TÉCNICO LISBOA

Perception of Emotion Expression in Synthetic Characters

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Resumo

Personagens Sintéticas estão a ser cada vez mais usadas em aplicações mundialmente. Aquando da criação de Personagens Sintéticas que interagem com utilizadores humanos é importante expressar corretamente as emoções destas personagens se queremos alcançar uma comunicação mais efetiva e credível. Este trabalho propõe um método baseado no *Repertory Grid (RG)* para a criação de um modelo de como as pessoas percecionam as animações de emoções em personagens sintéticas específicas, com o intuito de ajudar na criação de futuras animações, melhorando a forma como as emoções são comunicadas para que sejam corretamente reconhecidas pelos utilizadores.

O método usa dois questionários à volta de seis diferentes animações de emoções: Raiva, Nojo, Medo, Surpresa, Tristeza e Felicidade. O Questionário 1 tinha o próposito de elicitar importantes construtos dos participantes, 9 construtos foram selecionados através de Análise de Conteúdo. Para o Questionário 2, os participantes tiveram que dar uma classificação às animações tendo em conta os construtos selecionados. Através de uma Análise de Componentes Principais e de uma Análise de *Clusters*, para detetar semelhanças, quatro *clusters* foram identificados, Raiva e Nojo foram agregados num *cluster*, quanto ao Medo e a Surpresa noutro *cluster* e finalmente a Tristeza e a Felicidade encontravam-se nos seus próprios *clusters*.

Palavras-Chave

Personagens Sintéticas; Expressão de Emoções; Repertory Grid; Reconhecimento de Emoções.

Abstract

More and more Synthetic Characters (SC) are being used in applications worldwide. When designing Synthetic Characters (SC) that interact with human users it is important to correctly express the emotions of these characters if we want to achieve more believable and effective communication. This work proposes a method based on the Repertory Grid for the creation of a model of how users perceive animations of emotions in specific Synthetic Characters (SC), with the intent of helping the development of future animations, improving the way emotions are communicated so that they are correctly recognized by the users.

The method used two questionnaires that focused on six different animations of emotions taken from specific Synthetic Characters (SC): Anger, Disgust, Fear, Surprise, Sadness and Happiness. Questionnaire 1 had the purpose of eliciting meaningful constructs from the participants, we selected 9 meaningful constructs through Content Analysis. As for Questionnaire 2, participants were asked to rate the animations against the selected constructs. By using Principal Component Analysis (PCA) and Cluster Analysis (CA) to detect similarities we identified four clusters, where Anger and Disgust were aggregated into one cluster, then Fear and Surprise in another and finally both Sadness and Happiness were placed in their own.

Keywords

Synthetic Characters; Emotion Expression; Repertory Grid; Emotion Recognition.

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Acronyms

RG	Repertory Grid
SC	Synthetic Characters
VTA	Virtual Tutoring Application
VA	Virtual Assistants
NPCs	Non-Player Characters
PCA	Principal Component Analysis
CA	Cluster Analysis

1

Introduction

Contents

1.1 Motivation

With the emergence of more realistic synthetic characters follows the need to better communicate the emotions they are expressing. Nowadays more and more applications make use of emotion expression, either for ludic purposes as seen in video games such as The Sims 4[1], for education purposes or even health related [4–6]. Yet, emotion expression is not always correctly perceived, meaning that the emotion being expressed is not correctly identified by the receiver, which can have negative effects on the interaction.

Generating interesting and appropriate facial expressions for synthetic characters is difficult, but it is very important for the overall experience, it being in video games, movies like "Avatar"[2] or even virtual assistants. It allows people to connect with the characters they interact with and to identify with said characters and create a bond with them.

Imagine you are interacting with a virtual agent that helps you through your daily life, you expect it to interact naturally with you, similarly to the way that humans interact with one another. Or at least for it to express some kind of emotion so that you can identify with said agent. If the expressions the virtual agent communicates are not recognizable by the user, it will all seem lacking. Having characters be emotionally disconnected could tarnish the user's experience, and might go as far as completely demotivate the user from continuing using the application.

Therefore, if we want to accurately express emotions, one will have to identify which are the aspects that would help better communicating these emotions.

1.2 Problem

Recognizing emotions is a difficult process for people, both with human interactions and virtual characters interactions [3, 7–9], especially without context. Even if we consider all aspects of communicating emotions, verbal and non verbal communication, confusions are still a problem.

In particular, if we consider non verbal communication, more specifically facial expressions, *how can we improve the communication of emotions in a way that they are better recognized by the users interacting with synthetic characters.*

1.3 Hypothesis

To help mitigate the problem, we first propose the creation of a method for an informed creation of emotion expressing animations. In previous studies [9], it was performed a dual comparison, side by

[1] Maxis 2014, The Sims 4, Eletronic Arts
[2] Avatar. 2010, CAMERON, J. 20th Century Fox

side, of different versions of animations of a certain emotion, while it improved emotion expression, it wasn't able to show improved emotion recognition.

Instead, we will create a method based on the Repertory Grid (RG). We hypothesize that with this method it is possible to create a model for how users perceive different expressions of emotions of a specific Synthetic Character. The model has the intent of detecting problems and guiding the development of future animations, improving the way emotions are communicated so that they are better recognized by the users.

1.4 Objectives

This work aims to add the following contributions:

- Adding to the state of the art on facial expressions of emotion and the Repertory Grid (RG).
- Implementation of a method using the RG to inform how users perceive different expressions of emotions;
- Application of the method using specific Synthetic Characters (SC).

1.5 Outline

The remaining of the document is organized as follows. Chapter 2 delves into related work on emotion and emotion expression, more specifically facial expressions. After that, emotion recognition will be addressed, where we will focus more on the confusions made by people when trying to recognize each emotion. We will be defining the repertory grid and its technique, specifically the triad comparison. We will also explain the base application used for our work, Virtual Tutoring Application. In Chapter 3 we explain our implementation of the RG with the use of two different questionnaires. With Chapter 4 the results of both questionnaires are explained. Finally, in Chapter 5 we have a small overview of the whole study and the conclusions we achieved, as well as what it is expected in future works.

2

Related Work

Contents

This section will focus on emotions as well as how they are expressed, focusing on facial expressions. Those known as the six basic families of emotion (fear, anger, disgust, surprise, happiness and sadness) [10] will be greatly discussed. We will then delve into emotion recognition, especially understanding which emotions are mistaken with another. Followed by the the definition and explanation of the Repertory Grid and its triad comparison. Lastly, we will talk about the Virtual Tutoring Application, the application portraying the Synthetic Characters (SC) used in the evaluation.

2.1 Emotions

Since our work will revolve around emotions, a small introduction to this topic is needed. Along the years many definitions for emotion appeared and we can easily see that emotional processes and states are complex and can be analyzed from so many points of view that a complete picture is virtually impossible [11].

Even with so many definitions, for our study we will define emotions as a positive or negative experience that occur throughout life. Emotions are considered to be relatively short in duration, with changes in motor behavior, physiological changes, and cognition [12].

Ekman uses the adjective *"basic"* to list six separate emotions which differ one from another in important ways [13], Anger, Disgust, Fear, Happiness, Sadness and Surprise. We will focus on these six emotions categories because they anchor common beliefs about emotions and their expressions representing the clearest, strongest test of the common view [14].

2.2 Expression of Emotions

If we want to better communicate emotions we first need to consider how they are expressed. An emotional expression is a behavior that communicates an emotional state or attitude. Each emotion expression has unique signals, the most identifiable being in the face and the voice [15]. Since we will not approach voice in our study we will focus on facial expressions, which is one of the briefest emotional signals usually lasting only mere seconds [15].

Facial expressions are *"rapid signals produced by the movements of the facial muscles, resulting in temporary changes in facial appearance, shifts in location and shape of the facial features, and temporary wrinkles"* [10]. Photographs are an efficient way to better analyse facial expressions, facial blueprints like Ekman *et al.* called it [10], and they are registered by changes in the forehead, eyebrows, eyelids, cheeks, nose, lips, and chin.

In our work, we will focus on the six basic families of emotion and its expressions: Anger, Disgust, Fear, Happiness, Sadness and Surprise as we can see on Figure 2.1. We will discuss each one and

also some of the key aspects in their expressions:

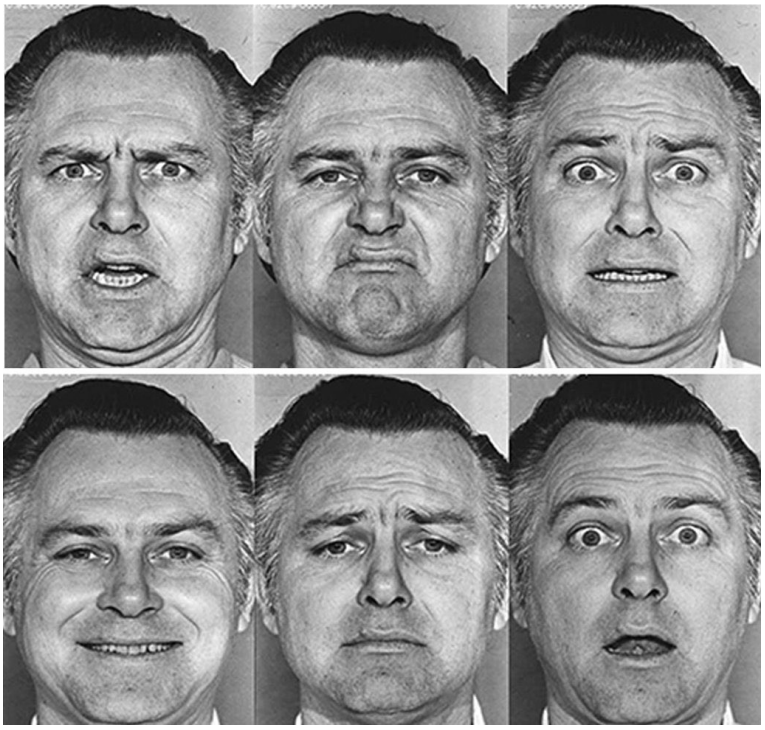

Figure 2.1: The six basic emotions, Anger, Disgust, Fear, Happiness, Sadness and Surprise.

Fear - a natural, powerful, and primitive human emotion and can have a short duration, but also occur gradually. Fear alarms us about the possibility of threat or the chance of danger, whether that danger is physical or psychological, varying in intensity from apprehension to terror. Any of the other emotions can accompany fear, you may feel fear, then anger, then sadness. Three important points during fear are, the eyebrows are raised and drawn together, the eyes are open and the lower lid is tensed, and the lips are stretched back [10].

Anger - is a primary, natural emotion which has evolved as a way of surviving and protecting yourself from what is considered a wrong-doing. Low intensity anger leads to slight irritation or annoyance, while high intensity leads to rage or fury [10]. Three important points to take into account, the eyebrows are lowered and drawn together, the eyelids are tensed, and the eye appears to stare in a hard fashion. Finally, the lips are either tightly pressed together or parted in a square shape [10].

Disgust - arises as a feeling of aversion towards something offensive. It can be triggered by something we perceive with our physical senses (sight, smell, touch, sound, taste), by the actions or appearances of people, and even by ideas [10]. Disgust can vary in intensity, nausea and vomiting being at the extreme end and at the opposite a mild-dislike [10]. The most important points are in the mouth and nose, the upper lip is raised, while the lower lip may be raised or lowered, the nose is wrinkled, but the lower eyelids and eyebrow are also important, them being pushed up and lowered respectively.

Surprise - the briefest emotion. If you have time to think about the event and consider whether or not you are surprised, then you are not. Surprise is caused both by the unexpected and by the "misexpected" event [10]. Surprise lasts only until we figure out what is happening, after that it merges into fear, amusement, relief, anger, disgust, and so forth, depending upon what it was that surprised us [10, 15]. Surprise varies in intensity from mild to extreme. Three important points during surprise are, the eyebrows are raised, the eyes are opened wide, and the jaw drops open, parting the lips [10].

