, Sobota, and Čurilla 2014) is an extension of the agent-oriented reasoning software Jadex to augment rational reasoning with irrational elements—emotions. It is intended to be used in an immersive virtual environment for training fire service personnel. The OCCr model of emotions, an inheritance-based hierarchy of emotions based on OCC (Steunebrink, Dastani, and Meyer 2009), was chosen due to a previous proposal to combine it with the Belief-Desire-Intention (BDI) model (Bratman 1987) implemented in Jadex as well as being implementation-friendly.

Moving Forward

These are only a small sample of the many systems that have been proposed over the years for intelligent and emotional computers. The first models of human intelligence ignored emotions for their supposed irrationality as seen in the original designs of SOAR and ACT-R. Interest in various forms of emotion simulation grew when emotions were subsequently found to be important for many aspects of human intelligence (Picard 2003). Unfortunately, much like psychological research of emotion, most attempts to build a computational model of emotion fail to reuse or compare new models with existing ones, preferring instead to reinvent the wheel (Reisenzein et al. 2013). No example makes this clearer than the many designs and implementations of the OCC model. Due to the lack of documentation, it is unclear why this model has been used so frequently although an analysis of the thought process behind its selection would be beneficial for directing other designs.

Ultimately, the ideal approach is to analyze several emotion theories of the same type and create a general computational model from their similarities (Reisenzein et al. 2013). Then the selection of a single theory would be used to *configure* the model to fill in the information that is not common between theories, but needed to make a functional design. Some progress has already been made on this front by Marsella, Gratch, and Petta (2010). We use CA as our evaluation process for emotion generation, which could also serve as a configuration of a general appraisal process.

Computational Models of Emotion

There is inconsistent evidence for what emotions are—are they explanations for why people behave certain ways or are they classification schemes that people impose on their perception of the world (Barrett 2006)? This fundamental, unanswered question on the nature of emotion makes specifying a computational model difficult. However, this also affords the freedom to choose emotion theories that are more likely than others to achieve a desired effect—in the case of entertainment, these are the models that are closely aligned with how people construe emotion in imaginary and fictional scenarios. Some defining elements of an *emotional episode* recur, such as physiological responses, subjective feeling states, and action and expression tendencies, but definitions deviate beyond this point. For design purposes, we define emotion as an internal state that manifests in the external environment by way of behaviours and expressions. Note that any chosen model's working definition of an emotion might not match the layman's definition, and can even differ between psychological models. Thus, to avoid confusion, it is imperative that the conceptual framework used for emotion be clearly defined in EE design specifications.

There are many different theories regarding the number and type of core emotions, but the model proposed by Robert Plutchik (1980), psychoevolutionary synthesis (PES), has two advantages:

- A limited palette of eight *primary* emotions arranged in a simple structure representing their degree of similarity to each other, and

- A method for defining non-primary, or *compound emotions*, analogous to the colour wheel requiring little or no additional information or evaluation beyond what is needed for the primary emotions.

One can picture this model as being *continuous*, rather than strictly discrete, which fits our vision of a modern game engine.

Compound emotions have not enjoyed the same level of attention in research psychology, but there is evidence to support that they can be recognized in facial expressions (Du, Tao, and Martinez 2014). Including compound emotions in PES increases design and narrative freedom.

A drawback of PES is the minimal specification of what factors influence different emotions and how the factors are related. Addressing this shortcoming requires a distinction between *affect* and *emotion*. Affect describes "something's ability to influence your mind in a way that is linked to your body" (Barrett and Bliss-Moreau 2009, pp.168). Emotions, then, are type categories that *affect dimensions*—the factors that create emotion—are mapped to. It is common to see *pleasantness* and *arousal*, or activity and attention level, as independent affect dimensions but this still leaves the mapping of affect regions to emotions for individual emotion theories to detail. For video games, the decision of what dimensions to include and how to calculate them are left to the designer as the purpose is not necessarily to achieve *correct behaviours* so much as *interesting behaviours*. However, the design should be grounded in human psychology to improve the plausibility of NPC behaviours, which aids the player's suspension of disbelief (Broekens, Hudlicka, and Bidarra 2016). The engine should output a set of emotion values, and optionally intensities, with the computational details remaining *abstract*.

Another theory of emotion, Richard Lazarus's cognitive appraisal (CA) (Smith and Lazarus 1990), provides a connection between affect and emotion that is coherent with PES. Both theories state that emotions arise as an individual's *goals* or *motivations* are impacted by changes in their environment. CA additionally proposes a set of questions to evaluate *how* goals are impacted. These questions form the foundation for developing affect dimensions which can then be mapped to the emotion types in PES.

Robert Plutchik's Psychoevolutionary Synthesis

PES is a structural model of emotions which aims to unify findings from evolution, psychophysiology, neurology, and psychoanalysis research (Plutchik 1980). It postulates that emotions arise in response to survival issues and that there are a set number of patterns shared by all organisms. Eight primary emotions—joy, sadness, disgust, trust, fear, anger, surprise, and anticipation—are arranged in a circular structure where opposing emotions appear on opposite sides of the circle. The two dimensional, circular model of the primary emotions can be expanded into three-dimensional space when emotion intensities are added, creating an inverted cone shape (Figure 1). Low intensity emotions appear near the point of the cone and the highest intensity emotions appear around the outer circle of the cone’s base. Three intensity levels add an additional sixteen *secondary* emotions to the design space.

