Master Thesis

Non-verbal Emotional Dictionary

Automatic generation of facial expressions from text input

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ABSTRACT

A human face is an extremely important source of information during human communication. We learn to recognize facial expressions long before we learn to communicate verbally. Facial expressions are the most effective way to communicate our emotions. For years most researchers centred their attention in the automatic recognition of facial expressions and the most important for them was the recognition of the shape of mouth, eyes and eyebrows. Nowadays, researchers are getting more interested in the automatic generation of facial expressions using an input text. This approach can be of a big importance in many disciplines, such as human communication through computer interfaces and games.

Based on this approach, my Master thesis will be focused on building a Non-verbal Emotional Dictionary (NED) where the most important aspect is the relation between from one side an emotional word, and from the other side its corresponding facial expression coded by Action Units (AU) representation and facial expression. This dictionary can then be used as a bridge between an emotional text analyzer and a 3D Talking face system to mimic humane conversations using emotions in a virtual world.

To accomplish this, the database of the NED system should include a number of the most used emotional words with there corresponding AU's. Of course this database will not include all existing emotional words, but will use another database, the Dictionary of Affect Language (DAL) to find the link between the words that are not listed in my database to words that are listed in it.

This database (NED) will help, when combined with a 3D talking face system with a text as its input, in the automatic generation of facial expressions. The idea consists of, given an input text, the system should be able to recognize the different emotions and the mood that this input text contains. In this way the "3D face" system should be, in the future, able to read a text or a story as emotionally as a human would do. Using such technology we will achieve a big step in the future of the human communication in the digital world.

PREFACE

I want to take this opportunity to express my gratitude to all the people for their contribution and support they gave me to accomplish this thesis. This thesis project has taken a lot of effort from all of them. Nevertheless the time has come to express my gratitude to the following people for their contribution and support because I could not have done it without their help.

First of all, I would like to thank my advisor Prof. Drs. Dr. Rothkrantz, who gave me much help and with his enthusiasm during the duration of this project. And finally for his guidance to bring this thesis to a good end. I would also like to thank all participants who voluntarily participated in my experiment for data acquisition and application testing.

Next, many thanks go to my parents, for their unfailing support over the years. I want to express my gratitude to them for always backing me up from distance. Finally, special thanks to my wife who stood by me along this journey and looked after me every day. Thank you for motivating and supporting me in difficult times. Thank you for your love and belief in me.

Mehdi Biyaye

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EXTENDED SUMMARY

The goal of my Master thesis, at the Man Machine Interaction Group of the Delft University of Technology, is to build a Non-verbal Emotional Dictionary for emotional expressions using emotional words as input text. The Non-verbal Emotional Dictionary (NED) application gets an emotional word as an input, and from that it will generate the output. This output will be a translation of this emotional word in the form of the corresponding Action Unite (AU) combination with its representation in the 2D octants space related to Pleasure-Activation and an emotional face with the appropriate facial expression.

To meet this goal, a number of research objectives were established and specific tasks were undertaken. One of the research objectives was to determine how emotions could be recognized from text, in the case of this thesis it was from a word, and how to represent them by facial expression. The answer to the first part of the question about the recognition of emotions in words was by classifying those words by their Pleasantness and Activation scores. In fact, Whissell [12] have developed the Dictionary of Affect in Language (DAL) in an attempt to quantify emotion in language. In the Whissell's dictionary thousands of words have been rated in terms of their Pleasantness and Activation. So by using those data I have accomplished the first part of recognitions of emotions in words. The second part was the use of these scores. Based on Russell's and Desmet's [7][8] researches, 41 emotion words were collected that were not ambiguous. Those 41 emotional words will form the basis of the comparison of the data from Whissell's dictionary. Next, the answer to the second part of the question about the representation of those emotions in facial expressions was by using the Facial Expression Modeller application of Anna Wojdeł [19] to represent each emotion with a facial expression based on Action Units. Paul Ekman and Wallace F. Friesen [1][3] introduced Facial Action Coding System (FACS). It was designed to aid human observers in describing facial expressions in terms of visually observable movements on the human face. In FACS each facial expression is described in terms of AU's. AU is a basic element of any facial movement and can be seen as being analogous to phonemes in speech. Each AU is controlled by contraction or relaxation of a single muscle or a small set of strongly related muscles. With the activation of a number of Action Unites an emotion could represented. Most emotions are blended emotions, a combination of a fixed set of basic emotions. Most researchers take different set of basic emotions. In my research 41 words are selected as basic, to represent each emotion. But because it was not possible in the project to create a facial expression for each one of the thousands of words that Whissell's dictionary contains, it was chosen to only represent the 41 words from Russell's and Desmet's experiences due to their non ambiguity. And then to use the Pleasantness and Activation scores of Whissell's dictionary and compare them to the scores of the Russell's and Desmet's 41 emotional words. In this way, I was able to assign a facial expression to all the words from Whissell's dictionary.

The next task undertaken to meet the objectives was to represent the data gathered and presenting a way to use it. This task was to design and implement a system to analyse and recognize emotional words. For this purpose the NED application was implemented. Given any emotional word, the NED web application is able to find its emotional representation in the 2D octants space related to Pleasure-Activation and give a number of information about its emotional status and illustrate this word with an emotional face. To accomplish this, the NED application operates in 3 different levels. Each level represents a stage to find the appropriate representation of an emotional word. If a stage isn't able to find the correct information, the next stage is triggered to analyze the input in next level. In the first level, the application will search for the given emotional word in the database of 41 most used emotional words based on the 41 expressions of Desmet [8]. If the emotional word is not found in this level, the application will then search in the second level. In this level, the application will search for the given word in the database. But this time the search job will be done in a list of synonyms of each one of the 41 emotional words of database. Which takes the amount of direct hits from 41 to almost 200 words. If the input is listed as a synonym of one of those 41 emotional words, the application will give the same representation and emotional face to the input as this emotional word. If not, the application will resume its search in the third and final level. In this level, the application will use the Pleasure and Activation scores and compare them with the Pleasantness and Activation scores of the 41 basic emotional words in the 2D octants space related to Pleasure-Activation. When search finds the nearest scores as a point in the 2D space representing a basic emotion, the application will assign its emotional information to represent the word found from the last level. One of our assumptions is that if words are similar (short Euclidian distance in tow dimensional Pleasant-Activation space) then the corresponding facial expressions are similar (short distance in 43 dimensional AU space). During the research I proved that the semantic labelling of facial expressions us rather complex. One emotion can be expressed in many ways, and different AU's have different weighs. To give an example Happiness can be expressed by corners of the mouth upwards and eyes squeezed. But some people laugh with open mouth and open eyes.

Finally, I have tested the NED application by letting a number of persons use it. Unfortunately, a fully testing of the system was not possible. Due to the lack of time, I couldn't let enough users test the system to get complete result. Especially results regarding the emotional words colleted from Whissell's dictionary. But one result was that some users were not completely satisfied with the facial expressions generated from a few number of emotional words of the Whissell's dictionary. Which means that the Pleasure and Activation scores for these words could be not for 100% corresponding to the meaning of these words. Due to the huge amount of the words gathered from Whissell's dictionary, complete test of the application concerning especially the Pleasure and Activation scores has been put as a recommendation to future work. Nevertheless, after the tests I came to the conclusion and I have shown that the performance of the NED website, concerning aspects such as the usability and speed were more than accepted and appreciated by users. Indeed, this was very clear based on the comments of the users that the Non-verbal Emotional Dictionary (NED) website is easy to understand and to use. The user did not get any kind of training. They were able to intuitively relate the actions needed to use the functionalities of the application.

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LIST OF ABBREVIATIONS

NED : Non-verbal Emotional Dictionary
AU : Action Unite
AJAX : Asynchronous JavaScript and XML
PHP : Personal Home Page
SQL : Structured Query Language
FEM : Facial Expression Modeller
FACS : Facial Action Coding System
OMCS : Open Mind Common Sense
DAL : Dictionary of Affect in Language
HTML : Hypertext Markup Language
XML : Extensible Markup Language
URL : Uniform Resource Locator
PDA : Personal Digital Assistant
W3C : World Wide Web Consortium
LAMP : Linux-Apache-MySQL-PHP
RDBMS : Relational Database Management System
FDP : Face Definition Parameters
FAP : Face Animation Parameters
MPEG : Moving Picture Expert Group
VHML : Virtual Human Markup Language
FML : Face Modeling Language
XMT : eXtensible MPEG-4 Textual Format
DOM : Document Object Model

1 INTRODUCTION

At first sight all human faces are the same, in a way that all faces have a pair of eyes, a nose, a mouth etc. But a human face is an extremely important source of information. It is the face that plays the most important role in communication between people. We also learn to recognize facial expressions long before we learn to communicate verbally. For example the face does not only gives us the primary information about the person we are talking with like its sex and age, but also gives as a number of extra communicative functions like how we manage the conversation and how we express ourselves towards what is being said. The face is also an excellent way in a conversation for a confirmation or being surprised without using any word. But yet the most important of all is that facial expressions are the most effective way to communicate our emotions.

For years human communication using computers has been dominated by a keyboard and a mouse. It would be better if we could communicate using computers as we communicate face-to-face. Which conserves every emotional and natural aspect of communications. To accomplish this, computers should recognise and understand emotions in a multimodal way and communicate them to the other person we are communicating with.

1.1. Problem overview

Facial animation is a subject of interest of researchers from different disciplines like computer graphics, artificial intelligence and psychology. Facial animation applications are used in very diverse areas of our live like in the entertainment industry, movies, computer games and also in the medical world and in multi-modal learning and teaching. For years most researchers centred their attention in the automatic recognition of facial expressions and the most important for them was the recognition of the shape of mouth, eyes and eyebrows. Nowadays, researchers are getting more interested in the automatic generation of facial expressions using an input text. This approach can be of a big importance in many disciplines, such as human communication through computer interfaces and games, where people can still have natural / emotional communication even without face-to-face contact. Based on this approach, this thesis will be focused on building a non-verbal emotional dictionary that will enable the automatic recognition of emotions in text and generate facial expressions using an input text.

1.2. Societal relevance and possible applications

As stated before, researchers from different disciplines are very interested in the automatic generation of facial expressions from the analysis of text as an input because we use it in many areas of our live. This approach has a very importance in many disciplines, such as human communication through computer interfaces and games, where people can still have natural communication even without face-to-face contact but by using 3D personages. 3D personages like the new Avatars that Microsoft uses in the New Xbox Live Experience of their Xbox 360.

Because emotions play a very crucial role in human face-to-face communication, it is very important to understand the human emotions. Also emotions influence our conversations and are at the origin of a constant motion in our face when we talk to each other, those motions are also called facial expressions and differ from one emotion to another.

The use of methods for the automatic generation of facial expressions from the analysis of text as an input will generate a more human like communication. When combined with a 3D talking face system, it will improve the way people can communicate in a very natural way using multiple communication technologies without seeing each other. For example by MSN alike programmes without using webcams, in this case a 3D face modelled as a duplication of the user you are communicating with could read the text being typed in real time. Another example is having an email application where we can customise 3D faces for all our contacts, then those 3D faces will read each email as if the sender is talking to you on the screen. Not only human communication will profit of such technologies, but also the digital information world will achieve a big step in the future of passing information. News for example could be read via the internet by a 3D presentator in exactly the same way a human will do. In this way passing information could be instantaneous in the whole world using just a mouse click. Also children will get many advantages from such technologies. Not only in case of e-learning when a child gets his lesson at home behind his computer screen, but also when he wants to get his bed time story.

1.3. Research goal

The goal of my Master thesis, at the Man Machine Interaction Group of the Delft University of Technology, is to build a non-verbal emotional dictionary to automatically generate facial expressions. So, given an input text, the system should be able to recognize the different emotions and the mood that this input text contains. Within this system, the most important aspect is the relation between from one side an emotional expression, and from the other side its corresponding Action Units (AU) representation and facial expression. This dictionary can then be used as a bridge between a text analyzer and a 3D Talking face system to mimic humane conversations using emotions in a virtual world.

The idea is to use the Facial Expression Modeller (FEM) of Anna Wojdeł [19]. The FEM is a system for the generation of facial expressions. With the use of the FEM application, the idea is to build an application where its input will be an emotional word, and the output will be a translation of this emotion in the form of the corresponding AU's with an emotional face. This idea can be illustrated in Figure 1:

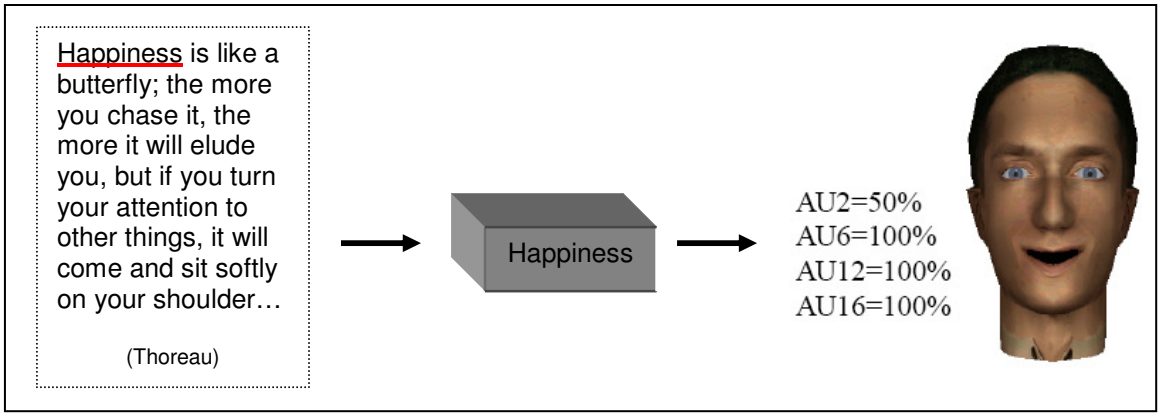


Figure 1: An idea of the interface of the application

As we see in this figure, a user will be able to search for an emotional word, in this case the emotional word 'happiness'. As a result of this search, he will get a number of information over the emotional state of this word. Information like the corresponding AU's combination and the appropriate emotional face.

To accomplish this, the database of this non-verbal emotional dictionary should include a number of the most used emotional words with there corresponding AU's. Of course this database will not include all existing more than two thousands emotional words. Many words are more or less related to each other; we have synonyms, antonyms … To bridge the gap we will use another database to find the link between the words that are not listed in my database to the words that are listed in it.

1.4. Research questions

The objective of this project is *to build a Non-verbal Emotional Dictionary (NED) for emotion generation/analysis using emotional words as input text*. To reach this goal I will have to answer the next research questions:

a) How to represent emotions by facial expressions?

The way I will represent facial expressions in this project is by using the method Paul Ekman and Wallace F. Friesen introduced: the Facial Action Coding System (FACS) [3]. FACS is a system that was designed to describe facial expressions in how movements on the human face occur. Facial expressions are then described in terms of Action Units (AU's). AU's are controlled by the contraction or the relaxation of muscles of the human face. With the activation of a number of Action Unites an emotion could be represented.

b) How to recognize emotion from text as input in practice?

Analysing text and recognising the emotional words and terms in it is crucial for the understanding of the background information in that text and the mood and feelings in it. The most used methods for textual affect sensing are: keyword spotting, lexical affinity, statistical natural language processing, hand-crafted models, and large-scale real-world knowledge based approach [2]. In section 2.4 I will describe each one of those methods.

c) How to classify emotional words?

Many researchers have been working on the classification of emotional words. Two of the most used approaches are these of Russell [7] and Desmet [8]. Their analysis of the degree of pleasure and the degree of activation of emotional words has helped to create a scoring system to represent emotional words in a 2D space of pleasure vs. activation.

By answering all those questions, I would have set up a good analysis of all the components needed to accomplish my goal. I will have then to specifically determine the methods needed to use and implement those components to build the Non-verbal Emotional Dictionary (NED). In the next section I will describe the methods that will be used and the components that will be implemented.

1.5. Methods

In order to accomplish the goal mentioned in the previous section, I will have to take several steps. Those steps can be defined as follow:

1. Literature research

The first step I took was starting with a literature research to have a complete overview and a good analysis of all the components that are needed to get a system to analyse an input text, recognise the emotions and the mood in it. The main goal of the literature research was to gather knowledge about emotions and facial expressions in human face-to-face communication and the existing methods for the recognition and classification of those emotions and facial expressions.

2. Data acquisition

In this step, all the data needed for the NED application was gathered. Based on the design of the system and its needs, the data was collected from different sources and in different steps. Some steps, due to the big amount of data and its importance in this project, could be seen as sub-projects within this Master thesis. Finally in this step some of the data was to be controlled for its correctness and completeness. This was done in the form of a survey.

3. *Designing and implementing system to analyse emotional words*

The last step of the process involves designing the software system that will be able to recognize emotion. In this step, the structure of and the techniques I used in this system will be explained, as well as the way to analyse and represent emotions. Based on the design of the system, the system was implemented for online use. The system has a very simple and fast user interface.

1.6. Thesis outline

The rest of this report is subdivided into six parts that cover different sections of the problem and its solution.

The next chapter (Ch.2) illustrates the results of the literature research that has been done. As I explained before, the main objective of this research was to gain an understanding of the human emotions and the important of emotions that play a very crucial role in human face-to-face communication and how our emotions influence our conversations and are at the origin of a constant motion in our face when we talk to each other. Those motions are also called facial expressions and differ from one emotion to another.

In chapter 3 I will explain the existing methods for the classification of emotional words. Two of the most important approaches are these of Russell and Desmet. Their analysis of the degree of pleasure and the degree of activation of emotional words has helped to create a scoring system to represent emotional words in a 2D space of pleasure vs. activation.

Then in chapter 4, I will describe the system design of the NED application. First, the design requirements will be presented. Then the global design of the NED system will be explained. After that, the concept of the NED application will be illustrated. In the latest section of this chapter, the different implementation aspects of the NED system will be explained.

Chapter 5 describes the implementation details of the Non-verbal Emotional Dictionary. In section 5.1, the tools used during the development are described. Section 5.2 gives insight into the database structure and data acquisition process of the NED. The implementation details of the NED website are presented in section 5.3.

Chapter 6 details the results of the project. The performance of the NED website will be analyzed. Important aspects of the performance are the usability, speed, extendibility and adaptability and security of the website.

Finally, chapter 7 contains the conclusions of this thesis work, which is organized as follows. First, an evaluation of the results based on the problem definition is summarized. Then, the future work of what can be done to further development of the system is explained.

2 LITERATURE RESEARCH

An understanding of the human emotions is important because emotions play a very crucial role in human face-to-face communication and how our emotions influence our conversations and are at the origin of a constant motion in our face when we talk to each other. Those motions are also called facial expressions and differ from one emotion to another.

In this chapter I will explain what emotions and facial expressions are and why they are so important in our daily face-to-face communications. Then I will illustrate how to recognise and represent facial expressions and I will elaborate on some methods for textual affect sensing. After that I will present some face modeling and animation languages where I will elaborate one the Face Modeling Language and the iFace application that uses it. Finally I will talk about what to expect from a 3D emotional talking face.

2.1. Face-to-face communications

We learn how to communicate with facial expressions long before learn to speak and use words and sentences. The human face is in continuous motion and is therefore a very important way of communication between humans. Facial expressions are very efficient in providing background information about the mood of the person we are talking to and what this person is really trying to say. For example we often shake the head vertically as a sign of confirmation and horizontally as a sign of disagreement and we also use facial expressions to draw the attention of the person we want to talk.

2.2. Emotions

Emotion is an affective state involving a high level of activation, intuitive changes and strong feelings. It is still important to differentiate the word emotion from other affective states like moods and sentiments. We can for example have mixed emotions; we can feel more than one emotion at the same time. This is not the case for moods. As I said before, the human face is changing all the time, and the changes that happen while experiencing an emotion are for example changes in blood pressure and muscle tension.

Based on researches of psychologists Paul Ekman and Wallace Friese [1], on relations between emotions and facial expressions, they found that there are six basic emotions that can be easily distinguished from each other on the basis of facial activities:

- *Anger* is an emotion that can be provoked by frustration, physical threat;
- *Disgust* involves feeling of dislike to taste, smell, touch, appearance, or some action;
- *Fear* occurs when person is expecting to be physically or psychologically hurt;
- *Happiness* mostly experienced together with excitement, pleasure, or relief;
- *Sadness* is a feeling of suffering caused by loss, disappointment, or desperation;
- *Surprise* is evoked by unexpected or misexpected event.

Based on those six basic emotions, the NED application will not have sufficient basic emotions to represent the diversity that emotional words could have. For this reason, I will use a lager number of basic emotions. To be exact, I will use 41 different emotions. Emotions that have been found by researches as not being ambiguous. In section 3.1. I will explain and elaborate on these emotions.

The next important step after understanding emotions, is to know how to represent them. For this purpose a coding system to observe and represent emotions in human faces has been developed. In the next section I will explain and describe this coding system.

2.3. Facial movements in speech

Ekman [20] scientifically investigated the relation of speech and eyebrow movement. In his revolutionary research we find that certain words and also large parts of a sentence are often accompanied by raising or lowering of both the inner and the outer part of the brows. These facial gestures are called *batons*, when only one word is emphasized, or *underliners* for multiple words. The type of movement depends largely on the context. For example the brows will most probably be lowered in situations of perplexity, doubt or other difficulties. Also eyebrow movements also serve as *punctuators*. Lowered brows indicate difficulties, doubt, or perplexity, but also seriousness and importance. To indicate that a question is being asked, eyebrows are often raised. During pauses caused by the speaker searching for words, raised brows occur accompanied by an upward gaze direction. Looking at a still object to reduce visual input is another typical behaviour for word searches. Especially in conjunction with an '*errr*' sound, eyebrows may also be lowered in this situation. If these kinds facial expressions in a face to face communication are missing, it will become difficult to understand the meaning of the message, to underline that a question is being asked, to express emotions or opinions [22].

2.4. Facial expressions

Facial expressions can add an emotional state to the information which helps us to understand a message according to the intention of the subject. There are many methods for describing the changes on a human face that form a specific facial expression. One of

the methods is to provide a verbal description of the phenomenon e.g. “eyes shut and mouth a little bit open”. The prime example of the codified version of verbal description is Facial Action Coding System (FACS), widely used by psychologists.

The FACS system was introduced by Paul Ekman and Wallace F. Friesen [3]. It was designed to aid human observers in describing facial expressions in terms of visually observable movements on the human face. In FACS each facial expression is described in terms of Action Units (AU’s). AU is a basic element of any facial movement and can be seen as being analogous to phonemes in speech. According to Ekman and Friesen, each facial expression can be described as an activation of an appropriate set of AU’s. Together with the set of AU’s, FACS provides also the rules for AU detection in combinations of two and more AU’s. Using these rules facial expression can be uniquely encoded as set of Action Units that produce a given expression.

The obtained facial expression scoring is universal across a broad spectrum of disciplines. Therefore FACS is widely used by psychology researchers because the data obtained using this system insures an international and multilingual exchange of information and experiences in project of different domains. The use of FACS is also very common among researchers that work with facial expression analysis by machines, such as analysing images or videos taken of persons expressing different facial expression by the use of calculation of the movements of single muscles of the human face. Movements that computers recognise as fixed points in the human face.

Action Units

An AU represents the simplest visible facial movement, which cannot be decomposed into more basic ones. Each AU is controlled by contraction or relaxation of a single muscle or a small set of strongly related muscles. Activation of an AU is described by observable changes in the face caused by activity of the underlying muscles. Ekman and Friesen[3] introduced in 1978 44 AU’s describing movements on the surface of the face, 6 AU’s for gaze direction and 8 AU’s representing head movements. A list of the AU’s as introduced by Ekman and Friesen is given in Table 1.

Face AU	Description	Face AU	Description
AU1	Inner Brow Raiser	AU24	Lip Presser
AU2	Outer Brow Raiser	AU25	Lips Part
AU4	Brow Lowerer	AU26	Jaw Drop
AU5	Upper Lid Raiser	AU27	Mouth Stretch
AU6	Cheek Raiser	AU28	Lip Suck
AU7	Lid Tightener	AU29	Jaw Thrust
AU8	Lips Toward Each Other	AU30	Jaw Side To Side
AU9	NoseWrinkler	AU31	Jaw Clencher
AU10	Upper Lip Raiser	AU32	Lip Bite
AU11	Nasolabial Furrow Deepener	AU33	Cheek Blow
AU12	Lip Corner Puller	AU34	Cheek Puff
AU13	Cheek Puffer	AU35	Cheek Suck
AU14	Dimpler	AU36	Tongue Bulge
AU15	Lip Corner Depressor	AU37	Lip Wipe
AU16	Lower Lip Depressor	AU38	Nostril Dilator

AU17	Chin Raiser	AU39	Nostril Cimpressor
AU18	Lip Puckerer	AU41	Lid Drop
AU19	Tongue Show	AU42	Slit
AU20	Lip Stretcher	AU43	Eyes Closed
AU21	Neck Tightener	AU44	Squint
AU22	Lip Funneler	AU45	Blink
AU23	Lip Tightener	AU46	Wink

Head AU	Description	Eyes AU	Description
AU51	Head Turn Left	AU61	Eyes Turn Left
AU52	Head Turn Right	AU62	Eyes Turn Right
AU53	Head Up	AU63	Eyes Up
AU54	Head Down	AU64	Eyes Down
AU55	Head Tilt Left	AU65	Walleye
AU56	Head Tilt Right	AU66	Crosseye
AU57	Head Forward		
AU58	Head Back		

Table 1: A list of AU's as introduced by Ekman and Friesen

From this table we can, as stated before, distinguish between 3 different groups of AU's. The first group contains 30 AU's describing movements on the surface of the face. Movements like making the lips separate or sucked into the mouth, raising or lowering the brows and opening or closing of the eyes. The second group contains 8 AU's that controls the directions of the head. With those 8 AU's we can turn the head to the left or to the right, we can make him look down or up and also make him tilt left or right. The last group containing 6 AU's is used to control the direction the eyes are looking to. With the combination of a number of those AU's, we could describe an emotion and represent it as a facial expression.

2.5. Methods for textual affect sensing

Analysing text and recognising the emotional words and terms in it is crucial for the understanding of the background information in that text and the mood and feelings in it. We, as human, do this in a natural and automatic way. But how do computers this. The most used methods for textual affect sensing can be grouped into the following categories: keyword spotting, lexical affinity, statistical natural language processing, hand-crafted models, and large-scale real-world knowledge based approach [2]. I will deal with each one of them in the following sections of this chapter.

2.5.1. Keyword spotting

Keyword spotting is the most simple and the most popular approach because it's accessible and economic. Text is classified into affect classes based on the presence of affect words like "distressed", "enraged", and "happy". A weakness of this approach may

be the poor recognition of affect when negation is involved. For example while this method will correctly classify the sentence “today was a happy day” as being happy, it will possibly fail on a sentence like “today wasn’t a happy day at all”. Also this method will fail with sentences with strong emotions but with no emotional keywords like “My husband just filed for divorce and he wants to take custody of my children away from me”.

2.5.2. Lexical affinity

This method is a bit more complicated than keyword spotting. It doesn’t only detect affect words, but it also assigns arbitrary words a probabilistic resemblance with a particular emotion. For example “accident” might be assigned a 75% probability of being negative if used like in “car accident” and “hurt by accident”.

2.5.3. Statistical natural language processing

This method uses a different approach. By providing a machine learning algorithm a large training quantity of affectively annotated texts, it is possible for the system to not only learn the affective valence of affect keywords as in the keyword spotting approach, but such a system can also take into account the valence of other arbitrary keywords (like lexical affinity), punctuation, and word co-occurrence frequencies. This method can only be efficient and work with acceptable accuracy when given a sufficiently large text input.

2.5.4. Large-scale real-world knowledge based approach

This method relies on having large-scale real-world knowledge about people’s common affective attitudes toward situations, things, people, and actions. Examples of those large-scale generic knowledge bases of commonsense are: Cyc [4], Open Mind Common Sense (OMCS) [5], and Thought Treasure [6]. The most interesting is the OMCS because its English-sentence representation of knowledge is rather easy to manipulate and analyze using shallow language parsers. In OMCS, commonsense is represented by English sentences that fit into about 20 sentence patterns expressing a variety of different commonsense relations between concepts. Here are some affective examples of knowledge in OMCS:

- *Some people find* ghosts *to be* scary;
- *A person wants* popularity;
- *A consequence of* riding a rollercoaster *may be* excitement.

Within this project I will use the keyword approach. This choice is simply based on the fact that the goal of this project is to analyse single emotional words to provide them with different emotional information. While the other methods are more efficient in the analysis of the emotional status of sentences or entire texts.

2.6. Face modeling and animation languages

Analysing texts and recognising the different emotions and moods in them is very important. What also important is, is to translate this texts to files that 3D Facial application can read. Face Modeling and Animation Languages are special languages that describe in details facial movements and how to control them when show one or more emotions.

2.6.1. Existing facial animation languages

Many researches have been done to represent and describe certain facial actions with predefined sets of “codes”. One of techniques is the MPEG-4 that includes Face Definition Parameters (FDPs) and Face Animation Parameters (FAPs). FDPs define a face by giving measures for its major parts and features such as eyes, lips, and their related distances, and FAPs encode the movements of these facial features. Together they allow a receiver system to create a face (using any graphics method) and animate that face based on low level commands in FAPs. The concept of FAP can be considered a practical extension of Facial Action Coding System (FACS) used earlier to code different movements of facial features for certain expressions and actions. FAPs do not need to be used with a synthetic face and geometric models, they are independent of animation method and simply define the desired movements.

Virtual Human Markup Language (VHML) is an XML-based language for the representation of different aspects of “virtual humans”. In VHML, timing of animation-elements in relation to each other and in relation to the realization of text is achieved via the attributes “duration” and “wait” that take a time value in seconds or milliseconds.