Happiness - the emotion most people want to experience, where it can be characterized by feelings of joy, satisfaction, contentment, and fulfillment, being the only inherently positive emotion. There are various types of happiness such as pleasure, excitement, being sated or content and finally, happiness can be self-centered, something happens that enhances your view of yourself [10]. Happiness varies not only in type but intensity as well, it can vary from a mild feeling, to a sensation of ecstasy or joy, depending on the event [10]. These next aspects will take into account a non laughing happiness expression: the corners of the lips are drawn back and slightly up and they can be parted or not [10].

Sadness - is characterized as the quiet, normative response to suffering. Sadness is a variation or form of distress and the former often follows the latter if the distress is prolonged or if the coping actions to remove the source of distress are unsuccessful [10]. Sadness also varies in intensity from slight feelings of being gloomy to the extreme felt during mourning [10]. For the three important aspects, the inner corners of the eyebrows are raised and may be drawn together, the inner corner of the upper eyelid is drawn up, and the lower eyelid may appear raised and finally, the corners of the lips are drawn down, or the lips appear to tremble [10].

In order to get our virtual agents to show facial expressibility, we need to know which aspects of the face to transform in order to achieve the desired emotion. One of the more prominent techniques for achieving this goal is the Facial Action Coding System [15]. The system encodes movements of individual facial muscles from distinct momentary changes in facial appearance, is a comprehensive, anatomically based system for describing all visually distinct facial movement. It breaks down facial expressions into individual components of muscle movement, called Action Units (AUs), and all of the six basic families of emotion can be described by them. Some works in computer graphics use this system to better represent facial animations [2, 16]. In Table 2.1 we can see which AUs describe each emotion.

2.3 Emotion Recognition

Our work focuses in communicating emotions correctly, and how one recognizes said emotion, so it is essential to understand how emotional reactions vary between different individuals, being it sex, age, etc. For this, a definition of emotional intelligence is important and can be defined as the ability to monitor

AUs	Descriptor	Happpiness	Surprise	Sadness	Fear	Disgust	Anger
1	Inner brow raiser	x	x	x	x		
2	Outer brow raiser	x	x		x		
4	Brow lower	x		x	x		x
5	Upper lid raiser	x	x		x		x
6	Cheek raiser	x					
7	Lid tightened	x		x			x
9	Nose wrinkler				x		
10	Upper lip raiser				x	x	
12	Lip corner puller	x					
15	Lip corner depressor	x	x		x		
16	Lower lip depressor		x		x		
17	Chin raiser					x	
19	Tongue thrusting				x		
20	Lip stretcher		x		x		
23	Lip tightened						x
24	Lip pressor						x
25	Lips part					x	
26	Jaw drop		x				
43	Eyes closed			x			

Table 2.1: Action Units for each of the six basic emotions [2].

one's own and others' feelings and emotions, to discriminate among them and to use this information to guide one's thinking and actions [17].

To better understand what we mean by recognizing one's emotion we will say that emotion recognition represents the ability to encode an ensemble of sensory stimuli providing information about the emotional state of another individual [18].

The gender of the observer has been consistently a factor influencing the transmission of emotional information in the sense of nonverbal communication [19]. Current research in the topic [7, 19, 20] revealed a main effect of participants' gender on emotion recognition, with women presenting higher agreement rates, anger and contempt being significantly higher. In Dores *et al.* [7] study, models with different gender were used and it also had some impact on the recognition, with emotions being generally better recognized when models were women.

Experimental studies show that with age, emotion recognition, particularly negative emotions, decreases [21, 22]. Mill *et al.* [21] found that the recognition of sadness and anger, declined with older

participants starting at about 30 years of age. While other expressions remained at approximately the same level until 60 years of age, which would then decrease.

2.3.1 Confusion Of Emotions

Some common mistakes are made when trying to recognize emotions. Focusing on the facial movement patterns created by the expression of the six basic emotions, research shows that some are easily recognized, like happiness and surprise, while others are commonly confused with one another [3, 7–9]. In Bassili's research [3] we are able to see some of this confusions and where they usually happen, it being in the upper or lower areas of the face. For a brief summary refer to Table 2.2.

	Happpiness	Surprise	Sadness	Fear	Disgust	Anger
Happiness			x			
Surprise				x		
Sadness				x	x	
Fear	x	x	x			
Disgust				x		x
Anger				x	x	

Table 2.2: Summary of Bassili's findings on emotion recognition [3]. It shows common emotional confusions between expressed emotions (row) and perceived emotions (column).

Happiness consists of an upward displacement of each side of the mouth and of the cheeks, a smile. *Happiness was surprisingly confused with sadness in upper face movements.*

Sadness consists of a slight upward displacement in the area of the chin, whereas the forehead area reflects an inward and upward movement of the eyebrows. Movements of the bottom of the face yielded *confusions with disgust*. However, when the full face or top face was shown, *confusions occurred mainly with fear.*

Fear involves a downward and outward movement in the mouth area. The forehead area is similar to that of sadness, an inward and upward movement of the eyebrows, with it being more pronounced because the brows are raised higher. This can be seen in Bassili's research where in the upper face conditions fear was often *confused with sadness*. Fear was also *confused with surprise* in the upper face area, probably caused by the strong upward movement of the brows characterizing the expression of surprise. Another common error involved *happiness* in lower face displays.

Surprise was one of the easiest emotions to recognize in Bassili's study. It involves a strong upward displacement of the brows and an equally strong downward displacement of the jaw. Major *confusions only occurred with fear* in upper face displays.

Anger involves a downward movement in the forehead area caused by a frown, along with a compression in the mouth area, caused by the pinching of the lips. Anger was *confused with disgust* in lower

face displays. Upper face displays yielded *confusions with fear*. Finally, it yielded some *confusion with sadness*.

Disgust consists in the wrinkling of the nose, which causes an upward movement on its sides as well as on the cheeks. Moreover, the expression can involve an upward movement in the area of the chin. Even with the wrinkling of the nose, which no other expression has, this emotion has low recognition rates. Disgust was mainly *confused with anger*, especially in upper face displays. The bottom face displays lead to *confusion with fear*.

Some other studies by Dores *et al.* [7] and Langner *et al.* [8] are able to tell us that happiness was the most frequently recognized expression, whereas anger was the least frequently recognized expression only in the former study. Both studies had a similar confusion matrix, faces with intended surprise were sometimes confused with fear, and vice versa. Intended disgust was sometimes mistaken for anger.

If we consider all of the studies above we can easily see which are the emotions that have more problems being recognized, Anger, Fear and Disgust. As seen in Bassili's research and other studies [7, 8], Anger and Disgust are a problematic case, where they are usually mistaken with each other. Although Fear is not usually mistaken for both emotions of Anger and Disgust, the same doesn't happen the other way around, even in Silva *et al.* research [9], Disgust and Anger were pointed out as being similar to Fear.

2.4 Evaluation Methods

One important aspect that we need to consider is the evaluation methods, since our work revolves around the evaluations to be done. In past works [9, 23], some limitations are discussed when using a comparative task to assess emotions (e.g. "How would you rate A_i and A_j when comparing the two in the context of expressing a specific emotion *E*?"). The works discussed how a model was shown to have better emotion expression in a comparative task against a base model, but have shown no improvement in an emotion recognition task. Therefore, we will present another type of evaluation with the purpose of improving emotion recognition, a triad comparison using a Repertory Grid.

2.4.1 Repertory Grid

Repertory Grid Technique [1] is a powerful research tool in many situations, a method for eliciting personal constructs, and is normally used to explore an interviewee's views on a particular topic with the absence of researcher bias. This technique was first developed for use in psychology but throughout the years it started being used by other areas as well.

The fundamental premise on which the technique of repertory grid is based is Kelly's Personal Construct Theory (PCT) [1]. We indirectly develop *"rules"* by which we view or categorise situations, these

rules are our constructs. There are two important aspects to take into account when talking about the Repertory Grid, the *elements* and the *constructs*. Kelly defined an element as *"the things or events which are abstracted by a construct"* [24] as for the latter it is *"a way in which two or more things are alike and at the same time different from one or more things"*.

The first design decision is the selection of elements. Elements should be within the range of convenience of the constructs used. Constructs applies only to a limited number of people, events or things, depending on the subject at hand. To be more specific if we are constructing a grid where the constructs will deal with the youth, having one or two old people between the elements it is not exactly in the range of convenience of the youth type of construct [24].

In order to elicit meaningful constructs, each element is written manually on a card. Different triads (a set of three elements) are presented to the interviewee until all combinations have been covered, or the interview is terminated. Five or more elements are needed to produce a sufficient number of triads so that construct elicitation can be repeated.

For eliciting constructs a question is to be asked for each interviewee when showing each triad. The general question from Kelly's work is, *"in what way are two of these alike and at the same time different from the third?"*. This will have to be adapted depending on the study at hand, but it is always important to have in mind observer bias, in other words it is important that the question does not guide the observer to a biased answer (e.g. asking "in what way are two of these better than the third?" guides an answer to be done under a value judgement).

For rating the elements of the study the constructs are reused using normally a simple five or seven point scale forming a matrix. However, other possibilities include a simple bipolar scale.

To give a more general idea of what it is exactly, we will start with an example. Considering a repertory grid interview investigating different emotions. See Figure 2.2.

The interview will consist in a list of emotion expressions, an animation for each, let's call them A, B, C, D, E and F. These are called the *elements* of the test, refer to Figure 2.2A. The interviewee is then presented with a set of three elements (termed a triad) chosen randomly, refer to Figure 2.2B.

As the triad is presented to the interviewee, they are asked a question in which we can build our *constructs* based on the answer that is given, for example *"why are two of these expressions similar and different from the third?"*. A typical response could be that two of the emotion expressions have the *"brow raised"*, whereas the third has the *"brow lowered"*, creating our construct. Each of the interviewee's elements is then rated against this first construct, refer to Figure 2.2C.

With this method we hope to achieve a better understanding of the features that are more similar between emotions and those that we consciously use to distinguish them apart. Considering that the features are our constructs and the different animations are our elements, we will have a matrix that will provide data on the features that are common in the emotions we are studying, informing us of the

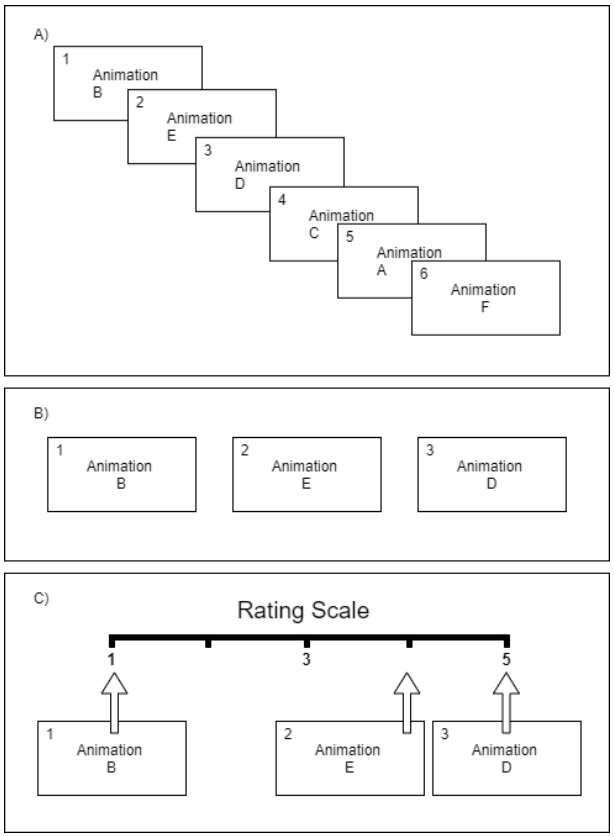

Figure 2.2: Example of a Simple Repertory Grid Test. (a) The Elements of the Test. (b) The First Triad presented to the Interviewee. (c) The Rating of the Elements in the First Triad. Adapted from [1].

possible causes for similarities between them.