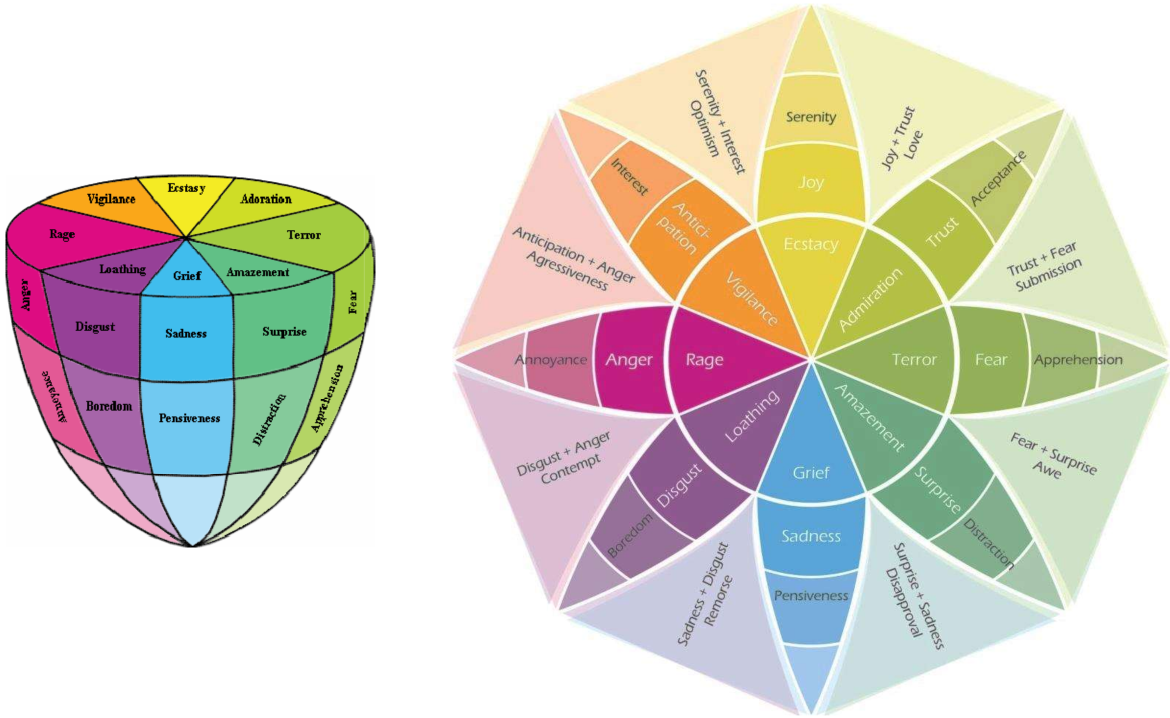

Figure 1: A 3D and a flattened view of Plutchik's Emotion Solid

A constraint of models like OCC is the static number and type of emotions. While it is theoretically possible to extend these models to include additional emotions, there are no defined guidelines on how to do so. This can lead to some difficult design problems, specifically when adding an emotion that is not adequately described by one of the existing types. PES provides a method, analogous to the colour wheel, for creating new emotion types using the primary emotions and, optionally, their intensities (Table 1). For example, mixing the primary emotions of *disgust* and *anger* creates the secondary emotion *contempt*, combing the feelings of rejection and destruction. This flexibility allows designers to include and exclude non-primary emotions as needed, a luxury that has not been afforded by other models.

Complex Emotion	Mixture
Pride	Joy + Anger
Outrage	Anger + Surprise
Hope	Trust + Anticipation
Panic	Terror + Anticipation
Hatred	Loathing + Anger

Table 1: Examples of Compound Emotions

Each emotion is associated with a *behaviour prototype* (Table 2) that describes how individuals will respond to feeling the emotion, such as disgust describing rejection-oriented actions. Emotional responses can be further specified based on the current context (e.g. ignoring someone in social disgust versus vomiting in physical disgust).

Primary Emotion	Behaviour Prototype	Example
Joy	Reproduction	Meeting with loved ones
Sadness	Reintegration	Cry for Help
Fear	Protection	Flight
Anger	Destruction	Fight
Trust	Incorporation	Welcoming guests into the home
Disgust	Rejection	Avoiding a target person
Surprise	Orientation	Evaluating a new object
Anticipation	Exploration	Curiosity

Table 2: Primary Emotions in PES

Richard Lazarus's Cognitive Appraisal

The association of emotions to prototypical behaviours lends itself to another model of emotion—cognitive appraisal (CA) (Smith and Lazarus 1990). CA, while disagreeing with Plutchik's assumption that there are only eight prototypical behaviours shared by all organisms, agrees with the relationship between survival issues and emotion, and describes a process that predicts which emotion is generated by an event. The disagreement on prototypical behaviours does not affect their compatibility in an EE.

CA states that an emotion arises from an appraisal of the individual-environment relationship (*event*) that has a foreseeable benefit or harm. Emotions are differentiated from actions like startling and hunger by their generality—startling and hunger arise from specific triggers, whereas emotions arise from a class of related stimuli, requiring judgement and reasoning developed via learning to determine which class elements in the environment fall into. Emotions have a class of related behaviours designed to interact with the environment in response, reducing the number of input-specific reflexes and drives required to navigate a complex environment. Appraisals are based on existing motivational and bias values which interact with a set of environmental demands, constraints, and resources. CA assumes that if an individual's appraisal of the environment is known, then their felt emotion can be predicted. For example, if a *threat to well-being* is identified, then an individual will have an urge to either *avoid* or *neutralize* the threat. What constitutes a *threat to well-being* and the actions of *avoid* or *neutralize* depends on what the individual has associated with those classes based on their goals and internal world model (e.g. a *threat* could be a predator or the disapproval of a co-worker). This knowledge is further influenced by social factors and personality.