Some of the conclusions so far are that FACS and MPEG-4 FAPs provide the means of describing low-level face actions but they do not cover temporal relations and higher-level structures. Languages like SMIL do this in a general purpose form for any multimedia presentation and are not customized for specific applications like face animation.

A language bringing the best of these two together, customized for face animation, seems to be an important requirement. Face Modeling Language (FML) is designed to do so, filling the gap in XMT framework for a face animation language. Therefore I have chosen to use FML in my project as input file for the 3D Facial application written in a Face Modeling and Animation Language.

2.6.2. Face Modeling Language (FML)

Face Modeling Language (FML) is a Structured Content Description mechanism based on Extensible Markup Language. The main ideas behind FML are:

- Hierarchical representation of face animation;
- Timeline definition of the relation between facial actions and external events;
- Defining capabilities and behaviour templates;
- Compatibility with MPEG-4 XMT and FAPs;
- Compatibility with XML and related web technologies and existing tools.

Fundamental to FML is the idea of Structured Content Description. It means a hierarchical view of face animation capable of representing simple individually-meaningless moves to complicated high level stories. This hierarchy can be thought of as consisting of the following levels (bottom-up):

- Frame, a single image showing a snapshot of the face (Naturally, may not be accompanied by speech);
- Move, a set of frames representing linear transition between two frames (e.g. making a smile);
- Action or Act, a "meaningful" combination of moves;
- Story, a stand-alone piece of face animation.

FML defines a timeline of events (Figure 2) including head movements, speech, and facial expressions, and their combinations. Since a face animation might be used in an interactive environment, such a timeline may be altered/determined by a user. So another functionality of FML is to allow user interaction and in general event handling (Notice that user input can be considered a special case of external event.). This event handling may be in form of:

- Decision Making; choosing to go through one of possible paths in the story
- Dynamic Generation; creating a new set of actions to follow

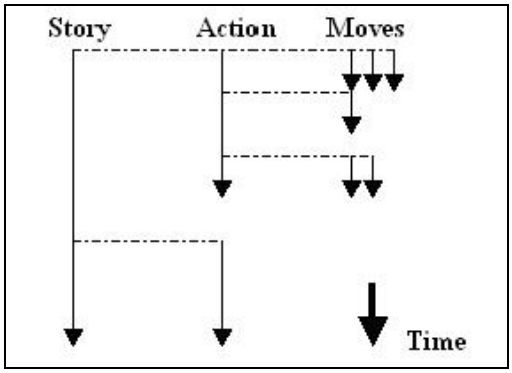


Figure 2: FML timeline and temporal relation of face activities

A major concern in designing FML is compatibility with existing standards and languages. Growing acceptance of MPEG-4 standard makes it necessary to design FML in a way it can be translated to/from a set of FAPs. Also due to similarity of concepts, it is desirable to use SMIL syntax and constructs, as much as possible. Satisfying these requirements make FML a good candidate for being a part of MPEG-4 XMT framework.

2.6.3. FML document structure

FML is an XML-based language, following the same structural rules (e.g. well-formedness constraints) and sharing the same syntax. The choice of XML as the base for FML is based on its capabilities as a Markup language, growing acceptance, and available system support in different platforms. Figure 3 shows typical structure of an FML document.

```
<fml>
    <model> <!-- Model Information -->
        <model-info-item>
    </model>
    <story> <!-- Animation Time Line -->
        <act>
            <time-container>
                <move-item>
                <...>
            </time-container>
            <...>
        </act>
        <...>
    </story>
</fml>
```

Figure 3: FML Document Map

An FML document consists, at higher level, of two types of elements: model and story. A model element is used for defining face capabilities, parameters, and initial configuration. A story element, on the other hand, describes the timeline of events in face animation. It is possible to have more than one of each element but due to possible sequential execution of animation in streaming applications, a model element affect only those parts of document coming after it.

Face animation timeline consists of facial activities grouped into act modules. Within each group, activities are defined as simple Moves and their temporal relations. The timeline is primarily created using two time container elements, seq and par, corresponding to sequential and parallel temporal relation between moves (Figure 4). A story itself is a special case of sequential time container. The begin times of activities inside a seq and par are relative to previous activity and container begin time, respectively. Story and act are special cases of sequential time container which can only be used at top levels of FML document.

```
<act>
    <seq begin="0">
        <talk>Hello</talk>
        <hdmv end="5" type="0" value="30" />
    </seq>
    <par begin="0">
        <talk>Hello</talk>
        <expr end="3" type="3" value="50" />
    </par>
</act>
```

Figure 4: FML Primary Time Container

FML supports three basic face activities (moves): talking, facial expressions, and 3D head movements. Combined in time containers, they create an FML act. This combination can also be done using nested containers.

Also supported in FML are behavioural templates as a primary means of behavioural modeling. Templates work similar to subroutines in normal programming languages (Figure 5).

```
<model>
    <img file="me.jpg" type="front" />
    <range type="left" value="60" />
    <template name="hi" >
        <seq begin="0">
            <talk>Hello</talk>
            <hdmv begin="0" end="5" type="0" value="30" />
        </seq>
    </template>
</model>
<story>
    <behavior name="hi" />
</story>
```

Figure 5: FML Model and Templates

2.6.4. Advantages of FML

Event Handling and Decision Making

Dynamic and interactive applications require the FML document to be able to make decisions, i.e. to follow different paths based on certain events. To accomplish this, excl time container and event element are added. An event represents any external data, e.g. the value of a user selection. As shown in Figure 6, the new time container associates with an event and allows waiting until the event has one of the given values, then it continues with action corresponding to that value. Iterations are possible through the use of repeat attribute in all time containers which can also be associated to an external event instead of a fixed number.

```
<event name="user" value="-1" />
. . .
<excl event_name="user">
    <talk event_value="0">Hello</talk>
    <talk event_value="1">Bye</talk>
</excl>
```

Figure 6: FML Decision Making and Event Handling

Compatibility

The XML-based nature of this language allows the FML documents to be embedded in web pages. Normal XML parsers can extract data and use them as input to an FML-enabled player, through simple scripting. Such a script can also use XML Document Object Model (DOM) to modify the FML document, e.g. adding certain activities based on user input. This compatibility with web browsing environments, gives another level of interactivity and dynamic operation to FML-based system.

Another aspect of FML is its MPEG -4 compatibility, achieved by:

1. Translation of FML documents to MPEG-4 codes by the media player;

2. Embedded MPEG-4 elements (fap element is considered to allow direct embedding of FAPs in FML document);
3. Translation to MPEG-4 FAPs in XMT framework.

2.6.5. The iFace: a 3D face animation system

iFACE [26] is a parameterized face animation system, i.e. animation is defined and created through activation of groups of parameters interacting with each other as illustrated in Figure 7.

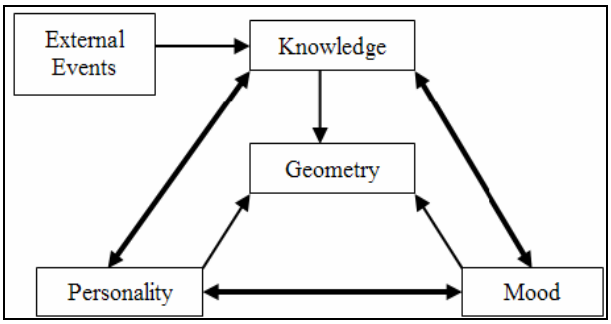


Figure 7: Parameter Spaces for Face Multimedia Object

Geometry is the foundation of facial animation. iFACE uses a hierarchical model that provides different layers of abstraction (such as Features, Components) (Figure 8) on top of head data, each with their own interfaces exposing functionality related to that layer.

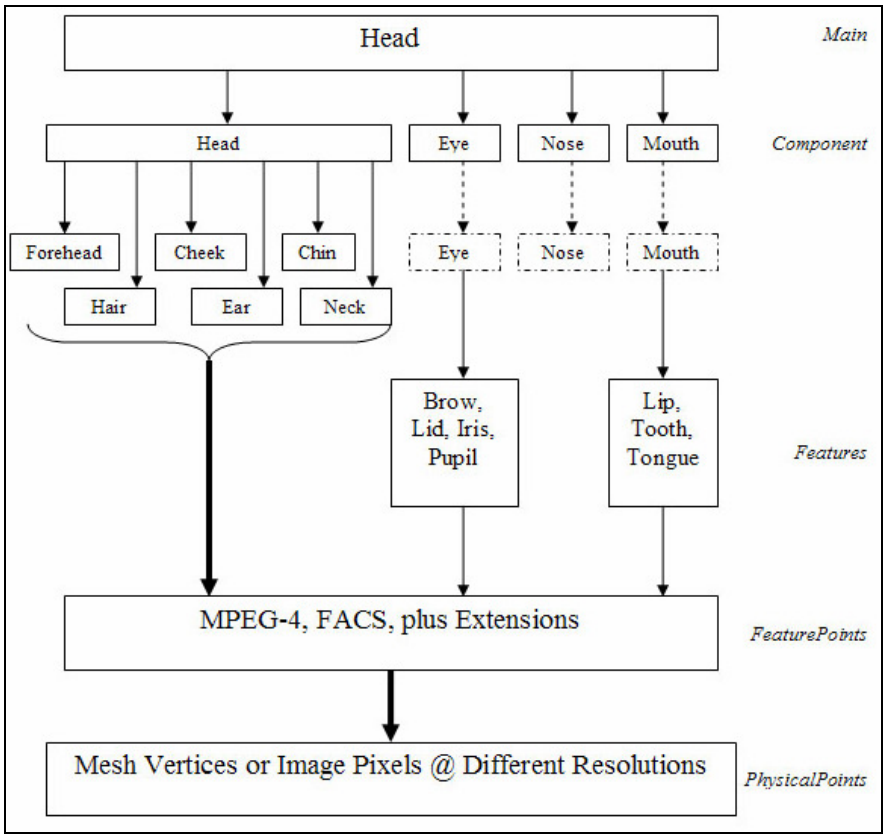


Figure 8: iFace's hierarchical model

The system will translate higher-level functions and commands to lower-level ones, and eventually to point-level manipulation. This means that animators and programmers do not need to be involved in details unless they want to override the default behaviour of the system.

Knowledge, Personality, and Mood are designed as components around the Geometry, exposing their own interfaces for access by the application programs. Knowledge receives the input script and external events, and holds the rules of interaction. All of these are applied to Geometry in the form of parameters at the appropriate layer of abstraction. Personality (which can be configured through input scripts or interactively) suggests facial gestures and states based on the explicit actions requested by Knowledge. For example, if the script requires a piece of speech, Knowledge translates this to a set of phonemes and visemes and their timing, so the Geometry can animate the face. Meanwhile, Personality suggests certain head movements, facial gestures, visemes and expressions that are attributes of the chosen character's personality, based on the content of speech and energy level. Mood applies a base facial state to all the facial actions.

iFACE includes an off-line design environment, iFaceStudio, for creating animations and configuring the head objects, and a wrapper control, FacePlayer, that can be easily used in web forms and similar GUI applications. Using FML we can control the animation by accessing the object methods and properties.

2.7. A 3D emotional talking face

The goal of this literature research to study how to develop a system that can automatically generate of facial expressions. In other words, a 3D Emotional Talking Face. So, given an input text, the system should be able to recognize the different emotions and the mood that this input text contains. To accomplish this goal, I have done this research where I succeeded in getting a complete overview and a good analyse of all the components that I need to get a 3D face system to analyse an input text, recognise the emotions and the mood in it, and to read it in a natural and emotional way like a person will do. I have now reached some understanding of the human emotions, their role in human face-to-face communication, how our emotions influence our conversations and how to sense emotions in words. The next step of the literature research was the study of Face Modeling and Animation Languages. One of these languages is the FML. And also the study of the iFace as a 3D face modeling system which is very well to use with the FML.

This 3D Emotional Talking Face system that, from the analyse of a given an input text, will have to be able to recognize the different emotions and the mood that this input text contains and read this text or a story like a human would should have an architecture which can be decomposed into the following modules:

1. a text segmenter/analyser module;
2. an emotion analyser module;
3. and a face animation system.

The input text should be first segmented by the text segmenter module into paragraphs, sentences, then into independent clauses, which are the smallest story units that can capture an event. The system should now know the grammatical category of each word, i.e., to know if a word is a verb, noun, adjective. Next, using this segmentation, the system should be able to decide which words have to be selected as emotional words. These words will be the input for the next module.

In the emotion analyser module, each parsed and processed sentence should be then evaluated. Using one of the methods for textual affect sensing a scoring function will generates a score for this sentence using the basic six emotions in a formula like:

[*a* happy, *b* sad, *c* anger, *d* fear, *e* disgust, *f* surprise]

So as an output of this module each sentence will be annotated with one of the six basic emotions, or “neutral”. The annotated sentences should be then expressed by the system. A possible system should be the iFace. More over the iFace is explained in the next chapter.

This system architecture could be summarised in the following figure:

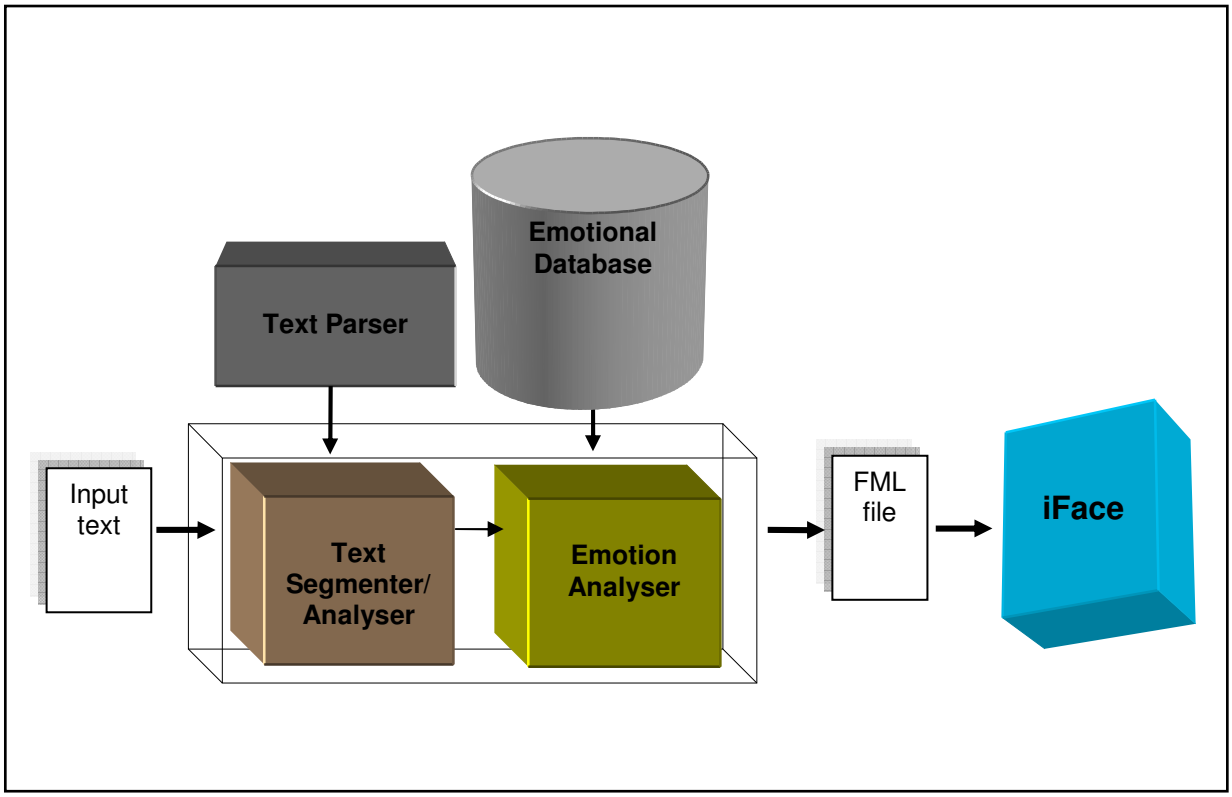


Figure 9: System architecture

In a few words, the input text will be first segmented by the Text Segmenter / Analyser module using a Text Parser. Then the segmented text will be, using the am emotional database and in de emotional Analyser module, translated into an FML file which can then be used in the iFace. The iFace will be then able to read the input text with emotions like a human would do.

2.8. Conclusion

In this chapter we saw how important facial expressions are in communication between humans. They are very efficient in clearing what a person is really trying to say and background information about the mood of this person and his emotional status at this moment. Then I described what emotions are and their relations to facial expressions. Based on researches on those relations, I said first that Paul Ekman and Wallace Friese determined that there are 6 basic emotions: anger, disgust, fear, happiness, sadness and surprise. I explained also why those 6 emotions are not sufficient for this project and, as I will illustrate further in this report, I will use the result of newer researches of Desmet where they specified 41 non ambiguous basic emotions. After explaining the importance of emotions, I describe how to represent them. To do this, a coding system to observe and represent emotions in human faces has been developed. In section 2.4 I explained and described this coding system. The FACS system was introduced by Paul Ekman and Wallace F. Friesen to describe facial expressions in terms of visually observable movements on the human face. These movements are described in terms of AU's. An AU represents a contraction or relaxation of a single muscle or a small set of strongly related muscles of the human face. Those AU's will be used as basic to the composition of a facial expression related to an emotion in this project.

In section 2.5. I explained several methods for textual affect sensing. Those methods are: keyword spotting, lexical affinity, statistical natural language processing and large-scale real-word knowledge based approach. Because the last 3 approaches deals with words within a context or analysing entire text, and because in my project I have to analyze single emotional words provide them with different emotional information, I will use the keyword approach. Simply in the way that given a single emotional word to analyse will result in a number of data and emotional information as we will see in the following chapters.

Then in section 2.6 and 2.7 I elaborated on a general aspect of accomplishing a 3D Emotional Talking Face system. As I said in section 1.2, the use of such a 3D Emotional Talking Face application using methods for the automatic generation of facial expressions from the analysis of text as an input will help to improve the way people can communicate in a very natural way using multiple communication technologies without seeing each other. With figure 9 I illustrated and explained the architecture of such a system which can be decomposed into a text segmenter/analyser module, an emotion analyser module and a face animation system.

The goal of my thesis project as sited in section 1.3, which consist on building a non-verbal emotional dictionary to automatically generate facial expressions, plays a very important role in the future of accomplishing the build of a 3D Emotional Talking Face. One important module of such a system is, as I explained before, represented by an emotion analyser module. The core of this module consists on the ability to analyse emotional words and recognize the different emotions and the mood that this words contains. This very important functionality can not be reached without a good emotional database. This emotional database will be created within this Master project and will be named the Non-verbal Emotional Dictionary.

3 METHODS

Many researchers have been working on the classification of emotional words. Two of the most important approaches are these of Russell [7] and Desmet [8]. Their analysis of the degree of pleasure and the degree of activation of emotional words has helped to create a scoring system to represent emotional words in a 2D space of pleasure vs. activation.

In this chapter I will explain a method for emotional words classification. The method, first developed by Russell [7] and then elaborated by Desmet [8], uses a degree of pleasure and a degree of activation that the meaning of a word contains. In first section of this chapter I will describe this method. Then in section 3.2. I will explain how I will use this method in this project. Finally, in the last section of this chapter I will illustrate how to analyse emotional words further than the emotions collected by Desmet using the Whissell's Dictionary of Affect in Language.

3.1. Russell's and Desmet approaches

In many researches on the English language a list has been defined of more than 200 words that are used to cover the full range of emotions. The meaning of these words contains a degree of pleasure and a degree of activation (in section 3.2. will explain the meaning of those degrees). This is also the same for sentences that contains some of these words; the sentence will then also have these degrees of pleasure and activation that appears because of the combination of these words. Recent attempts to analyse the degree of pleasure and the degree of activation of emotion words have been done by Russell [7] and Desmet [8]. Both depict these degrees on a 2D space of pleasure vs. activation.

Russell used a psychological approach to plot emotional words, in a circular form called the *Circumplex of Emotions*, based on the changing of geometrical features of human expressions when expressing a certain emotion type (figure 10). He claimed that people can use the 2D space to analyse the emotion tendency of each word and their expression in a glance.

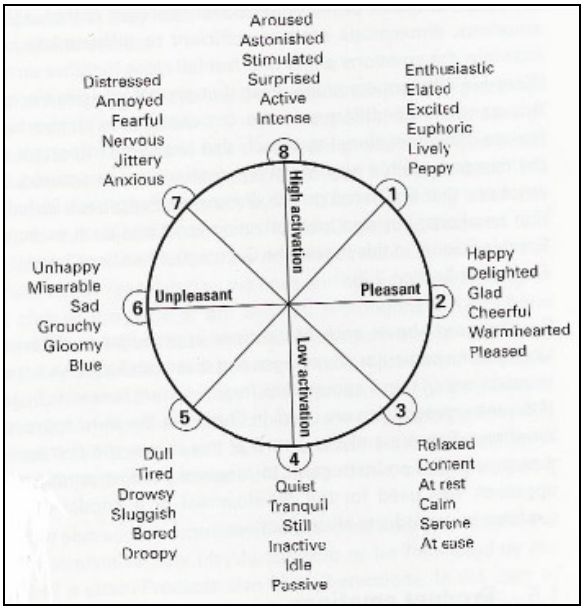


Figure 10: Russell's Circumplex of Emotions

Based on Russell's research, Desmet divided the 2D space into eight octants and conducted experiments. He used 347 emotion words (collected from three books [9] [10] [11]). Trough three experiments he collected 41 emotional words that were not ambiguous. He asked his participants to depict these words on one of the octants. In figure 11 we see how Desmet divided the 2D space in 8 octants and how plotted the 41 non ambiguous emotional words based on those 8 octants. Desmet claimed that these emotion words were used by people to express their emotion toward a product.

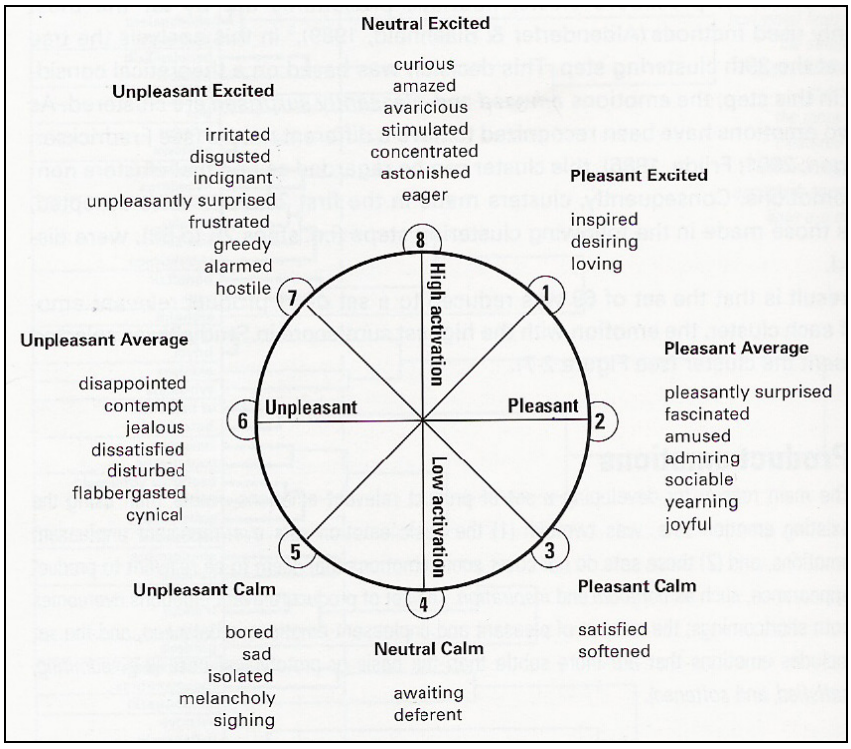


Figure 11: Desmet's classification

Both researches were performed to analyse quantitative values of emotion words based on the social value that was learnt during interaction with others or objects in daily life.

3.2. The pleasure and activation degree of emotional words

The two most common dimensions of emotions are arousal (calm/excite) and valence (negative/positive). The Circumplex model (figure 10), consists in a circular structure around which names for categories blend into another in a continuous form without beginning or end [7]. Terms closer to being synonyms (happy delighted) are closer together on the circle, antonyms (happy and sad) are at opposite end. Unlike a list of emotions, a Circumplex model specifies the degree to which categories are interrelated, the horizontal dimension represents the pleasure-displeasure dimension.

For the purpose of this project I will use the result of the experiments of Estefania González [13]. In her project she gave to the participants a picture with all the emotions and the respective facial expression in the form of labels (based on the 41 expressions of Desmet [8]) and a list of synonyms of each one and asked them to identify and classify them in octants of the *Circumplex of Emotions created* by Russell [7]. The two orthogonal axes in the Circumplex represent the dimension 'pleasantness' and 'activation'. The bipolar dimension (horizontal) 'pleasantness' ranges from unpleasant (e.g. sad) to pleasant (e.g. happy). The dimension activation (vertical) is defined as physiological arousal, and ranges from calm (e.g. melancholy) to excite (e.g. euphoric). Consequently, with these dimensions, expressions can be classified in eight octants. Figure 12 shows the list of emotion words in the form of labels on eight octants for pleasant-unpleasant and passive-active as Estefania used to plot the 41 labels.

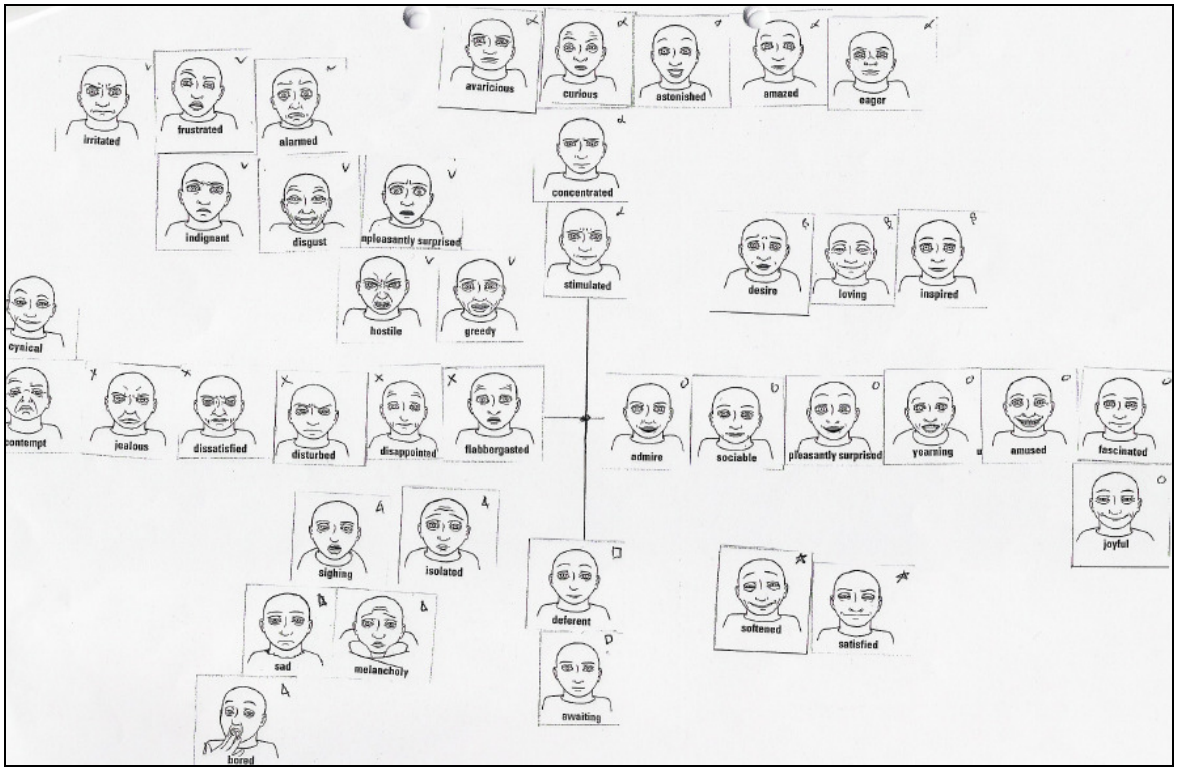


Figure 12: Classification related to Pleasure-Activation by Estefania Conzález

I will use the results of the experiments of Estefania González based on the researches of Desmet to determine the basic 41 non ambiguous emotional words I will use in my project. Also the labels will form the basis I will use to create the different facial expressions needed for my application. In section 5.2. I will elaborate on this.

But with only 41 different emotional words I won't be able to analysis a large number of words with my application. Therefore I will have to search for a source of information for more emotional word. To do this I have to use a dictionary that contains emotional information about a large number of emotional words. Within this information I should find specific variable that I can use to relate to the basic 41 non ambiguous emotional word. Those variables are off course the degree of pleasantness and the degree of activation. That is why I chose the Dictionary of Affect in Language of Whissell. In the following section I describe what this dictionary is and how I will use it.

3.3. Whissell's Dictionary of Affect in Language

Whissell [12] have developed the Dictionary of Affect in Language (DAL) in an attempt to quantify emotion in language. Volunteers viewed many thousands of words and rated them in terms of their Pleasantness, Activation, and Imagery (concreteness). The DAL is embedded in a computer program which is used to score language samples on the basis of these three dimensions. The DAL has been applied to studies of fiction (e.g., Frankenstein, David Copperfield), of poetry (e.g., the work of Frost, Blake), drama (e.g., Shakespeare's tragedies and comedies), advertisements, group discussions, and lyrics (e.g., the Beatles). It has also been used in the selection of words for memory research.

Using a score system based of the three dimensions listed before, the Dictionary of Affect in Language (DAL) is an instrument designed to measure the emotional meaning of words and texts. It does this by comparing individual words to a word list of 8742 words which have been rated by people for their pleasantness, activation and imagery. Given a list of words (for example the words happy, sad and loving), the DAL scoring system will generate an analysis of the emotional meaning of these words. Figure 13 gives an example of a result of the analysis of three emotional words using the three different dimensions: Pleasantness, Activation, and Imagery.

