Simulating Emotional Behaviors in a Strategy Video Game Artificial Player

An Emotional Artificial Intelligent Player for Starcraft II

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Abstract

The Artificial Intelligence sub area of Affect Computing is a subject of great interest, as it can be shown by the intense research and development over the last years. The incorporation of emotional models into computational systems has proven to have many applications in different domains like Robotics, Human-Robot Interactions, Social Simulations and Entertainment. In the entertainment industry, designers start to include emotional models into games and game characters, in order to increase the player’s game experience through believability. In the case of RTS Games, the game AI is deprived of emotions, and is usually very mechanical and predictable. In this thesis, we developed a trigger based architecture that simulates several emotional behaviors in the AI of the RTS Game Starcraft II in order to improve its believability and to identify some possible advantages (or disadvantages) of this new kind of Emotional Intelligent Artificial Player (EAIP). Our evaluation based on a survey containing game footage from this new type of AI showed that, in 36% of the cases, its behavior is considered to be more believable than the original AI, which also contributed to identify some interesting conclusions for the field of Affective Computing and RTS Games in general.

Resumo Analítico

A sub-área de Inteligência Artificial: Computação Afetiva, é um assunto de grande interesse, como pode ser demonstrado pela intensa pesquisa e desenvolvimento ao longo dos últimos anos. A incorporação de modelos emocionais em sistemas computacionais provou ter muitas aplicações em diversos domínios como a robótica, interações entre humanos e robôs, simulações sociais e entretenimento. Na indústria do entretenimento, os designers começam a incluir modelos emocionais em jogos e personagens do jogo, de forma a aumentar a experiência de jogo de um jogador através da credibilidade. No caso de jogos RTS, o jogador artificial é privado de emoções, e tem geralmente um comportamento muito mecânico e previsível. Nesta tese, desenvolvemos uma arquitetura baseada em triggers que simula vários comportamentos emocionais no jogador artificial do jogo RTS Starcraft II, a fim de melhorar a sua credibilidade e identificar alguns possíveis vantagens (ou desvantagens) deste novo tipo de jogador artificial emocional. A nossa avaliação baseada num questionário contendo vídeos com partes de jogos com este novo tipo de jogador mostrou que, em 36% dos casos, o seu comportamento é considerado mais credível que o jogador original, o que também contribuiu para identificar algumas conclusões interessantes para a área de Computação Afetiva e jogos RTS em geral.
Keywords:

Artificial Intelligence, Affective Computing, Emotional Agents, Emotional Behaviors, Agent Believability, RTS Games.

Palavras-Chave:

Inteligência Artificial, Computação Afetiva, Agentes Emocionais, Comportamentos Emocionais, Credibilidade de Agentes, Jogos RTS.
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1 Introduction

With videogames spreading across the globe and becoming more and more prevalent in everyday life, the industry has reported a worth of over $74bn dollars in 2011 [1], far more than the entertainment giant of Hollywood [2]. A video game’s success can come from many different factors like how fun it is to play, how it looks or how original it is. But, in the current days, one factor that is drastically increasing in importance is how the game moves the players emotionally [3, 4].

1.1 Motivation

Games that move a player emotionally increase player’s engagement with the game and transform the whole gaming experience into an experience to remember and tell others about, just because of the emotions that were felt by playing the game, thus improving the overall gaming experience and game success. Emotions are also important to players because one of the appeals of video games is their ability to provide novel experiences that let players try ideal aspects of their selves that might not find expression in everyday life and so generating emotions that may be lacking in the player’s real life.

Emotions can come from different game aspects like the game’s storyline or the game’s characters. One important source of emotions is also the ability to play the game with or against other human players. The player’s personality is strongly related with the type of emotions that player feels [5]. A cooperative player seeks and feels emotions like amusement, gratitude or naches. On the other hand, a competitive player seeks and feels emotions like pride, frustration or anger.

When in shortage of human players, many games offer the chance to play with or against a built-in Artificial Intelligence. However, despite some efforts, game AI behavior is still easily indentified when compared to a human player, which decreases the player’s emotional experience by playing with or against artificial players.

1.2 Problem Description

In order to address that lack of believability, and following the recent advances in the field of Affective Computing, we present in this thesis an attempt to simulate human emotional behavior in an artificial game player.
Since its appearance, Affective Computing has been contributing to research in several areas of artificial intelligence and robotics. Researchers and developers are now able to simulate, both in virtual and physical systems, behaviors that are more believable and similar to human beings. However, despite the extensive usage of Artificial Intelligence in the video gaming industry, Affective Computing ideas and Emotional Agents techniques are still underused in that area. In this thesis, we will see an experiment of incorporating those elements in video games, namely in RTS games ¹, where they are most lacking. We have developed and implemented an artificial Emotional Agent player which can simulate human emotional behaviors related to emotions that affect its gameplay. To do so, we have modified the existing AI (deprived of emotions) of the RTS game Starcraft II™ [6] from Blizzard Entertainment® [7].

1.3 Main Objectives

The main objective of this thesis is to create an Emotional Artificial Intelligent Player for the RTS game Starcraft II, and then to evaluate its resulting behavior. We want to show that we can increase believability in an artificial player by simulating emotional behaviors in it. Our working hypothesis is then as follows:

“By simulating Emotional Behaviors in an Artificial Player for an RTS Game we can achieve a higher degree of believability.”

It is important to refer that we are not trying to improve the existing AI by simulating emotions, such as making it more efficient or increasing its performance. The evaluation will, instead, be focused on two topics:

Believability of the new agent. To what extent can we say that the new agent is believable? How will the imposition of emotions influence the behavior of the artificial agent and whether these influences will make it more or less similar to the behavior of a human player? This evaluation concerns one of the goals of the Affective Computing area, which is creating synthetic characters that can emulate humans. Work on believability in this area has studied the ability of agents to create the suspension of disbelief, giving players who interact with them the illusion that they are alive [8]. In computer games, we can say that there is two types of believability [9]: Character Believability, which is the ability to lead a human player into believing that the character is real and exists in real life; and Player Believability, which is the ability to lead the human player into believing that his opponent is controlled

¹ RTS games: Real Time Strategy Games – Sub-genre of Strategy Games, with the difference that the game flows and develops in real time and in a continuous fashion. The player’s actions and decisions must also be taken in real time in order to be able to play the game.
by another human player instead of an artificial player. In this thesis, we are interested in Player Believability, because in RTS games we play against an opponent and we usually have no direct interaction with game characters.

Advantages and Disadvantages of the new agent. Which other conclusions can we bring to the Affective Computing area? Which are the main consequences of implementing an Artificial Emotional RTS Player? Can this Emotional Agent achieve better results than the original one? In this perspective, we can say that this evaluation concerns one of the goals of Affecting Computing, which is improving machine intelligence. Even if they may seem unrelated, emotions can play a large role in strategy especially when time is limited, like RTS games. Emotions are believed to improve our response time, increase our memory capacity, and provide quick communication [10]. We are able to notice things that we fear quicker than things we enjoy or are indifferent about, showing fear to be crucial to our response time. Thus, we will also see if the inclusion of emotions also increases the performance of the Artificial Emotional Player.

1.4 Document Outline

The remainder of this document is divided in four parts.

In “State of the Art”, we describe the scientific foundations and latest developments related to our work. We cover topics such as Affective Computing, Appraisal Theories and the influences and usages of emotions, as well as emotion modeling in Video Games and the state of Video Game AI.

In “Proposed Solution”, we describe in detail the scientific models behind our emotional AI player as well as its implementation.

In “Solution Evaluation”, we describe the evaluation process that we used to access the believability, advantages and disadvantages of this new type of player, as well as the analysis of the results.

Finally, in “Conclusions”, we summarize the main ideas behind this document, our final conclusions, as well as our proposed Future Work for this thesis.

2 State of the Art

Since the birth of Affective Computing, researchers from this field have been trying to incorporate emotion models into their systems in order to achieve the main goals of this area.

This section is divided in four parts. First, we describe the area of Affective Computing, as long with other scientific background that supports our work. Then, we discuss some of the applications and
usages of this recent area, and why is it so important and advantageous. After that, we cover the importance and inclusion of emotions and emotion models in Video Games. Finally, we describe the main AI’s characteristics in today’s RTS Games, with special attention to Starcraft II.

2.1 Background

2.1.1 Emotions and Affective Computing

The subject of this thesis falls within the field of Artificial Intelligence, in the sub area of Affective Computing. This modern branch of Computer Science originated with Rosalind Picard’s 1995 paper [11], where she defines (and named) Affective Computing as being “computing that relates to, arises from, or influences emotions”. It is an interdisciplinary field spanning Computer Science, Psychology, Physiology and Cognitive Science [12]. Picard also defined the main goals and motivations of this area [13]:

- To make machines less frustrating to interact with (Interface Agents);
- To conceive robots and synthetic characters that can emulate humans or animals (Believability of agents);
- To study human emotions by modeling them (Psychological and social simulations);
- To improve machine intelligence (more intelligent and resource effective agents).

Affective Computing deals with emotions. Defining emotions is a hard task. A very complete definition can be found in [14], where the authors describe emotions as a “complex set of interactions among subjective and objective factors, mediated by neural and hormonal systems, which can:

- Give rise to affective experiences such as feeling of arousal, pleasure and displeasure;
- generate cognitive processes such as emotionally relevant perceptual effects, appraisals and labelling processes;
- activate widespread physiological adjustments to the arousing conditions;
- lead to behaviour that is often, expressive, goal-directed and adaptive.”

Emotions can then be described in terms of Causes (what happened), Physiological Changes (e.g. heart-beat rate or trembling) and Behavioral Responses (what is the reaction). An emotion is, according to Damásio [15], and from a human being perspective, a conscious experience characterized by a “collection of changes occurring in both brain and body, usually prompted by a particular mental content” [15. p. 270], that makes us inclined to act in some way ("states of action readiness” [16, p. 469]), according to our concerns. It is often the driving force behind motivation [17]. The mental content, also
known as *appraisal*, is a result of confronting a given situation to the individual's concerns. The collection of physiological changes, also known as *arousal*, has the purpose to alert the brain for the emotion eliciting situation and to prepare the body for a responsive action. An emotion has a *valence* (positive or negative), *intensity* (its strength), an *arousal* (readiness to respond), an expected duration and a category (which are still not consensual). Emotions are not to be confused with other terms such as *Mood*: a weaker long-lasting affective state with fuzzy and sometimes multiple causes; *Feeling*: a perception of changes in one’s body; and *Sentiment*: a predisposition to trigger a certain affect with respect to a certain object.

### 2.1.2 Emotional Agents and Appraisal Theories

Affecting Computing seeks to create *Emotional Agents* through the modeling of emotions in an artificial fashion. An Emotional Agent is an Agent whose deliberative process and interactions with the environment (inputs and outputs) are affected by emotions. Emotional Agents generate emotions by the appraisal of a subjectively important event experienced by the agent. The result of this appraisal is the input to *Appraisal Theories* that determine which emotion or emotions should be generated by the agent. Appraisal theories essentially claim that emotions are elicited by the evaluation of events and situations [18]. The subjectivity of the appraisal depends on the agent’s beliefs, goals and concerns. Moreover, this significance to the agent is also classified according to dimensions such as pleasantness, certainty, novelty, agency, coping potential, compatibility with standards, among others. There are many different Appraisal Theories, where some of the most important are as follows:

**Lazarus’ Cognitive-Motivational-Relational Theory.** [19, 20] It considers two kinds of appraising: *Primary Appraising*, which assesses the type of relevancy of the situation, comprising three main components: *Goal Relevance*, *Goal Congruence* and type of *Ego-Involvement*; and *Secondary Appraising*, which assesses one’s coping options. This comprises three basic judgments: blame or credit for an outcome, *Coping Potential* and *Future Expectations* towards the person-environment relationship.

*Goal Relevance* is essential to all emotions. An emotion will be only be generated if a goal is at stake during an encounter (or if some new goal emerges from it) [19, p.149-150, p.222]. *Goal congruence* refers to the extent to which a transaction is consistent or inconsistent with what the person wants, i.e. it either thwarts or facilitates personal goals. *Goal congruence* leads to positive emotions and goal incongruence leads to negative ones [19, p.150]. *Ego-Involvement* refers to diverse aspects of ego-identity or personal commitments, like social-esteem, moral values, ego-ideals or life goals. Ego-identity is involved in almost every emotion, but in different ways depending on the type of ego-involvement being engaged [19, p.150].
The main characteristics of this theory are that it emphasizes the importance of *Coping Potential* to the emotion process and that it defines emotions according to "core relational themes", instead of differerntiating them in a process of evaluating variables. For instance, Sadness’s appraisals include low coping potential [19, p.249], contrary to Anger which includes high coping potential [19, p.225-226]. Lazarus explains that this is the only way the appraisal process can be so quickly executed. *Coping Potential* also influences the generated emotion’s intensities in the case of the Fear (Fright) emotion. Lazarus also says that if one “could avoid or escape the sudden danger, fright would be aborted or rapidly mitigated” [19, p.237]. This means that if a situation generates Fear, the Fear’s *intensity* is mitigated (or even eliminated) if we have the coping potential to deal with the threat.

*Future Expectancy* has to do with whether, in the future, things are likely to change psychologically for the better or for the worse [19, p150]. *Future Expectations* also influence the generated emotion’s intensities (with the exception of Fear). For example, with Happiness, if future expectations are guarded or unfavourable, then happiness can be muter or undermined [19, p.268] (or increased, in the case of favourable future expectations).

Furthermore, emotions are also characterized according to Action Tendencies (i.e. states of action readiness) and Pathology. For instance, the Action Tendencies for the Fear, Sadness and Anger emotions are, respectively, avoid or to flee from conflict [19, p.238], inaction and withdrawal into oneself [19, p.251] and attack on the agent held to be blameworthy of the offense [19, p.226]. The Pathologies for the same emotions are, for both Anger and Fear, dysfunction and distress [19, p.233, p.239] and depression for Sadness [19, p.253].

**Frijda’s Theory.** [21] Frijda’s Theory describes emotions as changes in action readiness characterized by “activation” and “action tendency”. When the “activation” is present, the “action tendency” may be translated in behavior. Both “activation” and “action tendency” are altered by regulatory processes. Different emotions will have different modes of “activation”, different kinds of “action tendencies”, and also different “autonomic responses”. The evoked emotion is determined based on how the individual appraises the set of stimulus. In this process, Frijda identifies two important evaluations: Relevance evaluation (concerns how the evoking situation may affect the individual) and the Context evaluation (concerns what the individual may be able to do to affect the evoking situation). This is an obvious influence from Lazarus’ theory, when we compare to the notion of primary and secondary appraising. To complement his theory, Frijda also postulated the Laws of Emotions [22, 23], which are rules that govern emotional processes and contain a great deal of essential information concerning the cognitive nature of emotions, in a motivation-oriented approach. Frijda stresses that emotions are not instant responses but rather processes over time, and that emotional experience is attained gradually as information is gathered at several instants.
The OCC Model. [24] According to this theory, emotions are a valenced affective reaction to one of three kinds of concerns, depending on whether their eliciting appraisals are focused on: the consequences of an event, the actions of an agent or the aspects of an object. It is widely used in the design of emotional agents due to its simplicity and implementability. It has a simple but exhaustive tree structure, using well-studied concepts in logic such as beliefs, desires and standards and a combination of finite set of appraisal variables which suffices for current applications [24, 25]. That hierarchy is used to structure emotions and their determining conditions. Starting from the top, an emotion is first categorized according to one of the three types of concerns. Descending in this hierarchy, local and global variables (such as the desirability of events or the appeal of objects) are used to further differentiate the emotion into one of 22 different types. This aspect implies that the agent maintains a structure with goals, standards and attitudes to guide the process.

Roseman’s Theory. [18, 26, 27] This theory’s structure is represented by a grid accounting for 16 different emotions. The structure can be quickly translated into computable rules that define which emotions are generated by each appraisal. The emotions are differentiated through a process of event assessments, where events are categorized according to five variables:

- **Situational State:** differentiates if the event is Motive-Consistent or Motive-Inconsistent according to the individual’s goals. It then determines if the emotion’s valence will be positive (i.e. get more of the stimuli) or negative (i.e. get less of the stimuli), respectively.
- **Probability:** differentiates between certain and uncertain events. The related response strategies are proactiveness and reactiveness, respectively. If the event was unexpected, it determines the “surprise” emotion.
- **Power:** much like Lazarus theory [19, 20], it differentiates if one’s control potential over the event is low or high (e.g. Fear has an low coping potential, contrary to Anger, which has a high coping potential). The related response strategies are accommodation or contending, respectively.
- **Motivational State:** differentiates if one’s motivation is maximize the rewards (“Appetitive Motive”) or minimizing the punishment (“Aversive Motive”). The related response strategies are initiation (i.e. “move toward”) and termination (i.e. “move away”), respectively.
- **Agency:** differentiates if the event was self-caused, other-caused, or circumstance-caused. It determines to where (self, other(s), object or outcome, respectively) the emotions are directed.

Roseman’s theory also recognizes several emotions families: Contacting (e.g. Joy and Love), Distancing (e.g. Sadness and Fear), Attacking (e.g. Anger and Frustration), and Rejection (e.g. Disgust and Shame). Emotions are also characterized by several Emotion Components: the Phenomenology,
The Expressiveness, the Behavioral and the Emotivational Goal. For instance, Joy and Relief have Expressive Emotional Components of smiling and exhalation, respectively. Sadness and Fear have Behavioral Emotional Components of inaction and inhibition, respectively. Anger and Frustration have Emotivational Goal Emotional Components of hurting and getting revenge, reproach and punish the self, respectively.

Anger and Frustration are also closely related [28]. Frustration can be defined as the blockage of goal attainment [29] or the blocking of a goal-directed behaviour sequence [30]. As such, it is represented in most accounts of anger, although it must be noted that the term frustration is sometimes also used to refer to a low-level emotional state itself, like in Roseman’s theory. Nevertheless, frustration is considered a central component of anger [31, 32, 33]. In general, the appraisal of goal-blocking or frustration is considered to distinguish between emotions of a positive and a negative valence. In Frijda, Roseman and Lazarus’ theories, events which are appraised as Goal-Incongruent can also be seen as Frustration events, eliciting negative emotions. Several responses to frustration can include loss of self-esteem and self-confidence, stress, depression, aggression and quitting, moving away or giving up [34, 35].

2.1.3 The Influences of Emotions

Long has been thought that the influence of emotions on reasoning was negative and an impairment to rational thought. Some philosophers like Plato, Kant and Descartes say that the emotions are sickness of the mind and an impairment of rational thoughts. In the first half of the 20th century, psychologists still considered emotions as a disturbance of organized thought. This view started to be contested, especially by Simon and Minsky, who said that “a general theory of reasoning and problem solving must incorporate the influences of motivation and emotion.” [36] and that “the question is not whether intelligent machines can have emotions, but whether machines can be intelligent without emotions.” [37]. Over the last years, work done in neuroscience, physiology and psychology has proven that emotions can have a significant weight in the rational decision making process of human beings and consequently, in artificial agents. Although there are some exceptions, more often than not emotions are essential to improve rational reasoning, decision making and human communication.