To determine what *core relational theme* (comparable to PES's *behaviour prototypes*) that *events* match, a number of questions must be answered. CA defines two appraisal units, primary and secondary, for this purpose (Table 3). Primary appraisal asks if the *event* is relevant to the individual's well-being, determining the motivational relevance (i.e. the extent to which the individual's goals are impacted), and congruence (i.e. does this benefit or harm the affected goals?). These two questions alone establish benefits, harms, and if the benefits/harms are a certainty, currently observable outcome, or a potential future outcome. Primary appraisal is used for all emotions and relevance must be established before determining congruence. Secondary appraisal asks what resources and actions are available that the individual can use to cope with the *event*. It establishes accountability (who, if anyone or anything, is responsible for the benefit/harm?), problem-focused coping strategies (what actions can be taken to influence the *event* directly?), emotion-focused coping strategies (can the internal emotional state be influenced?), and future expectancy (what perceived possibilities of outside influences exist that could alter the benefits/harms resulting from the *event*?). Once an appraisal is made and an emotional response is chosen, associated social communication (e.g. facial expressions, vocal cues) and behavioural actions (e.g. movement, attack) become available.

Stage	Factor	Question	Requires
Primary Appraisal	Motivational Relevance	Is this event relevant to me?	Goals
	Motivational Congruence	Is this event beneficial or harmful to me?	Goals
Secondary Appraisal	Accountability	Who or what is responsible for the benefit/harm?	Possible causes of the event
	Problem-focused Coping Strategies	What actions can be taken to influence the event directly?	Knowledge of available actions and their results
	Emotion-focused Coping Strategies	What options can be taken to regulate my emotions?	Knowledge of emotion modifiers and their results
	Future Expectancy	Is there anything else that could influence the event's benefits / harms?	Knowledge of the environment

Table 3: Appraisal Stages

The terms *primary* and *secondary* refer to their relative importance—if the results of primary appraisal determine the event to be irrelevant, then further appraisals have limited, if any, value. CA provides multiple affect dimensions: *desirability* (goal congruence), *controllability*, *power*, and *effort* (accountability, and problem/emotion-based coping strategies and their expected effectiveness), and expectation of future events and outcomes that would result from a potential outside influence (*future expectancy*). Different combinations of these affects can then be mapped to emotion types.

Combining the Models

Assuming that an event is relevant (motivational relevance is established), PES's eight emotion types combined with CA's appraisal values imply unique emotion patterns (Table 4). The *future expectancy* of both *surprise* and *anticipation* are listed as *either* because its evaluation heavily depends on the inciting event and personality.

Emotion	Desirable	Controllable	Effort	Future Expectancy
Joy	True	True	Low	Favourable
Sadness	False	False	Low	Unfavourable
Fear	False	False	High	Unfavourable
Anger	False	True	High	Unfavourable
Trust	True	False	Low	Favourable
Disgust	False	True	High	Unfavourable
Surprise	False	False	Low	Either
Anticipation	False	True	High	Either

Table 4: Mapping Emotion to Appraisal Dimensions[1]

Emotions do not last indefinitely—they dissipate after a time, i.e. there must be an emotion decay mechanism to return to a predetermined base emotion state. This in turn requires a specification of baseline values for each emotion, as well as a decay function.

Both PES and CA implicitly allow for personality to be expressed without changing the core mechanisms via goal, bias, value, and coping strategy definition. This implies that an explicit personality model might not be required.

Requirements Analysis

PES entails a rather simple (internal) representation of emotions: an 8-vector of values in [0,1]. Some invariants must be maintained, as one does not commonly experience opposing emotions, like joy and sadness, simultaneously. CA is considerably more complex to encode. Answering the appraisal questions requires NPCs to have an internal representation of their knowledge and view of the world. More explicitly this representation for each NPC should contain:

- Their goals, biases, motivations, and intentions, potentially with priority values,
- A model of their knowledge of events, characters, and objects in the world,
- A set of definitions representing how those events, characters, and objects affect their ability to achieve and maintain their goals,
- Actions that they can take and what their effect is on the world,
- Modifiers that they can use to control their emotional state.

The game environment will need to provide the EE with sufficiently rich information about the game and NPC states. On output, the engine acts as the selection mechanism for choosing between different behaviour, animation, and audio sets.

Expanding on some of these further, *goals* (motivation) can range from self-preservation to owning a successful business. For example, if an NPC has a *self-preservation* goal, then any in-game event that could reduce their health (or hit points) could be viewed as relevant and harmful. Goals can also be used to add more dimension to NPCs: consider a large, battle-scarred warrior—wouldn't it be interesting to see them become depressed when your party passes by their home village without stopping, negatively affecting their goal to visit home sometimes?

There are further technical requirements on an EE including:

- *Reasonable resource usage,* to limit the impact on other game elements, especially as the number of NPCs increases,
- *Efficacy,* so that emotional reactions are manifested in both number and times comparable to humans' own emotional reactions for suspension of disbelief, and
- *Portability,* such that the EE can be used in different games with changes limited to only the game-facing components.

The EE needs to be able to query game world state information—but needs the results to be game agnostic. To limit the resource usage of per-NPC queries, a notification architecture (instead of polling) makes sense: NPC agents can be notified when relevant, *visible* events happen in the game world. Resource usage can also be managed by using primary appraisal to filter events, which can be parametrized by goals and motivational relevance.