2.5 Virtual Tutoring Application

The Virtual Tutoring Application is a work initially brought forth by Lima *et al.* [25] and later improved in [9,23,26], this application had the objective of helping students through the struggles of their academic life, by providing them with individualized support and also help them establish their own academic goals. All of this done through two virtual tutors, they also assisted students in setting study milestones and keep track of their performance, while recognizing the subjects in which the students were lacking.

Silva *et al.* [9] contributed to the project by providing the visual expressiveness and believability to those two virtual tutors, who have been integrated into the application as two synthetic characters. Some animations were already provided and the goal was to maintain a desirable level of believability. Facial blending techniques were applied as well as changes to the speed, form and frequency of the already available animations. All of this was in order to achieve more interesting and rich interactions, able to satisfy the emotional needs of virtual tutoring agents. They are not simple virtual agents but believable

agents that engage in dialogues with one another and can form a relationship with the student.

2.6 Summary

In this chapter, we began by delving into emotion, and briefly discussed the six basic families of emotion, taking into account their facial expressions and how each emotion is different. We also discussed the importance of emotional intelligence, when it comes to accurately accessing displays of emotion. The mistakes that are commonly made were also addressed, as well as why they may happen. With this research we came to a conclusion of which emotions were more easily confused. We went deeper into the evaluation method, it being part of our hypothesis, the Repertory Grid, more specifically the triad comparison, and how this may help understand better the similarities and differences of each emotion. Lastly, we presented a brief description of the Virtual Tutoring Application, it being important since our work will begin with the animations provided in the application.

3

Triad Analyses Method

Contents

3.1 Methodology

Our goal is to model how people perceive expressions of emotions in an animation so that in the future we can use it to better understand what makes those expressions similar from one emotion to another.

Our method consists in using the Repertory Grid (RG) (see section 2.4.1), more specifically a Triad Analysis. We will first choose the elements for our RG, in our case animations of facial expressions, and understand the best way to present them. Secondly, we will elicit the constructs, personal rules by which we view or categorize situations, for each individual person, and finally they will be asked to rate each element against a set of selected constructs. With this method, we will know the most important constructs, in our case facial features, in each animation for each person and with the ratings understand how these are perceived by a group of people.

As Figure 3.1 shows our study involved two different questionnaires, one for determining the constructs by using Content Analysis which is commonly used to analyse qualitative data in RG [1, 27, 28] and the other for the rating of the animations against each construct, these responses will be analysed using Principal Component Analysis (PCA) and Cluster Analysis (CA), again common types of analysis used in RG [1, 27, 28]. Data gathering from both questionnaires was mainly aimed at national participants through convenience sampling. In the next sections we will explain in further detail each section of the questionnaires.

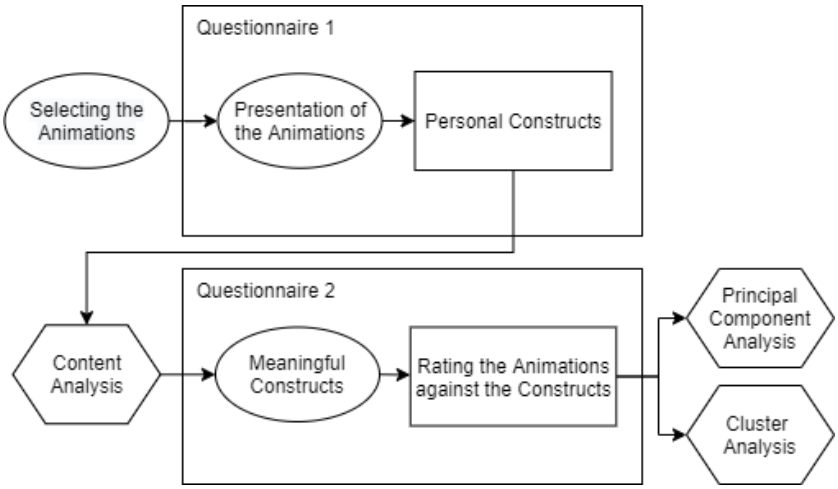

Figure 3.1: Overview of the method implemented.

3.2 Selection of Animations of Emotions

The first step for a triad analysis is choosing the *elements* that will be presented, in our case we want to compare different expressions of emotions in SC. We decided on six animations, each one representing

an emotion. As mentioned in Chapter 2, the six emotions used were Anger, Disgust, Fear, Happiness, Sadness and Surprise.

These animations were taken from the Virtual Tutoring Application (VTA), developed by Lima *et al.* [25] and later improved in [9,23,26]. In the VTA two SC exist, they go by the name of João and Maria, represented by a 3D head, modeled from the shoulders up, and they were provided by the modeling technology My Didimo, offered by the company Didimo, Inc [1]. An animation clip package for each of the characters was also used, developed by a team of 3D artists from the same company, and it provided the visual front end of the SC.

Silva *et al.* [9] provided the visual expressiveness and believability to the two virtual tutors in the application. However, the animations used were the base animations of both SC provided by Didimo and the team of 3D artists, without the changes from Silva's work. In Figure 3.2 we have a picture for each of the six animations of João in the emotion's highest intensity, Anger, Disgust, Fear, Happiness, Sadness and Surprise.

Figure 3.2: The six animations of João in the emotion's highest intensity. The emotions expressed are the following from top left to bottom right: Anger, Disgust, Fear, Happiness, Sadness and Surprise.

[1] Didimo, Inc, "Didimo - A digital version of you from a single photo", Software company, http://www.mydidimo.com/

Combination Pairs	Combination 1	Combination 2
0	A B C	D E F
1	A B D	C E F
2	A B E	D C F
3	A B F	D E C
4	A D C	B E F
5	A E C	D B F
6	A F C	D E B
7	A D E	B C F
8	A D F	B E C
9	A E F	D B C

Table 3.1: All 20 combinations of 3 animations distributed between 10 pairs.

3.3 Presentation of the Animations

The second step is how to present the elements to the participants. As mentioned in Chapter 2 the usual approach is to show to the participant three different animations, randomly presented until all combinations had been covered, or no more constructs were elicited.

To balance the amount of work required by each participant, we decided to display only a fixed number of combinations. If we take into account that we have six animations, by using the formula for combinations with no repetitions and no order restrictions we have a total of 20 combinations of 3 animations[2]. To maximize the number of different combinations seen by the participants, we decided to display six combinations per participant to allow for the elicitation of an adequate number of constructs while not tiring the participants.

To create the distribution, we considered 10 different lists each containing the six animations with different orders as seen in Table 3.1, each letter corresponds to a certain animation of emotion, six in total A, B, C, D, E and F. If we divide the lists in two we have the 20 combinations of three animations, each list containing a combination pair.

The next step was to distribute them evenly among the participants so that we can get the maximum amount of combinations. Since we wanted to show six combinations per person, we take three combination pairs of the ten available (e.g. pairs 0, 1, and 2 from Table 3.1). For each participant it is provided a different set of combination pairs, more specifically if we consider n to be the number of the participant, the chosen pairs will be $n_{mod}10$, $n_{mod}10+1$ and $n_{mod}10+2$ (e.g. if $n=13$, then the pairs chosen would be 3, 4, and 5).

Furthermore, we also decided to represent both SC from VTA, João and Maria, so each of the six combinations would have animations from the different avatars. The first combination would be from João and the second from Maria, and so on and so forth. The main reason for this was to check if a different avatar would have an impact on the perception of the animations.

[2]Having 6 elements and selecting 3, the number of possible combinations equates to: ${}^{6}_{3}\mathrm{C} = 20$.

The decision to use six combinations instead of any other number came from the first pilot test where we verified that two different combinations did not give us enough constructs to work with. In the said pilot, one pair was chosen instead of three, meaning that two combinations were shown instead of six. For each participant n the pair $n_{mod}10$ would be chosen (e.g. a participant $n = 13$ would be given the pair number 3, Combination 1 with $\{$A, B, F$\}$, Combination 2 with $\{$D, E, C$\}$).

3.4 Constructs and Ratings

In this section, we will explain in detail the main part of the RG. First, the participants have to elicit the *constructs*, in our case facial features, and then they will rate each of the six emotions against the constructs that they found.

To make this process possible as a first approach we created a questionnaire that contained both parts (in the actual studies we used two questionnaires, one for each part, more details are shown in section 3.4.4), with some demographic questions at the beginning like the age, gender, maternal language and interaction with SC. Furthermore, it was also given an example of how the experiment would occur, this example was given in another context with no connection to emotions so that the participant would not be biased. It mainly consisted in showing three different shapes, a circle, a square and a triangle, and we showed how we expected the answers to be.

3.4.1 Finding the Constructs

The most common way to begin is by presenting the animations as mentioned in section 3.3 and then to ask a specific question, as we can see from Kelly's work [1]. Depending on the study this question may differ slightly, in our case, we first ask the participant to choose the two animations that are more alike and then to justify the choice by asking *"how are two of them alike and at the same time different from the third"*.

The elicitation of constructs part of the questionnaire consists of six sections, each presenting a combination of three animations (see section 3.3 for more information in the distribution). Half of the sections present João's animations and the other half presents Maria's animations, we introduced Maria to check if a different avatar would have an impact on the perception of the animations, even though the animations are the same.

Each section had four questions:

- **Q1** *"By comparing the 3 animations presented above, identify the two that are alike"*
- **Q2** *"how are two of them alike and at the same time different from the third"*.
- **Q3** *"Provide us with one characteristic that you found was alike in the two animations"*

– **Q4** *"Provide us with the opposite characteristic from the one mentioned above, describing the different animation"*

3.4.2 Rating the Animations

The next step in the RG is to ask the participants to rate the animations with the constructs that they found in the previous step. For that, we added six more sections to the questionnaire, one for each emotion animation. The animation would be shown and, for each of the constructs that were found in the sections before, a seven point Likert scale was shown, the extremes being the answers from **Q3** and **Q4**. The participants were asked to rate the animation using each construct presented.

3.4.3 First Pilot Test

As a reminder, the original experiment consisted only in one questionnaire, where both the elicitation procedure and the ratings of the animations were present. Also, this first pilot consisted in only two combinations in the elicitation procedure, as mentioned in section 3.3.

We applied the questionnaire to a sample of 6 people, mainly to understand if the method was easy to comprehend and if the information that we would receive was enough. We made **four** important observations with this pilot.

Firstly, only having two combinations presented to the participants was not enough, we usually would only get a maximum of two constructs per participant. Therefore, after a further investigation about the matter, where we saw that the usual number of constructs elicited were between seven and ten [27], we decided on six different combinations per participant, changing between Maria's animations and João's, since we wanted to see if there would be some distinction in using different SC and we did not want to make the questionnaire too extensive by going further than six sections.

Secondly, we saw some repetitions on constructs from the same participant, although it might be harder for them to come up with six different constructs we still wanted some kind of variation so we added a line in the questionnaire asking to not repeat characteristics that were already mentioned before.

Thirdly, from the six participants, three mentioned names of emotions to justify the similarities at least once in the three sections. While emotions can elicit prototypes or memories of how one can express them, they are too broad of a category to be useful in our context, as we want more specific characteristics in the facial expressions. For this, we added a simple note asking for the participants to try not to mention names of emotions while justifying the similarities.