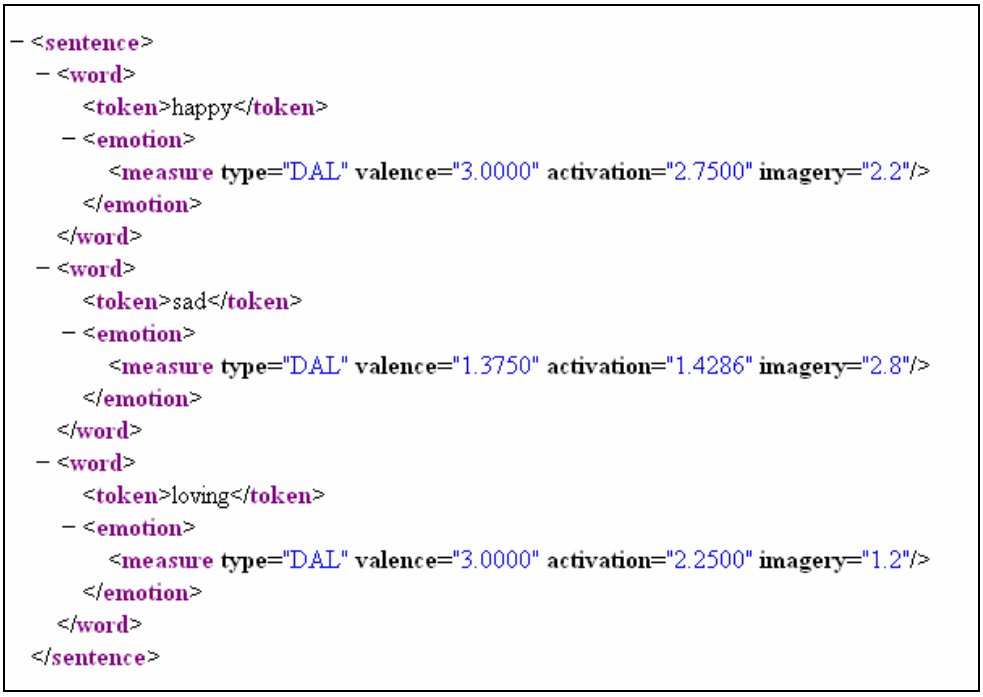


Figure 13: Emotional text recognition using Whissell's Dictionary of Affective Language

Those results are very important to relate to the 41 basic emotions of Desmet. In fact, I will use the Valence value which correspond to the pleasantness degree, and the activation value I get from the DAL to compare them with the pleasantness and activation degrees of the 41 basic emotions to find the nearest one of them. In this way for any given word I will be able to determine a facial expression that illustrates the emotional state of this word. In chapter 5 I will further explain how this will be done.

3.4. Conclusion

In this chapter we saw Russell's [7] and Desmet's [8] method for emotional words classification. They used a degree of pleasure and a degree of activation that the meaning of a word contains, to plot emotional words in a circular form called the *Circumplex of Emotions*. Desmet [8] used Russell's [7] first approach of the *Circumplex of Emotions* and divided the 2D space into eight octants where he plotted the 41 non ambiguous emotional words that he conducted from his experiments.

Then I explained how I will use in this project this method and Russell's [7] experiments results consisting in the 41 non ambiguous emotional words. Finally, in the last section of this chapter I explained that Desmet's 41 words will not be sufficient as data for this project. Therefore I illustrated why I chose to use the Dictionary of Affect in Language of Whissell. I explained that this dictionary uses for all the words it contains the same degree of pleasure and the degree of activation that Desmet's 41 emotional words uses. With the results of a comparison between the 41 emotional words of Desmet and the data of the DAL application using the pleasantness and activation degrees they both contain, I will be able the assign an emotional status to all the words of the DAL application. In the following two chapters, I will explain how I will implement this technique.

4 SYSTEM DESIGN

This chapter describes the system design and implementation of Non-verbal Emotional Dictionary (NED). First, the design requirements will be presented and the choice for a web based application will be explained. Then the global design of the NED system will be explained. After that, the database structure and data acquisition and testing process of the NED database will be explained. At last, the concept of the NED application will be illustrated.

4.1. Requirements

Non-verbal Emotional Dictionary (NED) will be a web application available on the net. I chose to implement my project as a web based application simply because I wanted to this application to reach as many people a possible. Nowadays, people are easily willing to visit a website for 2 main reasons: first they are more surfing on the net more than ever before and second because they would not have to perform any installation in order to use this application. Because it is a web based application, it will also be possible to modify or extend the NED system in future. Because of those facts, there are certain specific requirements to be followed. The main requirements are adaptability, extensibility and modularity.

The techniques that will be used to implement the system can be improved and extended by other students in the future. Therefore, the web application will be set up modularly, but more important is that there will be a separation between the codes of the different functions of the application on one side. On the other side, the “HTML” codes that determine the layout of the application in the form of templates so future improvements can be implemented easily.

A modular component-based architecture and a separation between the codes of the different functions and modules of the application guarantees minimum interdependence between system parts, and secures a future independent and parallel modification and extension of functions without having any effect on the rest of the application.

4.2. Structure

The NED application gets an emotional word as an input, and from it, will generate the output. This output will be a translation of this emotional word in the form of the corresponding AU combination with its representation in the 2D octants space related to Pleasure-Activation and an emotional face. Figure 14 shows the global design of the NED application represented as an UML sequence diagram.

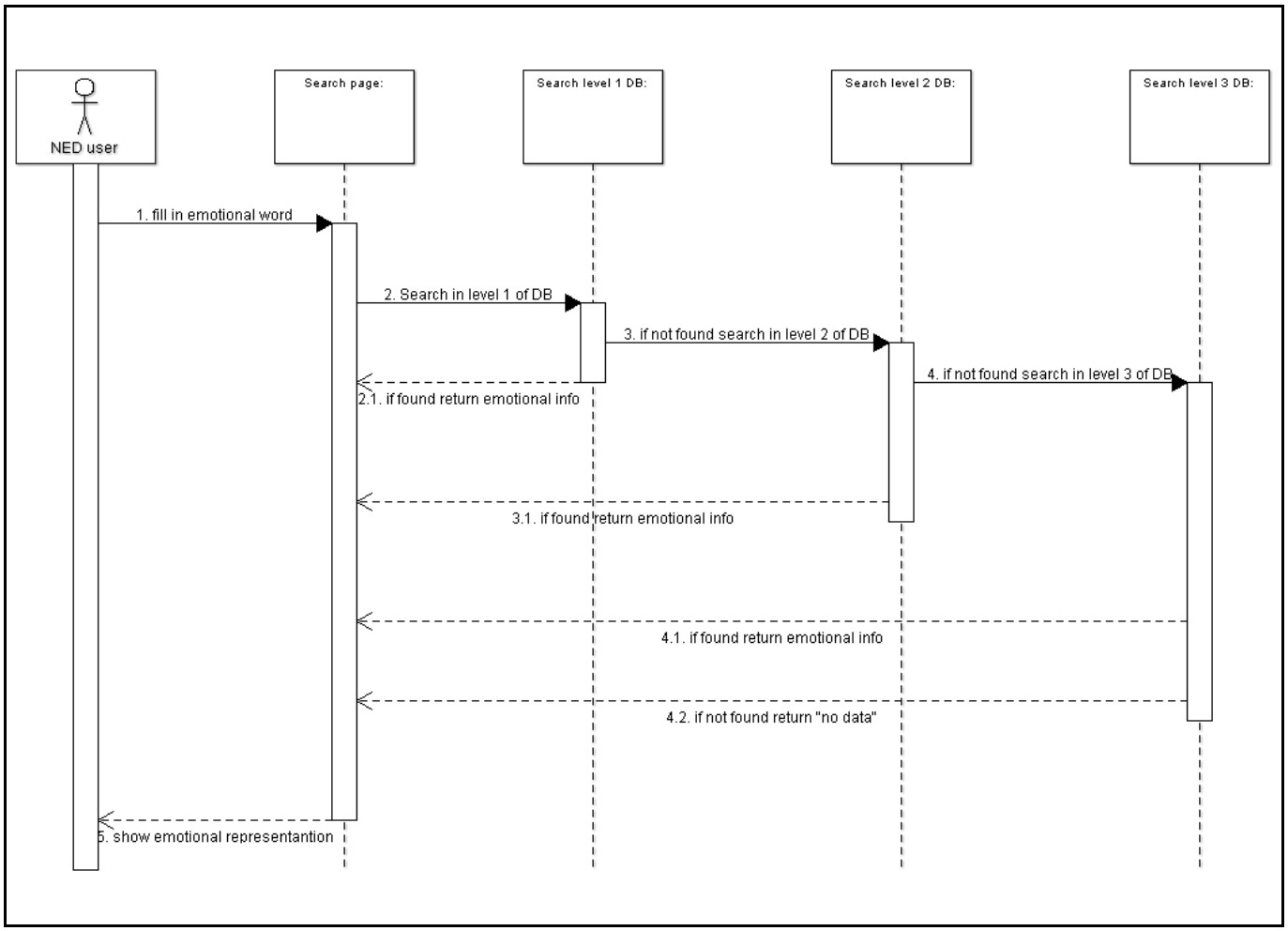


Figure 14: UML sequence diagram of the Non-verbal Emotional Dictionary

As this figure shows, the NED application should, given any emotional word, be able to find its emotional representation in the 2D octants space related to Pleasure-Activation and give a number of information about its emotional status and illustrate this word with an emotional face.

To accomplish this, the NED application operates in 3 different levels. Each level represents a stage to find the appropriate representation of an emotional word. If a stage isn't able to find the correct information, the next stage is triggered to analyze the input in next level. The 3 different levels are illustrated in the following figure:

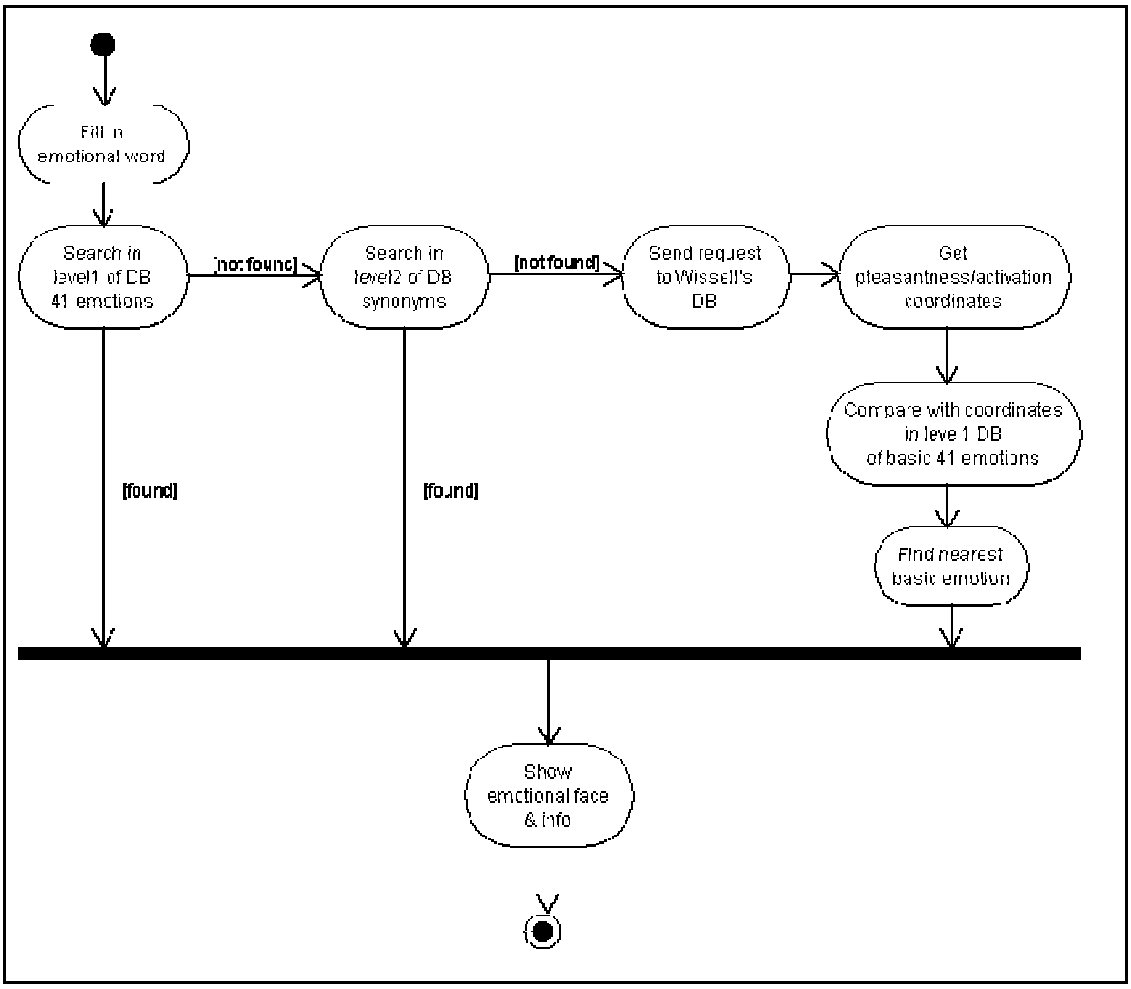


Figure 15: Activity diagram of the Non-verbal Emotional Dictionary

- **Level 1:**

In this level, the application will search for the given emotional word directly in the database of 41 most used emotional words based on the 41 expressions of Desmet [8]. If the input is one of those emotional words, the application will get its representation and the corresponding emotional face directly from the database. If not, the application will continue its search in the following level.

- **Level 2:**

In this level, the application will search for the given word also directly in the database. But this time the search job will be done in a list of synonyms of each one of the 41 emotional words of database. If the input is listed as a synonym of one of those 41 emotional words, the application will give the same representation and emotional face to the input as this emotional word. If not, the application will resume its search in the next level.

- **Level 3:**

In this last level, the application will send a request to Whissell's [12] Dictionary of Affect in Language (DAL) to get an analysis of the emotional meaning of this word. In this analysis a score is given of the different dimensions: Pleasantness, Activation, and Imagery (see figure 13). The Pleasantness and Activation scores will be used the search in the database for the emotional word with Pleasantness and Activation scores that are the nearest to the scores of the input word in the 2D octants space related to Pleasure-Activation. Then the application will assign its emotional information to represent the input word.

The following illustration gives a general overview of the total architecture of the NED system with the use of all three levels of the NED database:

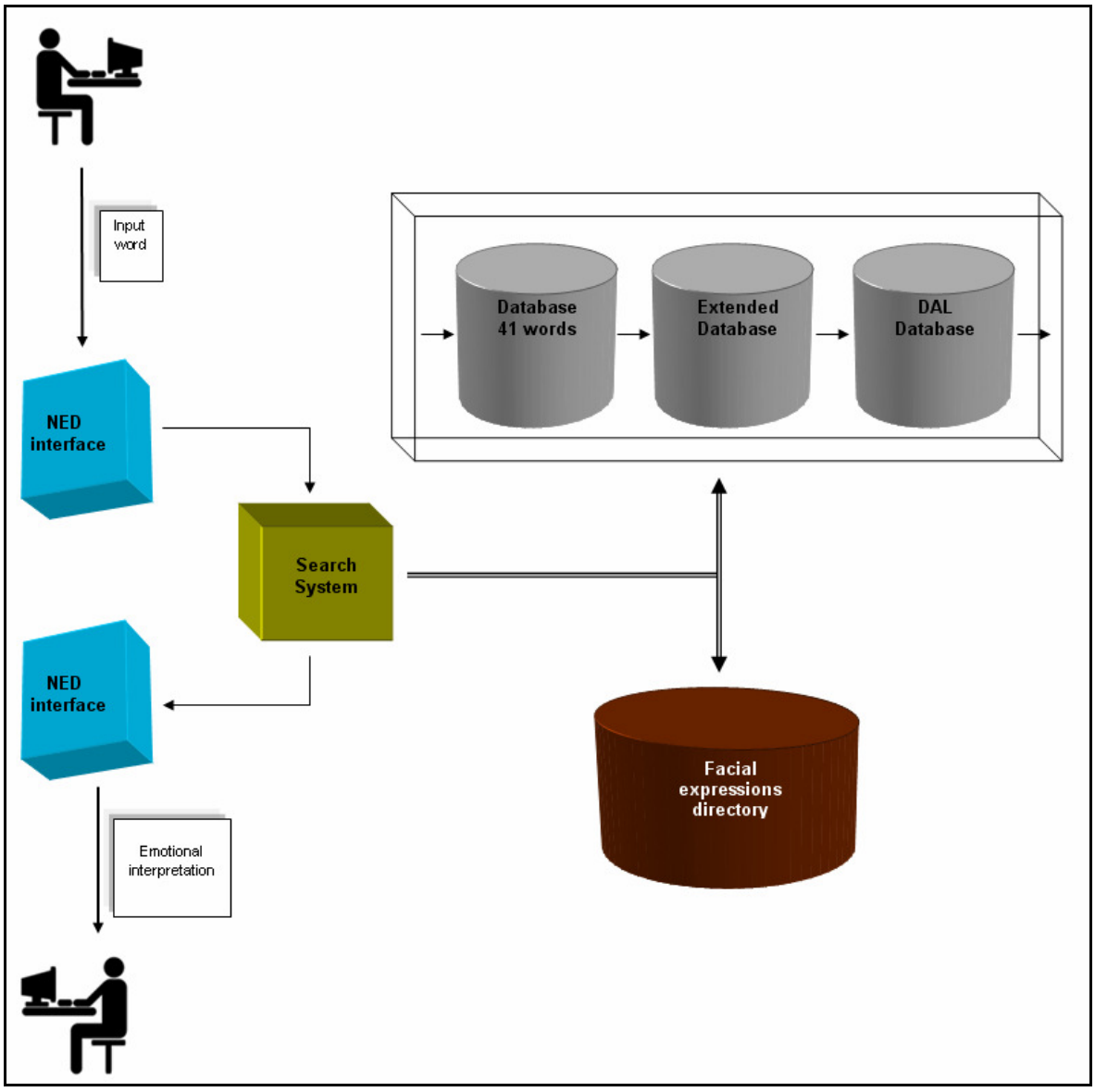


Figure 16: The NED system structure

The NED structure can be summarised as follow. The user inputs an emotional word, then the NED application begins a search job. As explained before, it searches first in level 1, if it founds no resulting facial expression then it searches in the following 2 levels. When the search system find an emotional representation, it delivers back all de emotional information accompanied with a facial representation to the NED interface.

4.3. The NED database

As explained in section 3.4. the NED application operates in 3 different levels. Each level represents a stage to find the appropriate representation of an emotional word. If a stage isn't able to find the correct information, the next stage is triggered to analyze the input in the next level. Those 3 levels will be illustrated and explained in the next section in how they are implemented in the NED database.

4.3.1. Data acquisition

Scientists have determined that there exist approximately 7000 different facial expressions. And the number of possible combinations of 44 Action Units is of course much larger, but not every combination can result in a meaningful facial expression. Therefore an ideal NED application would contain all the 7000 possible facial expressions, each with a scientifically valid AU combination. Which means that having a database with all those thousands of entries will take months an can be seen as a graduation project in itself, and scientifically validating each one of these entry and its interpretation is another project that should be left to psychologists.

For this reason, the goal by building the NED application is to get a database of the most used emotions and their AU combinations. So as explained in section 4.3., those most used emotions will make the first level of the database which the application will use to find the different data about an emotional word. If this input word is not found then the application will search in its synonyms. That's why the choice was the use of emotional words based on the 41 expressions of Desmet [8] as the emotional words that consist the first level of the database.

Because of the fact that the first level of the database contains the 41 expressions of Desmet [8], I will have to fill this database level with all the data the NED application will have to display. This data consist of the corresponding AU combination with its representation in the 2D octants space related to Pleasure-Activation and the appropriate facial expression.

The part of the data acquisition that consist of gathering the corresponding AU combination and the appropriate facial expression of all the 41 expressions of Desmet [8] can be seen as a sub-project within this thesis. For this purpose, I used the Facial Expression Modeller (FEM) of Anna Wojdeł [19]. The next section explains the working of the FEM application and illustrates the work that has been done to accomplish this part of the project.

Facial Expression Modeller (FEM)

Facial Expression Modeller (FEM) [19] is a system for the generation of facial expressions. It is implemented in C++ language on a PC platform. It uses multi-platform OpenGL and Qt GUI toolkits, and so it is available on both Windows and Linux operating systems (with the possibility of porting it to other systems as well).

The 3D face model is built from triangular mesh modelled and textured in 3D Studio Max. The shape of the wireframe was built on the basis of an existing person's face. In order to create a texture two pictures of this specific person have been: a frontal and lateral view of the face. Both pictures were orthogonally projected on a cylindrical texture, and blended together. This software includes a parser to read ".ase" files exported from 3D Studio Max, and builds an internal 3D model which is displayed in the main window.

The user interface consists of a window with 3D facial model and two controls for accessing facial expressions from the library, and editing them by editing the different AU controllers. This user interface is illustrated in the following figure:

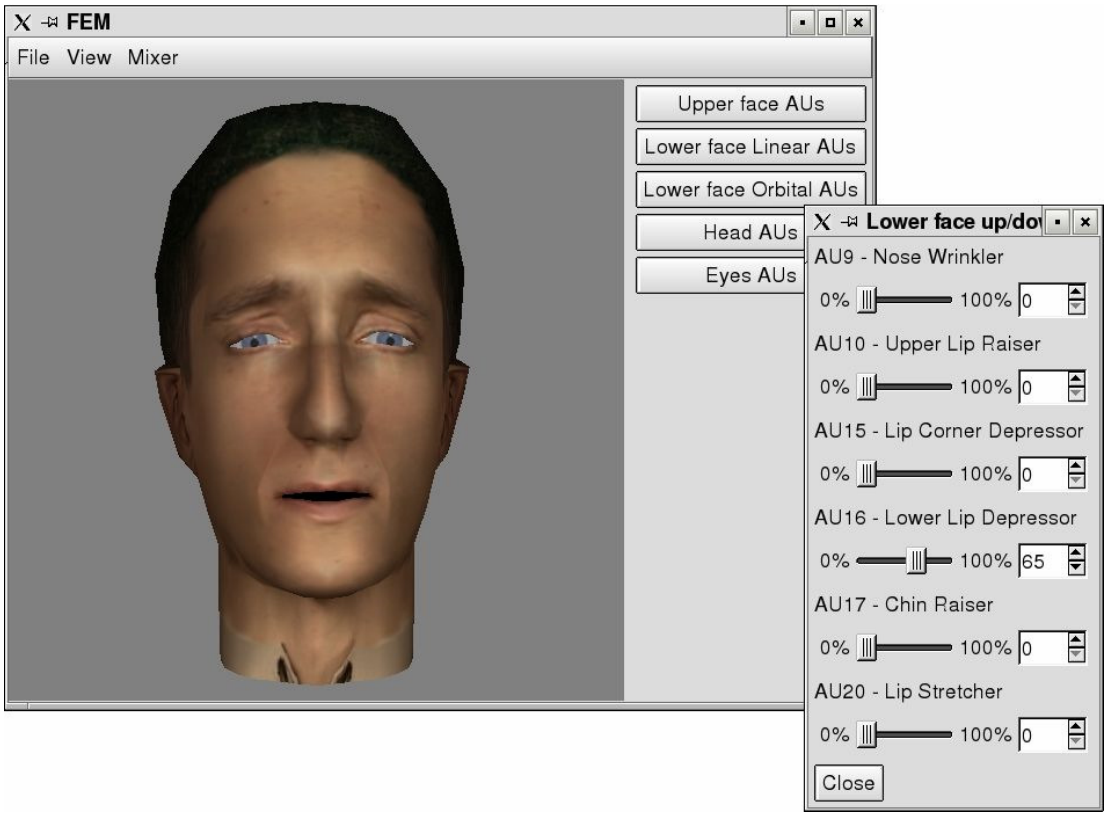


Figure 17: The Facial Expression Modeller

The facial model is based on FACS, but the user of this system does not have to be an expert in FACS in order to use the system itself. For the user a facial expressions script language was designed that wraps up the AU's in more intuitive terms. While designing a new facial expression, a user can make use of pre-defined facial expressions, which can be loaded from the library. It is assumed that each expression in the library is defined by a unique name, and that any given expression has a fixed set of AU's with their intensities.

The user can also create facial expressions and save them into the library. There is also an editor to modify an existing facial expression. In order to edit or to create new facial expressions, a user can access lower-level animation controls (using GUI elements that control all of the parameters corresponding to each AU). He can interactively move sliders and observe changes on the face resulting from activation of a given AU. These controls are divided into 5 groups of AU's: Upper face AU's, Lower face linear AU's, Lower face orbital AU's, Head AU's, Eyes AU's.

Using the different sliders of the FEM application corresponding to different AU's, I tried all different possible positions to get all the 41 expressions of Desmet [8] and their representation in Action Units and the corresponding faces (see Figure 22). With a trial-error manner I started moving a few of the sliders and observe the resulting facial expression, then I moved other sliders and changed some to manipulate the resulting facial expressions. In this way I experimented with the FEM application to get each of the facial expressions I wanted. As a starting point, I used the labelling of Estefania González [13] as illustrated in Figure 12, that she used based on the 41 expressions of Desmet illustrated in Figure 11. Each one of those label was created as a representation of one of the 41 facial expressions. The following figure shows some examples of those labels (all the labels can be found in Appendix A):

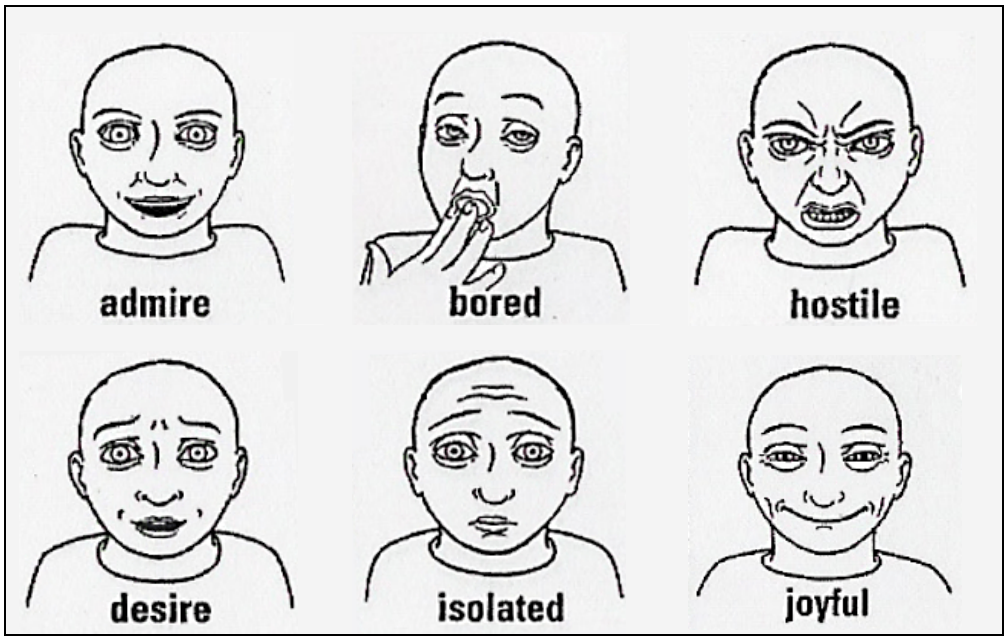


Figure 18: Labels representing different facial expressions

I tried to duplicate each one of those labels into new facial expressions. To create this new facial expression in the FEM application, I had to use the FACS controls (using GUI elements that control all of the parameters corresponding to each AU as shown in figure 22). By interactively moving the different sliders of the Upper face AU's, Lower face linear AU's, Lower face orbital AU's, Head AU's and Eyes AU's and observe changes on the face resulting from activation of a given AU, I created for each label its duplicate facial expression based on AU's. The following table shows some examples of those facial

expressions with their corresponding Action Unit combination (all the facial expressions can be found in Appendix A):

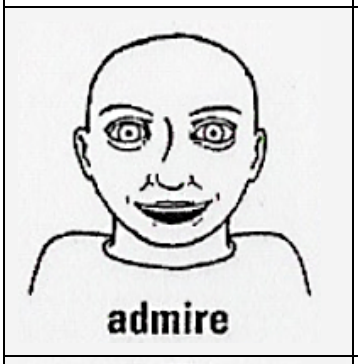
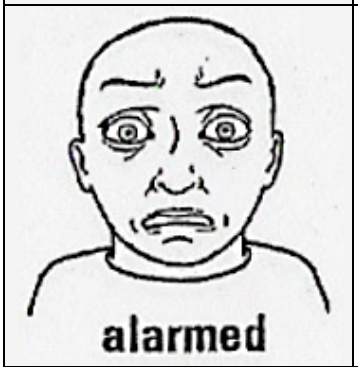
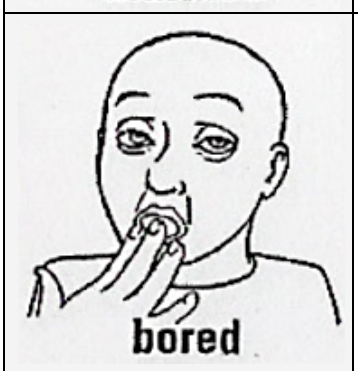
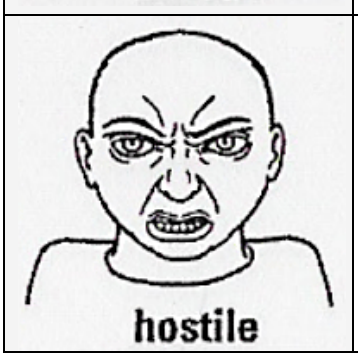
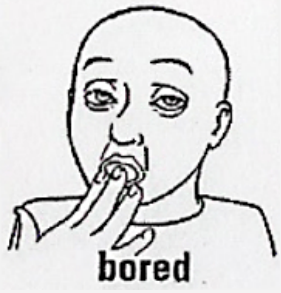
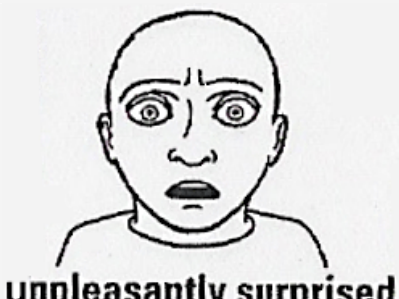
Label	Facial expression	AU's combination
		AU1 80% AU2 70% AU5 70% AU6 75% AU7 20% AU9 40% AU12 60% AU16 15% AU20 70% AU25 75% AU54 5% AU63 35%
		AU1 100% AU2 100% AU5 100% AU9 40% AU15 60% AU16 50% AU26 30% AU27 10% AU53 10%
		AU1 50% AU15 30% AU16 100% AU27 15% AU43 50% AU51 8% AU52 7% AU53 35% AU54 20% AU55 19% AU58 100% AU61 100% AU62 30%
		AU2 100% AU4 100% AU5 100% AU6 100% AU9 100% AU15 40% AU17 30% AU18 30% AU23 50% AU24 80% AU54 50% AU63 40%

Table 2: Labels and their facial expressions and AU's combinations

4.3.2. Data user test

Of course after interpreting each label to a facial expression using the FEM application, a logical step was to test this data gathered. Those facial expressions will have to be controlled for its correctness and completeness. This has been done in the form of a survey. This survey consisted on asking people how they perceive the created facial expression in comparison to the original labels. The questioned persons were given the list of all the labels. In this list each label was not accompanied by only its corresponding facial expression created with the FEM application, but also with two more facial expression that more or less have some similar points with the correct facial expression. Similar points could consist in the fact that two of the three have the same shape of the mouth and two others have the same positions of the eyes or the eyebrows. Those different points of comparison (*the shape of the mouth*, *the position of the eyebrows*, *the opening of the eyes* and *the position of the iris*) were carefully explained to all the participants. By each one of them was asked that he or she will have, while looking for the correct facial expression, to concentrate his comparison on the facial comparison points cited before.