After emotions have been generated according to an Appraisal Theory, they have, among other consequences, influences on reasoning. Many authors refer to that influence as coping [38, 39, 40]. When an Agent’s behavior is altered due to emotions, it is said the agent has Emotional Behaviors. There are two kinds of coping that we can consider: Problem-focused coping, where the agent focuses on altering the source of the emotion (the emotional eliciting situation), by acting on the environ-
ment; and Emotion-focused coping, where the agent aims at altering one’s emotional state (the emotional weight of the situation) by acting on one’s frame of mind.

As several authors agree, emotions can change, improve or deteriorate several agents’ processes such as Reasoning [15], Belief Management and Revision [41, 42], Decision Making [15, 43, 44, 45], Risk Perception and Estimate [46, 47, 48, 49], Risk Taking [48, 49] and Action Execution and Control [50 Section 6]. As the authors describe in [46], “whereas fearful people expressed pessimistic risk estimates and risk-averse choices, angry people expressed optimistic risk estimates and risk-seeking choices”. Additionally, fearful people are more risk-averse, contrary to angry people, who are more risk seekers [48] (with the exception of person-based risk, where the observations are inverted). People who are angry or happy make more optimistic risk estimates than people who are sad [47]. Furthermore, as said in [50], research in neuroscience concludes that emotions significantly influences action generation, execution and control, as “the pathways of emotional responses mediated by the amygdale descend to the brain stem, which organizes and coordinates most relatively simple, stereotypic motor responses and facial expressions” [50, p.14]. “It is hard to put a thread through the eye of a needle when you are in a state of rage or anxiety, simply because you cannot accurately control your hands in such a mood.” [50, p.13].

According to [51], we can identify three important roles played by emotions: Motivation, because they are essential in establishing one’s objectives; Resource Management, because they guide the reasoning in order to assure that the limited resources of time, memory and attention are not wasted; and Communication, because they often include emotional expressions and behaviors.

### 2.2 Affective Computing and the use of Emotions

Affective Computing had a great impact on Robotics, notably in the area of Human-Robot Interactions (HRI). By incorporating emotions into robots, researchers have been trying to improve the quality of interactions between humans and machines, and ultimately reaching the first goal of Affective Computing: making machines less frustrating to interact with. Leaders of the field claim that it is highly important that user interfaces of the future are able to “detect subtleties of and changes in user’s behavior, especially his/her affective behavior, and to initiate interactions based on this information rather than simply responding to the user’s commands” [52]. Affect detecting can be made in several ways, such as facial expressions and mental states [53, 54, 55, 56], speech [57, 58, 59] and body posture or gesture [60, 61, 62, 63, 64]. As for affect generation in robots and artificial characters, research in several affective channels is being explored, like facial animation [65] (mainly using Hanson Robotic’s patented Frubber(tm) skin), gestures [66] and speech [67]. Robots are now designed in a more Affective-Centered way, which assures that the interactions are of high affective quality, and more likely to
be enjoyed, believable and accepted by humans [68]. Emotional based robots have several areas of application:

**Personal and Domestic Robots.** Each year, more and more robots enter our domestic space. According to the International Federation of Robotics, it was estimated that 1.96 million domestic robots were sold just in 2012, and that sales amount will reach almost 15.5 million units in the period of 2013-2016, with an estimated value of US$ 5.6 billion [69]. This type of robots supports all kinds of household chores like vacuum and floor cleaning or lawn-mowing. There is also entertainment and leisure robots, like toy robots or hobby systems. Emotion models are started to be incorporated into these robots [70], notably in robotic vacuum cleaners that are capable of reading their owner’s emotional state and act accordingly [71].

**Entertainment.** In the case of entertainment and toy robots, about 1.1 million units were sold in 2012 according to the International Federation of Robotics. Many companies, especially Asian ones, offer low-priced toy robots. Among those mass products there are more sophisticated products for the home entertainment market, like the LEGO® Mindstorms® Program [72]. The total value of the 2012 sales of entertainment robots amounted to US$ 524 million [69]. Some entertainment robots, like Keepon [73] or Sony’s AIBO [74], proved that the appearance of the robot and its emotional behavior were critical for the children to accept it and play with it.

**Therapeutics.** With the focus of affective centered design and emotional models, several robots have been developed in order to improve the quality of healthcare. We have many examples like Huggable™, a robotic companion for healthcare, education and social communication [75]; Paro, an advanced interactive therapeutic robot designed to stimulate patients with Dementia, Alzheimer’s, and other cognition disorders and to reduce stress and depression among elder people [76]; or KASPAR, a friendly robot that helps children with autism to communicate comfortably [77].

**Industry.** Even in industry robots we can take advantage of the use of emotions. For example, in the case where an industrial robotic arm and a human employee are working together, the robot can be made aware of the worker’s emotional state by reading his motions. The robot then uses that information to calculate a “danger level” and modify its behaviors accordingly in order to increase the person’s safety [78].
Additionally, emotion models are also been used in the field of Social Simulations\(^2\). Agent-based simulations now make use of Emotional Agents, which allows researchers to study the human (or other) emotional behavior in much more detail [79], which corresponds to the third goal of Affective Computing. Several works have been undertaken in order to better understand emotion spreading in social networks [80], online chats [81] or online communities [82], the influence of emotions and mood in decision making [83] and emotion contagion processes in general [84, 85].

### 2.3 Emotional Behaviors in Video Games

The video gaming industry has been growing considerably over the past few years, being one of the fastest growing sectors in the U.S. Just in 2012, computer and video game companies had revenue of US$ 21 Billion, and the market will continue to grow [86]. Video games themselves have gone through serious developments since the rudimentary OXO [87] and Spacewars! [88], especially due to many advancements and innovations in computer hardware like sound cards, graphics cards and faster CPUs, and also in network technology, which allows players to play against anyone around the world. Games have become increasingly more complex and intellectually demanding [89] but at the same time more fun to play, watch and learn.

#### 2.3.1 The importance of Emotions in Video Games

A video game success can come from many different factors such as how fun it is to play, how it looks, how accessible it is, its durability or replayability, its social aspects, its originality or even its marketing. But in the current days, one factor is drastically increasing in importance which is how the game moves the players emotionally [3, 4]. Emotions are important to players because one of the appeals of video games is their ability to provide novel experiences that let players try ideal aspects of their selves that might not find expression in everyday life, thus generating emotions that may be lacking in the player's real life. Video games are more intrinsically motivating and have the greatest influence on emotions when players' experiences of themselves during play are in synchrony with players' conceptions of their ideal selves [90]. Playing a video game can make the player feel many types of emotions, including the most basic human ones. Nevertheless, the player's personality and play style is strongly related with the type of emotions that player feels. Basing ourselves in four emotional keys, we can explain what motivates a player and which emotions can be expected during its play [5]:

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\(^2\) Social Simulations: research field that applies computational methods to study issues in the social sciences. The issues explored include problems in psychology, organizational behavior, sociology, political science, economics, anthropology, geography, engineering, archaeology and linguistics.
**Hard Fun.** Players seek challenge, strategy, problem solving and achieving objectives by overcoming obstacles. This is the case of general RTS games such as Starcraft II. The generated emotions are frustration and fiero\(^3\).

**Easy Fun.** Players seek sheer enjoyment of experiencing the game’s activities, exploration, role play and immersion in a story. The generated emotions are curiosity, surprise, wonder, and awe.

**Serious Fun.** Players seek changing their internal feeling and spirit with the game, clearing the mind, feeling better about themselves or at something that matters, avoid boredom and playing the game as a therapy. The generated emotions are excitement, relaxation and relief.

**People Fun.** Players seek player interaction, social experience, playing with others (by competition or cooperation) and social recognition. Players may even dislike the game, but they like to spend time with their friends. The generated emotions are amusement, admiration, schadenfreude\(^4\) and naches, which are emotional gratifications or pride, especially taken from the achievements of one’s children or pupil.

Furthermore, the combination of Affective Computing, Human-Computer Interaction and video games gave birth to the recent field of Affective Gaming. In games based on Affective Gaming, not only the player’s traditional input controllers enable the player to play the game, but also the player's emotional state. The player's emotions affect the game and game play, and not only the other way around [91]. This gives to ability to generate game content dynamically, with respect to the affective state of the player; the adoption of new game mechanics based on the affective state of the player (e.g. [92]); or enables the communication of the affective state of the game player to third parties or opponents he is playing against. To read the player’s affective state in real-time, Affective Gaming uses a series of non-intrusive sensors, like biofeedback devices to read the physiological responses of the player (e.g. heartbeat rate variations [91] or skin variations like sweat [93]); and motion sensor devices for behavioral responses (e.g. gestures [94], body postures [95], facial expressions or the pressure made on the buttons of a gamepad [96]). There is also a very complete description of the requirements necessary to build an affective game engine capable of supporting the development of affective games, where it is also stated that much progress must still be achieved in Affective Computing before real-time affect-adaptive gaming can become a reality [97]. Nevertheless, some game design heuristics are already being developed to help us to designing better affective video games [91].

\(^3\) Fiero: an italian word for personal triumph.

\(^4\) Schadenfreude: a german word for malicious joy. Is is the pleasure from others misfortunes.
2.3.2 The inclusion of Emotions in Video Games

Due to this increasing importance of emotions in video games, game designers are turning their attentions too how they create a game that generate emotional responses from the player [98]. One of the most recognized researchers is the film and videogame writer and narrative designer David Freeman [99], an evangelist in making games emotionally resonant with his Emotioneering™ techniques. Emotioneering™ is the vast body of techniques described in [100], which can create, for a player or participant, a breadth and depth of emotions in a game or other interactive experience. "It's not just a matter of having a compelling story, it's a matter of having characters that you can identify with," said David Freeman. "It's a matter of having the player go on the emotional journey." [101].

On the other hand, we can also increase the player's emotional experience with the inclusion of emotional models in the games themselves [97]. Computational models of emotion are relevant for game development for two reasons: they can facilitate the creation of more detailed affective models of the players; and they can also enable the game and game characters to dynamically generate affective behavior in real time, in response to situations within the game, and to player behavior. Such adaptive behavior is more believable than 'scripted' behavior, and the resulting realism contributes to an increased sense of engagement by the player. The type of models required to generate affective behavior varies with the complexity of the game. In many games, simple models are adequate, for instance, if a player fails to finish a level, his character shows a sad face. Those simple models are termed 'black-box' models, because they make no attempt to represent the underlying affective mechanisms, taking only the data available from the affective sciences which provide the basis for defining the necessary mappings "triggers-to-emotions" and "emotions-to-effects". However, as the complexity of video games is increasing, resulting in more dynamic plots and narratives, more sophisticated game characters and player interactions, more different game objectives (e.g., entertainment, education or therapy) the need for more sophisticated affective modeling arises [97].

By the end of the 20th century, computer scientists in the field of autonomous agents began to analyze how the artistic principles of animated characters could be used to design believable agents. For instance, Bates’ work in the OZ Group [102] was inspired by Thomas and Johnston's The Illusion of Life: Disney Animation [103]. Two of the key ideas guiding Bates were: an agent’s emotional state must be clearly defined; and the agent’s actions must express what it is thinking about and its emotional state. Loyall [104], also working in the OZ Group, further expanded the definition of agent believability, proposing requirements related with the idea of personality. By personality he considers “all of the particular details – especially details of behavior, thought and emotion – that together define the individual”. Some other requirements were [102, 104, 177].
1. **Emotion**: agents should display emotions coherently with their personalities, and act according to the displayed emotions;

2. **Self Motivation**: agents should act on their deliberation and be pro-active;

3. **Change**: agents should grow (preferably aligned with their personalities);

4. **Consistency of Expression**: all possible means of physical expression should be consistent with the agent's thought process;

5. **Appearance of Goals**: agents should appear to have goals and, or, desires;

6. **Reactive and Responsive**: agents should be able to react in a reasonable timing according to their personality;

7. **Situated**: agents should change their behavior according to the situations;

8. **Resource Bounded**: agents should have limits to what they can physically and mentally do;

This idea is also consistent with Ortony's believability definition [105], where he considers that the evaluation perspective and behavior displayed by an agent should always be according to the agent's emotional state and be coherent across different types of situations and the agent's experience.

Since then, many computational emotion models have been developed for both research and applied purposes, mainly in order to create more believable characters or bots [106, 107, 108, 109, 110, 111, 112, 113, 114, 115]. These models typically focus on basic emotions, and use many different methods taken for psychology and sociology (as these areas where recognized to be the foundation for believable behavior [116]) to implement emotion generation via appraisal [117, 118, 119, 120] or even via parametric modeling [121]. Most emotion models are based on the OCC model [24], Ekman's model [122], Mehrabian's PAD Emotional State Model [123], or the explicit appraisal dimension theories [124, 30]. Typically, symbolic AI is used to implement the “stimulus-to-emotion” mapping. The difficulty of this process lies in analyzing the domain stimuli, like the features of a game situation, behavior of game characters or player behavior, and extracting the appraisal dimension values. This may require representing complex mental structures [125], like the game characters' and players' goals, plans, beliefs and values. Rules, semantic nets, Bayesian belief nets, finite state machines [106, 126] and BDI Agents [127, 128] are also some of the frequently used formalisms to implement this mapping. Some emotional agent architectures have been developed, like Cathexis [129], as well as others specifically developed for video game characters [130, 131, 132]. Game character believability can be achieved by developing the character kinetically, cognitively and emotionally [133, 134], by using motion capture to film real life actors' motions and facial expressions [135], by using emotional agent frameworks [136, 137, 138], by creating agents with social capabilities [139, 140, 141], or by creating personality models [134, 142, 143, 144, 145], which are mainly based on Myers-Briggs Type Indicator [146], the Five Factor Model [147] or others [148, 149].
2.4 AI’s characteristics in RTS Games

In the case of RTS games, it seems there isn’t much room for the incorporation of emotion models comparing with, for example, RPG games\(^5\), where the number of virtual characters and interactions is much more abundant (with the exception of single-player RTS campaigns, where sometimes it exists some character interactions). However, when playing against the RTS games’ AI players, we can still somehow recognize we are not playing against a human player, and that is what can be improved by incorporating emotion models into the AI. With an emotional model, the AI can exhibit more human behaviors, appear more believable and less mechanical, which offers a much more rewarding experience to the player. Examples of this can be found in the video game The Sims 4™ [150], where the virtual characters’ actions are guide by emotions and mood states; an emotional IA player created for the RTS game Age of Mythology™ [151, 152]; and the game of Globulation [153], where the players, instead of controlling each individual unit (an agent), they just define their behavior in chosen areas of the map, and then the AI takes control of each unit, whose decision making process is also affected by its current emotions [154].

2.4.1 RTS AI Techniques

In the context of recent RTS games, AI has undergone major advances, not only with the advances in the processing power of computers, but also in the quality of the artificial agents created. There has been an effort to reduce cheats (such as having full information of what the human player is doing and where he is or having access to greater amounts of resources) to simulate intelligence and create genuinely smarter agents, but maintaining the strength similar to the strength of a human being. Several techniques are being used [145] such as rule-based techniques (finite or fuzzy state machines), machine learning and intelligence techniques (neural networks, decision trees and evolutionary techniques), extensible AI techniques (parameter tweaking, plug-in interfaces, scripting), knowledge based techniques, agents and annotated environments. There are two main architectures that are used to create AI game players:

**Reactive Architectures.** They use a reactive agent architecture to create the AI player. The most commonly used reactive architectures are divided in the following types: Finite State Machine [155], subsumption architectures [156] and behavior trees [157, 158]. With this architecture, agents perform no look-ahead and map game states to actions or behaviors. Most of the computational calculations are made before the game begins, which lowers the processing level and memory usage during the

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\(^5\) RPG Games: Roleplaying Games – Games where players assume the role of characters in a fictional setting. Then, usually through a game narrative, players interact with the game world and other characters (possibly other players), normally as they develop their own.
game. However, these agents have difficulties in reacting to unforeseen situations, because they do not reason about expectations and do not detect discrepancies between expected and actual game states.

**Planning architectures.** It is a Goal-Oriented Action Planning [159], where the game states are mapped to goals instead of actions. An example of this can be found in [160], where authors applied the conceptual model of Goal-Driven Autonomy [161] to an IA RTS player. With it they made a planning architecture composed of goals, plans and actions which can generate, at run time, a game strategy and adapt it to discrepancies that may appear between the expected result and the game. This model differs from the traditional BDI architecture since the goals are not linked to the plans or the execution, nor are the plans to the goals. In this architecture there is a planning component which is responsible for selecting the set of atomic actions and assembling them together in plans that lead to an objective state.

Game AI is closely related to adversarial real-time planning, decision making under uncertainty, opponent modeling, spatial and temporal reasoning, resource management, collaboration, and path finding [162]. One system that is working to improve gaming AI in all of these aspects is ORTS [163]. This system is an open source RTS game engine for studying real-time AI problems such as path finding, dealing with imperfect information, scheduling, and planning in the domain of RTS games. The current state of RTS game AI lacks planning and learning, which are areas in which humans are currently much better than machines. Therefore, RTS games make an ideal test-bed for real-time AI research. Several studies have been made to address the planning problem using techniques like behavioral knowledge [164], conceptual neighborhoods [165], data mining [166], evolutionary methods [167] or agents [168]. We are seeing the growing of middleware game “AI SDK” with generic solutions which is gaining acceptance in the industry, also with the help of the IGDA AI Standards Committee [169]. However, the relationship between academic research and the commercial game developers is still in bad shape. The commercial interests between game companies make them too much protective of their intellectual property resulting in a lack of co-operation with academic researchers, which is an important issue that has been discussed at various conferences. Although game developers welcome the development of techniques that they can profit from, they prefer not to share their own results with the research and academic community.

### 2.4.2 The Starcraft II AI

Starcraft II is a RTS game whose story is based on the war between three races: the Terrans, futuristic humans with versatile weaponry; the Zerg, dangerous insectoid species that assimilate life forms to continue evolving; and the Protoss, technologically advanced aliens with vast psionic powers.
In Starcraft II, players take command over these races and, like any other traditional RTS, gather resources in order to build structures, train units and develop technologies so they can destroy their opponents. Each race has its own strengths and weaknesses, and knowing their tactical profiles can mean the difference between victory and defeat. The asymmetry between the races, the engaging, strategic, tactical, fast paced, “rock-paper-scissor”-typed\(^6\) gameplay and the astounding graphics with an improved physical effects engine contributed to make Starcraft II one of the best RTS of the moment, if not the best ever. The game also comes with a powerful editor tool, that allows to modify the game in all its aspects (from unit characteristics and map shapes to game objectives and game AI), thus creating entirely new game modes and genres. As many researchers have used the editor from the Starcraft II predecessor: Starcraft I, to modify the game AI and study the implementation of some AI and Agent techniques such as Goal-Driven Autonomy [160], Data Mining [166], clustering datasets [170] and Bayesian Models [171], we will use the Starcraft II editor to implement our emotional artificial player.