CA supports one of our design goals—portability between both characters and games— because it is parametric in the evaluation of goals, biases, values, and NPC's coping strategies. PES allows a varying number of emotions; this enables artistic flexibility by providing multiple mechanisms to express character traits.

Internal emotional states must somehow have an external manifestation if they are to be perceived by the player. Observable components of emotion include:

- *Behaviours*—actions that are performed and have some physical impact on the external environment, and

- *Expressions*—social signals including facial expressions and vocal cues that have no direct impact on the external environment but serve to communicate what the NPC's internal emotion state is to others.

These are analogous to an NPC's AI behaviours and cosmetic elements—animations and audio cues—respectively. Existing NPCs already have these, and thus game designers need only to determine which to execute for each emotion type.

In a very flexible architecture, NPC behaviours, animations, and audio elements can be essentially continuous. For the time being, as behaviours and animations are most frequently discrete, some kind of thresholding is needed before a behaviour, animation, or audio clip is triggered, with some extra care to avoid hysteresis. Threshold values can be tailored to fit an NPC's personality by dictating how intense an emotion should be before they show any observable signs. For example, an NPC that is slow to anger would have a much higher threshold value for that emotion than one who is quick to anger. Discrete thresholds can also be defined for different behaviours and expressions based on intensity, such as physical shaking in mild anger and aggressive actions for intense anger; these lie in the same continuum of actions.

It is important to keep behaviours, animations, and audio separate as they functionally different aspects of the NPC, and also allows them be triggered asynchronously. Thus a character can perform actions from different emotion types, such as running away and smiling, to further enrich an NPC's narrative relationship with the player and game environment.

A Computational Architecture of Emotion

All models have some points in common: goal specification, attention, evaluation processes for converting stimuli into emotions, emotion decay, and a behaviour expression mechanism. Evaluation and emotion state are unaffected by personality, biases, and values[2], leaving the expression of these factors to the goal specifications, attention, behaviour and expression regulation, and the emotion decay process.

If we encapsulate each of these processes in a module, and link them via the obvious data dependencies, we obtain an EE design for NPCs (Figure 2). The *environment monitor* is event-driven, receiving notifications only when events of interest occur. NPC attention filters, followed by goal and motivation-based filters, mean that only relevant information is passed to the evaluation module for conversion into emotion types and intensities. NPCs can be implemented as stateful Actors who store their current emotional state, including intensity. Emotion decay directly modifies the emotion state over time. The expression thresholds are directly compared to the current emotional state to determine what, if any, new behaviours, animations, and audio to trigger.

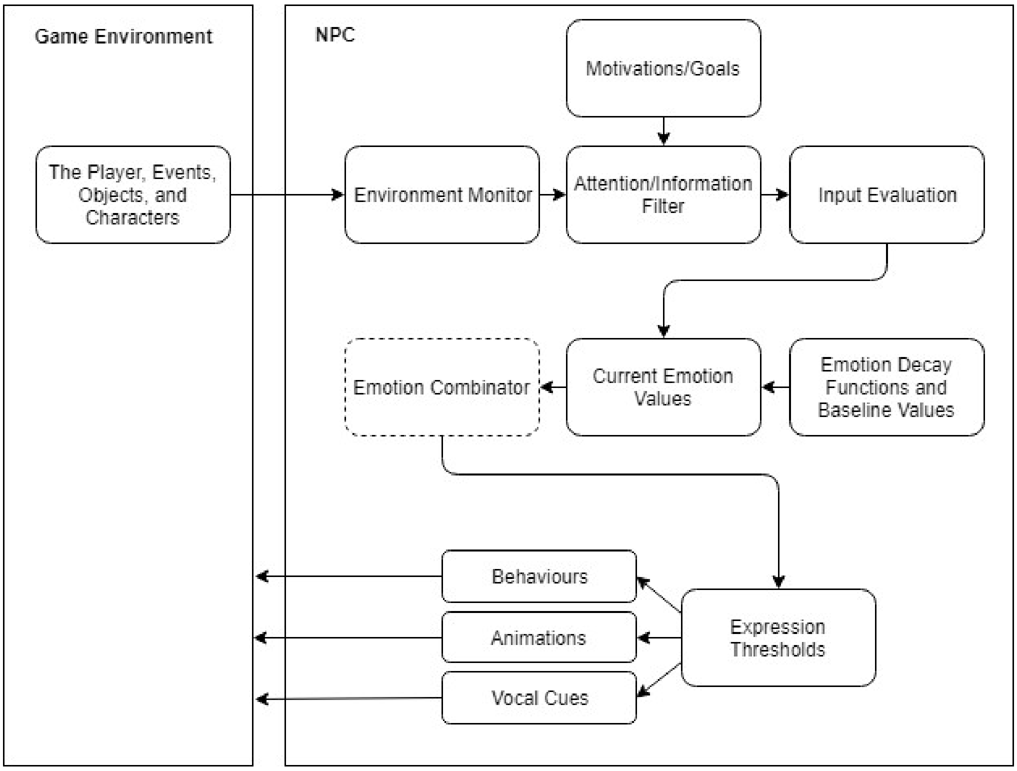

Figure 2: Information flow through the emotion architecture

Scenarios: Testing the Architecture

Given an implementation of our specification, we need to ensure that NPCs react to scenarios in expected ways. Every game has a set of scenarios that are integral to the game narrative where NPCs should have a known, predictable emotional reaction, which can serve as test cases. Test cases are scenarios where following are all known:

1. The NPC's design (goals, motivation, current state, etc.),
2. The relevant world state,
3. The expected emotional reaction, including values for the appraisal dimensions, and
4. The expected behaviour, visual, and auditory cues.

