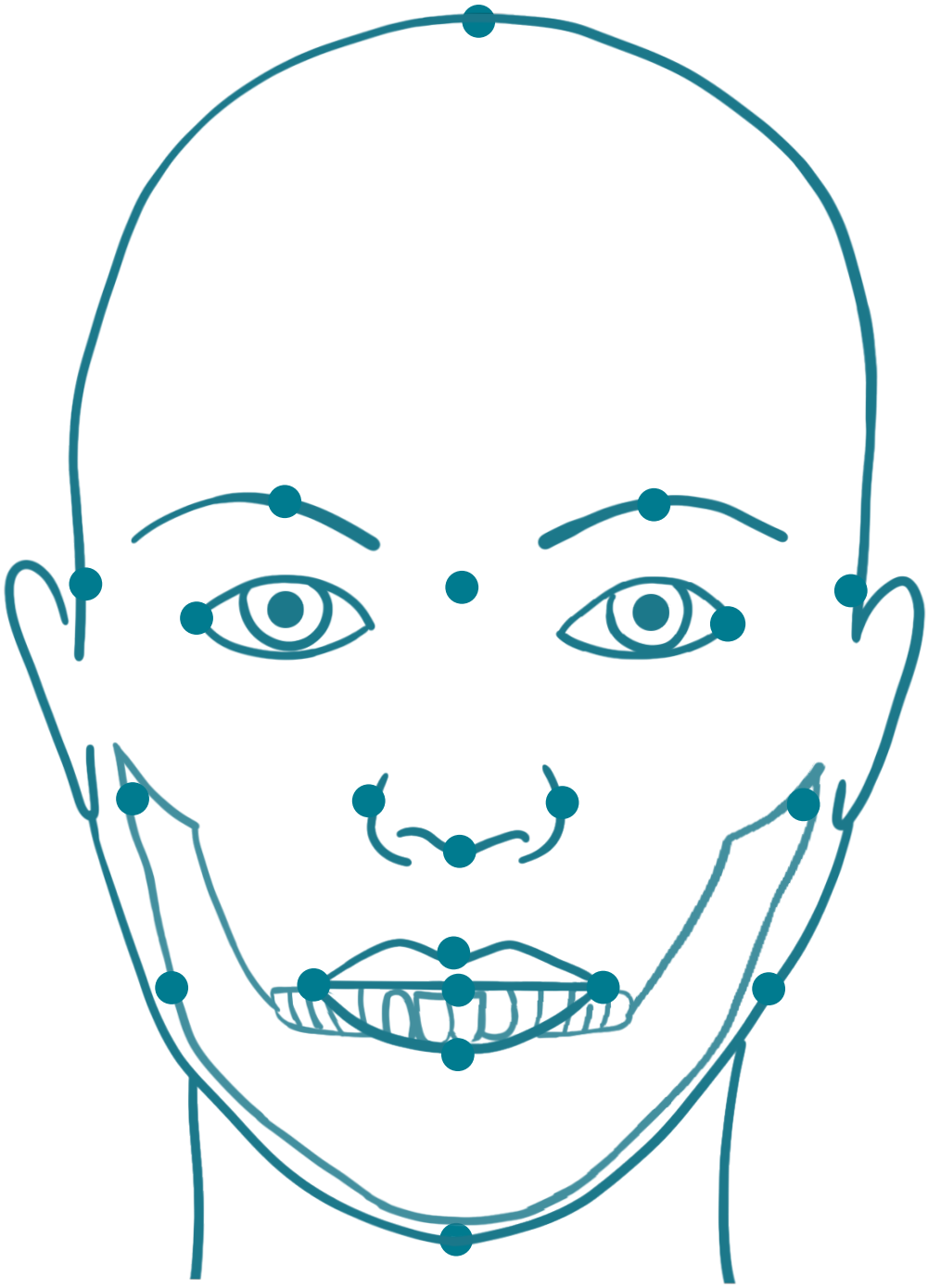
Appendix Fraos

A tool to predict and communicate facial recognition after orthognathic surgeries

Master thesis
Tamara Ribbers



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Appendix 1: Sensemaking model exploration

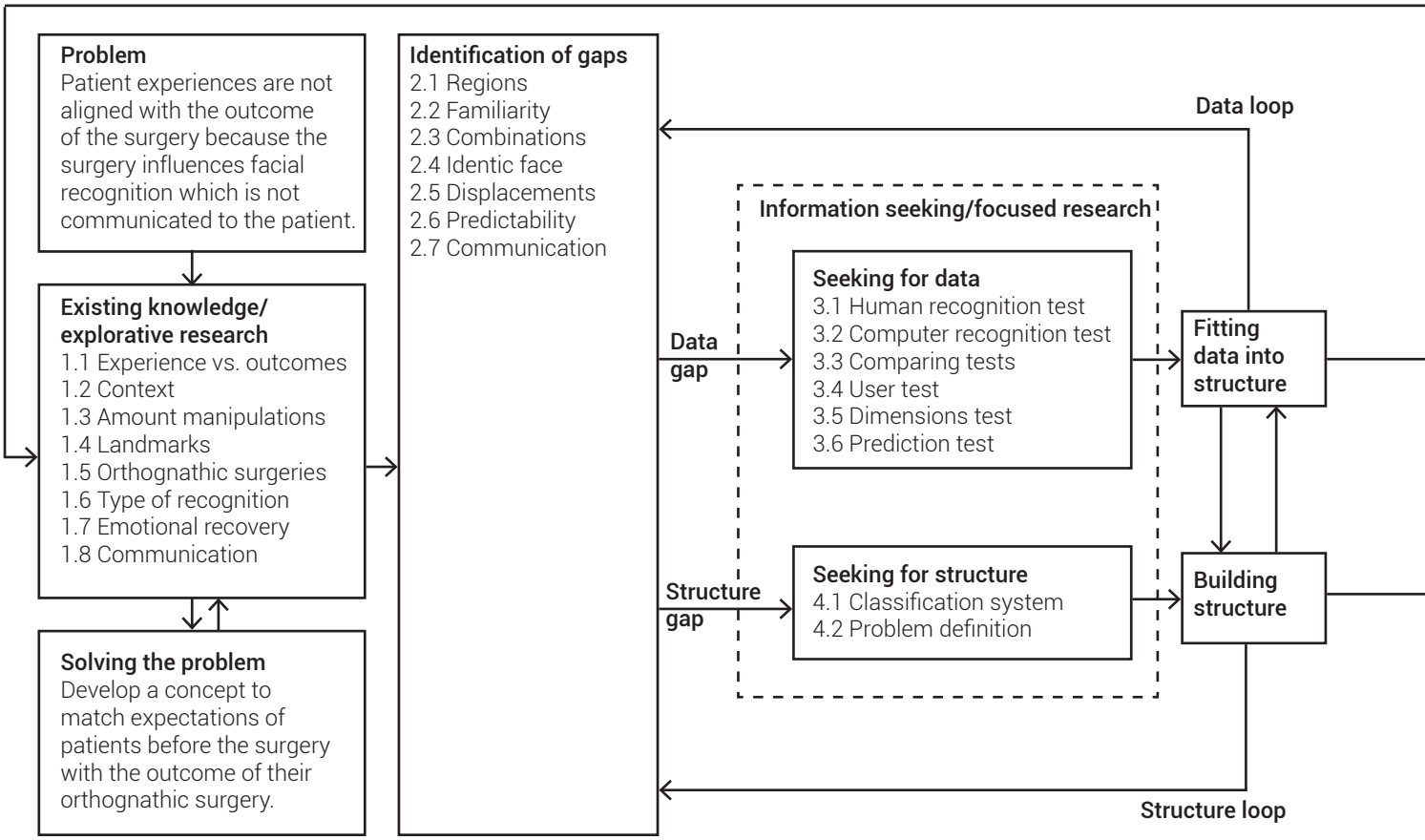


Figure A1.1: Implementation of the model of the cognitive process and mechanisms of individual sensemaking

Existing knowledge
1.1 Experience vs. outcomes: The patient's perception and expectations about the surgery should align with the treatment plan, if not, this should be resolved before proceeding the treatment. Patients can be dissatisfied with results of the surgery, even if the outcome of the surgery is optimal, because of poor communication between patient and surgeon before the surgery.

1.2 Context: If a patient is recognized by his acquaintances depends on more than just the face. Things like the context where the patient is seen, the voice, hair- or clothing style all play a role in recognition. When talking about facial recognition only, familiarity of the person plays a big role and this should always been taken into account in further research.

1.3 Amount manipulations: Local manipulations on the face can influence facial recognition. Surgeries influencing multiple facial features influence facial recognition the most.

1.4 Landmarks: Different sets of landmarks exist. The landmarks of Kiekens et al., (2008) describe the landmarks important in orthognathic surgeries. These landmarks are used to describe the landmark movements.

1.5 Orthognathic surgeries The type of orthognathic surgeries, how they are performed and how they influence the landmarks of Kiekens et al., (2008).

1.6 Type of recognition: Human perception is part of computer recognition methods. However, human recognition is variable and dependent on familiarity of the to be recognized person, which the constant computer recognition methods do not take into account.

1.7 Emotional recovery: Emotional recovery can be stimulated when the psychological model of adaptive nodes from Lehti (2016) is used in the design.

1.8 Communication: The best ways to communicate from surgeon to patient and designing for patient profiles is researched.

Identification of gaps
2.1 Regions: What orthognathic regions influence facial recognition the most?

2.2 Familiarity: How is facial recognition influenced when certain orthognathic surgeries are simulated on familiar faces?

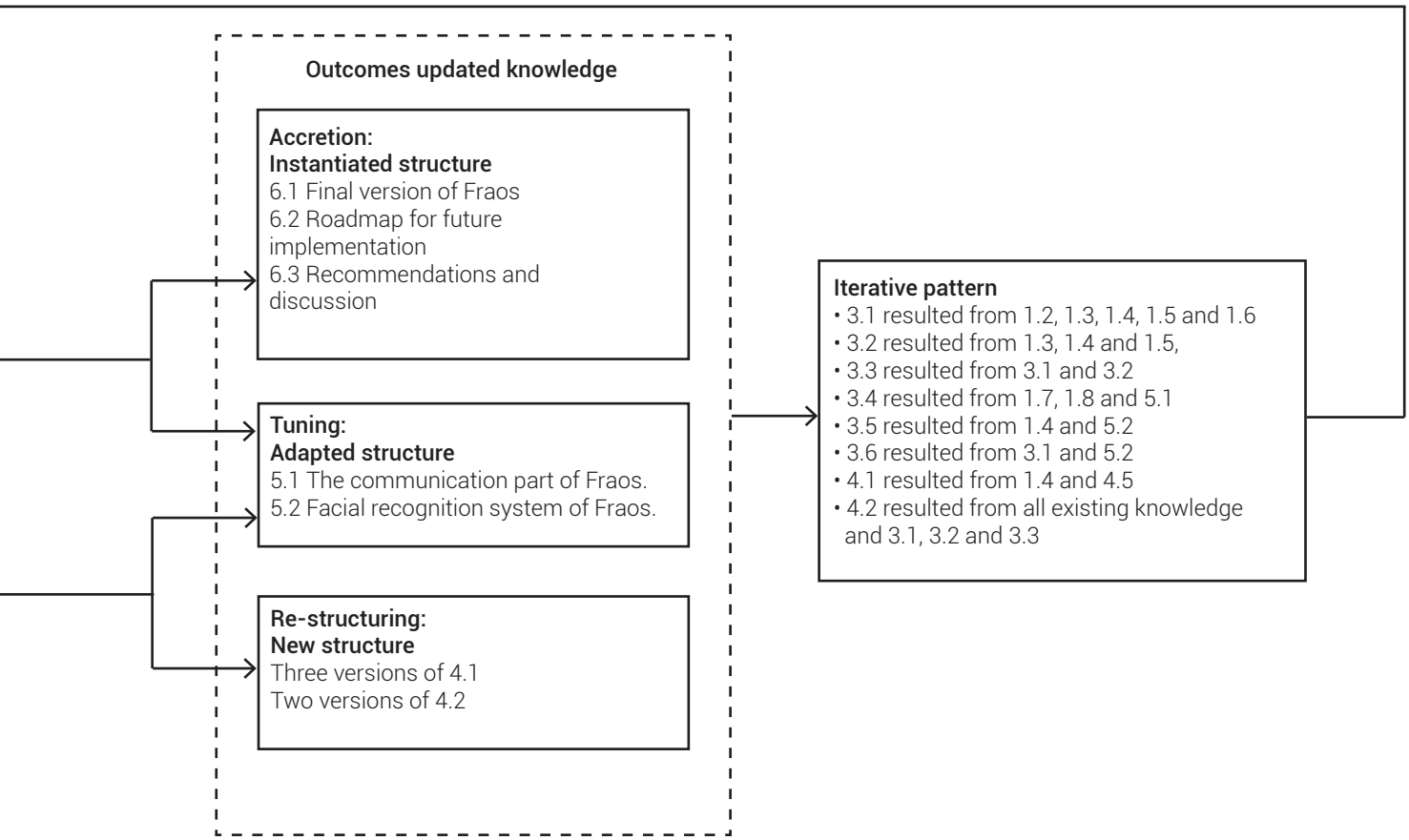
2.3 Combinations: How do combinations of regions and landmark movements influence facial recognition?

2.4 Identic face: How does the identic face of a patient influence facial recognition?

2.5 Displacements: How do the amount of displacements of landmarks play a role in facial recognition?

2.6 Predictability: How can similarity scores of orthognathic surgeries be predicted by manipulation of landmarks?

2.7 Communication: How can facial recognition best be communicated from surgeon to patient?



Gaps after the project

2.8 Prediction all surgeries: How can the similarity score of all surgeries be predicted?

2.9 Manipulate rotations: How to manipulate a picture with rotational landmark movements (d) or multiple combinations?

2.10 Complex surgeries familiar group: How are patients recognized in a familiar group when multiple surgeries are performed on one patient?

2.11 Specific area: What happens with recognisability when a distinction is made in manipulating a specific area of a certain region which happens in surgeries like Le Fort I, II and III?

2.12 Type of familiarity: What is the influence on facial recognition when looking at the type of familiarity (e.g. lover, brother, roommate, friend)?

2.13 Age: What is the influence of age on changes in facial recognition? How does age affect the ability to predict the similarity score?

2.14 Expectations vs. similarity score: Do the expectations of the patients after the surgery meet the similarity score? How can the threshold be adjusted so the expectations meet the similarity score?

2.15 Experience Fraos: How do the patients perceive Fraos? Does it positively influence their emotional recovery?

2.16 VUmc Data: Is the result of the 75 patient data the same as when a test is done with more data and with data from the VUmc?

2.17 3D pictures: Will prediction of facial recognition after orthognathic surgery be more precise when 3D pictures of patients are used? How can manipulation of these 3D pictures been done best?

2.18 Texture, expression, quality: What is the influence of the changes in skin texture, expression and quality of the picture on similarity scores?

2.19 Influence orthodontist: What is the influence of treatment at the orthodontist and wearing braces on facial recognition?

2.20 Surgery protocols: How can the surgery protocols been changed to improve facial recognition of orthognathic surgeries?

2.21 Patient evaluations: It is unclear what patients think about facial recognition and if they think if the concept is valuable.

Research section

Appendix 2: Interview with a patient

Gender: Female
Age: 56
Nationality: Dutch

This interview is translated from Dutch.

1. Wat surgeries did you undergo?
I had two surgeries. The first one was widening my upper jaw. The second one was a double surgery, my bottom jaw was lengthened and rotated.

2. When did you undergo the surgery/surgeries?
The first one in 2006 and the second one in 2009. I also wore braces during that time.

3. Why did you choose to undergo the surgery/surgeries?
To be honest, I told the health insurance my jaw locked many times. This way I got it insured. The real reason was because I absolutely did not like how I looked. My face looked pointed and I thought it looked bad. I have periodontal disease, which was quite bad at the time of my first surgery. How it looked by then, the possibility of all my teeth falling out in the future was present. Which meant that I would need a denture. Since my gums of my upper jaw were showing, a denture would mean that you would be able to see the plastic parts and you could see I wore a denture. This was the breakdown for making my choice to undergo the surgery.

4. What outcomes of the surgery/surgeries did you not expect?
After my first surgery, I had a crack of one centimetre between my teeth. I was not informed about this and I felt embarrassed. Since I just started a company where I worked with a lot of people, it would have been nice to have known since I maybe would have planned my surgery during another time in my life. After recovering from the second surgery, my nostrils were suddenly very wide and my nose looked extra big. I did not know this could happen before I went into surgery, it would have been nice if they informed me.

5. How did other people in your surroundings respond after your complete recovery?
Just recently someone told me I look way better now, which hurt me because it gives me the feeling I was ugly before the surgery. However, my husband did like how I looked before and after the surgery which is the most important.

6. Have there been people who did not recognize you after the surgery? How did they react to you and how did you feel about this?
After the surgery I participated to a volleyball tournament in the neighbourhood, my neighbour whom I did not see for some years asked me where I was from, while I already lived there for 20 years. This hurt me, I felt I was a nobody. I did not realize that the surgery was probably why he did not realize me. I realize now that this happened multiple times. People whom I did not see for some years had troubles recognizing me after the surgery.

7. What would you have changed about the aesthetic changes which happened due to the surgery?
Really my nostrils. I went to a plastic surgeon to ask if he could make them smaller, but this was not possible. So maybe this is just something which is unavoidable when undergoing the surgeries I did, but it would have been nice if I was informed so I knew what to expect. Right now I accepted it and I am completely fine with it, I like how I look.

Appendix 3: Research questions

Main question
How do orthognathic surgeries change facial landmarks of patients and how does this influence facial recognition?

1. Human
1.1 How do humans recognize faces?
1.2 What type of orthognathic patients cannot be recognized after the surgery by human recognition?
1.3 What is the human threshold?

2. Computer
2.1 How do computers recognize faces?
2.2 What are things the computer does not take into account when comparing it with human recognition only?
2.3 What type of orthognathic patients cannot be recognized after the surgery by computer recognition when using the known computer threshold?

3. Orthognathic surgery
3.1 How does the VUmc classify their orthognathic patients?
3.2 What research is done in facial recognition after orthognathic surgery?
3.3 How can the patients be classified when focusing on landmark movements?

Appendix 4 : Facial recognition

4.1 Facial recognition after orthognathic surgery

Literature research has been done on how orthognathic surgery influences facial recognition. Unfortunately, only a little research has been done on facial recognition after orthognathic surgery. In total, one test has been done and this is done by Keshtgar et al., (2019). The result of this test is that it shows orthognathic surgery influences facial recognition, other conclusions can not be made from this research.

There are a few assumptions on why this problem is not being studied:
- The availability of a database which contains pre- and post-pictures of orthognathic patients;
- The privacy issues involved in the sensitive nature of this database;
- It has not been researched how to detect the orthognathic changes the best;
- Surgeons see the problem of patients struggling with recognizing their face, but do not know whom to address to research this problem.

What is known is that when a facial feature is reshaped, the local skin texture around this feature may also change. Altough, this is not researched in the computer method used in chapter 7. Also, when changing a facial feature, the whole face geometric structure and appearance will be disturbed (Liu et al., 2013). These things change face recognition and are applicable for orthognathic surgeries.

4.1.1 The one and only test

Research at an airport has been done to test the recognition of patients after having orthognathic surgery. From 35 patients who participated, six of them had problems passing through passport control. Two of them used human-operated controls and four of them used automated controls (figure A4.1). The automated recognition which is used at this specific airport exist out of four stages and is explained as follows (Keshtgar et al., 2019):

1. The patient scans the so-called e-passport with an integrated RFID chip containing the biographical and biometric information of the patient. The facial features are captured by the device.
2. This data is converted into a template using face points and an algorithm
3. The biometric features are compared with the template of the patient and to old samples from the patient
4. A positive match is found between all templates, and the electronic gat opens

Unfortunately, the paper does not explain any more details about the recognition method and what type of algorithm is used is not known. No further research on the effect of orthognathic surgery on facial recognition has been found in this project and also according to Keshtgar et al., (2019), they were the only ones researching facial recognition after orthognathic surgery. Unfortunately, their foundings are not elaborated on, as well as the automated and human recognition system which is used. The poor amount of data and the unclear test set-up makes that only one conclusion can be drawn: orthognathic surgery indeed influences facial recognition. The questions about the 'why', 'how', 'when' and 'who' still need to be examined.

Summary of malocclusions in patients who had problems at border control.

Preoperative malocclusion	Preoperative overjet or overbite	Orthognathic surgery	Border control
Class III	2 mm reverse overjet	Maxillomandibular advancement	Automated
Class III	7 mm reverse overjet	Maxillomandibular advancement	Automated
Class III	4 mm reverse overjet	Maxillomandibular advancement	Automated
Class III div 1	10 mm overjet	Mandibular advancement	Automated
Class III	9 mm reverse overjet	Maxillary advancement	Human-operated
Class III	Class III & anterior overbite	Maxillomandibular advancement	Human-operated

Figure A4.1: (Keshtgar et al., 2019)

4.1.2 Comparable research

Facial recognition after plastic surgery (FRAPS) has been done before and will be examined to see if certain knowledge can be used for facial recognition after orthognathic surgery. Plastic surgery does affect the facial features globally and locally and can, therefore, be classified into two (Singh et al., 2010):

1. Local surgery: The goal is to reshape/restructure facial features to improve aesthetics. Examples of this would be: correcting jaw and teeth structure, chin, forehead, eyelids and the nose structure. This surgery does change the distances between the facial features, but the overall texture and appearance look similar to the 'before' face.

2. Global surgery: This completely changes the facial structure. The goal is to reconstruct features to cure functional damage and not aesthetics. The facial texture, facial features and appearance are reconstructed to look like a 'normal' human face, but it does most of the time not look like the 'before' face. This can make it hard for facial recognition machines to recognize these faces.

Research from Singh et al., (2010) compared different face recognition systems to see how accurate they were on recognizing patients after different types of plastic surgery. Apparently, it is difficult to face recognition algorithms to match before and after surgery pictures. They discovered that the local facial regions have a crucial role in face recognition. Even small variations in one of the local facial regions have an effect on the neighbouring features. Although changing one local facial region does not change the appearance of the face that much, changing more local facial regions can result in a different face. These are called non-linear variations, and engineering was lacking recognition algorithms which can account for this in 2010. However, non-linear algorithms have been developed between 2010 and now (2020).

Since other, more recent, research about FRAPS cannot be found there can be concluded that analysis with a non-linear algorithm is needed in order to know what happens in a face after orthognathic surgeries. On many patients, multiple types of surgeries are performed and therefore multiple local facial regions change after orthognathic surgeries (chapter 7). This makes an analysis of these type of patients complex and this will need a non-linear algorithm. The chosen method is described in appendix 4.3.

4.2 Human facial recognition

To understand how humans recognize other faces, literature research has been done. No research about the change of human facial recognition after orthognathic surgery can be found in the literature. However, understanding how humans process faces can help to estimate the influence of orthognathic surgery on facial recognition. After reflecting on this analysis and the facial recognition after orthognathic surgery analysis from chapter 3.3, a human recognition test is set up (chapter 6) to fill up the gaps in this research.

4.2.1 Factors which influence recognition

Identifying a person is not only done by face recognition. Therefore, research in cognitive models is done first to find out if taking only the face into account in this project, can be done.

Cognitive models of recognition can be seen as a series of processing stages or modules. Recognition can be done through face but also through other multiple ways such as: voice, name, personal belongings, body physique, body motion and handwriting (Barton & Corrow, 2016). The contextual information affects facial recognition of familiar faces (Bruce & Young, 1986). Neurologic disorders, like prosopagnosia, have been used as sources of data to create cognitive models (Barton & Corrow, 2016). When suffering from prosopagnosia, a face can be recognized as a face but the identity of the face cannot be recognized. Humans first recognize the face as a face, before identifying it (Bruce & Young, 1986). In these models, the so-called person identity node (PIN) is created by voice, name and face of the to be identified person (Barton & Corrow, 2016; Gainotti, 2014)(figure A4.2). Which results in Facial Recognition Units (FRU), Voice Recognition Units (VRU) and Name Recognition Units (NRU). Identifying people concerns face perception, which is one of the most important evidence for the neuropsychology. Therefore, the most dominant cognitive model of personal recognition focuses on face processing (Barton & Corrow, 2016).

Research of Barton & Corrow (2016) shows evidence that familiarity for faces, names and voices can be affected independently. This independence can also be seen in all of the cognitive models in figure A4.2. Therefore, in this project, researching facial recognition related to orthognathic surgery by only taking the face into account, could be done.

4.2.2 Sociocultural effects

The way humans process faces does not differ per race or culture. However, the focus of face information to process faces differs per culture (Blais et al., 2008). Research from Blais et al., 2008 proved that people from Western countries look the most at the eye region and a little less but also, at the mouth region when processing the face whereas East Asian people look more on the central region of the face (e.g. nose). In East Asian cultures eye contact can be considered as rude, which explains this way of looking to a face. Since this project will be done for the VUmc hospital, the research focuses on facial processing by Europeans.

According to research from Mishra et al. (2019) face recognition of women faces in countries with no gender equality is much lower than in countries with gender equality. Therefore, culture can affect cognitive processes. Also, the so-called 'other-race effect' happens in human face recognition. The human ability to recognise the identity of faces from our own race is better than the faces from other races (Phillips & O'Toole, 2014) (Sangrigoli et al., 2005). This has a relationship with processing familiar faces, as described later in appendix 4.2.4 about the face-space. The other-race effect can be changed in childhood when the child interacts with people from other races (Sangrigoli et al., 2005).

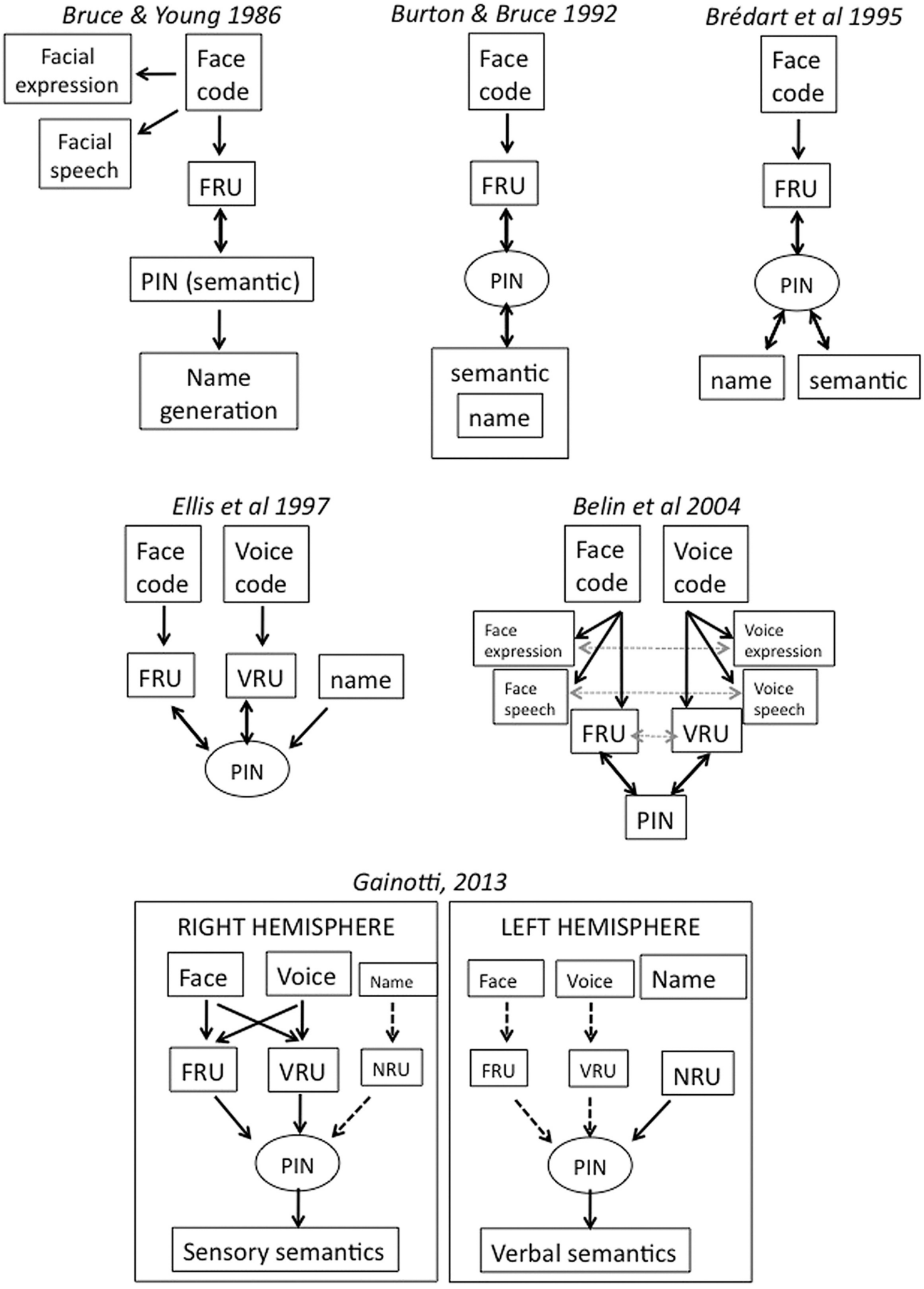


Figure A4.2: Cognitive models of recognition (BJC & Corrow, 2016)

4.2.3 Facial features

Facial recognition of humans is based on the facial features and their relation to each other (eyes, nose, mouth, ears). Humans are so good in recognizing a face as a face, they even can see faces in objects when the facial features are having the correct relationship to each other like in a real human face (figure A4.3). This is called pareidolia (Robson, 2014) (SciShow Psych, 2018). Detecting facial features is done first by the interior occipital in the brain where after the facial features are combined and a face is identified by the lateral fusiform gyrus (figure A4.4) (Atkinson & Adolphs, 2011).

When you see a person's face, the facial features are combined by the brain in such a way you can recognize the person. Research shows that recognition is not only about analyzing the separate facial features but also by creating relationships among features (Gold et al., 2012) (Atkinson & Adolphs, 2011). Which means, the perception of a face is the sum of its parts. This is called holistic face processing (Fuentes-Hurtado et al., 2019) (Gold et al., 2012). Therefore, recognizing familiar faces from individual features is because of the holistic face processing difficult (Fuentes-Hurtado et al., 2019). The position and shape of facial features play a big role in facial recognition and since the relationships among features are how human recognize faces, the distances between features play a role as well. The inferior occipital gyrus is involved in processing the metric distances between features and the inferior occipital cortex is involved in perceiving the shape of features of the face (Atkinson & Adolphs, 2011). In orthognathic surgery, the shape of the jaw can change and the positions of landmarks of facial features change. Therefore, facial recognition can change due to orthognathic surgery. Mathematically, distances between facial features can be measured by creating landmarks which describe the length, width and position of the facial features. This can be used to simulate how humans process the relationships between facial features. When a line is drawn between these landmarks, the distance between the landmarks can be measured. In computer science, a representation of landmarks and the lines between them is called a 'faceprint', which is unique per individual (figure A4.5)(Zhang & Wang, 2009). In this project, certain landmarks are used to determine what points in the face are influenced after orthognathic surgery. The landmarks are described in chapter 4.

The way the face is processed depends on the familiarity of the face (Gold et al., 2012). When researching facial recognition, there should be a clear indication of using familiar or unfamiliar faces as stimulus material (Ellis et al., 1979). The context of this project is about the people who know the patient and therefore the patient's face is familiar. Therefore, only facial recognition of familiar faces is tested in chapter 6.

Figure A4.3: Facial features in a car (Robson, 2014)

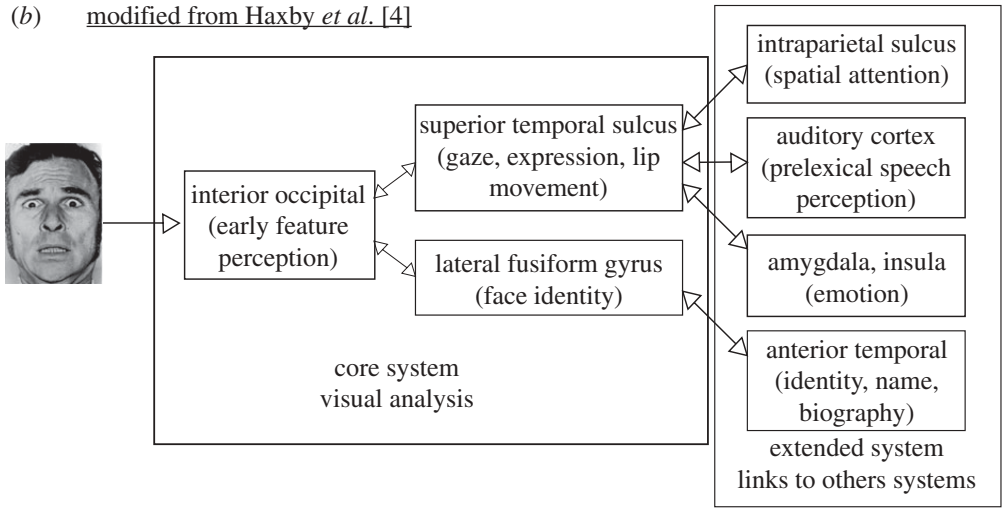


Figure A4.4: Neuropsychology of processing a face (Atkinson & Adolphs, 2011)

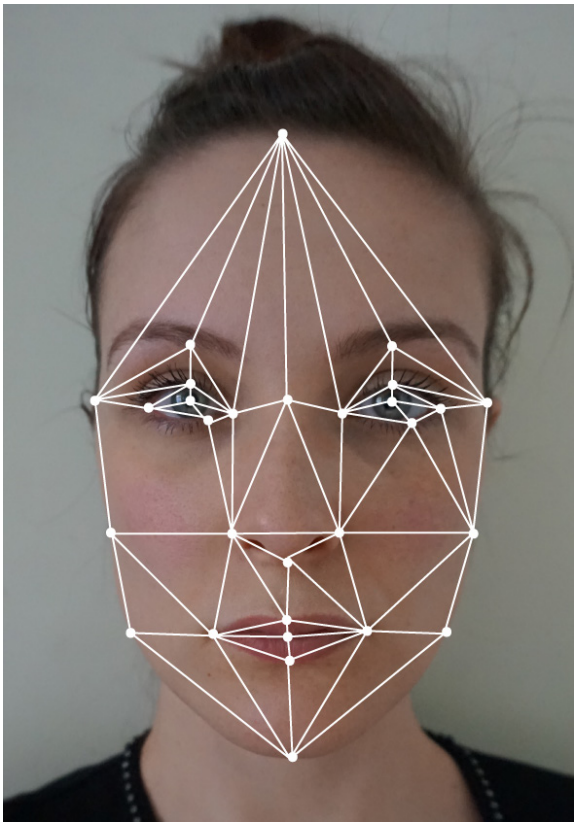


Figure A4.5: An example of a faceprint

4.2.4 Face-space framework

The face-space (figure A4.6) is a multidimensional vector spaced framework to understand face identification. In this space, a database of individual faces exists and they are all compared to the average of all faces present in the database. This is also how it works in the human brain. The database of a person exists out of all the faces the person has ever seen. The distances among faces in this database represent their perceived similarity (Nishimura et al., 2010) (Valentine, 2001). The dimensions of the face-space are unspecified but can represent any structural aspects of faces such as 'nose' or 'length' or abstract aspects like 'attractiveness'. Each individual face in the face-space is represented as a vector along multiple dimensions. The further away a face lies from the average face in the space, the more distinctive and therefore recognizable the face is. The face-space is optimized according to the population of faces most commonly experienced and the space is not optimized to identify faces from other populations, e.g. from other-ethnicities (Conway et al., 2019) (Valentine, 2001). In research from Papesh & Goldinger (2010) the inter-face distances between dark-skinned faces and light-skinned faces were measured from a two-dimensional face-space. The average distance among dark-skinned faces was significantly smaller than the average distance among light-skinned faces. This means that the perceived race has a strong influence on the distribution of the face-space. Different computer recognition methods use the face-space framework (Valentine, 2001).