The following table gives some examples of this survey (the totality of the survey is to be found in Appendix C):

Smiley Label	Option 1	Option 2	Option 3
			
			
			

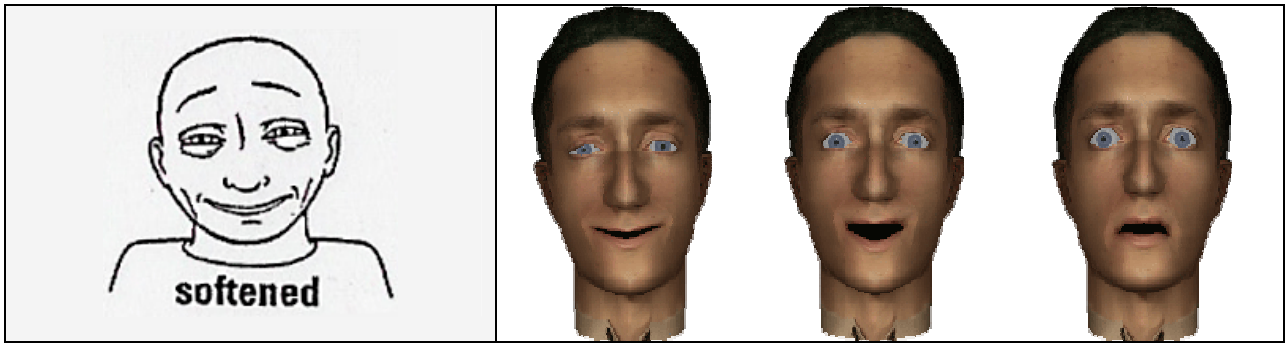


Table 3: The Labels - Facial expressions survey

So the objective of this survey is to control the created facial expression for their correctness and completeness. For my target group, I was interested in all of the daily persons. It was also important to have a very varied targeted group. I was interested in men and women but also in children of different ages, young and older persons. The figures below illustrate the variation of the targeted group.

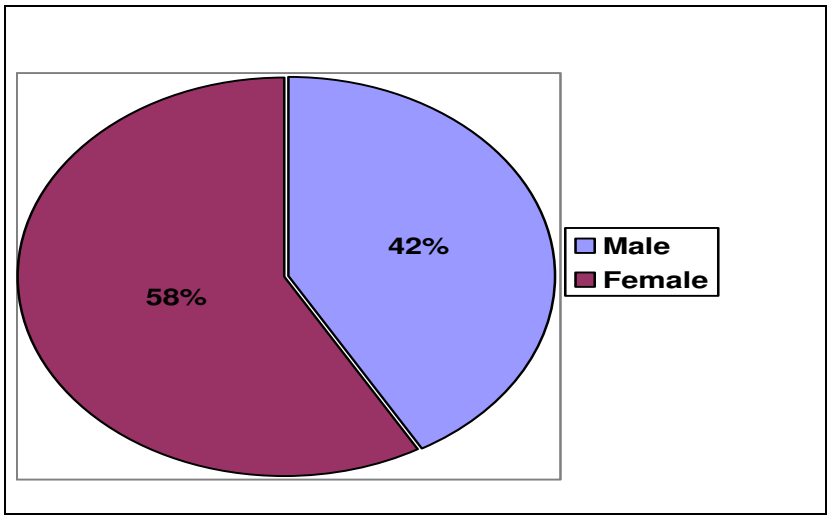


Figure 19: The male / female percentage

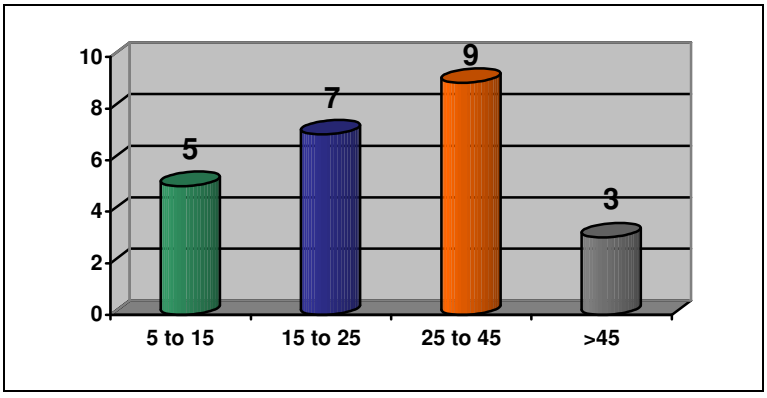


Figure 20: The age of the participants

The results of the survey were very encouraging (the total result of this survey can be found in Appendix C). Only five facial expressions were found confusing to find the correct one that corresponds to the label. Those facial expressions were:

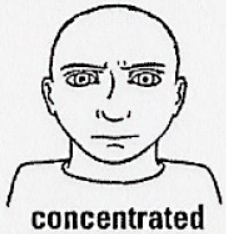
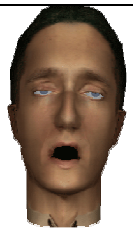
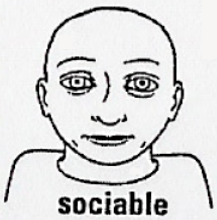
Smiley Label	Option 1	Option 2	Option 3
 avaricious	 avaricious 11	 5	 8
 concentrated	 4	 4	 concentrated 16
 disgust	 0	 disgust 15	 9
 satisfied	 5	 satisfied 16	 3
 sociable	 sociable 16	 5	 3

Table 4: List of facial expressions that were not easily recognised

We can see that some people found some difficulties to recognise the correct facial expression corresponding on those five labels. Nevertheless, using the feedback of the persons how participated on this survey, those five labels will be improved. This way we can get 100% of acceptance of all the facial expressions created for this project. On the other hand it was encouraging to see that the participant had no difficulty recognising the large majority of the facial expressions corresponding to the labels. Not only by all the labels, expect the five cited above, were found correctly, but for 18 of the labels of this survey more than 90% of the participants had totally no problem finding the correct facial expression. The percentage of 90% corresponding to those 18 well recognised labels is based on the fact that 22 participants or more had absolutely no problem recognising the correct facial expression corresponding to a label. Those 18 facial expressions are:

 surprised	 stimulated	 yearning	 inspired	 fascinated	 disappointed
 flabbergasted	 frustrated	 greedy	 astonished	 awaiting	 hostile
 loving	 contempt	 cynical	 irritated	 desire	 melancholy

Table 5: List of facial expressions that were the most easily recognised

From the result of this survey I can conclude that the created facial expressions using the FED application were accepted for almost 89%. Which is a very positive result and from it I can go on with this project knowing that I will be working with facial expression that are well accepted and would more accepted when the 5 facial expressions that were not easy to recognise are improved. The following figure illustrates the acceptance result of the survey over the created facial expressions:

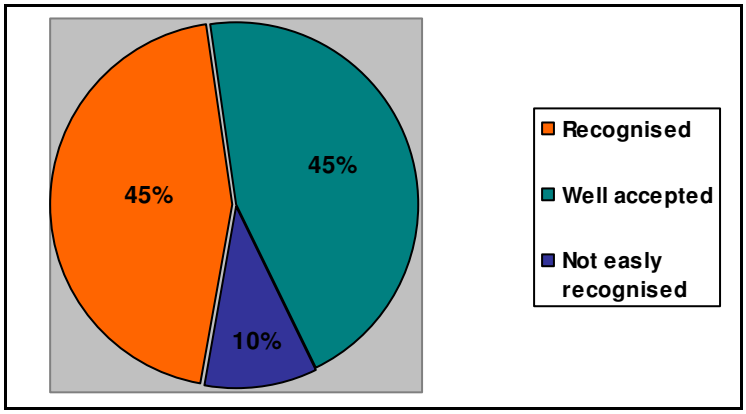


Figure 21: The acceptance survey results of the created facial expressions

The next step was the gathering of data for level 2 of the search job of the NED application. In this level, the application will look for a given emotional word when it is not corresponding to one of the 41 emotions of Desmet, in the synonyms of those 41 emotional words [13]. In other words, this data consist of a number of direct synonyms of the basic emotions of the NED application. Which means that the search job can search, in the first two levels, within almost 200 entries that could be seen as direct representation of the emotional word we are looking for. A number of those synonyms can be seen in the following table (all the 41 emotional words and their synonyms can be found in Appendix B):

Emotion	Synonyms
Admire	treasure value adore delight in
Alarmed	nervous Protest
Bored	covetous acquisitive grabby grasping itchy Prehensile
Hostile	inimicable inimical unfriendly attack competitive argumentative opposed warlike fierce Cruel

Table 6: Emotions and their synonyms

The last part in the gathering of the data for the NED application in level 3 consist in getting the Pleasantness and Activation scores of the emotional word that is not found in the first two levels. Those scores will come from a request that will be sent to Whissell's [12] Dictionary of Affect in Language (DAL). The Pleasantness and Activation scores will be used to the search in the database for the emotional word with Pleasantness and Activation scores that are the nearest to the scores of the input word in the 2D octants space related to Pleasure-Activation. Then the application will assign its emotional information to represent the input word.

But during the implementation of the NED application the code, written in AJAX, to send a request to Whissell's online DAL dictionary to get the needed information in a XML format (like shown in figure 13) did not work as expected. I was all the time getting JavaScript error's that the access was denied. Because I could check that it was not due to the security measures of the university network, it was soon clear that the online version of Whissell's dictionary was protected against those kinds of requests. Which means that gathering data for level 3 of the search job of the NED application directly via an online request was not going to work.

The only solution to this problem, and the only way to gather data of words that are not included in the first two levels of the database in such a way that the NED application covers a large scope of emotional words, is that the NED application itself is able to use its own data with a huge number of words with Pleasantness and Activation scores. So the question at the time was: where to get this data from?

While searching for another way to get the needed data from Whissell's dictionary, it became clear that I find that it was possible to use the executable demo of the Whissell's dictionary in the same way as the online version. Only this time the executable version offers more. Using it, you are not only able to analyse a single word, but you can analyse an entire text and get data of each word on this text. Data like Pleasantness and Activation scores. The following figure illustrates the use of the executable version of Whissell's dictionary to analyse the emotional state of words:

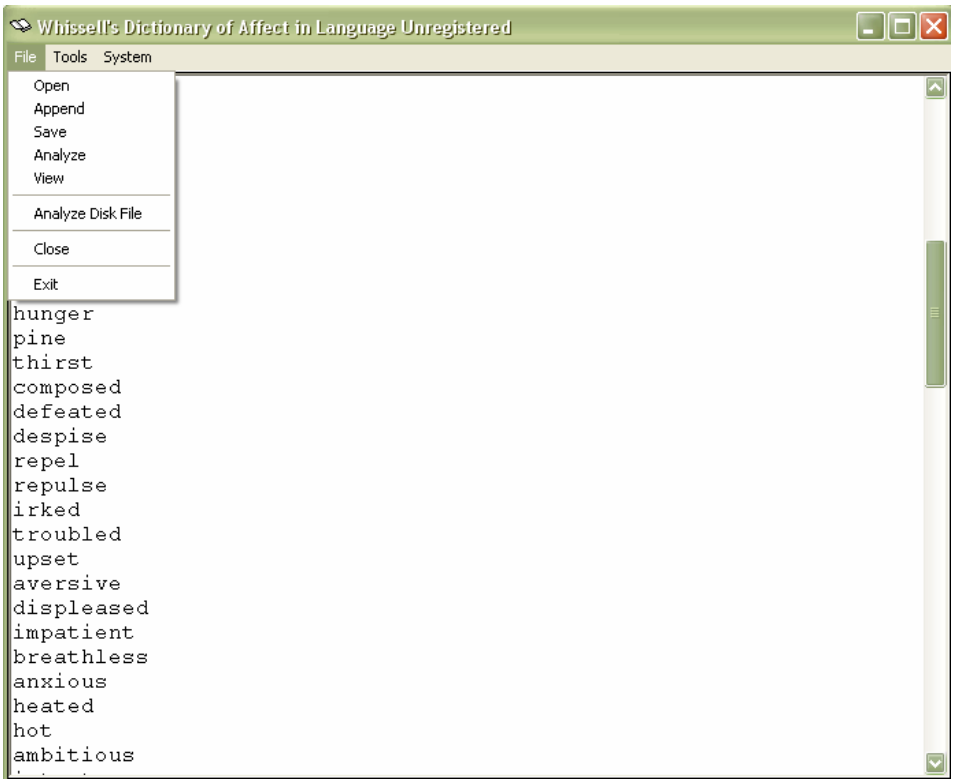


Figure 22: Whissell's Dictionary of Affect in Language

This analysis resulting from the of Whissell's dictionary, where the Pleasantness and Activation scores are presented in this case in the form of 'kpleasent' and 'kactive', is illustrated in the following figure:

```
1   word;kpleasant;kactive
2
3   treasure;4,35;4,45
4   frightened;1,2222;2,4545
5   scared;1,375;1,5714
6   nervous;1,5;2,6667
7   surprised;2,8571;2,8
8   entertained;2,2857;2,1366
9   longing;1,5714;1,8
10  aroused;2,25;2,75
11
```

Figure 23: Analysis of emotional words in the Whissell's Dictionary

Using these results I analysed as many different texts as possible in order to gather as many word with their Pleasantness and Activation scores as possible. Each time I analysed a text using the DAL application I had to analyse to results as shown in figure 28. I filtered those result to only get the input words accompanied with their both 'kpleasant' and 'kactive' scores. Those are the first two decimals on in the result. The second task, during the entire process of filtering the data, was to eliminate all the

repeated data to only let single words in the database. The work that has been done to get data of this kind with more than 8.000 entries could be seen as another sub-project on its own. Table 9 of section 5.2.2. gives a preview of this data. The large number of this data could be seen in its totality in Appendix B.

4.3.3. Structure

The next figure represents the NED database structure in the form of an entity-relationship diagram:

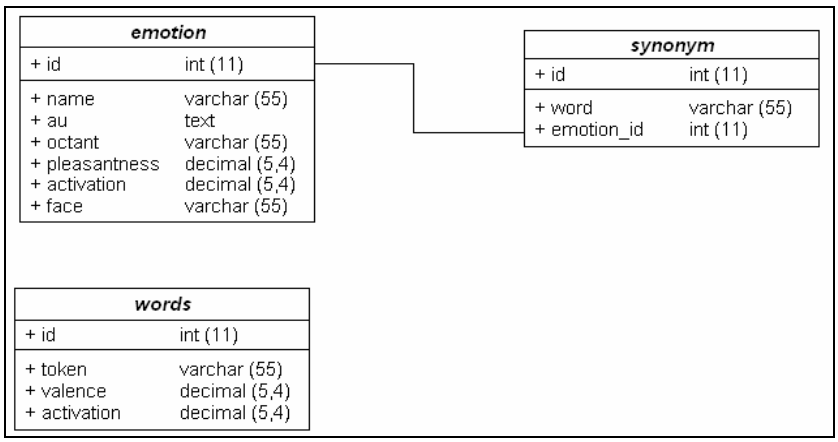


Figure 24: Entity-relationship diagram for the NED database

In this figure you can see that the database of the NED application consists of 3 tables: the 'emotion' table, the 'synonym' table and the 'words' table. The tables and data of the NED database can be found in appendix B. Each one of those tables is used in one of the different levels of the analysis of an emotional word. In this section I will further elaborate on each one of those tables.

- **'emotion' table:**

In the 'emotion' table data over the 41 most used emotional words are saved that are based on the 41 expressions of Desmet [8]. Data like the name of the emotion, it's representation in Action Units and the Pleasantness and Activation scores for the representation of the emotional word in the 2D pleasantness - activation space. A preview of this data is shown in following table:

id	name	au	octant	pleasantness	activation	face
1	admire	AU1 80 AU2 70 AU5 70 AU6 75 AU7 20 AU9 40 AU12 60 AU16 15 AU20 70 AU25 75 AU54 5 AU63 35	pleasant average	1,9	1,6	admire.gif
2	afraid	AU1 100 AU5 80 AU7 20 AU16 80 AU27 20 AU58 100	unpleasant excited	1	2,375	afraid.gif
3	alarmed	AU1 100 AU2 100 AU5 100 AU9 40 AU15 60 AU16 50 AU26 30 AU27 10 AU53 10	unpleasant excited	1	2,375	alarmed.gif

Table 7: A number of emotional words from the 'emotion' table

So in the first level, the application will search in this directly table for the given emotional word. If the input is one of those emotional words, the application will get its representation and the corresponding emotional face directly from the database. If not, the application will continue its search in the following level in the 'synonym' table.

- **'synonym' table:**

In the 'synonym' table a number of synonyms of the emotional words from the 'emotion' table are saved. Each word from the 'synonym' table is assigned an emotion_id to represent the relationship between the 'emotion' table and the 'synonym' table. A preview of this data is shown in following table:

id	synonym	emotion_id
1	treasure	1
2	value	1
3	adore	1
4	frightened	2
5	scared	2
6	terrified	2
7	nervous	3

8	protest	3
9	mad	4
10	outraged	4
11	surprised	5
12	entertained	6
13	diverted	6
14	astounded	7
15	overwhelmed	7
16	longing	8
17	aroused	8

Table 8: A number of synonyms from the 'emotion' table

In the second level of the search job, the application will search for the given word also directly in the database. But this time the search job will be done in a list of synonyms of each one of the 41 emotional words of this database. If the input is listed as a synonym of one of those 41 emotional words, the application will give the same representation and emotional face to the input as this emotional word. If not, the application will resume its search in the next level in the 'words' table.

- **'words' table:**

In the 'words' table more than 8.000 words with their Pleasantness and Activation scores for the representation of the emotional word in the 2D pleasantness - activation space are gathered. A preview of this data is shown in following table:

token	valence	activation
abandoned	1,1429	2,1
abated	1,6667	1,3333
abnormal	1	2
absurd	1	1,5
abusive	1,6667	2,6667
accused	1	1,7143
admirable	2,7778	1,6667
admired	2,75	1,8182
aggressive	1,2	2,6923
alarming	1	2,5833
alcoholic	1	2,1667
alert	2	2,5
alive	2,6667	2,5
alone	1	1,4545
amazing	2,25	2
applause	1,7778	2,8889
arrested	1	3
beautiful	3	1,6429
belong	2,2857	1,4444
bleeding	1	2,6154

Table 9: A number words from the 'words' table

In this last level, the application will use the valence and activation scores and compare them with the Pleasantness and Activation scores of the emotional words from the 'emotion' table as points in the 2D octants space related to Pleasure-Activation. In other words, the 41 basic emotional word of the 'emotion' table of level 1 will be plotted as points in a 2D space. In this 2D space the x-axe represents the Pleasantness value and the y-axe represents the Activation value. When the application is analysing a word that is found in level 3 of the database, it will also plot this word in the same way on the 2D space using its valence and activation scores. Then the application will look for the nearest point to this word. When the search finds the nearest point in the 2D space, which is representing an emotion from the 'emotion' table, the application will assign its emotional information to represent the input word.

4.3.4. Validation study

The NED database is composed of 41 basic representations of emotional expressions. Every expression is coded in FACS by AU's. The whole database is a cloud of 41 points in a 43-Dimensional space. I assumed that the Euclidian metric corresponds with the semantic similarity of the facial expressions. This means that the closer two expressions are, the more similar they are.

To research this hypothesis, the cloud of the points has been mapped to a 2-Dimensional space, using the Principal Component Analysis (PCA). The goal is to compare those results to the results of mapping the 41 basic representations of emotional expressions on a 2D-space using Whissell's scores of their Valence and Activation values. The results of this mapping will be discussed in chapter 4.3.5.

PCA [27] is mathematically defined as an orthogonal linear transformation that transforms the data to a new coordinate system such that the greatest variance by any projection of the data comes to lie on the first coordinate (called the first principal component), the second greatest variance on the second coordinate, and so on. PCA is theoretically the optimum transform for a given data in least square terms.

PCA can be used for dimensionality reduction in a data set by retaining those characteristics of the data set that contribute most to its variance, by keeping lower-order principal components and ignoring higher-order ones. Such low-order components often contain the "most important" aspects of the data. However, depending on the application this may not always be the case.

To plot the cloud of the points in a 2D space, PCA has been applied on the dataset (see table 10) that has been composed using the AU values obtained from the FEM system as described in Chapter 4.3.1. An example of this dataset is shown in the following table:

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	...
AU1	80	100	100	0	60	30	60	0	50	0	0	0	0	0	100	50	...
AU2	70	0	100	0	100	40	100	80	0	0	100	100	0	100	15	25	...
AU4	0	0	0	100	0	20	0	40	0	20	70	20	60	40	30	0	...
AU5	70	80	100	100	45	20	45	55	0	0	0	80	0	30	80	0	...
AU6	75	0	0	90	60	100	60	70	0	0	0	0	50	80	60	0	...
AU7	20	20	0	0	0	0	0	0	0	20	0	70	0	0	0	0	...
AU8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	...
AU9	40	0	40	0	0	40	0	0	0	0	70	0	0	0	0	0	...
AU10	0	0	0	20	15	0	0	0	0	0	0	0	0	26	0	0	...
AU11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...

Table 10: The Emotinal words/AUs matrix used in the PCA plot

In this table the columns represent the 41 basic representations of facial expressions and the rows represent the AU values of each representation as obtained from the FEM system. The result of the plot can be seen in the following figure:

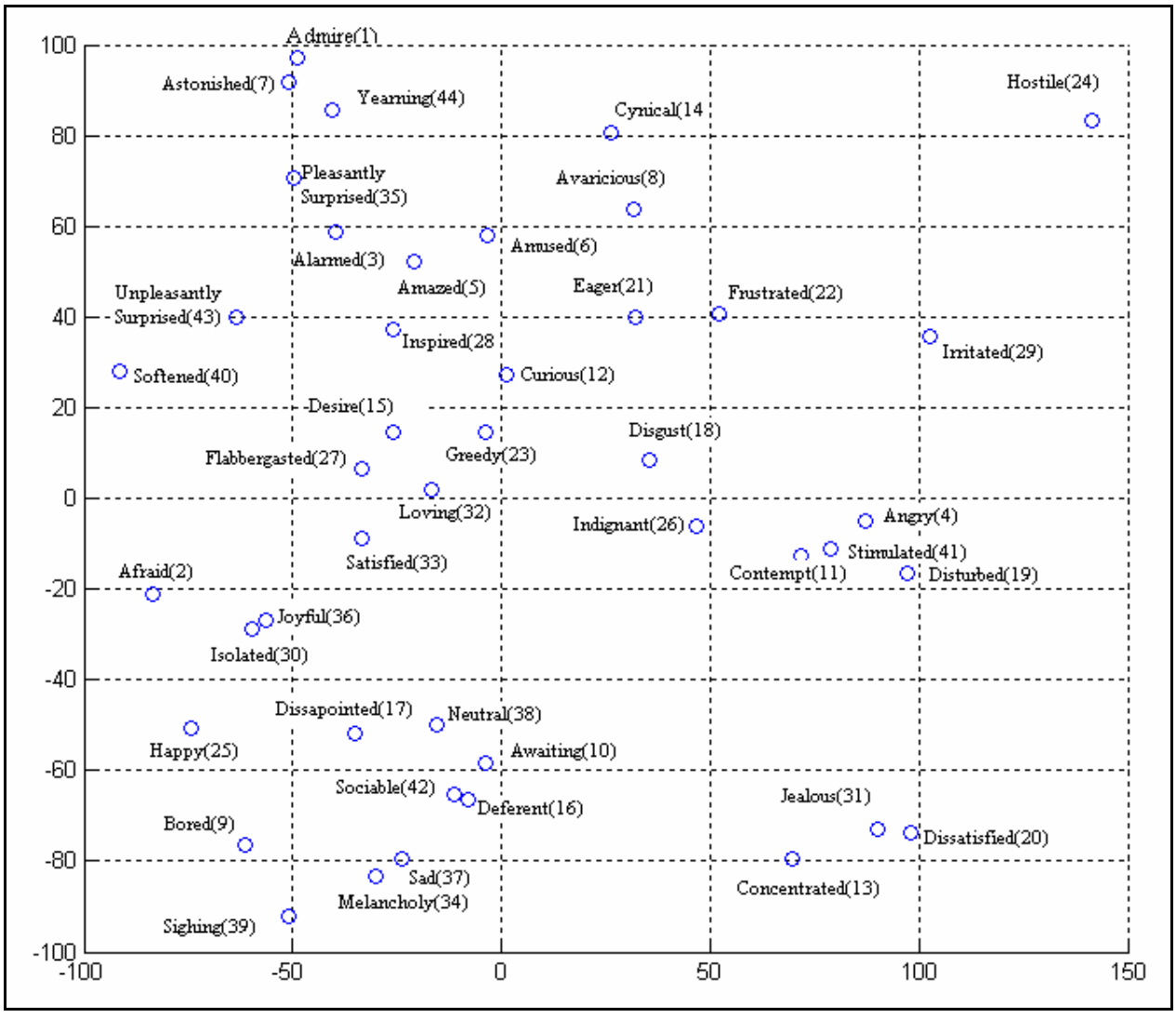


Figure 25: Results of the PCA plot of the Emotinal words/AUs matrix

As we can see in this figure, for the most expressions we can observe a cluster, for example the words [sad, melancholy], [loving, desire, satisfied], [admire, astonished], and also [dissatisfied, jealous]. But this doesn't seem to apply for all the emotional expressions, for a few words it seems that they are not totally represented in their correct environment. Despite this fact, we can see that those results as expected and can be seen as positive. Especially when compared with the direct representation of the 41 basic emotions in a 2D space using Whissell's scores of their Valence and Activation values as we will see in the next chapter.

4.3.5. Validation of measures

To validate the measures and values of Whissell's scores of the Valence and Activation values of the 41 basic emotional expressions, I will plot those 41 emotional expressions in a 2D space the see if the words that have approximately the same meaning are grouped in the same space. This plot is to be seen in the following figure. This representation when judged positive, will be compared to the representation the basic emotional expressions of Estefania Conzález as shown in figure 12.