No recorded attempt of creating an emotional player for Starcraft II was founded by our research. The most similar work can be found in [151], where the authors also modified the game AI of an RTS game (in this case: Age of Mythology) with the incorporation of emotional models. Those models were based on The Five-Factor Model [147] and the Emotion-Connectionist Model [172], and contained a very simple set of emotions (Arousal, Pain, Pleasure, Confusion, and Clarity), whose strength of emotional change is influenced by the personality of the bot. However, in contrast with our goal of achieving a higher degree of believability, the main objectives of the authors was to increase the AI’s performance, as well as evaluating the performance of each of the personalities.

Starcraft II offers several ways to play. We can play trough the storyline of the single-player campaign, in custom made games or in the ladder system, which is the most important feature of the game, from a competitive point of view. In the ladder we play against other human players and try to compete in a ranking system. On the top of the ranking system is where we find the best players of the world, as well as professional players who play in well paid tournaments of the e-sports\(^7\) industry.

Besides from playing against other human players, we can also play versus the game AI. The developers of Starcraft II have put a lot of effort in creating the AI player. The AI player, as any other

\(^6\) “rock-paper-scissor”-typed gameplay – game where the possible selection of weapons or units interact in a rock-paper-scissor style, where each selection is strong (it counters) against a particular choice, but is weak against another. Such mechanic can make a game self-balancing, and prevent gameplay from being overwhelmed by a single dominant strategy.

\(^7\) e-sports: Electronic Sports – Sub genre of traditional Sports, with the difference that the competition is made over video games. The most common video game genres associated with e-sports are RTS, fighting games, first-person shooter (FPS), and Multiplayer Online Battle Arena (MOBA).
agent, is a computational system situated in some environment, in this case, a Starcraft II game, which has several characteristics:

**Dynamic.** As with all RTS, the game environment is dynamic, which means the game changes while the AI is deliberating.

**Discrete.** There are a finite number of possible actions (e.g. building, research, train units, move, use unit’s abilities or gather resources) and a finite number of percepts (e.g. spotting the opponents units or buildings, their abilities usage). The actions and percepts can be related to a single unit or building as well as to a group of them. However, even if there is a finite number of possible actions and percepts, their number is considerably big, as there is a multitude of units, abilities, buildings, technologies and map coordinates in a game. Therefore, the environment can also be seen as Continuous for practical purposes.

**Non-Deterministic.** In Starcraft II, there are no random elements affecting gameplay (like damage dealt, critical strikes, movement speeds, training units, building or research times, resource gathering…), as all can be calculated through simple arithmetic, with no random probabilities included. However, as we are playing against an opponent (and the game isn’t turn based), we never know if our actions will all be successfully executed as intended as they depend on what the opponent also does (e.g. when we send a unit across the map, we can never be sure it will reach its destination because it can, for example, be attacked or destroyed by the enemy), thus making this environment a Non-Deterministic one.

**Inaccessible.** The AI player (like a human one) has no complete information about the game environment as it does not know the complete information about its opponent (e.g. number of bases and locations, number of units and unit types, resources possessed technologies developed…). The AI can only reason over what it has seen or is seeing. This is also what makes scouting so important in this game, for human and artificial players alike.

We can conclude that what makes this kind of AI player hard to create are the dynamic, inaccessible, and high number of possible actions and percepts characteristics of the environment, which we must take into account for the development of our emotional agent player.
Like in many other RTS games, we have the possibility to select a difficulty level for the AI player, which, in the case of Starcraft II, limits the number of APM\(^8\) it can make. Even though the Starcraft II AI can be considered very “intelligent”, it is still easily recognized when compared to a human player due to several characteristics (some of them are common to other RTS games):

- Deprived of attention focus;
- Parallel processing of the units, with simultaneous orders dispatching;
- Perfect management of resources and buildings;
- Constant and regular game play over the game;
- Awkward decision making in some situations;
- Usually always makes the same response for the same situation.

In addition to those characteristics, the AI has no Gratefulness or “Holding the Grudge” mechanics as described in the paper [173] (especially in multiplayer games) as well as no human emotions and other human characteristics (like mental or physical conditions) that affect its gameplay. All of these elements contribute to the lack of believability in this kind of AI players, which we try to address in this thesis.

However, the Starcraft II developers have increased the quality of the AI through several aspects. The most interesting one is that the AI has no access to cheats or information about the opposing players, that is, the AI only knows what it have seen, as if it were a human player. Furthermore, the AI is capable to react to what it sees and, for instance, starts training units that counter the opposing ones, or attack a newly founded opponent’s base. We can also select a game plan that an AI player will follow in the game (e.g. full rush, economy focused, timing attack, aggressive push, air based units, or a randomly chosen plan) and, when we are playing with AI players in our team, we can directly issue them orders in-game, in real time. We can order an AI player to attack, defend, scout, build a base, and provide detection at a target location. We can also select or change an opening build for an AI player: Rush, Timing Push, Aggressive Push, or Economic Focus; as well as deciding a late game army composition that the AI player will use, such as: large amounts of basic units, the most powerful units, the most powerful air units, or support and spell caster units. An AI player also report their statuses and call out specific buildings, bases, or unit types they've encountered on the map, using both minimap pings and audio cues.

\(^8\) APM: Actions per Minute - Term used in the RTS games which refers to the total number of actions that a player can perform in a minute (such as selecting units or issuing an order). Human players' APM range from 50, for beginner players, to 400 for professional ones. High APM is often associated with skill, however, the majority of APMs are repetitions of orders already given, so APM is not considered one of the best indicators of skill.
These features have a range of applicability. They offer replayability to games with AI players, professional and average players can train against many different kinds of opponents and fans even suggest a new type of game based on these developments: two human players, backed by up to three AI players each, would oppose each other. These players would command their own armies as well as issue orders to their computer allies. This new game, named “1v1 Generals”, would test players’ abilities to play the game as well as issue effective commands to their subordinates.

However, even with these advances there are still large gaps in the behavior of AI players, making them easily identifiable when compared with human players [174]. By incorporating human emotions into the AI, we will try to reduce that gap and increase the believability of the AI player, as we describe in the next section on our proposed solution.

3 Proposed Solution

As discussed before, this thesis consists in the development and implementation of an emotional artificial intelligent player (EAIP) for the RTS game Starcraft II, by modifying the existing AI which is deprived of emotions. We are going to simulate emotional behaviors on the artificial player which hopefully will allow us to increase its believability and also access some advantages and disadvantages of this new kind of player from the perspective of Affective Computing, game performance, and RTS games. As stated in Section 1.3, our working hypothesis is then as follows:

“By simulating Emotional Behaviors in an Artificial Player for an RTS Game we can achieve a higher degree of believability.”

In order to prove this hypothesis, we present in next section our proposed solution.

3.1 Solution Models

The EAIP’s gameplay and decision making will be affected by a set of human emotions that we will incorporate in the AI. By simulating human emotional behavior on the EAIP we hope to achieve a higher degree of believability. In the following sections we describe the models, decisions and justifications that guide the implementation of our EAIP.
3.1.1 The EAIP’s chosen Influences of Emotions

As mentioned in Section 2.1.3, emotions are integral to the process of reasoning and decision making of a human being, for worse or for better [15]. Taking that into account, we have chosen four aspects of the EAIP’s gameplay to be influenced by emotions:

- **1) Fight / Retreat**: Deciding if it is better to keep fighting or retreat during a battle.
- **2) Passive / Aggressive**: Adopting a more passive and defensive position (staying at base) or a more aggressive one (more regular attacks with the army).
- **3) Miss clicks / Miss Targeting**: The precision from which the EAIP targets its unit abilities.
- **4) Rage Quit**: Surrender and leaving the game prematurely.

We chose these four aspects because we believe they can contribute to the believability of the EAIP as they are consequences to the EAIP’s gameplay in key game moments (battles, unit’s abilities and strategy) which can also be perceived and visualized by a human player. We also took into consideration some other aspects like increasing or decreasing the EAIP’s APM, focusing some feared units during battles or making the wrong unit counters. However, this other aspects aren’t as game changing and visible for the opponent as the four that we chose. Furthermore, the four possible aspects were chosen based on the possible influences of emotions, as described in Section 2.1.3. The first and second aspects - “Fight / Retreat” - and - “Passive / Aggressive” - are related to the influence of emotions in *Reasoning, Decision Making, Risk Perception* and *Risk Taking*. The third aspect - “Miss clicks / Miss Targeting” - is related to the influence of emotions in *Action Execution and Control*. The fourth aspect - “Rage Quit” - is related to the influence of emotions in *Reasoning, Decision Making* and *Motivation*.

3.1.2 The EAIP’s Emotional Behaviors

In order to influence the four aspects of the EAIP’s gameplay, we need to simulate the corresponding emotions which can have as consequences influences on the aspects that we chose so that we can generate the desired *Emotional Behaviors*, i.e. the *consequences of emotions* (that we shall name, for now on, the *effects*), which affect the EAIP.

Starting with the first *effect* - “Fight / Retreat” -, we can say that deciding to retreat from a fight or keep fighting is a decision related to *Risk Perception, Evaluation and Estimation* and *Risk Taking*. As described in Section 2.1.3, “whereas fearful people expressed pessimistic risk estimates and risk-averse choices, angry people expressed optimistic risk estimates and risk-seeking choices” [46]. Additionally, people who are angry or happy make more optimistic risk estimates than people who are sad.
[47], and fearful people are more risk-averse, contrary to angry people, who are more risk seekers [48]. Taking those studies into account, for the first effect, we need to simulate the emotions of Happiness, Anger, Fear and Sadness. Anger and Happiness will influence the EAIP’s risk perception during battles on an optimistic way (e.g. the battle will appear to be more easy to win than it actually is), opposed to Fear and Sadness, which will influence in a negative way. In addition, Anger will facilitate risk seeking choices (e.g. fighting even with low chances of winning), contrary to Fear, which will facilitate risk aversion (e.g. retreating even with high chances of winning). Furthermore, as described in Section 2.1.2, according to Lazarus’ theory, Fear’s Action Tendency is to avoid or to flee [19, p.238] and, according to Roseman’s theory [26], Fear’s Emotivational Goal and Response Strategy are getting to safety and moving away, respectively. This means, as in concordance with the effects of Fear on risk estimation and choice, Fear must influence the EAIP’s decision of retreating from a fight in a positive way.

For the second effect - “Passive / Aggressive” - we know that passiveness is often related with Sadness or Fear, and aggressiveness is often related with Anger. As mentioned in Section 2.1.2, Lazarus wrote in [19, p.251] that Sadness’ Action Tendency is characterized by inaction and withdrawal into oneself, and Fear’s Action Tendency is characterized by avoidance and escape to conflict [19, p.238]. On the other hand, Anger’s Action Tendency is characterized by the attack on the agent held to be blameworthy of the offense [19, p.226]. Likewise, Roseman’s theory [26] also recognizes that Sadness and Fear have Behavioral Emotional Components of inaction and inhibition, respectively, and belong to the Distancing Family of appraisals. Anger belongs to the Attack Family of appraisals and with an Emotivational Goal Emotional Component of hurting, getting revenge, and a strategy which involves “moving against other”. Taken this into account, the second effect - “Passive / Aggressive” - needs the emotions of Sadness, Fear and Anger, which were already needed due to the first effect - “Fight / Retreat”.

For the third effect - “Miss clicks / Miss Targeting” -, we know that it is related to the influence of emotions in Action Execution and Control. In the world of video games, players often fail to perform a desired action or command due to a miss-click, which can be pressing the wrong keyboard key, or clicking an undesired spot on the screen. In RTS games, this can manifest as giving a wrong unit command or missing a targeting unit spell or ability. This unconscious phenomenon can be caused by several reasons: psycho-motor abilities, psychological stress (especially under competition), body fatigue or lack of training, among others. One emotion often related to this problem in Anger. As a player starts feeling angry his ability to take control of his actions in a precise way starts to deteriorate. We can make an analogy to surgeons who are forbidden to perform a surgery if they are on an angry state. As stated in Section 2.1.3, research in neuroscience concludes that emotions significantly influ-
ences action generation, execution and control, as “the pathways of emotional responses mediated by the amygdale descend to the brain stem, which organizes and coordinates most relatively simple, stereotypic motor responses and facial expressions” [50, p.14]. “It is hard to put a thread through the eye of a needle when you are in a state of rage or anxiety, simply because you cannot accurately control your hands in such a mood.” [50, p.13]. As described in Section 2.1.2, Lazarus also agrees that one of the Anger’s Pathology is dysfunction and distress [19, p.233]. That being said, the third effect - “Miss clicks / Miss Targeting” – needs the emotion of Anger, which is already needed due to the first two effects.

For the fourth and last effect - “Rage Quit”, we consider that rage quitting happens when some player leaves a game prematurely. As described in Section 2.1.2, Anger and Frustration are closely related [28]. Frustration can be defined as the blockage of goal attainment [29] or the blocking of a goal-directed behaviour sequence [30]. In the case of video games, this can be the blockage of victory. Several responses to frustration can include loss of self-esteem and self-confidence, stress, depression, aggression and quitting, moving away or giving up [34, 35]. These latests can be related to video games, in the form of “rage-quitting”. This often happens when a player feels a large amount of anger or frustration in a short period of time, i.e. an anger spike [35]. In video games, this can be caused by several reasons such as: the player was having a good game, but suddenly the situation reverses considerably; “cheap” tactics were being used against the player; “If I can't win this game, no one can!” type of moments; the player wanted to revenge against “bad” teammates; the player was being harassed by the opponents; the player couldn’t stand losing the game; the player is unable to play the game due to lag; the player has bad sportsmanship; among others. In Starcraft II, players sometimes rage quit during a game when they lose a big advantage for nothing over the opponent and fell anger or frustrated about what happened. That being said, and since Anger is already needed for the other three effects, we will use Anger in order to influence this fourth effect - “Rage Quit”.

To summarize, we then have four emotions that we have to simulate in the EAIP: Happiness, Anger, Fear and Sadness. We can see that they belong to the set of six basic emotions defined by Paul Ekman in 1972, so they prove to be a simple and solid foundation to the implementation of our EAIP.

3.1.3 The Emotional Appraisal Theory

After this description of our set of four emotions and their corresponding effects, we need to use a well established Appraisal Theory (or combination of theories) in order to know for each of the game’s events, which emotion should be generated by the EAIP. The chosen Appraisal Theory must be adequate to the type of agent and environment that we are dealing with: the EAIP in a Starcraft II “1 ver-
sus 1° game. Here follows the analysis of the main Appraisal Theories described in the Section 2.1.2 in order to find the best one for our scenario.

At first sight, it appears that the OCC Theory is a good candidate to be used in our EAIP. As described in Section 2.1.2 it is widely used in the design of emotional agents due to its simplicity and implementability. However, it does not deal with coping potential which is an essential to determine the generated emotion as well as its intensity in a game of Starcraft II. For instance, if the EAIP’s opponent destroys one of the EAIP’s bases, the EAIP must evaluate if it has the potential to deal with that situation (i.e. the capability to recover from the loss; the capability to rebuild a new base). If the potential is high, it shouldn’t generate too much Anger, but if the coping potential is low, it should generate Sadness instead. Therefore, the OCC Theory isn’t adequate for our EAIP. On the other hand, as mentioned in Section 2.1.2, Lazarus’ Theory includes an evaluation of coping potential on its Secondary Appraisal Components. For instance, Sadness’ appraisals include low coping potential [19, p.249], contrary to Anger which includes high coping potential [19, p.225-226]. Nevertheless, Lazarus Theory isn’t particularly adequate to be used in implementations of Emotional Agents because it includes no explicit single appraisal process which aggregates all the emotions; some of the appraisal components for several emotions are said to be sufficient and necessary, and others don’t, which may arise some ambiguous cases; and it is more directed to human beings (as it includes ego-involvement, esteem, moral values, ego-ideals, well-being). Now considering Roseman’s theory, as described in Section 2.1.2, it shares some similarities with Lazarus’ theory (e.g. coping potential, directed blame), it has been updated several times over the last years (with the last very recent version dating from 2013 [26]), it considers the four emotions that we need for the EAIP and has a simple table structure which can be quickly translated into computable rules that define which emotions are generated by each appraisal. Taking this into account, we have chosen the Roseman’s Theory as our main Appraisal Theory for our EAIP, as long with some influences from the Lazarus’ Theory and Frijda’s Theory (this can easily be done as some of the cognitive dimensions of these three theories tend to overlap [19, p.149]).

From Lazarus’ Theory, we are going to use the Primary Appraisal components of Ego-Involvement and the Secondary Appraisal component of Future Expectancy, as described in Section 2.1.2. Ego-Involvement refers to diverse aspects of ego-identity or personal commitments, like social-esteem, moral values, ego-ideals or life goals. Ego-identity is involved in almost every emotion, but in different ways depending on the type of ego-involvement being engaged [19, p.150]. Future Expectancy has to do with whether, in the future, things are likely to change psychologically for the better or for the worse [19, p.150]. The other appraisal components overlap with those from Roseman’s theory: Goal Rele-
vance and Coping Potential exist in both cases, and Goal Congruence overlaps with Motive Consis-
tency.

From Frijda’s Theory we are going to use some of his postulated Laws of Emotions [22, 23], as de-
scribed in Section 2.1.2. These are rules that govern emotional processes and contain a great deal of
essential information concerning the cognitive nature of emotions, in a motivation-oriented approach.
According to Frijda emotions are not instant responses but rather processes over time, and that
emotional experience is attained gradually as information is gathered at several instants. The laws that
are useful for our work are [23, p.4-19]:

- **Law of Concern**: If the meaning of a situation is irrelevant to an individual's concerns, no emo-
tion is generated. This is in concordance with the Lazarus' Theory Primary Appraisal component
of Goal Relevance.

- **Law of Change**: Emotions are elicited not so much by the presence of favorable or unfavorable
conditions but by actual or expected changes in favorable or unfavorable conditions. Emotions
are elicited by events with respect to a measure of desirability that is not absolute but rather
relative to some referential. It is the change between that referential and the new event that de-
termines the type and intensity of the emotion.

- **Law of Comparative Feeling**: The nature and intensity of emotion depend on the relationship
between an event and some frame of reference with which the event is compared. This law is a
generalization of the previous law, the Law of Change. For emotion elicitation, what matters is
the frame of reference (i.e., a referential) to which the new event is compared. This frame of
reference may be the current state of affairs, the expectations about the event, one’s idea of
normality or justice, among others.