4.2.5 Inner and outer features

Research with Scottish subjects has been done by Ellis et al., (1979) to test the effect of the inner and outer features on facial recognition of familiar faces (figure A4.7). It seems difficult to identify a face from only the inner or outer features, which is in line with the research from Fuentes-Hurtado et al., (2019) from chapter 3.1.3. 50% Of the subjects identified the face from only the inner features and 30% from only the outer features. Therefore, the inner features play a bigger role in the identification, but the outer features are important as well. However, 80 % of their subjects identified the face from seeing the whole face (Ellis et al., 1979). This means that the relationship between the inner and outer features plays a big role in the identification of familiar faces. Since orthognathic surgeries are changing one or multiple relationships between the outer features (e.g. chin, jawline) and the inner features (e.g. lips, maxilla, mandible) but also within the outer features and inner features, according to this theory it should definitely influence facial recognition. Especially the surgeries influencing multiple features in the face, like on both the mandible and maxilla, it is expected that these surgeries will influence facial recognition the most. When identifying the whole face, the attention goes to the hairline over the jawline and the eyes get more attention than the nose and mouth. It is important to notice that the test subjects were Scottish, who are part of the European socio-culture described in chapter 3.1.2. However, when the face is split into inner and outer features, all the features get the same amount of attention (Ellis et al., 1979). When setting up the human recognition test in this project (chapter 3) to see what points in the orthognathic region influence facial recognition, it is best to blur the hairline, so the subjects will be forced to recognize the person by looking at the jawline.

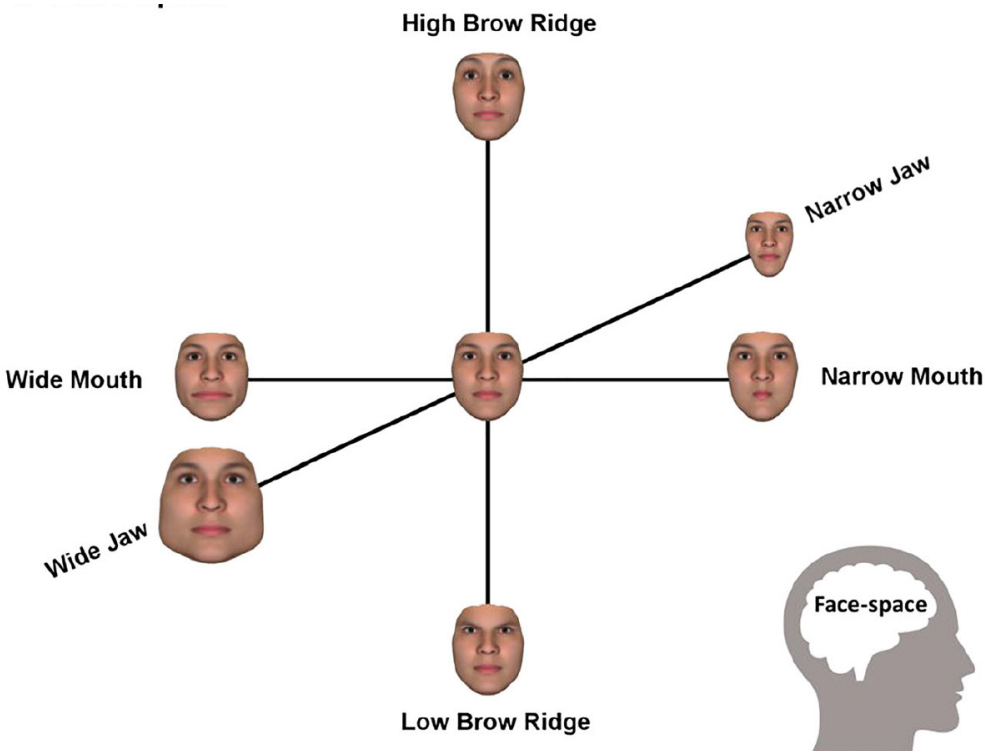


Figure A4.6: A face-space representation with facial feature dimensions. The average face in the center (Conway et al., 2019).

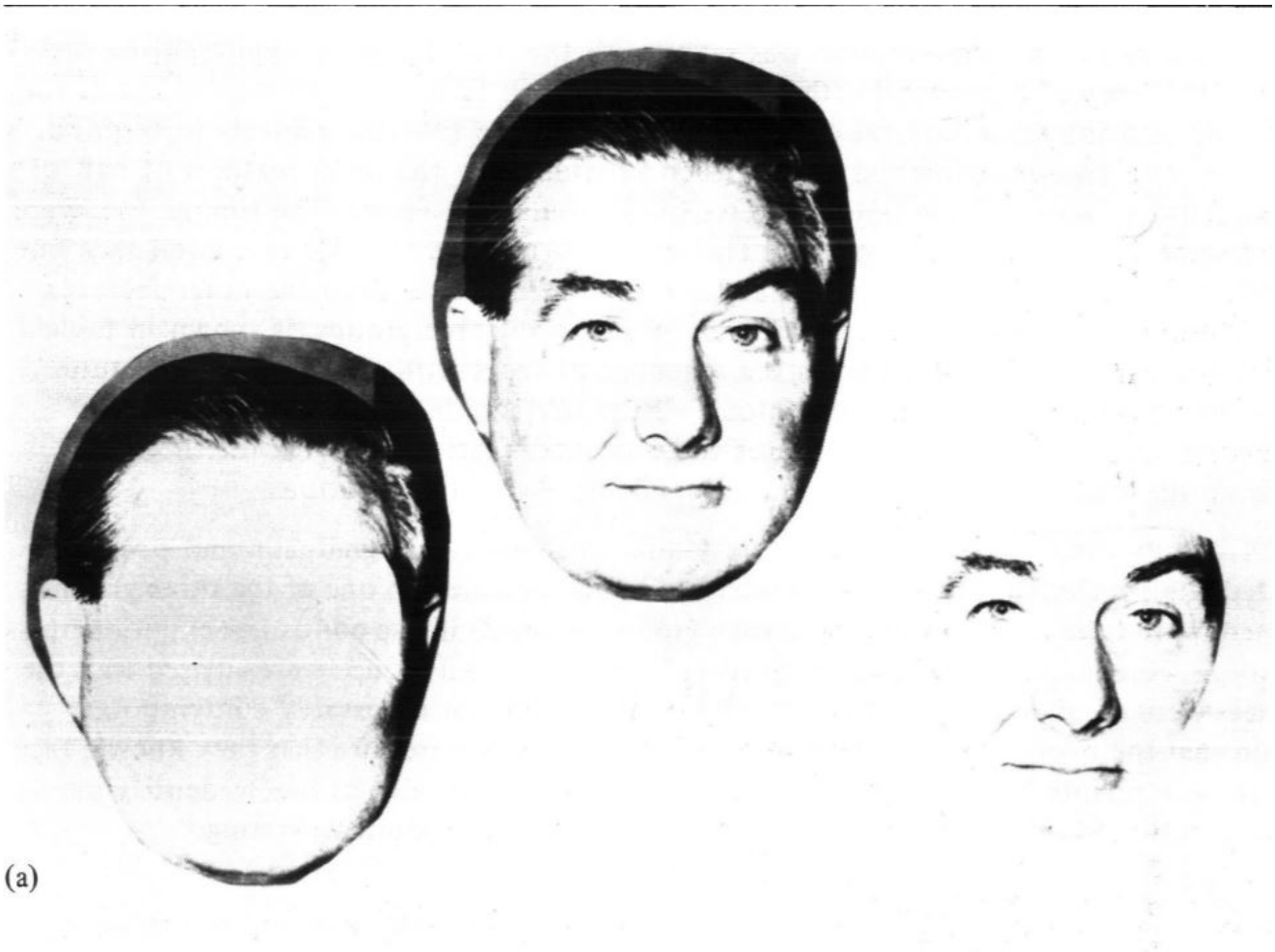


Figure A4.7: Test with outer features, all features and inner features respectively (Ellis et al., 1979) .

4.3 Computer facial recognition

Research in computer recognition is done to see how it is based on neuropsychological facts which humans use to recognize faces. Also, data analysis of pre and post-surgical pictures is done with a computer to analyze complex pictures and a bigger amount of data (chapter 7). Since many methods for computer recognition are available, it was not possible to analyze and test them all within this project. Figure A4.8 shows how a face-recognition system works. The method which is chosen to be used for the computer test uses 'feature geometry' as an approach. Therefore, the skin colours and textures have not been taken into account.

A human recognition test with pictures is done (chapter 6), but it was not possible to test complex facial changes or a big amount of data with them. Therefore, computer recognition is used to analyze all the data to be able to compare all the classified patients to see differences in recognition. This chapter will focus on describing the most suitable facial recognition approach for this project.

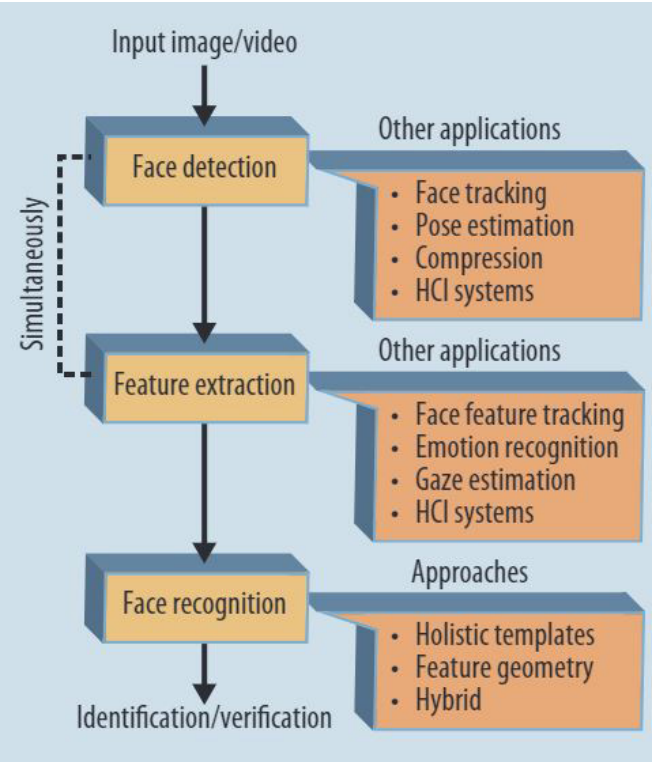


Figure A4.8: Generic face-recognition system (Chellappa et al., 2010)

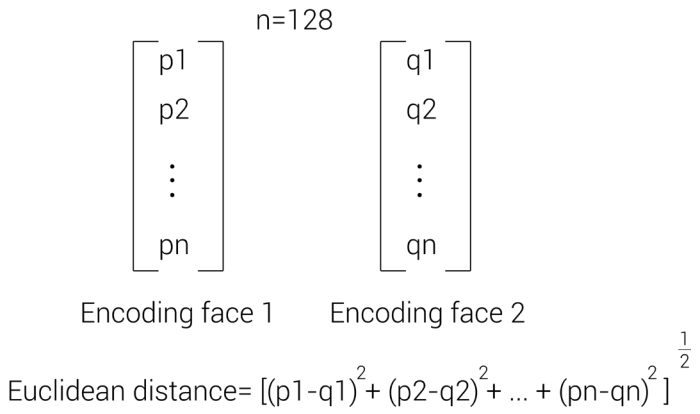


Figure A4.9: How calculating the Euclidean distance from the encodings of the pre- and post-surgical face is done

4.3.1. The method

The goal of the computer recognition test was to see what happens with the landmarks when a patient is or is not recognizable anymore after the surgery. However, after the analysis of the available methods, this seems not to be possible. Nevertheless, information about how much facial recognition is influenced after orthognathic surgeries can be retrieved. A similarity metric can be used which is influenced by the landmarks indirectly. Instead of finding a true or false score if the two faces are similar or not, the similarity score can give information about how similar the faces are. The similarity score in this method is the difference in face distance between the pre and post-surgical face which is determined by comparing 128 'random' face values. The face_ recognition and dlib libraries are used to achieve this.

4.3.2. Dlib library

Dlib is an open-source software library using deep metric learning and it was written in the programming language C++. The library contains machine learning algorithms and can, therefore, be used for face recognition purposes. The dlib library was trained on the 68 landmark iBUG 300-W dataset (King, 2009). The creators of this dataset manually labelled each of the 68 coordinates in each of the 7764 images in the dataset. Therefore, the iBUG 300-W dataset can predict the location of the 68 landmarks (Rosebrock, 2020).

In chapter 4, landmarks are defined based on orthognathic surgery. However, in this project, it was not be possible to train these landmarks because manually labelling images and finding a training set of data would be too time-consuming for the available time. However, the VUmc can expand this research in a later stage, which is written in the roadmap to implementation in chapter 13. For the research in this report, the pre-trained facial landmark detector inside the dlib library has been used. The dlib library is trained to learn how to map the characteristics of a human face to a face embedding, which is a feature vector with 128 values called the 128-d embedding (figure A4.12)(King, 2009). Training the network is done using triplets (Rosebrock, 2020). The network used in dlib is trained by the founder of dlib, Davis King, on a dataset of ca. 3 million images (King, 2009) (Rosebrock, 2020). This is used by the face detector to create a bounding box around the face (King, 2009). According to the founder of the face_ recognition library Geitgey (2018), it is not clear what the 128 measurements mean exactly.

The face detector which is used is the classic Histogram of Oriented Gradients (HOG)(figure A4.10), which is a gradient matrix, serving as a feature map for a learning algorithm (Mustard, 2019). The HOG is combined with the image pyramid, which is a type of linear classifier. Dlib also estimates the pose of the face to put the landmarks in the right place by using a shape predictor algorithm from Kazemi & Sullivan (2014). This algorithm is created by using a so-called 'ensemble of randomized regression trees' (King, 2009). The algorithm takes the following three steps to estimate the positions of the landmarks:
1. It examines a set of input pixel intensities, which are in this case the facial features from the input picture.
2. It passes these features into the ensemble of randomized regression trees.
3. The accuracy of the predicted locations of the landmarks is improved trough a cascade of regressors (which are algorithms based on supervised learning used to find the relationship between variables).
(Rosebrock, 2020)

A simplified summary of the steps of the dlib (figure A4.11):
1. Creating a bounding box (called ROI) for the face in the image by using a face detector
2. Find the landmarks by using a shape predictor
3. Make the face in the bounding box larger and ask the shape predictor what the pose of the face is
5. The face is scaled and positioned to a standard size

4.3.3. Face_recognition library

The face_recognition library is built upon the dlib library. This is used to be able to perform face recognition tasks on a folder of images, instead of running the code per image (Geitgey, 2018). Therefore, this library will spare time when using it for the patient data. Also, when the VUmc wants to analyze their own patient pictures, it can be done fast and it is user friendly.

This library is a trained face recognition model based on deep learning. It is trained on western faces and therefore it is not accurate in telling apart faces from other ethnic groups. This library is used to tell faces apart by measuring features in the face. The computer looks at individual pixels in an image, which makes face recognition for computers different than for humans. The code compares the face encodings of two faces with each other by using the face_recognition library. The similarity score is the Euclidean distance between the two encoded faces (Geitgey, 2018; Ahdid, 2017). Figure A4.9 shows how this Euclidean distance is calculated. Each encoded face is represented as a vector, containing the 128 values (figure A4.12). The Euclidean distance is calculated by filling in all of the values in the formula. Therefore, it is clear that the landmarks do not play a role in creating the similarity score, they are only created to scale and position the face where after the face is encoded.

4.3.4. Comparison to human recognition

According to appendix 4.2, humans recognize faces by comparing them to the average face in their database. Faces from other races are more difficult to recognize because not a lot of these people are present in this database. In other words: the face is recognized based on where it is trained on. This is exactly what happens in computer facial recognition as well. In the method, the landmarks are not used to identify the face, but only to detect the face by detecting the facial features. This differs from human recognition since humans process faces by measuring the distance between facial features while the dlib and face_recognition databases compare faces trough the 128 values.

According to the founder of the face_recognition library, Facebook can recognize faces as good as humans can, with an accuracy of 98% (Geitgey, 2018). However, by using the dlib library, the accuracy is 99.38% (Geitgey, 2017). This means the method used has higher accuracy than humans recognition.

4.3.5. Recommendation for the VUmc

What could be done is to train an own dlib shape predictor by only taking the landmarks into account which are influenced by orthognathic surgeries. The landmarks which are defined in the iBUG 300-W dataset are used but all the localizations are discarded except the orthognathic region part. After, this shape predictor can be used in the currently used code (appendix 15). A face encoder will be made which is only including the orthognathic region. With this, it can be found how much the orthognathic region changes after surgery by finding the similarity score of only this region. However, knowing exactly what landmarks in the orthognathic region influence facial recognition and how and how much they need to move to influence facial recognition would be the most valuable information for the VUmc. Since this information is physical and can be used to change surgery protocols. Before doing research, the goal was to retrieve this information. But unfortunately, retrieving this information needs some more steps in between. A method like this does not exist yet and it is not clear if it is possible to extract this information with the current libraries. Therefore, the VUmc could work together with a software engineer who can tell them more about the possibilities in this field and maybe he can write a code extracting landmark information from the orthognathic region.

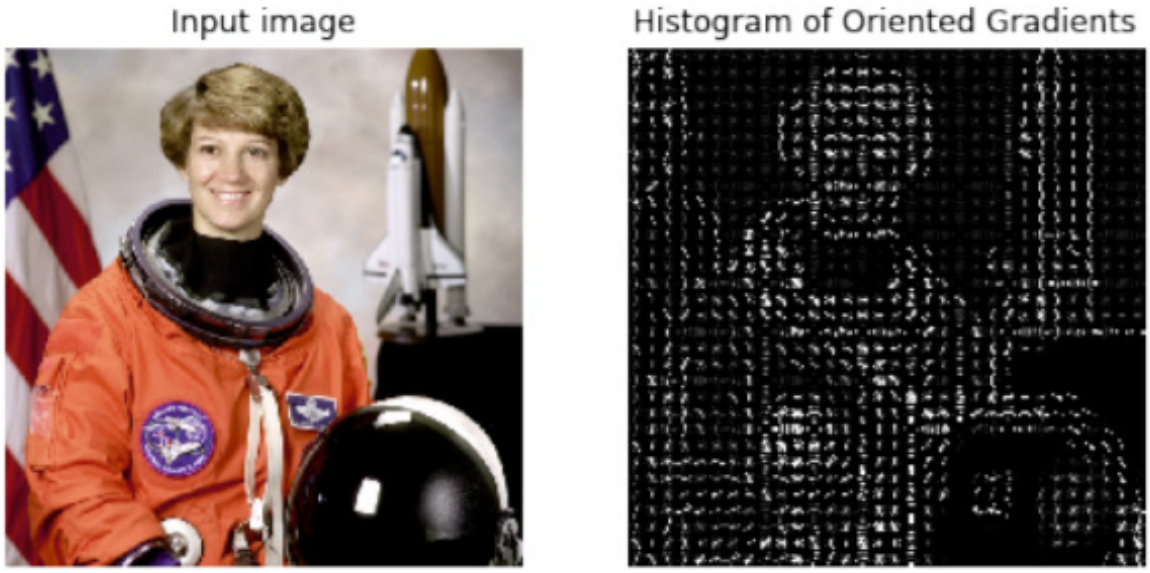


Figure A4.10: HOG (Mostard, 2019)

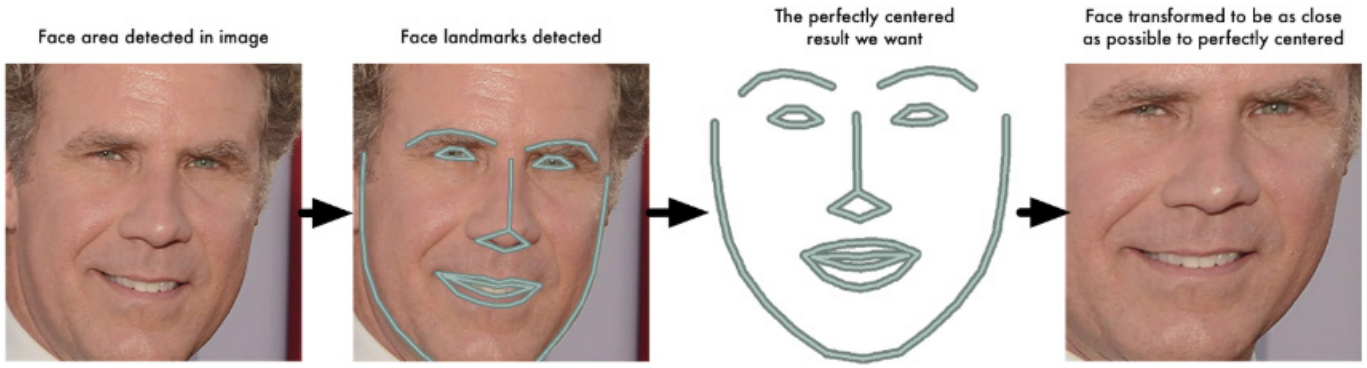


Figure A4.11: What the dlib does (Geitgey, 2018)

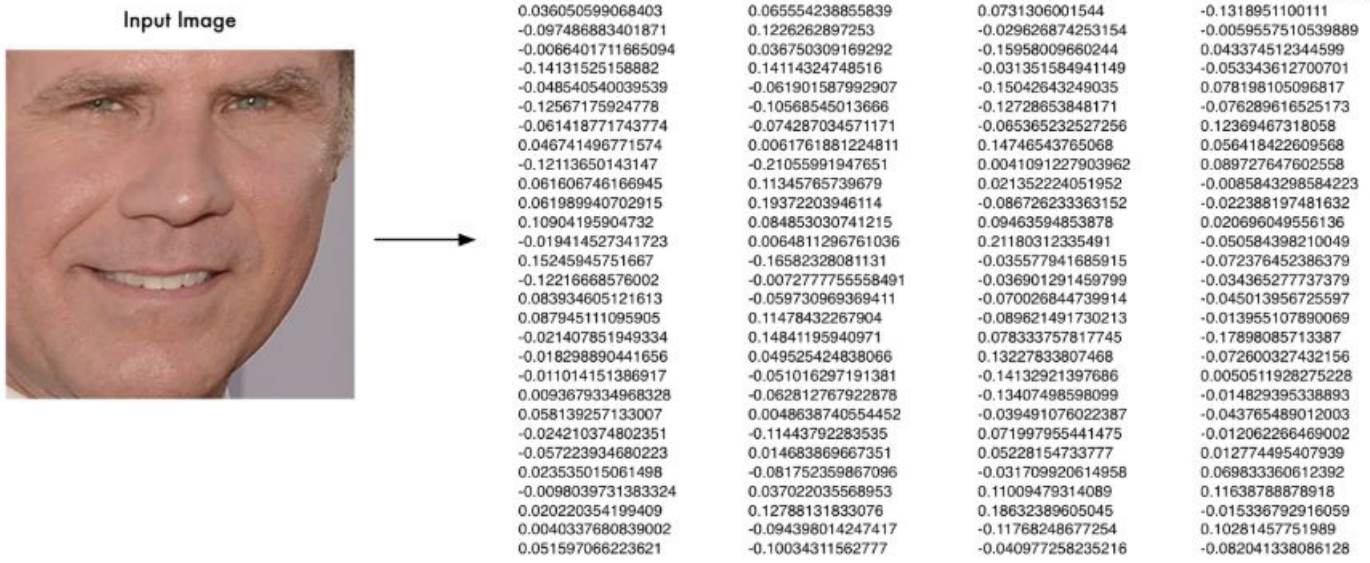


Figure A4.12: 128d embedding (Geitgey, 2018).

4.3.6. Psychological plausibility of facial recognition systems

All the computer facial recognition methods are created by humans and are based on human perception and therefore all methods will overlap with the way human recognize faces. However, it is not clear which method overlaps the most. Multiple computer facial recognition methods exist. Figure A4.13 shows most of the facial recognition approaches. This project cannot analyze them all. Therefore, the history of facial recognition systems has been explored to see what these methods are based on.

The first facial recognition algorithms were set-up in the late '80s and early '90s. Two were called still-face-recognition subspace methods like the principal component analysis (PCA) and the linear discriminant analysis (LDA). One was a structural approach and was called elastic graph matching (EGM). Since this time, researchers used these three algorithms as a foundation to extend on.

What stands out in researching facial recognition systems in this project, is that there are lots of systems to be found but the link to the psychological part of facial processing by humans is missing. Research already performed in 1996 from Hancock et al., also describes the fast progress of artificial facial recognition systems, but without considering the psychological plausibility of the used coding schemes. In the paper from Hancock et al., (1996) this psychological plausibility is examined for the PCA method. The most important founding from this paper is that decomposition of images into separate facial features and using the Euclidean distances is what is done by PCA as well as by humans. This paper concludes that PCA can give insights into human facial processing, and therefore it partly overlaps but is not the same as human facial recognition. Bruce et al., (1998) compared human and PCA recognition of faces and according to them, the PCA method can be used as a proper model for human facial recognition. However, even though PCA lies closest to human facial recognition, this method is not used in practice to analyse the before- and after pictures of patients. The reason for this is explained in 'algorithms in practice'.

4.3.7. Algorithms in practice

According to Y. Song (personal communication, March 26, 2020) who is collaborating in this project, the SVA method is more feasible to use in this project than PCA since SVA can solve non-linear problems (appendix 4.1) which PCA cannot. Since images of faces are non-linear and since SVA can be used for the amount of data which is available, this could be a nice algorithm to use. Since SVA is a classifier, there may be a need to combine this with another algorithm in order to achieve the desired result. Literature also describes that SVA can solve problems in high dimensions, which is needed since facial images exist out of multiple dimensions and the amount of landmarks describe the amount of dimensions. It also gives a good accuracy with images having a variation in illumination, perspective movement, differences in facial expression and scaling (Anand & Shah, 2016).

In practice, PCA cannot be used altough it has the most psychological plausability. From SVM, it is not clear how psychological plausible this is. Also, to set up a SVM model, data needs to be trained and the data needs to be classified. The amount of data (75 pre and post surgical pictures) which is available for this research, is not enough to train an accurate SVM model. Also, the data needs to be classified by humans, in order to create psychological plausability. This cannot be done in the time frame of this project.

From this analyses, a new plan arose. The goal was to see what happened with the landmarks when a patient is or is not recognizable anymore after the surgery. A similarity metric could be used which is influenced by the landmarks. Instead of finding a true or false score if the two faces are similar or not, the similarity score can give information about how similar the faces are. The similarity score is the difference in face distance between the pre- and post surgical face which is determined by comparing the landmarks. The face_recognition and dlib libraries are used to achieve this. These libraries already scales the faces in the pictures to define the face distance between the landmarks. The dlib library was trained on the 68 landmark iBUG 300-W dataset. Therefore, for this research the pre-trained facial landmark detector inside the dlib library has been used.

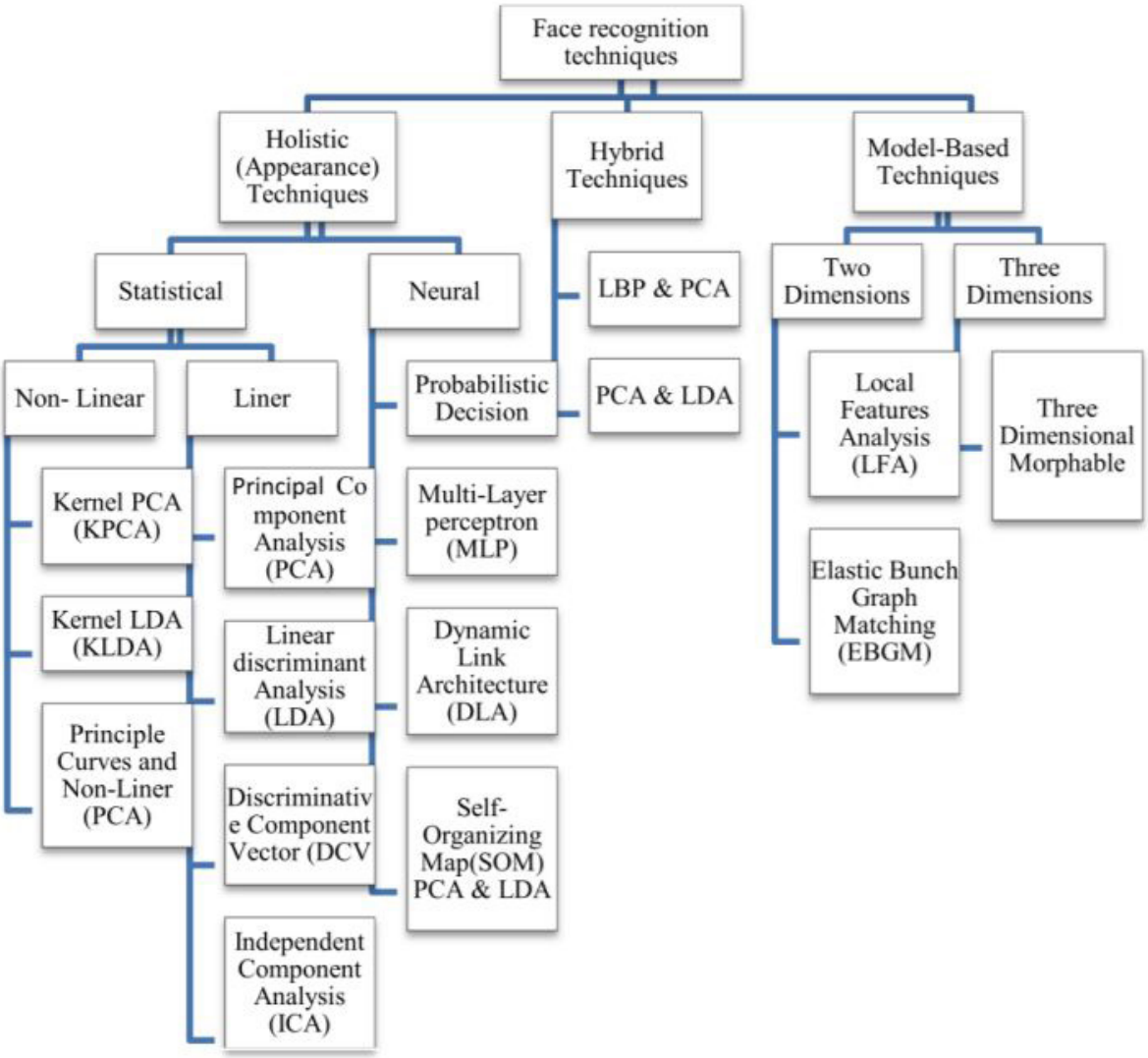


Figure A4.13: Face recognition approaches (F. Kak et al., 2018)

Appendix 5: Landmarks

5.1 In computer science

Multiple different sets of landmarks can be defined, this differs per software. In literature, papers all describe a different amount of points. The number of points needed differs per scenario, the more points, the richer the information, the more time it costs to detect all the points (Wang et al., 2018). However, the default amount of predefined landmark points is 27 and can be seen in figure A5.1 (Farley, 2019). Other landmarks can be predicted or can be done by humans manually. All methods within computer recognition localize and label the mouth, eyebrows, eyes, nose and jaw (Rosebrock, 2020). Therefore, the jaw is localized with the use of the default landmarks. The points on the edge of the face, such as the jaw, cannot be accurately localized manually or automatically (Çeliktutan et al., 2013). However, this does not matter for the computer test (chapter 7) since the landmarks are only used to detect the face. The method used in the computer test (chapters 3.2 and 7) has an accuracy of 99.38%. The most used landmarks found in literature and software is 68 (figure A5.2), which is based on the default amount of 27 landmarks. The landmarks which can be used for exploring the movements in the orthognathic region are examined in the next appendix. These 68 landmarks are also used in the method used in the computer test analysis of chapter 7.

When transforming the annotation points from the 2D image to a 3D scan, it is likely to fail in areas like the jaw since points from the 2D image are wrongly projected to the neck (Fagertun et al., 2014). This should be kept in mind for further research after this project (chapter 13)..

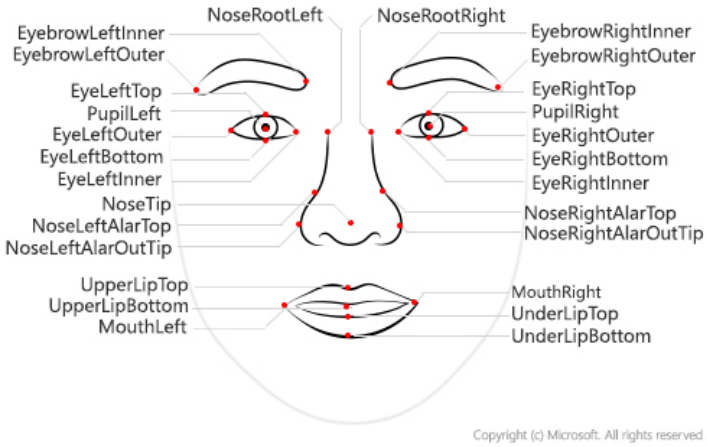


Figure A5.1: Default 27 landmarks in software (Farley, 2019)

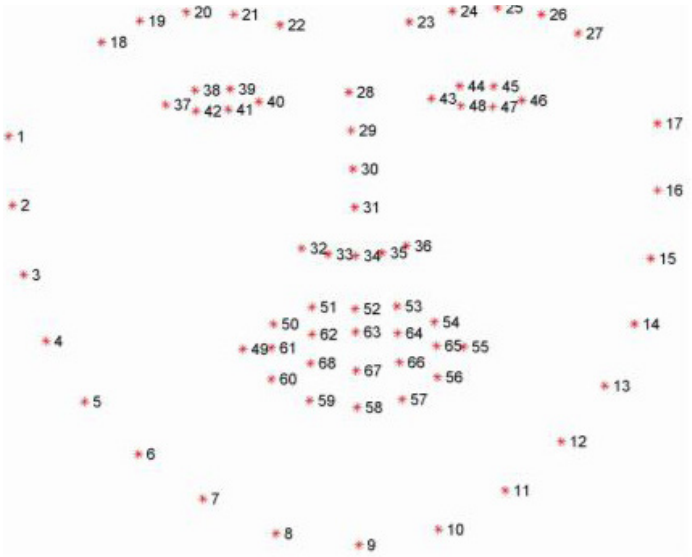


Figure A5.2: The amount of landmarks used the most in literature and software is 68 (Amato et al., 2018)

5.2 In orthognathic care

In orthognathic treatment planning, anthropometric facial analysis is used by some different type of physicians for the soft-tissue facial analyses (Kiekens et al., 2008) (Sforza & Ferrario, 2006). However, in the VUmc, the orthognathic surgeons use cephalometric landmarks of the hard-tissue for treatment planning (T. Fouranzanfar, personal communication, March 31, 2020). In this chapter, the anthropometric landmarks are found and the cephalometric landmarks are be found which can after this project be used to link to the anthropometric landmarks, to be applied in the surgeries of the VUmc.

5.2.2 The optimal anthropometric landmarks for orthognathic surgery

An average ideal face which can be used in orthognathic care has been created by Kiekens et al., (2008), showing the optimal relations between landmarks. Professionals in orthognathic care use the ideal ratios and angles as guidelines in their treatment plans (Kiekens et al., 2008). The guidelines of the VUmc are mostly functional, and their guidelines only consist of advise to optimize aesthetics. During the orthognathic surgeries in the VUmc, the functional part which belongs to the hard-tissue is the focus and the aesthetics which belongs to the soft-tissue are done instinctively after the functional part is done since a prediction of the movement of the soft-tissue cannot be done and differs per patient. The surgeons know how to influence the soft-tissue to make the patient look aesthetically good, but it is not explicitly mentioned in their guidelines (T. Fouranzanfar, personal communication, March 31, 2020).

In further research, it is important to take the aesthetic guidelines into account to find a balance between facial aesthetics and recognition. The optimal position of landmarks should be found, taking the recognition margin into account. This way, surgical techniques could be improved in the future.