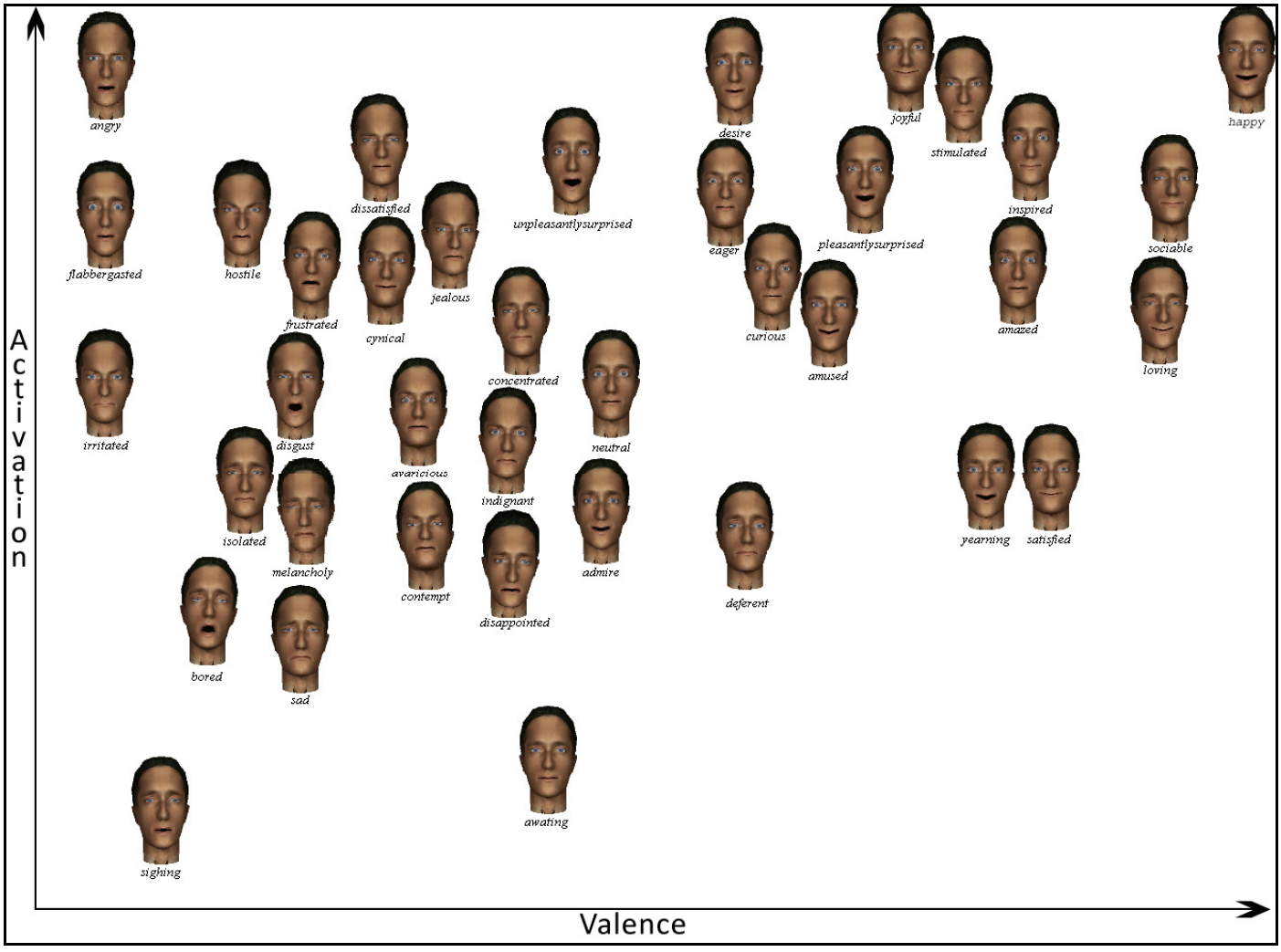


Figure 26: The 2D plot of the 41 basic emotional expressions using Whissell's values

As we can see, the results of the plot of the 41 emotional expressions in a 2D space using their Valence and Activation values with Whissell's scores is very positive. In fact we can see that all the emotional words that approximately the same meaning have are plotted together. For example the words [happy, sociable, loving], [inspired, amazed, stimulated, pleasantly surprised] and [bored, sad, isolated, melancholy]. Those results are to be seen as very encouraging in a way that when using the data of the NED application we can be satisfied over the resulting comparison between the different words using their Valence and Activation values to find the facial representation of the correct emotional expression.

4.4. Concept

The Non-verbal Emotional Dictionary (NED) will have to be a web application easy to understand and to use for an end-user, without requiring any specialized training. The user should be able to intuitively relate the actions he needs to perform on the web page, with other interactions he sees in the general domain of life e.g. press of a button leads to some action.

To accomplish this, the concept of the web application should follow specific rules referred to by the word "usability"[14]. The most important rules of usability are:

- **Learnability:** How easy is it for users to accomplish basic tasks the first time they encounter the design?
- **Efficiency:** Once users have learned the design, how quickly can they perform tasks?
- **Memorability:** When users return to the design after a period of not using it, how easily can they re-establish proficiency?
- **Satisfaction:** How pleasant is it to use the design?

Those rules can be translated while designing the concept of the NED application in such a way that the information should be presented to the user in a clear and consist way. The correct choices should be given to the users in a very obvious way. Their should be no ambiguity regarding the consequences of an action and the most important information should be placed in the right place.

Following those usability requirements, a design for the NED application has been created. First a global prototype has been plotted on paper for first impressions. This first prototype has been discussed with a number of Master students to determine if any ambiguities or misinterpretations of the goal of this project have been made in the prototype. This important phase has help refining and improving the prototype of the NED application which resulted in the final concept illustrated in figure 27 and figure 28. The

website on the NED application can be visited using the following URL: http://riga.twi.tudelft.nl/~mehdi/ . Figure 27 shows the homepage of the application where the user gets some information about the NED application and can start a search on an emotional word. Figure 28 shows the result of the search job on an emotional word and gives a number of information about its emotional representation and illustrates that information with the corresponding emotional face.

The learnability aspect of this concept consists in the easiness of accomplishing the task of analysing an emotional word. The first time that a user will visit the application, he directly sees a simple menu choice where he can clearly read where he has to fill in an emotional word to be analysed. Further he can always use the help page where he gets information about the application and what is does. The efficiency of the concept will be explained in the implementation section and it consists in how fast the application will be. Using AJAX technology (see section 5.1.) the user get information instantly without having the filling that the application is sending any kind of request for getting the search task performed. As for the memorability and satisfaction, the concept is made with such a design and simplicity that could never get difficult to get a task done or make it possible to get the task done in a different way. Also the design was done with such attention that it will be always visually enjoyable to use this application.

In the next chapter I will further discuss the implementation of this concept.

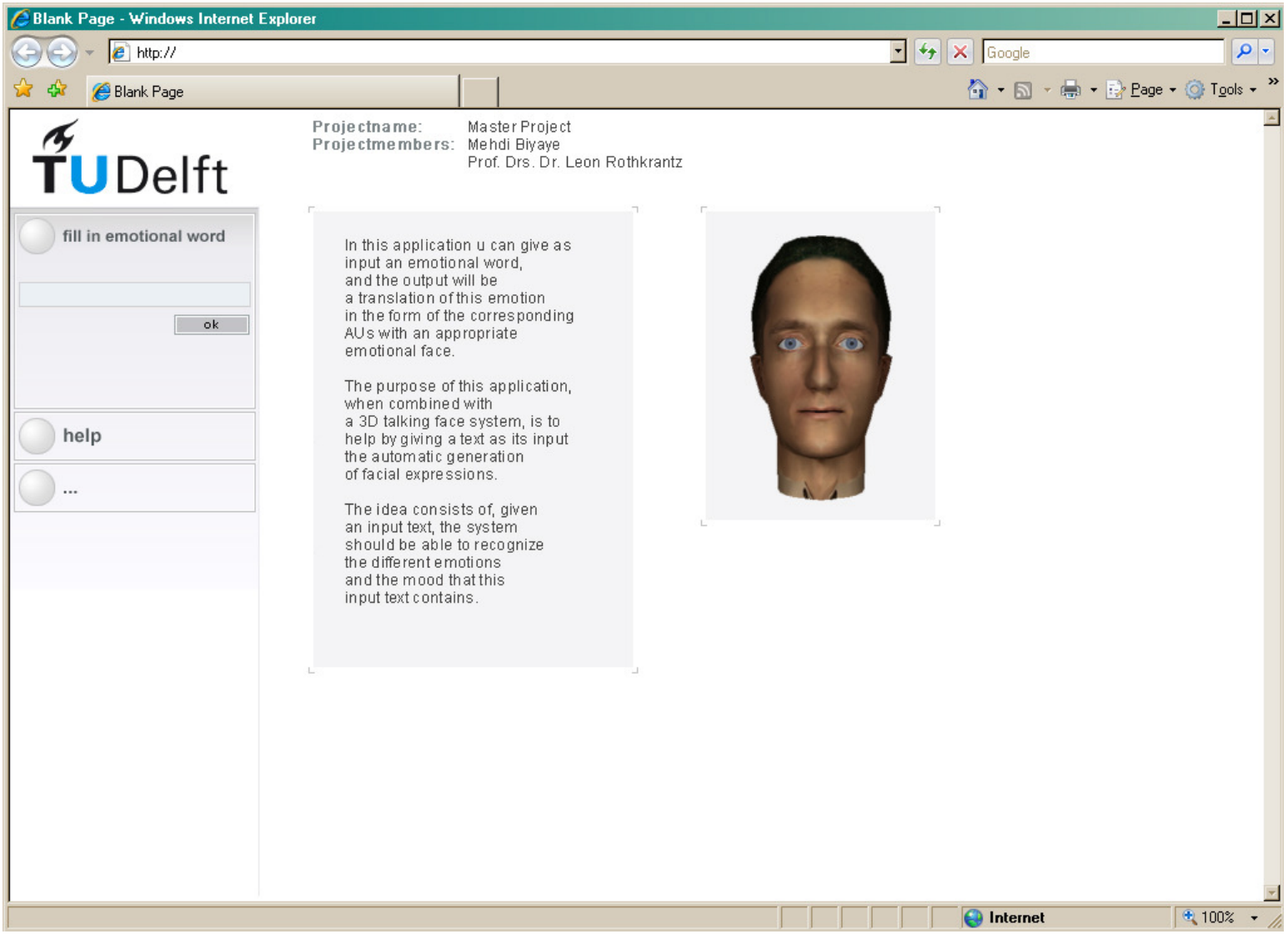


Figure 27: Concept Non-verbal Emotional Dictionary - Homepage

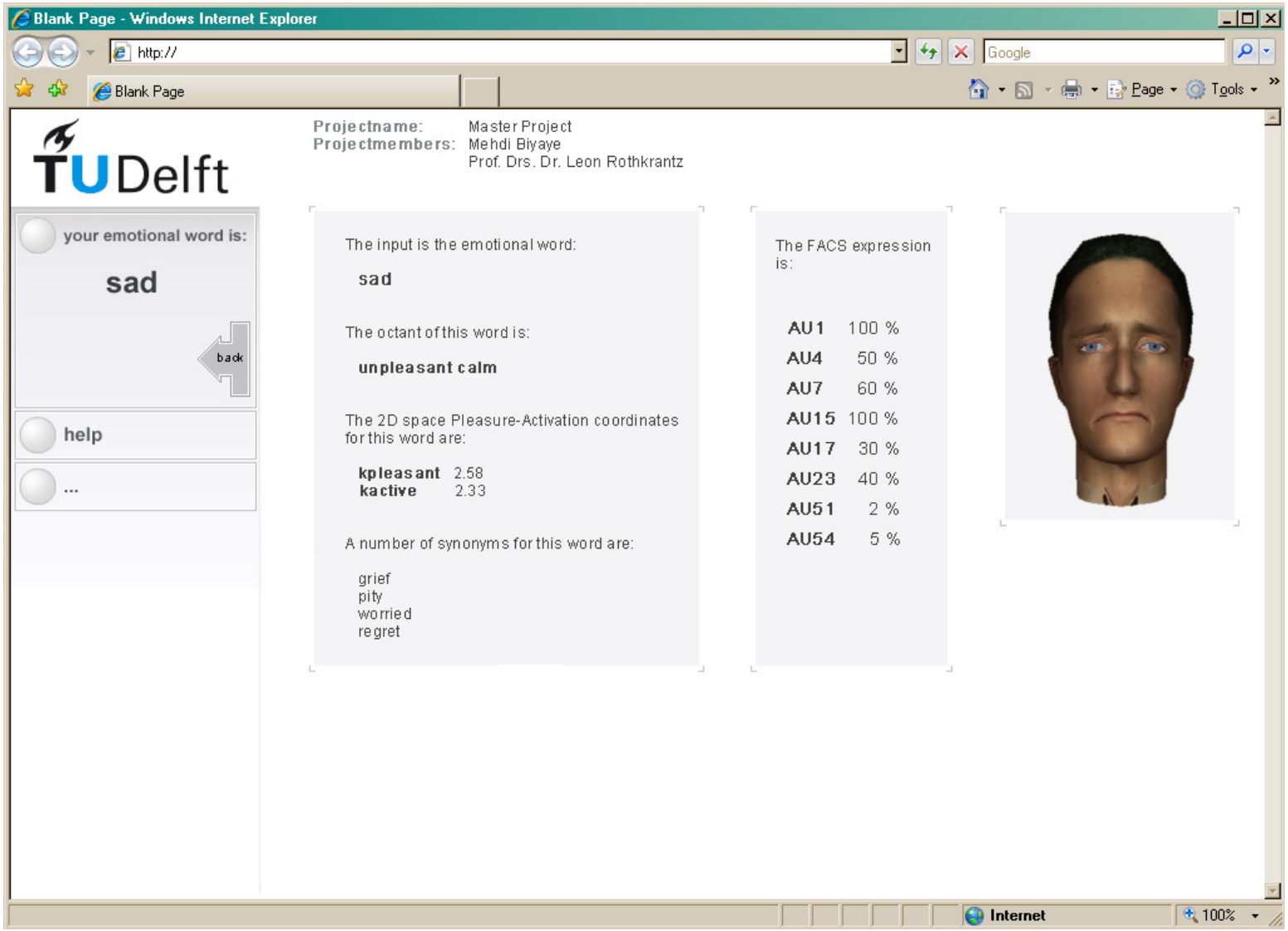


Figure 28: Concept Non-verbal Emotional Dictionary - Showing emotional word 'sad'

5 IMPLEMENTATION

In this chapter I will describe the development and implementation details of the Non-verbal Emotional Dictionary. In section 5.1 the tools used during the development are described.

5.1. Development tools

In this section the different tools and techniques used in the development of the NED are described. The first two subsections give a description of the two main tools used to implement the NED: the Ajax programming language and the relational database management system MySQL in combination with PHP, which is a scripting language designed for producing dynamic web pages.

5.1.1. Ajax

Ajax [15][16] is a group of interrelated web development techniques used for creating interactive web applications or rich internet applications. With Ajax, web applications can retrieve data from the server asynchronously in the background without interfering with the display and behaviour of the existing page (see figure 29 in section 5.1.2.). Data is retrieved using the XMLHttp object or through the use of Remote Scripting in browsers that do not support it. Despite the name, the use of JavaScript, XML, or its asynchronous use is not required.

Ajax refers specifically to technologies like:

- XHTML and CSS for presentation;
- The Document Object Model for dynamic display of and interaction with data;
- XML , XSLT, preformatted HTML or plain text for the interchange and manipulation of data, respectively;
- The XMLHttpRequest object for asynchronous communication;
- JavaScript or VBScript to bring these technologies together.

Advantages:

- In many cases, the pages on a website consist of much content that is common between them. Using traditional methods, that content would have to be reloaded on every request. However, using Ajax, a web application can request only the content that needs to be updated, thus drastically reducing bandwidth usage and load time.

- The use of asynchronous requests allows the client's Web browser UI to be more interactive and to respond quickly to inputs, and sections of pages can also be reloaded individually. Users may perceive the application to be faster or more responsive, even if the application has not changed on the server side.

- The use of Ajax can reduce connections to the server, since scripts and style sheets only have to be requested once.

Those advantages were successfully implemented in the NED application. Indeed, the user will perform task and get information he want in such a fast way that the user would not get the feeling that the application is sending any request to the server. Therefore, their will be zero response time when using the application.

Disadvantages:

- Dynamically created pages do not register themselves with the browser's history engine, so clicking the browser's "back" button would not return the user to an earlier state of the Ajax-enabled page, but would instead return them to the last page visited before it. Workarounds include the use of invisible IFrames to trigger changes in the browser's history and changing the anchor portion of the URL (following a #) when AJAX is run and monitoring it for changes. This problem is solved by the use of created ‘back’ button that are easy to find and use on the application. In this way, the user will have no difficulties navigating into the application.

- Opens up another attack vector for hackers that web developers might not fully test for. To prevent such attack the system will validate each data input for type and syntax before accepting the data for display or storage.

5.1.2. PHP & MySQL

PHP [17] originally stood for Personal Home Page and is a scripting language originally designed for producing dynamic web pages. PHP is a widely-used general-purpose scripting language that is especially suited for web development and can be embedded into HTML. It generally runs on a web server, taking PHP code as its input and creating web pages as output. It can be deployed on most web servers and on almost every operating system and platform free of charge. PHP is installed on more than 20 million websites and 1 million web servers. Significant websites are written in PHP including the user-facing portion of Facebook, Wikipedia (MediaWiki), Yahoo!, MyYearbook, and Tagged.

PHP primarily acts as a filter, taking input from a file or stream containing text and/or PHP instructions and outputs another stream of data; most commonly the output will be HTML. It can automatically detect the language of the user. From PHP 4, the PHP parser compiles input to produce byte-code for processing by the Zend Engine, giving improved performance over its interpreter predecessor.

Originally designed to create dynamic web pages, now PHP's principal focus is server-side scripting, and it is similar to other server-side scripting languages that provide dynamic content from a web server to a client, such as Microsoft's ASP.NET system, Sun Microsystems' JavaServer Pages, and mod_perl.

The LAMP architecture has become popular in the web industry as a way of deploying web applications. PHP is commonly used as the P in this bundle alongside Linux, Apache and MySQL, although the P may also refer to Python or Perl.

MySQL [18] is a relational database management system (RDBMS) which has more than 11 million installations. The program runs as a server providing multi-user access to a number of databases. MySQL is popular for web applications and acts as the database component of platforms like the Windows-Apache-MySQL-PHP platform, and for open-source bug tracking tools like Bugzilla. Its popularity for use with web applications is closely tied to the popularity of PHP, which is often combined with MySQL. PHP and MySQL are essential components for running popular content management systems such as Expression Engine, Drupal, e107, Joomla, WordPress and some BitTorrent trackers. Wikipedia runs on MediaWiki software, which is written in PHP and uses a MySQL database. Several high-traffic web sites use MySQL for its data storage and logging of user data, including Flickr, Facebook, Wikipedia and YouTube.

In addition to the above-mentioned tools developed by MySQL AB, there are several other commercial and non-commercial tools available. An example is including phpMyAdmin, a free Web-based administration interface implemented in PHP.

Figure 29 illustrate how I used AJAX, PHP and MySQL to implement the NED application. With the use of HTML I created webpage’s where no PHP code can be found. To extract data from the database into the HTML pages for display, I used AJAX in JavaScript codes in those pages to asynchronously communicate with the server.

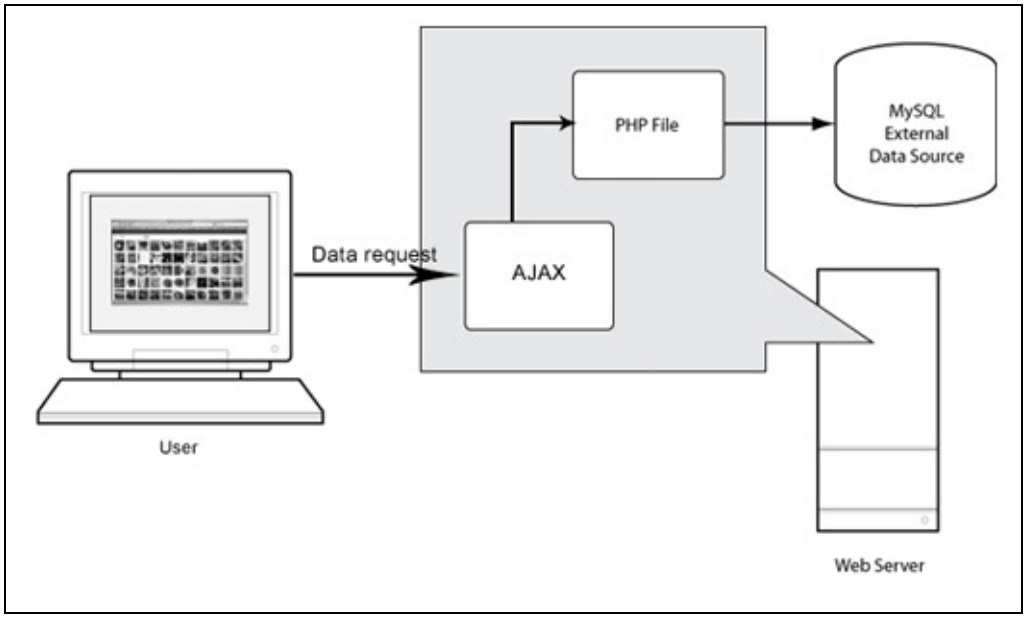


Figure 29: The interaction between AJAX and PHP

The most important aspect of this is the use of XMLHttpRequest object. The following figures illustrate this method. Where I will illustrate how AJAX, when used on a web page, can fetch information from a database.

The first figure contains a simple HTML code and a link to a JavaScript in it:

```
<html>
<head>
    <script src="include/emoword.js"></script>
    <title>Non-verbal Emtotional Dictionary - NED - Homepage</title>
    <meta http-equiv="Content-Type" content="text/html; charset=iso-8859-1">
</head>
<body bgcolor="#FFFFFF" leftmargin="0" topmargin="0" marginwidth="0" marginheight="0">

<table width="1000" height="74" border="0" cellpadding="0" cellspacing="0">
    <tr>
        <td colspan="7" width="1000" height="74">

                    <table width="315" height="555" border="0" cellpadding="20" cellspacing="0">
                        <tr><td background="images/analyse_r_04.jpg" width="315" height="373" va

                            <span id="txtName">
                                <h5>Non-verbal Emotional Dictionary<br />NED</h5>
                                <img name="logo_ned" src="images/logo_ned.jpg" border="0">
                            </span><br />
                            <span id="txtOctant"></span>
                            <span id="txtPleasantness"></span>
                            <span id="txtActivation"></span><br />
                            <span id="txtSynonym"></span>

                        </td></tr>
                        <td><img name="ok" src="images/ok.jpg" width="60" height="16" border="0"
="ok.src='images/ok.jpg'" value="Submit" onclick="showEmotion(word.value)"></td>
                        <tr><td background="images/analyse_r_11.jpg" width="315" height="182"></
                    </table>
                </td>
```

Figure 30: A HTML code and a link to a JavaScript for the use of AJAX

As you can see it is just a simple HTML code. It contains spans called "txtName", “txtOctant”, “txtPleasantness”... The span is used as a placeholder for info retrieved from the web server. When the user asks for some data, a JavaScript function using AJAX called " showEmotion()" is executed. The execution of the function is triggered by the "onclick" event. The JavaScript code in the file “emoword.js” is listed in the following figure:

```
function showEmotion(str){
    if (str.length==0){
        alert('Full in emotional word!');
        return;
    }
    xmlHttp=GetXmlHttpObject();
    if (xmlHttp==null){
        alert ("Browser does not support HTTP Request");
        return;
    }

    var url="include/getemotion.php";
    url=url+"?q="+str;
    url=url+"&sid="+Math.random();
    xmlHttp.onreadystatechange=stateChanged;
    xmlHttp.open("GET",url,true);
    xmlHttp.send(null);

}

function stateChanged() {
    if (xmlHttp.readyState==4 || xmlHttp.readyState=="complete"){

        xmlDoc=xmlHttp.responseXML;
        document.getElementById("txtName").innerHTML=xmlDoc.getElementsByTagName("txtName")[0].childNodes[0].nodeVal
        document.getElementById("txtOctant").innerHTML=xmlDoc.getElementsByTagName("txtOctant")[0].childNodes[0].noc
        document.getElementById("txtPleasantness").innerHTML=xmlDoc.getElementsByTagName("txtPleasantness")[0].childc
        document.getElementById("txtActivation").innerHTML=xmlDoc.getElementsByTagName("txtActivation")[0].childNode
        document.getElementById("txtAU").innerHTML=xmlDoc.getElementsByTagName("txtAU")[0].childNodes[0].nodeValue;
```

Figure 31: The JavaScript code stored in the file "emoword.js"

The server page called by the JavaScript, is a PHP file called "getemotion.php”. The page is rewritten in PHP. The code runs an SQL against a database and returns the result to the HTML page.

5.2. Conclusion

In this chapter I described the development and implementation details of the Non-verbal Emotional Dictionary. I have introduced the tools in the development of the NED are described. The two main tools used to implement the NED were the AJAX programming language and the relational database management system MySQL in combination with PHP. I have explained why I have chosen those techniques, how I have taken profit of their advantages and what I have done to eliminate their disadvantages.

6 PERFORMANCE RESULTS

This chapter details the performance results of the project. The performance of the NED website will be analyzed. Important aspects of the performance are, as discussed in sections 4.1. and 5.1. the usability, speed, extendibility and adaptability and security of the website. Those aspects will be elaborated in each one of the following section.

6.1. Usability

The Usability test made for the NED application can be considered as an evaluative test. My purpose was to confirm that I have met usability requirement as mentioned is section 4.3. During the test, the focus was made on tasks. As a plan for the test, I created test objectives which I translated into a list of tasks the test users will have to perform. Those tasks were made in such way that the test user will have no problem understanding theme. So they were made in a clear language and were not ambiguous. First I explained to the test users the goal of the NED application and the context it was made in. Then I gave to each one of the test users a demonstration of the application and how the perform the tasks made for this test. Those tasks were delivered verbally to the test users and the after each test a verbal interview was done. In this interview, the test user was asked question to evaluate its how I perceives the global use of the application. Some examples of those questions are:

- Does the search for an emotional word take more time than u have expected?
- Was the use of the interface as u would have expected from a digital dictionary?
- What was the most appreciated aspect of the dictionary?
- What changes would users like to see?
- Will users need a wizard (intelligent agent) to guide them through certain complex tasks?

The NED website was tested by a group of 10 students of the Delft University of Technology with ages between 20 and 28, and 4 children where the ages differ from 10 to 15. The design was approved in general and the explanation of the system was found to be clear. All users were able to perform the different tasks to search for an emotional word very fast. Especially due to the “Suggestions” functionality which they appreciated the most. Also all of the test users said that they would need no wizard to guide them though the use of the NED application. It should be noted that these students all are

skilled with computers, but the children are not. Small changes to improve the usability have been made based on suggestions of users. Changes like the presentation of the facial expressions and the way the help / information page is displayed.

6.2. Speed

When it comes to the speed of the NED website, the most important issue is the time that is needed to process a query request and display the results to the user. In general, a number of factors determine the time needed. Factors like the speed and memory of the server determine how long it will take to receive and process a certain query request. But in the case of the NED website, it has been implemented using AJAX technology. Ajax is a web development technique used to create web applications that can retrieve data from the server asynchronously in the background without interfering with the display and behaviour of the existing page. This way, users may perceive the application to be faster or more responsive, even if the application has not changed on the server side.

The use of Ajax can reduce connections to the server, since scripts and style sheets only have to be requested once. Even if given the fact that more than 8.000 entries are stored in the NED database, the performance of the website remains very superior in speed.

6.3. Extendibility and adaptability

The NED website is set up modularly. The HTML code is totally separated from the PHP code in which the data query can be found. This modular design ensures that adaptation and extension of the NED website can be accomplished with relative ease. Because of that the layout of the website could be changed or extended without having any risks of influencing the functionalities of the application. The same for editing the functionalities. The function code and the SQL query, even the structure of the database, could also be edited without having any risk on the design of the website.

6.4. Security

Attacks are usually implemented in JavaScript, which is a powerful scripting language. Using JavaScript allows attackers to manipulate any aspect of the rendered page. JavaScript allows the use of XmlHttpRequest, which is typically used by sites using AJAX technologies, even if victim site does not use AJAX today. Using XmlHttpRequest, it is sometimes possible to get around a browser's same source origination policy and thus forwarding victim data to hostile sites, and also to create complex worms and malicious zombies that last as long as the browser stays open. Also important is to know that AJAX attacks do not have to be visible or require user interaction. The goal is to verify that all the parameters in the application are validated and encoded if necessary before being included in HTML pages.

Preventing such attacks across, I followed a number of preventive approaches during the implementation. Approaches like validation of the input data for example for type and syntax before accepting the data to be displayed or stored. And also the encoding of the output in the database.

7 CONCLUSION & FUTURE WORK

This chapter contains the conclusions of this thesis work, which is organized as follows. First, an evaluation of the results based on the problem definition (as described in section 1.4) is summarized. Then, the future work of what can be done to further development of the system is explained.

7.1. Conclusion

The goal of this thesis was as stated in section 1.3 and 1.4 to build a Non-verbal Emotional Dictionary for emotion recognition using emotional words as input text. So the NED application gets an emotional word as an input, and from that it will generate the output. This output will be a translation of this emotional word in the form of the corresponding AU combination with its representation in the 2D octants space related to Pleasure-Activation and an emotional face. In chapter 1 we introduced a number of research objectives that were established to meet this goal:

d) How to represent emotions in facial expressions?

In chapter 2 I have explained what emotions and facial expressions are and why they are so important in our daily face-to-face communications. And I have illustrated how to recognise and represent facial expressions using Facial Action Coding System (FACS) that was introduced by Paul Ekman and Wallace F. Friesen and which is based on Action Units (AU's). AU's represents movements of single muscles of the human face. Those AU's were used as basic to the composition of a facial expression related to an emotion in this project.

e) How to recognize emotion from text as input in practice?

Also in chapter 2 I have elaborated on some methods for textual affect sensing, which are: keyword spotting, lexical affinity, statistical natural language processing and large-scale real-word knowledge based approach. And because the last 3 approaches deals with words within a context or analysing entire text, and because in my project I had to analyze single emotional words provide them with different emotional information, I have chosen to use the keyword approach.

f) How to classify emotional words?

In chapter 3 we gave the answer to this question by classifying those words by their Pleasantness and Activation scores. In fact, Whissell [12] have developed the Dictionary of Affect in Language (DAL) in an attempt to quantify emotion in language. In the Whissell's dictionary thousands of words have been rated in terms of their Pleasantness and Activation. So by using those data the classification of emotions in words was made possible. Because it was not possible in the project to create a facial expression for each one of the thousands of words that Whissell's dictionary contains, it was important the base this classification on a basic emotional database. Based on Russell's and Desmet's [7][8] researches, 41 emotion words were collected that were not ambiguous. This was the reason why those 41 emotional words were chosen to form the basis of the comparison of the data from Whissell's dictionary. Then using the Pleasantness and Activation scores of Whissell's dictionary and comparing them to the scores of the Russell's and Desmet's 41 emotional words, I was able to assign a facial expression to all the words from Whissell's dictionary.