- **Law of Habituation**: This law is complementary to the Law of Change. If one gets used to re-
peatedly experience a favorable or unfavorable situation then the resulting emotions will gradu-
ally become weaker. Considering the Law of Change and the Law of Comparative Feeling, we
can say that the repeated situation gradually becomes one’s referential and, therefore, new
repetitions of that situation present no change in the state of affairs or expectations. This law, as
long with the laws of Change and Comparative Feeling, are then in concordance with the Laza-
rus’ Theory Secondary Appraisal component of Future Expectancy. However, there are certain
situations that do not cause habituation no matter how often they occur (e.g. extreme pain). This
is another law: The Law of Hedonic Asymmetry, which tells us that the laws of Habituation and
Comparative Feeling operate within limits.

Taking these theories into account, we then have an appraisal flowchart to be implemented in our
EAIP’ Appraisal System, as presented in Figure 1:
Keep in mind that we only generate four emotions (Happiness, Anger, Fear and Sadness), which allows us to simplify the appraisal tree. This is also possible by doing the following considerations: first of all, we only take into account for the EAIP events and agent actions which are Appetitive Motive, i.e. in which the response strategies are always maximizing the rewards (“move towards”) and minimizing the punishments (“stop moving toward”), as described in Section 2.1.2. This allows us to put apart many emotions of the Roseman’s emotions table that we won’t need. Then, when there is a Motive Consistent event or agent action for the EAIP, the EAIP attributes the agency of that situation to two entities: to itself (it played well) and to the circumstances (the game flow leaded to that situation). According to Roseman’s theory, when attributing those two agencies, the EAIP generates Pride and Joy, respectively. However, as we are not simulating influences from the Pride emotion, we only focus in the Joy emotion. The same happens for Anger and Sadness. When there is a Motive Inconsistent event with high Coping Potential, the EAIP generates Guilt, Anger, or Frustration (with itself, the opponent or circumstances agencies, respectively). However, as we are not simulating influences from the Guilt and Frustration emotions, we only focus in the Anger emotion. With Sadness, there is low Coping Potential, and the EAIP generates Regret, Dislike or Sadness (with itself, the opponent or circumstances agencies, respectively). As we are not simulating the influences from the Regret and Dislike emotions, we only focus in the Sadness emotion.

Figure 1 – The EAIP’s Appraisal Flowchart.
As explained, we have four appraisal components: Goal Relevance, Motive Consistency, Certainty and Coping Potential, which were taken from the Lazarus’, Frijda’s (Law of Concern) and Roseman’s theories. Only events or agent actions (i.e. player actions) which have goal relevance (i.e. influence the EAIP on achieving its goal of victory in the game) will be able to generate emotions. Motive Consistency allows us to distinguish between goal congruent and goal incongruent events. Goal congruent events (i.e. they facilitate victory for the EAIP) can only generate positive emotions, in our case: Happiness. If the event is motive inconsistent (i.e. it hinders the EAIP’s victory), then Fear, Anger or Sadness can be generated. Event Uncertainty allows us to distinguish Fear from the other motive inconsistent emotions. The EAIP’s Coping Potential against the event can be high or low, which allows us to distinguish between Anger and Sadness, respectively.

As described in Section 2.1.2, the generated emotion’s intensities are also influenced by several aspects like Ego-Involvement, Future Expectations and Coping Potential. The EAIP’s goal is to win the game. So, much as a human player, the Ego-Involvement is an aspect to consider for the EAIP. Its “meaning”, “life goal” or “ego-ideal” is to win the game, it wants to have good conditions to do so (i.e. “well-being”) and it wants to preserve itself against assaults (i.e. the opponent’s attacks, which difficult the objective of winning). This means that the more an event contributes to the EAIP’s goal of winning the game, the bigger should be the intensity of the generated emotion (in this case Happiness) and vice-versa for the goal incongruent emotions. In the case of the Fear emotion, Ego-Involvement is important to the appraisal on how the EAIP reacts to the event (i.e. a personality, which may increase or decrease the fear’s intensity) [19, p.236].

As mentioned in Section 2.1.2, Future Expectations also influence the generated emotion’s intensities (with the exception of Fear). For example, with Happiness, if future expectations (i.e. the state of the game, the probabilities of winning the game) are guarded or unfavourable, then happiness can be muted or undermined [19, p.268] (or increased, in the case of favourable future expectations). This means that, for instance, if the EAIP builds a new base (which is a Motive Consistent, as it facilitates winning the game), it should generate Happiness (with a big intensity, because building a base greatly contributes to the goal of winning the game, thus it has a very positive future expectancy), however, if the EAIP is already several bases ahead (or behind) of his opponent, the generated Happiness’ intensity should be mitigated because the future expectancy doesn’t change too much. The same happens for the Anger and Sadness emotions. For instance, if the EAIP loses several important units, but still has much more important units than its opponent, it shouldn’t generate too much Anger or Sadness, as the future expectancy is still good. This leads us to the laws of Change and Comparative Feeling, previously described. When the EAIP experiences a favourable (or unfavorable) situation, the generated emotion’s intensity must be amplified (or reduced) accordingly to the future expectations, i.e., the
change on the EAIP’s expectations on winning the game, i.e. a referential, as it is described on the Frijda’s laws. The referential can vary for each situation (e.g. when building, destroying or losing a base, the referential is the number of bases each player has) or, in a more general situation, the referential can be a general sense of who is at a better position in the game. The Law of Habituation is also implicitly used because, if some favorable (or unfavorable) event repeats itself, the future expectations will increase (or decrease) with each repetition (as long with the referential), and the generated emotion intensities will, by the same process, start to mitigate.

As described in Section 2.1.2, Coping Potential also influences the generated emotion’s intensities in the case of the Fear emotion. According to Lazarus and Roseman, Fear has an uncertain and low coping potential, respectively [19, p.236][26]. Lazarus also says that if one “could avoid or escape the sudden danger, fright would be aborted or rapidly mitigated” [19, p.237]. This means that if a situation generates Fear, the Fear’s intensity is mitigated (or even eliminated) if we have the coping potential to deal with the threat (e.g. the opponent has several harass units, which can attack at any instant, but if the EAIP has sufficient defences at his bases, the generated Fear’s intensity must be reduced).

3.1.4 The EAIP’s Architectural Model

Using the ideas described in previous sections, we have a complete architectural model for our EAIP, as it is presented in Figure 2:

![Figure 2 – The EAIP’s Architectural Model.](image-url)
As described before, we will modify the existing AI in order to obtain the desired Emotional Behaviours. As we can see in Figure 2, the EAIP’s architectural model consists in three main components: The Appraisal System, the State Variables (which are the emotion’s intensities and a representation of the game’s current state) and the Emotional Behaviours. When a percept (i.e. a game event) comes from the game environment (e.g. building, losing or destroying a base, building or unit, starting a battle, having no resources) it is evaluated by the Appraisal System to determine which emotion is generated, if any. As described in Figure 1 from Section 3.1.3, the Appraisal System evaluation process is guided by four Appraisal Components: Goal Relevance, Motive Consistency, Certainty and Coping Potential. When an emotion is generated, its intensity is influenced by the Coping Potential (only for the Fear emotion), Ego-Involvement and Future Expectations (which by themselves depend on the Game’s State and the Fridja’s Laws of Change, Habituation and Comparative Feeling). The EAIP’s current emotions’ intensities are then updated accordingly. Then, as described in Section 3.1.2, the emotions’ intensities will influences the original AI’s components of Reasoning, Motivation, Action Execution and Control, Decision Making, Risk Perception and Risk Taking in order to achieve the desired Emotional Behaviours by modifying the AI’s actions. Keep in mind that the AI’s actions are only influenced by the emotions went their intensities are at specific states, which means that, when the emotions’ intensities aren’t sufficient enough to generate an Emotional Behaviour, the EAIP will behave as the original AI.

Following this presentation of our model and its foundations, we describe in the next section how we implemented this solution in our EAIP.

3.2 Solution Implementation

The EAIP was implemented using the Starcraft II game editor tool which allows to modify the game’s base AI. As we saw in the previous section, the EAIP’s architecture contains three main components: the State Variables, the Appraisal System and the Emotional Behaviours. Therefore, we will start by describing the EAIP’s main State Variables as well as their role, followed by the description of the trigger based implementation for both the EAIP’s Appraisal System and Emotional Behaviours.

3.2.1 The EAIP’s Base Variables, General Game State and Levels System

The EAIP’s emotions - Happiness, Sadness, Anger and Fear - are represented by a set of four variables. Each of the variables holds the corresponding emotion’s actual intensity (an integer value ranging from 0 to 1000). As most emotions’ intensities decay as the time passes [11], each emotion’s intensity decreases each game second (by 2 points).
Due to the high number of possible events for each of the emotions, to simplify the monitoring and evaluation of the EAIP during testing and because we believe it wouldn’t bring any additional value to our work, we have decided to adopt this linear decay rate to update the emotion’s intensities (instead of the more traditional exponential decay rates) and not to implement emotional threshold values (i.e. emotional resistances) that determine how strong must an emotion be when it arises in order to affect the EAIP (we assume that each of the game events we capture are always relevant enough for the EAIP in order to generate an emotion).

One important EAIP variable is the General Game State (GGS). The GGS is a rational number (ranging from 0 to 1) and it is an indicator of the general game state of the EAIP, i.e. how well the game is going for the EAIP. It is a weighted sum of the EAIP’s performance in several Game Aspects (GA) when comparing to its opponent and to game standards (e.g. Income, Army Strength, Number of Upgrades). The several GAs used for the calculation of the GGS, as well as their corresponding weighting factor, are described in detail in Anex A. Each of the GAs can also be evaluated separately, and the EAIP’s performance in each one of them is ranked using a Level System. There are three different levels: LOW, NORMAL and HIGH (and NONE, which is for special cases). HIGH means the EAIP is performing very well in that particular GA, contrary to LOW. NORMAL means an average performance. The purpose of the GGS, as well as each of the GAs evaluators, is to influence emotion’s intensities during the EAIP’s appraisal process, as we describe in the next section.

3.2.2 The EAIP’s Appraisal System

First of all, we start by describing in Table 1 to Table 4 all of the considered game situations, events or event actions (that we shall name, for now on, the sources) that cause our four emotions to be generated.

Each of tables describes all the possible sources (all of them goal relevant) from which, through the EAIP’s appraisal process, generate the corresponding emotion. For example, in Table 1, all sources are Motive Consistent, thus they will generate the Happiness emotion. In Table 2, all sources are Motive Inconsistent and Uncertain (e.g. “the opponent has harass units” is an Uncertain Source because the EAIP doesn’t know when those units will attack him; “the opponent’s army is much stronger” is an Uncertain Source because the EAIP doesn’t know when the opponent will attack him with the army, i.e. it is just a future potential threat, the opponent may even decide never to attack).
### Table 2 – Fear emotion’s Sources.

<table>
<thead>
<tr>
<th>Category</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bases</td>
<td>The opponent has much more</td>
</tr>
<tr>
<td>Buildings</td>
<td>(None)</td>
</tr>
<tr>
<td>Resources</td>
<td>(None)</td>
</tr>
<tr>
<td>Units</td>
<td>Lacking detection for attacking cloaked units</td>
</tr>
<tr>
<td></td>
<td>Lacking of counters to the opponent’s units</td>
</tr>
<tr>
<td></td>
<td>The opponent has harass units</td>
</tr>
<tr>
<td>Upgrades</td>
<td>(None)</td>
</tr>
<tr>
<td>Battle</td>
<td>(None)</td>
</tr>
<tr>
<td>Others</td>
<td>The opponent’s army is much stronger</td>
</tr>
</tbody>
</table>

### Table 3 – Sadness emotion’s Sources.

<table>
<thead>
<tr>
<th>Category</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bases</td>
<td>Low number in certain game times</td>
</tr>
<tr>
<td>Buildings</td>
<td>Losing special</td>
</tr>
<tr>
<td>Resources</td>
<td>No income</td>
</tr>
<tr>
<td>Units</td>
<td>Losing high tier</td>
</tr>
<tr>
<td>Upgrades</td>
<td>Loosing a building that was researching</td>
</tr>
<tr>
<td>Battle</td>
<td>Losing</td>
</tr>
<tr>
<td>Others</td>
<td>More Population than supply</td>
</tr>
</tbody>
</table>

### Table 4 – Sadness and Anger emotion’s Sources.

<table>
<thead>
<tr>
<th>Category</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bases</td>
<td>Losing</td>
</tr>
<tr>
<td>Buildings</td>
<td>Losing special</td>
</tr>
<tr>
<td>Resources</td>
<td>No income</td>
</tr>
<tr>
<td>Units</td>
<td>Losing high tier</td>
</tr>
<tr>
<td>Upgrades</td>
<td>Loosing a building that was researching</td>
</tr>
<tr>
<td>Battle</td>
<td>Losing</td>
</tr>
<tr>
<td>Others</td>
<td>More Population than supply</td>
</tr>
</tbody>
</table>

**Table 1 and Table 3** have some sources named “in certain games times”, that we call *objective sources*. Those *objective sources* function on a different fashion: at the beginning of the game, the EAIP always has a pre-selected (or randomized) build order that he wants to follow for the first minutes of the game, i.e. its initial game plan or strategy (much like a human player). Thus it has several pre-established objectives like “at 5 minutes in game, I want to have 1000 in army strength” or “at 7 minutes in game in want to have 2 bases”. If the EAIP manages to complete its objectives, it generates Happiness. If not, it generates Sadness, because it has no coping potential that would allow him
to recover from a missed objective (i.e. it is impossible to “have 2 bases at the 7 minute mark after the 7 minutes”). Table 4 contains sources which are Motive Inconsistent and Certain, thus they can generate Sadness or Anger, depending if the EAIP’s Coping Potential over the source when it arises is low or high, respectively.

The EAIP’s Appraisal System is mainly based on triggers. When one of the possible sources arise during the game, a trigger is fired in order to evaluate which emotion, if any, is generated, as well as its intensity, i.e., the appraisal process. These are called the Appraisal Triggers (AT). Each of the sources has its own AT. Not all ATs function in the same way, and a complete identification of the AT types that are used for each source can be found in Anex B. Nevertheless, we now present in detail several ATs for different sources.

First we will start by describing a simple AT: the one which is related to the “Build new Base” source (Happiness emotion). In Figure 3 we present the full code for the AT “Build Base”. As we can see in the AT’s code, when a unit’s construction progress is completed, i.e. the trigger’s Event, if that unit belongs to the EAIP and it is of the type “Command Center”, “Hatchery” or “Nexus” (which are the main base building for the three Starcraft races), i.e. the trigger’s Conditions, then we raise the EAIP’s Happiness according to an intensity, i.e. the trigger’s Actions. That intensity is calculated using the formula:

\[
\text{Intensity} = \text{Trunc}((\text{Base Build Int Hap} \times (\text{Base Build Intensity Factors})))
\]  

Expression 1 – “Build new Base” intensity calculation formula.

The “Trunc” function is used to truncate the result to an integer value. “Base_Build_Int_Hap” is a constant value which represents the amount of Happiness the EAIP generates when it builds a new base. (225 in this case, as building a new base should generate lots of Happiness because it greatly contributes to victory, i.e. there is a big Ego-Involvement). That constant value is then attenuated by the function “Base Build Intensity Factors()” which returns a rational value from 0 to 1 (that we shall name this type of functions, for now on, the Intensity Factors). The Intensity Factors represent the Future Expectations of the EAIP after building the new base as long with any influences of the Frijda’s Laws of Emotion that might modify the generated emotion’s intensity, as described in Section 3.1.3. If Future Expectations are favorable or unfavorable, the generated intensity must by modified accordingly. In Figure 4 we present a code excerpt from the “Base Build Intensity Factors()” function.
As we can see, the *Future Expectations* are based on the number of bases comparing with the opponent and on the *Income Level*, which is a GA. If the EAIP has now 2 or more (or less) bases than its opponent, then the *intensity factor* is set at 1 (or 0.2). If the difference in bases is now of 1 or less, the *intensity factor* is set at 0.4, 0.6 or 0.8. This means we have the following graphic (ignoring the influence of the income *Level*), as presented in *Figure 5*: 

![Figure 3 – “Build Base” AT code excerpt.](image)

*Figure 4 – “Base Build” Intensity Factors code excerpt.*
This sigmoid type of graph is in direct correspondence with Frijda’s Laws of Change and Comparative Feeling, as described in Section 3.1.3, with the Referential being, in this case, the different in bases between the EAIP and its opponent. The more (less) bases the EAIP has over its opponent, the more the Happiness starts to attenuate, as the referential moves up (down) and positively (negatively), i.e. the changes in Future Expectancy are less and less relevant. On the other hand, if the EAIP and its opponent both have one base, and the EAIP manages to build a new one, the intensity factor (0.8 in this case) as long with the generate Happiness are big, as the EAIP has now the double of bases over its opponent, i.e. the Future Expectations and change of Referential are now much higher (than, for example, building a sixth base when the opponent only has 2).

As we can see, the income Level also influences the intensity factor, but only with a minor effect. The income Level can have four values (0, 1, 2 and 3, respectively NONE, LOW, NORMAL and HIGH), as it was described in Section 3.2.1 about the Levels System. Other ATs that function on a similar fashion that this “Base Build” AT can be found in Anex B.

The AT related to the “Research Upgrade” source (Happiness emotion) has a similar structure to the previous AT but with the difference that the generated intensity uses the GGS as the Intensity Factor:

\[
\text{Intensity} = \text{Trunc}((\text{Upgrade}_\text{Research}_\text{Int}_\text{Hap} \times (\text{General State Intensity Factors})))
\]

Expression 2 – “Research Upgrade” intensity calculation formula.

In this case, we have decided to use the GGS instead of any specific GA because researching an upgrade has no explicit referential to which we can compare to see if there was any significant improvement on the EAIP’s Future Expectations. There are many types and many different upgrades in Starcraft II, and it is impossible for the EAIP to know what upgrades its opponent already has in order to do any kind of comparison. Thus, we must use the GGS as it is a general indicator of how well is

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**Figure 5** – “Base Build” Intensity Factor Graph.
going the game for the EAIP. It functions like an aggregator of all GAs, i.e. all *referentials*. The Laws of Change and Comparative Feeling are then left apart for this type of ATs, and the generated *intensity* rises linearly as long with the GGS *Intensity Factor*. Other ATs that function on a similar fashion that this “Research Upgrade” AT can be found in Anex B.