Lastly, because we wanted to analyse the answers as a whole and not individually we decided that it would be best to supply the constructs to the participants ourselves so that everyone had the same constructs. Another reason to try this approach was that with only six responses we already saw the

same constructs being used by different people.

3.4.4 To Elicit or to Supply Constructs

Following the first pilot tests, we noticed that it would be better for the participants to have the same constructs. We have to remember that the constructs used need to be meaningful to the individuals at hand, so just supplying them with no input from the participants would not work. When in doubt about what kind of constructs are applicable to a certain group of people, it is common practice to collect a sample of constructs from a comparable group or from the group itself [24]. That way you can safely assume that the most commonly used constructs for that group will be meaningful to the participants. As long as the constructs are carefully selected and meaningful to the participants, there is no reason to not use them. Therefore, we decided to split the original questionnaire into two different ones.

3.4.4.A Questionnaire 1 - Construct Elicitation

In this questionnaire, we collect a sample of constructs from a group of people and then sort them into themes by using content analysis. This questionnaire remained very similar to the first part of the original questionnaire. Like before we started with the same demographic questions, followed by the example of the three different shapes, square, triangle and circle, and finally, six sections containing different combinations of emotions (refer to section 3.3).

All four questions mentioned in section 3.4.1 remained the same with the addition of the notes asking to *not repeat characteristics* and *not use names of emotions to justify the choice*. We decided on keeping both **Q3** and **Q4** so that we could better understand the characteristics that the participants had in mind.

Content analysis is a subjective qualitative analysis by which elements and/or construct labels are placed into common categories or main issues and interpreted for meaning [28]. After all responses were received we used Content Analysis to find meaningful constructs by sorting them into themes and analysing the frequency in which they appeared. The selected constructs were then used to create the second questionnaire.

3.4.4.B Questionnaire 2 - Animations' Ratings

After selecting an amount of constructs elicited, the ones mentioned the most, we ask participants to rate the animations against these constructs. This questionnaire was similar to the second part of the original one, where we ask the participants to rate the six animations, this time they had to rate them against the selected constructs. With the Content Analysis, we found nine different constructs that were meaningful. Furthermore, a similar demographic characterization of the participants was made, with the

addition of how many people had answered the first questionnaire, since it was not required for them to have answered it.

3.4.5 Final Pilot Tests

Second Pilot Test - it was necessary for Questionnaire 2. After analysing all answers from Questionnaire 1 and having decided on the constructs that would be used, the second questionnaire was distributed to a sample of 4 people. This pilot's purpose was to see if individuals that did not participate in the elicitation process would have any difficulties in comprehending the constructs used.

No participant mentioned having difficulties with the constructs itself, only with the scaling, saying they found it "hard to quantify the intensity of the movements", only after answering around three different sections they started to find it easier. It was not particularly a problem since we want to know how each person sees each construct separately. To guarantee that the same order of presentation of the animations would not be shown to the participants, to not create a bias on the answers, we made use of the *Latin Square*, an $n \times n$ array filled with n different symbols, each occurring exactly once in each row and exactly once in each column. In our case, we will consider our six animations and we want to present them in different orders using six different versions of the questionnaire in a way that no animation occurs in the same spot in more than one version, reducing the bias that was mentioned before.

Third Pilot Test - since we changed the tool being used (from jsPsych to Google Forms) to make the questionnaire we found that it was better to make a third pilot test, a sample of another 4 people was used. No more observations were made by the group from the pilot test so we started with the actual testing.

3.5 Tools

Throughout our study, we used different tools for making all questionnaires. For the questionnaire in the first pilot test (see sections 3.4.1 and 3.4.2) and the Questionnaire 1 used in the study (see section 3.4.4.A) we made use of jsPsych[3]. This tool provides a flexible framework for building a wide range of laboratory-like experiments that can be run online. It also allowed us to show different videos side by side and to take the responses from previous questions into new questions. For Questionnaire 2 we made use of Google Forms[4], it was a well known tool used for questionnaires. This change is due to the functionality that allows the participant to go back to previous sections in the questionnaire, something that was not trivial to make in jsPsych and it was not present in the first version.

[3] jsPsych version 6.3, a JavaScript library for running behavioral experiments in a web browser, https://www.jspsych.org/6.3/

[4] Google Forms, by Google: https://www.google.com/forms/about/

Since we were using the VTA's agents and it was developed using the Unity 3D Engine[5], we also made use of the engine to visualize the animations that VTA provided and to record them using the computer so that we could show the videos in the questionnaires.

3.6 Summary

This chapter explains how our study was conducted and also all of the necessary changes that were made to our initial approach. We start by briefly explaining our method based on the RG, going into the details of each important step, such as the chosen animations, the way we presented them to the participants, the constructs that were elicited and finally the rating of each animation. Furthermore, we explain why we decided on splitting the initial questionnaire in two, the first one the elicitation of the constructs, and the second one the ratings for each different animation using the constructs that were selected with the Content Analysis. We close the chapter by showcasing what tools were used to develop the questionnaires.

[5]Unity is a cross-platform game engine developed by Unity Technologies, first announced and released in June 2005. https://unity3d.com

4

Results

Contents

4.1 Elicitation of the Constructs

This section will describe the results of Questionnaire 1 (see section 3.4.4.A). We tried to find a small sample with a wide demographic spectrum. First, we discuss the demographic characterization of the population such as age, gender and experience with Synthetic Characters (SC). Secondly, we present the features that were found.

4.1.1 Demographic Results

In total 21 answers were submitted to the questionnaire. The demographic spectrum is wide: our group of participants is aged between 21 and 56 years with a mean of 26 years old and a standard deviation of 9.540. Regarding gender 52% are male and 48% are female.

As for experience with SC, 85.7% interacted with Non-Player Characters (NPCs) in videogames and 90.5% interacted with Virtual Assistants (VA). As for the interaction with Social Robots only 28.6% had interacted with one previously and finally, of the 21 participants, only 1 had worked with or developed SC/VA.

4.1.2 Selected Constructs

The purpose of this questionnaire was to discover the constructs that each individual person observed while looking at three different animations representing different emotions. In the end, we wanted to see if the same constructs were mentioned more than once by different participants.

Looking back at Chapter 3, an important part of this method is to ensure that the constructs are meaningful to the participants. This questionnaire allows for the collection of constructs that are understood by the participants and surrounding community, thus providing meaningful constructs to Questionnaire 2 for the rating of the animations.

Each participant supplied us with 6 different constructs making it a total of **126**. We had to discard a total of 25 constructs (leaving a total of 101) due to the following problems:

- We identified people that used the same construct more than once, 4 constructs were identified as having this issue;
- The use of emotions to describe the different constructs, a total of 14 to be exact, we did try to minimize this number by specifically saying not use emotions;
- There were 7 answers that had to be discarded as they weren't specific enough to get any conclusions (e.g. "eyebrows" – without an explanation of the movement or context).

Construct			
Pole 1	**Pole 2**	**Frequency**	**Percentage %**
mouth opens wide	mouth barely opens/closes	15	71
eyebrows go down[1]	eyebrows go up[1]	12	57
eyes open	eyes close	9	43
forehead goes down[2]	forehead goes up[2]	7	33
teeth visible	teeth not visible	7	33
face contracts	face expands	6	29
eyebrows move[1]	eyebrows do not move[1]	5	24
cheeks go down	cheeks go up	4	19
round shaped mouth	curved shaped mouth/smile	4	19
forehead moves[2]	forehead does not move[2]	4	19
teeth close together	teeth wide apart	3	14

Table 4.1: Frequency for each meaningful construct found mentioned by the participants and the percentage of the participants who mentioned it, sorted by most frequent to less.
[1] Construct merged to create a single 'eyebrows go down/up'.
[2] Construct merged to create a single 'forehead goes down/up'.

The next step consists in doing Content Analysis, we took the remaining 101 constructs and found common themes in the constructs. After conducting the analyses we reduced it to 32 constructs in total. We came to the conclusion that a frequency of mentions below 3 occurrences was not meaningful enough to consider, given that, we can say that a total of 11 constructs were found as shown in Table 4.1.

Under further investigation, we saw that two of these 11 constructs could be merged with other two constructs. The first construct removed was "eyebrows move/eyebrows do not move" and the second one "forehead moves/forehead does not move", the reason for this is because they can be considered a part of the movement of the eyebrows and forehead respectively, which is already implied in "eyebrows go up/eyebrows go down" and "forehead goes up/forehead goes down" (see Table 4.1).

We can finally say we found 9 different constructs, each one given by the participants, therefore reducing the possibility of not supplying meaningful constructs to complete the RG.

4.2 Rating of the Synthetic Characters Animations

In this section we discuss the results of Questionnaire 2 (see section 3.4.4.B). First, we will start with the demographic characterization of the participants and then we will delve into the analyses of the RG that was built with the ratings of each animation. We build our model for the perception of animations of emotions by people using both Principal Component Analysis (PCA) and Cluster Analysis (CA).

It is important to notice that the constructs were supplied to the participants using the answers from the previous questionnaire, 9 constructs in total to be exact.

4.2.1 Demographic Results

In total 40 answers were submitted to the second questionnaire. Of all the participants 62.5% did not answer the first questionnaire. The demographic spectrum is wide: our group of participants is aged between 15 and 56 years old, with the mean being 25 years old and a standard deviation of 7.808. Regarding gender 40% are male and 60% are female.

As for experience with SC, 80% interacted with NPCs in videogames and 77.5% interacted with VA. As for the interaction with Social Robots only 27.5% and finally, of the 40 participants only 2 had worked with or developed SC/VA.

4.2.2 Principal Component Analysis (PCA)

We performed PCA for grouping constructs that are correlated. PCA is a variable-reduction technique, it aims to reduce a larger set of variables into a smaller set of variables.

By using SPSS Statistics[1] dimension reduction analyses we run it with a fixed number of factors such as two, three, four and five, in order to find the optimal number of factors. We found through the scree plot in Figure 4.1 that more than five factors did not account for much more variance so we stopped considering further, as for two factors only 57% of variance was not enough so it was also discarded.

We will first discuss the three factors solution, with 69.9% of the variance. In Table 4.2 we have the rotated component matrix, where two of the constructs cross loaded on more than one component: items with a loading less than 0.4 were removed as recommended and standard process [29]. From this analysis was born the concept of a model which we called *Perception of Animations of Emotions' Model*.

Component 1 reveals that the forehead, eyebrows, eyes, mouth movement, teeth visibility and face usually move in a similar direction, for example, something we can clearly see is that the animations for Surprise and Fear would be in one extremity and the animations for Anger and Disgust would be the other. The face expanding is clearly connected with the forehead and eyebrows going up, the eyes and

[1] IBM SPSS Statistics version 26 is a software platform that offers advanced statistical analysis. https://www.ibm.com/products/spss-statistics

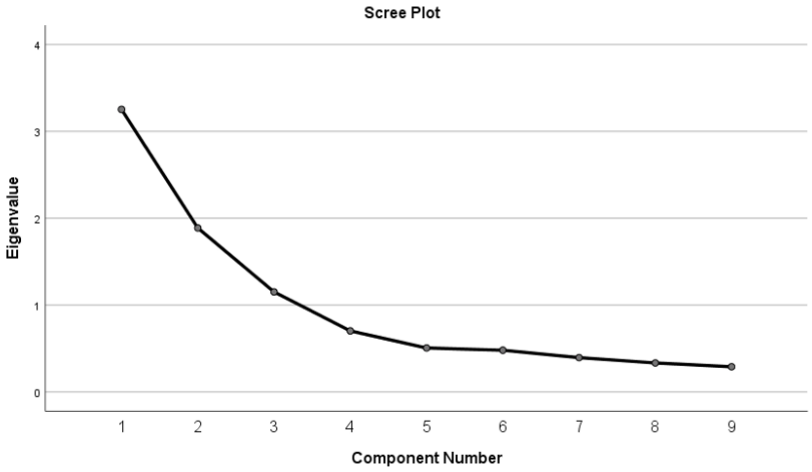

Figure 4.1: Scree Plot.