After succeeding to answer all research objectives, the next task was the implementation of the Non-verbal Emotional Dictionary (NED). In chapter 4 I described the system design and implementation of the NED system. First, I presented the design requirements that I followed by the creation of a concept for the NED application and then I explained my choice for the use of a web based application. Then I presented the global design of the NED system and I illustrated the concept of the NED application.

Then in chapter 5 was the next task undertaken to meet the objectives, which was to represent the data gathered and presenting a way to use it. This task was to design and implement a system to analyse and recognize emotional words. For this purpose the NED application was implemented. Given any emotional word, the NED web application is able to find its emotional representation in the 2D octants space related to Pleasure-Activation and give a number of information about its emotional status and illustrate this word with an emotional face. To accomplish this, the NED application operates in 3 different levels. Each level represents a stage to find the appropriate representation of an emotional word. If a stage isn't able to find the correct information, the next stage is triggered to analyze the input in next level. In the first level, the application will search for the given emotional word in the database of 41 most used emotional words based on the 41 expressions of Desmet [8]. If the emotional word is not found in this level, the application will then search in the second level. In this level, the application will search for the given word in the database. But this time the search job will be done in a list of synonyms of each one of the 41 emotional words of database. Which takes the amount of direct hits from 41 to almost 200 words. If the input is listed as a synonym of one of those 41 emotional words, the application will give the same representation and emotional face to the input as this emotional word. If not, the application will resume its search in the third and final level. In this level, the application will use the Pleasure and Activation scores and compare them with the Pleasantness and Activation scores of the 41 basic emotional words in the 2D octants space related to Pleasure-Activation. When search finds the nearest scores as a point in the 2D space representing a basic emotion, the application will assign its emotional information to represent the word found from the last level.

Finally, in chapter 6 I explained how I have tested the NED application by letting a number of persons use it. Unfortunately, a fully testing of the system was not possible. Due to the lack of time, I couldn't let enough users test the system to get complete result. Especially results regarding the emotional words colleted from Whissell's dictionary. But one result was that some users were not completely satisfied with the facial expressions generated from a few number of emotional words of the Whissell's dictionary. Facial

expressions like avaricious, sociable and concentrated. This means that the Pleasure and Activation scores for these words could be not for 100% corresponding to the meaning of these words. Due to the huge amount of the words gathered from Whissell's dictionary, complete test of the application concerning especially the Pleasure and Activation scores has been put as a recommendation to future work. Nevertheless, after the tests I came to the conclusion and I have shown that the performance of the NED website, concerning aspects such as the usability and speed were more than accepted and appreciated by users. Indeed, this was very clear based on the comments of the users that the Non-verbal Emotional Dictionary (NED) website is easy to understand and to use. The user did not get any kind of training. They were able to intuitively relate the actions needed to use the functionalities of the application.

7.2. Future work

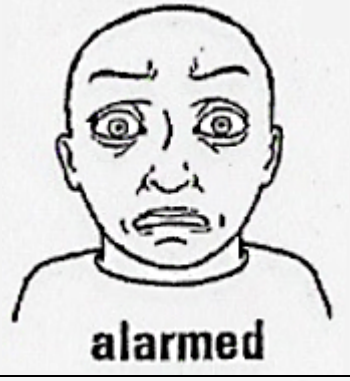
As mentions in the section before, an important aspect of future tasks is a complete test of the NED application. Especially for the completeness and correctness of the Pleasure and Activation scores of the data gathered from Whissell's dictionary. It is also very important to improve the created facial expressions used in the NED application to insure more correctness and acceptation of the data.

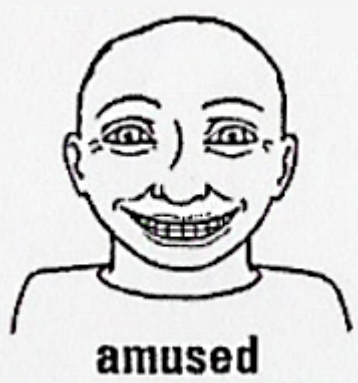
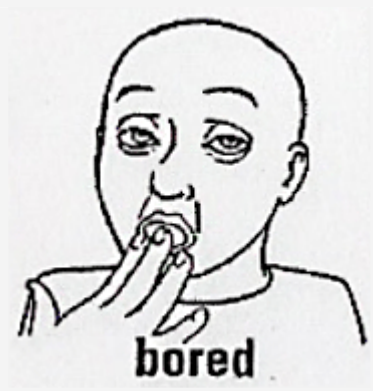
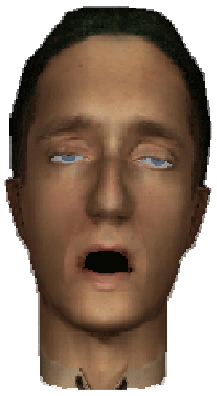
Furthermore the results from this project show several possibilities for further work. Like the integration of 3D faces based on Action Unites instead of images for the representation of the different emotions. Because a 3D image of a facial expression would contain more information than a 2D image such as used if the FEM application of Anna Wojdeł. It will be mush more interesting to introduce a concept of an application using both the web interaction, the data and the functionalities of the NED application, with the 3 dimensional and real time generation of faces based on Action Units of the FEM application. Then the next big step will be the upgrade of such application form words analysis to text analysis. By using such technology, the digital communication of people in a natural way without seeing each other will be so much improved. Not only human communication will profit of such technology, but also the digital information world will achieve a big step in the future of passing information. News for example could be read via the internet by a 3D presentator in exactly the same way a human will do. In this way passing information could be instantaneous in the whole world using just a mouse click. Also children will gate many advantages from such technologies. Not only in case of e-learning when a child gets his lesson at home behind his computer screen, but also when he wants to get his bed time story.

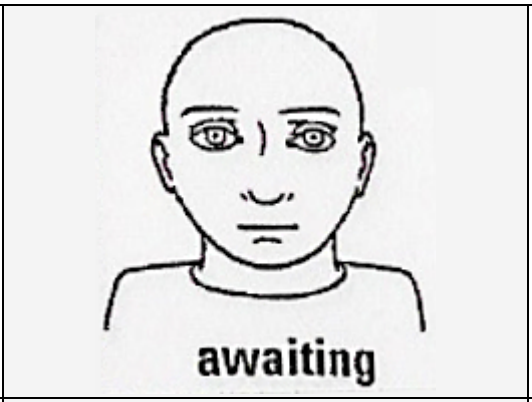
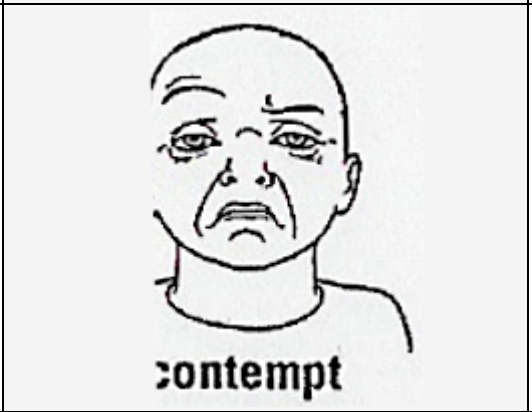
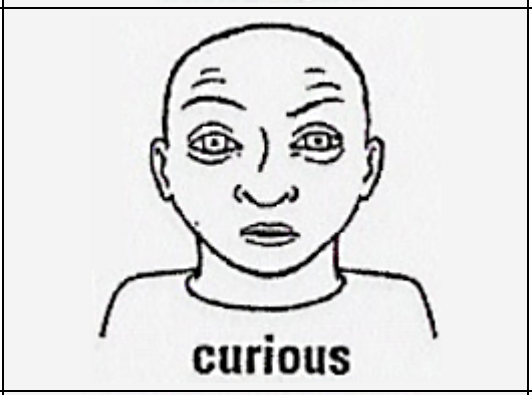
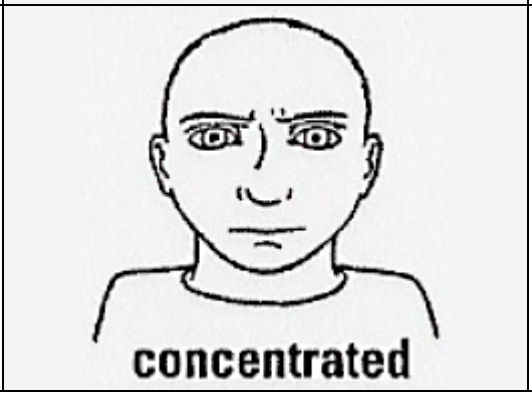
APPENDIX A

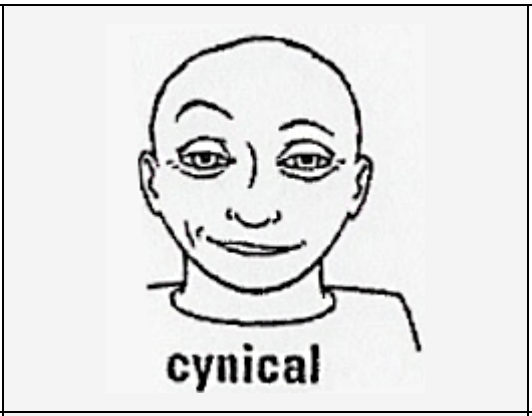
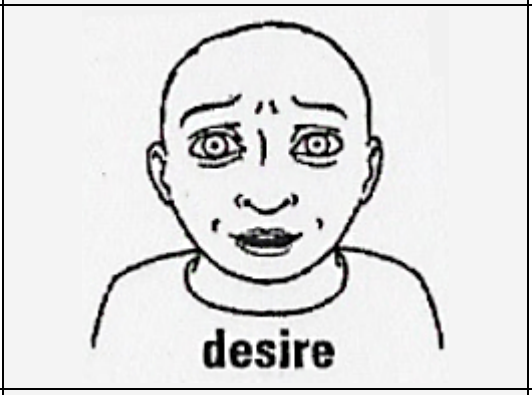
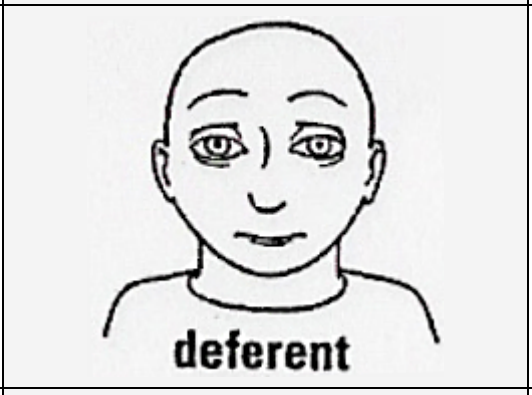
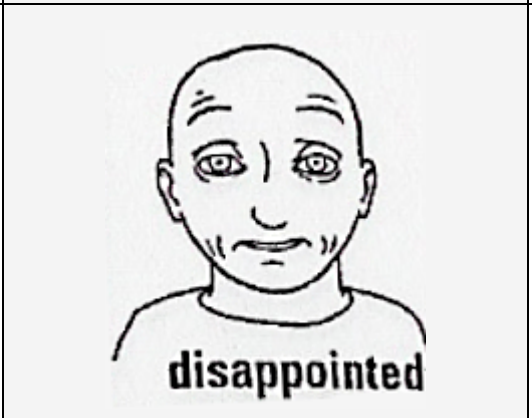
List of the 41 expressions of Desmet

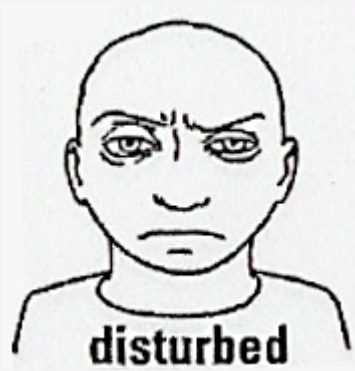
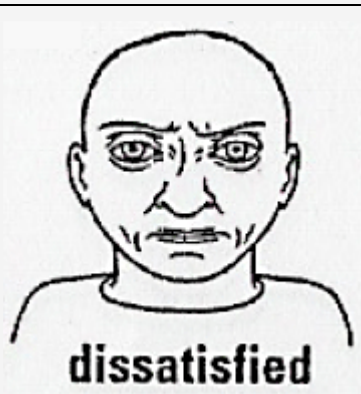
In the following table, all 41 expressions of Desmet are represented with their labels, facial expressions and AU's combinations created in the FEM application.

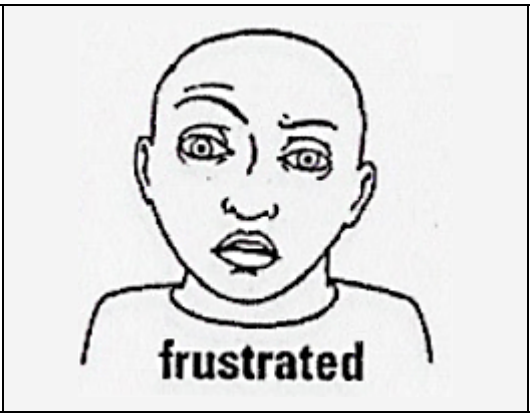
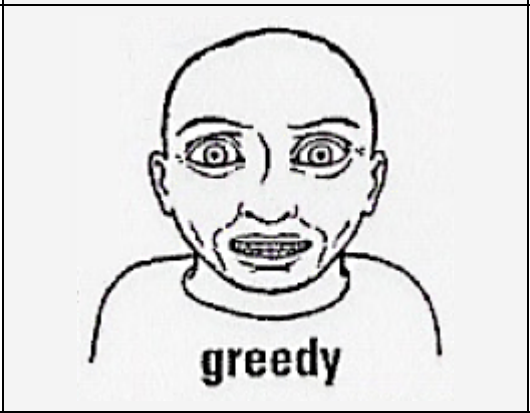
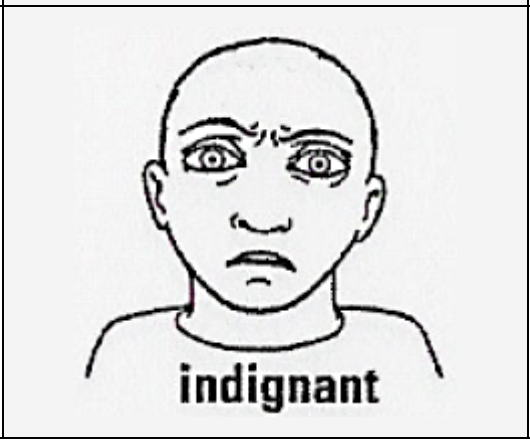
Emotional Word	Label	Facial expression	AU's combination
Admire			AU1 80 AU2 70 AU5 70 AU6 75 AU7 20 AU9 40 AU12 60 AU16 15 AU20 70 AU25 75 AU54 5 AU63 35
Alarmed			AU1 100 AU2 100 AU5 100 AU9 40 AU15 60 AU16 50 AU26 30 AU27 10 AU53 10
Amazed			AU1 60 AU2 100 AU5 45 AU6 60 AU10 15 AU12 10

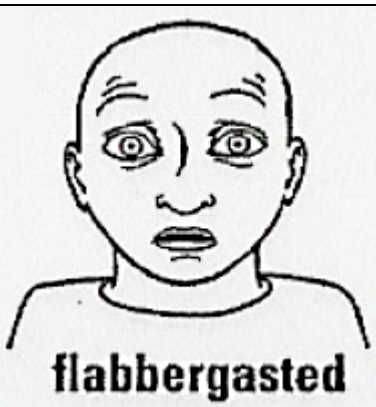
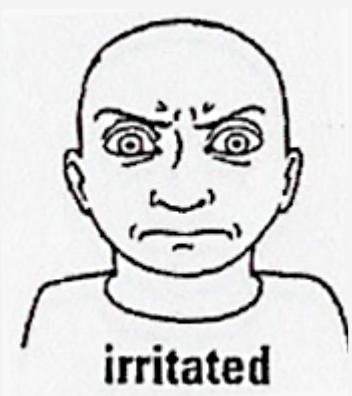
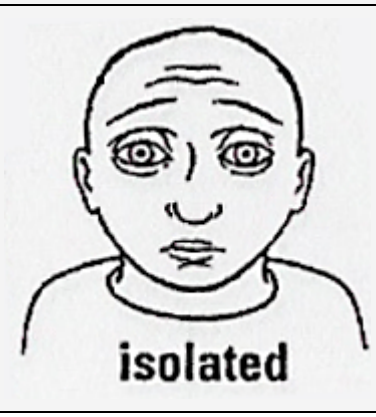
Amused			AU1 30 AU2 40 AU4 20 AU5 20 AU6 100 AU9 40 AU12 100 AU15 20 AU16 30 AU18 40 AU20 80 AU23 30 AU24 10 AU25 27 AU54 15 AU63 10
Astonished			AU1 60 AU2 100 AU5 45 AU6 60 AU12 40 AU16 70 AU20 100 AU25 40 AU27 10 AU53 10 AU64 15
Avaricious			AU2 80 AU4 40 AU5 55 AU6 70 AU16 20 AU17 30 AU20 100 AU53 15 AU64 25
Bored			AU1 50 AU15 30 AU16 100 AU27 15 AU43 50 AU51 8 AU52 7 AU53 35 AU54 20 AU55 19 AU58 100 AU61 100 AU62 30

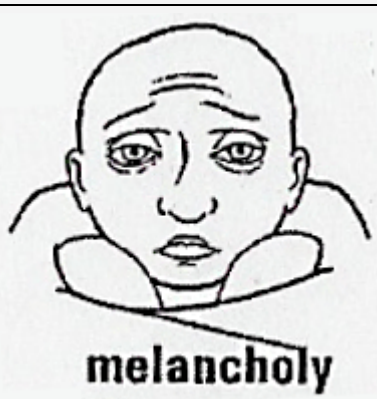
Awaiting			AU4 20 AU7 20 AU12 5 AU23 30 AU25 20
Contempt			AU2 100 AU4 70 AU9 70 AU12 20 AU15 40 AU16 15 AU17 40 AU24 50 AU43 20 AU53 20 AU56 14 AU64 100
Curious			AU2 100 AU4 20 AU5 80 AU7 70 AU24 60 AU43 40 AU54 15 AU55 9
Concentrated			AU4 60 AU6 50 AU20 30 AU23 100 AU43 30 AU53 10 AU56 10 AU62 20 AU64 100

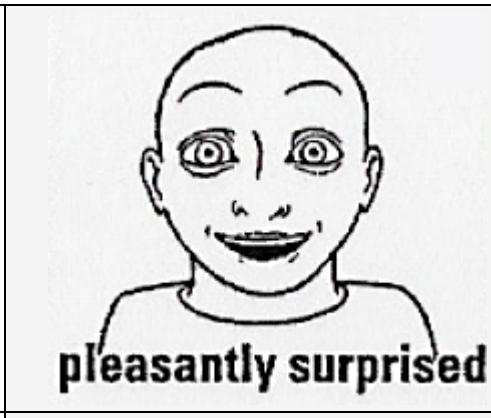
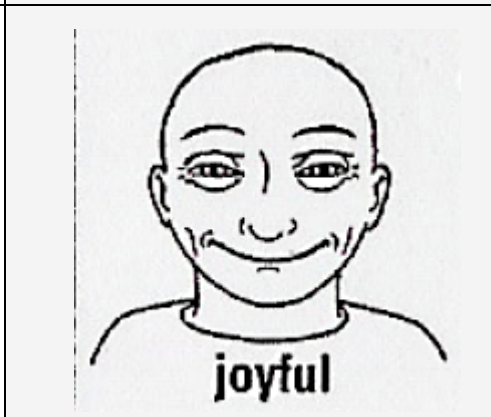
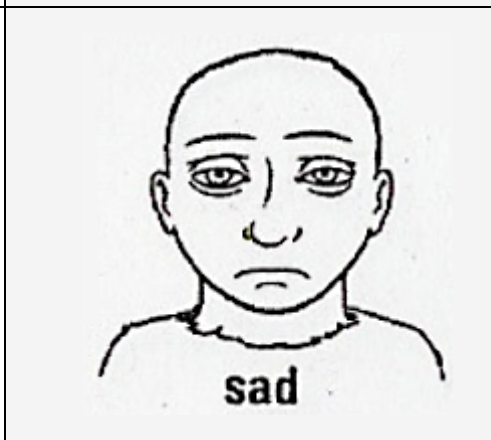
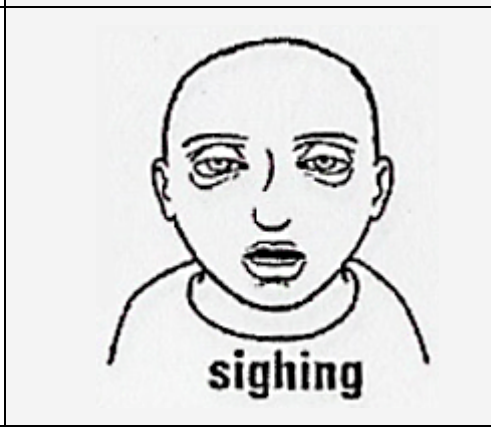
Cynical			AU2 100 AU4 40 AU5 30 AU6 80 AU10 26 AU12 40 AU17 40 AU20 100 AU28 36 AU53 5 AU55 15 AU62 10
Desire			AU1 100 AU2 15 AU4 30 AU5 80 AU6 60 AU12 30 AU16 40 AU23 50 AU25 20 AU54 10 AU56 10
Deferent			AU1 50 AU2 25 AU15 30 AU23 70 AU43 30 AU51 5 AU53 7 AU64 50
Disappointed			AU1 70 AU2 30 AU4 12 AU7 60 AU10 20 AU15 60 AU24 50 AU27 10 AU28 10 AU51 5 AU54 60 AU55 20 AU61 20 AU64 20

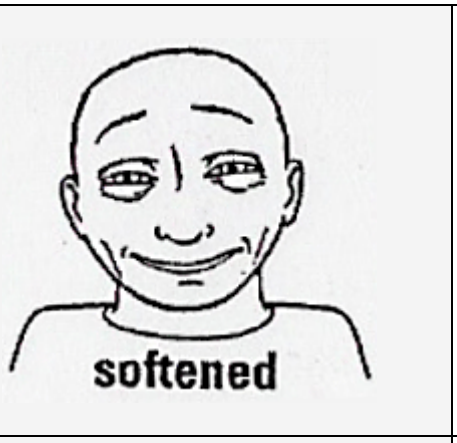
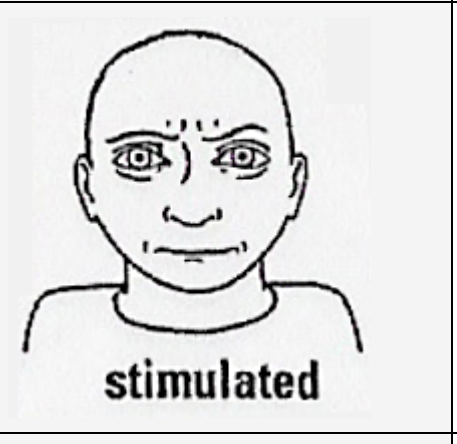
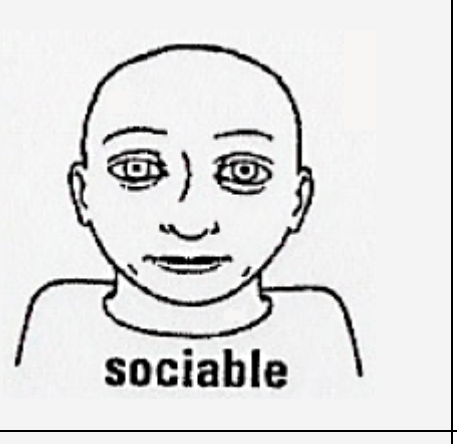
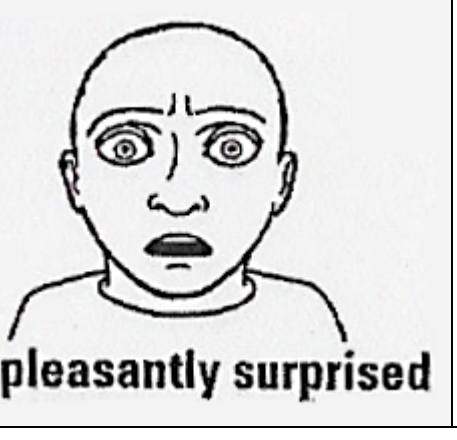
Disgust			AU4 70 AU6 80 AU9 100 AU16 100 AU20 100 AU26 60 AU27 20 AU54 10 AU58 100
Disturbed			AU2 50 AU4 100 AU5 30 AU6 70 AU15 50 AU17 30 AU23 50 AU24 30 AU51 5 AU54 20 AU56 15 AU62 10 AU64 20
Dissatisfied			AU4 100 AU6 50 AU9 30 AU16 10 AU17 30 AU18 20 AU23 100 AU43 10 AU51 3 AU54 10 AU56 10 AU62 10 AU64 60
Eager			AU1 20 AU2 90 AU4 20 AU5 40 AU6 40 AU9 75 AU17 20 AU24 30 AU28 15 AU53 10 AU64 25

Frustrated			AU1 30 AU2 90 AU4 90 AU5 70 AU6 40 AU10 45 AU15 30 AU16 20 AU24 40 AU55 15
Greedy			AU1 50 AU2 20 AU5 70 AU6 60 AU10 20 AU12 40 AU15 20 AU18 50 AU23 45 AU24 40 AU54 30 AU63 20
Hostile			AU2 100 AU4 100 AU5 100 AU6 100 AU9 100 AU15 40 AU17 30 AU18 30 AU23 50 AU24 80 AU54 50 AU63 40
Indignant			AU2 60 AU4 80 AU5 50 AU15 50 AU54 10 AU55 15

Flabbergasted			AU1 70 AU2 30 AU5 100 AU18 20 AU26 50 AU43 30 AU54 20 AU64 40
Inspired			AU1 80 AU2 85 AU5 40 AU6 60 AU12 20 AU23 30 AU28 10 AU54 10
Irritated			AU2 100 AU4 85 AU5 100 AU9 70 AU12 20 AU15 80 AU17 50 AU23 80 AU24 20 AU28 40 AU54 30 AU63 20
Isolated			AU1 100 AU2 20 AU6 70 AU7 90 AU12 20 AU15 40 AU17 80 AU18 10 AU28 40 AU43 10 AU54 20

Jealous			AU2 30 AU4 100 AU9 20 AU15 80 AU16 15 AU17 10 AU23 50 AU24 40 AU28 20 AU51 10 AU54 30 AU55 10 AU62 20 AU64 60
Loving			AU1 30 AU6 100 AU9 20 AU12 80 AU16 15 AU20 100 AU43 50 AU51 8 AU54 20 AU64 100
Satisfied			AU2 70 AU7 40 AU12 80 AU15 20 AU17 35 AU43 15 AU54 10
Melancholy			AU1 100 AU4 50 AU7 60 AU15 70 AU17 20 AU43 16 AU52 5 AU54 40 AU56 10 AU62 29 AU64 52

Pleasantly surprised			AU1 80 AU2 100 AU5 70 AU6 60 AU7 20 AU10 30 AU12 70 AU16 40 AU22 20 AU23 30 AU25 40
Joyful			AU1 20 AU2 25 AU7 60 AU12 100 AU17 10 AU24 40 AU53 5
Sad			AU1 100 AU4 50 AU7 60 AU15 100 AU17 30 AU23 40 AU51 2 AU54 5
Sighing			AU1 60 AU7 100 AU16 80 AU23 100 AU51 5 AU56 5 AU64 30

Softened			AU1 100 AU2 85 AU7 70 AU9 10 AU12 90 AU16 20 AU20 80 AU23 50 AU25 40 AU54 15 AU56 20
Stimulated			AU2 50 AU4 70 AU6 100 AU15 10 AU23 70 AU24 20 AU54 30 AU63 20
Sociable			AU1 40 AU2 30 AU6 40 AU12 50 AU15 10 AU23 60 AU43 40 AU51 6 AU53 30 AU54 20 AU58 100 AU62 15 AU64 100
Unpleasantly surprised			AU1 100 AU2 70 AU5 100 AU7 20 AU12 40 AU16 43 AU18 10 AU27 30 AU51 2 AU54 5

Yearning			AU1 75 AU2 85 AU5 70 AU6 30 AU7 20 AU9 60 AU10 20 AU12 50 AU16 5 AU20 70 AU27 15 AU54 25 AU63 35

APPENDIX B

The NED database

The database of the NED application consist of 3 tables: the ‘emotion’ table, the ‘synonym’ table and the ‘words’ table.