The NPC's design and relevant world states are test inputs while the next two are the expected results. In particular, scenarios should be explicit about what appraisal dimensions are being used—here, they are *relevance*, *desirability*, *controllability*, *effort*, and *future expectancies*. Test failures present an interesting challenge to designers—was it an error in the character design or did the NPC remain in character in unexpected ways? Unfortunately an EE is not too dissimilar to a neural network, whose inner workings can be fiendishly difficult to fathom.

The usual way to test a set of modules with a well-defined interface to a larger program is by *mocking* the missing modules. Thus we need to simulate only part of the game environment—just enough to enable testing. We can then send simulated game events to the EE to get an NPC’s reactions. The NPCs themselves should be fully fleshed out (with their goals, values, motivations, etc.) for accurate testing. To further ease testing, we can look at the triggers for the behaviours, animations, and vocal cues, rather than those outputs themselves, perhaps by stubbing those modules.

In the next few subsections, we will give some sample scenarios—two in detail and the remaining ones as descriptions—to illustrate our design. These are drawn from animated movies, as both the characters and their reactions are made deliberately clear to the audience. We also give more details about the emotions to clarify how each scenario exemplifies them. We use <angled brackets> as signifiers for game states or mechanics; these should be readily implementable.

Serenity, Joy, and Ecstasy

Safe and familiar settings that typically require little personal effort create feelings of *joy* (Ekman 2007). This broadens attention and thinking and builds personal skills and resources (Fredrickson 2009). Low intensity joy, *serenity*, is characterized by a low arousal state (Sunddararajan 2009). The intensity of the arousal state grows to match the intensity of *joy* and *ecstasy*.

Jasmine from Disney’s *Aladdin* (1992) illustrates each intensity level of joy. Three characters are involved—Jasmine, her preferred suitor Aladdin, and her father; her goal is to marry for love, not duty (Table 5). She may choose who to marry, but must first get her father’s approval which is dependent on Jasmine's happiness and the law stating that she must marry a prince by her sixteenth birthday (Table 6). As king, Jasmine’s father can change laws.

Goal		Marry for Love	
Priority	High	**Agency**	Low
Requirements		**Can Influence?**	
Good relationship with partner		Yes	
Get her father’s blessing		Yes	

Table 5: Model of Jasmine's goal Marry for Love

World State	**Can Change?**		
	Jasmine	**Aladdin**	**Father**
Suitors must be royalty	X	X	✓
Princesses must be married by sixteen	X	X	✓
Passage of time	X	X	X

Table 6: Jasmine’s knowledge of the World State

Jasmine can <get her father’s blessing> if she <chooses a suitor> who fulfills <Suitors must be royalty> and then <informs her father> of her choice. Her father assumes that if she has performed this action, then <Jasmine is happy>.

Jasmine believes Aladdin to be a prince (Table 7). Although she has made her own choice, she has no control over the conditions themselves. The effort to fulfill the preconditions is low (Table 8).

Character	Aladdin	
Known	**Affects**	**Alignment**
Is a prince	<Get her father’s blessing>	Positive
Loves Jasmine	<Good relationship with partner>	Positive
Jasmine’s preference		Positive

Table 7: Jasmine's model of the character Aladdin

Dimension	**Factors**	**Evaluation**
Desirable	Aladdin → Jasmine’s preference, Loves Jasmine	Mid +
Controllable	<chooses a suitor> subject to <Suitors must be royalty> and <Princesses must be married by sixteen>	Low +
Effort	(Aladdin → Is a prince) means Jasmine can <get her father’s blessing> by <informing her father>	Low
Future Expectancy	<get her father’s blessing>	Favourable
Emotion State	Serenity (Joy—Low Intensity)	
Behaviour	<sitting calmly>	
Animation	<brushing her hair>	
Audio	<humming to herself>	

Table 8: Jasmine's evaluation of her ability to complete the Marry for Love goal

When Jasmine <informs her father>, she <gets her father’s blessing>, towards her goal *Marry for Love*. To proceed, Jasmine must <publically announce her decision> to make her engagement official, improving *desirability* as her goal is almost complete (Table 9).

Dimension	**Factors**	**Evaluation**
Desirable	Aladdin → Jasmine’s preference, Loves Jasmine Father → granted blessing	High +

Controllable	Jasmine must <make her decision public>	Low +
Effort	Jasmine must <publically announce her decision>	Low
Future Expectancy	Complete goal → Marry for Love	Favourable
Emotion State	Joy (Joy—Medium Intensity)	
Behaviour	<hugging Aladdin>	
Animation	<smiling and nodding at her father>	
Audio	N/A	

Table 9: Jasmine's reevaluation of her ability to complete the Marry for Love goal

Later it is discovered that Aladdin is not a prince (Table 10), violating the <Suitors must be royalty> condition necessary for Jasmine to <get her father’s blessing>.

Character	Aladdin	
Known	**Affects**	**Alignment**
Is not a prince	<Get her father’s blessing>	Negative
Loves Jasmine	<Good relationship with partner>	Positive
Jasmine’s preference		Positive

Table 10: Jasmine's updated model of Aladdin

However, Jasmine’s father is so impressed with Aladdin’s heroic deeds that he <changes the law> from <Suitors must be royalty> to <Suitors must be deemed worthy> (Table 11). This grants Jasmine additional control under the law and she <chooses Aladdin> to be her husband. Jasmine’s updated model of Aladdin is shown in Table 12 and her evaluation of the scenario in Table 13.