Construct		Component 1	Component 2	Component 3
forehead goes down	forehead goes up	0.810		
eyebrows go down	eyebrows go up	0.791		
eyes close	eyes open	0.601		
cheeks move down	cheeks move up		0.815	
mouth remains closed	mouth opens widely	0.420		0.795
round shaped mouth	curved shaped mouth/smile		0.863	
teeth not visible	teeth totally visible			0.907
teeth close together	teeth wide apart	0.526	-0.442	
face contracts	face expands	0.846		

Table 4.2: Rotated Component Matrix for 3 components with absolute value above 0.4.

mouth opening and the teeth separating from each other, the characteristics for Surprise and Fear as we will see with more detail in the next section.

Component 2 tells us that the mouth area it is highly correlated with the cheeks and the closeness of the teeth, for example, if our SC is smiling, the cheeks would go up and the teeth are closer. Looking at the animation of Happiness we can verify these points.

Component 3 reveals that the more the mouth is opened the more teeth are visible.

A detailed analysis with four factors was also discussed since it covers 77.7% of the variance, almost 8% more than the three factors approach. On Table 4.3 we have again the rotated component matrix

but this time for the four components. By looking at the table and comparing it with the previous results the main difference is that the teeth closeness construct gets a component just for itself, meaning that it is probably the construct with fewer correlations with the others, so we could say that it might not be relevant for our model. Because of this, we concluded that three factors were ideal for our model.

Construct		Component 1	Component 2	Component 3	Component 4
forehead goes down	forehead goes up	0.733			
eyebrows go down	eyebrows go up	0.804			
eyes close	eyes open	0.722			
cheeks move down	cheeks move up		0.851		
mouth remains closed	mouth opens widely			0.783	
round shaped mouth	curved shaped mouth/smile		0.804		
teeth not visible	teeth totally visible			0.906	
teeth close together	teeth wide apart				0.812
face contracts	face expands	0.807			

Table 4.3: Rotated Component Matrix for 4 components with absolute value bellow 0.4.

4.2.3 Cluster Analysis (CA)

As already mentioned some emotions are easily confused with one another and with CA we found a way to group them together using our method of the RG, we can then identify prototypes of the emotions that are more distinct. CA tries to divide a certain number of observations into different groups that share common characteristics. With a total of 240 cases, with them being the six different animations of emotions multiplied by the number of participants, 40 to be exact, we tried to see if different emotions would somehow be put together in the same cluster, considering the values of the 9 different constructs. This could mean that they share some characteristics and we analyse what those might be.

We used SPSS k-means clustering, which aims to partition n cases into k clusters, each case belongs to the cluster with the nearest mean, called cluster centers or cluster centroids, which serves as a prototype of the cluster. We used the squared Euclidean distances method that SPSS provides to minimize within-cluster variances, all 9 constructs were considered for the variables and we had an $n = 240$. Since k-means needs a value for k beforehand we had to understand the optimal number of clusters for our data.

We used two common methods to determine the optimal number of clusters, the *Elbow Method* and the *Silhouette Method*.

Elbow Method - it runs k-means clustering on the data set varying k, we experimented with values between 1 and 10. Next, we calculate the within sum of squared distances to the centroids across all data points at each number of clusters. Figure 4.2 shows the graph for the total within sum of squares for each k, the point where it passes from steep to shallow would be the optimal number, in our case $k = 3$ or $k = 4$.

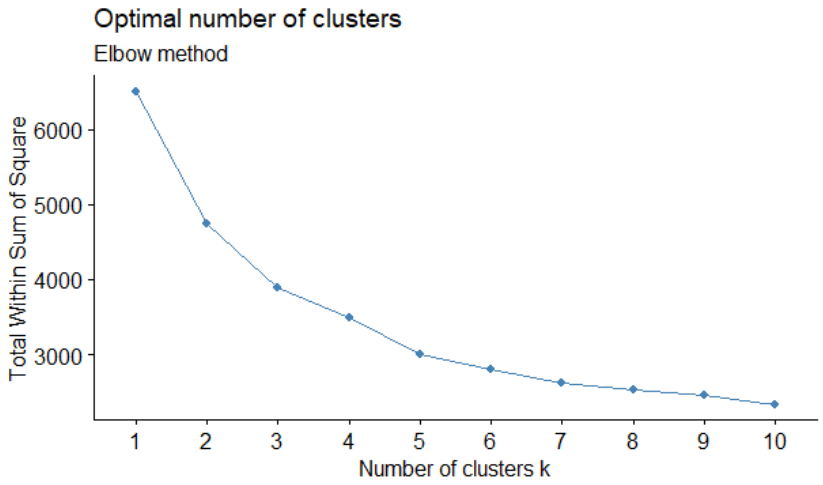

Figure 4.2: The total within sum of squares per number of clusters k.

Silhouette Method - it also runs k-means clustering on the data set varying the k, it calculates the average of the silhouette coefficient, a measure of how similar a data point is within-cluster compared to other clusters, for each different k.

$$S(i) = \frac{b(i) - a(i)}{max\{a(i), b(i)\}} \tag{4.1}$$

With $S(i)$ being the silhouette coefficient of a data point i, $a(i)$ the average distance between i and all the other data points in the cluster to which i belongs, finally $b(i)$ is the average distance from i to all clusters to which i does not belong. Figure 4.3 shows the graph for the average silhouette for the value k varying between 1 and 10. We can see that the average is bigger for $k = 4$, although the values for the average silhouette are relatively small for every k.

However, looking at the two different methods we can see that it does not give us a clear answer to how many clusters would be ideal. Therefore, we decided on running the k-means clustering in SPSS with values of k ranging between 3 and 5, since the two methods were pointing in this direction. For each k we verified how many cases each cluster contained and also how the data was distributed.

We concluded that 4 clusters is the optimal number of clusters for our study. We get a relatively equal

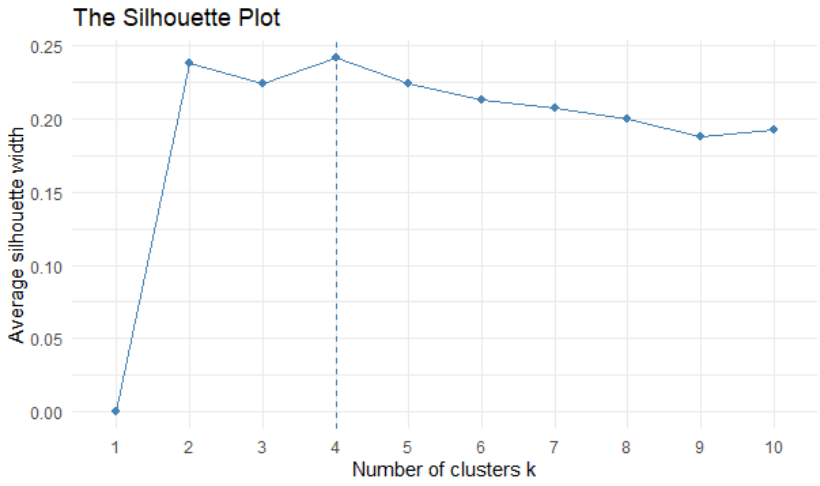

Figure 4.3: Average silhouette value for each number of clusters k.

amount of cases in each cluster, as we can see by looking at Table 4.4. **Cluster 3** did group fewer cases together compared to the other three clusters, however, if we look closely we notice that the cluster is mainly represented by the emotion of Sadness, meaning that no other emotion has similar features. Furthermore, we can confirm that Anger and Disgust have some features that are very alike as they were mainly in **Cluster 1**, although Disgust was also very present in **Cluster 4** along with the emotion of Happiness. As for Fear and Surprise, the same conclusion can be made, as they appear in **Cluster 2** with a percentage above 80% in both cases, which means that their features are also perceived similarly. At last, the emotion of Happiness is concentrated in **Cluster 4** with 97.5% of all 40 participants.

Cluster	Anger	Disgust	Fear	Surprise	Sadness	Happiness	Number of cases
1	34	26	0	1	6	0	67
2	1	2	35	33	0	0	71
3	1	2	0	2	29	1	35
4	4	10	5	4	5	39	67
Total	**40**						**240**

Table 4.4: Number of cases in each cluster. The cases were compared with the squared Euclidean distance between their respective constructs ratings.

Furthermore, in Table 4.5, we have the cluster centers for each construct that was elicited in the first questionnaire, where a rating of 1 corresponds to the extreme on the left and a rating of 7 to the extreme on the right. Looking at the centers we can identify the features that might represent each cluster, and therefore represent the emotions that were grouped in each one.

Cluster 1 is represented by *Anger* and *Disgust* and the main features to consider are: Forehead goes down; Mouth opens more but not completely; Teeth are totally visible and close together; Face contracts.

Cluster 2 is represented by *Fear* and *Surprise* and the main features to consider are: Forehead goes up; Eyebrows go up; Eyes open more; Mouth opens almost completely with a round shape; Teeth are very visible but not totally and wide apart; Face expands.

Cluster 3 is represented by *Sadness* and the main features to consider are: Forehead goes down; Eyebrows go down by a bit; Cheeks move down by a bit; Mouth opens barely; Teeth almost not visible but close together; Face contracts.

Cluster 4 is represented by *Happiness* and the main features to consider are: Eyebrows go up by a bit; Cheeks move up; Mouth opens almost completely with a curved shape, a smile; Teeth are very visible but not totally and they are close together; Face expands.

Construct		Cluster 1	2	3	4
forehead goes down	forehead goes up	2	5	2	4
eyebrows go down	eyebrows go up	4	6	3	5
eyes close	eyes open	4	5	4	4
cheeks move down	cheeks move up	4	4	3	6
mouth remains closed	mouth opens widely	5	6	3	6
round shaped mouth	curved shaped mouth/smile	4	2	4	6
teeth not visible	teeth totally visible	6	5	2	5
teeth close together	teeth wide apart	2	6	2	3
face contracts	face expands	3	6	3	5

Table 4.5: The cluster centers for each construct analysed.

4.2.4 Cases Distribution

To visualize all cases in a 3D space we considered the Perception of Animations of Emotions' Model that consists of 3 components created using PCA. For each case to be represented we had to find their factor scores. Since a factor is by nature unobserved, we need to first predict or generate plausible factor scores. We used the Regression method in SPSS to generate the factor scores of each case. Figure 4.4 shows the distribution of the cases labeled with the emotion it represents, each axis represents the different components.

After generating all factor scores we made one more Cluster Analysis (CA), we once again used SPSS k-means clustering with all 240 cases. The variables, for calculating the squared Euclidean distances, being the new factor scores, three to be exact. The value for k, the optimal number of

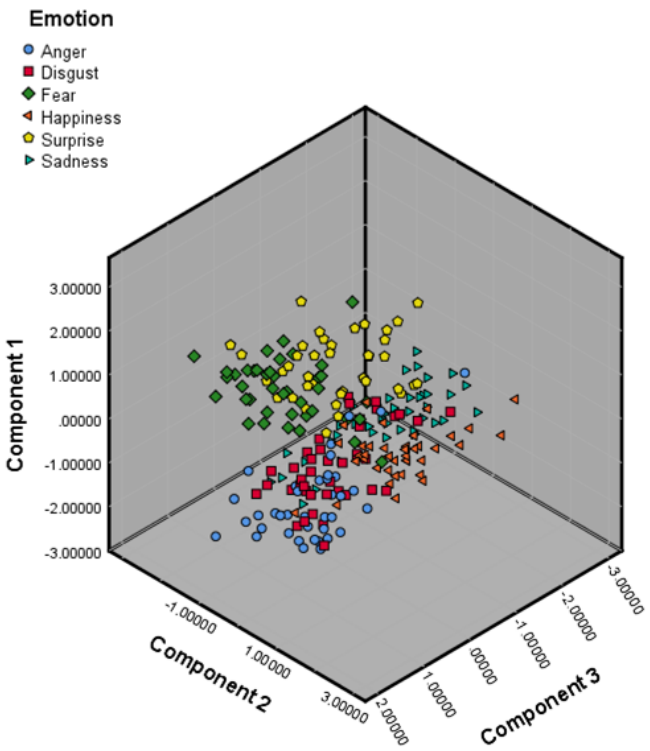

Figure 4.4: Distribution of the cases labeled with the emotion it represents, using the calculated factor scores for each case.

clusters, was 4 (see section 4.2.3). Table 4.6, shows the number of cases in each cluster when using the factor scores for each component as variables instead of the 9 constructs.