The ‘emotion’ table

id	name	au	octant	pleasantness	activation	face
1	admire	AU1 80 AU2 70 AU5 70 AU6 75 AU7 20 AU9 40 AU12 60 AU16 15 AU20 70 AU25 75 AU54 5 AU63 35	pleasant average	1,9	1,6	admire.gif
2	afraid	AU1 100 AU5 80 AU7 20 AU16 80 AU27 20 AU58 100	unpleasant excited	1	2,375	afraid.gif
3	alarmed	AU1 100 AU2 100 AU5 100 AU9 40 AU15 60 AU16 50 AU26 30 AU27 10 AU53 10	unpleasant excited	1	2,375	alarmed.gif
4	angry	AU4 100 AU5 100 AU6 90 AU10 20 AU16 80 AU23 100 AU54 20	unpleasant excited	1	2,5	angry.gif

5	amazed	AU1 60 AU2 100 AU5 45 AU6 60 AU10 15 AU12 10	neutral excited	2,5556	2,4167	amazed.gif
6	amused	AU1 30 AU2 40 AU4 20 AU5 20 AU6 100 AU9 40 AU12 100 AU15 20 AU16 30 AU18 40 AU20 80 AU23 30 AU24 10 AU25 27 AU54 15 AU63 10	pleasant average	2,2857	2	amused.gif
7	astonished	AU1 60 AU2 100 AU5 45 AU6 60 AU12 40 AU16 70 AU20 100 AU25 40 AU27 10 AU53 10 AU64 15	neutral excited	0	0	astonished.gif
8	avaricious	AU2 80 AU4 40 AU5 55 AU6 70 AU16 20 AU17 30 AU20 100 AU53 15 AU64 25	neutral excited	1,5714	1,8	avaricious.gif
9	bored	AU1 50 AU15 30 AU16 100 AU27 15 AU43 50 AU51 8 AU52 7 AU53 35 AU54 20 AU55 19 AU58 100 AU61 100 AU62 30	unpleasant calm	1,25	1,5556	bored.gif
10	awating	AU4 20 AU7 20 AU12 5 AU23 30 AU25 20	neutral calm	1,8	1,1	awating.gif

11	contempt	AU2 100 AU4 70 AU9 70 AU12 20 AU15 40 AU16 15 AU17 40 AU24 50 AU43 20 AU53 20 AU56 14 AU64 100	unpleasant average	1,5714	1,75	contempt.gif
12	curious	AU2 100 AU4 20 AU5 80 AU7 70 AU24 60 AU43 40 AU54 15 AU55 9	neutral excited	2,2	2,0769	curious.gif
13	concentrated	AU4 60 AU6 50 AU20 30 AU23 100 AU43 30 AU53 10 AU56 10 AU62 20 AU64 100	neutral excited	1,7143	2	concentrated.gif
14	cynical	AU2 100 AU4 40 AU5 30 AU6 80 AU10 26 AU12 40 AU17 40 AU20 100 AU28 36 AU53 5 AU55 15 AU62 10	unpleasant average	1,5	2,1667	cynical.gif
15	desire	AU1 100 AU2 15 AU4 30 AU5 80 AU6 60 AU12 30 AU16 40 AU23 50 AU25 20 AU54 10 AU56 10	pleasant excited	2,1429	2,375	desire.gif
16	deferent	AU1 50 AU2 25 AU15 30 AU23 70 AU43 30 AU51 5 AU53 7 AU64 50	neutral calm	2,1667	1,5385	deferent.gif

17	disappointed	AU1 70 AU2 30 AU4 12 AU7 60 AU10 20 AU15 60 AU24 50 AU27 10 AU28 10 AU51 5 AU54 60 AU55 20 AU61 20 AU64 20	unpleasant average	1,7143	1,75	disappointed.gif
18	disgust	AU4 70 AU6 80 AU9 100 AU16 100 AU20 100 AU26 60 AU27 20 AU54 10 AU58 100	unpleasant excited	1,375	1,875	disgust.gif
19	disturbed	AU2 50 AU4 100 AU5 30 AU6 70 AU15 50 AU17 30 AU23 50 AU24 30 AU51 5 AU54 20 AU56 15 AU62 10 AU64 20	unpleasant average	1,25	1,875	disturbed.gif
20	dissatisfied	AU4 100 AU6 50 AU9 30 AU16 10 AU17 30 AU18 20 AU23 100 AU43 10 AU51 3 AU54 10 AU56 10 AU62 10 AU64 60	unpleasant average	1,5	2,333	dissatisfied.gif
21	eager	AU1 20 AU2 90 AU4 20 AU5 40 AU6 40 AU9 75 AU17 20 AU24 30 AU28 15 AU53 10 AU64 25	neutral excited	2,125	2,25	eager.gif

22	frustrated	AU1 30 AU2 90 AU4 90 AU5 70 AU6 40 AU10 45 AU15 30 AU16 20 AU24 40 AU55 15	unpleasant excited	1,375	2,1	frustrated.gif
23	greedy	AU1 50 AU2 20 AU5 70 AU6 60 AU10 20 AU12 40 AU15 20 AU18 50 AU23 45 AU24 40 AU54 30 AU63 20	unpleasant excited	0	0	greedy.gif
24	hostile	AU2 100 AU4 100 AU5 100 AU6 100 AU9 100 AU15 40 AU17 30 AU18 30 AU23 50 AU24 80 AU54 50 AU63 40	unpleasant excited	1,25	2,2	hostile.gif
25	happy	AU7 100 AU12 100 AU16 50 AU27 10	pleasant average	3	2,75	happy.gif
26	indignant	AU2 60 AU4 80 AU5 50 AU15 50 AU54 10 AU55 15	unpleasant excited	1,7143	1,7778	indignant.gif
27	flabbergasted	AU1 70 AU2 30 AU5 100 AU18 20 AU26 50 AU43 30 AU54 20 AU64 40	unpleasant average	1	2,2	flabbergasted.gif
28	inspired	AU1 80 AU2 85 AU5 40 AU6 60 AU12 20 AU23 30 AU28 10 AU54 10	pleasant excited	2,5714	2,4444	inspired.gif

29	irritated	AU2 100 AU4 85 AU5 100 AU9 70 AU12 20 AU15 80 AU17 50 AU23 80 AU24 20 AU28 40 AU54 30 AU63 20	unpleasant excited	1	1,8571	irritated.gif
30	isolated	AU1 100 AU2 20 AU6 70 AU7 90 AU12 20 AU15 40 AU17 80 AU18 10 AU28 40 AU43 10 AU54 20	unpleasant calm	1,2857	1,6667	isolated.gif
31	jealous	AU2 30 AU4 100 AU9 20 AU15 80 AU16 15 AU17 10 AU23 50 AU24 40 AU28 20 AU51 10 AU54 30 AU55 10 AU62 20 AU64 60	unpleasant average	1,5556	2,2	jealous.gif
32	loving	AU1 30 AU6 100 AU9 20 AU12 80 AU16 15 AU20 100 AU43 50 AU51 8 AU54 20 AU64 100	pleasant excited	3	2,25	loving.gif
33	satisfied	AU2 70 AU7 40 AU12 80 AU15 20 AU17 35 AU43 15 AU54 10	pleasant calm	2,7143	1,6667	satisfied.gif

34	melancholy	AU1 100 AU4 50 AU7 60 AU15 70 AU17 20 AU43 16 AU52 5 AU54 40 AU56 10 AU62 29 AU64 52	unpleasant calm	1,3333	1,6	melancholy.gif
35	pleasantly surprised	AU1 80 AU2 100 AU5 70 AU6 60 AU7 20 AU10 30 AU12 70 AU16 40 AU22 20 AU23 30 AU25 40	pleasant average	2,37	2,35	pleasantly_surprised.gif
36	joyful	AU1 20 AU2 25 AU7 60 AU12 100 AU17 10 AU24 40 AU53 5	pleasant average	2,4	2,6429	joyful.gif
37	sad	AU1 100 AU4 50 AU7 60 AU15 100 AU17 30 AU23 40 AU51 2 AU54 5	unpleasant calm	1,375	1,4286	sad.gif
38	neutral	AU1 0		1,9091	1,6364	neutral.gif
39	sighing	AU1 60 AU7 100 AU16 80 AU23 100 AU51 5 AU56 5 AU64 30	unpleasant calm	1,1	1	sighing.gif
40	softened	AU1 100 AU2 85 AU7 70 AU9 10 AU12 90 AU16 20 AU20 80 AU23 50 AU25 40 AU54 15 AU56 20	pleasant calm	0	0	softened.gif

41	stimulated	AU2 50 AU4 70 AU6 100 AU15 10 AU23 70 AU24 20 AU54 30 AU63 20	neutral excited	2,5	2,5455	stimulated.gif
42	sociable	AU1 40 AU2 30 AU6 40 AU12 50 AU15 10 AU23 60 AU43 40 AU51 6 AU53 30 AU54 20 AU58 100 AU62 15 AU64 100	pleasant average	3	2,5714	sociable.gif
43	unpleasantly surprised	AU1 100 AU2 70 AU5 100 AU7 20 AU12 40 AU16 43 AU18 10 AU27 30 AU51 2 AU54 5	unpleasant excited	2,01	2,3	unpleasantly_surprised.gif
44	yearning	AU1 75 AU2 85 AU5 70 AU6 30 AU7 20 AU9 60 AU10 20 AU12 50 AU16 5 AU20 70 AU27 15 AU54 25 AU63 35	pleasant average	2,6	1,6667	yearning.gif

The 'synonym' table

id	synonym	emotion_id
1	treasure	1
2	value	1
3	adore	1
4	frightened	2
5	scared	2
6	terrified	2
7	nervous	3
8	protest	3
9	mad	4
10	outraged	4
11	surprised	5
12	entertained	6
13	diverted	6
14	astounded	7
15	overwhelmed	7
16	longing	8
17	aroused	8
18	covetous	9
19	acquisitive	9
20	grabby	9
21	grasping	9
22	itchy	9
23	prehensile	9
24	passive	10
25	anticipating	10
26	dissaproving	11
27	disagreement	11
28	wonder	12
29	fixate	13
30	focus	13
31	settle	13
32	grouchy	14
33	moody	14
34	grumpy	14
35	hangker	15
36	longing	15
37	hunger	15
38	pine	15
39	thirst	15
40	composed	16
41	defeated	17
42	despise	18
43	repel	18
44	repulse	18
45	irked	19
46	troubled	19
47	upset	19
48	aversive	20
49	displeased	20
50	impatient	21
51	breathless	21
52	anxious	21
53	heated	21
54	hot	21
55	ambitious	21
56	intent	21
57	defeated	22
58	desperation	22
59	desirous	23
60	wishful	23
61	ill	24
62	inimicable	24
63	inimical	24
64	unfriendly	24
65	attack	24
66	competitive	24
67	argumentative	24
68	opposed	24
69	warlike	24
70	fierce	24
71	cruel	24
72	prosperous	25
73	furious	26
74	histerical	27
75	sorrow	27
76	doubtful	27
77	enthusiastic	28
78	elate	28
79	exhilarate	28
80	stimulated	28
81	excited	28
82	fire	28
83	devoted	28
84	eager	28
85	hearty	28
86	obsessed	28
87	passionate	28
88	arden	28
89	euphoria	28
90	annoyed	29
91	bothered	29
92	diilusioned	30
93	separate	30
94	suspicious	30
95	malice	31

96	appreciate	32
97	cherish	32
98	prize	32
99	relaxed	33
100	fulfilled	33
101	comfortable	33
102	gloomy	34
103	cheerless	34
104	miserable	34
105	sorrowful	34
106	unhappy	34
107	appreciating	35
108	well	35
109	fit	35
110	lighthearted	35
111	cheerful	36
112	overjoyed	36
113	grief	37
114	pity	37
115	worried	37
116	regret	37
117	neutral	38
118	pokerfaced	38
119	expressionless	38
120	dispirit	39
121	tired	39
122	cozy	40
123	intimate	40
124	smile	40
125	dreamy	40
126	cautious	40
127	provoke	41
128	quicken	41
129	energize	41
130	vitalize	41
131	motivated	41
132	move	41
133	innerve	41
134	aroused	41
135	encouraged	41
136	inspired	41
137	appetitive	42
138	close	42
139	familiar	42
140	puzzle	43
141	confuse	43
142	bewildered	43
143	fear	43
144	appalled	43
145	disbelief	43
146	guess	44
147	wish	44
148	lust	44

The 'words' table

Due to huge amount of entries in this table (more than 8.000 word), I will only present a part of the data.

token	valence	activation
a	2	1,3846
abandon	1	2,375
abandoned	1,1429	2,1
abandonment	1	2
abated	1,6667	1,3333
abilities	2,5	2,1111
ability	2,5714	2,5
able	2,2	1,625
abnormal	1	2
aboard	1,8	1,875
abolition	1,5	2,1818
abortion	1	2,7273
about	1,7143	1,3
above	2,2	1,25
abroad	2,6	1,75
abrupt	1,2857	2,3
abruptly	1,1429	2,2
abscess	1,125	1,5455
absence	1,5	1,5556
absent	1	1,3
absolute	1,6667	1,4444
absolutely	1,6	1,5
absorb	1,8	1,75
absorbed	1,4	1,625
absorption	1,7778	1,6667
abstract	1,6667	1,4444
abstraction	1,4286	1,4
absurd	1	1,5
abundance	2,6667	1,5556
abuse	1,4286	2,5
abusers	1,25	2,7273
abusing	1,25	2,8182
abusive	1,6667	2,6667
abut	1,7143	1,4
academic	1,8	1,5
academy	2	1,625
accelerated	2,1667	2,4444
acceleration	2,2857	2,5
accept	2,4444	1,5
acceptable	1,8889	1,5
acceptance	2,5	1,4286
accepted	1,6667	1,3333
accepting	1,5	1,2857
access	2,4545	1,9231
accident	1	2,375
accommodate	2	1,7143
accompanied	2,1429	2,2
accompanying	1,8333	2,1111
accomplish	2,75	2,3636
accomplished	2,7143	2,4
accomplishments	2,625	2,2727
accordance	2	1,5556
according	1,6667	1,6667
accordingly	1,8	1,375
account	1,6	1,5
accounting	1,5	2
accounts	1,5556	1,75
accumulated	1,8571	2,1
accumulation	2,1429	1,6
accuracy	2,625	2
accurate	2,5714	2,1
accurately	2,5	1,7273
accuse	1	2,2222
accused	1	1,7143
accustomed	2,1667	1,1111
ace	3	1,2857
aced	2,75	2,1429
achieve	2,8889	2,8333
achieved	2,7143	2,8
achievement	2,75	2,7143
achievements	2,5	2,7273
achieving	2,8	2,625
achy	1	2,3
acid	1,25	2
acknowledge	1,8	1,25
acknowledged	2,1429	1,5
acquainted	2,2	1,5
acquire	2,2	1,625
acquired	1,75	1,7143
acquiring	2,1818	2,0714
acquisition	1,8333	1,6667
acreage	1,6667	1,3333
acres	2	1,5455
across	2	1,625
act	1,7143	2,4
acted	1,4	2
acting	1,75	2,4545
action	2	2,8889
actions	2,3333	2,9167
active	2,4	2,625
actively	2,4286	2,4

activist	2,2	2,375
activities	2,3333	2,4167
activity	2,6667	2,4444
actor	2,4	2
actors	1,8333	2,3333
actor's	2,1	2,3077
acts	2,1667	2,4444
actual	2	1,25
actually	1,6667	1,4444
acute	1,3	1,8462
ad	2,1667	1,4444
adaptation	1,5714	2,2
adapted	2	2
add	2	1,7778
added	2	1,6667
adding	2,1429	1,9
addition	1,6	1,375
additional	1,8333	1,4444
addled	1,8	1,375
address	1,875	1,6364
addressed	1,875	1,6364
addresses	1,7143	1,4
adds	2,2	1,5
adequate	2,2	1,5
adequately	2	1,6
adjacent	1,7143	1,4
adjoining	1,875	1,6364
adjust	1,8333	1,8889
adjusted	2,2857	1,8
adjusting	1,5	1,7778
adjustment	1,6	2
adjustments	1,6	1,875
administered	1,2	1,625
administration	1,8889	1,8333
administrative	1,5	1,5556
administrator	1,2857	1,7
admirable	2,7778	1,6667
admiration	2,5	1,7778
admire	1,9	1,6
admired	2,75	1,8182
admission	2	1,6364
admit	1,6667	1,6667
admitted	2	2
adolescence	1,8	1,875
adolescent	1,4	2
adopt	1,8333	2,5556
adopted	1,7143	2,5
adopting	2,1111	2,75
adoption	1,6667	2,25
adoring	2,75	2,1429
adrenaline	2,3333	2,6667
ads	2,25	1,1429

adult	2,4	2,0769
adults	1,8	1,875
advance	2,25	1,7143
advanced	2,4286	1,7
advancement	2,3333	1,7778
advances	2,5	2,1818
advantage	2,5714	2,1
advantages	2,5	2,0909
adventure	2,8333	3
adventures	2,6667	2,8333
adverse	1,4	1,625
advertising	2	2
advice	2,5	1,9091
advise	2,3333	1,5833
advised	2	2,1
advisee	2	1,6
advisers	2	1,7273
advisory	1,5714	1,7
advocate	2,25	2
aesthetic	2,1667	1,3333
affair	1,25	2,2857
affairs	1,1667	2,3333
affect	1,75	1,8571
affected	2	1,5714
affection	2,7778	2,25
affects	2	1,9
affirm	2	1,8571
affixed	1,7143	1,4
affliction	1,4	1,625
afford	2,375	1,9091
afforded	1,75	1,7143
afraid	1	2,375
africa	2,1429	1,6
african	2	1,375
after	1,8	1,25
afternoon	2,4545	1,4286
afternoons	2,3333	1,5556
after-thought	1,75	1,4286
afterward	2,1667	1,3333
afterwards	1,875	1,3636
again	1,8	1,5
against	1,1429	1,3
age	1,8	1,875
aged	1,5	1,7273
agencies	1,8333	1,5556
agency	1,75	1,8182
agent	1,6	1,25
agents	1,4286	1,4
ages	1,6	1,625
aggravate	1,1111	2,4167
aggravating	1	2,2222
aggression	1	2,25

aggressive	1,2	2,6923
aghast	1	1,7778
agitated	1,3333	2,2222
ago	1,6	1,1429
agree	2,6667	1,8889
agreeable	2,7	2,0769
agreed	2,6667	1,7778
agreement	2,5714	2
agreements	2,1667	1,6667
agrees	2,4	1,625
agricultural	1,8	1,25
agriculture	2,2857	1,3
ah	2,4	1,5
ahead	1,5556	1,6667
aid	2,2	1,625
aided	2,5	1,7273
aids	1,625	2,0909
aim	2,5714	1,8
aimed	2	1,625
aims	2,4	1,875
ain't	1,1429	1,5
air	2	1,4
aircraft	1,875	1,7273
airplane	1,5	1,7778
airplanes	1,7143	1,8
airport	1,6667	1,7778
akin	1,8	1,125
alarm	1	2,25
alarmed	1	2,375
alarming	1	2,5833
alas	2	1,2222
alcohol	1,7143	2,2
alcoholic	1	2,1667
alert	2	2,5
alien	1,4286	1,8
alienation	1	1,7273
alike	2,25	1,3636
alive	2,6667	2,5
all	2	1,4
epidemic	1,6	2,3636
episode	2,2	1,8182
equal	2,3333	1,5
equality	2,1429	1,25
equally	2,3	1,3636
equation	1,8333	1,2857
equations	1,8182	1,5833
equestrian	2,375	2,4444
equilibrium	2,5	1,7778
equipment	2,2857	1,625
equipped	2,25	2
equitable	2,0909	1,75
equivalent	2	1,5385

era	2,1667	1,1429
erase	1,6	2,3333
erect	2,1429	2,75
erected	2,2308	2,5714
errands	2	2,1429
error	1,75	1,4444
errors	1,8571	1,5
escape	2	3
escaped	2,1	3
especially	2,3	1,6
essay	1,7	1,7273
essence	2,3333	1,3
essential	2,2	1,6364
essentially	2	1,5455
establish	2,2222	2,2
established	2,125	2
establishing	2,3333	2,2
establishment	2,375	1,8889
estate	1,875	1,4444
estimate	1,8571	1,875
estimated	1,9	2,2727
estimates	1,8889	1,9
etc	2	1,5455
eternal	2,1667	1,4286
ethical	2	1,7143
ethics	1,7143	1,625
ethnic	1,4	1,3333
european	1,7	1,5455
evaluate	2	2,4286
evaluated	1,8571	2,125
evaluation	1,8889	2,3
even	2	1,125
evening	2	1
evenings	2,5	1,1818
event	2,375	2
eventful	2,1667	2,1429
events	2,1667	2,2857
eventual	1,7143	1,375
eventually	1,6667	1,4286
ever	2,0769	1,6429
every	1,8889	1,5
everybody	2,375	1,8889
everyday	1,7778	1,7
everyone	2,2857	1,625
everything	1,8333	1,4286
everywhere	2,25	1,5
evidence	2,1	1,7273
evidenced	2,1111	1,7
evident	1,75	1,6667
evidently	1,75	1,5556
evil	1,875	2,4444
evoking	2	2,4286

evolution	2,3	2
exact	1,8571	1,25
exactly	2,25	1,4444
exaggerated	1,8333	2,5385
exam	1,7143	2,375
examination	2	3
examine	1,7778	2,7
examined	1,6667	2,4
examiner	1,8182	2,25
example	2,125	1,5556
examples	2,1	1,5455
exams	1,6667	2,3
exceed	2,25	2,1111
exceeds	2	2
excellence	2,5	2,3636
excellent	2,1429	2,125
except	1,7143	1,625
exception	1,5	1,4286
exceptional	2,4444	2
exceptions	1,7	1,5455
excess	1,875	1,7778
excessive	1,7143	2,25
exchange	1,8333	2,5714
excited	2,5	2,9091
excitement	2,2857	2,875
exciting	2,5	2,7778
exclaimed	2,2	2,6364
excluding	1,5556	1,5
exclusive	1,875	1,6667
exclusively	2	1,5
excuse	2,1667	1,5714
executed	1,6667	2,3636
execution	1,6	2,6364
executive	2,25	1,8889
exercise	2,625	3
exercised	2,2	2,7273
exercises	2,6	2,9091
exercycle	1,8889	2,5
exert	2,2857	2,4444
exerted	2,2	2,5455
exhausted	2	2,2857
exhausting	1,5455	2,0833
exhaustion	1,875	1,8889
exhibit	2	2
exhibited	2	1,875
exhibition	2,25	1,8889
man	2	1,875
manage	1,8	1,5
managed	1,6667	2
management	1,75	1,9091
manager	1,5	1,8182
managerial	1,75	1,6364
managers	1,6667	1,75
manchester	2	1,7273
mane	1,8	1,25
mangled	1,2	1,625
manhattan	2,1667	1,6667
maniacal	1,3333	1,7778
manifold	1,8333	1,5333
mankind	2,25	1,8182
manned	1,8333	1,4444
manner	1,8889	1,6667
manners	2,2	1,875
manpower	1,8	2
man's	2,0909	1,8571
mantle	2,25	1,4286
manufacture	1,7778	2
manufactured	1,75	1,9091
manufacturer	1,8571	1,9
manufacturers	1,75	1,7273
manufacturing	1,875	2,0909
many	2	2
map	2	1,5385
maps	2	1,3333
marathon	1,5714	2,2
marble	2,2727	1,6429
march	2	2
marching	2,2	2
mare	2,2222	1,5
mares	2	1,75
margaret	2	1,6364
margin	1,8571	1,2
marginal	1,375	1,1818
maria	2,25	1,3636
marijuana	1,625	1,7273
marina	2,2	1,5
marine	2,1429	1,8
marines	1,5	1,8889
marital	2,6	2,125
mark	2	1,375
marked	2,25	1,9091
market	2,2857	1,8
marketing	2,1667	1,8889
markets	2,1667	1,6667
marking	2	2
marks	1,8889	1,75
marriage	2,6667	2,4444
marriages	2,5	2,1111
married	2,7778	2,1667
marry	2,8571	2,4
mars	2,375	1,5455
marshal	1,6667	1,5556
marshall	1,5	1,5556
martial	1,75	1,8182

martyrdom	1,5556	1,8333
marvellous	3	2,5833
masquerade	2,5714	2,1
mass	1,875	1,8182
masses	1,625	1,7273
massive	1,875	1,4545
master	1,6	1,375
masters	1,6667	1,75
mastery	1,8	1,625
match	1,8889	1,75
matched	1,7143	1,8
matches	1,4286	1,7
matching	1,8333	1,8889
mate	2,6	1,875
material	1,9	1,6154
materials	1,8	1,5385
mates	2,3333	1,5556
mathematical	1,4	1,75
mathematics	1,8333	1,8889
matter	1,8	1,6154
matters	1,5	1,4286
mature	2,1429	1,7
maturity	2	1,625
max	2	2,2222
maximum	2,25	2,1818
maxwell	1,875	1,5455
may	1,7143	1,5
maybe	2	1,2
mayor	1,8571	1,6
mays	1,8	1,3846
me	2,125	1,8182
meadow	2,8571	1,4
meal	2,5	1,7273
meals	2,1429	1,7
mean	1,25	1,6364
meaning	1,8571	1,8
meaningful	2,625	1,9091
meaningless	1,25	1,2727
meanings	1,8889	1,8333
means	1,6667	1,4444
meant	1,4	1,375
meantime	1,8333	1,2222
meanwhile	1,6	1,25
measure	1,8	1,6923
measured	1,6	1,625
measurement	1,6667	2
measurements	1,5	1,5455
measures	1,875	1,6364
measuring	1,875	1,9091
meat	2	1,5
meathead	1	1,4545
meats	1,4	1,4

mechanical	1,2	2,2
mechanics	1,5	2,5
mechanism	1,3333	1,8333
mechanisms	1,5833	1,9167
meddle	1,25	2,5
media	1,5	2,5
medical	1,8889	2,3333
medication	1,4	1,8
medicine	1,6	1,8
projector	1,2857	2,1429
projects	1,2857	2
prolonged	1,9231	1,9231
prominent	2,0909	2,2727
promise	2,25	2,25
promised	2,5	2,1667
promises	2,7143	2,4286
promising	2,7273	2,1818
promontory	1,6667	1,6667
promote	2,375	2,25
promoted	2,4	2,2
promoting	2,4286	2,5714
promotion	2,6667	2,2222
prompt	2	1,875
promptly	2	2,5556
prone	1,2222	1,5556
pronounced	1,1429	1,8571
proof	1,6667	1,6667
propaganda	1,4	2,2
propeller	1,25	2,5
propelling	1,625	2,375
proper	2	2
properly	1,8889	1,8889
properties	1,7778	1,8889
property	1,6667	1,6667
proportion	1,5714	2
proportional	1,8	2,1
proportions	1,2857	2,1429
proposal	2,1429	1,8571
proposals	2,2857	2
propose	1,6667	1,6667
proposed	2,25	2,0833
proposition	1,4286	2,1429
proprietor	1,7143	2,1429
prose	1,8	1,9
prospect	1,75	2
prospective	2,1111	2,2222
prospects	2,3	2,3
prosperity	2,25	2
prostitution	1	2
protect	2,4286	2
protected	2,5714	2,1429
protection	2,8571	2,1429

protective	2,5833	2,25
protein	2,5556	1,6667
proteins	2,2857	2,1429
protest	1	2,375
protestant	1,1667	2
protestantism	1,1667	2,1667
protestants	1	2,4
protested	1	2,0833
protests	1	2,1111
protocol	1,5714	1,7143
proud	2,7778	2
prove	1,75	2,125
proved	2	2,2857
proven	2	2
proverbs	2	1,5556
proves	1,75	2,25
provide	2,4167	2,25
provided	2	2,2857
providence	1,4286	1,8571
provides	1,8889	2,1111
providing	2,3636	2,3636
province	2	1,9
provinces	1,8889	1,8889
provision	1,5556	2,1111
provisions	1,8889	2
provoking	1,2	2,6
prow	1,2857	2
pro-western	1,1667	1,1667
psalms	2,125	1,75
psychiatry	1,75	2,25
psychoanalysis	1,6667	1,8333
psychological	1,6667	2
psychologist	2	2
psychologists	1,875	2,25
psychology	2,1429	2,2857
public	1,625	1,75
publication	1,7143	1,5714
publications	1,9	2
publicity	1,5	1,8333
publicly	1,4286	2
published	2,1	2,3
publishers	1,75	2,125
publishing	2,25	2,375
pudding	2,4286	1,7143
pueblo	1,4444	1,5556
pueblos	1,375	1,875
puff	1,5	1,375
puke	1	2,3636
pull	1,4444	2,3333
pulled	1,5	2,4
pulley	1,5	1,75
pulling	1,25	2,25
punches	1,2857	2,5714
punishing	1,1111	2,4444
punishment	1	2,3333
puns	2,1	1,6
pupil	1,5714	1,5714
pupils	1,7143	2
pupil's	1,6667	1,7778
puppies	2,8571	2
purchase	2,1538	2,2308
purchased	2,2727	2,4545
senate	1,7778	1,25
senator	1,3333	1,25
senators	1,7	1,4444
send	2,4286	1,8333
sending	2,375	2
senior	1,75	1
sensation	2,5	1,2
sensations	2,3333	1,6
sense	2,6364	1,6
sensed	2,375	1,5714
senses	2,2857	2
sensible	2,75	1,2857
sensitive	2,7143	1,3333
sensitivity	2,8	1,3333
sent	2,2	1
sentence	1,7143	1,3333
sentences	1,7273	1,5
sentiment	2,625	1,1429
sentimental	2,5	1,2857
separate	1,375	1,7143
separated	1,1818	1,6
separately	1,625	1,4286
separation	1,4286	1,5
september	2	2
sequence	2,1111	1,625
serene	2,6	1,2222
sergeant	1,75	1,4286
series	2,125	1,7143
serious	2,1429	1,6667
seriously	1,8	1,5556
sermon	1,1667	1
servant	1,7778	1,625
servants	1,8571	1,5
serve	1,7778	2
served	1,5714	1,8333
serves	1,7143	1,8333
service	2	1,8333
services	2,0909	2
serving	1,875	2,1429
session	2	1,2
sessions	2	1,4286
set	2	1,4