World State	**Can Change?**		
	Jasmine	**Aladdin**	**Father**
Suitors must be deemed worthy	X	X	✓
Princesses must be married by sixteen	X	X	✓
Passage of time	X	X	X

Table 11: The world state model after <changes the law> is performed

Character	Aladdin	
Known	**Affects**	**Alignment**
Is worthy	<Get her father’s blessing>	Positive
Loves Jasmine	<Good relationship with partner>	Positive
Jasmine’s preference		Positive

Table 12: Jasmine's model of Aladdin after her father <changes the law>

Dimension	**Factors**	**Evaluation**
Desirable	Aladdin → Jasmine’s preference, Loves Jasmine Father → granted blessing	MAX +
Controllable	Jasmine no longer restricted by <Suitor must be royalty>; must still <make her decision public>	Mid +
Effort	Jasmine must <publically announce her decision>	Low
Future Expectancy	Complete goal → Marry for Love	Favourable
Emotion State	Ecstasy (Joy—High Intensity)	
Behaviour	<running to Aladdin>	
Animation	<jumping>	
Audio	<Dialogue—“Him! I choose him!”>	

Table 13: Jasmine's evaluation of her ability to complete the Marry for Love goal after her father <changes the law>

Pensiveness, Sadness, and Grief

Sadness is commonly felt when an event, caused by others or circumstance, is appraised as unpleasant, obstructive to personal goals or concerns, and the individual perceives themselves as unable to cope with or modify the situation (Zammuner 2009). It tends to arise in response to a personal loss, disappointment, or hopelessness, with the intensity varying with the importance of the person, item, or concept to the individual (Ekman 2007). *Sadness* naturally cycles through different intensity levels, which PES labels *pensiveness* and *grief* for low and high intensities respectively.

Elsa from Disney’s *Frozen* (2013) expresses all three intensity levels. Simplifying for clarity, we only consider Elsa and her sister, Ana, in these test cases. Elsa’s highest priority goal is to protect Ana (Table 14) and she considers her other goal, personal happiness (Table 15), to be less important than maintaining Ana’s safety. As children, the sisters built up a good relationship. Elsa knows that her powers can injure others and but cannot use them if she conceals her hands. She believes the world to be dangerous and uncontrollable after her parents died on a trip. In their kingdom, the queen is the highest authority. In this world, death is permanent (Table 16).

Goal		Protect Ana	
Priority	High	**Agency**	Low
Requirements		**Can Influence?**	
Ana’s safety		Yes	
Control ice powers		No	

Table 14: Model of Elsa's goal Protect Ana

Goal		Personal happiness	
Priority	Low	**Agency**	High
Requirements		**Can Influence?**	
Ana’s happiness		Yes	
Good relationship with Ana		Yes	

Table 15: Model of Elsa's goal Personal Happiness

World State	**Can Change?**	
	Elsa	**Ana**
Ana lives in the castle	✓	✓
Elsa’s powers can cause injury	X	X
Concealing Elsa’s hands blocks her powers	X	X
The world is dangerous and uncontrollable	X	X
The queen is the highest authority in her kingdom	X	X
Death is permanent	X	X
Good relationships requires in-person interactions	X	X

Table 16: Elsa's knowledge of the World State

When Elsa injured Ana with her powers, she decided that she was dangerous and her powers uncontrollable. This made her a threat to Ana’s well-being and that self-imposed isolation, despite being the queen, was the best way to keep Ana safe (Table 17).

Our first scenario finds Elsa imprisoned in the dungeon as high-status visitors believe that her uncontrolled powers were actually a murder attempt. If Ana knew where she was, she would insist on <seeing her sister>. This violates Elsa’s <self-isolation> and she values <Ana’s safety> more than her own <personal happiness>. Elsa’s hands are <restrained>, which <conceals her hands> but prevents her from <distancing herself> from her kingdom—her strategy for keeping Ana safe. She is able to <break her restraints> and <escape>, but this might <cause injury> to a bystander. As queen, Elsa is the highest authority and, given that she <is dangerous>, she hopes to

<convince> her jailors to <release her> willingly so that she can return to <self-isolation>. However, she cannot <convince her jailors> directly and must rely on a liaison to deliver her message. If she remains imprisoned and loses control of her power, Elsa has no guarantee of her sister's safety (Table 18).

Character	Elsa	
Known	**Affects**	**Alignment**
Loves Ana	<Ana's safety>	Negative
	<Good relationship>	Positive
Is dangerous	<Ana's safety>	Negative
Self-isolation	<Ana's safety>	Positive
	<Good relationship>	Negative
Is queen	—	—

Table 17: Elsa's character model of herself

Dimension	**Factors**	**Evaluation**
Desirable	Elsa → Is dangerous and <Ana lives in the castle>, violating <Ana's safety> <concealing hands> <blocks her powers> thus <Protecting Ana> <In castle> means <Ana is close>, violating <Self-isolation>	Low -
Controllable	Elsa → Is queen <highest authority>, may help with <convince jailors> to <release her> <physically restrained> so cannot maintain <Self-isolation>	Low -
Effort	Choices: 1) <break her restraints> and <escape> *2*) <ask a liaison> to <convince her jailors> to <release her> (lower risk)	Low
Future Expectancy	<Ana's safety> at risk; the restraints temporarily maintain <Control ice powers>	Unfavourable
Emotion State	Pensiveness (Sadness—Low Intensity)	
Behaviour	<idle>	
Animation	<pulling on her restraints>	
Audio	<Dialogue, pleading—"You have to let me go!">	

Table 18: Elsa's evaluation of her ability to complete the Protect Ana from Powers goal, influenced by her Personal happiness goal

Next, Elsa and Ana have a fight where Ana claims that she is unhappy being confined to the castle. In response, Elsa tells her to leave. This tells Elsa that <Ana’s happiness> is at risk and thus if Ana <leaves> then she will be both happy and safe. However, Elsa will no longer have a <Good relationship with Ana>. There is no guarantee that <Ana’s safety> will be maintained because <the world is dangerous and uncontrollable>. Elsa resolves to <not stop Ana> from <leaving> and becomes sad (Table 19).