If we look at Figure 4.5 we have another 3D graph with the distribution of the cases labeled with the corresponding cluster, each axis represents the different components. By comparing both 3D graphs, Figures 4.4 and 4.5, we can confirm that both Anger and Disgust were merged in one cluster as well as Fear and Surprise. We can go even further than that and look at the cluster centers for each of the three components in the Perception of Animations of Emotions' Model (see Table 4.7). We notice that Anger and Disgust are mainly represented by Component 1 negatively and Component 3 positively. For Fear

Cluster	Anger	Disgust	Fear	Surprise	Sadness	Happiness	Number of cases
1	36	27	0	1	9	1	74
2	0	2	36	29	1	0	68
3	2	3	0	9	27	1	42
4	2	8	4	1	3	38	56
Total	**40**						**240**

Table 4.6: Number of cases in each cluster. The cases were compared with the squared Euclidean distance between their respective factor scores.

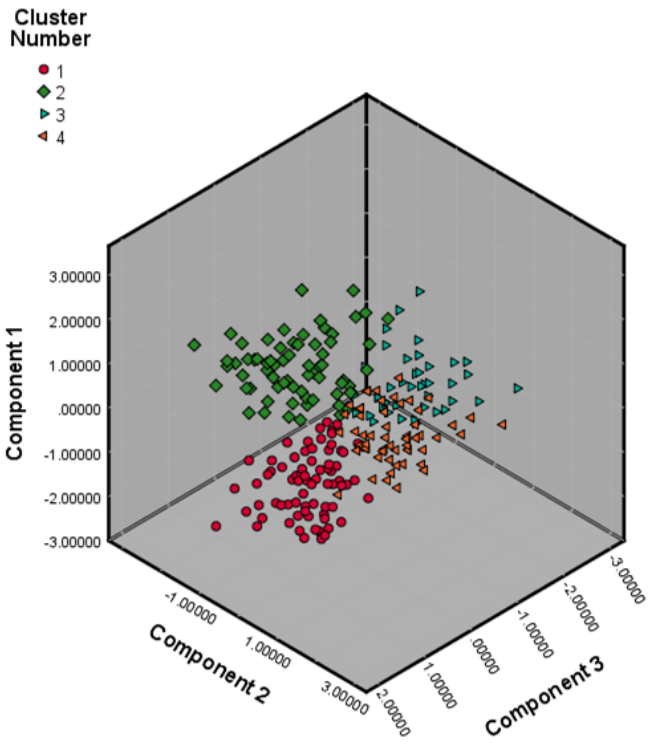

Figure 4.5: Distribution of the cases labeled with the cluster it belongs, using the calculated factor scores for each case.

	Cluster			
Component	**1**	**2**	**3**	**4**
1	-1.0	1.0	-0.3	0.4
2	-0.1	-0.8	-0.3	1.3
3	0.7	0.3	-1.7	0.0

Table 4.7: The cluster centers for each component in the Perception of Animations of Emotions' Model.

and Surprise, we have positive values for Component 1 and negative values for Component 2. Sadness is mainly characterized by Component 3 with negative values and finally, as for Happiness, we have Component 2 with positive values.

4.3 Discussion

Throughout this chapter, we presented and explained the results obtained for the two questionnaires that were implemented. It is important to refer that this methodology can be applied on every Synthetic Characters (SC), but that the results are specific to our application as the extracted constructs were specific to our application, guiding the following results. We analysed a total of 21 responses from Questionnaire 1 - Elicitation of the constructs - and 40 responses from Questionnaire 2 - Rating of the

Animations.

For Questionnaire 1 the demographic spectrum is wide with participants aged between 21 and 56 years and 52% being male. The majority of the participants also had some experience with SC while interacting with NPCs and VA. As for the constructs that were elicited we had a total of 126 constructs, but after doing Content Analysis and discarding some constructs due to some problems we selected a total of 9 different constructs. The most mentioned ones were the movement of the mouth, eyebrows, eyes, forehead, cheeks, and also two features regarding the teeth, the shape of the mouth and finally the face in general, if it was expanded or contracted.

As for Questionnaire 2 the demographic spectrum was also wide with participants ranging between the ages of 15 and 56 and 60% of females. To analyse the data, a total of 240 cases, with them being the six different animations of emotions multiplied by the number of participants, 40 to be exact, we made use of Principal Component Analysis (PCA) and Cluster Analysis (CA). We performed PCA with the intent of grouping constructs that were correlated. We found through the scree plot that the optimal number of factors would be 3 explaining 69.9% of the variance. With the 3 components was born the concept of a model which we called Perception of Animations of Emotions' Model. Component 1 corresponded to how people viewed the face in general, if it was more contracted or expanded. Component 2 was related to the movement of the mouth and its relation to the cheeks movement. Finally, Component 3 explained how the opening of the mouth is related to the visibility of the teeth.

As for CA, we saw how each emotion was grouped together using the k-means clustering. We performed it in two ways, first using all 9 constructs to calculate the within-cluster variance, using the squared Euclidean distance. The second one instead of the 9 constructs we used the factor scores of the 3 Components, computed for each case using the Regression method. We found that the optimal number of clusters was 4 and that the results obtained in both analyses were very similar. Anger and Disgust were grouped in Cluster 1, Fear and Surprise in Cluster 2 and then Sadness and Happiness had their own cluster, 3 and 4 respectively.

Lastly, by looking at the cluster centers for each of the three components we came to a conclusion that Anger and Disgust are mainly represented by a contraction of the face, in the upper area involving the eyes and forehead (Component 1). As for Fear and Surprise, they are the opposite of the other two, with the face being more expanded and the mouth more rounded with the teeth wide apart (Component 1 and 2). Finally, Sadness is characterized by having the mouth more closed with almost no teeth visible (Component 3) and Happiness is characterized by its smile (Component 2). As we hypothesized, this model explains the way the participants consciously perceive and discriminate the six animations of emotions from these specific SC.

5

Conclusion

Contents

Synthetic Characters are being used more and more every day, and the recognition of their emotions is a main issue if we want to show more believable characters. The main goal of this study was to understand if we could create a model for how people perceive emotions in specific SC and at the same time try to identify the aspects that may lead to poor emotion recognition, in particular for non-verbal communication such as facial expressions.

We took a set of six animations from specific SC, each representing a different emotion. We made use of a triad comparison to find meaningful constructs, personal rules by which we view or categorize situations, and with these constructs, we built a model for how people perceive the different animations.

We first had to understand which constructs were meaningful by requesting a small group of people to fill out a questionnaire. This questionnaire contained a small section for a demographic characterization of the participants and six sections for the elicitation of the constructs using a triad comparison, a common method for making a RG. After analysing a total of 126 constructs using content analysis we reduced it to 9 different constructs.

The second step was to create a model for the perception of animations of emotions, a second questionnaire was necessary. We took the 9 constructs that were selected and made a questionnaire where each animation was to be rated against each construct on a Likert scale with seven points. We used PCA and CA to create the model. PCA reduced the number of constructs to 3 components, the first corresponding to how people viewed the face in general, if it was more contracted or expanded, the second the movement of the mouth and its relation to the cheeks movement and the third and last one the mouth opening and how it is related to the visibility of the teeth. With CA we could see how each different animation was similar as they were grouped together in 4 clusters, Anger and Disgust were grouped in Cluster 1, Fear and Surprise in Cluster 2 and then Sadness and Happiness had their own Cluster, 3 and 4 respectively.

We conclude that with the RG method it is possible to see how people perceive different emotions and that it indeed shows us that different emotions are confused with each other due to specific features. We can visualize which features are more prominent in each different cluster and thus how the different animations are more alike. Anger and Disgust are characterized mainly by the first component and the third, Fear and Surprise by the first component and the second, Happiness mainly by only the second and finally, Sadness by the first and the third component.

5.1 Future Work

With the data that we received in our study, it is possible to try to improve emotion recognition of the animations of the Synthetic Characters (SC) used in our study. As such the next step would be to make a new set of animations, focusing on the emotions that we saw were similar, such as Anger and Disgust,

and Fear and Surprise. We will focus on the constructs that we found, as well as the model that we created using the three components to inform how better distinguish similar emotions (e.g. Anger and Disgust).

A final evaluation has to be made to verify if the new set of animations would really improve emotion recognition. So we would compare the results obtained with an emotion recognition evaluation, one from the base animations used in our study and another with the new animations created. We will verify if emotion recognition was improved. We could also take the changes made by Silva [9] to the animations and compare the three.

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A

Result Analysis

A.1 Ratings of the Animations

Construct		Anger		Disgust		Fear		Surprise		Sadness		Happiness	
		Mean	Std. Deviation	Mean	Std. Deviation	Mean	Std. Deviation	Mean	Std. Deviation	Mean	Std. Deviation	Mean	Std. Deviation
forehead goes down	forehead goes up	1.95	1.825	2.35	1.791	4.88	1.381	4.78	1.143	2.28	1.320	4.20	.608
eyebrows go down	eyebrows go up	3.38	1.675	4.50	1.783	6.10	.928	6.33	.797	2.68	1.228	4.25	.439
eyes close	eyes open	3.93	.694	3.83	.781	4.88	1.223	5.10	.928	3.73	.751	3.88	.648
cheeks move down	cheeks move up	4.47	.877	5.05	.959	3.55	1.300	3.80	1.224	2.93	1.185	6.18	.903
mouth remains closed	mouth opens widely	5.35	1.424	5.23	1.165	6.60	.591	5.65	1.231	3.25	1.629	5.45	1.239
round shaped mouth	curved shaped mouth/smile	4.18	1.500	4.05	1.300	2.35	1.578	2.93	1.385	3.88	1.090	6.38	.807
teeth not visible	teeth totally visible	6.35	.975	5.73	1.154	5.70	1.091	4.03	1.625	2.73	1.432	5.53	1.037
teeth close together	teeth wide apart	1.78	1.625	3.18	2.049	5.70	1.728	4.88	1.742	2.95	1.694	2.83	2.099
face contracts	face expands	2.65	1.528	3.68	1.685	5.60	1.105	5.35	1.099	2.88	1.285	5.10	1.317

Table A.1: The mean and standard deviation for each construct depending on the emotion in Questionnaire 2 (Rating of the animations).

B

Questionnaires

B.1 Questionnaire 1

Completion Progress

Expressions on Synthetic Characters

Thank you for your participation in this study. This study is part of a Master's dissertation at Instituto Superior Técnico that aims to study the animation of expressions in synthetic characters. Your participation and collaboration are, therefore, very much appreciated.

The experiment will take place in two parts, separated by 1 to 2 weeks. Both parts mostly consist in watching very short videos (a few seconds each) depicting facial expressions and comparing these animations. You are free to rewatch the videos as many time as you so desire.
The first part should take about 20 minutes, and the second part about 10 minutes of your time. All the answers will be anonymous and used solely for statistical purposes.