In the research from Kiekens et al., (2008), sixty-one landmarks which they frequently found in literature referring to the ideal ratios and angles for an aesthetic face, have been used to position landmarks. Also, three pre-treatment pictures of 64 adolescents (frontal, three quarter smiling and lateral) have been collected from the Department of Orthodontics and Oral Biology, Radboud University Nijmegen Medical Centre, the Netherlands, from 1990 to 2000. 29 Landmarks were selected on the frontal photographs and 22 landmarks were selected on the lateral photographs. The patient angle classes on which these ideal landmarks and rations have been defined are not used in the VUmc but are widely used in literature (figure A5.3):

- Class I: neutroclusion and neutral relationship of the jaws

- Class II Division 2: distoclusion and distal relationship of the jaw with retroclined maxillary incisors

- Class III: mesioclusion and mesial relationship of the jaws

The reason they use such a wide range of dental and skeletal variations is to obtain the landmarks which can be applied to all orthognathic patients. Kiekens et al., (2008) performed a data quality control and the outliers defined as individual points were eliminated. They chose to take a median measurement error equal to or less than 5 pictures as criteria. After this, 29 frontal and 16 lateral landmarks were left. They also found the ideal ratios and angles by analyzing 21 scientific papers, relating to the ideal aesthetical face which is preferable for physicians (appendix 8). The P-value which is noted * in appendix 8 is the level of statistical significance. The smaller this value, the stronger the evidence is. A P-value less than 0.05 is statistically significant, which is the case in the ratios/angles where the * can be seen. This means that these cases have the strongest evidence-based on this research and that these results are not due to chance (Dahiru, 2011).

Since the landmarks in figure A5.6 are based on a wide range of orthognathic patients, it will be assumed that these landmarks cover the landmarks which will be influenced by the orthognathic surgeries on the different patient clusters which will be used as data. Therefore, these are the landmarks which will be used as landmarks in this project.

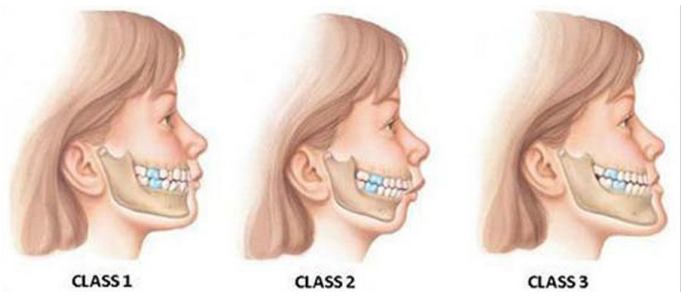


Figure A5.3 The classes of malocclusion (Top Class Dental, n.d.)

5.2.3 Cephalometric landmarks for orthognathic surgery

Different research has been done about generating cephalometric and anthropometric landmarks on x-ray images with the use of deep learning. Generating the cephalometric landmarks is usually done by orthodontics and surgeons manually, which is also how the VUmc does it (figure A5.4). How they use these landmarks to classify patients is described in (chapter 5, appendix 6). The cephalometric landmarks are used to measure the distance and angles between different hard-tissue features (Lee et al., 2019). In this project, the focus lies on what happens on the soft-tissues, since this is what can be seen on the outside of a face which is what influences facial recognition. However, when the surgeon changes the hard-tissue, the soft-tissue also moves (figure A5.5). Although it is not possible to predict the movement of soft-tissue it is still possible to estimate what anthropometric landmarks are influenced when an underlying hard-tissue is moving. Therefore, how the soft-tissue moves is not researched in this project, but what part of the soft-tissue is expected to move can be described per patient class (chapter 5). By creating a link between the cephalometric and anthropometric landmarks, it will be easier to transfer and implement this information in the VUmc since they are already familiar with cephalometric landmarks. This can be used in the future, when more research is done in this topic.

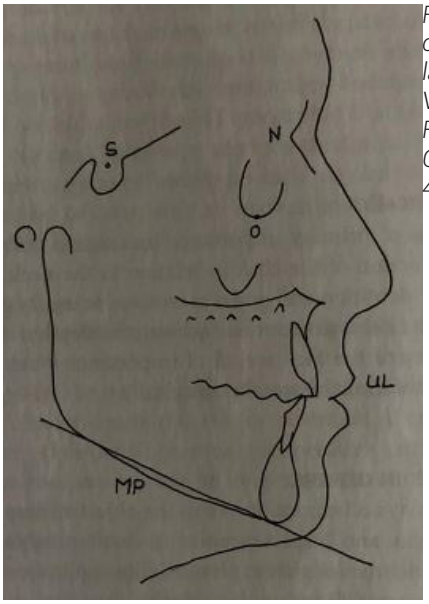


Figure A5.4: cephalpmetric landmarks the VUmc uses (T. Fouranzanfar, Personal Communication, April 4, 2020)

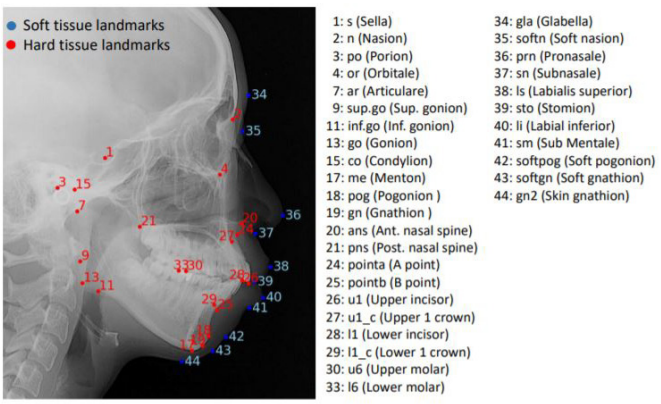


Figure A5.5: often used cephalometric and anthropometric landmarks and their relationship (Lee et al., 2019)

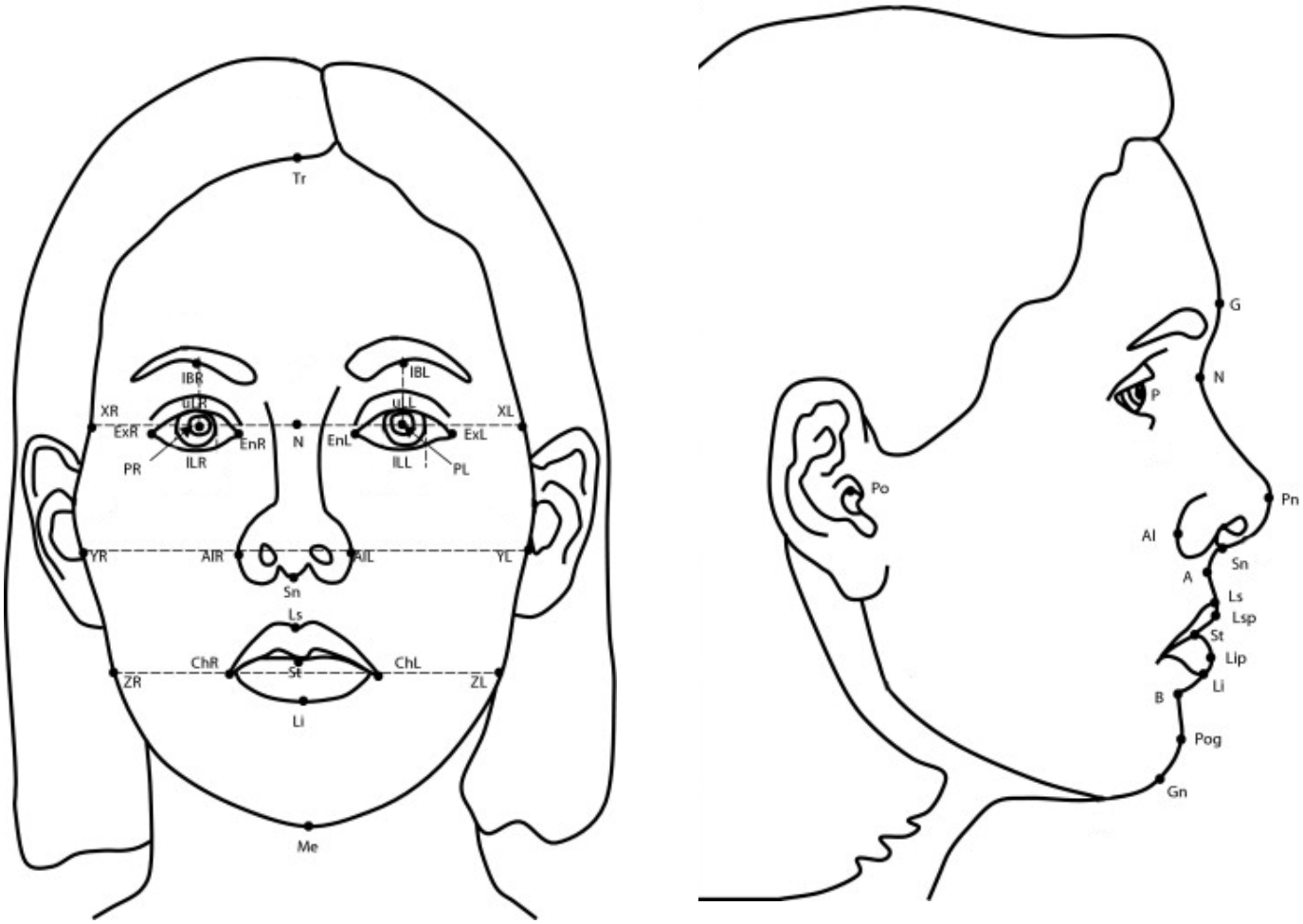


Figure A5.6 a,b: The landmarks left after the data quality control by Kiekens et al., (2008). With a) the frontal landmarks and b) the lateral landmarks.

List of names of figure A5.6
a), TR, trichion; lBR, lower border of the eyebrow on the right side; lBL, lower border of the eyebrow on the left side; N, skin nasion at bipupil line (constructed point); ExR, exocanthion on the right side; ExL, exocanthion on the left side; EnR, endocanthion on the right side; EnL, endocanthion on the left side; uLR, upper limbus the right side; uLL, upper limbus on the left side; lLR, lower limbus on the right side; lLL, lower limbus on the left side; PR, middle of the pupil on the right side; PL, middle of the pupil on the left side; AlR, alare on the right side; AlL, alare on the left side; Sn, subnasale; St, stomion; ChR, cheilion on the right side; ChL, cheilion on the left side; Ls, labrale superior; Li, labrale inferior; Me, menton; XR-XL, face width at bipupil line (XR and XL = constructed points); YR-YL, face width at alare (YR and YL = constructed points); ZR-ZL, face width at stomion (ZR and ZL = constructed points).

b) Landmarks on the lateral photograph: G, glabella; N, nasion; P, pupil; Pn, pronasale; Al, alare; Sn, subnasale; A, soft-tissue Point A; Ls, labrale superior; Li, labrale inferior; St, stomion; Lsp, most protruded point of upper lip; Lip, most protruded point of lower lip; B, soft-tissue Point B; Pog, pogonion; Gn, gnathion;

Appendix 6: Classification

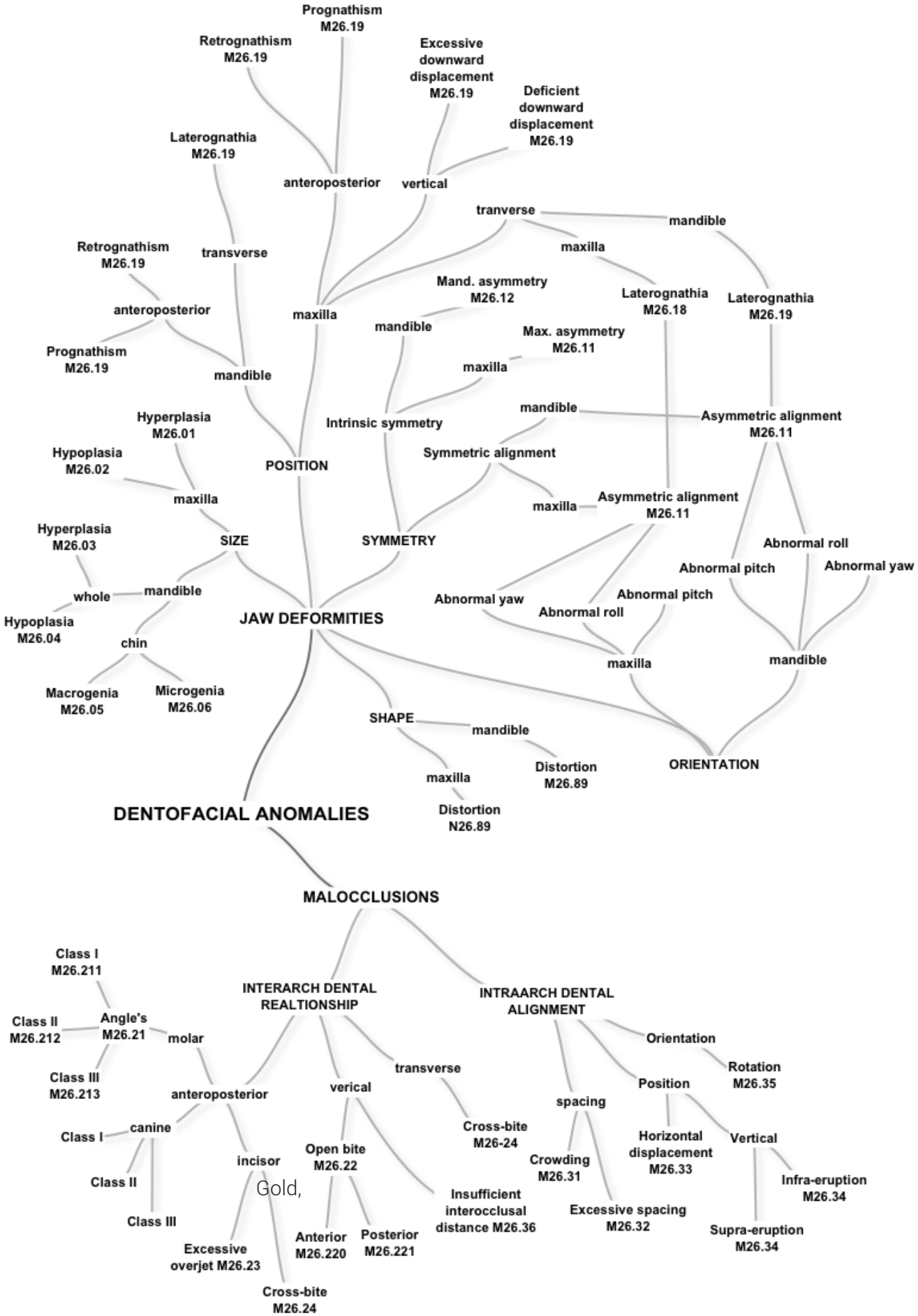


Figure A6.1: Mindmap of the dentifactial anomalies (Gateno & Xia, 2015)

6.1 VUmc

The VUmc uses the cephalometric analysis of Steiner-Köle as a classification system. A lot of different cephalometric analysis can be found in research, containing multiple landmarks. However, according to T. Forouzanfar (personal communication March 6, 2020) the analysis the VUmc uses is one of the fastest and easiest analysis to do since the treatment planning can be done in a few minutes and it always works. They perform their analysis on only a few landmarks of the bones since this hard-tissue is a constant factor while the movement of soft-tissue cannot be predicted.

The landmarks which are used in this system to come to a quick conclusion about the nature of the deformity are (figure A6.2):
- Sella (S): the entrance of the sella turcica
- Nasion (N): the most retruded point of the frontonasal suture
-Orbitale (O): the most inferior point of the infraorbital rim
- UL: the most anterior point on the upper lip

Mandibular plane (Mp): the line that touches the most inferior point of the bone chin and the most inferior point of the mandibular ascending ramus.

In orthognathic surgeries, the direction of the mandibular plane (MP) is the most relevant. The landmarks are used to create lines from one landmark to another. For example, the Sella-Nasion line can be used as a reference to distinguish the divergent, convergent and normal facial architecture (figure A6.3). More reference lines like this can be created, but these are not elaborated on.

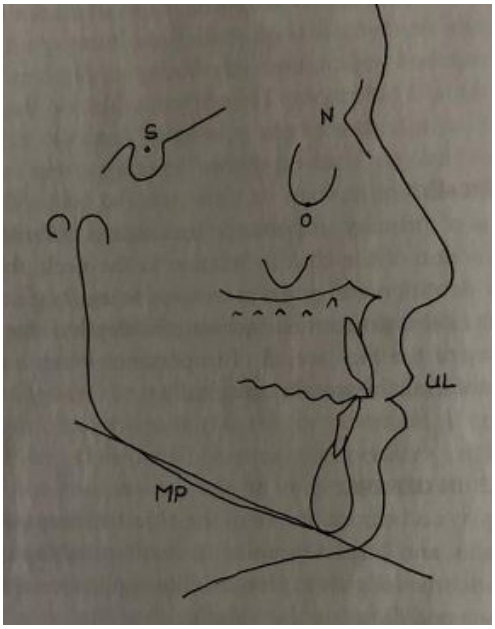


Figure A6.2: These landmarks can be used to come to a quick conclusion about the nature of the deformity (T. Forouzanfar, personal communication, April 4, 2020)

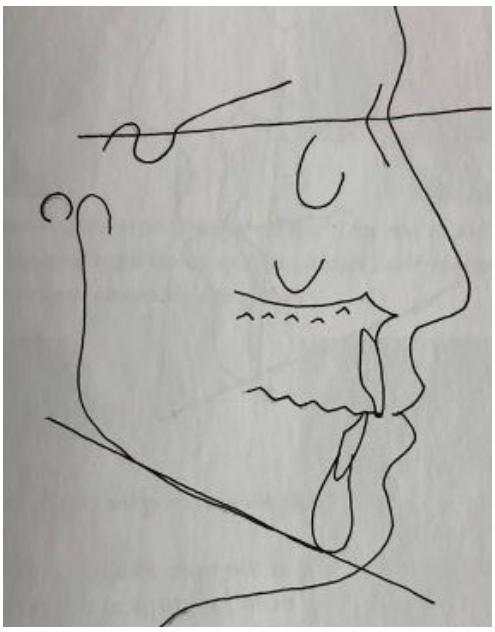


Figure A6.3: The Sella-Nasion line (T. Forouzanfar, personal communication, April 4, 2020)

With the use of the classification method, the VUmc classifies the patient in five classes. What should be noticed is that patients within these types may need different surgeries since more factors than only the five classes contribute in deciding on the right treatment plan. Therefore, only an example of surgeries is part of the description of the five types of classes. The five types of classes are (figure A6.4):

- Type A: mandibular prognathism
This group is characterized by a reversed overjet, which means the lower teeth are positioned further than the upper teeth. Three things can be done to correct this type. The maxilla can be positioned forward, the mandible can be a setback or a bi-maxillary procedure (also called maxillomandibular advancement) which moves both the maxilla as mandible forward (Olivi & Garcia, 2014), can be done. What type of surgery is done depends on other aesthetics aspects of the face. For this type, a deep nasolabial fold (wrinkles from the bottom of the nose to the corners of the mouth), big nose and normal chin-threat angle can indicate a maxillary advancement, which means the patient needs a surgery which positions the maxilla forward.

- Type B: mandibular prognathism with open bite
This group is characterized by a reversed overjet with an open bite, which is type A but the mouth cannot close. It can be caused by multiple different deformities and can be solved by a different type of surgeries depending on the deformity.

- Type C: mandibular retrognathism with low/ normal mandibular plane angle
This group is characterised by an overjet and/or overbite, they have a low or normal mandibular plane and it looks like the opposite of type A. The surgical procedure generally consists of a mandibular advancement, which exists out of a bilateral sagittal split osteotomy (figure A6.5) or distraction osteogenesis (figure A6.6).

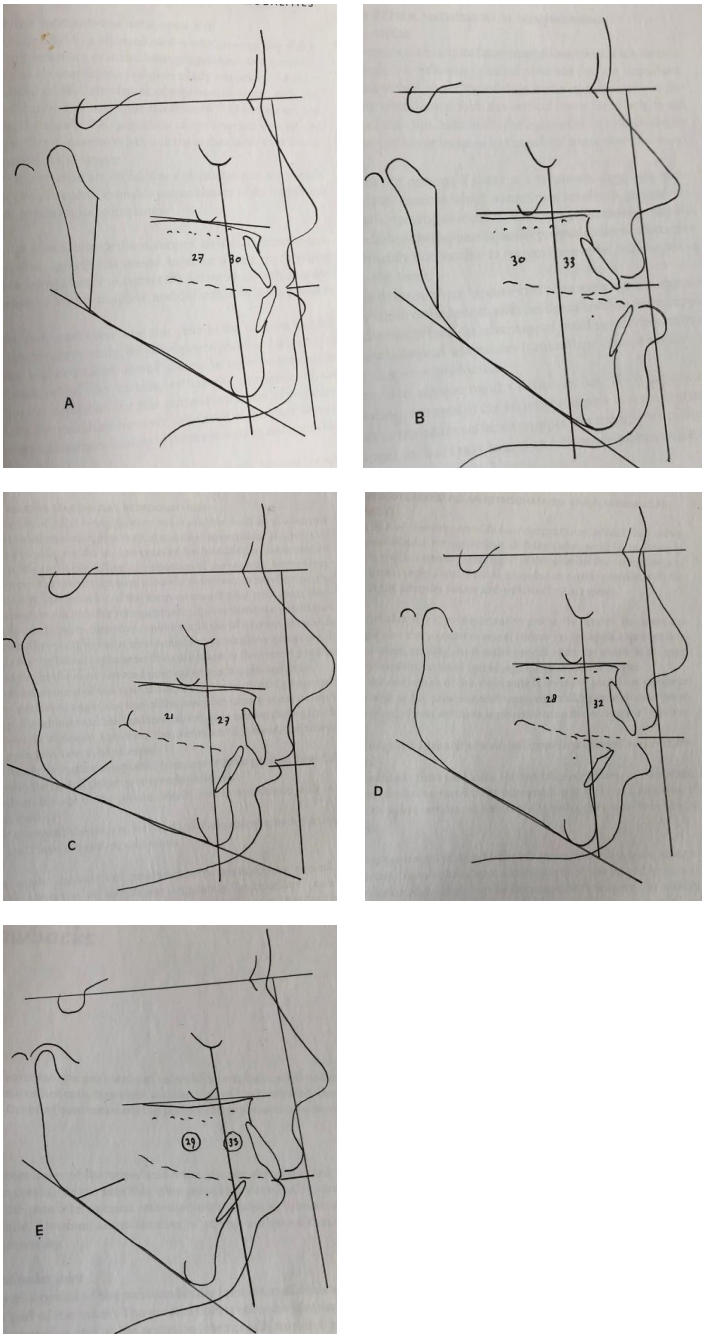


Figure A6.4: (A) mandibular prognathism, (B) mandibular prognathism with open bite, (C) mandibular retrognatism with low/normal mandibular plane angle , (D) relative mandibular retrognathism, (E) absolute mandibular retrognatism (T. Forouzanfar, personal communication, April 4, 2020)

- Type D: relative mandibular retrognathism
This group is characterized by the retruded mandible. This can be solved by a surgery which rotates the mandible or by performing a bi-maxillary procedure by positioning the maxilla and mandible forward.

- Type E: absolute mandibular retrognatism (high mandibular plane angle). As the name of this type provokes, this group is characterized by the high mandibular plane angle. In all cases of this type, the surgery consists of mandibular advancements with a bilateral sagittal split osteotomy (figure A6.5). Aesthetically seen, there is almost no chin. Therefore, for aesthetic reasons, a genioplasty can be done to create a chin (figure A6.7).

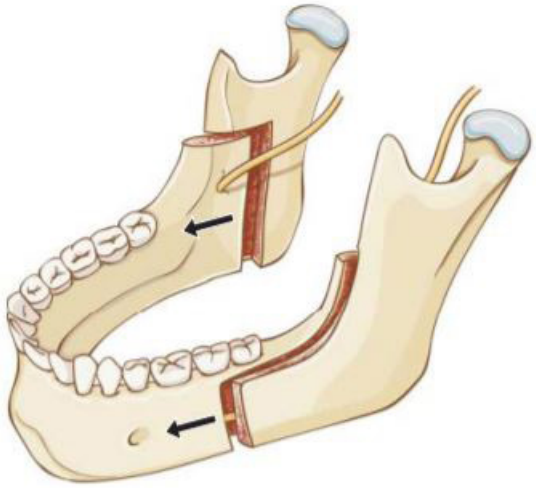


Figure A6.5: bilateral sagittal split osteotomy (Saman et al., 2013)

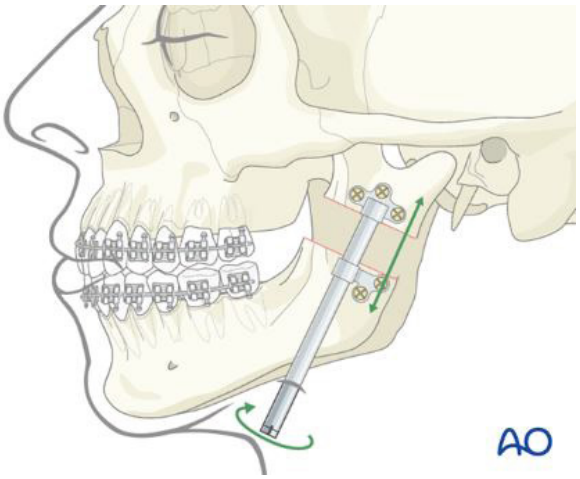


Figure A6.6: distraction osteogenesis (Homsi, n.d.)

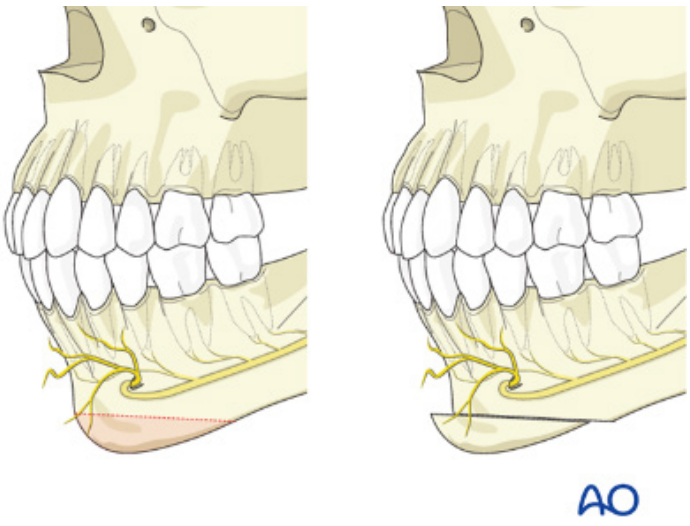


Figure A6.7: Genioplasty (Homsi, n.d.)

6.2 New classification system

The data of the patients should be classified according to the movements of the landmarks. The current classification system used by the VUmc (appendix 6.1) contains five types, but in these types, different surgeries are performed which leads to different and multiple landmark movements within one type. Also, other classification systems from literature are too complex to use for describing landmark movements. Describing landmarks movements was needed for the human recognition test since the pictures of the test subjects were manipulated on certain landmarks. The landmarks which were manipulated in chapter 6 were selected based on what landmarks change due to surgery. This type of classification did not exist yet and is done manually. The data available from patients which are used for the computer recognition test (chapter 7), consists out of patients undergoing different types of surgeries. The difficulty is that almost no patients undergo the same surgery since different types of surgeries are performed on one patient at once.

An example is shown in figure A6.9. This patient had a receding mandible, protruding maxilla and her maxilla was too broad. Therefore she received these type of surgeries according to the Facial Sculpture Clinic (2020) where she was treated:
- Advancement lower jaw (BSSO)
- Setback upper jaw (Le Fort I)
- Chin surgery (Sliding genioplasty)
- Transversal narrowing upper jaw

Instead of calling the type of surgeries like this, the new classification system simplifies the description. The VUmc will classify this patient as a type C patient.

After applying the new system, this patient will get the classification: 1abFL, 2aF, 3aL. Where the numbers describe the amount and type of regions affected, the letter describes the movement of the landmarks in this region and the F and L describes in what plane the landmark movement can be seen. Figure A6.8 shows the legend of classification annotations. The reasoning behind this classification system is explained next.

The new classification system can be used for 2D images from the front and lateral view. Mark that the depth of the images is not taken into account, therefore the classification system is meant for classifying landmarks in two dimensions only. However, all the movements in the F plane could affect the face in the L plane and vice versa but the classification system only describes in what plane the movement itself happens.

Since this project is looking into what landmarks change position, different orthognathic regions are created to be able to classify the patients according to landmarks. The regions are enclosed by landmarks and only address movements of the soft-tissue. Since the movement of the soft-tissue cannot be predicted, the soft-tissue regions are estimated and are only used as a communication tool to see which type of surgery addresses which part of the face and to see which regions influence facial recognition. The regions in figure A6.11 are bounded by the landmarks of chapter 4 and appendix 5 and planes are created in figure A6.12.

When analysing the data and according to Mayo Clinic (2018), the functional orthognathic surgeries from the data can be divided into three orthognathic regions (figure A6.11):
1. Upper jaw (Maxilla)
2. Lower jaw (Mandible)
3. Chin

However, the cheek region will be added since some functional surgeries from the patient data use cheek implants for optimizing aesthetics. The VUmc uses cheek implants rarely and manipulates the cheekbones to create the same effect.

Region		Movement		Plane	
1	Maxilla	a	Horizontal Lengthening/Shortening	F	Frontal
2	Mandible	b	Widen/Narrowing	L	Lateral
3	Chin	c	Vertical Lengthening/Shortening		
4	Cheek	d	Rotating		
		e	Smoothening jaw line		

Figure A6.8: legend of classification annotations

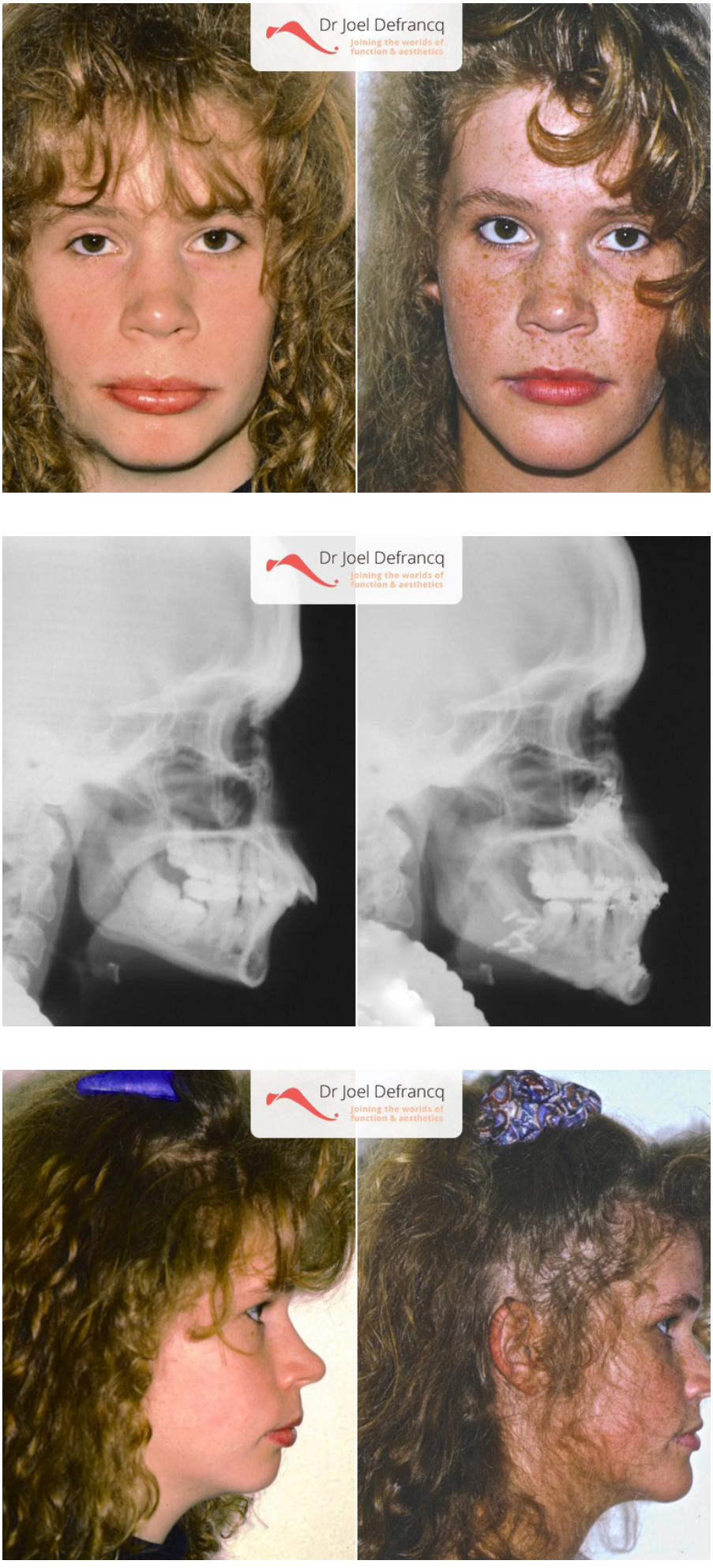


Figure A6.9: A patient who underwent multiple surgeries (Facial Sculpture Clinic , 2020)

Therefore, the cheek area should be taken into account. A genioplasty on the chin is sometimes performed to create a chin for aesthetic reasons (T. Forouzanfar, personal communication, April 4, 2020).