In Figure 6 we present a code excerpt from the AT related to the “High Income” *source* (Happiness emotion):

![Figure 6](image-url)

As we can see, the AT’s code is similar to the first AT we described (“Base Build”). However, it has two major differences: contrary to most AT, this AT runs every 5 seconds of game time (it is a periodic event) and it has an *Emotion Cooldown Timer*. The purpose of this AT is that the EAIP generates Happiness each time it reaches a high income GA. Still, we don’t want the EAIP to be constantly generating Happiness when it is in a high income GA state and the emotion repeats itself. Thus, following the ideas behind Frijda’s Law of Habituation, as described in Section 3.1.3, we disable this AT (in this case, during 3 minutes) each time the *source* arises, which we call an *Emotion Cooldown Timer*. As this is an AT that can only occur each 3 minutes (or more), the Laws of Change and Comparative Feeling are less relevant in this situation because of its rarity and because of its big advantages (i.e. when it happens, it is always very good for the EAIP). Taking that into consideration, the *intensity factors* only include GAs related with *Future Expectations*: the Level of Production Buildings and the Level of Special Buildings, as we show in Figure 7. This means that there is no reason to be happy if we have a high income if we have no efficient way to spend the money. As we can see in Figure 6, the higher the *Levels* in those GAs, the higher is the *Intensity Factor*. Other ATs that function on a similar fashion that this “High Income” AT can be found in Anex B.
The AT related to the “Losing Base” source (Sadness and Anger emotions) is similar to the first AT that was described, “Base Build”, but with one difference: as losing a base is a source which can generate Sadness or Anger, we must evaluate the EAIP’s coping potential to recover from that loss, i.e. if the EAIP has the capability to rebuild the lost base, as it is show in Figure 8 which presents an excerpt of the coping potential evaluation code. As we can see, we check if the EAIP has enough resources or income Level in order to be able to rebuild a new base. The Intensity Factors that influences the generated emotion (Sadness or Anger) are identical to those of the first AT described: “Base Build”. Other ATs that function on a similar fashion that this “Losing Base” AT can be found in Anex B. One of those ATs is the one related with the “Losing Special Buildings” source, which functions in the same way as this AT “Losing base” but uses the GGS as the Intensity Factor, for the same reasons it is used on the AT “Research Upgrade” described previously.

AT related to the “No Income” and “More Population than supply” sources use structures similar to the ATs related to the “High Income” and “Losing Base”, i.e. they have a coping potential evaluation to see if the EAIP generates Sadness or Anger, and they function with Emotional Cooldown Timers.
The AT related to the “Winning or Losing Battle” sources functions in a different way, as it can generate Happiness, Sadness or Anger emotions. First of all, not all the battles should be relevant for the EAIP emotionally, such as isolated skirmishes. When a unit attacks another unit, we only consider it to be a battle (in a sense that it will be emotionally relevant for the EAIP) if, inside the circle with a specific radius centered at the middle of the distance between the two units, there is at least 60% of both player’s total army (in army value). After a battle begins we keep track of each player’s score, i.e. the values (in resources) of the units killed during the battle (including buildings). A battle is only considered to have ended when no unit (or building) dies after a specific number of seconds. If the EAIP has a bigger score, it wins the battle, and Happiness is generated, using the GGS as the Intensity Factor (as all GAs must be taken into account to see if Future Expectations are good after winning a battle). If not, we must evaluate the coping potential needed in order to recover from the loss, i.e. if the Levels of Production Buildings, Resources in Bank or Income GAs are sufficient to rebuild the lost army (depending on its value). If that is true, then Anger is generated, and Sadness otherwise (both of then using the GGS as the Intensity Factor). No emotion is generated in the case of ties.

To finalize the description of the EAIP’s Appraisal System, we will now explain the ATs related to the sources of the Fear emotion. Starting with the “The opponent has much more bases” source, its AT functions like the one related to the “High Income” source, but with some differences (as well as generating Fear instead): it also a periodic trigger, but it has no Emotional Cooldown Timer. This happens because now we are dealing with the Fear emotion, and any type of Fear must disappear as its threat disappears. So, the AT functions as follows (the AT related to the “The opponent’s army is much stronger” functions in an analogous way): when the opponent has much more bases than the EAIP (in our implementation this is 2 or more bases), Fear is generated. The Fear’s intensity then starts to decay normally, but if at any time, the opponent ceases to have much more bases, the Fear’s
intensity is instantly dropped by the same amount it was raised (taking into account the decay rate that already has passed), as the threat does no longer exists.

As explained in Section 3.1.3, the Coping Potential also influences the generated emotion’s intensities in the case of the Fear emotion, i.e., it corresponds to the Fear’s Intensity Factors. This means that if a situation which generates Fear, the Fear’s intensity is mitigated (or even eliminated) if the EAIP has the coping potential to deal with the threat. In this case, the Coping Potential is calculated using the GAs of “Resources in Bank”, “Income”, “Remaining Resources in Bases”, “Army Strength” and “Army Strength Compared to the Opponent” which are the GAs that can indicate if the EAIP is able to survive against being so many bases behind. If so, then the generated Fear's intensity is mitigated.

The ATs related to the sources “Lacking of counters to the opponent’s units” and “The opponent has harass units” function using what we called the Known Unit Structure (KUS). The KUS contains how many units of each unit type the EAIP knows its opponent has, i.e., they were seen by the EAIP, as well as, for each opponent type of unit, how many units the EAIP has which are counters to that unit type (using the game's original unit counters database). Each 5 game time seconds, the KUS is updated. After each update, we see if the EAIP has made any progress (or regression) in terms of countering its opponents units and if the opponent has more (or less) harassing units, comparing to the last update, in order to adjust the generated Fear accordingly.

For the lack of counters to the opponent's units, the process is made as follows: for each pair “opponent unit type – EAIP unit counter” we calculate a “counter” ratio between the number of Opponent’s units of the unit type to counter (in resources value) and the number of EAIP’s units which counter that unit type (also in resources value). Then, the result is converted to a ranking system (LOW, NORMAL and HIGH, HIGH meaning that the EAIP severely lacks of counters to an opponent unit type, and LOW meaning the opposite). The new rank is then compared to the rank from the previous KUS update, which was also stored. If there is a difference, we keep that difference as a score (e.g., changing from HIGH to LOW has a score of +2). A detailed example of these calculations can be found in Anex C. After calculating the scores for each pair “opponent unit type – EAIP unit counter”, we sum all the scores, and then we have a measure of the progress (or regression) of the EAIP in terms of countering its opponents units. If the sum of the scores is negative, it means the EAIP has less counters to the opponent’s units than on the previous update, thus it must generate Fear accordingly. The Coping Potential affecting the Fear's intensity takes into account the GAs of “Army Strength” and “Army Strength comparing to the opponent”, because we can say that if the EAIP doesn’t have the counters for its opponent’s units, but has a much stronger army, the Fear from that lack of counters must be mitigated. If the sum of the scores is positive, it means the EAIP has more counters to the opponent’s units than on the previous update, thus it must lose Fear accordingly (tak-
ing into account the decay rate that already has passed). If the sum of the scores is neutral, no Fear is generated, although any existing Fear decays each game second.

For the opponent’s harass units, the process is similar but simpler: as the KUS contains the number of opponent’s units for each unit type, we have to search for unit types which are capable of harassing. Then, for each harassing unit type, we compare the existing units of that type comparing to the last KUS update – we call that difference the score. The sum of all the scores for each of the opponent’s harassing unit types is the indicator if the opponent has more harassing units than the previous update (positive sum), or if the EAIP has managed to destroy some of them (negative sum), and we can then generate (or lose) Fear accordingly, as it is done for the “lack of counters” just described. The Coping Potential affecting the Fear’s intensity takes into account the GA of “Defenses Level”, because we can say that if the EAIP has a good average of defences in each base, the Fear of harassing units coming to attack must be mitigated.

The AT related to the “Lacking Detection against attacking cloaked Units” functions using an Emotional Cooldown Timer so that the EAIP doesn’t generate Fear each time a cloaked unit attacks it. The Coping Potential is based on if the EAIP has the capability to build more detector units and on the GAs of Income and Detectors Level (i.e. the number of EAIP Detector units on the map and the average number of anti-cloaked defences on each of the EAIP’s bases).

Following this description of the EAIP’s Appraisal System, we present in the next section how the Emotional Behaviors were implemented.

3.2.3 The EAIP’s Emotional Behaviors

At the beginning of Section 3.1.2 we described the four Emotional Behaviors, i.e. the effects, which affects the EAIP:

- 1) Fight / Retreat
- 2) Passive / Aggressive
- 3) Miss clicks / Miss Targeting
- 4) Rage Quit

As we have the ATs for dealing with the appraisal process, we now have Effect Triggers (ET) to deal with the several effects. We now present, for each effect, how to it was implemented on the EAIP.

1) Fight / Retreat. This effect is about deciding if it is better to keep fighting or retreat during a battle. It only influences the EAIP during relevant battles (those of the type described in the AT related to
the “Winning or Losing Battle” sources). Until the battle ends, the ET for this effect works as follows (as it can be seen in an excerpt from the ET’s code in Figure 9): the ET is a periodic trigger, firing each 3 game time seconds during the battle. At each of its execution, the EAIP decides if it wants to continue fighting, or prefers to retreat to the nearest base. That decision is made over several steps and it is influenced by the EAIP’s emotions. First, we calculate the raw chances of the EAIP winning the battle (the “Winning Chances()”). This is done using several GAs like the “Army Strength” and “Army Strength comparing to the opponent” and other indicators like the average lack of counters against the opponent’s units and battle upgrades. Then, as described in Section 3.1.2, Anger and Happiness will influence the EAIP’s risk perception during battles on an optimistic way, opposed to Fear and Sadness, which will influence in a negative way. So, the winning chances are changed accordingly to those emotion’s intensities (“Emotional Risk Perception(Winning Chances())”) creating an “winning_chance_emotional”. Now that the EAIP has “an idea” of its chances of winning the battle, it must decide how much risk it wants to take. As described in Section 3.1.2, Anger facilitates risk seeking choices, contrary to Fear, which facilitates risk aversion. The “winning_chance_emotional” is then inflated and deflated, respectively, according to those emotions’ intensities (“Emotional Risk Taking(winning_chance_emotional”)). If the final result is greater (or equal) than 50%, the EAIP decides to continue to fight, otherwise it retreats to the nearest base. A graph version of this decision process can be found in Annex D.

2) Passive / Aggressive. This effect is about deciding to adopt a more passive and defensive position or a more aggressive one, which we call the Passive and Aggressive Stances, respectively. It is implemented using a periodic ET that runs each 2 game seconds. As we saw in Section 3.1.2, the emotions related with the Passive Stance are Sadness and Fear, and those related with the Aggressive Stance are Anger. So, each time the ET runs, we check if the EAIP’s Stance changes (to Pas-
sive, Aggressive or None) according to those emotions’ intensities. This is done using the decision tree presented in Figure 10:

![Passive / Aggressive Stance Decision Tree](image)

**Figure 10** – “Passive / Aggressive” Stance Decision Tree.

The “Threshold” is an “Emotional Stance Threshold”, which is a constant value (in our implementation: 175) which acts as a minimum intensity the emotion must have in order to trigger a Stance (to prevent the EAIP to enter a Stance when the emotion’s intensities are almost none existent). In order to enter the Passive Stance through the Sadness emotion, we also include the test with Happiness because it wouldn’t make sense to enter a passive state if the Happiness’ intensity was bigger than Sadness’. To prevent constant fluctuations among the three Stances and strange behaviors, we also have implemented what we called a Stance Cooldown Timer, which functions much like the Emotional Cooldown Timers describe for the ATs, i.e. whenever the EAIP changes Stance, it cannot change again until after some time (in our implementation: 1 minute).

After determining if the EAIP’s Stance has changed or stays the same, the current Stance now takes effect. When in the Passive Stance, the EAIP never attacks its opponent, and positions all of its units defending its bases. When on the Aggressive Stance, the EAIP is constantly “blindly” attacking its opponent with its units. When in none of those Stances there is no additional effect. To prevent strange behaviors like staying at base when another base is being destroyed or running away from its opponent’s attacks, we disable the Stances’ effects as well as the possibility to change Stances when the EAIP is under attack and during relevant battles. At the same time, when on the Aggressive Stance, to prevent the EAIP from attacking with very few units knowing its opponent has a much bigger army (i.e. which is pointless to attack, thus, a strange behavior), we only allow him to attack if the GA of “Army Strength comparing to the opponent” Level is at least NORMAL.
3) Miss clicks / Miss Targeting. This effect is about the precision from which the EAIP targets its unit abilities. As we saw in Section 3.1.2, the emotion related to this problem of action execution and control is Anger. Therefore, this effect is implemented using an ET which runs every time the EAIP uses units’ abilities. Only abilities targeting map points are considered (i.e. “skill-shots”), as they are usually the hardest to aim, when comparing, for example, to targeted abilities, as they don’t miss after the target is selected. When the EAIP uses one of those abilities, and Anger’s intensity is above a certain threshold (as it was done with the previous effect, i.e. it is the level of Anger intensity from which we consider the EAIP’s capabilities on aiming abilities start to deteriorate. In our implementation: 200), the ET cancels that ability and makes the unit re-use it targeting a new generated point, just as if the EAIP had its aiming capabilities deteriorated. The new point is generated in the following way: we create a circle with the center being the original point where the ability was being targeted at and with a radius that increases as long with the Anger’s current intensity. Then, we chose a random point inside that circle, which is the new target for the ability. This way, the bigger the Anger’s intensity, the greater the circle and the greater are the chances of having bigger and bigger distances on the miss-click, and so failing the ability completely.

4) Rage Quit. This effect is about surrender and leaving the game prematurely. As we saw in Section 3.1.2, this happens when a player feels a large amount of Anger in a short period of time, i.e. an Anger spike. As a consequence, this effect is implemented using a periodic ET which runs every game second and checks for Anger Spikes. This is done by storing, for each of the last 15 seconds, how much the Anger’s intensity has increased (or decreased) when comparing to the previous second (how much was the fluctuation). Then, if the sum of the fluctuations over the last 15 seconds is greater than a threshold (in our implementation: 500), then we consider to have an Anger Spike. When an Anger Spike occurs, we perform additional checks to see if it is acceptable for the EAIP to rage quit the game. Therefore, even if an Anger Spike occurs, the EAIP doesn’t rage quit if Happiness’ intensity is greater than Anger’s intensity (as it wouldn’t make sense) or if the Level of the GAs “Number of Bases comparing to the opponent” or “Army Strength” is HIGH, in order to prevent strange behaviors like quitting the game while having a huge army.

Following this description of our EAIP’s implementation, we describe in next section how we have evaluated our solution.
4 Solution Evaluation

As discussed in Section 1.3, the evaluation of the solution is focused on two topics: assessing the believability of the EAIP and analyzing possible advantages or disadvantages of this new AI player from the perspective of Affective Computing, game performance, and RTS games. In this section, we start by describing our evaluation procedure for those two topics, followed by the analysis of the data we obtained and finalizing with the results and conclusions extracted from that data.

4.1 Evaluation Procedure

4.1.1 Evaluating the EAIP’s Believability

This evaluation concerns to the second goal of the Affective Computing area, which is creating synthetic characters that can emulate humans, as we described in Section 2.1.1.

First of all, we could think that the best way to evaluate the EAIP’s believability is to make a series of challenges between human players against the EAIP and then we could ask the players if they think they were playing against the game’s AI or against another human player. This would allow us, at a high level, to evaluate the level of differentiation of the EAIP from the original AI and, if it is regularly confused with a human player, we can say we have achieved a good level of believability. However, finding a sufficient number of available players as well as making series of games against the EAIP is a hard task, as the games also take some time to unfold. Additionally, even if we had that sufficient number of available players, most of their time spending playing a game against the EAIP will be for nothing, as the EAIP’s Emotional Behaviors aren’t always taking effect over the course of a match, i.e. they are only visible in specific situations. For instance, the first effect – “Fight / Retreat” - is only visible during battles and the third effect – “Miss clicks / Miss Targeting” - is only visible when the EAIP uses its unit’s abilities. Therefore, we have decided to put apart the idea of making series of matches against the EAIP and we chose to make a more simple survey coupled with video footage from the EAIP’s gameplay (also including some comparative cases with the original AI).

The survey we created was developed using Google Forms. It consists on a series of questions about small videos each of them showing a specific in-game situation where the EAIP is influenced by one of the four implemented Emotional Behaviors. This allows us to focus on the game situations where the emotions actually take effect on the EAIP, as well as obtaining answers in a quicker fashion. We tried to create videos which are general enough and present common game situations in order to avoid inclinations to specific answers.
For each of the videos, we ask the participants if they are able to identify the identity of a specific player (i.e. the EAIP, in all the cases), to which they can answer: “It is a human player”, “It is the game AI” or “I have no idea”. If they answer “It is a human player” or “I have no idea”, then we ask why they think that player acted that way, to which they can give a pre-established answer (which includes reasons related to emotions) or they can give an open answer. On the other hand, if they answered “It is the game AI”, we then ask for a level of believability (from low “1” to high “5”) of that player’s actions. Nevertheless, in either ways, we also ask which of the cases participants think it is more believable: the one from the video, i.e. the EAIP, or a case with the same player having the opposite reaction (e.g. fight instead of retreat), i.e. the AI original reaction. For the third – “Miss clicks / Miss Targeting” – and fourth – Rage Quit – effects, we present pairs of videos, both about the same game situations, but one where the player isn’t affected by emotions (i.e. it is the normal AI) and the other where it is (i.e. it is the EAIP). The asked questions remain the same, the only difference being that we have a pair of videos instead of just one (we didn’t use pairs of videos for the first two effects because the nature of the effects allowed us to do so, and it also allowed to reduce survey answer times). Keep in mind that during the survey we never reveal to the participants the true identities of the players in the videos (Human, EAIP or AI) nor we mention the existence of an EAIP.

The answers to those questions allow us to see to what extent we can say that the new agent is believable. If the majority of the participants fail to identify the EAIP as a game AI, i.e. by answering “I have no idea” or “It is a human player”, we can say that the EAIP’s behavior can at least differentiates itself from the original AI, or even be as believable as a human player, respectively. On the other hand, if the participants identify the EAIP as being a normal AI, we can at least have an idea on the degree of believability of the EAIP’s behaviors (with the level of believability question). Furthermore, by asking which of the cases (the EAIP or AI) is more believable (if any or both) we can also evaluate whether the EAIP is more believable than the original AI.

The survey was distributed through social networks, the university’s Intelligent Agents and Synthetic Characters Group (GAIPS) and through the Starcraft II community (from which we received most of the answers), using the game’s forums and chat rooms. This distribution allowed us to get answers from participants who have a good level of knowledge about RTS games and Starcraft II in particular. Here we provide a link to our online survey:

https://docs.google.com/forms/d/1H0V5QIA2NatIW3a74GcPxH5NtsrUOC2Uu6NPFeEqCng/viewform?usp=send_form
4.1.2 Evaluating the EAIP’s Advantages and Disadvantages

As described in Section 1.3, besides increasing the AI Player’s believability, we also want to search for other types of advantages and disadvantages of this new type of player from the perspective of Affective Computing, game performance, and RTS games. Although there are situations in which emotions can impair reason, more often than not emotions are essential to improve rational reasoning, decision making and human communication. From this point of view, we can say that this evaluation concerns the fourth goal of Affecting Computing, which is improving machine intelligence, as we described in Section 2.1.1.