We also gently remind you that:
- participation is voluntary and you can withdraw at any time;
- you have the right to ask any question related to the experiment at any given time (e-mail: taissa.ribeiro@tecnico.ulisboa.pt);
- you will not be identified at any stage of the study and individual results will not be shared;
- your participation does not involve physical or psychological risks.
By proceeding to the questionnaire you are giving your consent.

Thank you for your time and consideration.

Continue

Completion Progress

Age:*

Gender:*

- ○ Female
- ○ Male
- ○ Prefer not to say
- ○ Other

Maternal Language:*

- ○ Portuguese
- ○ English
- ○ Other

What is your experience with Synthetic Characters?

- ☐ Interacted with NPCs (non-player characters) in videogames
- ☐ Interacted with Virtual Assistants (e.g. Siri, Cortana, Google Assistant, in museums, etc.)
- ☐ Interacted with Social Robots (in scientific experiments, museums, etc.)
- ☐ Worked with or developed Synthetic Characters/Virtual Characters

Continue

Completion Progress

The Experiment

In the following 6 sections you will be asked to compare 3 animations with different facial expressions by telling us the **two that are more alike**, **why** the two are more alike and how they **differ from the third**.

Here is an example:
Consider 3 different shapes, a **circle**, a **square** and a **triangle**. We could say for example that the **square** and the **triangle** are more **alike** because they are defined by **straight lines** and they are **different** from a **circle** because it has **curved lines**.
Please, do not reuse the same pair of characteristics more than once, even if it is the most obvious characteristic to distinguish between the animations.

The following section exemplifies how the questionnaire would be filled.

Continue

Completion Progress

Example

Example of a possible answer.

The images below are representing three different shapes.

A B C

By comparing the 3 animations presented above, identify the two that are alike:

☑ A ☑ B ☐ C

Considering your previous answer, how are two of them alike and at the same time different from the third:

A and B are more alike because they are defined by straight lines and they are different from C because it has curved lines

Provide us with one characteristic that you found was alike in the two shapes:
(Use 1 to 3 words)

straight lines

Provide us with the opposite characteristic from the one mentioned above, describing the different shape:
(Use 1 to 3 words)

curved lines

Continue

Completion Progress

Beginning of the experiment

The experiment itself starts in the next section.

Below you can find the example that was given before, in PDF format:

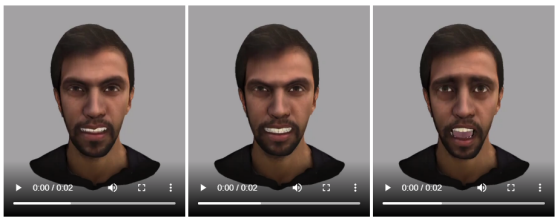
Example

Continue

Completion Progress

Comparison 1 of 6

The videos below are showing 3 animations of different emotion expressions.



A B C

By comparing the 3 animations presented above, identify the two that are alike:*

☐ A ☐ B ☐ C

Considering your previous answer, how are two of them alike and at the same time different from the third (Please try **not** to use names of emotions to justify the similarity):*

Provide us with one characteristic that you found was alike in the two animations:
(Use 1 to 3 words)*

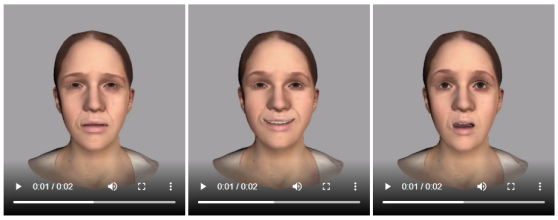
Provide us with the opposite characteristic from the one mentioned above, describing the different animation:
(Use 1 to 3 words)*

Continue

Completion Progress

Comparison 2 of 6

The videos below are showing 3 animations of different emotion expressions.



A B C

By comparing the 3 animations presented above, identify the two that are alike:*

☐ A ☐ B ☐ C

Considering your previous answer, how are two of them alike and at the same time different from the third (Please try **not** to use names of emotions to justify the similarity):*

Please do not repeat characteristics from previous sections

Provide us with one characteristic that you found was alike in the two animations:
(Use 1 to 3 words)*

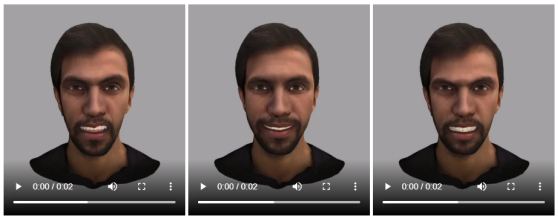
Provide us with the opposite characteristic from the one mentioned above, describing the different animation:
(Use 1 to 3 words)*

Continue

Completion Progress

Comparison 3 of 6

The videos below are showing 3 animations of different emotion expressions.



A B C

By comparing the 3 animations presented above, identify the two that are alike:*

☐ A ☐ B ☐ C

Considering your previous answer, how are two of them alike and at the same time different from the third (Please try **not** to use names of emotions to justify the similarity):*

Please do not repeat characteristics from previous sections

Provide us with one characteristic that you found was alike in the two animations:
(Use 1 to 3 words)*

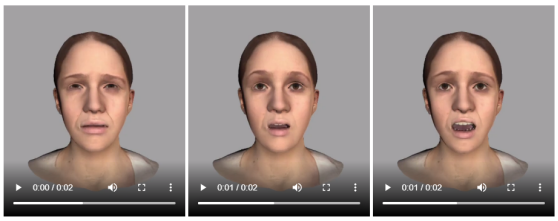
Provide us with the opposite characteristic from the one mentioned above, describing the different animation:
(Use 1 to 3 words)*

Continue

Completion Progress

Comparison 4 of 6

The videos below are showing 3 animations of different emotion expressions.



A B C

By comparing the 3 animations presented above, identify the two that are alike:*

☐ A ☐ B ☐ C

Considering your previous answer, how are two of them alike and at the same time different from the third (Please try **not** to use names of emotions to justify the similarity):*

Please do not repeat characteristics from previous sections

Provide us with one characteristic that you found was alike in the two animations:
(Use 1 to 3 words)*

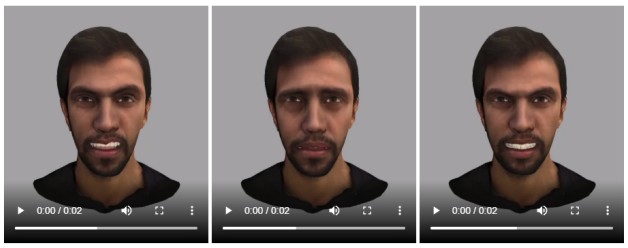
Provide us with the opposite characteristic from the one mentioned above, describing the different animation:
(Use 1 to 3 words)*

Continue

Completion Progress

Comparison 5 of 6

The videos below are showing 3 animations of different emotion expressions.



A B C

By comparing the 3 animations presented above, identify the two that are alike:*

☐ A ☐ B ☐ C

Considering your previous answer, how are two of them alike and at the same time different from the third (Please try **not** to use names of emotions to justify the similarity):*

Please do not repeat characteristics from previous sections

Provide us with one characteristic that you found was alike in the two animations:
(Use 1 to 3 words)*

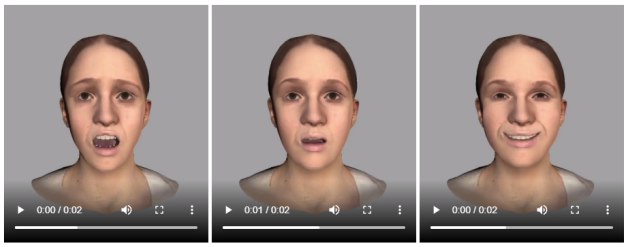
Provide us with the opposite characteristic from the one mentioned above, describing the different animation:
(Use 1 to 3 words)*

Continue

Completion Progress

Comparison 6 of 6

The videos below are showing 3 animations of different emotion expressions.



A B C

By comparing the 3 animations presented above, identify the two that are alike:*

☐ A ☐ B ☐ C

Considering your previous answer, how are two of them alike and at the same time different from the third (Please try **not** to use names of emotions to justify the similarity):*

Please do not repeat characteristics from previous sections

Provide us with one characteristic that you found was alike in the two animations:
(Use 1 to 3 words)*

Provide us with the opposite characteristic from the one mentioned above, describing the different animation:
(Use 1 to 3 words)*

Continue

Completion Progress

End of the experiment

I would like to remind you that all data is used solely for statistical purposes and also the second questionnaire that we will give you in 1 to 2 weeks.

Submit

B.2 Questionnaire 2

Synthetic Emotions

Thank you for your participation in this study. This study is part of a Master's dissertation at Instituto Superior Técnico that aims to study the animation of expressions in synthetic characters. Your participation and collaboration are, therefore, very much appreciated.

You will be shown 6 very short videos depicting facial expressions and you will be asked to rate each animation against 9 different characteristics.
The questionnaire should take about 10 minutes. All the answers will be anonymous and used solely for statistical purposes.

We also gently remind you that:
- participation is voluntary and you can withdraw at any time;
- you have the right to ask any question related to the experiment at any given time (e-mail: taissa.ribeiro@tecnico.ulisboa.pt);
- you will not be identified at any stage of the study and individual results will not be shared;
- your participation does not involve physical or psychological risks.

By proceeding to the questionnaire you are giving your consent.

Thank you for your time and consideration.

* Required

1. Did you participate in the other study by the name of Expressions on Synthetic Characters? *

   Mark only one oval.

   - ◯ Yes
   - ◯ No

2. Age: *

3. Gender: *

Mark only one oval.

- ◯ Female
- ◯ Male
- ◯ Prefer not to say
- ◯ Other: _____

4. Maternal Language: *

Mark only one oval.

- ◯ Portuguese
- ◯ English
- ◯ Other: _____

5. What is your experience with Synthetic Characters?

Check all that apply.

- ☐ Interacted with NPCs (non-player characters) in videogames
- ☐ Interacted with Virtual Assistants (e.g. Siri, Cortana, Google Assistant, in museums, etc.)
- ☐ Interacted with Social Robots (in scientific experiments, museums, etc.)
- ☐ Worked with or developed Synthetic Characters/Virtual Characters

Rating of animation 1 of 6

Rate the following animation:

http://youtube.com/watch?v=4joMgZgTGXs

6. Rate the animation by looking at the forehead (Select 4 if the forehead does not move) *

Mark only one oval.

	1	2	3	4	5	6	7	
Forehead moves down/ Scowl	◯	◯	◯	◯	◯	◯	◯	Forehead moves up/ Frown

7. Rate the animation by looking at the eyebrows (Select 4 if the eyebrows do not move) *

Mark only one oval.

	1	2	3	4	5	6	7	
Eyebrows move down	◯	◯	◯	◯	◯	◯	◯	Eyebrows move up

8. Rate the animation by looking at the eyes (Select 4 if the eyes do not move) *

Mark only one oval.

	1	2	3	4	5	6	7	
Eyes close tightly	◯	◯	◯	◯	◯	◯	◯	Eyes open wide

9. Rate the animation by looking at the cheeks (Select 4 if the cheeks do not move) *

Mark only one oval.

	1	2	3	4	5	6	7	
Cheeks move down	◯	◯	◯	◯	◯	◯	◯	Cheeks move up

10. Rate the animation by looking at the mouth *

Mark only one oval.

	1	2	3	4	5	6	7	
Mouth remains closed	◯	◯	◯	◯	◯	◯	◯	Mouth opens widely

11. Rate the animation by looking at the mouth shape (Select 4 if it is a neutral shaped mouth) *

Mark only one oval.

	1	2	3	4	5	6	7	
Round shaped mouth	◯	◯	◯	◯	◯	◯	◯	Curved shaped mouth/ Smiling

12. Rate the animation by looking at the teeth *

Mark only one oval.