In the United States, a widely used classification system of jaw deformities is called the ICD-CM (International Classification of Diseases, Clinical Modification) (Gateno & Xia, 2020). The whole classification system can be seen in figure A6.1. This classification system also contains medical terms which were found regularly in literature and it can be seen as a summary of the found literature. The classification system which is created summarizes the ICD-CM classification system without using medical terms. Therefore, also people outside the medical world will be able to understand the movements of the landmarks. From the ICD-CM classification system, the six attributes which are described to belong to 'jaw deformities' and their belonging aspects and medical terms can be seen in figure A6.10.
The 'completeness' attribute will not be taken into account since these types of deformities are too complex to cover in this project. However, the rest of the attributes are used and the aspects are translated to the following, which describes the movements of the landmarks relative to each other and which summarize the surgeries:

a. Horizontal Lengthening/Shortening: It moves a set of landmarks further or closer to each other over the x-axis of the lateral image (movement which influences the lateral landmarks)

b. Widening/Narrowing: It moves a set of landmarks further or closer to each other on the x-axis and over the maxillary-plane and mandible-plane of the frontal image (movement which influences the frontal landmarks)

c. Vertical Lengthening/Shortening: It moves a set of landmarks on a plane or in a region up or down on the y-axis (movement which influences both frontal as lateral landmarks)

d. Rotating: It turns a set of landmarks around one of the three-axis (depending on the type of rotation (roll, pitch, jaw) it influences frontal and/or lateral landmarks)

e. Smoothening jawline: It repositions one or multiple landmarks (repositions frontal and/or lateral landmarks)

Figure A6.10: ICD-CM attributes of jaw deformities (Gateno & Xia, 2020)

Attribute	Aspect	Names
Size	Too big	Hyperplasia, macrognathia, macrogenia
	Too small	Hypoplasia, micrognathia, microgenia
Position	Anteroposterior	Prognathism, retrognathism
	Transverse	Laterognathia
	Vertical	Excessive downward displacement, insufficient downward displacement
Orientation		Malrotation
Shape		Distortion
Completeness		Agenesis, cleft, defect
Symmetry	Object	Asymmetry
	Alignment	Asymmetric alignment

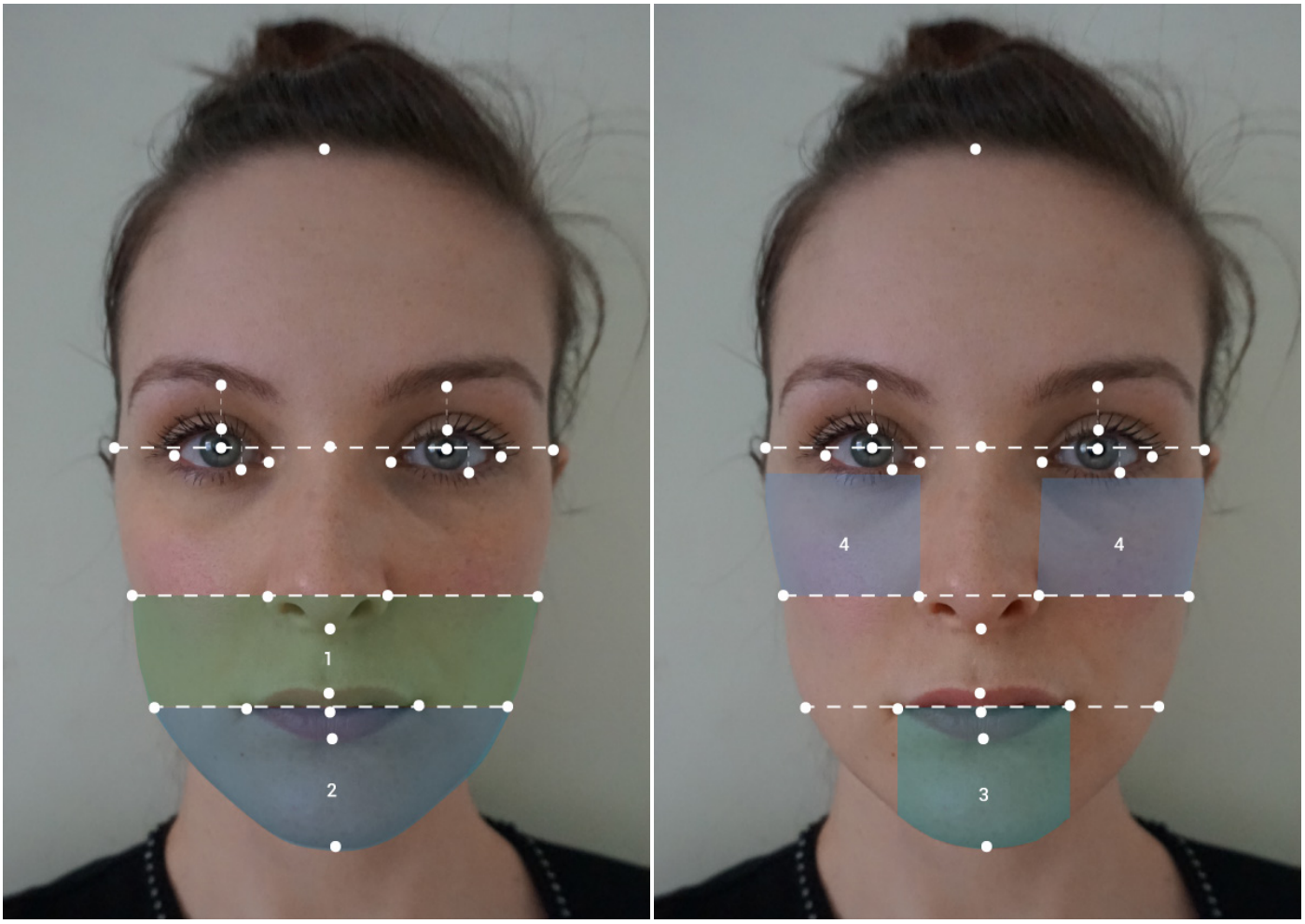


Figure A6.11: the four regions bounded by the landmarks

Figure A6.12: the planes defined by the landmarks and the original face

What could be noticed is that movements over the x-axis only influence the landmarks of the corresponding frontal or lateral plane and the movements over the y-axis influence the landmarks of both planes (figure A6.13 and A6.14).

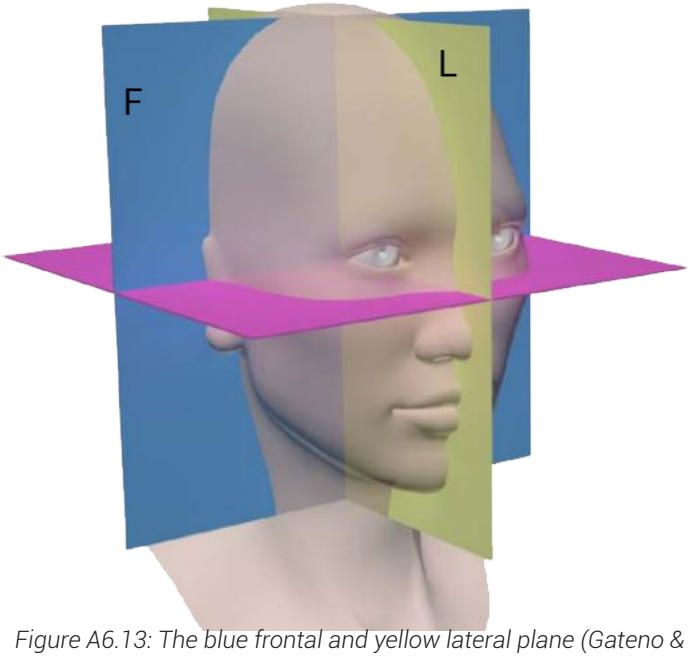


Figure A6.13: The blue frontal and yellow lateral plane (Gateno & Xia, 2020, edited image)

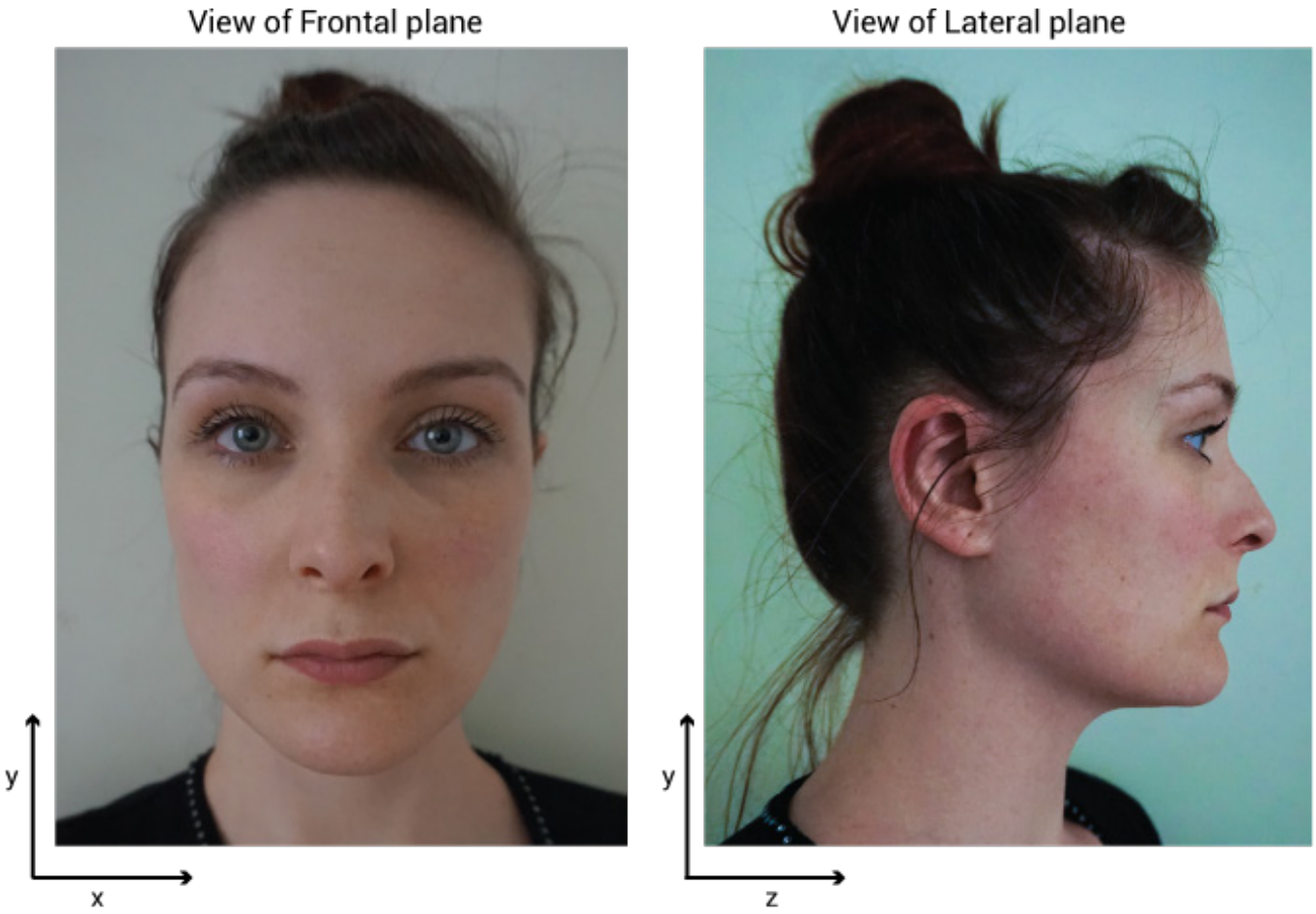


Figure A6.14: The axes of both planes. The x-axis of the Lateral plane is the same as the z-axis of the Frontal plane.

6.2 Iteration classification system

The research in chapter 5, appendix 6.1 lead to the classification system shown in figure A6.8. However, after the dimension test in chapter 12.1 a change has been made in the classification system. According to this test, the type of movements lengthening/shortening and widen/narrowing should be separated since lengthening and shortening show other results in facial recognition and so do widen and narrowing. Also, during chapter 10 changes were made on the annotiation for the type of movement. Therefore, the final version of the classification system is shown in figure A6.15.

Region		Movement	Type of movement	Plane	
1	Maxilla	a	Horizontal Lengthening (L) or Shortening (S)	F	Frontal
2	Mandible	b	Widening (W) or Narrowing (N)	L	Lateral
3	Chin	c	Vertical Lengthening (L) or Shortening (S)		
4	Cheek	d	Rotating		
		e	Smoothening jaw line		

Figure A6.15: legend of classification annotations version 2

Appendix 7: Orthognathic anatomy and surgeries

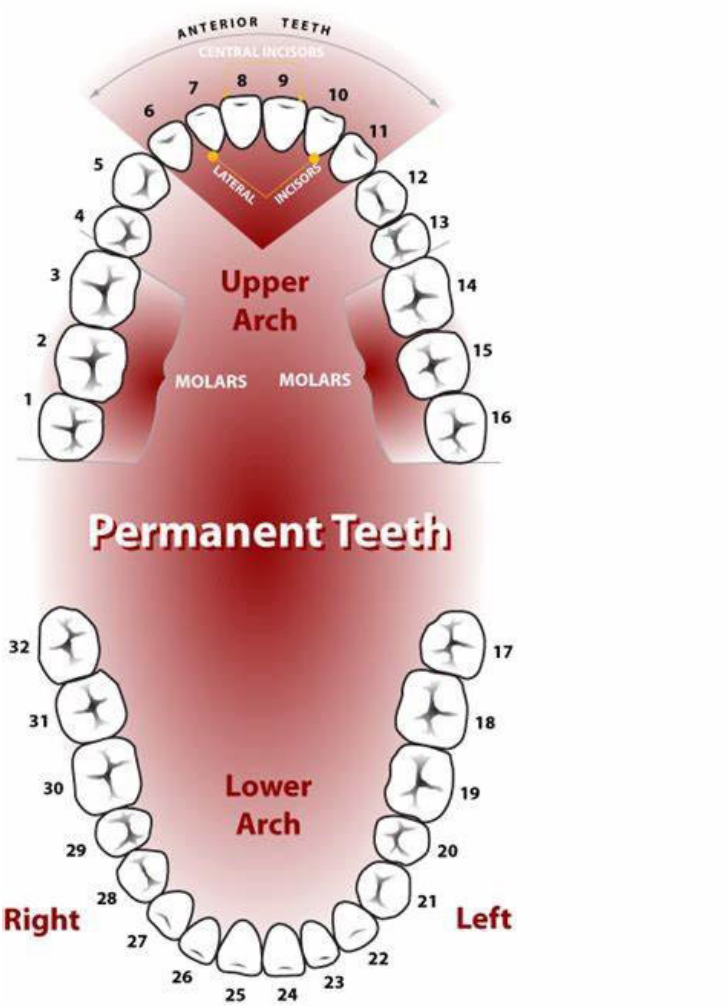


Figure A7.1: Names of the permanent teeth (United Concordia, n.d.)

Commonly used surgical techniques

Maxillary
Le fort I (figure A7.2): Moving the maxillary forward and backwards.

Le fort II (figure A7.2): Moving the maxillary with the nose forwards and backwards

Le fort III (figure A7.2): Correcting symmetrical issues and mid-face recession. Rotating and putting forwards.

Le fort III modified Kufner (figure A7.3): Neusal bidge is good, but the maxilla and zygomatic bone are flat. It is le fort III but excluding the nose.

Segmental alveolar maxillary osteotomy (figure A7.4): Can move the maxilla upwards, downwards, rotational. This surgery can be performed in different ways like the posterior segmental osteotomy or anterior segmental osteotomy.

Posterior segmental osteotomy (figure A7.5): This is an interdental osteotomy, which happens between the posterior teeth.

Anterior segmental osteotomy (figure A7.6): This is an interdental osteotomy, which happens between the anterior teeth.

Mandible
Bilateral Sagittal Split Osteotomy (BSSO) (figure A7.7): Moving mandible forwards, downwards, rotational. Can solve mandibular advancements up to 12mm. Can solve mandibular setback up to 8mm. Can solve minor asymmetry.

Vertical Subsegmoid Osteotomy (VSO)(figure 7.8): Inverted L osteotomy : Moves mandible vertically as horizontally.

Body osteotomy (figure A7.9): Set back the mandible horizontally.

Lower labial segmental Osteotomy (also called subapical osteotomy) (figure A7.10): Combines labial segment surgery with genioplasty. Moving part of the mandible vertically up or horizontally forward.

Distraction osteogenesis (figure A7.11): To correct an overjet and/or overbite.

Chin
Reduction genioplasty: Reducing chin vertical or horizontally by moving it up or back.

Augmentation genioplasty (figure A7.12): Augmenting the chin vertical or horizontally by moving it down or forward.

Figure A7.2: Area of the surgery of Le fort I, II and III (Royal medical services, 2017)

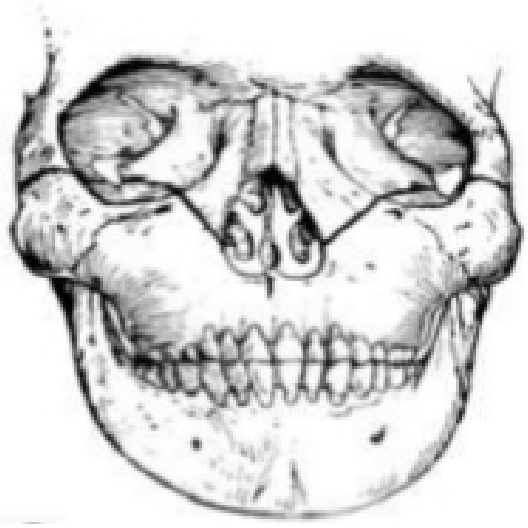
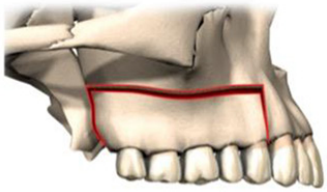


Figure A7.3: Area of the surgery of Le fort III modified Kufner (Royal medical services, 2017)

Figure A7.4: Segmental osteotomy between maxillary laterals and canines (Royal medical services, 2017)



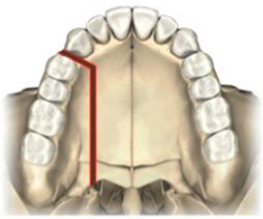
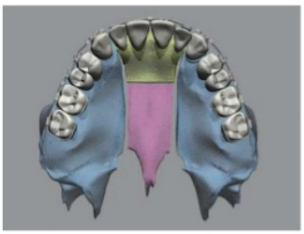


Figure A7.5: Posterior segmental osteomy (Kashani, 2016)



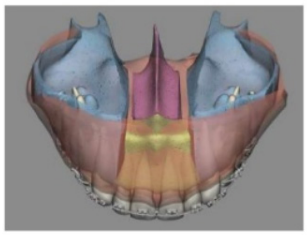


Figure A7.6: Anterior segmental osteomy (Royal medical services, 2017)

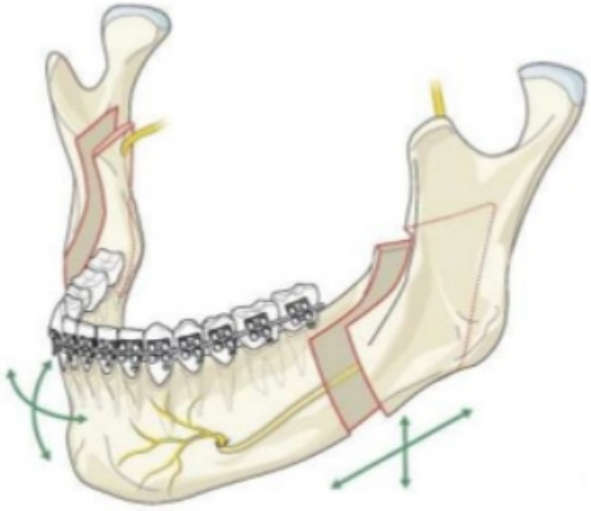


Figure A7.7: BSSO (Royal medical services, 2017)

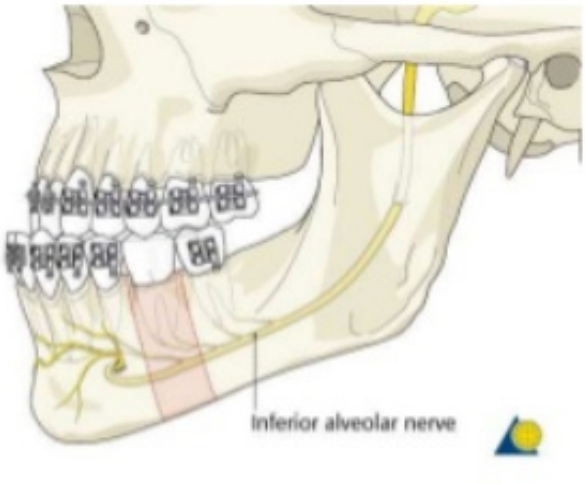


Figure A7.8: Body osteotomy (Royal medical services, 2017)

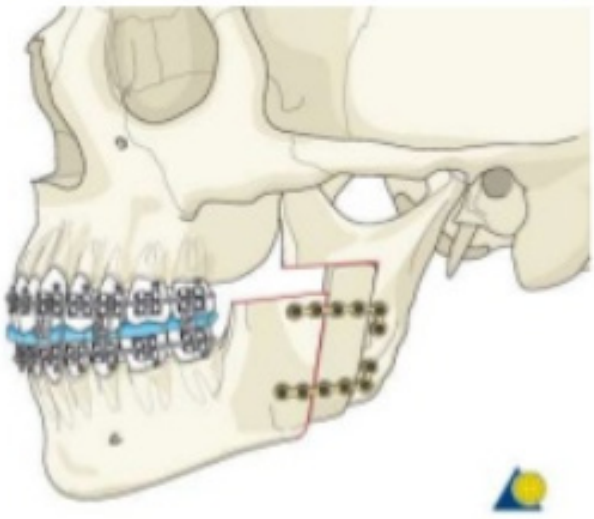


Figure A7.9: nverted L osteotomy (Royal medical services, 2017)

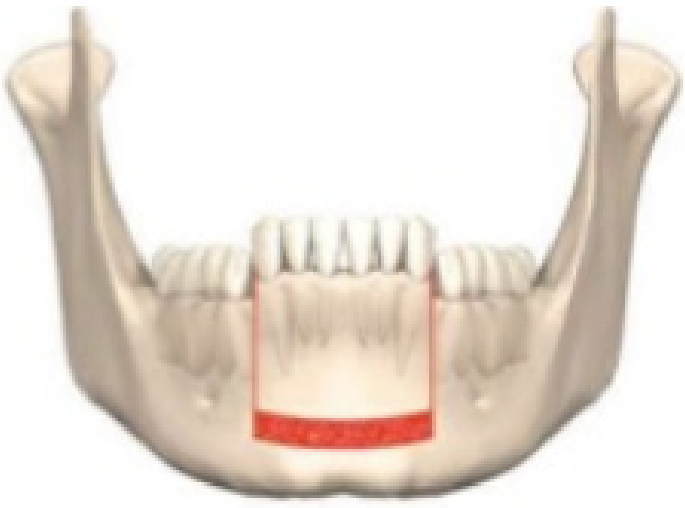


Figure A7.10: Lower labial segmental osteotomy (Royal medical services, 2017)

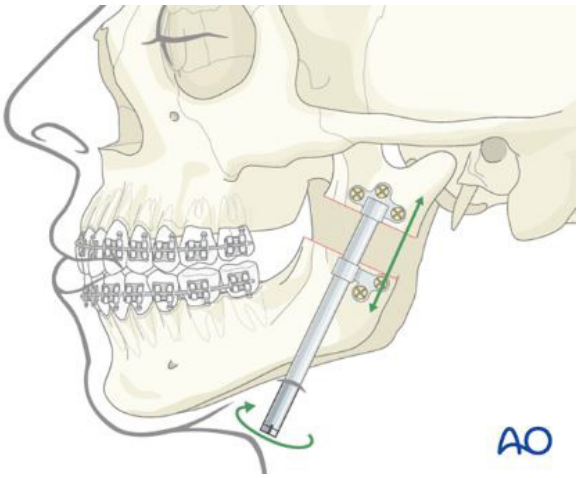


Figure A7.11: distraction osteogenesis (Homsi, n.d.)

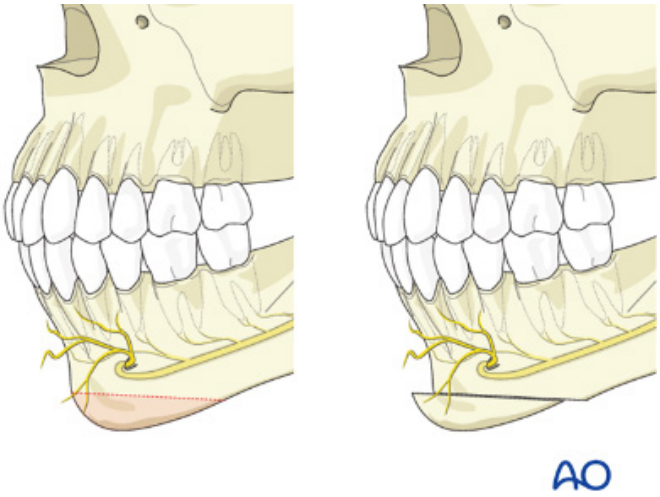


Figure A7.12: Genioplasty (Homsi, n.d.)

Appendix 8: Facial recognition - The ideal face

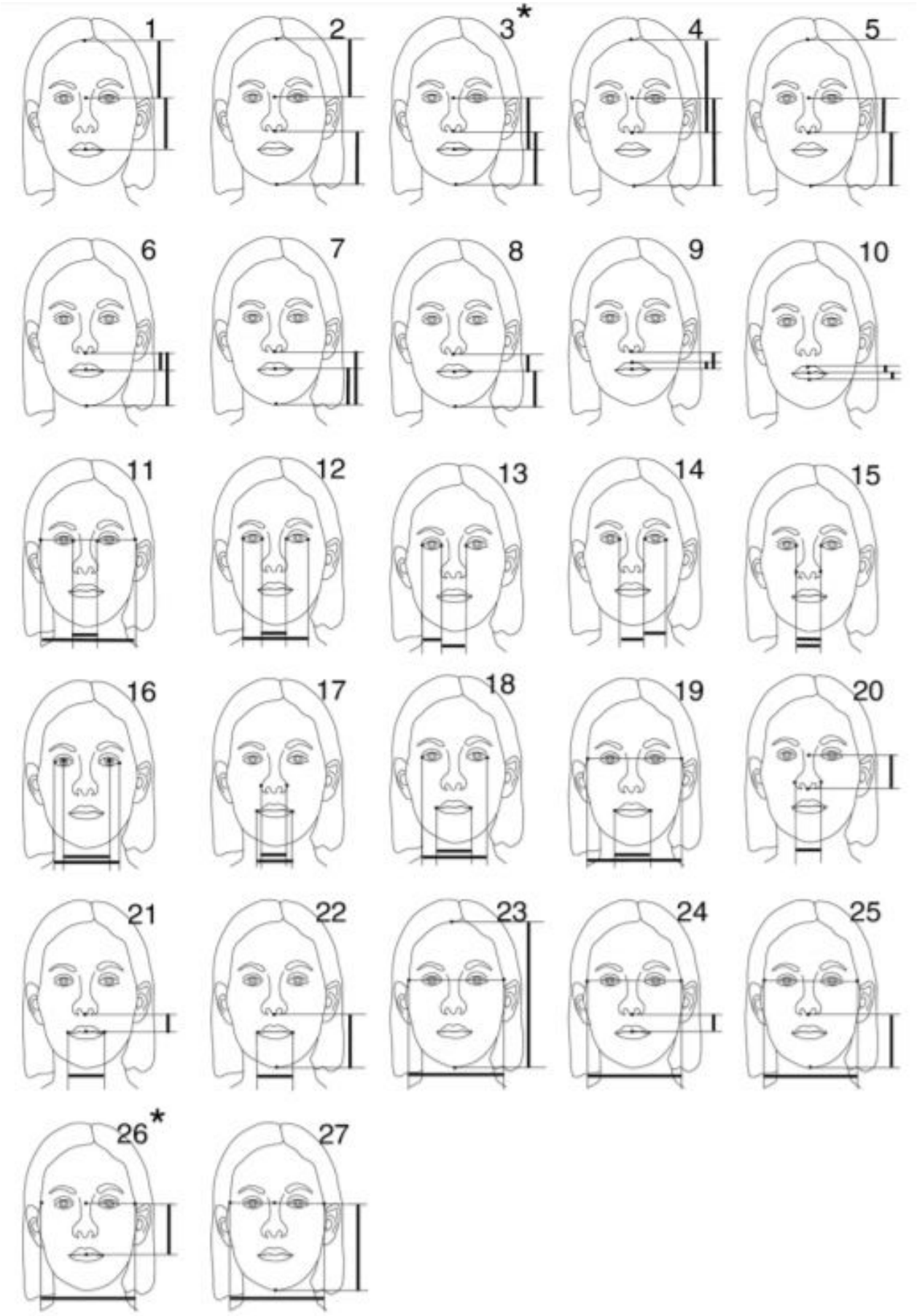


*Figure A8.1: Twenty-seven "ideal" ratios on a frontal photograph, based on the accepted landmarks in the literature. *Significant at P < .05. (Kiekens et al., 2008)*

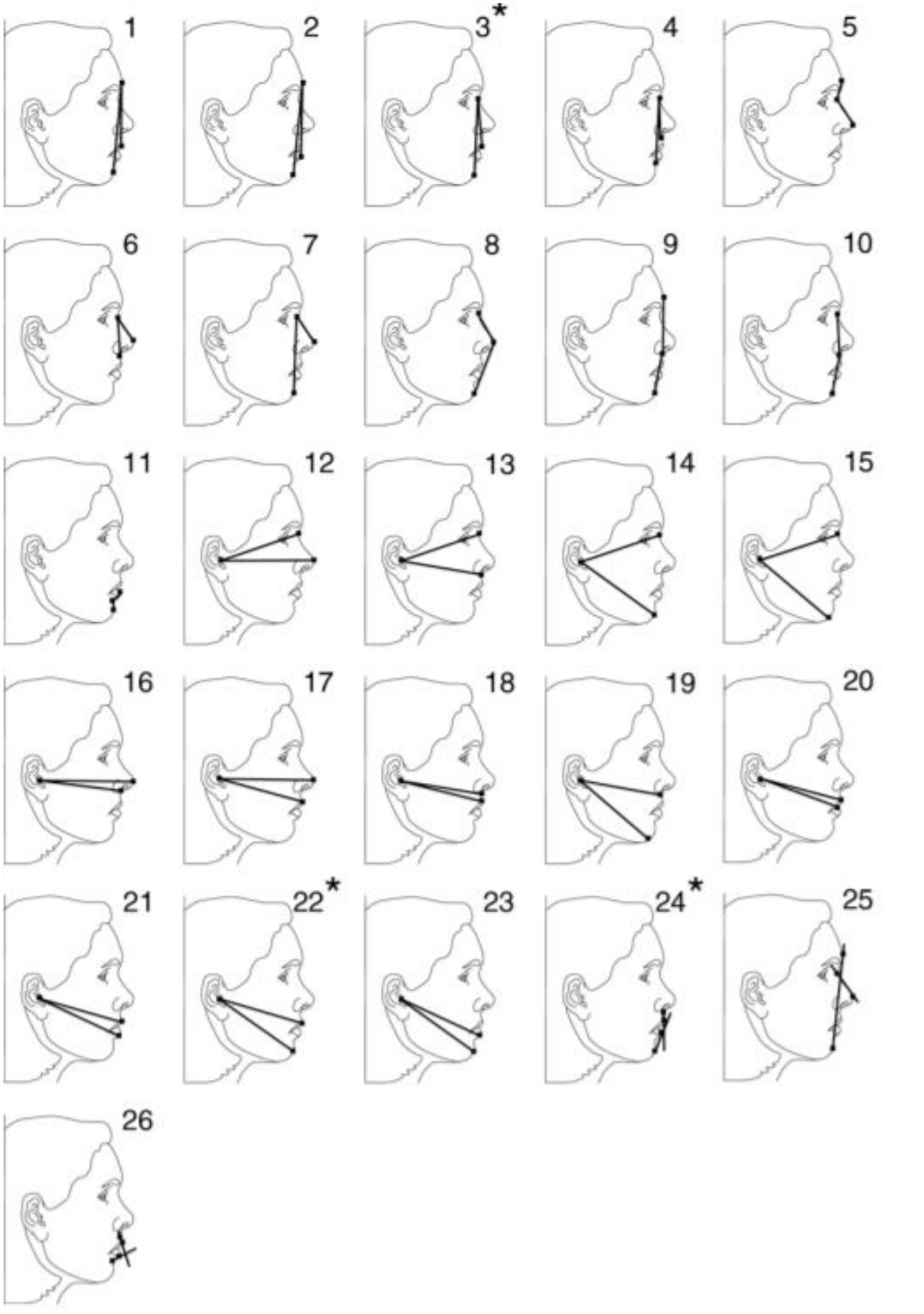


*Figure A8.2: Twenty-six "ideal" ratios on a lateral photograph, based on the accepted landmarks in the literature. *Significant at P < .05. (Kiekens et al., 2008)*

Appendix 9: Human test - Data processing

This chapter explains step by step how the data of the human tests was processed to get the results of chapter 6.

All the responses of the Google form were saved in an Excel file. The following steps were done:
1. From the respondents was checked if they only filled in the form once. One person filled in the test anonymously and was therefore removed since it could not be checked if this person filled in the test twice. After this, 64 respondents were left existing out of 22 women and 42 men

2. To all the people who did not grow up in Europe was asked were they grew up (for a next test, ask this right away in the form). From the 64 respondents, 3 did not grow up in Europe. 1 Grew up in New Sealand, 1 in Curacao, 1 in Botswana (with Dutch parents) and 1 somewhere in Asia (with Dutch parents). There was chosen to only remove the person who grew up in Asia, since the research (chapter 3) proved the differences between facial recognition in Asia and Europe. There is assumed the others recognize faces like the European culture. After this, 63 respondents were left.

3. The responds of the test question were removed, since this question does not count for the result.

4. The responds per before and after pictures were labelled by their group:
Up_Mandible
Widening_Mandible
Down_Mandible
Up_Maxilla
Widening_Maxilla
Down_Maxilla

5. Every respondent of the test who's picture was used in the test recognized him/herself. Therefore the 'this is me' answers do not participate in the results of facial recognition.

6. The second picture showing the original picture was to test if the respondent recognized this person. The answers of the respondents who did not recognize the face on the original picture, so who answered 'no' on the second question, where removed.
The maximum amount of respondents who did not recognize a person was 8. The average is 3 people, which is 4,8 % of the total amount of respondents.

7. The total amount of respondents was set as 60 people (63 – 4,8%), to remove the respondents which did not know the original face.

8. Per group the average number of people who did not recognize the familiar faces is calculated and the percentage of the total amount of respondents from 7. (60 respondents)

Group	Average no	Percentage from total amount of respondents
Up_Mandible	8.75	5.25
Widening_Mandible	4.5	2.7
Down_Mandible	3.2	1.92
Up_Maxilla	4.8	2.88
Widening_Maxilla	2	1.2
Down_Maxilla	2	1.2

Figure A9.1: Step 8

9. The amount of smiles with teeth was summed up. 15 people did not smile with teeth or did not smile at all and 21 did smile with teeth. While distributing the pictures over groups, the smiles were not taken into account. No clear indication about the influence of smiles can be seen from the percentages, however, it could have influenced the results.

	Amount of smiles
Up_Mandible	1
Widening_Mandible	6
Down_Mandible	1
Up_Maxilla	3
Widening_Maxilla	6
Down_Maxilla	5

Figure A9.2: Step 9

10. The P-value was generated for all groups to see if they were statistically significant. This was done in excel by selecting 'data', 'regression'. From the regression table, the P-value was coppied to the overview of figure A9.3. Every P-value below 0.05 was statistically significant. All mandible manipulations were statistically significant. For the maxilla region, only the up movement was statistically significant.

	Up Maxilla					
yes	61	44	62	62	58	50
no	1	15	1	0	3	4
P = 0.01						
Statisticly significant	YES					
	Up Mandible					
yes	62	60	57	58	30	56
no	0	0	2	2	27	4
P=0.00001						
Statisticly significant	YES					
	Down Maxilla					
yes	60	60	56	59	61	60
no	0	3	2	2	2	1
P=0.78						
Statisticly significant	NO					
	Down Mandible					
yes	55	59	55	59	59	58
no	5	1	7	0	1	2
P=0.002						
Statisticly significant	YES					
	Widening maxilla					
yes	57	55	59	56	62	57
no	1	2	1	5	0	1
P=0.19						
Statisticly significant	NO					
	Widening mandible					
yes	45	58	63	57	61	60
no	11	3	0	3	1	0
P=0.0003						
Statisticly significant	YES					

Figure A9.3: Step 10

Appendix 10: Human test - Selections of the manipulations

Selecting the movements
36 amount of public pictures has been collected from members of the student society S.R.C. Thor. The pictures which were found online and which were send by the members voluntary only have a frontal view. Therefore, only the landmarks which lie in the frontal view will be examined in this test. The movement annotations from chapter 5 belonging to these landmarks are:
b. Widen/Narrowing
c. Up/down
e. Rotating
f. Smoothening jaw line

These annotations can all happen on the maxilla and mandible region (1 and 2) and since these are the areas in which orthognathic surgeries happen the most, these are the areas of which the landmarks will be manipulated. However, since the manipulation will also move skin outside the fixed landmarks, the the other two regions (3 and 4) may also be affected and the chin landmark in region 3, will be variable during the mandible manipulations. It is unknown if the direction of the movement of the landmarks influences the facial recognition. Therefore, multiple possibilities are possible within the movement annotations.

In this human recognition test, a, e and f will not be tested from the movement annotations. a Will not be tested since only pictures on the Frontal plane are available. e will not be tested because too many possibilities or rotations exist and rotations are difficult to manipulate. f will not be tested because the landmarks which smoothen the jaw line are already tested in b and d and also, smoothening can be done in many ways.

From this selection, eight possibilities for the manipulations which are possible and shown in figures A10.1-A10.8 and are:
1.b (widen)
1.b (narrowing)
1.c (up)
1.c (down)
2.b (widen)
2.b (narrowing)
2.c (up)
2.c (down)

Also combinations of these are possible, which leads to 82 possibilities, so 64 possibilities can be done for the manipulation. This is not possible within the time frame, therefore the eight possibilities will not be combined in this test. This is also giving a better result, since more can be concluded about the recognition of a few specific landmarks after the test.