Dimension	**Factors**	**Evaluation**
Desirable	Elsa is not maintaining <Ana’s happiness> Ana can <leave the castle> → <Good relationship> violated because <no interactions> with Ana	Mid -
Controllable	<Ana’s safety> not guaranteed as <world is dangerous and uncontrollable>	Mid -
Effort	Elsa <will not stop Ana> if she decides to <leave the castle>. Elsa will continue her <Self-isolation>	Low
Future Expectancy	<Ana’s safety> → possible to achieve <Personal happiness> → FAILURE	Unfavourable
Emotion State	Sadness (Sadness—Medium Intensity)	
Behaviour	<idle>	
Animation	<turn to look at Ana>	
Audio	< Dialogue, directed at Ana, sad–“Then leave.”>	

Table 19: Elsa’s evaluation of her ability to complete the Protect Ana goal, influenced by her Personal happiness goal

For grief (Table 20), Ana has <died> as a direct consequence of Elsa’s powers. Ana’s death means that it is impossible for Elsa to <Protect Ana> or achieve <Personal happiness>. Since <death is permanent>, Elsa has no means to change the event.

Dimension	**Factors**	**Evaluation**
Desirable	Ana → <died>	MAX -
Controllable	<Death is permanent> → event cannot be changed Elsa’s powers are the cause of the event	MAX -
Effort	<Death is permanent> → event cannot be changed	Low
Future Expectancy	<Protect Ana> → FAILURE <Personal happiness> → FAILURE	Unfavourable

Emotion State	Grief (Sadness—High Intensity)
Behaviour	<hug Ana's body>
Animation	<shaking and crying>
Audio	<loud sobs and Dialogue, distressed–"No…">

Table 20: Elsa's ability to complete her Protect Ana and Personal happiness goals

Annoyance, Anger, and Rage

Anger is a high energy, negative emotion that commonly arises in response to unwanted or harmful situations, mobilizing the individual to remove or attack the offensive individual or object (Kuppens 2009). Unwanted situations can be interpreted as interference with a personal goal, such as threats and rejection (Ekman 2007).

Beast from Disney's *Beauty and the Beast* (1991) is a natural choice to demonstrate this emotion due to his naturally angry disposition. His main goal is to maintain his pride, to which he attaches his outward appearance and his desire to not be opposed.

- Beast gets *annoyed* when a girl appears to be questioning his decision to move her from the dungeon to nicer living quarters but doubts that she truly wishes to oppose him. He confirms this by asking her if she wants to be moved and gets a positive response, preventing him from getting angrier.
- Later, he gets *angry* with the girl when she ignores his demands to not clean his open wounds.
- Beast's *rage* is triggered by a man who stares at him in horror, and assumes that he only came to ridicule him.

Apprehension, Fear, and Terror

Any threat of harm—physical, psychological, or emotional—results in the feeling and expression of *fear* (Ekman 2007). Its primary purpose is to ensure survival by either avoiding or escaping the event appraised to be harmful. How someone reacts to being afraid does depend on their past experiences, but follows the same behaviour pattern: immobilization followed by either escaping or becoming angry in an attempt to physically remove the threat.

Mrs. Brisby, a field mouse in Don Bluth's *The Secret of NIMH* (1982), is a good example of the primary purpose of fear—self-preservation.

- She is *apprehensive* about entering the Great Owl's home, despite his invitation and knowing that he is intelligent. In Mrs. Brisby's mind, she is still prey to this skilled predator.

- Running across an open space, especially in a human home that owns a cat, scares Mrs. Brisby. The intensity of her *fear* is reduced as she has a friend watching the area for her and she has an important task to complete.

- Her fear is at its highest (*terror*) when she sees a predator that was stalking her get crushed by a large, living thing—she could be crushed just as easily.

Boredom, Disgust, and Loathing

Disgust is the emotion felt when encountering something that is revolting or contaminated, but is not a threat otherwise (Rozin, Haidt, and McCauley 1999). It is the feeling of aversion, usually involving some type of removal or avoidance strategy. *Boredom* is described as a weak aversion to an event with an avoidance strategy aimed at finding a more interesting one.

Emperor Kuzco from Disney's *The Emperor's New Groove* (2000) provides examples of the different levels of disgust.

- Kuzco has no interest in others, so he quickly gets *bored* when he tries to carry on a conversation about someone else,

- Kuzco is repulsed by the idea of eating bugs, so the sight of seeing one as a meal *disgusts* him,

- *Loathing* occurs when he observes his companion eating, and enjoying, the cooked bug, which is further amplified by the slurping and eating noises of his companion.

Acceptance, Trust, and Admiration

Trust is an adaptive behaviour which promotes survival in risky endeavours, such as hunting, where some personal control is exchanged for an otherwise unobtainable benefit (Nooteboom 2002). *Acceptance*, low-intensity trust, refers to the implicit agreement that everyone adhere to established behaviours or habits of ethical conduct. This expectation of habitual routine reduces risk in daily life because it is easier to predict future events. *Admiration*, high-intensity trust, is a positive response to extraordinary displays of skill, talent, and achievement (Haidt and Seder 2009). This can motivate self-improvement but can also cause others to see less risk in events because they expect the admired to handle it.