sets	1,8333	1,2
setting	1,875	1,5714
settle	2	1,3333
settled	2,125	1,1429
settlement	2,4444	1,125
settlers	2,2222	1,625
settling	2,2222	1,125
seven	1,875	1,1429
seventeen	2,1429	1,3333
seventh	2	1,5
several	2	1,5556
severe	1,2222	1,875
severely	1,25	2
sewage	1,2857	1,5
sewer	1,1111	1,5
sewing	1,8889	1,625
sex	2,7778	2,625
sexes	2,4286	1,8333
sexual	2,6667	2,375
shade	2,1429	1
shades	2,1667	1
shadow	2,3333	1,2
shadows	2	1
shaft	1,5833	1,7273
shake	1,75	2
shaken	1,4444	1,875
shaking	1,375	2,7778
shall	1,875	1,5556
shallow	1,2857	1,25
sham	1,3333	1,8
shame	1	1,75
shamed	1	2
shan't	1,5	1,5556
shape	1,8333	1,4286
shaped	2	1,8571
shapes	2,1	1,6364
share	2,75	2,2222
shared	2,875	2,5556
shares	2,75	1,8889
sharing	2,75	2,4
sharp	1,75	2,2
sharply	1,2	2
shattered	1	2,0833
she	1,7143	1,875
shear	1,5	1,7143
shears	1,5	1,8571
shed	1,5556	2
she'd	1,5714	1,625
sheep	2,4444	1,6
sheer	1,8333	1,2857
sheet	1,5556	1,6
sheets	1,6667	1,7143
sheik	1,8333	2
shelf	1,5	1,7778
shell	2,0909	1,6667
shelley	1,4444	1,6
shells	2,375	1,3333
shelter	2,625	1,7778
shelters	2,125	1,8889
sheriff	1,6667	2,2
she's	1,875	1,6667
shift	1,1667	2
shifted	1,2857	2,25
shifting	1,2857	2
shifts	1,2	2
shining	2,6	2,1667
ship	2	1,7273
shipments	1,7143	2
shipping	1,5	2
ships	1,8571	1,875
shipwreck	1,3333	2,2857
shirked	1	1,9
shirt	1,25	1,4
shirttail	1,3333	1,4286
shit	1,2	2,1818
shits	1	2
shitty	1	2,375
shivering	1	2,625
shock	1,1	2,5455
shocked	1,1429	2,625
shoe	1,6667	1,5714
shoes	1,7778	1,7
shooed	1	2,1111
shook	1,2222	2,4
shoot	1,1429	2,625
shooting	1	2,75
shop	2,1667	2,4286
shopping	2,7778	2,5
shops	2,4	2
shore	2,5	2
shorn	1,6667	1,4286
short	1,125	1,5556
shortage	1,1667	1,4286
shorter	1,3333	1,3846
shortly	1,7	1,4545
shorts	1,8571	1,75
short-term	1,1667	1,4286
shot	1	1,8333
shots	1	2,5
should	1,5556	1,6
shoulder	1,4	1,5
shoulders	1,4286	1,75
shouldn't	1,1667	1,5714
shouted	1	2,75

shouting	1	2,8889
show	2,25	1,6667
showed	1,5714	1,75
shower	2	2,25
showing	1,1667	2,2857
showmanship	1,75	2,1111
shown	1,6667	1,7
shows	2	1,7778
shrank	1,1429	1,25
shrieking	1	2,4286
shrivelled	1	2
shrugged	1,375	1,8889
shrunken	1,25	2,1111
shut	1	1,1429
shuts	1,5	1,4444
shy	1,5	1,4286
shyness	1,2	1,5
siblings	1,6	2,1667
sick	1	1,6667
side	1,6364	1,5
sides	1,2857	1,625
sidewalk	1,5	1,5556
sieves	1,375	1,6667
sigh	1,625	1,8889
sighed	2	1,25
sighs	1,6667	1,4
sight	2,2857	1,75
sights	2	1,5
sightseer	2,25	1,7778
sign	1,5	1,5714
signal	1,6667	1,8571
signals	1,9	2,1818
transit	1,8333	2,2
transition	2	1,8889
translate	2,1667	1,6
translated	1,8333	1,4
translation	2	1,8571
transmission	1,5	1,6
transom	1,5	1,5714
transparent	1,5	1,6
transport	1,6667	2,625
transportation	2,1667	2,4
trap	1	2,4444
traumatic	1	2,2
travel	2,5714	3
travelled	2,6667	2,8
travelling	2,6	2,7778
tray	1,7143	1,5
treasurer	2,1667	2
treasury	2,6364	2
treat	2,75	2,2857
treated	2,8571	2,5
treating	2,6667	2,4
treatment	2,2	2,25
treatments	1,8	2,3333
treats	3	2,3333
treaty	2	1,6
tree	2,8333	1,6
trees	2,5714	1,6667
tremble	1,1429	2,5
trembling	1,375	2
tremendous	2,5	1,5
tremendously	2,2857	2,3333
trend	1,5	1,6
trends	1,875	1,8571
trial	1,25	2,1429
trials	1,375	2,1429
tribes	2,1667	2,2
tribune	1,6667	1,4
tribunes	1,5556	1,5
tribute	2,5	1,7143
trick	1,5	2,2857
tried	2	1,6667
tries	1,75	2,4286
trigger	1,1667	2,4
trim	2	2
trinkets	2	2
trip	2,1667	2,8
tripods	1,9	1,7778
trippers	1,8571	2
trips	2,5	2,8571
triumph	2,6667	2,625
trivial	1,8571	1,6667
troop	1,7143	2,1667
troops	1,8889	2,125
tropical	2,625	1,5714
trot	2	2,3333
trotting	2,5	2,5714
trouble	1,5	2
troubled	1,3333	1,6
troubles	1	2,4286
truck	2	2,2857
trucker	1,875	2,4286
trucks	1,7778	2,125
true	2,4	2
truelove	3	2,3333
truly	2,8	1,5
trust	2,9167	1,7273
trusted	2,3333	1,8
wilds	1,8	1,5
will	1,8333	1,4
willing	2,4615	2,25
willingness	2,4286	1,8333
willows	2,6667	1,2

wilted	1,1111	1,875
wimp	1	2
win	3	2,5556
wincing	1,3	2,3333
wind	2,2727	2,1
windings	1,7143	2,1667
window	2,4	1,5556
windows	2,5714	1,5
winds	2,5714	1,6667
wine	2,5	2,1111
wines	2,1818	2,3
wing	2,2222	1,625
wings	2,4444	2,5
winning	3	2,5
winter	2,3333	2,375
wipe	1,4	2,1111
wiped	1,5	1,8571
wipers	1,5	2
wipes	1,5	1,8571
wire	1,5	1,2
wired	1,5	1,6
wires	1,8	1,5556
wisdom	3	2,375
wise	2,6667	1,8
wish	2,6	1,6667
wished	2,7143	1,8333
wishes	2,8	1,6667
wit	1,8	1,5
witch's	1,4286	2,1667
with	1,8889	1,625
within	1,5714	1,5
without	1,2857	1,8333
witness	2	1,8333
witnessed	1,9231	2
witnesses	1,5714	2,3333
witty	2,8571	2,5
wives	2,5	2,2222
woke	1,8571	1,8333
woken	1,4444	1,875
wolf's	1,7143	2
woman	2,6	2
woman's	2,2857	2,1667
women	2,7273	2,1
women's	2,7143	2
won	2,5556	2,25
wonder	2,1667	2
wondered	2,25	2
wonderful	2,8571	2,3333
wonderfully	2,8333	2,3636
wondering	2,5556	2,25
won't	1,4286	1
wood	2,125	1,4286
wooden	1,8571	1,3333
woods	3	1,2
woodsmen	1,9167	2,0909
wool	2,6	1,75
word	1,7778	1,375
words	1,8571	1,1667
wore	1,375	1,2857
work	1,875	1,8571
workaholic	1	2,75
worked	1,5714	1,6667
worker	1,5	1,8571
workers	1,5714	1,8333
working	2,1	2,2222
works	1,8	2,2222
workshop	2,2222	1,875
world	2,2857	1,6667
world's	1,7143	2
world-wide	2,2222	1,875
wormed	1,4444	1,75
worn	1,5	2,4444
worried	1,25	2
worries	1,1111	1,5
worry	1,1429	2,1667
worse	1,1429	1,8333
worship	2	1,8333
worst	1,1429	1,8333
worth	2,3636	1,8
worthiness	1,5714	1,6667
worthy	2,4444	2,125
would	1,8	1,5556
wouldn't	1,625	1,4286
wound	1,4444	1,625
wounded	1,2	2,2222
wow	2,6	2,1111
wraiths	1,6	1,5
wrapped	2	1,625
wren	1,7143	1,6667
wrestling	2,1429	2
wriggled	1,875	2,1429
wright	1,8889	1,375
wrinkled	1,6364	1,6
wrist	2,1	1,8889
write	1,6667	1,6
writer	1,8	1,25
writers	1,8333	1,4
writes	2,2308	2,0833
writing	2	1,6667
writings	2	1,4
written	2,1111	2
wrong	1,25	2,2857
wrongful	1,1	2,1111
wrongly	1,1111	2

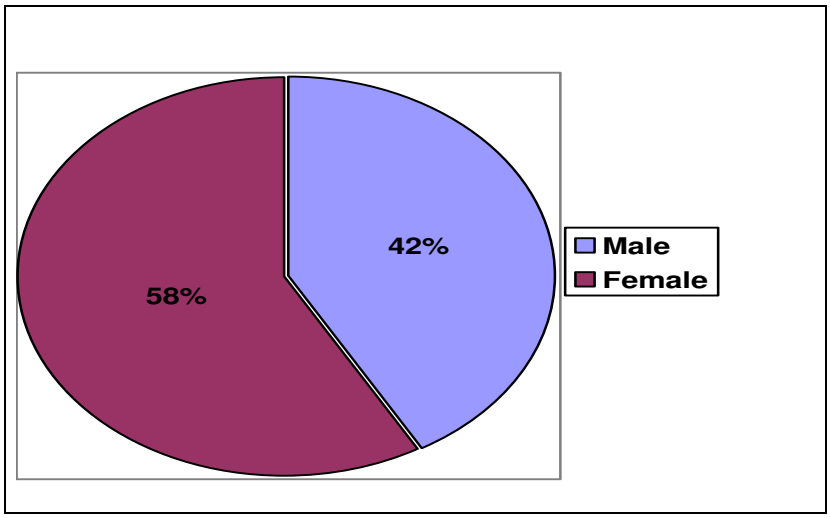
wrote	2	1,5
x-ray	1,375	2,4286
yankee	1,5455	1,9
yankees	1,8571	2,3333
yap	1,8571	2,3333
yard	2,5	1,7778
yards	2,0909	1,6
yarn	2	1,5
yawned	1,4444	1,125
ye	1,9	1,5556
yeah	2,7778	2
year	2	1,7778
yearly	1,5	1,2
years	1,625	1,2857
year's	1,875	1,8571
yech	1,1667	1,8
yelled	1,1667	1,8
yellow	2,3	2,1111
yells	1	2,375
yelping	1	2,8
yes	2,6	1,8889
yesterday	2,5714	1,8333
yet	1,7	1,4444
yield	1,4	1,75
yielded	1,5714	1,5
yodel	1,8889	2
you	2,1429	1,5
you'd	1,5714	1,6667
you'll	1,5714	1,6667
young	3	1,8333
younger	2,7	1,7778
youngest	2,4286	1,6667
youngsters	2,4444	2,375
your	1,7143	1,5
you're	1,7692	1,6667
yours	1,8	1,7778

C

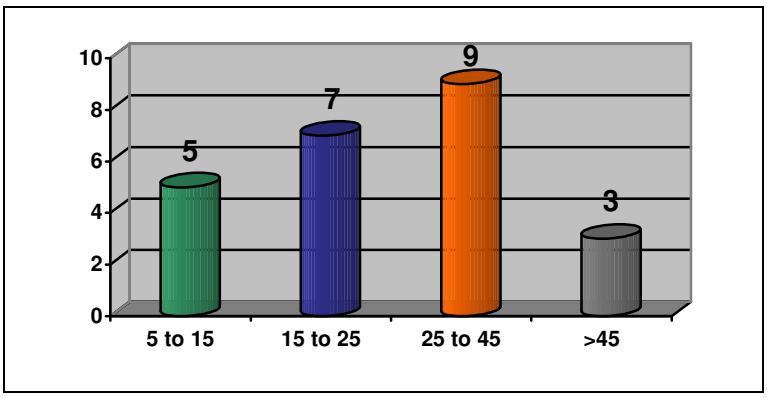
APPENDIX

Survey Results

In this chapter the total survey is listed. By each label, the percentage of the chosen facial expression is listed. Also the percentage of men and women is shown, accompanied with an analysis of the age of the participants at this survey.

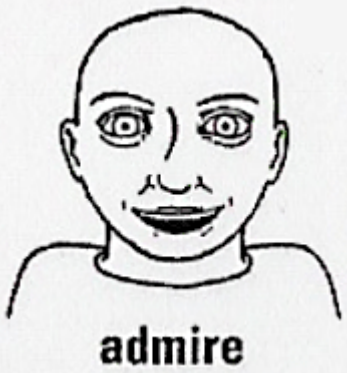
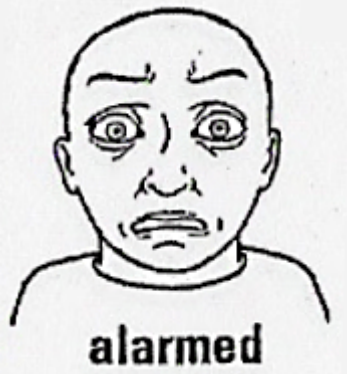


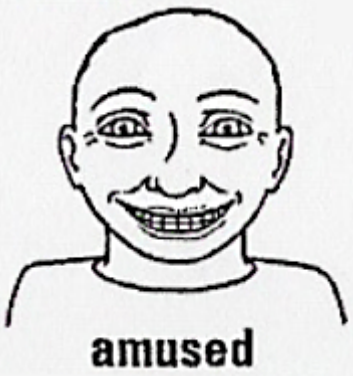
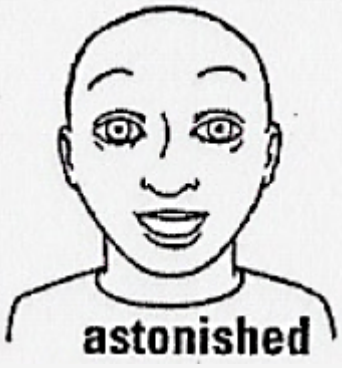
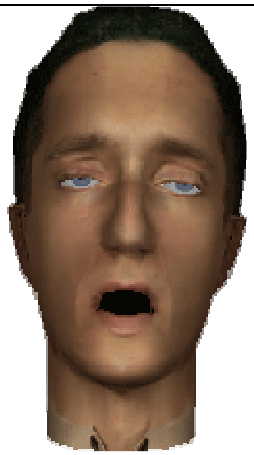
The male / female percentage



The age of the participants

Gender	Male : **40%**		Female : **60%**	
Age	9 to 15: **5**	15 to 25: **7**	25 to 45: **9**	>45: **3**

Smiley Label	Option 1	Option 2	Option 3
	 4	 admire 18	 2
	 alarmed 21	 1	 2
	 3	 amazed 21	 0

	 2	 2	 amused 20
	 2	 0	 astonished 22
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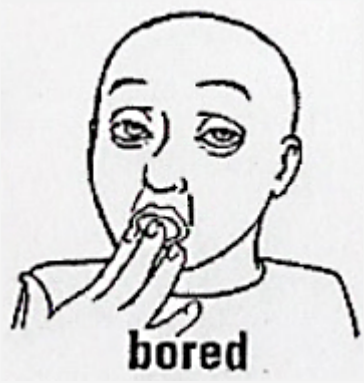		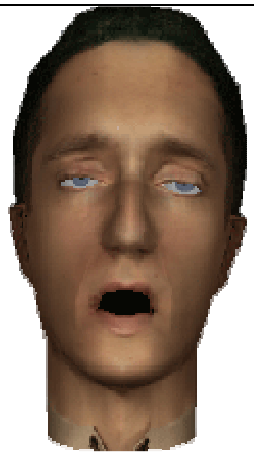	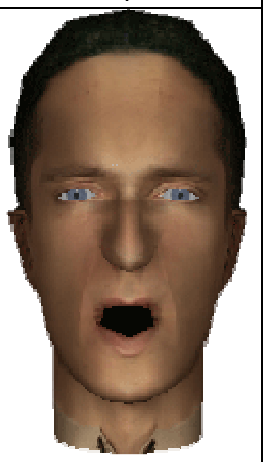
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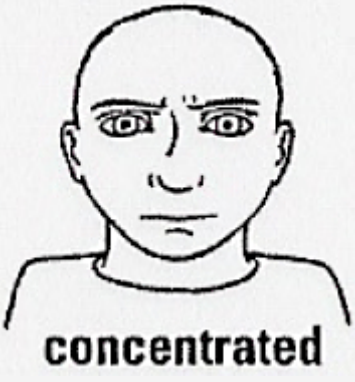			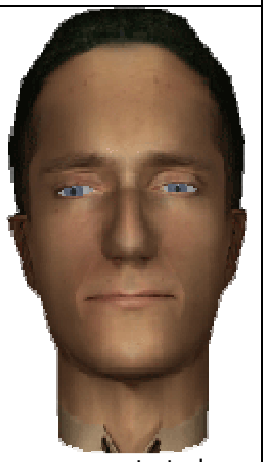
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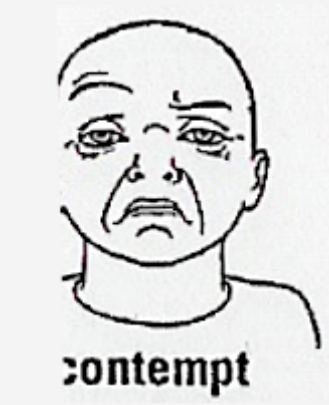	 contempt 23	 0	 1
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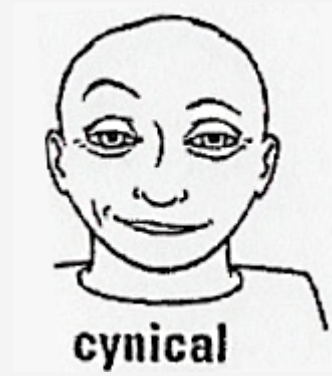
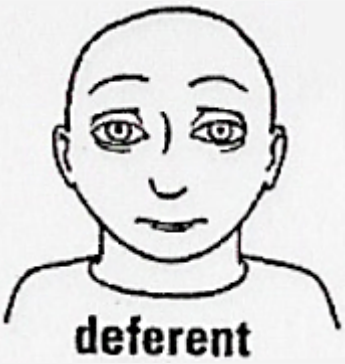
	 0	 0	 cynical 24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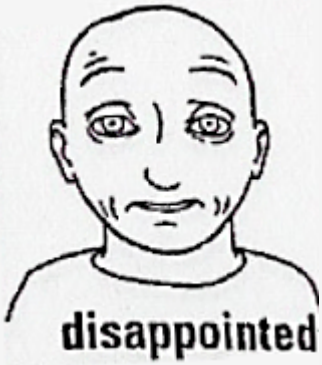			
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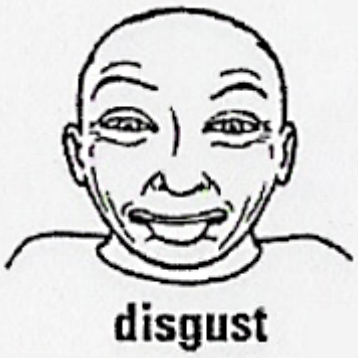

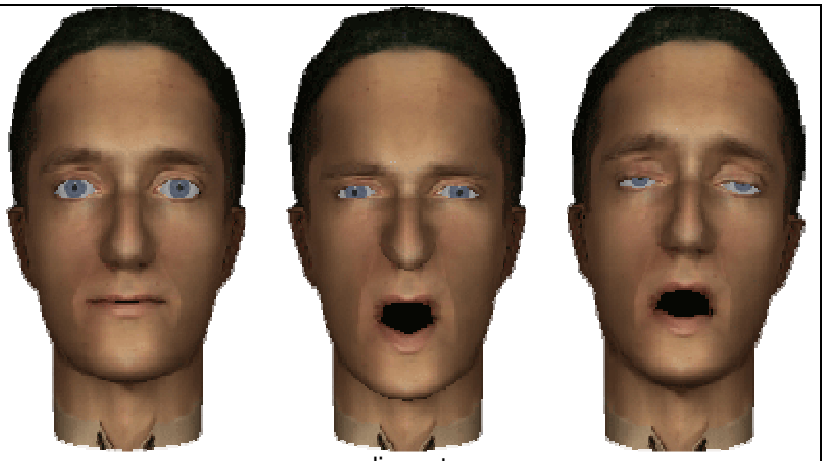

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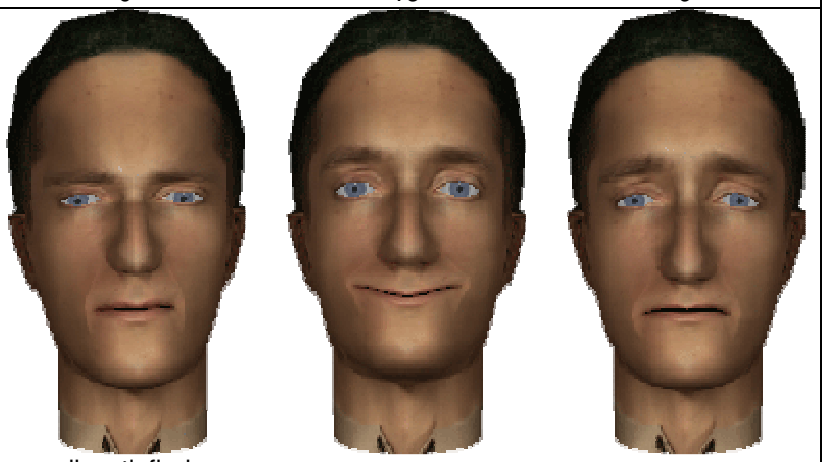

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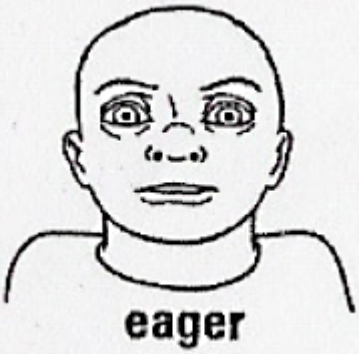

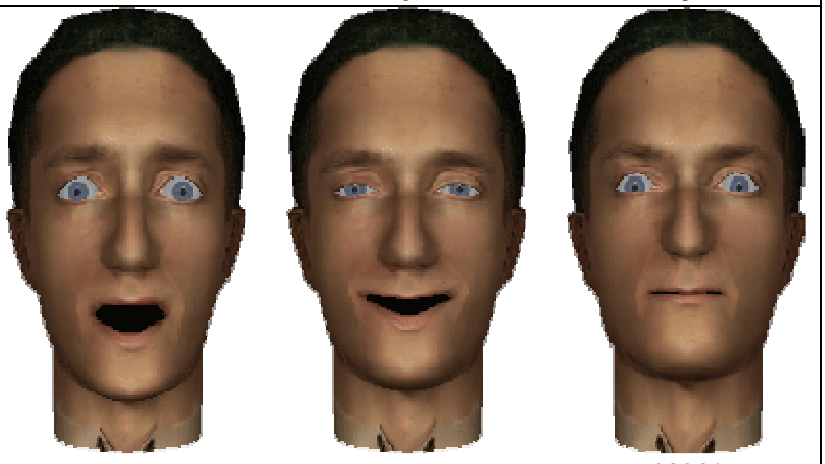

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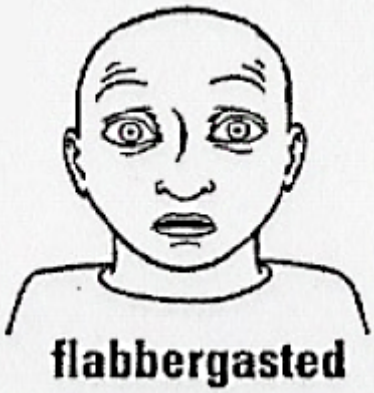
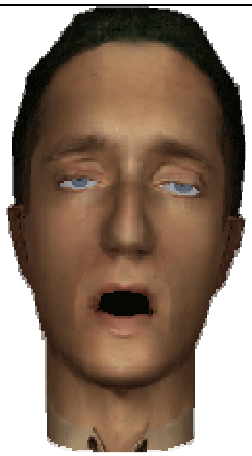
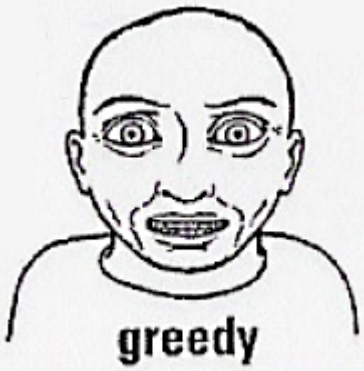
	 flabbergasted 24	 0	 0
	 1	 frustrated 23	 0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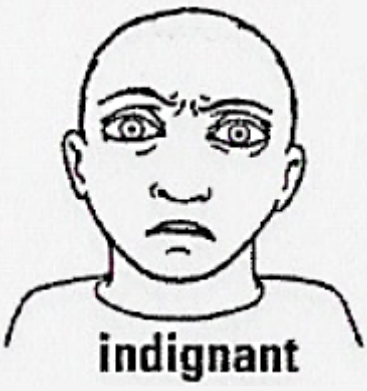	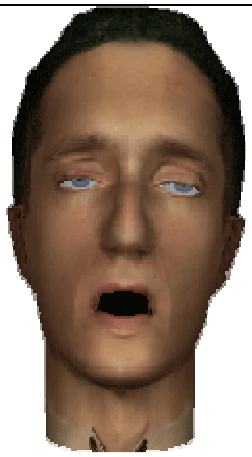		
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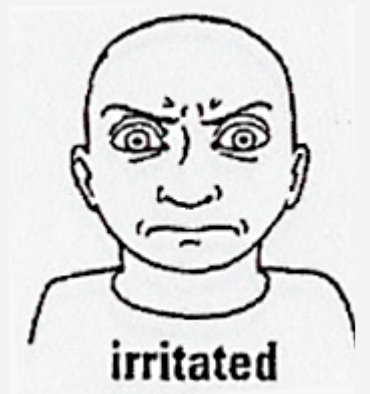
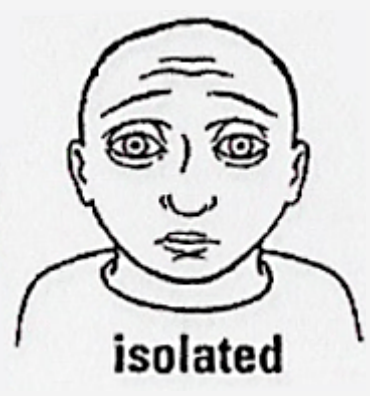
	 0	 irritated 24	 0
	 2	 2	 isolated 20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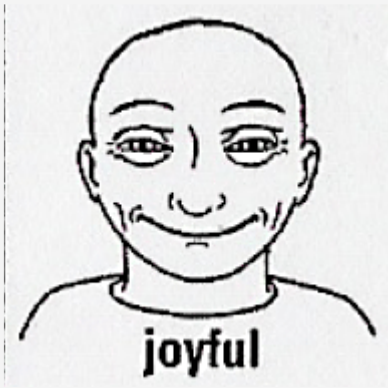			
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			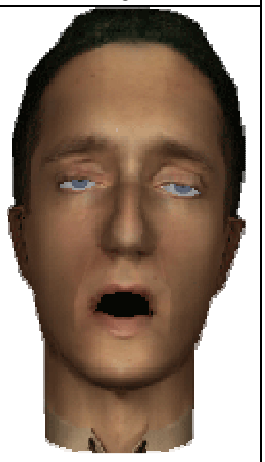
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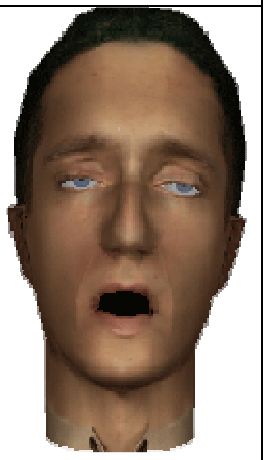
	 surprised 24	 0	 0
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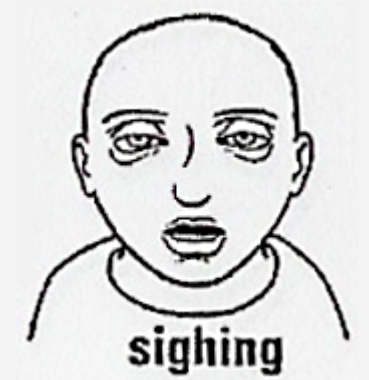			
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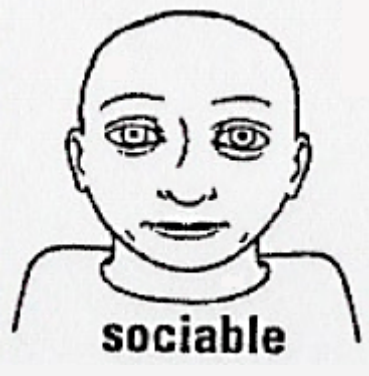			
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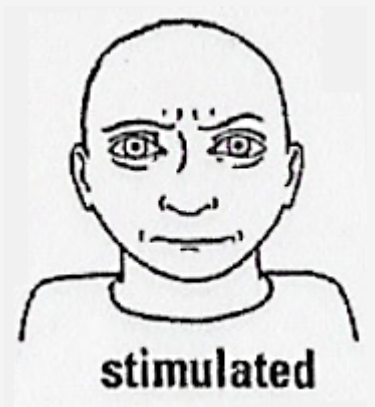
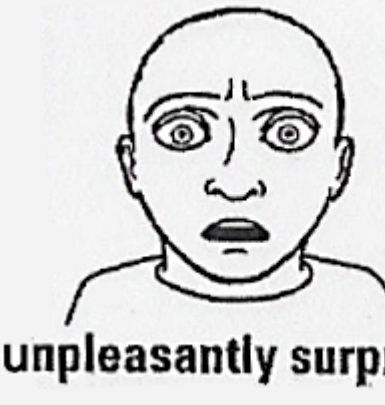
	 2	 stimulated 22	 0
	 3	 unpleasantly surprised 21	 0

yearning
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