Selecting the manipulations
An instinctive selection will be made from the manipulations which are done in figures A10.1-A10.8

The manipulations are done on the face of the author of this thesis and the author cannot judge her own face. Her first thoughts are that the widening and narrowing of both the mandible as maxillary seem to have less effect on the face than moving it up or down.
One person who knows the person in these manipulations has been asked what pictures look recognizable or not while knowing who the person was. He had 3 seconds to look at the picture to say the answer instinctively. After looking for a longer time the person was always recognizable because the eyes looked the same. The answers correspond with the first thoughts of the author and the widening and narrowing of both the mandible as maxillary seem to have less effect on the face .

The answers were:
1.b (widen) – a bit
1.b (narrowing) – yes
1.c (up) - no
1.c (down) - no
2.b (widen) – yes
2.b (narrowing) - yes
2.c (up) – no
2.c (down) –a bit

Therefore the following ia tested in the human recognition test:
1.b (widen) – a bit
1.c (up) - no
1.c (down) - no
2.c (up) – no
2.c (down) –a bit

Since it gives a better comparison when movements on the x as y-axis are tested and to be able to compare the mandible and maxilla, widening the mandible 2.b is also be tested.

Since the widen/narrowing manipulations do not look that different, it will be assumed that the 1.b (widen) can represent the other landmark movements over the x-axis as well.
There is expected that the person in the image will always be recognizable in these manipulations after looking to the face for some time, since the eyes will be the same. Because the respond on this small test, a time limit should be put on the human recognition test so the attention will lie on the whole face instead of the subject looking to one part of the face which stayed unchanged.

Selecting the landmarks for the manipulations
The landmarks which are manipulated to create the optimal result are selected.
Up/Down_maxilla: The landmaks on the maxillary plane (YR, YL, AIR, AIR), the Sn on the nose, the Ls and St on the nose are moved upwards on the y-axos..
Widening_maxilla: The YR and YL are positioned further away from each other on the x-axis.
Up/Down_mandible: The landmarks on the mandibular plane, the Li on the lip and the Me on the chin are moved upwards on the y-axis.
Widening_mandible: The ZR and ZL landmarks are positioned further away from each other on the x-axis.

Decisions setup test
The human recognition test is based on research. Therefore, a short overview of the reasoning behind the decisions of the setup of the human test in Chapter 3, appendix 4 is given:

- The hair of the faces in the pictures has been removed to draw attention to the jaw instead of to the hair

- The faces in the pictures are carefully selected because in the group the test is done, these are the faces from people who are active in the group. It is therefore a test between familiar people, which matches the context of the patient

- The nationality of the participants have been asked since people in the European culture process faces differently than other culture. Only the results of the Europeans have been taken into account

- After showing the manipulated face and asking the recognition question, the original picture is shown. The same question is asked as the one with the manipulated face, to confirm if the participant knows the person in the picture. One answer is added which is 'this is me'. Since people participating in the test may have provided their picture as well.

- The test is called 'The "Who Am I?" quiz'. This name is chosen to be playfull so people would be provoked more in doing the test.

- Only faces of people without glasses who regularly also do not have glasses have been used for manipulating. People could also recognize faces with a beard easier, therefore no pictures of people with beards are used, only pictures with a small amount of facial hair.

Figure A10.1: Widening maxilla

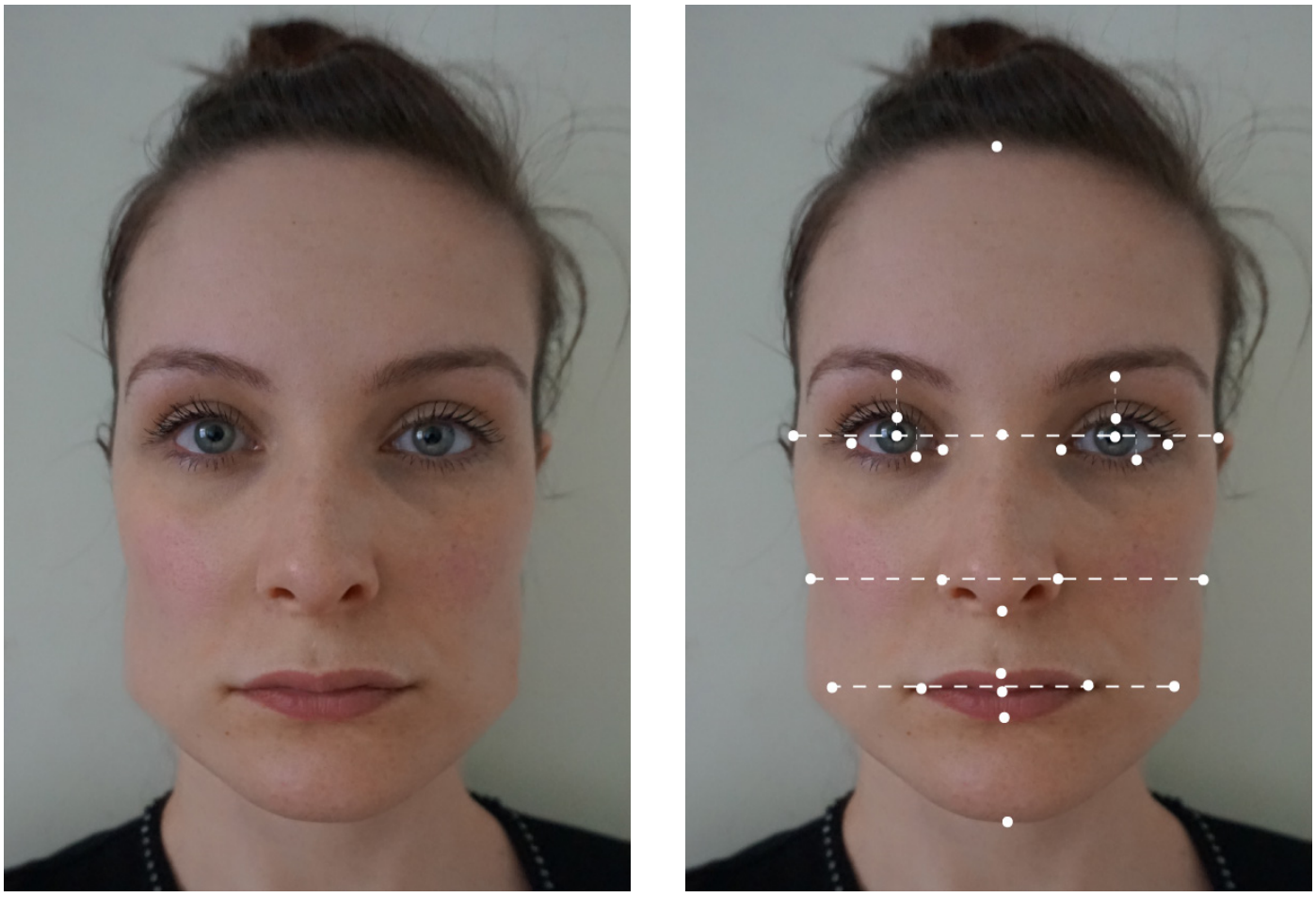


Figure A10.2: Widening mandible

Figure A10.3: Up maxilla

Figure A10.4: Up mandible

Figure A10.5: Down maxilla

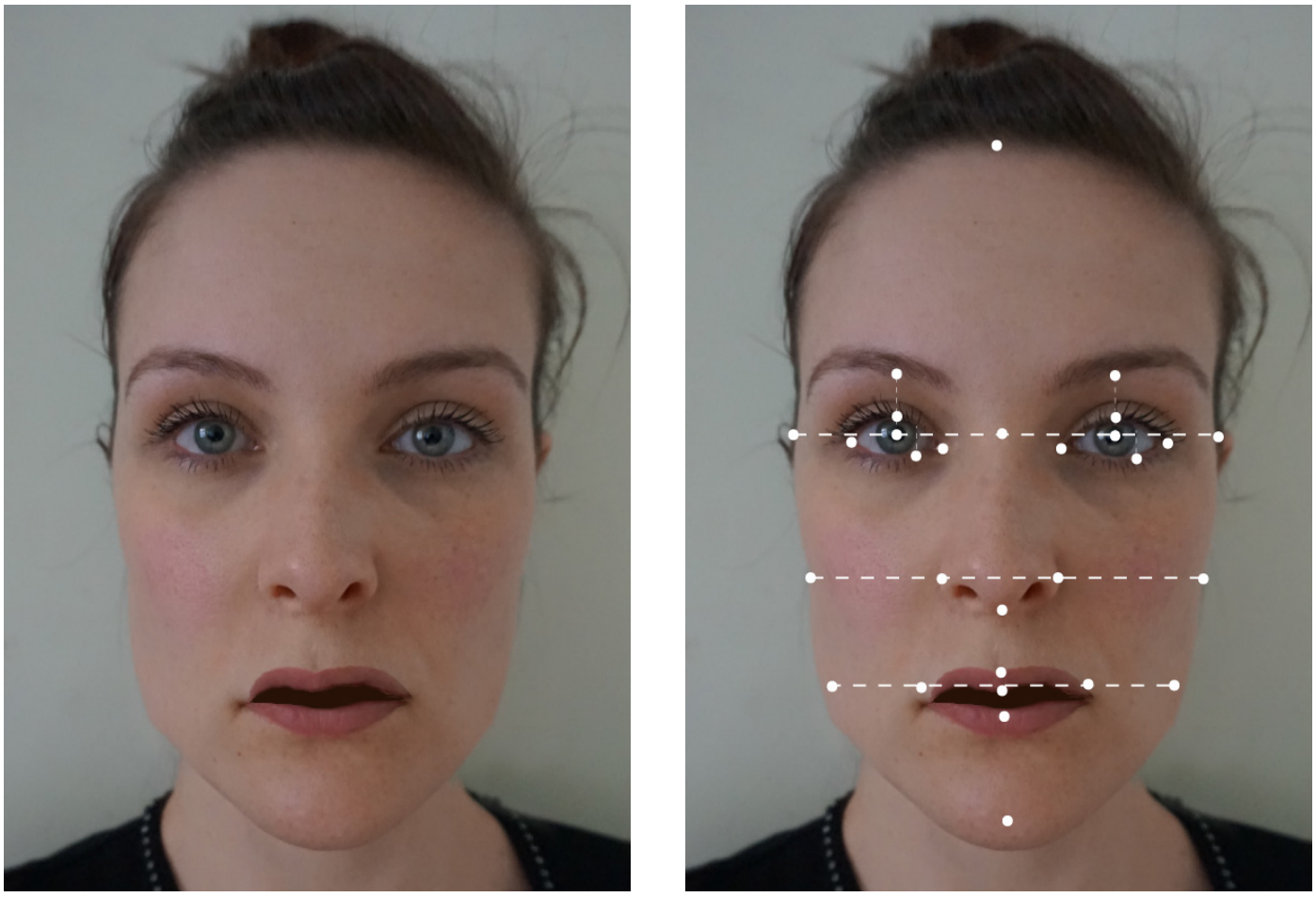


Figure A10.6: Down mandible

Figure A10.7: Narrowing Maxilla (not in human test)

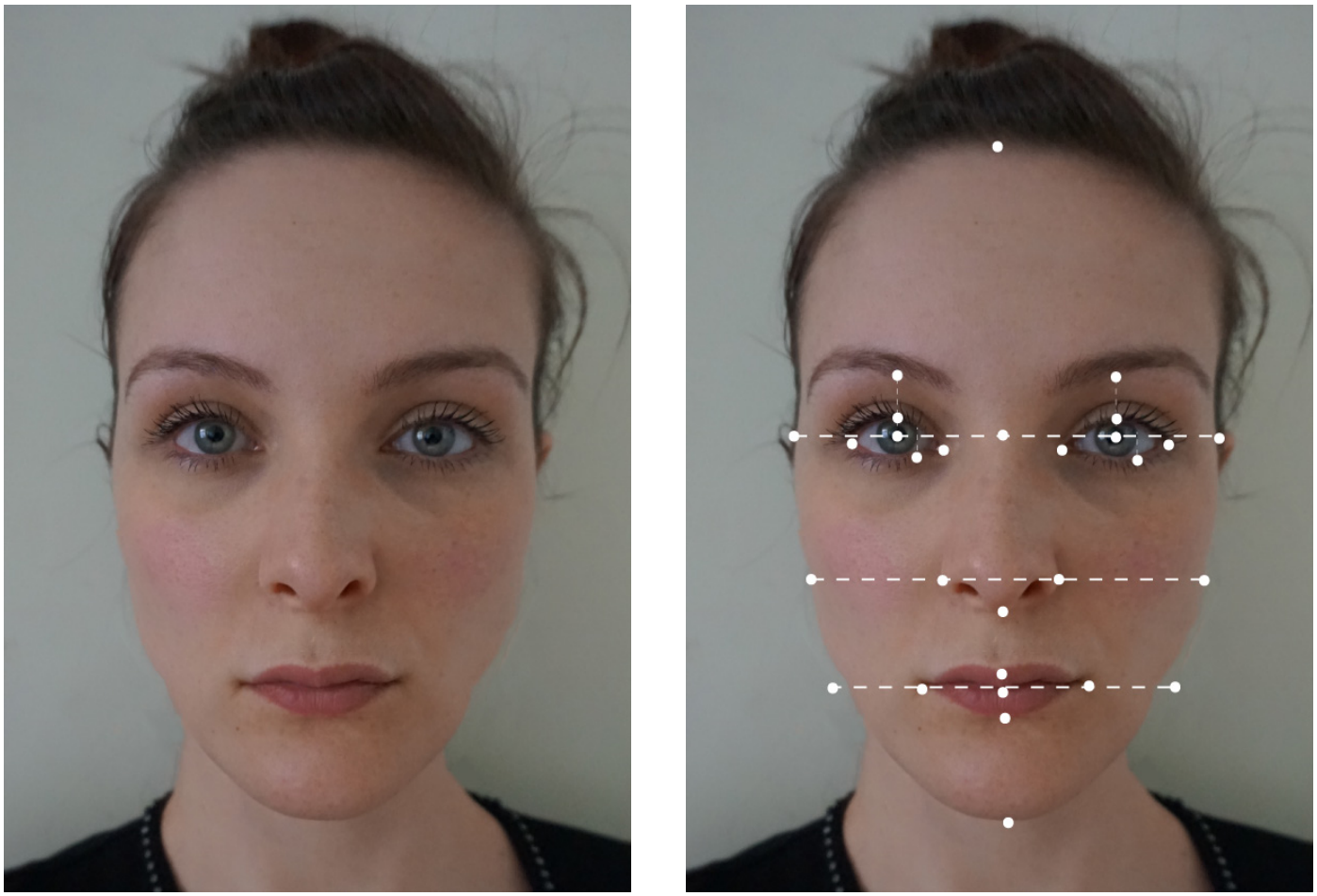
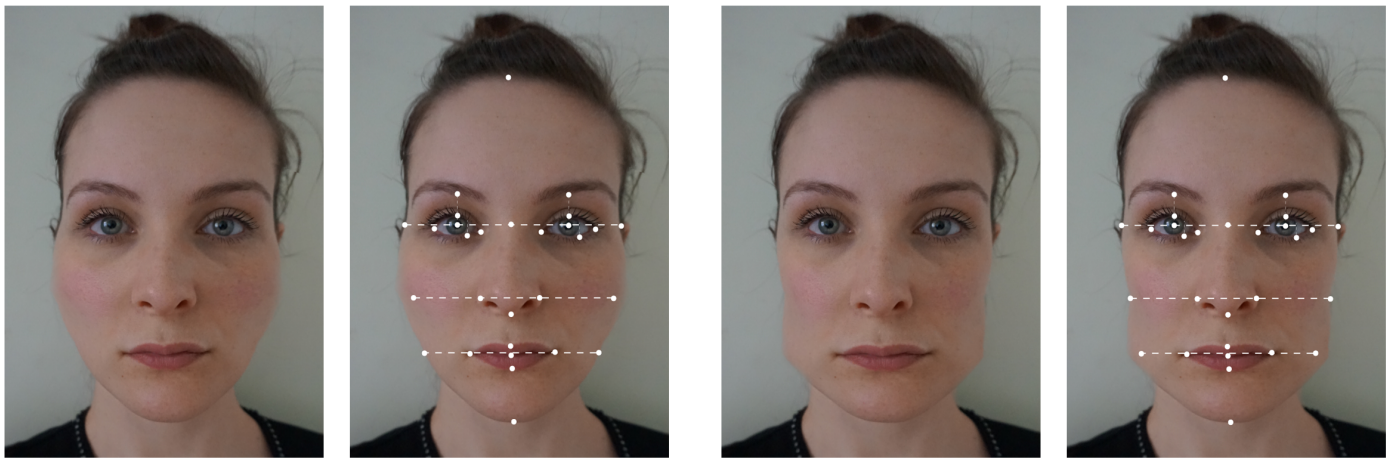
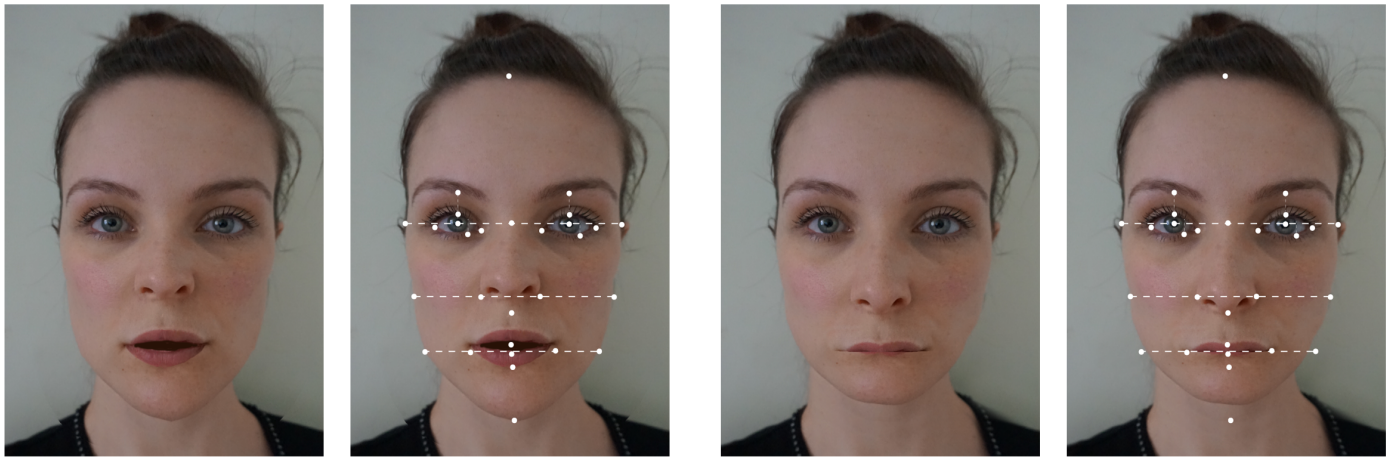


Figure A10.8: Narrowing Mandible (not in human test)



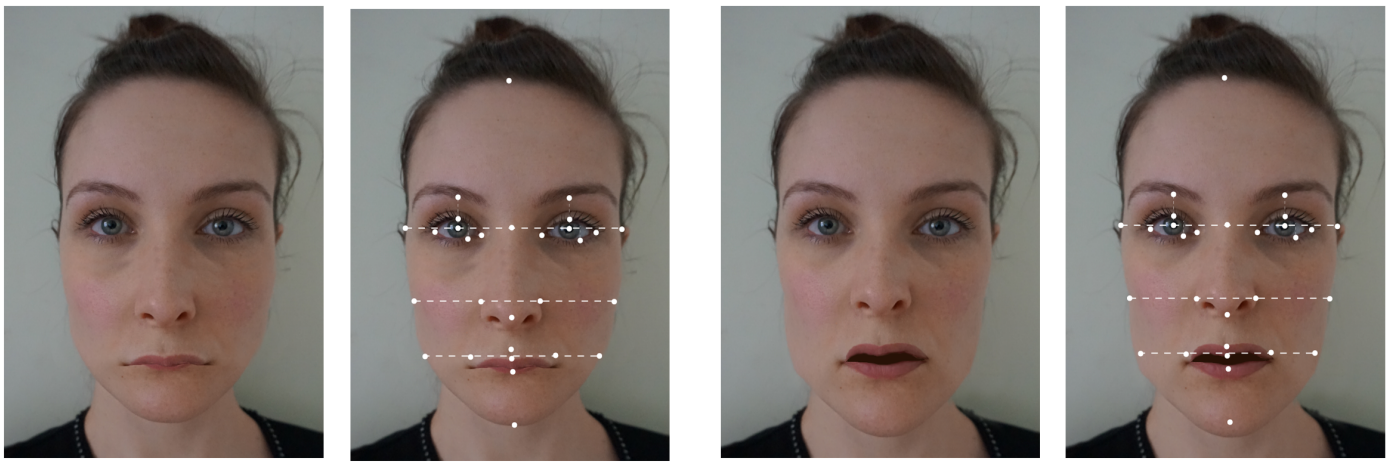
Widening maxilla (1b)

Widening mandible (2b)



Up maxilla (1c)

Up mandible (2c)



Down maxilla (1c)

Down mandible (2c)

Figure A10.9: The manipulations which are used in the human test

Appendix 11: human test - instruction of the manipulations

The puppet warp tool in Photoshop is used to create the manipulations. This is an example of widening the mandible. All the space in the mesh will move with the landmarks which are chosen to be moved, to simulate the soft-tissue.

Example of the Up_Maxilla manipulation
1. Figure A11.1: Select the Pen Tool and draw around the area which needs edit. Since the maxilla is positioned up, select the soft-tissue area between the mandible-plane and the landmarks which bound the eye. Carefully mark the upper lip and make sure you bound in part of the mandible region under the mandible-plane to let the soft-tissue after the manipulation feather into the mandible area.

2. Figure A11.2: Click the right mouse button and click on 'make selection'

3. Press Ctrl-J on your Keyboard (Windows), make sure your picture layer is selected. This creates a layer from your selection.

4. Select your new layer with the to be manipulated area.

5. Figure A11.3: In the taskbar click on Edit -> Puppet warp tool. This creates a mesh from your layer.

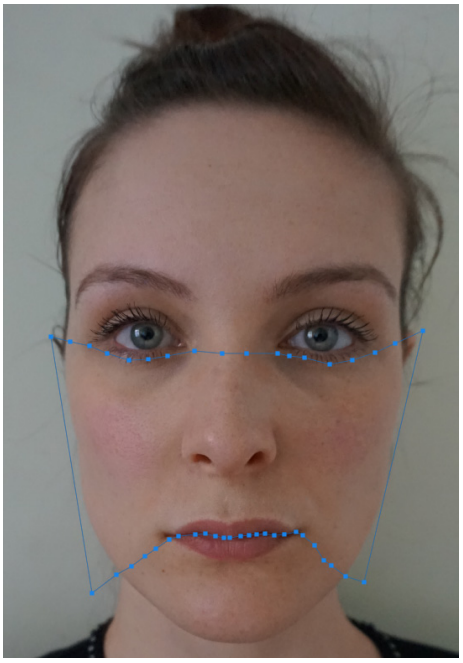


Figure A11.1

Figure A11.2

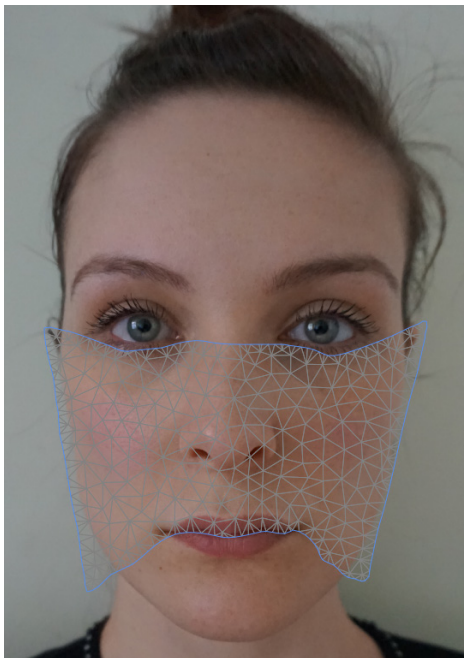


Figure A11.3

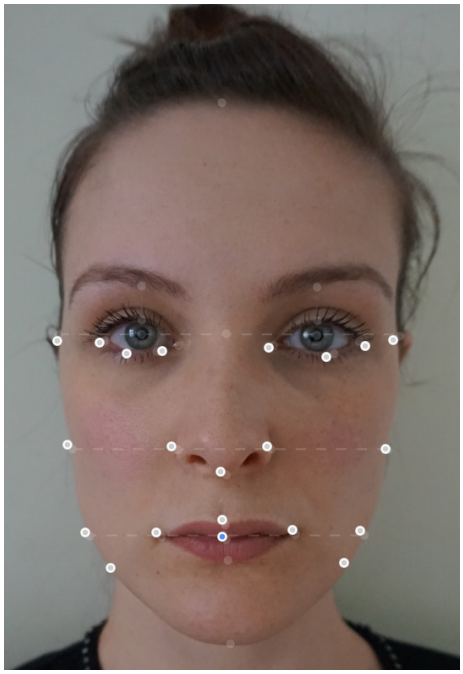


Figure A11.4

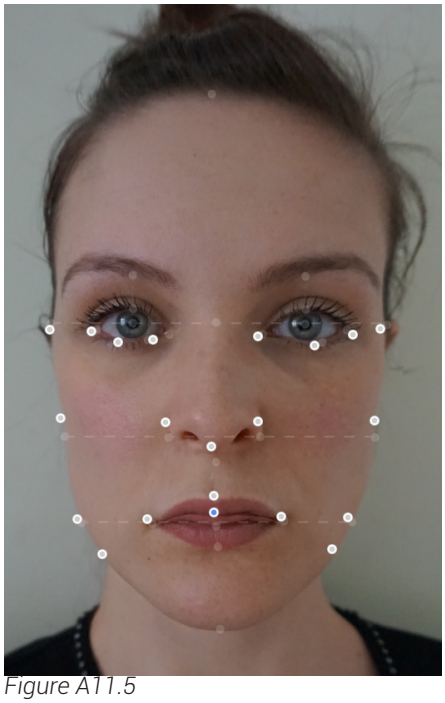


Figure A11.5

Figure A11.6

6. Figure A11.4: Click to create the pins. Put them on the landmarks (another layer which should be visible) to manipulate and on the places where the soft-tissue needs to be fixed. The mandible should be fixed, the zygonomatic bone, the eyes and the corners of the mouth.

7. Figure A11.5, A11.6: Move the pins to move the maxilla up. Move the pins on the maxillary plane, the subnasale, and the two pins on the upper lip (labrale superior and stomion). Move them straight up with approx. the same amount. After this, click the proceed button in the toolbar.

Figure A11.7

Figure A11.8

8. Figure A11.7, A11.8: The space between the mouth needs to be edited. Select this space with the Pen Tool en fill it with a colour which matches the inner line of the mouth, in this case a dark red colour.

9. If needed, the picture can be cleaned up by using a layer mask for the selected area. After, you can use a black brush tool to brush away the impurities.

Appendix 12: Human test - the pictures

Figure A12.1: The pictures of the faces before manipulation

Figure A12.2 The pictures of the faces after manipulation

Appendix 13: Human test - consent form

Helping Tamara - graduation research

Dear member of Thor,

For my graduation, I am researching facial recognition after orthognathic surgeries. I need to find out what points in the jaw region of the face influence facial recognition between people who know each other. Since we know most of the other members within Thor, this seems like the place for me to do research.

I would like to use a picture of you which is already public (e.g. from social media). I will manipulate this picture to see if other members from Thor still recognize you after this. I would like to get your permission to do this. I will also ask you if I can use your picture for in my report, but I will try to avoid this and work around it, I will just ask it to be sure so I know I have the rights to use it or not. If I use your picture in my report, your name will never be mentioned.

Thanks, you are helping me a lot!!

PS. If you don't have any public pictures but still like to help me, you can always send a selfie to me :)

What is your 'real' first and last name? (So not your Thor name)

Short-answer text

Tamara Ribbers is allowed to use my public pictures for her graduation research *

- ○ Yes
- ○ No

Tamara Ribbers is allowed to use my pictures for in her graduation report *

- ○ Yes
- ○ No
- ○ Yes, but only if she blurs my eyes

What is your 'real' first and last name? (So not your Thor name)	Tamara Ribbers is allowed to use my public pictures for her graduation research	Tamara Ribbers is allowed to use my pictures for in her graduation report
[redacted]	Yes	Yes
	Yes	Yes
	Yes	Yes
	Yes	Yes
	Yes	Yes
	Yes	Yes
	Yes	Yes
	Yes	Yes
	Yes	Yes
	Yes	Yes
	Yes	Yes
	Yes	Yes
	Yes	Yes
	Yes	Yes
	Yes	Yes
	Yes	Yes
	Yes	Yes
	Yes	Yes
	Yes	Yes
	Yes	Yes
	Yes	Yes
	Yes	Yes
	Yes	Yes
	Yes	Yes
	Yes	Yes
	Yes	Yes
	Yes	Yes, but only if she blurs my eyes
	Yes	Yes, but only if she blurs my eyes
	Yes	Yes
	Yes	Yes, but only if she blurs my eyes
	Yes	Yes
	Yes	Yes
	Yes	Yes
	Yes	Yes
	Yes	Yes
	Yes	Yes
	Yes	Yes
	Yes	Yes
	Yes	Yes

Appendix 14: Human test - Google form

The "Who am I?" quiz

Great that you're here! This quiz will probably be different from the ones you know...

It is important you perform this quiz on your own and that you don't use the internet to find the right answers since it will be used for Tamara's graduation research. The total time of this quiz will be approx. 5 minutes depending on how fast you are.

Before you will start this quiz, I would like to know who you are so I can see who did this test. Your name will not be used in any other way.

*Required

What is your name? *

Your answer

Did you grow up in Europe? *

- ◯ Yes
- ◯ No

Next

Let's get started!

You will get to see 42 pictures of faces, all from SRC Thor. Try to answer the question as fast as possible, do not take longer than 3 seconds to look at a picture. It is all about facial recognition, you don't have to know the name to recognize the face. So also answer 'yes' when you know the person only by face. The rest is quite self-explanatory.

Let's start with a test question to get to know what type of questions you will get!

Back Next

The "Who am I?" quiz

*Required

Test question

Do you recognize this person? Give your answer right away, don't look for longer than 2 seconds

Do you recognize this person? *

- ○ Yes
- ○ No
- ○ This is me

Back Next

Test question

This is the original picture. It is Tamara.

Do you recognize this person now? *

- ○ Yes
- ○ No
- ○ This is me

Back Next

Appendix 15: Code for calculating similarity score

With this code, the similarity score of multiple sets of images can be calculated at once. Only frontal of frontal-lateral views of the face can be analysed with this code.

```
Created on Thu Jan 30 01:33:33 2020

@author: Yu Song
"""

import os

import numpy as np

import dlib
import face_recognition

imgs =[]


# Getting the current work directory (cwd)
thisdir = os.getcwd()

# r=root, d=directories, f = files
for r, d, f in os.walk(thisdir):
    for file in f:
        print (file)
        if file.endswith(".jpg"):
            imgs.append(os.path.join(r, file))

for i in range(0,len(imgs),2):
    if(i+1)>=len(imgs):
        break

    imgA = face_recognition.load_image_file(imgs[i])
    imgB = face_recognition.load_image_file(imgs[i+1])

    encondingA = face_recognition.face_encodings(imgA)
    encondingB = face_recognition.face_encodings(imgB)[0]

    face_distance = face_recognition.face_distance(encondingA, encondingB)


    print("Measure 1: ", face_distance, "- With a normal cutoff of 0.6, very strict cutoff of 0.5")
```

Appendix 16: Computer test - Rest of the figures

Amount of movements	Total amount of patients	Not recognizable (%)
1	19	21
2	19	26
3	13	15
4	10	10
5	11	9
6	2	50
7	1	0

Figure A17.1: Amount of movements

Involvement of movement	Total amount of patients	Not recognizable (%)
1a	45	20
1b	7	0
1c	21	24
1d	20	10
1e	0	-
2a	53	19
2b	3	0
2c	4	25
2d	19	5
2e	2	0

Figure A17.2: Involvement of movement

Amount of regions	Total amount of patients	Not recognizable (%)	Region combinations		
1	24	21	nine from region 1	15 from region 2	
2	22	23	17 from region 1 and 2	three from region 1 and 3	two from region 2 and 3
3	22	9	18 from region 1, 2 and 3	four from region 1, 2 and 4	
4	7	29	7 from region 1, 2, 3 and 4.		

Figure A17.3: Amount of regions

Appendix 17: Computer test - Preparing patient data

All the steps which are done during the computer test are shown in this chapter.

Before finding the similarity score:
1. Delete all pictures in lateral view, these cannot be analysed by the code.
2. Classify all patients.
3. Convert pictures to jpg.
4. Place picture sets in a map (figure A18.1)
5. Check if all the pictures are present and if the picture sets match with the patient.
6. Run the code

The things which should be done step by step after finding the similarity score:
1. Copy the similarity scores with their belonging file name to Excel.
2. Mark the scores ≥0.45 as 'False'. These patients are seen as 'not similar' by the computer.
3. Create a list with all the patients which are not similar, including the similarity scores (figure A18.2). This can be used later to compare the classification and to write a conclusion.
4. Move the data to SPSS (appendix 19)

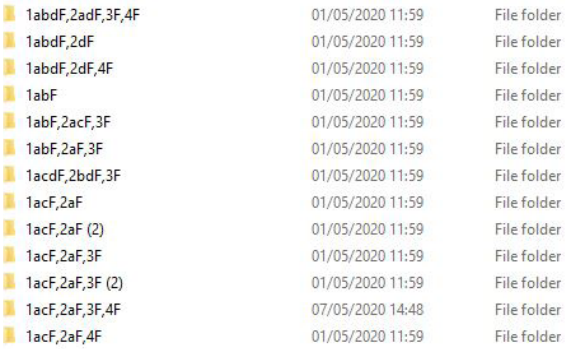


Figure A18.1: All the classified patient picture sets in maps

Patient	Similarity score
1acF,2aF (2)	0.48924
1acF,2aF,3F	0.52795
1acFL,2aFL,3FL,4FL	0.45933
1adF (5)	0.50019
1adF,2adF,3F,4F	0.47151
1aF (3)	0.54234
1aF,2aF (6)	0.49514
1aF,2aF (8)	0.45459
1aFL,2aFL,4FL	0.57398
1cF,2aF (2)	0.51280
1cF,2cF	0.44573
2aF (6)	0.52001
2aFL (4)	0.47861
2aFL (7)	0.46005

Figure A18.2: All patients which are not recognized by the computer

Appendix 18: Computer test - Data analysis SPSS steps

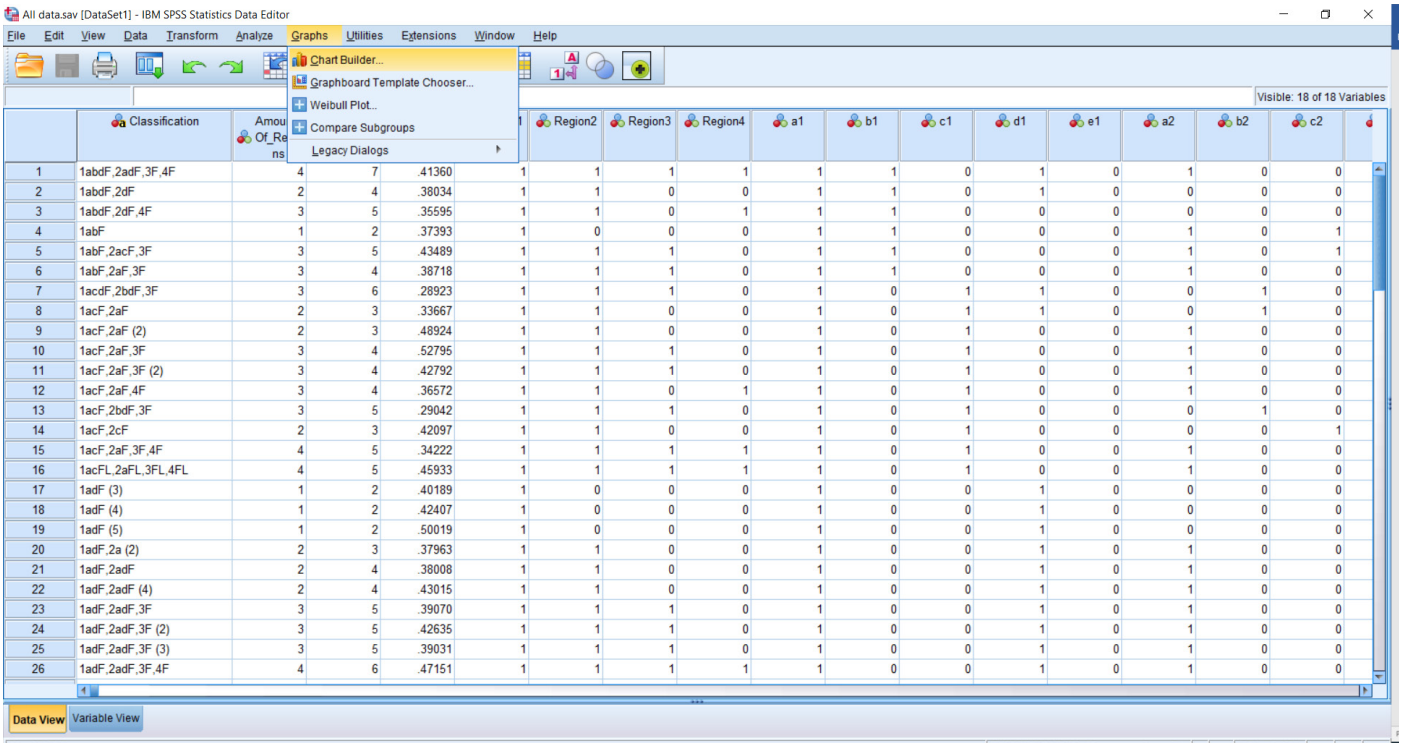
In this chapter, step by step is explained how the data analysis in the SPSS software is done during the computer recognition test. First, creating a scatter for amount of regions or amount of movements is explained. After is explained how to combine the scatter plots.