Tiana from Disney's *The Princess and the Frog* (2009) is the model for these scenarios.

- She has a consistent schedule working at a diner. Tiana has no reason to believe that any risk needs to be managed—she serves her customers and gets paid. As everyone is acting as expected, she settles into the routine (*acceptance*).

- As children, Tiana and her best friend listened to Tiana's mother tell them stories while she worked. One story said that wishes made on a star will become reality. Young Tiana *trusts* this, relinquishing some of her own achievement to the star.

- Tiana's father is her idol and she strives to replicate his hard-working spirit. When he tells her that she can achieve anything with hard work, she feels *admiration*.

Distraction, Surprise, and Amazement

Surprise is a response to a sudden, unexpected event that the individual is ill-prepared for (Ekman 2007). Depending on what the event is appraised as, other emotions might occur following surprise.

Mulan's first week at a military training camp in Disney's *Mulan* (1998) is full of surprising things for her. She has never been around men her age without them moderating their behaviour due to her being female nor has she seen many skilled military performances before (if at all).

- Mulan knows that her captain thinks the new recruits are unskilled, so she is caught off-guard when he throws out training weapons for them to catch. They are about to start training, so the distribution of weapons is not unexpected nor was its timing, so she is only mildly surprised (*distracted*).

- She is *surprised* by a fellow recruit who is showing off his new chest tattoo. Not only was his appearance sudden because Mulan was not watching where she was going, but it is uncommon for people to undress in public.

- Her captain's skill in an exercise is unexpected and inserted into his explanations with no warning. Mulan has never seen a performance this perfect, so she can only stare in *amazement*.

Interest, Anticipation, and Vigilance

Interest motivates individuals to achieve goals by enabling sustained periods of attention on a single object or thought (Tomkins 1962). This motivates long-term commitment and effort, which are necessary in interpersonal relationships and self-development. *Anticipation* directs attention to possible future events, preparing individuals for what might come (Grinnell 2018). This can influence decision-making, stress, and the elicitation of other emotions. *Vigilance* is a state of sustained attention, heightening an individual's ability to protect themselves from danger, identify self-benefits, and to clarify changes in the environment (Whalen 2009).

The superhero Elastigirl from Disney and Pixar's *The Incredibles 2* (2018) shows these states.

- Elastigirl is given a new super suit for her first mission. Her family is important to her, so Elastigirl is *interested* in her husband's comments about it.
- A police scanner broadcast reports suspicious activity near an opening ceremony in a populated area. Elastigirl *anticipates* a crime due to the ceremony's high-profile attendees, so she focuses her attention on the broadcast for details.
- Elastigirl suspects that her last mission was too easy, so very carefully reviews the footage captured by her suit's built-in camera, capturing her *full attention* (*vigilance*).

Conclusion

Multi-dimensional characters are crucial to literature and film narratives, even without agency on the part of the reader or viewer. NPCs with emotion and increased agency over their own destiny, thus creating complex game characters, should further enhance a player's enjoyment of interactive games. A full simulation of human cognition—which includes learning, memory, context switching, different types of intelligence, language development, and divergent thinking, among others—is still too complex for the purpose of video games due to processing power requirements, that are currently insufficient on PCs and consoles. For video games, only some models of emotion have been explored, mainly based on ease of implementation. We decided to go back to the psychology literature and see if different models might still be computationally feasible yet more adequate for the design task of giving NPCs emotions.

Through analysing many different models, some stood out as having both more support in the psychology literature on emotion as well as being quite flexible in design. For these reasons, PES and CA stood out as most promising for an EE specification. They are not necessarily as the *best* models, but rather appear to be the most viable compromise that would still enable us to achieve our goals: to create more complex NPCs that can still be reasonably implemented in a game setting, while affording designers greater freedom in their character designs.

We have proposed an EE design based on these models that could be implemented in different ways and included sample scenarios to test its effectiveness. One test scenario per emotion is inadequate to gauge the quality of an implemented EE, so our next step will be to gather more and build a scenario database, containing implementation-independent tables like those for Jasmine and Elsa. When an implementation of this EE is tested, these scenarios will serve as test cases to help alleviate the burden of their design. The scenarios analysed so far have identified information that is often, if not always, required to produce NPC emotion—the goal in question and its completion requirements; the world state and who can influence it; and knowledge about any other characters involved in the scenario. The scenarios have also highlighted the impact of a character's perception of each factor rather than the truth, such as Elsa believing her controllable powers are uncontrollable. This implies that instilling emotion into NPCs will require considerable creative input proportional to their role in the game's narrative. Once several scenarios have been analysed, appraisal formulas can be designed and compared with the expected results based on commonalities between character perceptions and their resulting emotion displays.

We view our analysis of emotion representation and appraisal models—and ultimately our choice of PES and CA—and the building of a database of analysed scenarios in which emotional reactions can be rationally explained, as our principal contributions towards building an EE for video games.

It is high time that NPCs enjoy some of the attention given to graphics and audio and giving them emotions is a step in the right direction.

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Notes

[1] These combinations are only suggestions and are based on personal understanding of the purpose of Plutchik's prototype behaviors—the authors claim no certainty of their correctness.

[2] Personality, biases, and goals affect how values are attached to elements in the environment and how emotions are regulated and acted on, but the evaluation process is the same for everyone.