Taking this into account, our evaluation procedure to discover the advantages and disadvantages of the EAIP will be done in three ways: by evaluating some of the participant’s answers on the survey (like the answers related to the behavioral reasons behind the EAIP’s gameplay or the open answers), through a personal analysis of the EAIP and by evaluating the EAIP’s performance. Although the main focus of this work is not to improve the performance of the AI and increase its winning capabilities by incorporating emotions, we will also test if this EAIP can achieve better results than the original one. To do so, we will also face the EAIP against the original AI, and see what winning rates we obtain. In this perspective, we can say that this part of the evaluation corresponds to one of the goals of Affecting Computing, which is improving machine intelligence, which can also bring some interesting conclusions to the differences, advantages or disadvantages of this new EAIP.

In next section we analyze the results we obtained from the survey.

4.2 Data Analysis

Our survey was answered by 54 participants over the course of a month. Their level of knowledge about RTS games and Starcraft II can be found in Figure 11 and Figure 12, respectively. The complete detailed answers can be found in Anex E. The result’s analysis is done in two parts, in the first one, we aggregate the answers according to videos related to the same effect. In the second part, we aggregate the answers from all the effects. Additionally, on the questions where the participants answer about why they think the player from the video (i.e. the EAIP) acted in some way, we aggregate the pre-established answers according to “emotional reason” (i.e. the player acted that way because of a particular emotion) and “non-emotional reason”. If some of the open answers from the “other” category also fit on the “emotional-reason” or “non-emotional-reason” categories we fit them accordingly. At the end of this analysis we also include the results from the performance tests.
4.2.1 Answers related to the videos about the Effect – “Fight / Retreat”

The survey contained four videos about the first effect – “Fight / Retreat” (two videos about “Keep Fighting” and two videos about “Retreating”) and each with four questions. The answers to the first question (Player Identification – participants are asked to identify the identity of a specific player i.e., the EAIP in all the cases) are presented in Figure 13, the answers to the second question (Behavioral Reason – participants are asked why they think the specific player, i.e. the EAIP in all the cases, acted in a certain way) are presented in Figure 14, the answers to the third question (AI Believability Level – participants are asked what they think of the specific player’s believability, i.e., the EAIP in all the cases, from low “1” to high “5”) are presented in Figure 15 and the answers to the fourth question (More Believable Case – participants are asked which of the two cases: the video, i.e. the EAIP case, or a case with the opposite reaction, i.e. the AI case; is more believable) are presented in Figure 16 (numbers in square brackets represent the actual number of answers). Keep in mind that we are aggregating the results from the four videos and that the second question is only presented to the participants when they answer “It is a human player” or “I have no idea” in the first question. Otherwise (when they answer “I have no idea”) it is the third question which is presented. The fourth question is always presented.
4.2.2 Answers related to the videos about the Effect – “Passive / Aggressive”

The survey contained three videos about the second effect – “Passive / Aggressive”. Much like the last effect, the answers to the first, second, third, and fourth questions are presented in Figure 17 (Player Identification), Figure 18 (Behavioral Reason), Figure 19 (AI Believability), and Figure 20 (More Believable Case), respectively.
4.2.3 Answers related to the videos about the Effect - “Miss clicks / Miss Targeting”

The survey contained two pairs of videos about the third effect – “Miss clicks / Miss Targeting”, each with four questions. The answers to the first question (Player Identification) are presented in Figure 21, the answers to the second question (Behavioral Reason, in the EAIP’s video) are presented in Figure 22, the answers to the third question (More Believable Case – participants are asked which of the two videos, i.e. the EAIP video and the AI video, they think is more believable) are presented in Figure 23 and the answers to the fourth question (AI Believability Level, in the EAIP’s video) are presented in Figure 24. Keep in mind that the second question is only presented to the participants when they answer “It is a human player in both videos”, “Only human in EAIP’s video” or “I have no idea” in the first question. Otherwise, when they answer “It is the AI in both videos” it is the third question which is presented and, when they answer “Only human in AI’s video, it is the fourth question which is
presented. Nevertheless, the fourth question is always presented when the third question is presented. Furthermore, to gather the results for the third question (More Believable Case) we also make the following considerations (which also allowed us to reduce some time for the participants to answer the surveys): according to the answers to the first question (Player Identification), we can make the following automatic assumptions to the answers of the third question: “It is a human player in both videos” to “Both cases are believable”, “Only human in EAIP’s video” to “More believable in EAIP case” and “Only human in AI’s video” to “More believable in AI case”.

**Figure 21** - Effect 3) “Miss clicks/Miss Targeting” **Figure 22** - Effect 3) “Miss clicks/Miss Targeting” Player Identification Graph. Behavioral Reason Graph.

**Figure 23** - Effect 3) “Miss clicks/Miss Targeting” **Figure 24** – Effect 3) “Miss clicks/Miss Targeting” More Believable Case Graph. AI Believability Graph.
4.2.4 Answers related to the videos about the Effect – “Rage Quit”

The survey contained two pairs of videos about the fourth effect – “Rage Quit”. Much like the last effect, the answers to four questions are presented in Figure 25, Figure 26, Figure 27 and Figure 28, respectively.

![Figure 25 - Effect 4) “Rage Quit”](image_url)

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**Figure 25 - Effect 4) “Rage Quit”**

Player Identification Graph.

![Figure 26 - Effect 4) “Rage Quit”](image_url)

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**Figure 26 - Effect 4) “Rage Quit”**

Behavioral Reason Graph.

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![Figure 27 - Effect 4) “Rage Quit”](image_url)

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**Figure 27 - Effect 4) “Rage Quit”**

More Believable Case Graph.

![Figure 28 - Effect 4) “Rage Quit”](image_url)

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**Figure 28 – Effect 4) “Rage Quit”**

AI Believability Graph.

4.2.5 Answers related to all the videos

In order to aggregate the answers from all videos, we need to make some considerations about the third and fourth effect’s questions about player identification: answering “It is a human player in both videos” and “Only human in the EAIP’s video” will count as “It is a human player” and, on the other hand, answering “It is an AI player in both cases and “Only human in the AI’s video” will count as “It is an AI player”. Therefore, the aggregated answers from all the videos about Player Identification, Be-
Behavioral Reason, More Believable Case and AI Believability Level are presented in Figure 29, Figure 30, Figure 31 and Figure 32, respectively.

![Figure 29 - All Effects) Player Identification Graph.](image1)

![Figure 30 – All Effects) Behavioral Reason Graph.](image2)

![Figure 31 – All Effects) More Believable Case Graph.](image3)

![Figure 32 – All Effects) AI Believability Graph.](image4)

4.2.6 Results from the Performance Tests

As described in Section 4.1.2 and in order to help in the evaluation of the EAIP’s advantages and disadvantages, we have also faced the EAIP against the AI to see what winning rates we obtain. This was done through a series of games facing the EAIP with the original AI, using the same levels of difficulty and interlaying several races matchups. The detailed complete results can be found in Anex F, and a summarized form is presented in Figure 33.
In next section we extract the relevant conclusions from the results we obtained from the survey.

4.3 Results Discussion

As mentioned at the beginning of Section 3, our working hypothesis is:

“By simulating Emotional Behaviors in an Artificial Player for an RTS Game we can achieve a higher degree of believability.”

In this section we examine to what degree we can say our working hypothesis was proved. Following the structure of the evaluation procedure from Section 4.1, we will start by analyzing the results related to the believability of the EAIP and then the results related to the advantages and disadvantages of this new kind of player.

4.3.1 Believability Analysis

In order to assess the believability of the EAIP we will use the results from the survey questions related to Player Identification, AI Believability Level and More Believable Case. This will allow us to see if the EAIP is capable of appearing to be a human player (Player Identification), if it can be more believable than the original AI (More Believable Case) and, when seen as an AI, what are its levels of believability (AI Believability Level). Therefore, we present in Table 5 and Table 6 a condensed form of the results related to Player Identification and AI Believability Level and of the results related to More Believable Case, respectively, from the previous section:
Starting with the first effect – “Fight / Retreat” - , considering Table 5, we see that it has the lowest percentage of “It is a human player” answers (45%) and the highest percentage of “I have no idea” answers (35%). Considering Table 6, we can see the results were almost evenly balanced. In almost on third of the cases the EAIP is considered to be more believable than the original AI, and the same goes for the opposite and for having the same believability than the original AI. Nonetheless, this is the effect with the highest percentage of “The AI case is more believable” answers (31%) and the lowest percentage of “Both cases are believable” answers (37%).

This was the effect which failed the most at convincing the participants the EAIP was a human player (with less than 50%, which means that more than half of the cases the EAIP fails at being considered as a human player) and, on the other hand, it was the effect which led the participants to be more undecided (35%).

The low percentage of “It is a human player” answers coupled with the high percentage of “I have no idea” make us conclude that, because this effect makes the EAIP fight battles with low chances of winning and retreat from battles in which it had high chances of winning, this effect can lead to many different perceptions about the player. The participants can have considered those decisions to be strange for a human or AI player, as they would normally have dealt with the situation differently. Furthermore, they can have considered that sometimes players (human or AI) can make mistakes or be unskilled in the game. This can be shown as many participants, after answering “I have no idea”, said as open answers that the reasons behind the player’s decisions were, among others: “unskilled decision”, “strange decision” or “Overconfidence” (which also shows that, although they answered “I have no idea”...

<table>
<thead>
<tr>
<th>EAIP Identification</th>
<th>AI Believability Level (Averages)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Human Player</td>
<td>AI Player</td>
</tr>
<tr>
<td>Effect 1</td>
<td>45%</td>
</tr>
<tr>
<td>Effect 2</td>
<td>55%</td>
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<tr>
<td>Effect 3</td>
<td>53%</td>
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<tr>
<td>Effect 4</td>
<td>76%</td>
</tr>
<tr>
<td>All Effects</td>
<td>55%</td>
</tr>
</tbody>
</table>

Table 5 – EAIP Identification Results.

<table>
<thead>
<tr>
<th>EAIP Case</th>
<th>Al Case</th>
<th>Both Cases</th>
<th>None of the Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Effect 1</td>
<td>32%</td>
<td>31%</td>
<td>37%</td>
</tr>
<tr>
<td>Effect 2</td>
<td>54%</td>
<td>5%</td>
<td>41%</td>
</tr>
<tr>
<td>Effect 3</td>
<td>25%</td>
<td>28%</td>
<td>45%</td>
</tr>
<tr>
<td>Effect 4</td>
<td>23%</td>
<td>5%</td>
<td>71%</td>
</tr>
<tr>
<td>All Effects</td>
<td>36%</td>
<td>19%</td>
<td>45%</td>
</tr>
</tbody>
</table>

Table 6 – More Believable Cases Results.
no idea”, they were already considering the player to be human). This also explains the high percentage of “The AI case is more believable”, as participants were expecting the opposite decision to be taken by the player (between fighting and retreating).

Nevertheless, the “I have no idea” answers can have several different meanings: it can mean that the EAIP, even though it is not completely identifiable as a human player, as suggested by the low percentage of answers, it can differentiate itself enough from the original AI in order to generate that confusion (which can count as a good result for our work); the EAIP’s behavior is very uncommon, weird or awkward, which also gives rise to the confusion (which is not such a good result because we don’t want to achieve believability using strange “non-human” behaviors); or simply because there wasn’t enough information on the video for the participant to answer the question.

We can then conclude that this first effect - “Fight / Retreat”, although it doesn’t contribute too much for the EAIP to be completely identified as a human player, it can at least create some confusion and differentiation from the original AI player. Even with the highest percentage of “The AI case is more believable” answers (31%), this effect also has an average percentage of “The EAIP Case is more believable” answers (32%), which makes a good contribution for the EAIP’s believability.

For the second effect - “Passive / Aggressive” - , considering Table 5, it has the second highest percentage of “It is a human player” answers (55%) and the highest average of $AI \text{ Believability Level}$ (3.4). Considering Table 6, it has the highest percentage of “The EAIP case is more believable” answers (54%) and one of the lowest percentage of “The AI case is more believable” (5%) answers.

This means that this is the effect which presents the best results in terms of believability. It is the only one where more than half of the cases (54%) the EAIP’s behavior (of deciding to be aggressive or passive) was considered to be more believable than the original AI (which has only 5% answers). Furthermore, in more than half of the cases the EAIP’s behavior is seen as a human one (55%) and when it doesn’t, its $AI \text{ Believability Level}$ is 3.4, which is also above average.

Despite the also high percentage of “Both cases are believable” answers (41%), we can then say that the original AI’s decisions about being passive or aggressive have some deficiencies, as they seem not to totally correspond to the expectations of the players.

We can then conclude that this second effect – “Passive / Aggressive” greatly contributes to the believability of the EAIP and, when it doesn’t, its behaviors are at least as good as those from the original AI.

For the third effect – “Miss clicks / Miss Targeting” – considering Table 5, it has the highest percentage of “It is the game AI” answers (31%) and the lowest average $AI \text{ Believability Level}$ (2.7). Considering Table 6, it has the lowest percentage of “The EAIP case is more believable” answers (25%) and the highest percentage of “The AI case is more believable” answers (28%).
Considering the remarks from Table 5, as well as the fairly high percentage of “It is a human player answers” (53%) and the fairly low percentage of “I have no idea” answers (16%) this means that, at the same time, under this effect, the EAIP can be easily identified as a human player (who missed the unit’s abilities) or as an AI player with low believability. This makes us deduce that the participants (i.e. the players) have a very similar mindset about the relation between aiming abilities and player controller (human or AI): they believe that missing abilities which require aim is more characteristic of a human player than an AI player. Considering the remarks from Table 6, we can see that this effect is the one that less contributes for the believability of the EAIP. As the percentages of “The EAIP case is more believable” “ and “The AI case is more believable “ are very similar and, if summed, we have roughly the same percentage of answers as “Both cases are believable”, we can say that, in average, the EAIP’s behavior is at least (45% of the cases) as believable as the original AI. This can be explained by the fact that, in Starcraft II, either missing or hitting the unit’s abilities are always two common outcomes.

This third effect – “Miss clicks / Miss Targeting” – make us conclude that it can have opposing consequences on the identification of the EAIP’s identity: in roughly most of the cases (53%) the EAIP is seen as a human player and, in almost a third of the cases (31%) it is seen as a poorly built AI. Despite having a contribution of 25% to the EAIP’s believability, almost most of the times (45%) the EAIP’s behavior is as believable as the original AI.

For the last and fourth effect – “Rage Quit” – considering Table 5, it has the highest percentage of “It is a human player” answers (76%) as long with the lowest percentage of both “It is an AI player” (11%) and “I have no idea” answers (13%). Considering Table 6, it has the highest percentage of “Both cases are believable” answers (71%) as long with the lowest percentages of both “The EAIP case is more believable” (23%) and “The AI case is more believable” answers (5%).

Therefore it is the effect with the best results in terms of Player Identification, as more than 75% of the cases the EAIP is, under that effect, seen as a human player. This can be explained by the fact that players generally associate rage quitting with a human player. However, considering the remarks from Table 6, we see that this effect has a very small increase in believability because, even if the percentage of “The EAIP case is more believable” answers is far more superior than the percentage of “The AI case is more believable” answers, 71% of the cases the EAIP’s behavior is as believable as the original AI.

We can then conclude that this effect – “Rage Quit” - despite greatly contributing to the identification of the EAIP as being a human player (which can also be seen as believability), the results on increased believability are not very substantial.

When considering all of the effects, we see that, in Table 5, The EAIP can roughly in most of the cases be seen as a human player (55%) and, in some of the cases, it can at least differentiates itself
from the original AI (25%). Roughly all of the four effects made the same contribution to this result. Although this doesn’t prove us that the EAIP is more believable than the original AI (because the original AI can also be identified as a human player) we can at least be sure of the existence of cases where the EAIP can be seen as a human player. If not, we could be falling in the error of having more believable behaviors, but still strange and non-human ones.

When analyzing the results from Table 6 we see that, in 36% of the cases, the EAIP’s behavior is considered to be more believable than the original AI (with the second effect – “Passive / Aggressive” being the one which contributed the most). Taking this into account, we can say that the results from our work in terms of improving the original AI’s believability, although they weren’t exceptionally positive or negative, prove to be encouraging. At least in 45% of the cases the EAIP is as believable as the original AI and only in 19% of the cases it is considered less believable.

We can then conclude that, besides the EAIP can be seen as a human player most of the cases, the results in believability from Table 6 are enough to prove our hypothesis that:

“By simulating Emotional Behaviors in an Artificial Player for an RTS Game we can achieve a higher degree of believability.”

Keep in mind that the EAIP’s believability was mainly evaluated by experienced players, and the achieved believability results are only related to the four effects we have implemented, and are not to be viewed in a more general perspective.

4.3.2 Other Relevant Conclusions

To further complement the results from the last section, we can also take additional conclusions related to the advantages and disadvantages of this new type of player. As described in Sections 1.3 and 4.1.2, we want to answer the questions of: “Which other conclusions can we bring to the Affective Computing area?”,” Can this Emotional Agent achieve better results than the original one?” and “Which are the main consequences of implementing an Artificial Emotional RTS Player?”. In the following paragraphs we present our answers to those questions.

Concerning the first question - “Which other conclusions can we bring to the Affective Computing area?” - We present in Table 7 a summarized form of the results from the answers related to Behavioral Reasons (i.e. why the participants think the player, in all cases, the EAIP, acted in a certain way) from Section 4.2:
The Non-Emotional Reasons include reasons related to strategy, tactics, skill, decision making and luck. By observing Table 7, we see that for both the first and third effects, the participants mostly consider the behavioral reasons of the EAIP’s gameplay to be non-emotional. As the first effect is related to fighting and retreating, and the third one is related to hitting unit’s abilities, we can conclude that most players consider those game aspects to be principally determined by strategic decisions and skill, respectively. This can also explain the similar percentages of “The EAIP case is more believable” and “The AI case is more believable” found in Table 6 from the previous section for these effects. Both behaviors (fighting or retreating and hitting unit’s abilities) and skilled related, and therefore it is always common or believable to see one or the other. On the other hand, we see that for both the second and fourth effects, the situation is reversed. For the fourth effect, this was already expected, as the main reason behind rage quit is anger, which is an emotional reason. For the second effect – “Passive / Aggressive” -, players mostly considers the reason of the behavior to be emotional, which leads us to conclude that sometimes, the reason that leads a player to be more offensive or defensive is not perceived to be only strategy related, but it can also be perceived to be emotionally related.