Creating a scatter plot

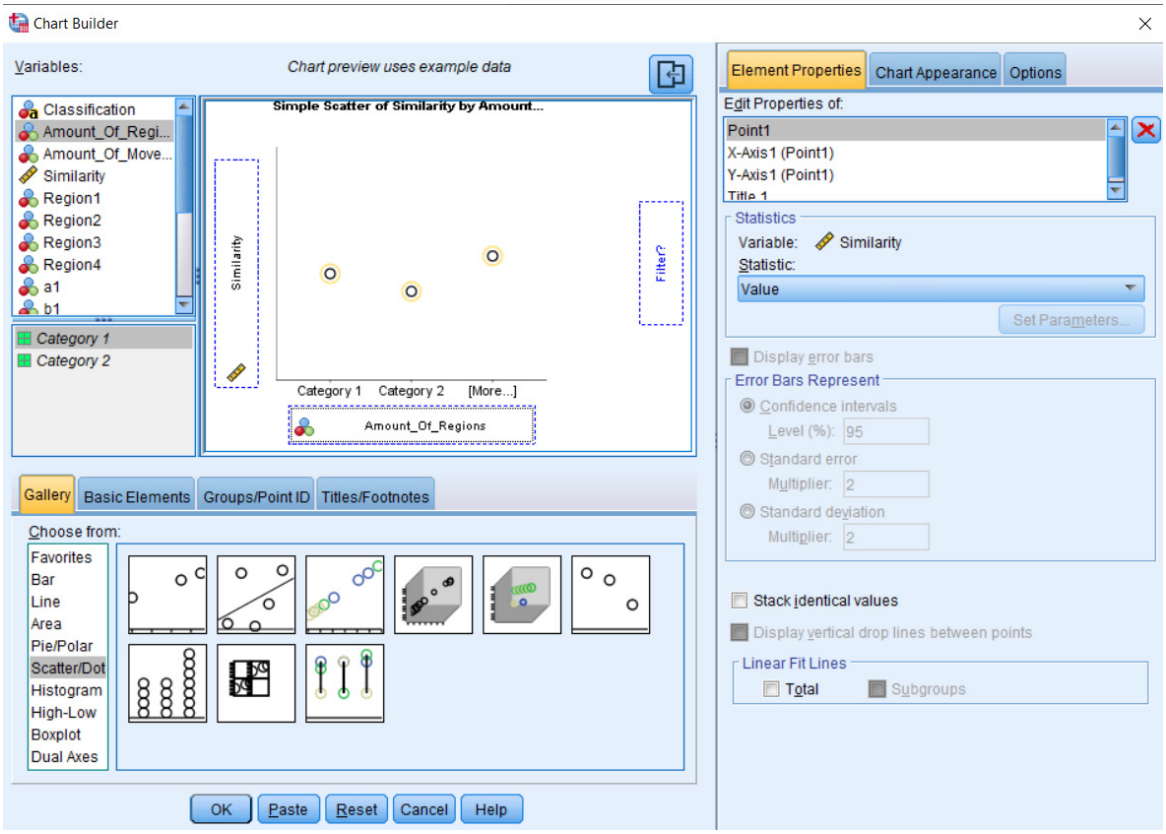
1. All the regions are per classification given a 1(true) or 0(false) score to indicate the presence of this region in the classified patient. The same is done with the movements where a1 is movement a in region 1 and a2 is movement a in region 2 etc.

Classification	Amount_ Of_Regions	Amount_ Of_Movements	Similarity	Region1	Region2	Region3	Region4	a1	b1	c1	d1	e1	a2	b2	c2
1abdF,2adF,3F,4F	4	7	.41360	1	1	1	1	1	1	0	1	0	1	0	0
1abdF,2dF	2	4	.38034	1	1	0	0	1	1	0	1	0	0	0	0
1abdF,2dF,4F	3	5	.35595	1	1	0	1	1	1	0	0	0	0	0	0
1abF	1	2	.37393	1	0	0	0	1	1	0	0	0	1	0	1
1abF,2acF,3F	3	5	.43489	1	1	1	0	1	1	0	0	0	1	0	1
1abF,2aF,3F	3	4	.38718	1	1	1	0	1	1	0	0	0	1	0	0
1acdF,2bdF,3F	3	6	.28923	1	1	1	0	1	0	1	1	0	0	1	0
1acF,2aF	2	3	.33667	1	1	0	0	1	0	1	1	0	0	1	0
1acF,2aF (2)	2	3	.48924	1	1	0	0	1	0	1	0	0	1	0	0
1acF,2aF,3F	3	4	.52795	1	1	1	0	1	0	1	0	0	1	0	0
1acF,2aF,3F (2)	3	4	.42792	1	1	1	0	1	0	1	0	0	1	0	0
1acF,2aF,4F	3	4	.36572	1	1	0	1	1	0	1	0	0	1	0	0
1acF,2bdF,3F	3	5	.29042	1	1	1	0	1	0	1	0	0	0	1	0
1acF,2cF	2	3	.42097	1	1	0	0	1	0	1	0	0	0	0	1
1acF,2aF,3F,4F	4	5	.34222	1	1	1	1	1	0	1	0	0	1	0	0
1acFL,2aFL,3FL,4FL	4	5	.45933	1	1	1	1	1	0	1	0	0	1	0	0
1adF (3)	1	2	.40189	1	0	0	0	1	0	0	1	0	0	0	0
1adF (4)	1	2	.42407	1	0	0	0	1	0	0	1	0	0	0	0
1adF (5)	1	2	.50019	1	0	0	0	1	0	0	1	0	0	0	0
1adF,2a (2)	2	3	.37963	1	1	0	0	1	0	0	1	0	1	0	0

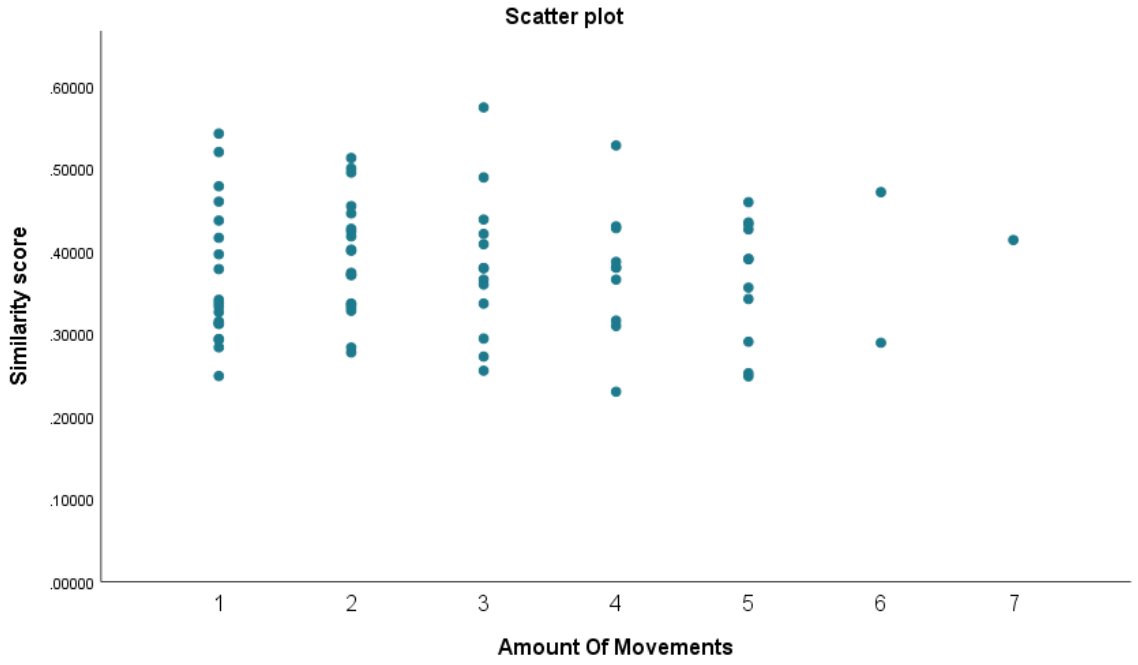
2. Click 'graphs' and 'chart builder' in the toolbar of SPSS



3. In the Chart Builder, choose the 'scatter/dot' from the gallery and pick the Similarity as y-axis and Amount_Of_Regions or Amount_of_Movements as x-axis. After click OK.

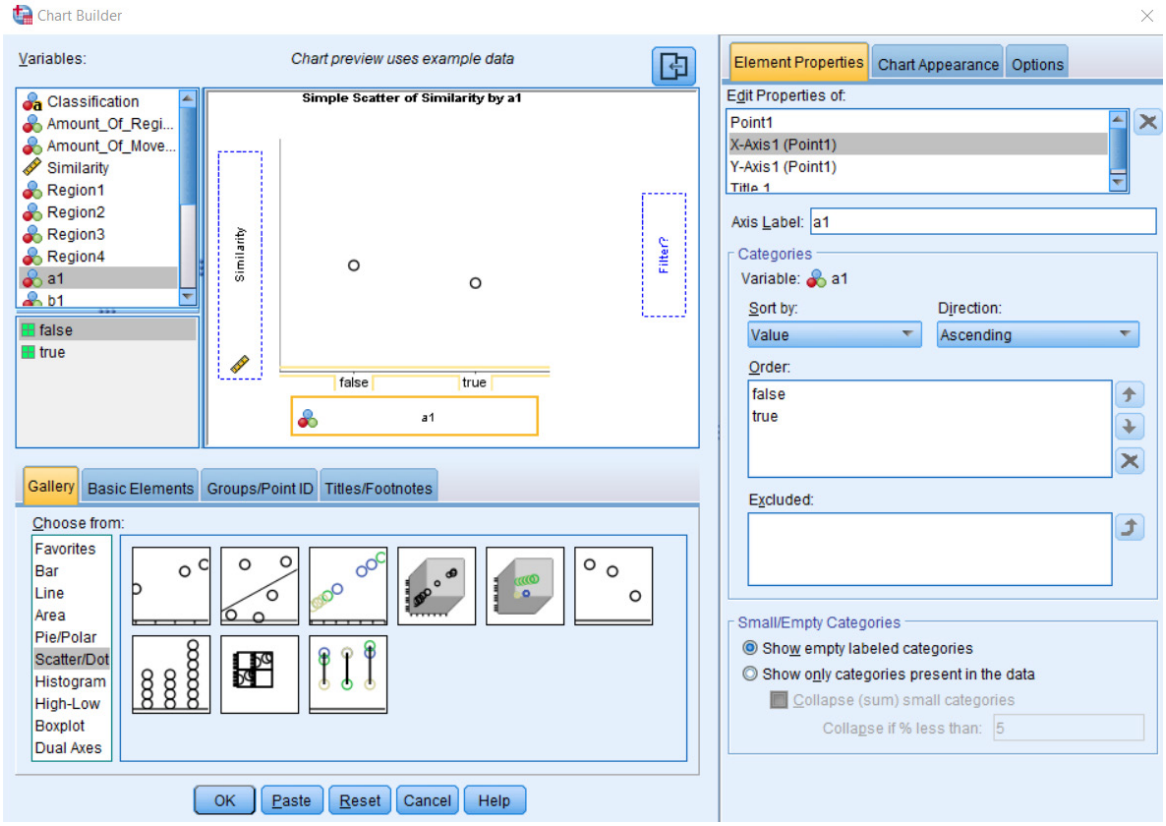


4. The result is this scatter plot.

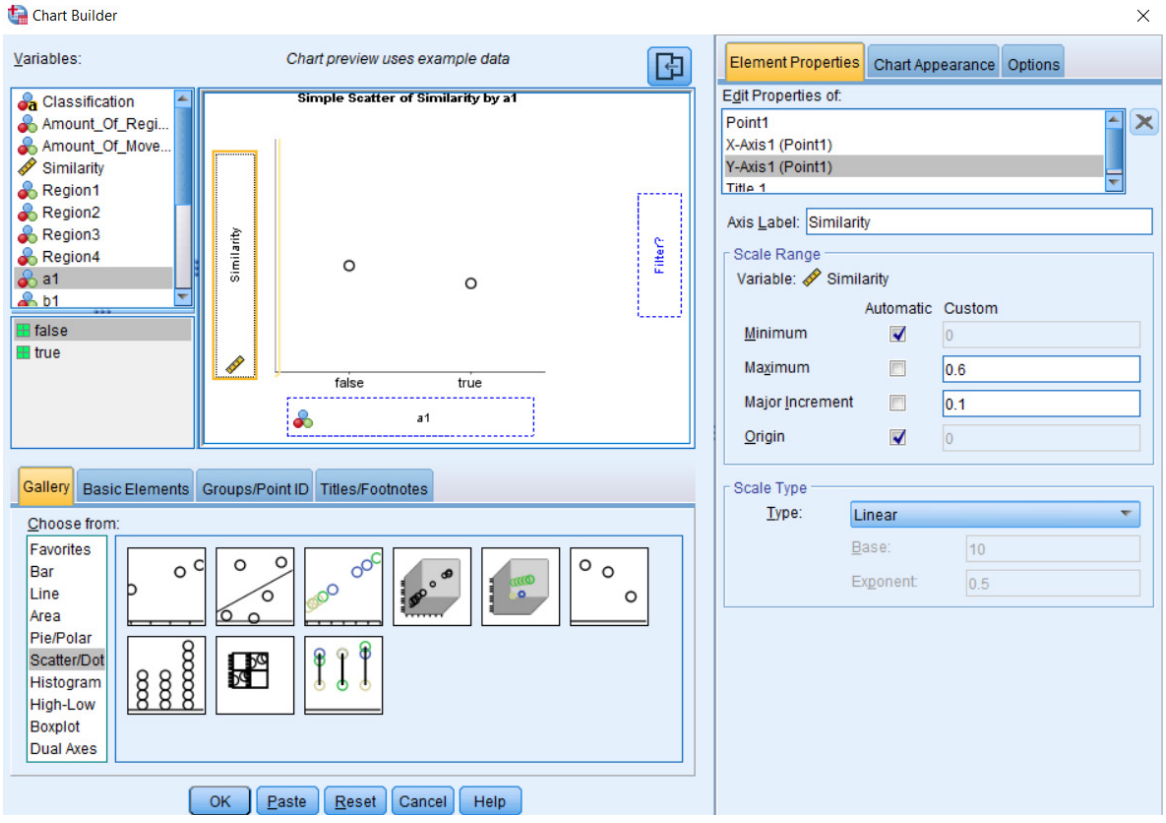


Combine scatter plots

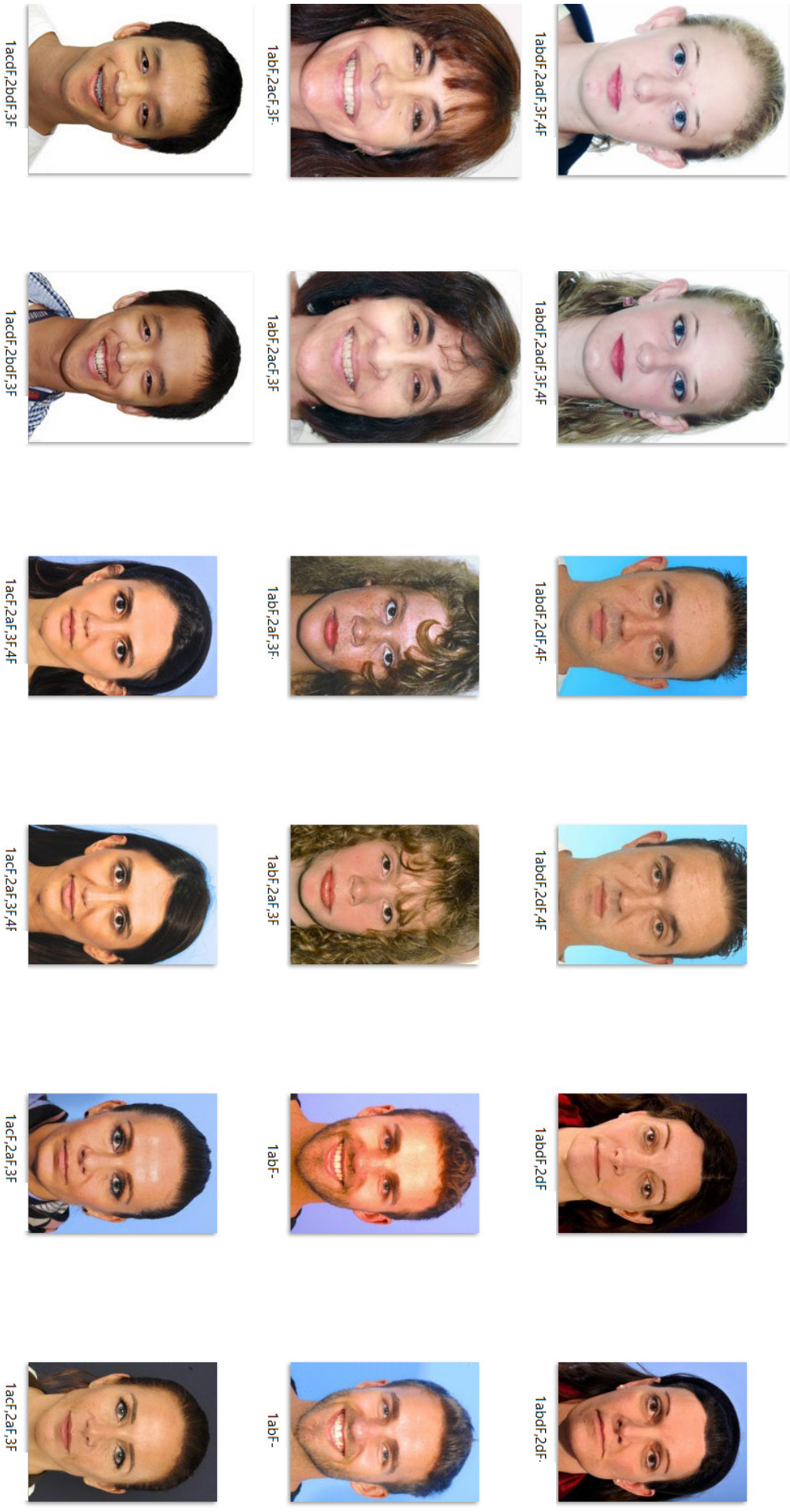
1. Follow the same steps as in 'create a scatter plot' but in the chart builder select first a1 as x-axis.
2. Click on the x-axis 'a1'.
3. In the Element Properties on the right, go to Order and click on 'False', now click on the red 'X', which removes the false values.



4. Click on the y-axis 'Similarity' and change the Maximum and Major Increment in 'Scale Range' on the right. Change Maximum to 0.6 and Major Increment to 0. By doing this, the scale of all movements will be the same which makes it possible to put all scatter plots in one graph manually.



Appendix 19: Computer test - Patient pictures




1acF,2aF·


1acF,2aF·


1acF,2bdF,


1acF,2bdf


1acF,2cF

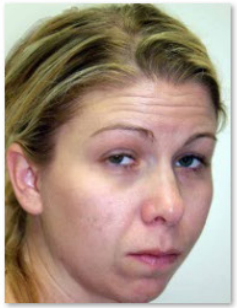

1acF,2cF


1acFL,2aFL,3FL,4FL


1acFL,2aFL,3FL,4FL


1adF,2a·

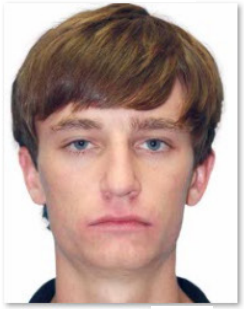

1adF,2a·


1adF,2adF,3F,4F·


1adF,2adF,3F,4F


1adF,2adF,3F·

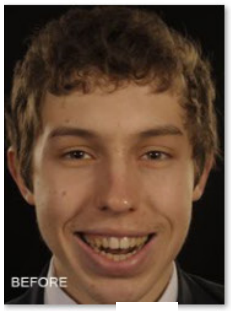

1adF,2adF,3F


1adF,2adF,3F


1adF,2adF,3F


1adF,2adF,3F

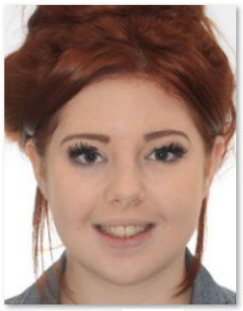

1adF,2adF,3F



1adF·

1adF-

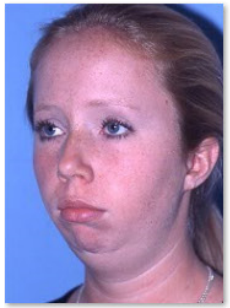
1adF-I



1adF

1adF·

1adF·

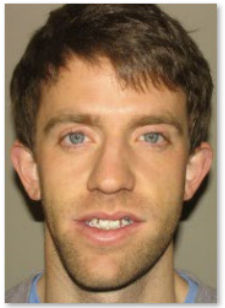


1adFL,2aFL,3FL·

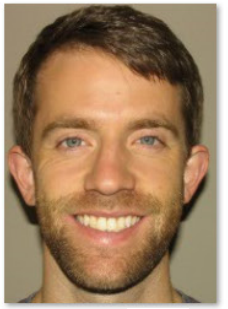
1adFL,2aFL,3FL-

1aF,2aeF,3F,4F

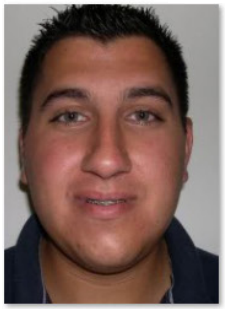
1aF,2aeF,3F,4F



1aF,2aF,3F



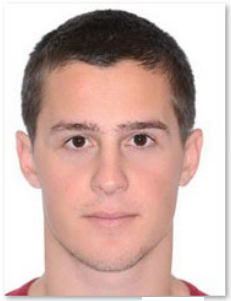
1aF,2aF,3F



1aF,2aF,3F·

1aF,2aF,3F-B

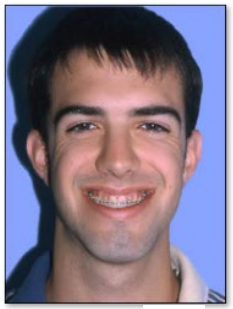
1aF,2aF,3F·

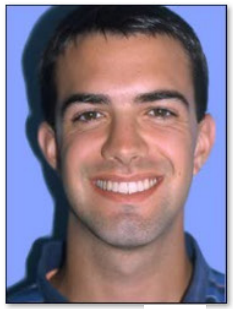


1aF,2aF,3F·

1aF,2aF

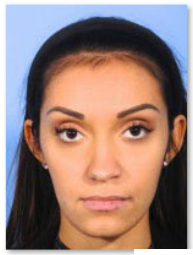
1aF,2aF


1aF,2aF·


1aF,2aF·

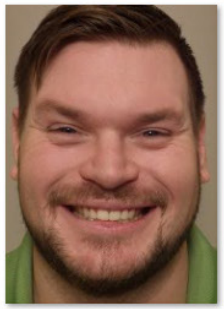

1aF,2dF,3aF,4F


1aF,2dF,3aF,4F·

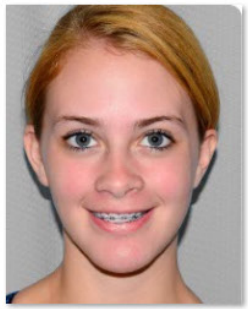

1aF,2dF,4F·

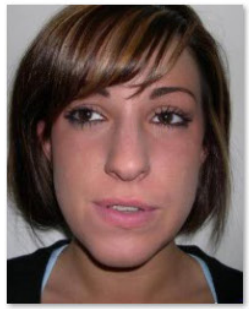

1aF,2dF,4F


1aF·


1aF

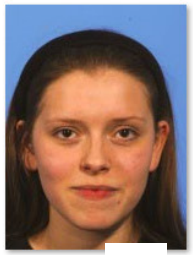

1aF


1aF

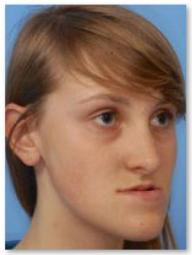

1aF·


1aF


1aF


1aF


1aFL,2aFL,4FL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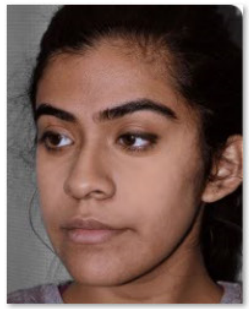
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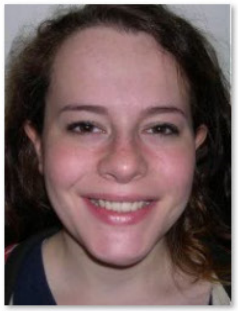
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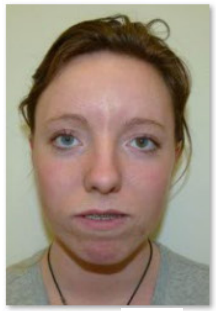
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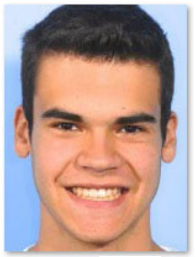
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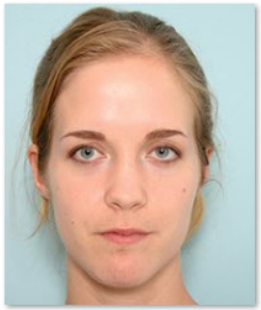
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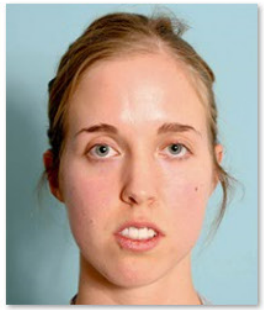
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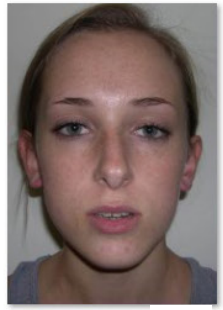
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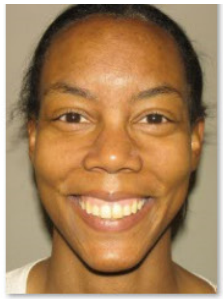

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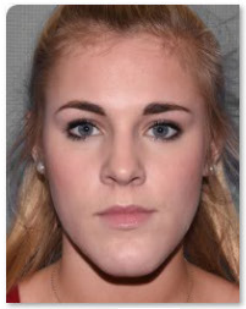

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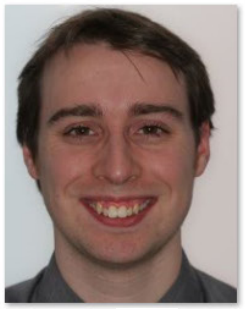

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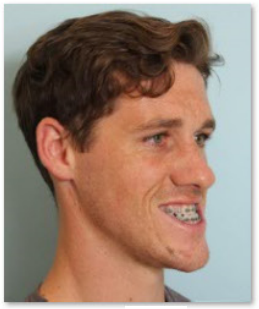

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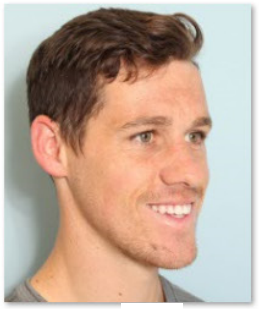

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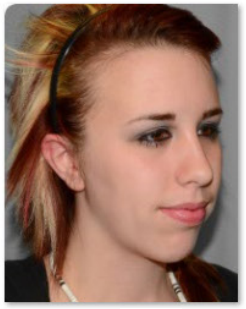

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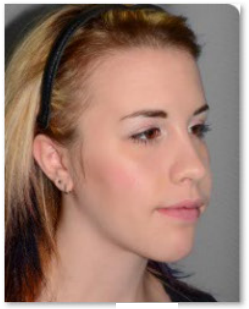

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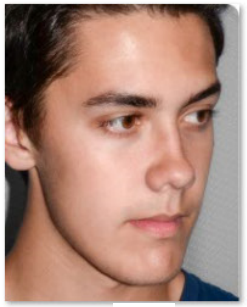
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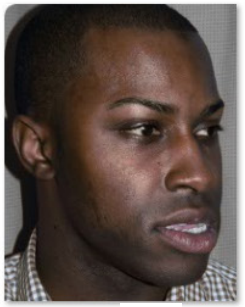
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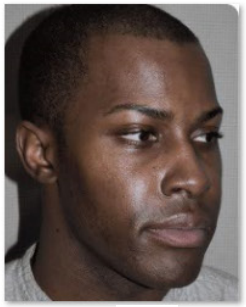
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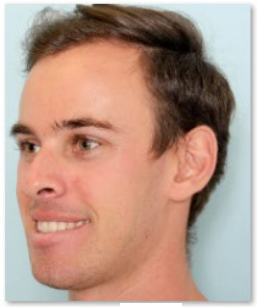
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2dF

Design section

Appendix 20: The list of requirements

1 General
- 1.1 The tool integrates the facial recognition system with the communication system
- 1.2 The tool should improve the expectations and therefore the outcome of the patient (chapter 2)
- 1.3 The tool should support the surgeon in informing the patient about changes in facial recognition which can happen due to the surgery (chapter 2, 6 and 7)
- 1.4 The tool should present the face recognition information about each specific patient (chapter 7)
- 1.5 The tool does not use patient's resources (appendix 23)

2 Communication system
- 2.1 The tool should support the patient psychologically in being able to process and get used to the changes the face will undergo (chapter 2, appendices 26 and 27)
- 2.2 The tool provides the patient with tailored information (meeting requirement 1.4)
- 2.3 The tool should combine visuals and text to provide understandable information for each patient (appendix 26)
- 2.4 The patients should be able to review the given information from the tool at home to process the given information (chapter 26 and 27)
- 2.5 The tool should inform the patient in such a way, shared-decision making is provoked (Appendix 23, 26 and 27)

3. Face recognition system
- 3.1 The tool should be applicable for each type of surgery
- 3.2 The tool should be able to combine each type of surgery
- 3.3 The tool should translate the similarity scores to visual information
- 3.4 The input of the facial recognition system which is selected by the physician can be done fast and it is user friendly (Chapter 10, appendix 26)

An overview is shown if the requirements are met:

1 General
- 1.1 Yes
- 1.2 Uncertain, it has to be tested with patients first
- 1.3 Uncertain, according to research it should work but it has not been tested in practice
- 1.4 Yes
- 1.5 Yes, the patient can take the flyer home from the hospital and only needs a computer if he desires to print the flyer again from MyChart.

2 Communication system
- 2.1 Uncertain, according to research it should work but it has not been tested in practice
- 2.2 Yes
- 2.3 Yes
- 2.4 Yes
- 2.5 Uncertain, according to research it should work but it has not been tested in practice

3. Face recognition system
- 3.1 No, only the tested landmark movements with the belonging surgeries can be predicted by the tool currently
- 3.2 No, the tool cannot combine surgeries yet
- 3.3 Yes
- 3.4 Uncertain, it is designed to be user-friendly and fast and it is designed to be integrated in Epic. However, tests should point out if physicians think it is user-friendly and fast.

Appendix 21: Ideation - Design process

This chapter describes all the steps taken during the ideation phase. The ideation phase was the first thing done after finishing the research phase. The ideation can be seen as a explorative phase, used to come up with ideas and a design direction. After ideation, a conceptualisation phase was started, which is described in appendix 23 till 27.

Scope and problem definition
Before starting the ideation, the problem definition and design vision have been created. A scope has been created after talking to T. Fouranzanfar, orthognathic surgeon at the VUmc. The tool could be created for three phases of the surgery: before, during and after the surgery. The phase 'after the surgery' has been removed right away, since you cannot do anything with facial recognition anymore after the surgery to match expectations with the outcomes. The first plan was to design a tool which would function as a guideline during treatment planning an during the surgery, which would support the surgeon into positioning the soft-tissue in a way the patient would stay recognizable. However, after talking to T. Fouranzanfar (Personal Communication, May 26, 2020), it was clear that creating something for during the surgery is not desired for multiple reasons:

- The patient has instruments in his mouth which makes it hard to perform a surgery on the soft-tissue (figure A21.1).

- The surgeon has to perform the surgery as fast as possible and does not have time to perform a surgery on the soft-tissue.

- The face of the patient sometimes already gets swollen during the surgery, which makes it hard to see how the soft-tissue should move.
Therefore, the tool will not be created for during the surgery. However, on longer term when more data is analysed and more proof about the different type of surgeries and the influence on facial recognition is gathered, the way the surgeries are performed could be revised and surgery of the soft-tissue might be considered since it will improve the outcome of the surgery.
With this has been decided that a tool will be created for the stage 'before the surgery'.

The goal of the tool is to match expectations of the patient with the outcome. If the tool will be used in this phase, it can be used as a communication tool between patient and surgeon. This can evoke shared-decision-making between patient and surgeon and can increase understanding of the patient about the outcome of the surgery.

Structure
The tool will exist out of two parts, namely, the facial recognition system and the translation of information from this system to the patient (figure A21.2). From this, the ideation has been started. Ideation methods are used to ideate about translating information from the system to the patients. No ideation about the system design has been done, it was just functioal design and it has been designed in a way it should work.

Ideation 1
The Synectics method together with visual and auditory Synectics has been used to generate ideas. The target has been described as: Communicate the outcome of facial recognition due to the surgery to the patient. The ideas can be seen in figures A21.6-A21.10.
Selection of ideas – ideation 1
From ideation 1, the interesting ideas have been selected which can be seen in figure A21.3.

Ideation 2
The second method which has been used is the 'How to' brainstorming method. This can be seen in figure A21.11.
Selection of ideas – ideation 2
From ideation 2, all ideas of the how to can be interesting.