	1	2	3	4	5	6	7	
Teeth not visible	◯	◯	◯	◯	◯	◯	◯	Teeth totally visible

13. Rate the animation by looking at the teeth *

Mark only one oval.

	1	2	3	4	5	6	7	
Teeth closed together	◯	◯	◯	◯	◯	◯	◯	Teeth wide apart

14. Rate the animation by looking at the face (Select 4 if the face is neutral) *

Mark only one oval.

	1	2	3	4	5	6	7	
Face contracts	◯	◯	◯	◯	◯	◯	◯	Face expands

Rating of animation 2 of 6

Rate the following animation:

http://youtube.com/watch?v=YhK4EugG8k4

15. Rate the animation by looking at the forehead (Select 4 if the forehead does not move) *

Mark only one oval.

	1	2	3	4	5	6	7	
Forehead moves down/ Scowl	◯	◯	◯	◯	◯	◯	◯	Forehead moves up/ Frown

16. Rate the animation by looking at the eyebrows (Select 4 if the eyebrows do not move) *

Mark only one oval.

	1	2	3	4	5	6	7	
Eyebrows move down	◯	◯	◯	◯	◯	◯	◯	Eyebrows move up

17. Rate the animation by looking at the eyes (Select 4 if the eyes do not move) *

Mark only one oval.

	1	2	3	4	5	6	7	
Eyes close tightly	◯	◯	◯	◯	◯	◯	◯	Eyes open wide

18. Rate the animation by looking at the cheeks (Select 4 if the cheeks do not move) *

Mark only one oval.

	1	2	3	4	5	6	7	
Cheeks move down	◯	◯	◯	◯	◯	◯	◯	Cheeks move up

19. Rate the animation by looking at the mouth *

Mark only one oval.

	1	2	3	4	5	6	7	
Mouth remains closed	◯	◯	◯	◯	◯	◯	◯	Mouth opens widely

20. Rate the animation by looking at the mouth shape (Select 4 if it is a neutral shaped mouth) *

Mark only one oval.

	1	2	3	4	5	6	7	
Round shaped mouth	◯	◯	◯	◯	◯	◯	◯	Curved shaped mouth/ Smiling

21. Rate the animation by looking at the teeth *

Mark only one oval.

	1	2	3	4	5	6	7	
Teeth not visible	◯	◯	◯	◯	◯	◯	◯	Teeth totally visible

22. Rate the animation by looking at the teeth *

Mark only one oval.

	1	2	3	4	5	6	7	
Teeth closed together	◯	◯	◯	◯	◯	◯	◯	Teeth wide apart

23. Rate the animation by looking at the face (Select 4 if the face is neutral) *

Mark only one oval.

	1	2	3	4	5	6	7	
Face contracts	◯	◯	◯	◯	◯	◯	◯	Face expands

Rating of animation 3 of 6

Rate the following animation:

http://youtube.com/watch?v=rik2qZXxhqQ

24. Rate the animation by looking at the forehead (Select 4 if the forehead does not move) *

Mark only one oval.

	1	2	3	4	5	6	7	
Forehead moves down/ Scowl	◯	◯	◯	◯	◯	◯	◯	Forehead moves up/ Frown

25. Rate the animation by looking at the eyebrows (Select 4 if the eyebrows do not move) *

Mark only one oval.

	1	2	3	4	5	6	7	
Eyebrows move down	◯	◯	◯	◯	◯	◯	◯	Eyebrows move up

26. Rate the animation by looking at the eyes (Select 4 if the eyes do not move) *

Mark only one oval.

	1	2	3	4	5	6	7	
Eyes close tightly	◯	◯	◯	◯	◯	◯	◯	Eyes open wide

27. Rate the animation by looking at the cheeks (Select 4 if the cheeks do not move) *

Mark only one oval.

	1	2	3	4	5	6	7	
Cheeks move down	◯	◯	◯	◯	◯	◯	◯	Cheeks move up

28. Rate the animation by looking at the mouth *

Mark only one oval.

	1	2	3	4	5	6	7	
Mouth remains closed	◯	◯	◯	◯	◯	◯	◯	Mouth opens widely

29. Rate the animation by looking at the mouth shape (Select 4 if it is a neutral shaped mouth) *

Mark only one oval.

	1	2	3	4	5	6	7	
Round shaped mouth	◯	◯	◯	◯	◯	◯	◯	Curved shaped mouth/ Smiling

30. Rate the animation by looking at the teeth *

Mark only one oval.

	1	2	3	4	5	6	7	
Teeth not visible	◯	◯	◯	◯	◯	◯	◯	Teeth totally visible

31. Rate the animation by looking at the teeth *

Mark only one oval.

	1	2	3	4	5	6	7	
Teeth closed together	◯	◯	◯	◯	◯	◯	◯	Teeth wide apart

32. Rate the animation by looking at the face (Select 4 if the face is neutral) *

Mark only one oval.

	1	2	3	4	5	6	7	
Face contracts	◯	◯	◯	◯	◯	◯	◯	Face expands

Rating of animation 4 of 6

Rate the following animation:

http://youtube.com/watch?v=LE-XQEXq_QY

33. Rate the animation by looking at the forehead (Select 4 if the forehead does not move) *

Mark only one oval.

	1	2	3	4	5	6	7	
Forehead moves down/ Scowl	◯	◯	◯	◯	◯	◯	◯	Forehead moves up/ Frown

34. Rate the animation by looking at the eyebrows (Select 4 if the eyebrows do not move) *

Mark only one oval.

	1	2	3	4	5	6	7	
Eyebrows move down	◯	◯	◯	◯	◯	◯	◯	Eyebrows move up

35. Rate the animation by looking at the eyes (Select 4 if the eyes do not move) *

Mark only one oval.

	1	2	3	4	5	6	7	
Eyes close tightly	◯	◯	◯	◯	◯	◯	◯	Eyes open wide

36. Rate the animation by looking at the cheeks (Select 4 if the cheeks do not move) *

Mark only one oval.

	1	2	3	4	5	6	7	
Cheeks move down	◯	◯	◯	◯	◯	◯	◯	Cheeks move up

37. Rate the animation by looking at the mouth *

Mark only one oval.

	1	2	3	4	5	6	7	
Mouth remains closed	◯	◯	◯	◯	◯	◯	◯	Mouth opens widely

38. Rate the animation by looking at the mouth shape (Select 4 if it is a neutral shaped mouth) *

Mark only one oval.

	1	2	3	4	5	6	7	
Round shaped mouth	◯	◯	◯	◯	◯	◯	◯	Curved shaped mouth/ Smiling

39. Rate the animation by looking at the teeth *

Mark only one oval.

	1	2	3	4	5	6	7	
Teeth not visible	◯	◯	◯	◯	◯	◯	◯	Teeth totally visible

40. Rate the animation by looking at the teeth *

Mark only one oval.

	1	2	3	4	5	6	7	
Teeth closed together	◯	◯	◯	◯	◯	◯	◯	Teeth wide apart

41. Rate the animation by looking at the face (Select 4 if the face is neutral) *

Mark only one oval.

	1	2	3	4	5	6	7	
Face contracts	◯	◯	◯	◯	◯	◯	◯	Face expands

Rating of animation 5 of 6

Rate the following animation:

http://youtube.com/watch?v=LCY2Ku_xZig

42. Rate the animation by looking at the forehead (Select 4 if the forehead does not move) *

Mark only one oval.

	1	2	3	4	5	6	7	
Forehead moves down/ Scowl	◯	◯	◯	◯	◯	◯	◯	Forehead moves up/ Frown

43. Rate the animation by looking at the eyebrows (Select 4 if the eyebrows do not move) *

Mark only one oval.

	1	2	3	4	5	6	7	
Eyebrows move down	◯	◯	◯	◯	◯	◯	◯	Eyebrows move up

44. Rate the animation by looking at the eyes (Select 4 if the eyes do not move) *

Mark only one oval.

	1	2	3	4	5	6	7	
Eyes close tightly	◯	◯	◯	◯	◯	◯	◯	Eyes open wide

45. Rate the animation by looking at the cheeks (Select 4 if the cheeks do not move) *

Mark only one oval.

	1	2	3	4	5	6	7	
Cheeks move down	◯	◯	◯	◯	◯	◯	◯	Cheeks move up

46. Rate the animation by looking at the mouth *

Mark only one oval.

	1	2	3	4	5	6	7	
Mouth remains closed	◯	◯	◯	◯	◯	◯	◯	Mouth opens widely

47. Rate the animation by looking at the mouth shape (Select 4 if it is a neutral shaped mouth) *

Mark only one oval.

	1	2	3	4	5	6	7	
Round shaped mouth	◯	◯	◯	◯	◯	◯	◯	Curved shaped mouth/ Smiling

48. Rate the animation by looking at the teeth *

Mark only one oval.

	1	2	3	4	5	6	7	
Teeth not visible	◯	◯	◯	◯	◯	◯	◯	Teeth totally visible

49. Rate the animation by looking at the teeth *

Mark only one oval.

	1	2	3	4	5	6	7	
Teeth closed together	◯	◯	◯	◯	◯	◯	◯	Teeth wide apart

50. Rate the animation by looking at the face (Select 4 if the face is neutral) *

Mark only one oval.

	1	2	3	4	5	6	7	
Face contracts	◯	◯	◯	◯	◯	◯	◯	Face expands

Rating of animation 6 of 6

Rate the following animation:

http://youtube.com/watch?v=izf_DXzrBjM

51. Rate the animation by looking at the forehead (Select 4 if the forehead does not move) *

Mark only one oval.

	1	2	3	4	5	6	7	
Forehead moves down/ Scowl	◯	◯	◯	◯	◯	◯	◯	Forehead moves up/ Frown

52. Rate the animation by looking at the eyebrows (Select 4 if the eyebrows do not move) *

Mark only one oval.

	1	2	3	4	5	6	7	
Eyebrows move down	◯	◯	◯	◯	◯	◯	◯	Eyebrows move up

53. Rate the animation by looking at the eyes (Select 4 if the eyes do not move) *

Mark only one oval.

	1	2	3	4	5	6	7	
Eyes close tightly	◯	◯	◯	◯	◯	◯	◯	Eyes open wide

54. Rate the animation by looking at the cheeks (Select 4 if the cheeks do not move) *

Mark only one oval.

	1	2	3	4	5	6	7	
Cheeks move down	◯	◯	◯	◯	◯	◯	◯	Cheeks move up

55. Rate the animation by looking at the mouth *

Mark only one oval.

	1	2	3	4	5	6	7	
Mouth remains closed	◯	◯	◯	◯	◯	◯	◯	Mouth opens widely

56. Rate the animation by looking at the mouth shape (Select 4 if it is a neutral shaped mouth) *

Mark only one oval.

	1	2	3	4	5	6	7	
Round shaped mouth	◯	◯	◯	◯	◯	◯	◯	Curved shaped mouth/ Smiling

57. Rate the animation by looking at the teeth *

Mark only one oval.

	1	2	3	4	5	6	7	
Teeth not visible	◯	◯	◯	◯	◯	◯	◯	Teeth totally visible

58. Rate the animation by looking at the teeth *

Mark only one oval.

	1	2	3	4	5	6	7	
Teeth closed together	◯	◯	◯	◯	◯	◯	◯	Teeth wide apart

59. Rate the animation by looking at the face (Select 4 if the face is neutral) *

Mark only one oval.

	1	2	3	4	5	6	7	
Face contracts	◯	◯	◯	◯	◯	◯	◯	Face expands

Please click submit so the data is received. I would like to remind you that all data is used solely for statistical purposes. If you have any further questions you can send an email to taissa.ribeiro@tecnico.ulisboa.pt.