When we take all effects into account, we see that, in general, the participants consider most of the times the reasons for the behaviors to be non-emotional. Maybe this happens because we need a higher quality EAIP, or because players aren’t used to the idea of emotional agent players, or because they underestimate the influences of emotions, especially in a RTS game. However, this can prove to be contradictory to the purpose of our work. Why building an emotional artificial intelligent player if, most of the times, the players will consider that the reasons behind its behaviors are non-emotional? Yes, we have improved its believability but, if the reasons for the behaviors are never considered to be emotional, maybe we can just simply incorporate randomly generated behaviors into artificial players and achieve the same level of believability, with less work, complexity and required processing power. The answers to these issues may require further investigation.

In order to answer the second question - “Can this Emotional Agent achieve better results than the original one?”, we need to analyze the results from the performance tests. As we can see in Figure 33, the EAIP won 31% of the games against an AI with the same level of difficulty. In Starcraft II, as with most RTS games, when we face two AI’s with the same level of difficulty, we have win rates
rounding the 50%. Thus, as the EAIP only won 31% of the games, we can conclude that the emotional behaviors have deteriorated the AI's performance. This can be explained because most of the effects we have implemented, although they can increase believability, they have a negative impact on the EAIP's gameplay. For instance, the first effect – “Fight / Retreat” – can make the EAIP keep fighting during a battle with low chances of winning, or retreat from a battle in which it had high chances of winning, both of which don't contribute to victory. The third effect – “Miss clicks / Miss Targeting” – only contributes for the EAIP to miss its unit's abilities, factor which can also be essential to achieve victory (it was one of the reasons why the EAIP never won as the Protoss race against the Terran race, as it sometimes failed to hit the precious “Psionic Storms” abilities, as it can be seen in Anex F). The fourth effect – “Rage Quit”, can also only contribute to defeat, as it makes the EAIP leave the game, sometimes prematurely, where it still had chances of winning.

Nevertheless, considering the third question - “Which are the main consequences of implementing an Artificial Emotional RTS Player?” -, the development of this EAIP can also bring some advantages to RTS games area. The trigger-based architecture we implemented, using Appraisal Triggers (AT) and Emotional Triggers (ET) can be used in other RTS games in order to achieve the same or other objectives, like performance. When in shortage of human players, the EAIP can also be used for competitive training, as its behaviors are closer to the human ones when comparing to the traditional AI.

However, the EAIP also has its disadvantages in RTS games. Sometimes players, for training purposes, only want to play against efficient and good players or AI, something that the EAIP fails to offer, as we saw that its performance is worse than the original AI. In addition, during the survey, some participants said in some open answers that they were against the fourth effect – “Rage Quit”, because no AI should rage quit for the sake of believability, as it takes the pleasure of winning from a human player (although some players enjoy making others rage quit). This can prove to go against the second goal of Affective Computing – making robots or machines which can emulate humans – as this time, the artificial case is preferred over the believable “human” on. Nevertheless, we can also say that, in those cases, victory is achieved nonetheless and making the other player rage quit can also be very satisfying. This problem can also be solved by making the “Rage quitting” behavior of the EAIP an optional one. Furthermore, The EAIP also requires more memory and processing power than the original AI, something that, if we want the EAIPs to be more complex and believable, can start to prove as a difficulty. In this work, we only implemented four emotional behaviors which only influence some specific moments over the curse of a game. In order to create a more believable EAIP, we may need to implement more emotional behaviors, as it is detailed in Section 5.3 - Future Work.
5 Conclusions

In order to finalize our work, we present in this section a summary of this thesis, its final conclusions and our proposals for Future Work.

5.1 Work Summary

In order to address the lack of believability in video game AI, and following the ideas behind the recent field of Affective Computing, our work consist in an attempt to simulate human emotional behavior in an artificial game player for an RTS game. We are not trying to improve the existing AI by simulating emotions, such as making it more efficient or increasing its performance. Our objectives are in fact: to see if we can increase the believability of the AI player through the simulation of emotional behaviors and evaluate possible advantages and disadvantages of this new type of player.

In pursuance to attempt to prove our hypothesis that by simulating emotional behaviors in an artificial player for an RTS game we can achieve a higher degree of believability, we presented four aspects of the EAIP’s gameplay that are influenced by the emotions: “Fight / Retreat”, “Passive / Aggressive”, “Miss clicks / Miss Targeting” and “Rage Quit”, as long with the respective related emotions: Happiness, Sadness, Anger and Fear. We then detailed the combination of Appraisal Theories and ideas which were used to implement the EAIP’s Appraisal System: the Roseman’s Theory, Lazarus’ Appraisal Components and Frijda’s Laws of Emotions. After building an appraisal flowchart, we finalized with the description of the EAIP’s Architectural Model.

We then presented the implementation of our trigger based solution. For each of the four emotions, we characterized its sources (agent actions or game events that cause the emotion to arise) and its effects (the consequences they have on the EAIP’s gameplay). The EAIP’s Appraisal System was implemented using Appraisal Triggers (AT) which fire for each of the sources and evaluate which emotion, if any, is generated as long with its intensity. The generated emotions’ intensities are based in the EAIP’s Future Expectations and Coping Potential, which both depend on the General Game State (GGS), kept and updated by the EAIP. The EAIP’s four Emotional Behaviors were implemented using Effect Triggers (ET) which fire in the corresponding situations and when the emotions’ intensities reach certain states.

In order to assess the EAIP’s believability, we created an online survey with videos about the EAIP’s gameplay showing specific in-game situations where the EAIP is influenced by one of the four Emotional Behaviors. Participants were then asked several questions about those videos related to player identification (human or AI), behavioral reasons and player believability. So we can evaluate the EAIP’s main advantages and disadvantages, we focused in three specific questions: “Which other
conclusions can we bring to the Affective Computing area?”, “Can this Emotional Agent achieve better results than the original one?” and “Which are the main consequences of implementing an Artificial Emotional RTS Player?”. To answer those questions, we analyzed some of the participants’ answers to the surveys, we made a performance test (i.e. a series of matches between the EAIP and the original AI) and we also made a personal analysis of the EAIP.

5.2 Final Conclusions

As described in Section 4.3.1, in 36% of the evaluation cases, the EAIP’s behavior was considered to be more believable than the original AI, which is enough to prove our hypothesis that:

“By simulating Emotional Behaviors in an Artificial Player for an RTS Game we can achieve a higher degree of believability.”

The second effect – “Passive / Aggressive” was the one which contributed the most to that increase in believability. It also made us conclude that the original AI may have some imperfections when it takes to deciding whether to be passive or aggressive, as it can be seen by not corresponding to the player's expectations.

The EAIP is also identified as a human player in most of the cases (55%), and it is most due to the fourth effect – “Rage Quit”. This can be explained by the fact that players generally associate rage quitting with a human player. Although this doesn’t prove us that the EAIP is more believable than the original AI (because the original AI can also be identified as a human player), these are good indicators to whether we have achieved a human-like behavior with the EAIP.

As described in Section 4.3.2, the reasons behind the EAIP’s behaviors were most of the time considered to be non-emotional (54%). This can prove to be contradictory to the purpose of our work and Affective Computing in general. Why building an emotional artificial intelligent player if, most of the times, the players will consider that the reasons behind its behaviors are non-emotional? Perhaps we can achieve the same level of believability by simply incorporating randomly generated behaviors into artificial players, which requires less work, complexity and processing power. These answers to these conclusions may require further investigation.

The EAIP’s performance was also deteriorated, as its win rate against the original AI is below the standard 50% (only 31). This is explained by the fact that most of the effects we have implemented, although they have increased the believability, they have a negative impact on the EAIP’s gameplay.

Nevertheless, the trigger-based architecture we implemented, using Appraisal Triggers (AT) and Emotional Triggers (ET) can be used in other RTS games in order to achieve the same or other objec-
tives, like performance. When in shortage of human players, the EAIP can also be used for competitive training, as its behaviors are closer to the human ones when comparing to the traditional AI.

However, the EAIP also has its disadvantages in RTS games. Sometimes players, for training purposes, only want to play against efficient and good players or AI, something that the EAIP fails to offer, as we saw that its performance is worse than the original AI. The issue of rage quitting for the sake of believability also goes against the second goal of Affective Computing, and this may also require further investigation. Furthermore, The EAIP also requires more memory and processing power than the original AI, something that, if we want the EAIPs to be more complex and believable, can start to prove as a difficulty.

In order to conclude, our increase in believability is encouraging for the continuation of our work. We hope that the development of this emotional player serves as the first steps for creating believable artificial emotional players with which we can play against, as well as contributing to the field of Affective Computing and RTS games in general.

In this work, we only implemented four emotional behaviors which only influence some specific moments over the curse of a game. In order to attempt to create a more believable EAIP, we may follow some suggestions, as it is described in the next section.

5.3 Future Work

In order to continue our work, we present three proposals which we believe can improve the EAIP’s quality and believability, as well as opening the possibility for new conclusions: new sources, effects and emotions, different EAIP personalities and a communication module.

5.3.1 More Sources, Effects and Emotions

The EAIP’s appraisal and emotional model can be expanded with additional emotions, sources and effects. For instance, we can include emotions like Pride, Relief, Surprise, Frustration, Shame, Nervousness, Hope or Worry, as long with their own sources, as they can also be part of a player’s set of emotions felt during a Starcraft II game. In addition, we can also develop other interesting effects, some of them related to some of those new emotions:

- **APM Increase / Decrease**: As described in Section 4.1.1, two requirements for believable agents are: “Reactive and Responsive”, i.e. agents should be able to react in a reasonable timing according to their personality; and “Resource Bounded”, i.e. agents should have limits to what they can physically and mentally do. Taking those requirements into consideration, we can
increase or decrease the EAIP's APM according to some emotions’ intensities, like Happiness, Sadness, Anger or Worry.

- **Focus Unit Type:** When the fear of a unit type passes a certain threshold, if the EAIP faces an opponent’s army which has units of that type, the EAIP would blindly focus those units during the battle as it is too afraid of them.

- **Make Strategy or Tactical Mistakes:** Like a human player, the EAIP can sometimes make mistakes such as making the wrong unit counters, neglect scouting or forgetting to build new bases or upgrades. The probability of those mistakes will be bigger if some corresponding emotions, like Sadness, Fear or Nervousness, also have bigger intensities.

- **Attention Focus:** As described in Section 4.1.1, one requirement for believable agents is “Resource Bounded”, i.e. agents should have limits to what they can physically and mentally do. In humans, attention is a powerful mechanism that helps us deal with the information overload by allowing us to ignore extra information and filter only what is relevant. The modeling of attention in artificial agents can be used to adapt the set of perceptions that the agent receives to an optimized subset of perceptions that are really relevant. This issue can be a subject of a complete different thesis, like it can be seen in [175] or [176], where the authors concluded that agents with affective focus of attention are at least as effective as those with access to all information from their environment. However, they are more efficient because they can achieve the same objectives with fewer steps and using less time. Building a full affective attention focus module is beyond the scope of this thesis. Nevertheless, changing the EAIP's attention focus can be done as follows: when the EAIP's attention is said to be focused to some area on the map, we only allow the EAIP to send commands to that area (like what happens to human players when their attention is attracted to some place). Those attention changes can come, for example from the Surprise, Anger or Fear emotions. With a focus of attention in one area the EAIP will stop sending commands to other areas, which will have some other consequences like not using special abilities in those other areas, not scouting or building new buildings, among others.

### 5.3.2 EAIP Personalities

The EAIP can also be parameterized with Personalities. Each personality type differs in the way the emotions are effected i.e., how much each of the emotions’ intensities rises (and decays) for each of the possible sources. For instance, a “Nervous” EAIP will see the intensity of the Nervousness emotion quickly rising each time the Nervousness’s sources occurs, as opposed to other personalities (like “Relaxed”). The decay rate of the Frustration emotion on a Raging player will be lower than in other types of personalities.

In the future, we might be able to select, not only the difficulty level of our AI opponent, but also its personality, which will allow for a much more personalized (thus attractive) experience for the human
players, even for competitive training. Having game AI with personalities can also prove to be interesting to Social Simulations, from a gaming domain point of view, where we can study which of the personalities is more successful than the others.

In Anex G we describe some examples of types of personalities that we can implement.

5.3.3 EAIP Communication Module

In the end of Section 2.1.3, we discussed that one important role played by emotions is their influence on Communication, because it often include emotional expressions and behaviors. Additionally, as described in Section 4.1.1, on requirement for believable agents is “Consistency of Expression” i.e., all possible means of physical expression should be consistent with the agent’s thought process. In the other hand, during a Starcraft II game between human players, the players are allowed to communicate with each other through chat messages. Taking these aspects into account, in order to further increase the EAIP’s believability, we can also implement a Communication Module that allows the same type of interactions while considering the EAIP’s emotional state. The exchanged messages will belong to a pre-defined set known to the EAIP. This could demonstrate how it would be to simulate chat messages and responses which vary according to the EAIP’s emotional state, and can also serve as a starting point for a future work (or even thesis) related to a full natural language interface. The Communication Module can be implemented with several types of messages, as described as follows:

- **Type 1 - The human player can send chat messages to the EAIP**: Those messages can have different purposes like greetings at the beginning of the match, taunting, praising, thanking, apologizing or saying “good game” at the end of the match. These messages can affect the intensity of the EAIP’s current emotions.

- **Type 2 - The EAIP can reply to the human players’ messages**: These replies will depend of the EAIP’s intensities of certain emotions, and can also serve as indicators about the EAIP’s current emotional state (e.g. the human player, after winning a battle, says “haha, I destroyed all your units”, and the EAIP replies “just shut up please”, this can indicate that the EAIP is feeling a great amount of Anger or Frustration).

- **Type 3 - The EAIP can send chat messages to the human player**: When certain emotions reach a certain intensity threshold, or when certain game situations or events arise, the EAIP can, by its own initiative, send a chat message to the human player. Like the human players’ messages, these messages can have several purposes like taunting or praising the human player, or just to comment a certain game situation. These messages can also serve as indicators about the EAIP’s current emotional state.

Some examples of chat messages can be found in Anex H.
References


[92] Zen Warriors, available at www.play-ground.co.uk


### Anex A – General Game State’s Game Aspects

<table>
<thead>
<tr>
<th>Game Aspect</th>
<th>Weight on General Game State</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resources in Bank</td>
<td>5%</td>
</tr>
<tr>
<td>Number of Special Buildings</td>
<td>5%</td>
</tr>
<tr>
<td>Number of Production Buildings</td>
<td>7,50%</td>
</tr>
<tr>
<td>Number of Upgrades</td>
<td>7,50%</td>
</tr>
<tr>
<td>Resources left in Bases</td>
<td>7,50%</td>
</tr>
<tr>
<td>Army Strength comparing to the opponent’s known army</td>
<td>10%</td>
</tr>
<tr>
<td>Army Strength comparing to the opponent’s known army</td>
<td>12,50%</td>
</tr>
<tr>
<td>Income</td>
<td>12,50%</td>
</tr>
<tr>
<td>Number of Bases comparing to the opponent’s Bases</td>
<td>15%</td>
</tr>
<tr>
<td>Battles Win / Loss Ratio</td>
<td>17,50%</td>
</tr>
</tbody>
</table>
Anex B – Different AT Types

### Happiness

<table>
<thead>
<tr>
<th>Category</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bases</td>
<td>Building</td>
</tr>
<tr>
<td></td>
<td>Destroying</td>
</tr>
<tr>
<td></td>
<td>High number in certain game times</td>
</tr>
<tr>
<td>Buildings</td>
<td>Building special</td>
</tr>
<tr>
<td></td>
<td>Destroying special</td>
</tr>
<tr>
<td>Resources</td>
<td>High income</td>
</tr>
<tr>
<td></td>
<td>High income in certain game times</td>
</tr>
<tr>
<td>Units</td>
<td>Training high tier</td>
</tr>
<tr>
<td></td>
<td>Destroying high tier</td>
</tr>
<tr>
<td></td>
<td>High number of high tier</td>
</tr>
<tr>
<td></td>
<td>Having units with many kills</td>
</tr>
<tr>
<td></td>
<td>Successfully using special abilities</td>
</tr>
<tr>
<td></td>
<td>High number in certain game times</td>
</tr>
<tr>
<td>Upgrades</td>
<td>Research</td>
</tr>
<tr>
<td></td>
<td>Destroying a building that was researching</td>
</tr>
<tr>
<td></td>
<td>High number in certain game times</td>
</tr>
<tr>
<td>Battle</td>
<td>Winning</td>
</tr>
<tr>
<td>Others</td>
<td>Reaching high population</td>
</tr>
</tbody>
</table>

### Fear

<table>
<thead>
<tr>
<th>Category</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bases</td>
<td>The opponent has much more</td>
</tr>
<tr>
<td>Buildings</td>
<td>(None)</td>
</tr>
<tr>
<td>Resources</td>
<td>(None)</td>
</tr>
<tr>
<td>Units</td>
<td>Lacking detection for attacking cloaked units</td>
</tr>
<tr>
<td></td>
<td>Lacking of counters to the opponent’s units</td>
</tr>
<tr>
<td></td>
<td>The opponent has harass units</td>
</tr>
<tr>
<td>Upgrades</td>
<td>(None)</td>
</tr>
<tr>
<td>Battle</td>
<td>(None)</td>
</tr>
<tr>
<td>Others</td>
<td>The opponent’s army is much stronger</td>
</tr>
</tbody>
</table>

### Sadness

<table>
<thead>
<tr>
<th>Category</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bases</td>
<td>Low number in certain game times</td>
</tr>
<tr>
<td>Buildings</td>
<td>(None)</td>
</tr>
<tr>
<td>Resources</td>
<td>Low income in certain game times</td>
</tr>
<tr>
<td>Units</td>
<td>Low number in certain game times</td>
</tr>
<tr>
<td>Upgrades</td>
<td>Low number in certain game times</td>
</tr>
<tr>
<td>Battle</td>
<td>(None)</td>
</tr>
<tr>
<td>Others</td>
<td>(None)</td>
</tr>
</tbody>
</table>

### Anger

<table>
<thead>
<tr>
<th>Category</th>
<th>Source</th>
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</thead>
<tbody>
<tr>
<td>Bases</td>
<td>Losing</td>
</tr>
<tr>
<td>Buildings</td>
<td>Losing special</td>
</tr>
<tr>
<td>Resources</td>
<td>No income</td>
</tr>
<tr>
<td>Units</td>
<td>Losing high tier</td>
</tr>
<tr>
<td>Upgrades</td>
<td>Losing a building that was researching</td>
</tr>
<tr>
<td>Battle</td>
<td>Losing</td>
</tr>
<tr>
<td>Others</td>
<td>More Population than supply</td>
</tr>
</tbody>
</table>

**Code Colored Legend:**

- Normal AT with specific Intensity Factors
- Normal AT with GGS Intensity Factor
- Normal AT differentiating Sadness and Anger, with specific Intensity Factors
- Normal AT differentiating Sadness and Anger, with GGS Intensity Factor
- Normal AT with Coping Potential as Intensity Factor and Emotional Cooldown Timer
- Periodic AT differentiating Sadness and Anger, with specific Intensity Factors and Emotional Cooldown Timer
- Periodic AT with Coping Potential as Intensity Factor
- Periodic AT with specific Intensity Factors and Emotional Cooldown Timer
- AT Related to the Objectives Sources
- Periodic AT related with the KUS
- Battles AT

[x] - Indicate ATs which are in fact the same AT
Anex C – Example of KUS pair score calculation

Supposing the EAIP is playing the Protoss race, and its opponent is playing the Terran race. Then, the KUS will have the pair of units “Marine – Colossus”, as the Colossus are the counters for the Marines. Supposing the Terran opponent has 25 (known) Marines and the EAIP has 3 Colossi. Each Marine has a Resource Value of 50 and each Colossus has a Resource Value of 500. The calculation of the “counter” ratio will then be as follows:

\[(25 \times 50) / (3 \times 500) \approx 0.8\]

Then we must apply the ranking system. The ranking system has two limits: 2 and 4 (which allow good classifications of unit counters relations). This means that values below 2 will be classified as LOW, values from 2 to 4 will be classified as NORMAL, and values greater than 4 will be classified as HIGH. As 0.8 < 2, the rank of this “counter” ratio is LOW, which means that the EAIP clearly has enough Colossi to counter the Marines.