Figure A21.1: Equipment in the patient's mouth during the surgery

Combining ideas
The selected ideas are put in one figure to summarize them. How ideas can be combined is also shown (figure A21.4). The ideas can be divided into four areas: info provider, tailored info, type of info and location. It is all about finding the most suitable way to inform the patient. The most suitable combinations are chosen with use of a morphological chart. From 'tailored info' the 'facial recognition about specific patient' idea has been removed, since this should be applied in all ideas. These are the boundaries for another ideation, to create more focused ideas which can be evaluated. Since all the ideas can be combined, the morphological chart does not focus on what ideas can be combined, but what ideas can be removed, which contain a red cross in figure A21.4. These are the argumentations:

- App: Most important is that research does show that video or multimedia techniques do not improve memory performances while a combination of spoken information and visuals do (Kessels, 2003). Overall, an app would be too much since the goal is to share information with the patient. The patients should get information mainly about changes in facial recognition of their face after the surgery. Creating an app will be time consuming and expensive, especially if the security of the app is high because of the privacy sensitive information it will contain about the patient (around 100.000 euros (Z1, n.d.). Therefore, printing it on paper will be much cheaper. Also, an app is not really needed since teh tool is mainly used for information transfer and the patient does not have to interact with the app, since the patient does not have to manage any disease and the patient does not have to do anything except undergoing the surgery and recover emotionally.

- Drawing of other patient pictures: This idea could be implemented when showing patient pictures is not possible because of privacy. However, it does not give any comparison to other patients since the drawings should be unrecognizable because of privacy reasons as well. When it is unrecognizable it is also hard to see the changes in facial recognition in the pre- and post-surgical drawing of a patient. Therefore, this idea will be dropped.

Idea Iteration
After crossing not feasible things away, the things which are left in the morphological chart can all be combined. The tool should be integrated in the system the VUmc uses now. All ideas which are left are based or inspired on research and can therefore all work. No idea iteration method has been used, since the idea should be based on research and feasibility.
However, it should be known what type fits best in the system of the VUmc. Therefore, there has been chosen to also provide the patient with general information about the surgery and the relationship to facial recognition. It will not contain information about physical preparation or aftercare of the surgery since the VUmc already has booklets for this (Amsterdam UMC, 2020) and since this is not influencing the expectations of the facial changes. However, it could be that the patients have questions about this and the topic can therefore be included in the design. The design can be used in the waiting room, during the consultation and/or at home.

Facial recognition system – calculating score
In this system a patient picture will be made before the surgery. This picture will be manipulated to the type and estimated dimensions of the surgery. It will be manipulated as done in the human recognition test (chapter 6) and this should be done automatically.

Facial recognition system – input of doctor
To use the tool to get the information to communicate to the patient, a few things need to be done manually (figure A21.5):
1. The pre-surgical patient picture should be made and the type of surgery needs to be selected, 2. the expected range in dimensions the surgery would cause and 3. the amount of information the patient should get according to the belonging patient profile (appendix 23). However, it might be more practical in the VUmc to let the nurse or assistant do step 1 and 2. It could also be that the doctor does not know the patient's background before the consultation and therefore, step 3 could be hard to estimate. Therefore, it could be a solution to print or show information on the screen which is the minimum amount of info. If the patient has more questions or is extrovert and eager to learn more, more information can be printed/shown accordingly during the consultation. In this case, the doctor should anticipate at the moment or ask if the patient wants more information.

Iteration: there has been decided to give an equal amount of information per patient. The consultations have a limited amount of time and giving more information to some patients is, besides that it is difficult to estimate if they want extra information, provoking more questions. It could also lead to an overload of information. Therefore, only the basic information about facial recognition is shown. For the extravert patients, information on the tool could provoke patients to seek for information themselves.

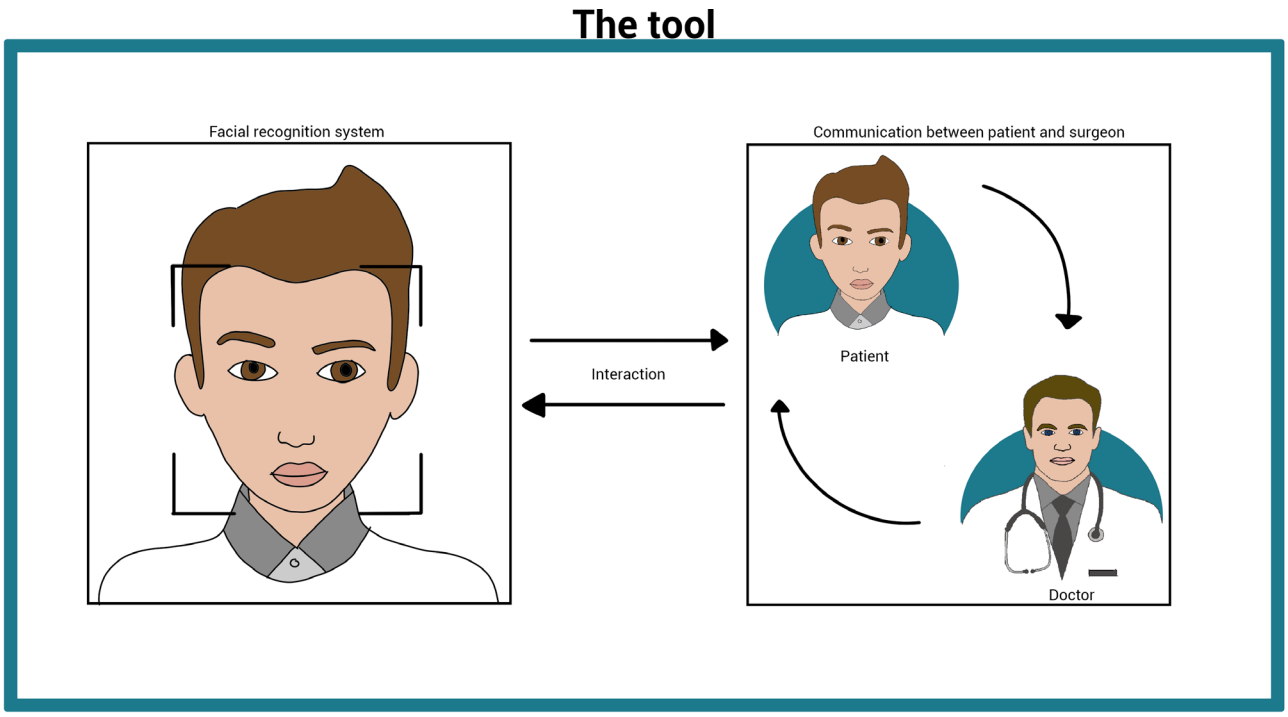


Figure A21.2: Interaction of the two parts of the tool

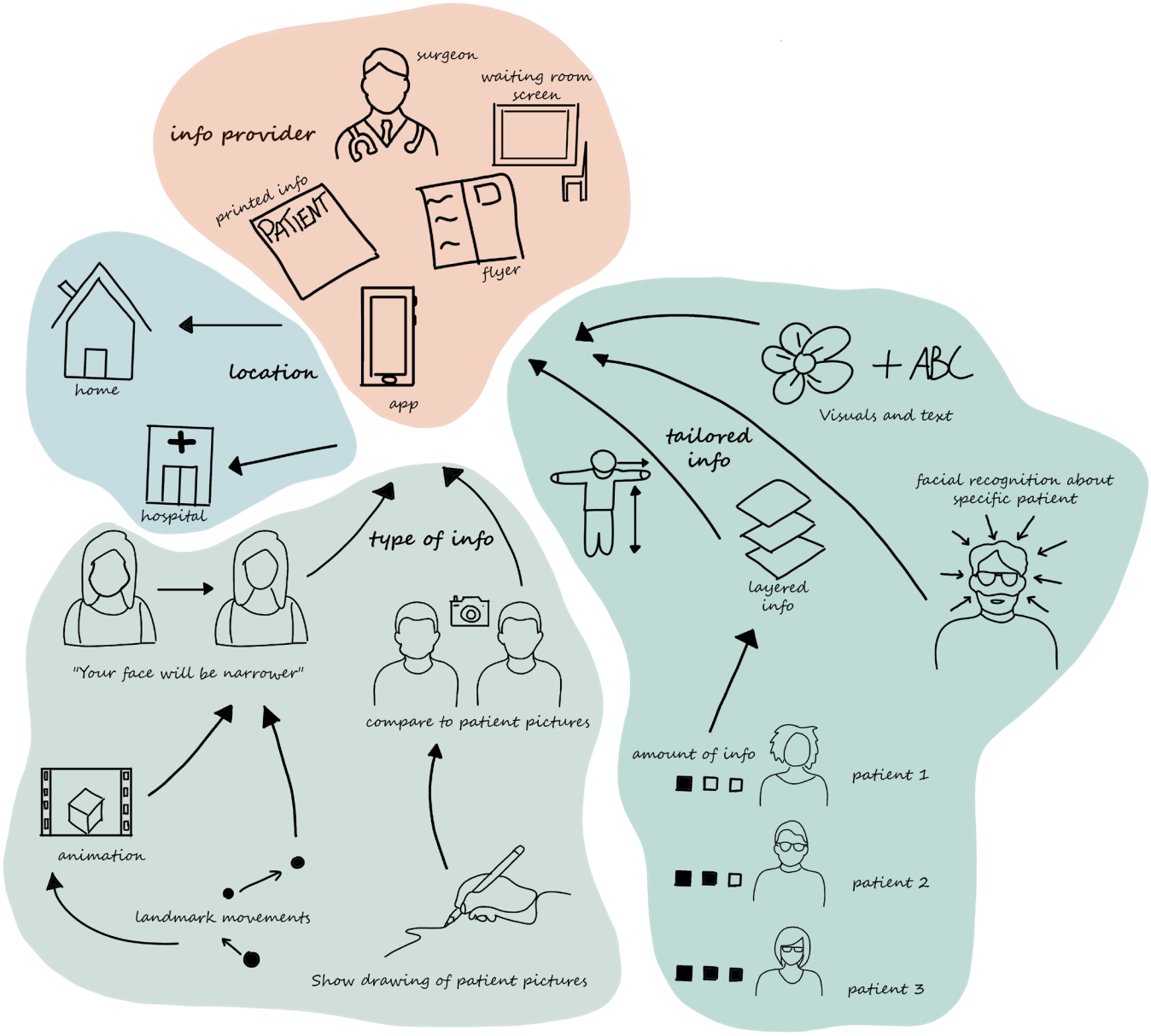


Figure A21.3: Summary of the interesting ideas.

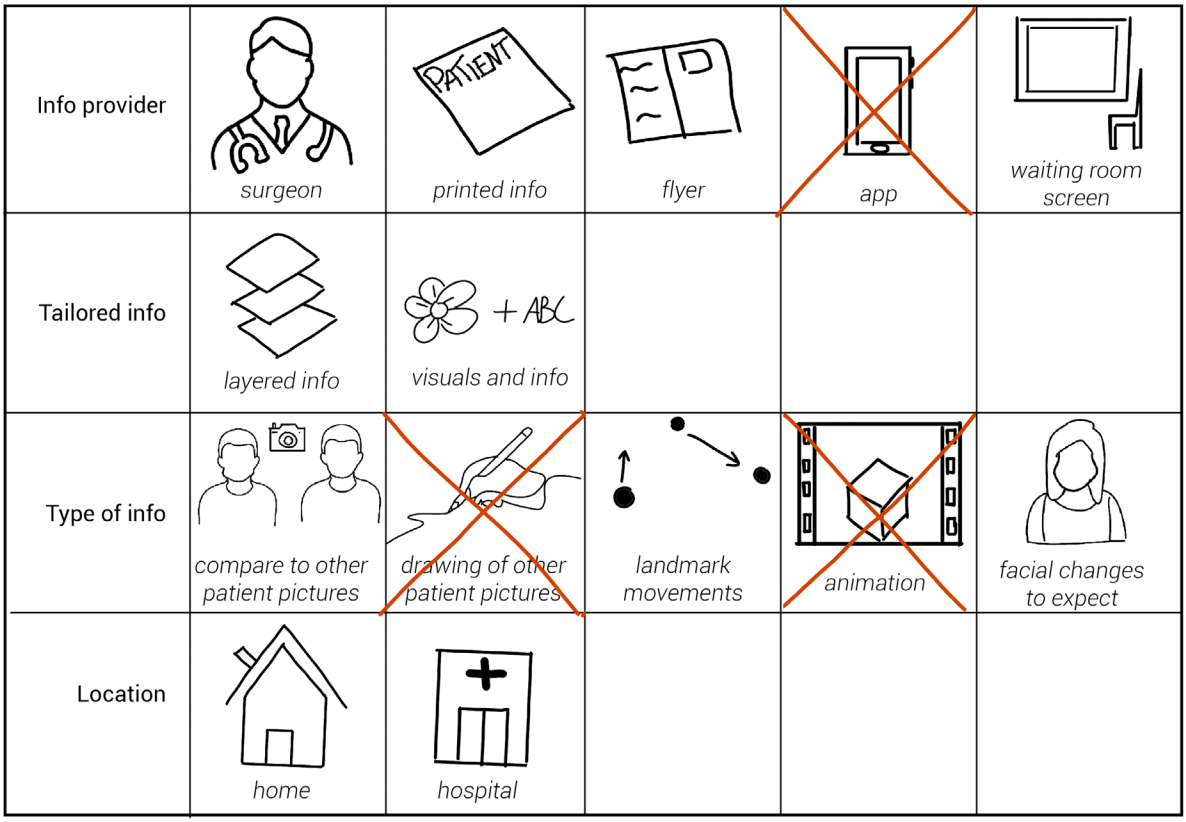


Figure A21.4: Variation on the morphological chart. Presenting most feasible ideas which could all be combined. The red crosses are ideas which are not feasible.

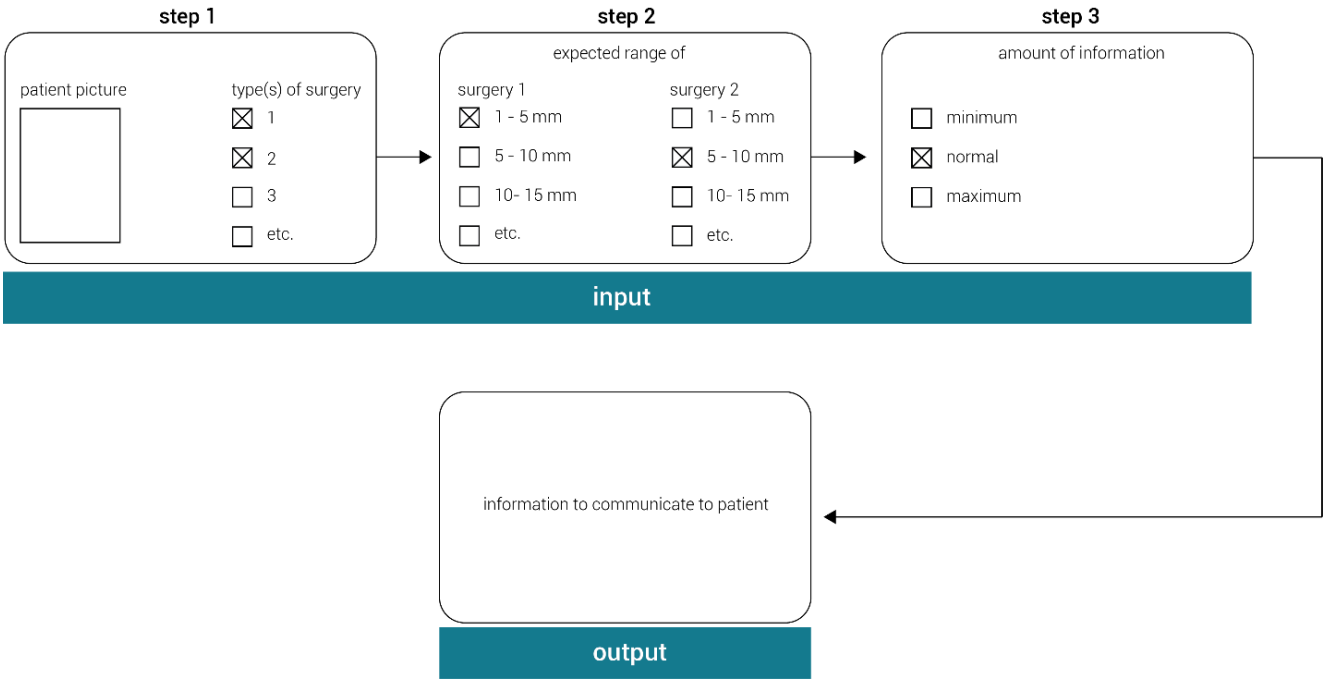


Figure A21.5: The flowchart of the input and output of the system before the last iteration

Synectics

TARGET: Communicate outcome of facial recognition due to the surgery to the patient

1ST IDEAS

- Show after picture
- Test relevance to patient first
- Show landmark movements
- Show animation
- Show pictures/images
- Red/green lights
- Scary sound if unrecognizable
- Example of patients who were also unrecognizable after similar surgery
- Calculate alternatives
- Local or global changes
- Is there a balance between wishes in functionality, aesthetics and identity (facial recognition)
- What are thoughts about patient's face and how does it matches the type(s) of surgery which will be performed?

Figure A21.6: The Synergy method as part of the ideation

2ND Calm music + images

- Look together (doctor/patient) to results
  - ↳ name picture → add surgery → result
- You will change for 60%
  - ↳ percentage of landmarks which move
- Face recognition probability
  - ↳ you should change passport pic
- Apple becomes pear

3RD up tempo music + images

- Euclidean distance of husband/wife to see if he/she still finds patient attractive
- See what faces patient finds attractive to see if face distance comes close

Figure A21.7: The visual and auditory Synectics as part of the ideation

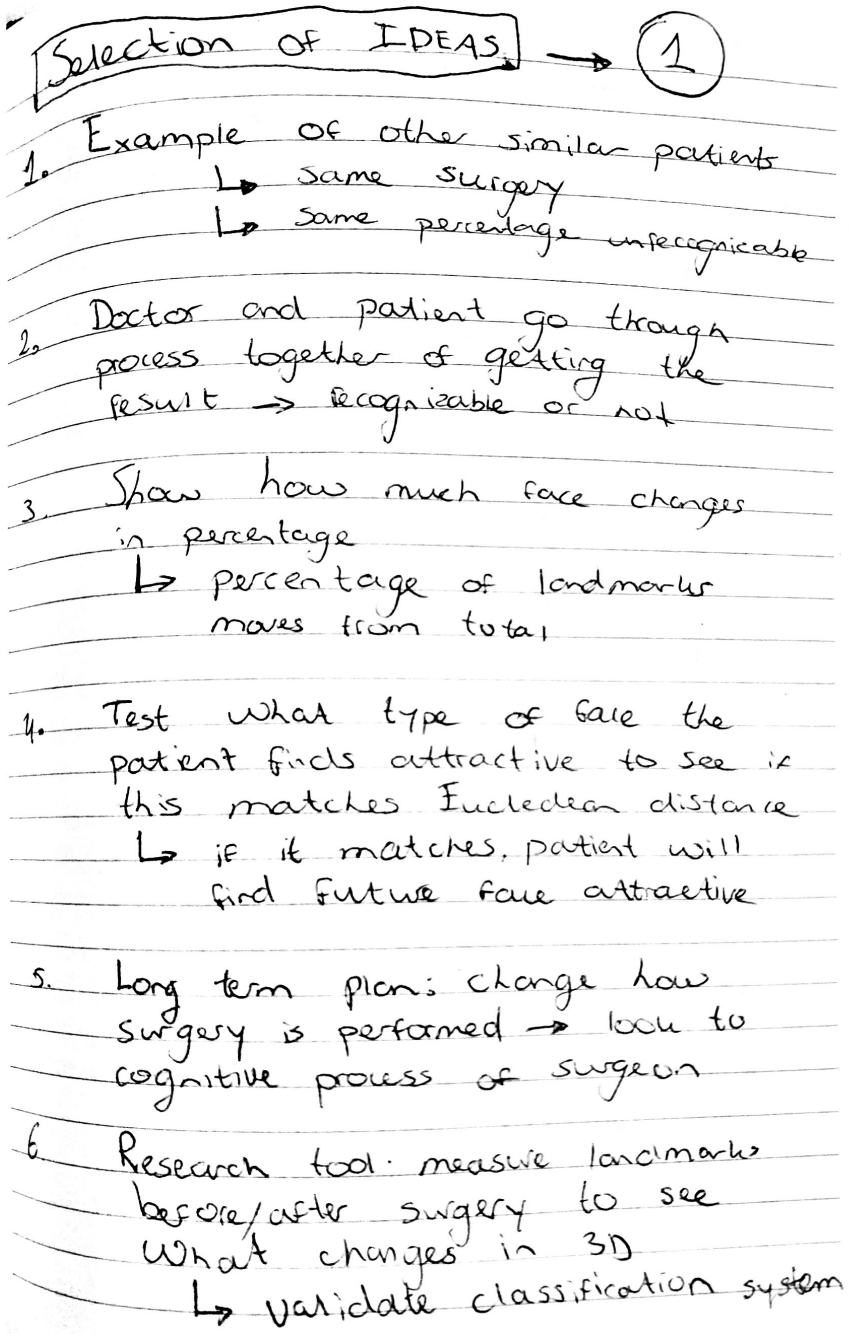


Figure A21.9: Selecting interesting ideas

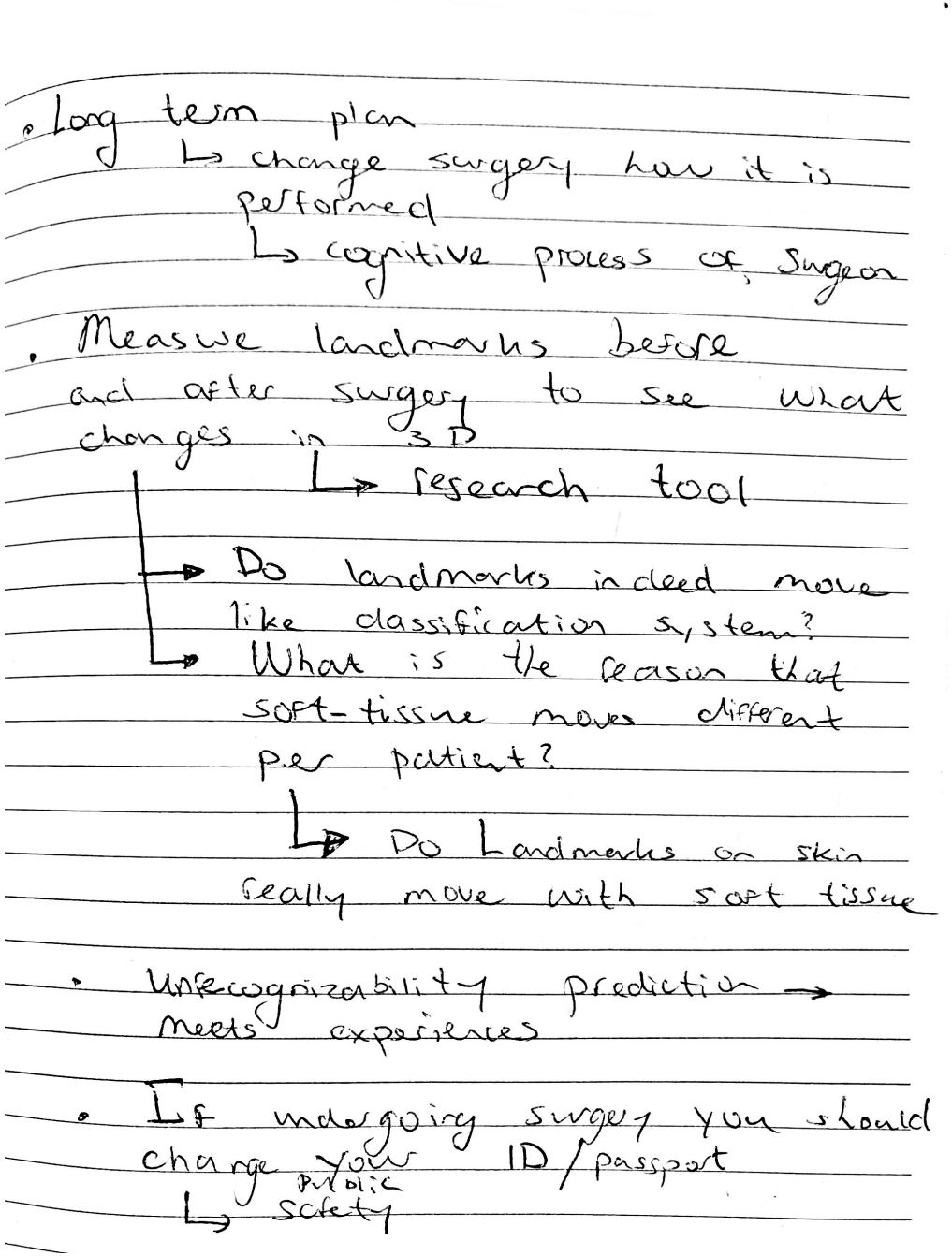


Figure A21.8: The visual and auditory Synectics as part of the ideation

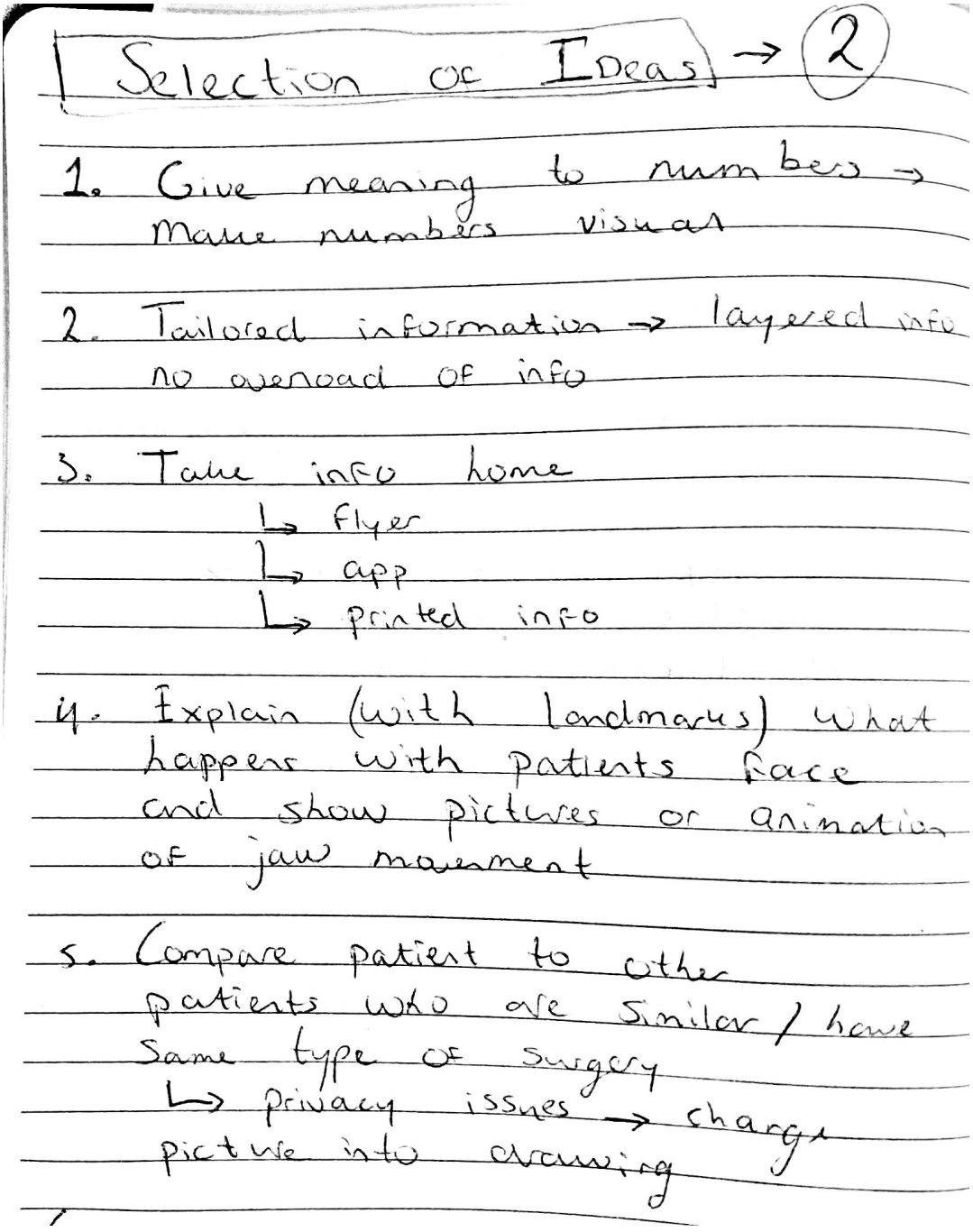


Figure A21.10: Selecting interesting ideas

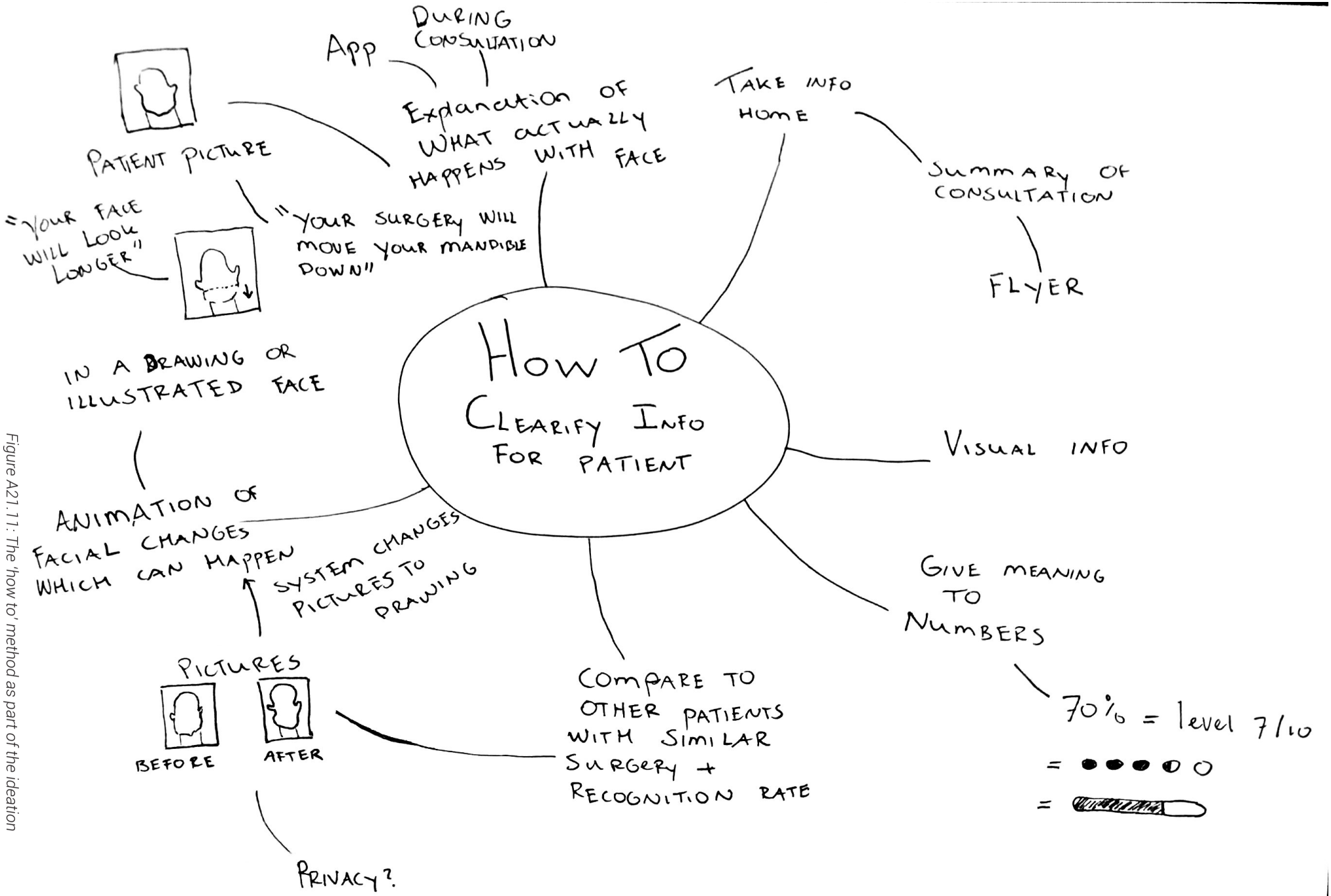


Figure A21.11: The 'how to' method as part of the ideation

Appendix 22: Ideation - Market research

The market of communication tools which can be used during the consultation is small. Overall, literature describes that good communication is essential to match expectations with outcomes and that there is a need for communication tools. However, only 'Doc talk cards' is the tool which is sometimes used at hospitals. Mostly, healthcare professionals and management companies recommend improving communication during the consultation by improving the skills of the healthcare provider, which is out of the scope of this project.

There are communication tools which could be barriers for communication. The hazard in communication channels (e.g. phone and email) is that it can be overwhelming because of the communication overload. Because of this, messages can often be missed. It is advised to avoid messages from different platforms (HealthManagement.org, 2020).

Doc talk cards
Some strategies to improve communication between doctor and patient are advised to implement in healthcare. One of the strategies is to give the patient 'Doc talk cards'. The cards are designed in a way that it is listing topics so it provokes questions for the patient. The cards are often designed to prompt patients for questions by listing topic areas such as symptoms and medications. These questions can be given to the doctor prior or during the consultation. The patient can get the cards during the consultation, in the waiting room or can print it out at home (AHRQ, 2017). The LUMC hospital in Leiden already uses a similar technique. They have flyers with questions on it in the waiting room which patients can take to the consultation (personal experience, 2019).

It is also comparable to the 'menu card' tool the nurses at VUmc use during the diabetes consultations (appendix A22.1). The nurses who are using this tool during diabetes consultations do have good experiences with it and it helps for shared-decision making and information transfer for all types of patients. However, diabetes is a completely different domain than orthognathic care. Where diabetes is about self-management of the disease, patients undergoing orthognathic surgeries do not influence their treatment plan that much, since the surgeon will decide on how to perform the surgery. Therefore, shared-decision making will be much lower among orthognathic consultations. Although, patients could have the feeling they can make decisions about their treatment and the knowledge to decide on pursuing the treatment or not. It is about emotional recovery which relates to meeting the expectations with the outcome. If a menu card is used, it should be redesigned with respect to orthognathic topics.

Coached care
What can also be done are coached care programs. Coached care programs improve the outcomes for patients and research shows that it enhances communication between doctor and patient without increasing the visit length. The cheap type of coached care is that the patients get flyers before the consultation (printed, via post or in the waiting room) that contains common questions (as done in the LUmc). A more expensive type is that a nurse interviews the patient and generates a list of questions the patient has for the doctor (AHRQ, 2017). However, because of the lack of staff in the VUmc (Ribbers et al., 2018), this type of coached care would not be feasible for the orthognathic department. However, giving the patient standard questions could be a way to improve shared-decision making in a simple and fast way.

Patient Teach-Back
This is not a tool but more a communication strategy for ensuring the patient has understood the information. The health provider explains health information to the patient and then asks the patient to explain the same information back to the health provider. This helps the patient to process the information and to let the health provider know if the patient understood (HIPAA Journal, 2020).

SpeechMED
This is a tool (figure A22.2) which focuses on low health literacy among elderly, chronic disease patients and immigrants. It is a platform which explains medical information in all type of languages.

Spiekbrief (cheat sheat)
Patients can find cheat sheats online to bring to consultation. One of them is the 'spiekbrief' in figures A22.3 - A22.5. It contains questions which helps the patient remember what to ask.