Now, this new rank is compared to the previous rank (which comes from 5 seconds ago) so we obtain the score. Supposing the previous rank was NORMAL. As LOW = 1, NORMAL = 2 and HIGH = 3, we then calculate:

NORMAL – LOW = 2 – 1 = 1.

The score of this pair “Marine – Colossus” is then 1. As it is positive, it means the EAIP is now more prepared to counter the Marines than before.
Anex D – “Fight / Retreat” Decision Process Graph Version

Relevant Battle Begins → Each 3 Game Seconds During Battle → Winning Chances()

Optimistic:
- Happiness (intensity contributes +0% to +12,5%)
  → Emotional Risk Perception()
  → winning_chance_emotional (can range from 7,5% to 92,5%)

Pessimistic:
- Sadness (intensity contributes -0% to -12,5%)
  → Emotional Risk Perception()
  → winning_chance_emotional (can range from 32,5% to 67,5%)

Risk Seeking:
- Anger (intensity contributes +0% to +7,5%)
  → Emotional Risk Taking()
  → battle_factor (can range from 0% to 100%)

Risk Averse:
- Fear (intensity contributes -0% to -7,5%)
  → Emotional Risk Taking()

battle_factor >= 50%?
  Yes → Keep Fighting
  No → Retreat to the nearest base
**Anex E – Detailed Survey Answers**

1) **Fight / Retreat**

********** Video 1A **********

**What do you think of the Protoss player controller?**

- It is the ga [11] [39%]
- It is a Human player. 21 39%
- It is the game A.I. 11 20%
- I have no idea. 21 39%

**Why do you think the Protoss player retreated the army from the battle?**

- The fear caused b... 15 28%
- He thought he was... 10 19%
- He preferred to fi... 8 15%
- He wanted to gain... 10 19%
- Other 2 4%

**If the Protoss player had keep fighting instead of retreating, would that have been...**

- As believable[23]
- Less believable than the video case. 6 11%
- More believable than the video case. 23 42%
- As believable as the video case. 25 46%
- None of the cases are believable. 0 0%
********** Video 1B **********

What do you think of the Zerg player controller?

- It is the ga [10]
- I have no idea [15]
- It is a Human [28]

Why do you think the Terran player retreated from the fight?

- He was afraid of...
- He was caught by...
- He thought he was...
- Other

He was afraid of the lack of counters against the Colossi (Vikings). 21 39%
He was caught by surprise which made him think the Protoss had a stronger army. 5 9%
He thought he was going to lose the battle. 12 22%
Other 6%

Evaluate the A.I.'s Believability in that decision.

- 1 0 0%
- 2 3 6%
- 3 3 6%
- 4 3 6%
- 5 1 2%

If the Zerg player had retreated instead of fighting, which should have been...

- More believable [21]
- As believable [12]
- Less believable than the video case. 21 39%
- More believable than the video case. 21 39%
- As believable as the video case. 12 22%
- None of the cases are believable. 0 0%

********** Video 1C **********

What do you think of the Terran player controller?

- It is the ga [10]
- I have no idea [22]
- It is a Human [21]

Why do you think the Zerg player fought so long against the Protoss instead of retreat?

- He thought he was...
- He thought the P...
- He was happy a...
- Other

He thought he was going to win the battle. 16 30%
He thought the Protoss army was weaker because of the difference in bases. 9 17%
He was happy about the new difference in bases that he fought longer. 17 31%
Other 3 6%
Evaluate the A.I.'s Believability in that decision.

If the Terran player had keep fighting instead of retreating, would that have been...

- Less believable than the video case: 16 (30%)
- More believable than the video case: 14 (28%)
- As believable as the video case: 24 (44%)
- None of the cases are believable: 0 (0%)

Why do you think the Zerg player fought so long against the Terran instead of retreating?

- He thought he was going to win the battle: 9 (17%)
- He thought the Terran was weaker after spending the Nukes: 3 (6%)
- He wanted to catch the Terran out of position after the three front attack: 5 (9%)
- He was angry against the Terran player after so many losses: 10 (19%)
- Other: 15 (28%)

******* Video 1D *******

What do you think of the Zerg player controller?

- It is the game A.I.: 12 (22%)
- I have no idea: 15 (28%)
- It is the ga: 12 (22%)
- I have no id: 15 (28%)

Evaluate the A.I.'s Believability in that decision.

- Less believable than the video case: 27 (50%)
- More believable than the video case: 8 (15%)
- As believable as the video case: 19 (35%)
- None of the cases are believable: 0 (0%)
2) Passive / Aggro

********** Video 2A **********

What do you think of the Protoss player controller?

- It is a Human [34] 63%
- It is the game A.I. [6] 11%
- I have no idea [13] 24%

Why do you think the Protoss player proceeds to attack the Zerg player after losing his base?

- The Zerg player's... [13] 24%
- He was angry because [30] 56%
- Other [4] 7%

The Zerg player's army could now be weaker after losing some Zerglings during the attack.

Evaluate the A.I.'s Believability in that decision.

<table>
<thead>
<tr>
<th>Believability Level</th>
<th>Number of Votes</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>0%</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>2%</td>
</tr>
<tr>
<td>3</td>
<td>2</td>
<td>4%</td>
</tr>
<tr>
<td>4</td>
<td>3</td>
<td>6%</td>
</tr>
<tr>
<td>5</td>
<td>0</td>
<td>0%</td>
</tr>
</tbody>
</table>

If the Protoss player decided not to attack, how should that have been...

- More believable [0] 0%
- As believable [12] 23%
- Less believable [42] 77%

********** Video 2B **********

What do you think of the Protoss player controller?

- It is the game [32] 59%
- I have no idea [12] 22%
- It is a Human [9] 17%

Why do you think the Protoss player adopted a defensive position after such a rush?

- He is afraid of... [25] 62%
- He wants to conti... [9] 23%
- Other [8] 15%

He is afraid of the cloaked Banshees that might come back.

<table>
<thead>
<tr>
<th>Reason for Defensive Position</th>
<th>Number of Votes</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>He is afraid of the cloaked Banshees that might come back</td>
<td>20</td>
<td>37%</td>
</tr>
<tr>
<td>He wants to continue developing his base</td>
<td>18</td>
<td>33%</td>
</tr>
<tr>
<td>Other</td>
<td>7</td>
<td>13%</td>
</tr>
</tbody>
</table>
Evaluate the A.I.'s Believability in that decision.

- 1 1 2%
- 2 2 4%
- 3 2 4%
- 4 2 4%
- 5 2 4%

If the Protoss player decided to attack, would that have been...

- As believable [21]
- Less believable [15]
- More believable [8]
- None of the cases [3]

Less believable than the video case. 15 28%
More believable than the video case. 8 15%
As believable as the video case. 31 57%
None of the cases are believable. 0 0%

********** Video 2C **********

What do you think of the Protoss player controller?

- It is the ga [16]
- I have no idea [15]
- It is a Human [22]

Why do you think the Protoss player proceeds to attack the Terran player after losing so many Pylons?

<table>
<thead>
<tr>
<th>Reason</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>It is a Human player</td>
<td>22</td>
</tr>
<tr>
<td>It is the game A.I.</td>
<td>16</td>
</tr>
<tr>
<td>I have no idea</td>
<td>15</td>
</tr>
<tr>
<td>He was angry because he lost to many Pylons and became supply blocked.</td>
<td>18</td>
</tr>
<tr>
<td>The Terran player's army could now be weaker after losing some units during the attack.</td>
<td>14</td>
</tr>
<tr>
<td>Other</td>
<td>5</td>
</tr>
</tbody>
</table>

If the Protoss player decided not to attack, would that have been...

- As believable [21]
- Less believable [30]
- More believable [0]
- None of the cases [0]

Less believable than the video case. 30 56%
More believable than the video case. 0 0%
As believable as the video case. 24 44%
None of the cases are believable. 0 0%
3) Miss Targets

********** Videos 3A1 / 3A2 **********

What do you think of the Zerg player controller, in both videos?

- Only Human [12]
- I have no idea [7]
- It is a Human [7]
- It is the A.I. [12]
- It is a Human player in both cases. 17 31%
- It is the game A.I. in both cases. 7 13%
- Only Human in 3A1. 12 22%
- Only Human in 3A2. 10 19%
- I have no idea. 7 13%

Why do you think the Zerg player missed so many Fungal Growth “skill-shots” in 3A1?

- He was unlucky or... 15 30%
- He was angry again... 11 22%
- Other 3 6%

He was unlucky or needs more training 19 38%
He was angry against the Terran player because he destroyed several important buildings. 13 24%
Other 4 7%

In which video do you think the A.I. was more Believable?

- Both cases were [4]
- None of the c [1]
- 3A1 [1]
- 3A2 [1]

Evaluate the A.I.’s Believability in 3A1

- 1 3 6%
- 2 5 9%
- 3 6 11%
- 4 2 4%
- 5 1 2%

********** Videos 3B1 / 3B2 **********

What do you think of the Protoss player controller, in both videos?

- Only Human [12]
- I have no idea [10]
- It is the A.I. [9]
- It is a Human [18]
- It is a Human player in both cases. 18 33%
- It is the game A.I. in both cases. 4 7%
- Only Human in 3B1. 9 17%
- Only Human in 3B2. 12 22%
- I have no idea. 10 19%

Why do you think the Protoss player missed so many Psionic Storm “skill-shots” in 3B1?

- He was unlucky or... 18 36%
- He was angry again... 13 26%
- Other 6 12%

He was unlucky or needs more training 18 36%
He was angry against the Terran player because he destroyed several important buildings. 13 26%
Other 6 12%
4) Rage Quit

********** Videos 4A1 / 4A2 **********

What do you think of the Protoss player controller, in both videos?

- It is a Human player in both cases: 22 (41%)
- It is the game A.I. in both cases: 6 (11%)
- Only Human in 4A1: 14 (26%)
- Only Human in 4A2: 2 (4%)
- I have no idea: 9 (17%)

Why do you think the Protoss player rage quits in 4A1?

- He quit the game: 15 (28%)
- He was too angry: 27 (50%)
- Other: 4 (7%)

In which video do you think the A.I. was more Believable?

- Both cases: 3
- None of the cases: 1
- 4A1: 1
- 4A2: 1

Evaluate the A.I.’s Believability in 4A1

- 1: 2 (4%)
- 2: 1 (2%)
- 3: 1 (2%)
- 4: 3 (6%)
- 5: 1 (2%)
**Videos 4B1 / 4B2**

What do you think of the Zerg player controller, in both videos?

- It is a human [39] 72%
- It is the game A.I. in both cases. 2 4%
- Only human in 4B1. 5 9%
- Only human in 4B2. 2 4%
- I have no idea. 5 9%

Why do you think the Zerg player rage quits in 4B1?

- He quit the game because he had no chances left. 16 30%
- He was too angry against the Protoss player after losing the Brood Lords for nothing. 28 52%
- Other 7 13%

In which video do you think the A.I. was more believable?

- Both cases were believable. 1 2%
- 4B1 [1] 1 2%
- 4B2 [0] 0 0%
- None of the cases were believable. 0 0%

Evaluate the A.I.’s Believability in 4B1

- 1 0 0%
- 2 1 2%
- 3 1 2%
- 4 2 4%
- 5 0 0%
## Anex F – Detailed Performance Tests Results

<table>
<thead>
<tr>
<th>Test ID</th>
<th>Match</th>
<th>EA/P</th>
<th>AI</th>
<th>Victory</th>
<th>Duration (min)</th>
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<tbody>
<tr>
<td>1</td>
<td>TvT</td>
<td>T</td>
<td>T</td>
<td>EAIP</td>
<td>16</td>
</tr>
<tr>
<td>2</td>
<td>TvZ</td>
<td>T</td>
<td>Z</td>
<td>AI</td>
<td>17</td>
</tr>
<tr>
<td>3</td>
<td>TvP</td>
<td>T</td>
<td>P</td>
<td>AI</td>
<td>21</td>
</tr>
<tr>
<td>4</td>
<td>ZvT</td>
<td>Z</td>
<td>T</td>
<td>AI</td>
<td>14</td>
</tr>
<tr>
<td>5</td>
<td>ZvZ</td>
<td>Z</td>
<td>Z</td>
<td>AI</td>
<td>18</td>
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<tr>
<td>6</td>
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<td>Z</td>
<td>P</td>
<td>EAIP</td>
<td>40</td>
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<td>PvT</td>
<td>P</td>
<td>T</td>
<td>AI</td>
<td>11</td>
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<td>PvZ</td>
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<td>T</td>
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<td>Z</td>
<td>Z</td>
<td>EAIP</td>
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<td>Z</td>
<td>P</td>
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<td>17</td>
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<td>PvP</td>
<td>P</td>
<td>P</td>
<td>AI</td>
<td>32</td>
</tr>
</tbody>
</table>

- **AI** - Victory: [25]  

**Legend:**  
- T - Terran  
- Z - Zerg  
- P - Protoss
## Anex G – EAIP Personality Types Examples

<table>
<thead>
<tr>
<th>Personality Type</th>
<th>Amplified Emotions</th>
<th>Weakened Emotions</th>
</tr>
</thead>
<tbody>
<tr>
<td>“Normal”</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Cheerful</td>
<td>Happiness, Pride</td>
<td>Anger, Sadness, Fear, Nervousness, Frustration</td>
</tr>
<tr>
<td>Relaxed</td>
<td>Pride</td>
<td>Anger, Surprise, Fear, Nervousness, Worry, Frustration</td>
</tr>
<tr>
<td>Nervous</td>
<td>Surprise, Fear, Nervousness, Worry</td>
<td>Relief</td>
</tr>
<tr>
<td>Raging</td>
<td>Anger, Frustration</td>
<td>Happiness, Relief</td>
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<tr>
<td>Confident</td>
<td>Relief, Hope, Pride</td>
<td>Fear, Surprise, Nervousness, Worry, Shame</td>
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</tbody>
</table>
### Anex H – Communication Module Example Chat Messages

<table>
<thead>
<tr>
<th>Player Message</th>
<th>EAIP’s High Emotional</th>
<th>EAIP’s Response</th>
<th>Increased EAIP’s Emotions</th>
</tr>
</thead>
<tbody>
<tr>
<td>“hf gl”</td>
<td>None (game start)</td>
<td>“hf gl”</td>
<td></td>
</tr>
<tr>
<td>“u look like a bronze player”</td>
<td>Anger or Sadness</td>
<td>“argh” or “i know ;(“</td>
<td>Nervousness, Worry, Shame, Frustration</td>
</tr>
<tr>
<td>“u mad?”</td>
<td>Anger, Frustration</td>
<td>“shut up”</td>
<td>Anger, Frustration</td>
</tr>
<tr>
<td>“well played”</td>
<td>Joy</td>
<td>“thx”</td>
<td>Happiness, Pride</td>
</tr>
<tr>
<td>“i have a surprise for you”</td>
<td>-</td>
<td>“where?!“</td>
<td>Nervousness, Worry, Fear</td>
</tr>
<tr>
<td>“i will destroy you”</td>
<td>Sadness</td>
<td>“pls no”</td>
<td>Sadness, Frustration, Anger</td>
</tr>
<tr>
<td>“gg”</td>
<td>Hope</td>
<td>“gg”</td>
<td>Hope</td>
</tr>
</tbody>
</table>

**Anex H - Example Messages of Type 1 and 2.**

<table>
<thead>
<tr>
<th>Message</th>
<th>Related High Intensity Emotions</th>
</tr>
</thead>
<tbody>
<tr>
<td>“you will lose!”</td>
<td>Hope</td>
</tr>
<tr>
<td>“i m so good!”</td>
<td>Pride</td>
</tr>
<tr>
<td>“oh yeah”</td>
<td>Happiness</td>
</tr>
<tr>
<td>“oh”</td>
<td>Surprise</td>
</tr>
<tr>
<td>“gg”</td>
<td>Hopelessness</td>
</tr>
<tr>
<td>T T</td>
<td>Sadness</td>
</tr>
<tr>
<td>“i m so bad”</td>
<td>Shame</td>
</tr>
<tr>
<td>“pls stop it”</td>
<td>Frustration</td>
</tr>
<tr>
<td>“arghhh”</td>
<td>Anger</td>
</tr>
</tbody>
</table>

**Anex H - Example Messages of Type 3 (Emotion Related).**

<table>
<thead>
<tr>
<th>Message</th>
<th>Related Events</th>
</tr>
</thead>
<tbody>
<tr>
<td>“this isn’t good for me”</td>
<td>Lacking of counters to the opponent’s units</td>
</tr>
<tr>
<td>“right on target”</td>
<td>Successfully using special abilities</td>
</tr>
<tr>
<td>“how did I miss that”</td>
<td>Missing special abilities</td>
</tr>
<tr>
<td>“have u seen my unit kills? :P”</td>
<td>Having units with many kills</td>
</tr>
<tr>
<td>“those &lt;unit type&gt; are pissing me off!”</td>
<td>Certain opponent’s unit type is having many kills</td>
</tr>
<tr>
<td>“are u kidding me?”</td>
<td>Losing a building that was researching</td>
</tr>
<tr>
<td>“lol, this is your army?”</td>
<td>The opponent’s army is weaker than expected</td>
</tr>
<tr>
<td>“time to fight?”</td>
<td>Reaching the population cap</td>
</tr>
</tbody>
</table>