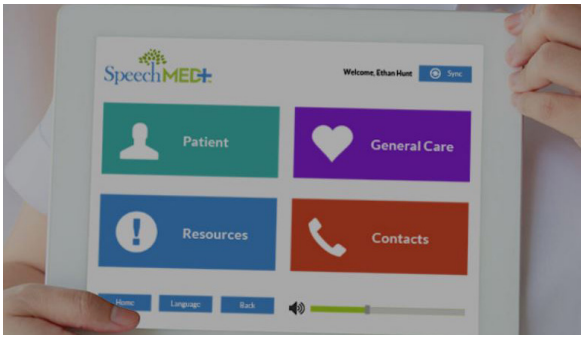


Figure A22.2: The SpeechMED tool (Speechmed, 2017)

Figure A22.1: Communication tool at the diabetes consultation at the VUmc

Pag. 2

Ik ga praten over de behandeling.

- Wat gaat er precies gebeuren tijdens de behandeling?
- Hoe kan ik me goed voorbereiden?
- Hoe lang duurt de behandeling/hoeveel behandelingen zijn het?
- Is er een risico op complicaties? Hoe vaak komen die voor en waar moet ik rekening mee houden?
- Wat kan ik na de behandeling wel en niet? Moet ik bijvoorbeeld vervoer of hulp thuis regelen?
- Hoelang duurt het voordat ik weer ben hersteld?
- Wat kan ik zelf doen om mijn herstel te bevorderen?
- Ruimte voor eigen vragen

Vraag:

Vraag:

Figure A22.4: Example of a communication tool for the consultation (CZ, n.d.)

Pag. 1

Ik ga praten over de behandeling.

Als de diagnose is gesteld bespreekt u met uw dokter de behandeling. Zorg dat u goed begrijpt wat de mogelijkheden zijn en wat dit voor u betekent. Dan kunt u samen met uw dokter de juiste beslissing nemen en weet u wat u te wachten staat. Deze vragen helpen u daarbij.

- Welke behandelingen zijn er (nog meer)?
- Wat zijn de voor- en nadelen van die behandelmogelijkheden?
- Wat betekent dat in mijn situatie (of voor de situatie van mijn naaste)?
- Ruimte voor eigen vragen

Vraag:

Vraag:

Vraag:

- **TIP:** Heeft u nog een andere aandoening, slikt u medicijnen of bent u in behandeling bij een andere dokter of therapeut? Vertel het uw dokter. De behandelingen kunnen effect op elkaar kunnen hebben.
- **TIP:** U kunt via CZ overleggen met een andere, onafhankelijke dokter of medisch specialist die u extra uitleg kan geven en u kan helpen als u twijfels of vragen hebt. Weet wat u te wachten staat.

Figure A22.3: Example of a communication tool for the consultation (CZ, n.d.)

Ik krijg een operatie en bespreek dit met de anesthesist en/of dokter.

Vragen die u aan de anesthesist of dokter kunt stellen over de operatie zijn:

- **Hoe lang duurt de operatie?**

_____
_____
_____
_____

- **Als ik weer naar huis mag, heb ik dan medicijnen nodig van de (ziekenhuis)apotheek?**

_____
_____
_____
_____

- **Hoe lang moet ik na de operatie nog in het ziekenhuis blijven?**

_____
_____
_____
_____

- **Ik slik op dit moment al medicatie, moet ik daar (tijdelijk) mee stoppen?**

_____
_____
_____
_____

- **Kan ik zelfstandig naar huis of moet iemand mij ophalen?**

_____
_____
_____
_____

- **Kan ik naar de auto lopen of heb ik een rolstoel nodig?**

_____
_____
_____
_____

- **Wat kan ik na de behandeling wel en niet doen? Moet ik nog vervoer, hulpmiddelen of hulp thuis regelen?**

_____
_____

- **Ruimte voor eigen vraag**

  Vraag: _____

_____
_____

- **TIP: Bij sommige operaties kunt u kiezen uit algehele narcose of plaatselijke verdoving, bijvoorbeeld met een ruggenprik. Vraag de anesthesist of dokter wat de voor- en nadelen van die keuzes zijn en beslis samen wat het beste past bij uw persoonlijke situatie.**
- **TIP: Hebt u nog andere gezondheidsklachten of slikt u medicijnen? Vertel dit en neem uw medicijnen mee (of een lijstje met de namen van de medicijnen).**

Figure A22.5: Example of a communication tool for the consultation (CZ, n.d.)

Appendix 23: Conceptualisation - Patient profiles

To get an idea of the type of different patients, patient profiles are created with information gathered from research. The patient profiles are based on types of information supply and shared-decision making. The factors which could influence information supply from doctor to patient and shared-decision making between them are background variables like socio-economic status, culture, age and gender (appendix 26). Research has been done in these variables and could be a guideline for designing. However, the patient profiles can function as a guideline and do not apply for every patient. The needs should therefore be examined per patient during every consultation.

Social-economic status
Doctors are less informative with patients from a lower social-economic class, because these patients are mostly not expressive and the doctor might (inaccurately) assume that the patient would not understand the information. This does not mean, these patients do not want information. Therefore, the tool could help to create a bridge between the different cultural backgrounds of patient and doctor. This is meeting the research from Willems et al., (2005) whom describe that there is a need for developing teaching methods on inequalities in communication. The doctors should be aware of the existing differences in giving information and also in involving lower social-economic classes in the conversation. Every patient should be encouraged to ask questions and to discuss their concerns independently from their social-economic class. Interventions show that this leads to measurable improvements in health outcome. Besides this, doctors are mostly concerned about the illness or physical problems to solve. However, they sometimes forget to focus on the holistic needs of the patient by taking the psychological and social wellbeing into account (Ha & Longnecker, 2010). Since orthognathic surgeries do have an influence on the psychological and social wellbeing (chapter 3), taking the holistic needs into account is necessary. If the doctor adapts the communication to socio-economic differences it could, therefore, meet the patients expectations which will lead to a more positive outcome for the patient (Willems et al., 2005).

Ethnic groups
Culture could influence the patients support network, which influences the psychological state and therefore satisfaction of the surgery. Apparently, white groups from the South of Asia score lower on facial body image than other ethnic groups. Therefore, facial appearance is more important in this culture. Also, the social support is higher in other ethnic groups than among the South Asia culture. Therefore, patients from e.g. this culture might need additional social support in order to cope with the facial changes and to satisfy them after orthognathic surgery (Cunningham et al., 2000). Religion could also play a role in coping with treatment and by getting social support. Identity issues can be caused by culture and are related to age and gender roles and life-cycle transitions like marriage and social status (Kirmayer et al., 2003). This can influence social support during the treatment. It is difficult to define if the patient wants the surgery, or that someone else is pushing the patient to do the surgery. This depends also per culture and is particularly a problem in the Indian culture, because the parents want to improve their daughters looks in order for her to be married off (Bonanthaya & Anantanarayanan, 2013).

Age
The communication should also take the age of the patient into account. Younger patients e.g. might like a gamification way of communication while older patients might not be comfortable with digital information or might not have the resources like a phone or computer to use digital information. Dissatisfaction with the facial body image increases over age (Cunningham et al., 2000). Therefore, it might be more important to inform older patients about their facial changes than younger patients. Also, older patients tend to only listen to the doctor without asking questions (AHRQ, 2017).

Gender
The social support is lower among male orthognathic patients but males report a higher self-esteem and higher body image than female (Cunningham et al., 2000). Therefore, males might need more support after surgery while mentioning the facial changes might be more important for females.

The patient profiles are created with use of the research in socio-economic status, culture, age and gender. The profiles Introvert/Extrovert can be combined with Supported/Unsupported. Since no patient is the same, within the profiles patients with different backgrounds can be found. The profiles can be used to design for information transfer and shared-decision making. However, the

type of information and decisions are completely tailored to the specific patient, since every patient has a different face and will change in a different way. The solutions for each profile can be found in appendix 23.1.

Introvert

This patient does not ask questions and does not show feelings about the treatment plan. This patient might not understand the doctor or has difficulties to see the doctor as a partner because of cultural reasons or a feeling of distance towards the doctor because of a difference in social-economic status. It could be that the patient would like to be involved in the treatment decisions or desires more information, but cannot make this clear to the doctor because of miscommunication or insecurity.

Pros:
- good listener
- believes doctor's advice

Cons:
- does not ask questions
- cannot make concerns or misunderstanding clear to doctor

Extrovert

This patient does ask questions and does show feelings about the treatment plan. This patient announces when the information is not clear and tends to have a partnership relationship with the doctor, resulting in better shared-decision making. This type is more likely to gather information about the treatment themselves at home than the introvert type.

Pros:
- shared-decision making with doctor
- gathers information from doctor and other sources

Cons:
- can get overloaded with desire for more information, leading to anxiety
- is more likely to ask for second opinion when treatment plan is not as desired

Unsupported

This patient does not have a social network which will give support during the treatment process which can result in difficulties processing the changes in facial appearance after the surgery. Also, it can be that this type of patient has a lower body image. This all can be dependent on the culture, gender, age or religion. Extra support given by the hospital can give a more positive treatment experience and outcome.

Pros:
- independent, not often being manipulated
- modest, has a lot of trust in the doctor

Cons:
- unrealistic expectations, cannot get used to facial changes
- problems in decision making concerning the surgery

Supported

This patient does have a social network which supports the patient during the treatment process. This can help the patient to be more positive about the outcome of the surgery and the corresponding facial changes and by processing this changes. Also, it can be that this type of patient is more satisfied about the body image than unsupported patients are.

Pros:
- satisfied about facial changes because of support in emotional recovery
- more confident about decisions concerning the surgery, shares experiences with social groups

Cons:
- decisions are not intrinsic motivated, can be manipulated or influenced by others opinions
- if family/friends are dissatisfied of outcome, it will influence emotional recovery negatively

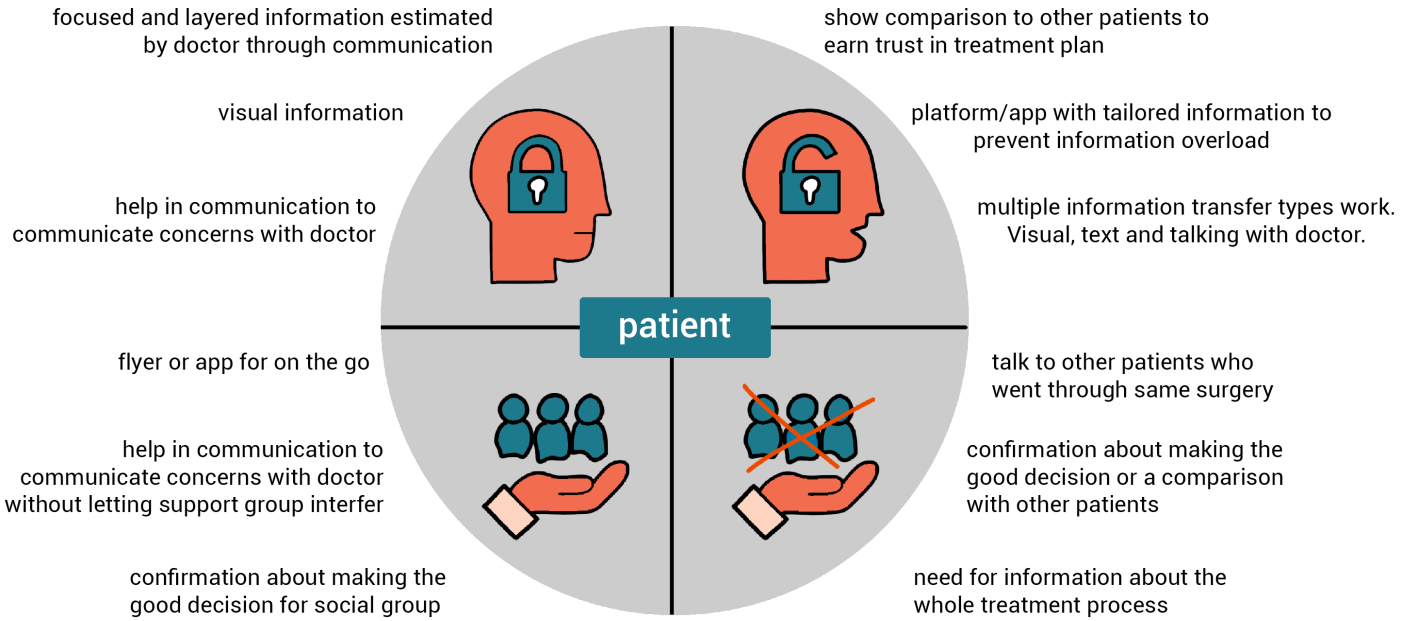


Figure A23.1: patient profiles and their solutions to information transfer and shared-decision making

Appendix 24: Conceptualisation - Design process

The conceptualisation phase focused on creating a feasibe concept. In this chapter, the design process of the facial recognition system and communication tool are shown.

Facial recognition system
The first step was to gather some handles to create the facial recognition system of the tool. A dimension test has been done (chapter 12) to find out if the amount of landmark displacement has an influence on the similarity score when a patient picture is manipulated. Also, within this test two different faces were manipulated the same with other similarity scores, which means that the similarity score is depending on the face and every patient needs their own similarity score.

Communication tool- final decisions

Cues
The flyer has been provided with cues for the curious patients to search for information themselves.

Font
A font which is most readable when it is printed should be selected. There was chosen for Open Sans, since this is one of the fonts which is the best to read when printed and which is sans serif which makes it easier to read (Vistaprint, 2018). The size of the font is 12 pt. Fonts of comfortable readable flyers vary between 9 and 12 pt (Flyerzone, 2020). 12 pt. is the biggest size in this range, which is chosen so most people will be able to read it. White space between text can be used to give a structured overview of the whole flyer, it can give an overall feeling of calmness and improves readability (Flyerzone, 2020). Therefore, in the lay-out of the flyer, white space between text has been used to optimize the reading experience .

Colour
For the colour accents, Teal has been chosen, a blue-green colour. Patients do respond best when colours correspond with the intended results of the treatment. Blue colours are mostly used for medical designs can be associated with depth, expertise and stability. The green colour gives people a feeling of calmness and trust. Green colours are likely to be used in the teething industry, like in toothbrushes (Bruens, 2011, pp. 66-67). It is therefore logical to use it in the orthognathic department as well. A combination of blue and green is Teal, which blends the properties of the blue and green colours (Color psychology, 2020).

Language
The personal information flyer will be a combination of visuals and text. For patients with low literacy, the doctor can explain the content of the information flyer and the patients can recall the information at home when looking at the visuals. For people with a language barrier, the information flyer can be printed in their mother language.

Appearance
It should create a positive experience of the treatment. The emotional design of a service like this, does affect its success (Interaction Design Foundation, 2002). The cognitive responses the patients will go through when seeing the information are shown in figure A24.1 and A24.2. The patient should feel confident and positive about the treatment. It should therefore have a positive appearance. The visuals should make it look appealing and playful.

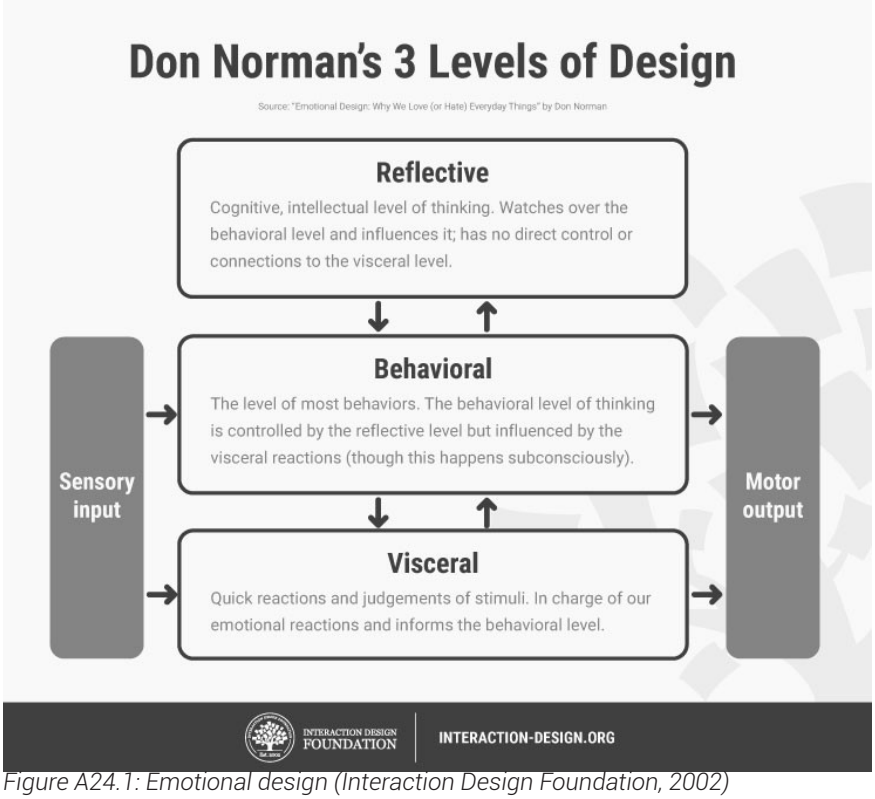


Figure A24.1: Emotional design (Interaction Design Foundation, 2002)

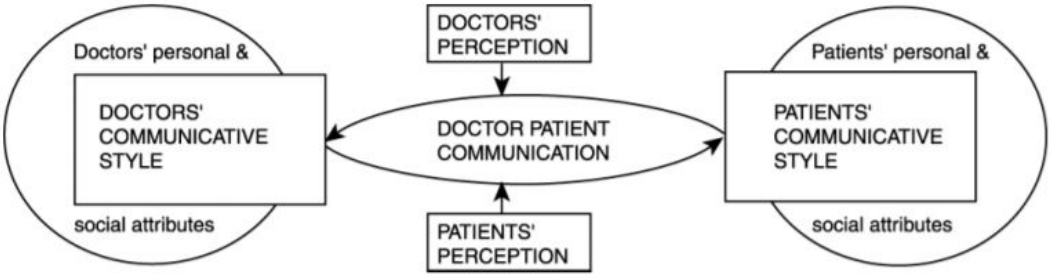


Figure A24.2: Communication patient and doctor (Willems et al., 2015)

Figure A24.3: Small ideation of visuals for flyer

Design decisions summary

While designing the communication part of the tool, some changes has been made. These are the steps of the decisions made in chronological order:

1. It has been decided that the design exists out of three parts: a menu card, personal information basic and personal information extended.

2. The ideas of the design and content of both the menu card and flyer has been made.

3. The content of the flyer has been determined and designed.

4. The personal information extended is dropped since it is too much trouble for the doctor to decide to give extra information to the patient and the patient can get an overload of information at once so it has been decided to only put the basic punctual information on the flyer. However, the flyer has been provided with cues for the curious patients to search for information themselves.

5. After conversation with the surgeon from the VUmc, the menu card idea has been dropped. The surgeons do not need a tool to communicate the current information since this already works well (T. Fouranzanfar, personal communication, June 22, 2020).

Design decisions explained

Type of communication tool

The information supply of the tool exists out of three layers:
Menu card: General topics, provoking questions and shared-decision making
Personal information basic: the info about the patient's face every patient will get.
Personal information extended: if they ask for more information or if they ask questions, the surgeon can print the second layer of information for this specific patient.

Content flyer and menu card

The content of the information flyer was determinaed. The flyer should integrate not only the facial recognition information, but should inform the patient about the most important things in the process and it should provoke the patient into asking questions which creates a feeling of shared-decision making. If only facial recognition will be covered by the tool, the experience might still not meet the outcome since the patient is not getting all the desired information and not only facial recognition is influencing the experience but the whole treatment is.

What and Where

It was determined what information should be given when and where. In all cases, the patient should be able to ask questions during the consultation.
The 'where' could be at home, in the waiting room or during the consultation
The 'what' could be general info, general questions, personal info basic and person info extended.
It is expected that the general info about the surgery like preparation, hospital stay and recovery is already provided in brochures the hospital provides them so this information will not be added (personal experiences, July 2013 & T.Fouranzanfar, personal communication, June 22, 2020). The personal info basic is the info about the patient's face every patient will get. Only if they ask for more information, the surgeon can print the second layer of information for this specific patient.

The personal information should be given to the patient during the consultation. Since it is about their own face, it can be overwhelming to already see the outcomes of facial recognition or facial changes the surgery would cause, without any context or explanation from the surgeon. Therefore, the surgeon should hand over this information and should explain what it means.

Menu card

The menu card type of information can be used in different type of ways:

1. Shown in the waiting room on the table, in the flyer stand or in poster format on the wall.
Pro:
- The patients can decide themselves if they are interested in preparing for the consultation in the waiting room with use of this card. Or it can give them confirmation when they are prepared well.

- Durable, it can be used over and over again
- If both a flyer and poster are present in the waiting room, the chance is higher that the patient will see it.

Con:
- They can ignore the card or miss it when they e.g. are on their phone.
- It can give the patient stress if they notice they are not prepared that well

2. Given to the patient when signing up at the front desk.
Pro:
- This way, the patients are extra provoked to

take a moment to prepare. Or it can give them confirmation when they are prepared well.
- The patient can take it also with him to the consultation room.
- It is durable

Con:
- It can give the patient stress if he does not know how to prepare with the card.
- It can give the patient stress if they notice they are not prepared that well

3. Send to the patient at home.
Pro:
- The patients are provoked to prepare at home

Con:
- It will cost the hospital time and sending expenses
- It is not durable
- The hospital does not know if the patient actually uses it

4. Given to the patient during the consultation (done at the diabetes department in the VUmc, appendix 26)
Pro:
- It can help when the patients do not know what to ask
- When the patients forgot their questions it can give them support
- The surgeon can help the patient with explaining the topics
- It can help the surgeon to remember the topics and to ask if the topics are clear

Con:
- If it is totally new for the patient he can get stressed. This can be solved by already showing it to them before the consultation.

Use of menu card
There has been chosen to always implement the menu card during the consultation as a supportive communication tool, which can only be used when necessary, depending on the needs of the patient and surgeon. During the consultation should not be the first moment the patient sees the card, since this can give them stress. There should be a possibility that they can already process it before the consultation. Sending the card to patients their home is eliminated, since this has too much cons in comparison with other ideas. Therefore, two possibilities for the menu card exist:
1. Use the menu card as a supportive tool during the consultation AND show the menu card on a flyer and poster in the waiting room.
2. Use the menu card as a supportive tool during the consultation AND give it to the patient when signing in at the desk
The menu card is designed with these two concepts still in the open. These two concepts are tested with the user test where after the best method is picked.

Type of information menu card
The information supply per topic was created where the patient could have a need for information. From this, a menu card was created. The facial recognition was left out of the topics in this, since a part of the information flyer will show this with personal information about the patients face.

Design flyer
The design decisions with arguments are shown in figures A24.8 and A24.9 and are further explained here.

The format of the flyer will be A4, since every printer can print this and no special paper is needed. This keeps it fast, simple and cheap for the hospital to print. It will have a front and back, with on the front the information and on the back the facial changes to expect and tips how to deal with facial changes. It has been decided to combine visuals with text to make it understandable for all patient profiles (appendix 23). Every icon shows the topic which is described in the text. The text on the front page is short and punctual. The story next to the image describes how the facial recognition analysis is done, how recognizable someone will be after the surgery and what to do with this information. The picture of the patient is shown to show that the results are really about the patient's face and it can help giving a bigger impact to the patient, that he realizes his face will really change.

This is why is chosen for the information on the front:

My surgeon: the name of the surgeon is shown to be transparent to the patient about who is performing the surgery. The patient always has the choice to search for the surgeons name online to see the experience and education to get more trust when needed. This is therefore one of the cues for curious patients to get more information themselves.

My consultation date: This is some practical information so the patient can always recall when the consultation has been.

My type of surgery: This information is given in medical language with an explanation of what it means. This is also one of the cues for curious

patients to get more information themselves. The medical name is given so the patient will always get the correct information.
My jaw problems: Here all the jaw problems the patient has is summarized. When the patient has difficulties emotionally to process information about the surgery or does not remember why he is going through a surgery, this can remember the patient what the reasons are he chose to undergo the surgery in the first place and to remember the goal.

My recognizability: It gives a short description about how recognizable the patient will be after the surgery, it is a summary of the text next to the picture. The doctor can use this summary to provide the patient with punctual information which can be explained fast.

My adaptation: This is providing the patient with some emotional view on the facial changes instead of only giving results. It also refers to the back of the flyer.
Text next to the picture: This text explains what analysis has been done on the picture of the patient and what the results mean.

This is why is chosen for the information on the back:

Tips: Four tips are written and shown in pictures. The tips can help patients to process the facial changes which will happen due to the surgery. This supports emotional recovery according to the psychological model in the emotional recovery research done in appendix 27.

Since the VUmc logo is blue, this colour has been used first for the lay-out of the flyer (figure A24.10 and A24.11). However, five people were asked for their opinion and they all thought it was uneasy and too bright for the flyer which lead to a chaotic feeling. Also it was received as too clinical. The other blue-green colour of figure A24.8 was received as a more relaxed and calm colour.

For the colour accents, Teal has been chosen, a blue-green colour. Blue colours are mostly used for medical designs can be associated with depth, expertise and stability. The green colour gives people a feeling of calmness. Green colours are likely to be used in the teething industry, like in toothbrushes (Bruens, 2011, pp. 66-67). It is therefore logical to use it in the orthognathic department as well. A combination of blue and green is Teal, which blends the properties of the blue and green colours (Color psychology, 2020).

Facial recognition clock
The similarity score needed to be translated to a visual representation, to make it understandable for the patient, so a small ideation has been done (figure A24.3) to come up with the best one. There has been chosen to use a clock which looks like a pressure gauge. Most people know how this works and how it can indicate different stages (orange, green, red). It can show the three stages of facial recognition:

Green is recognizable: The similarity score is not passing any threshold

Orange is slightly recognizable: The similarity score is passing the human threshold, but is not passing the computer threshold.

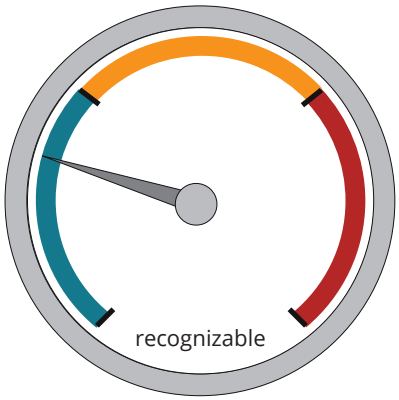
Red is unrecognizable: The similarity score is passing both human threshold as computer threshold.

Two versions of the design of the facial recognition clock exist. The first version is shown in figure A24.4 and the second version in figure A24.5. The first version translates the similarity score (x1) to a 1-10 scale (x2) by $x2 = 9 * x1 + 1$. However, after the green light meeting there has been decided that the user experience could be improved when the representation was not linear. Also, the scale has been removed since it can be confusing for the patient. Figure A24.5 shows the final design.

Since the recognizability score is still abstract, it can confuse the patient. Therefore, an idea resulted from the Greenlight meeting to show pre- and post-surgical pictures of patients with a corresponding similarity score to show the patient in a more concrete way how he can change how much he can change. Public pictures have been chosen for this, because of privacy reasons. Later on, when it is legally possible, the VUmc might use their own patient pictures for this. A sheet which could be shown to the patient during the consultation can be seen in figureA24.6, with the descriptions of the sheet in figure A24.7.

Figure 24.4: Design first version facial recognition clock

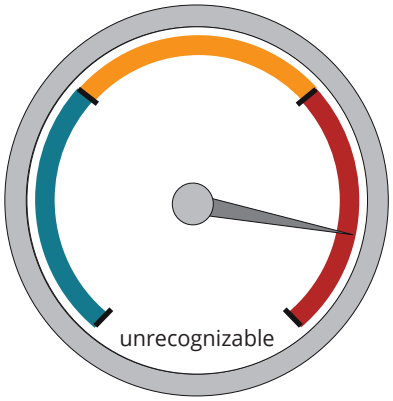
Facial Recognition Clock when x< 0.3



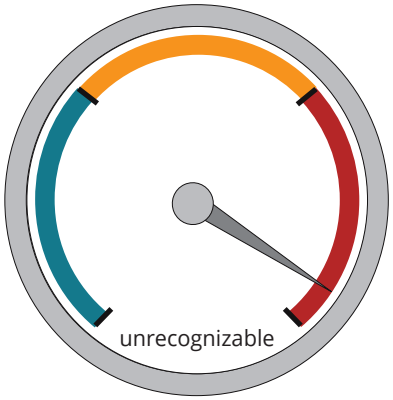
Facial recognition clock when 0.3 ≤ x < 0.43

Facial recognition clock when 0.43 ≤ x < 0.45

Facial recognition clock when 0.45 ≤ x < 0.6



Facial recognition clock when 0.6 ≤ x < 0.8
This score was never reached with the 75 patient pictures of chapter 7



Facial recognition clock when x ≥ 0.8. This score was never reached with the 75 patient pictures of chapter 7.

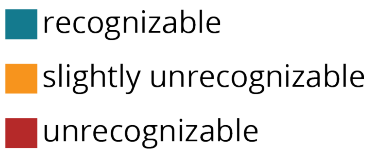


Figure A24.5: Design final version facial recognition clock

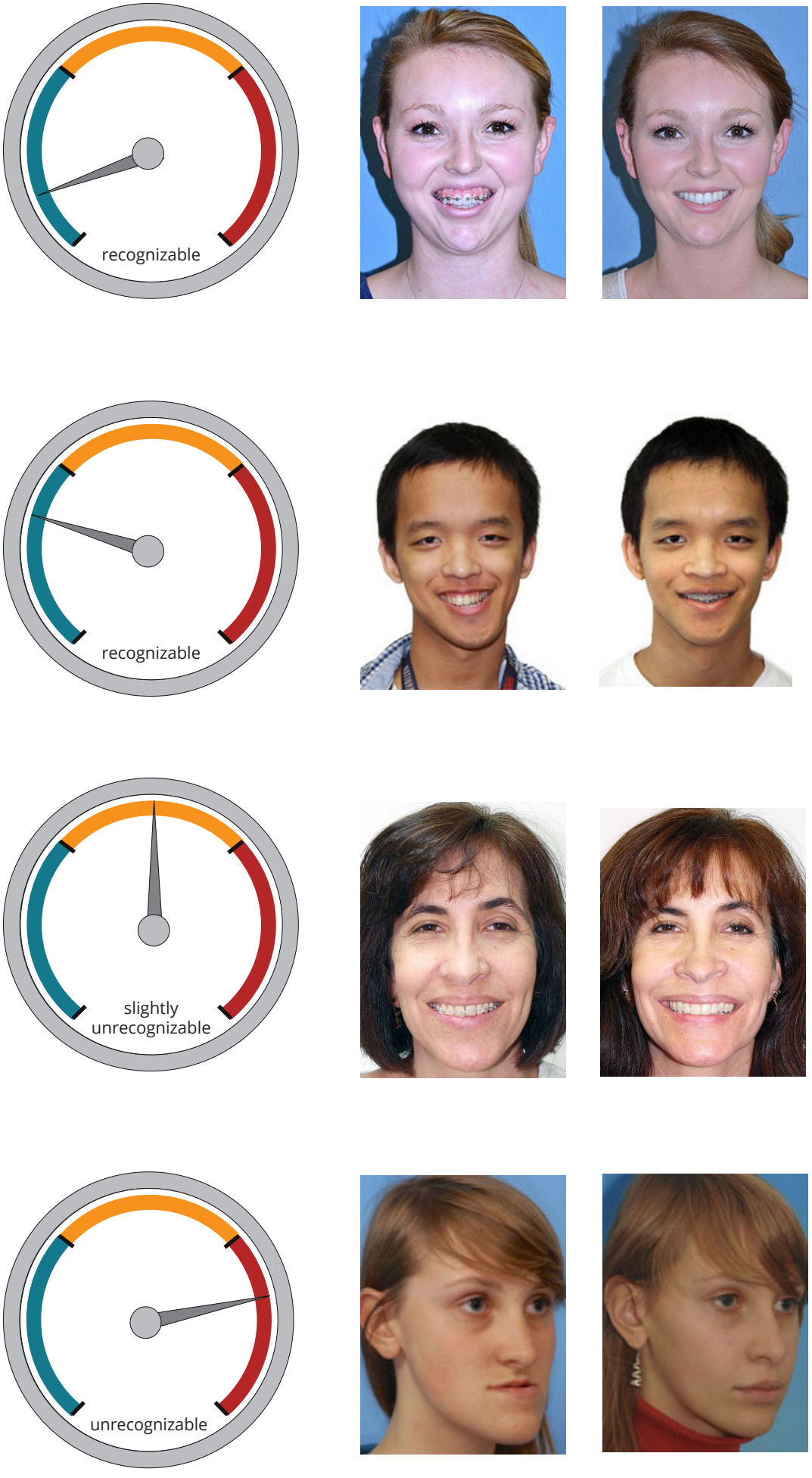
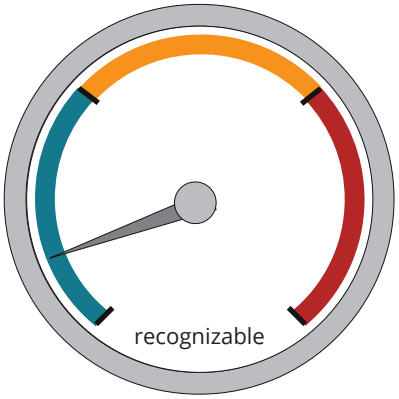
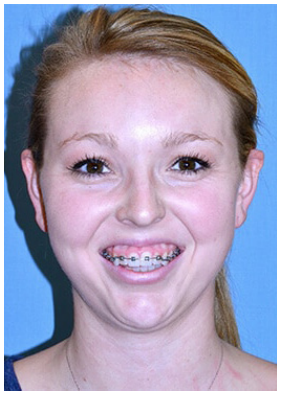


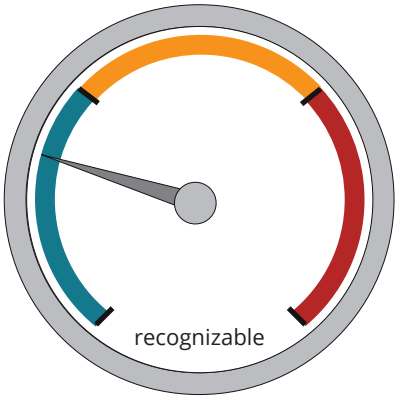
Figure A24.6: Facial recognition clocks belonging to patients which can be shown to the patients to make the clock more concrete.



Facial recognition clock when x < 0.3

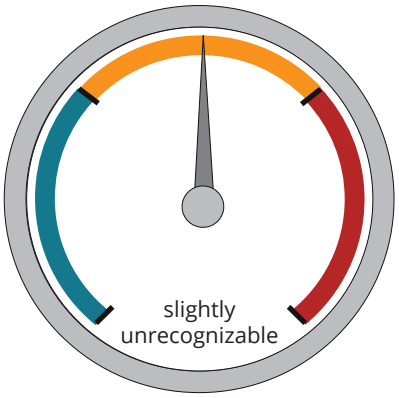



1adF,2aF,3F Patient with x < 0.3 (Dr. Richard W. Joseph, 2019)

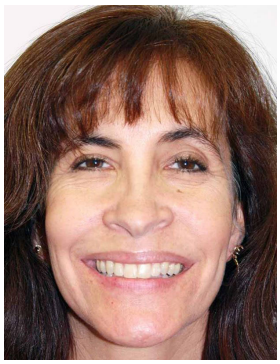


Facial recognition clock when 0.3 ≤ x < 0.43


1acdF,2bdF,3F patient with 0.3 ≤ x < 0.43 (Drantipov, 2020)

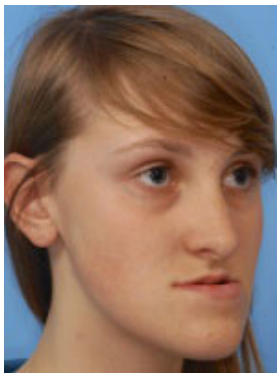


Facial recognition clock when 0.43 ≤ x < 0.45

1abF,2acF,3F patient with 0.43 ≤ x < 0.45 (Drantipov, 2020)

Facial recognition clock when 0.45 ≤ x < 0.6




1abF,2acF,3F patient with 0.45 ≤ x < 0.6 (Facial Sculpture Clinic, 2020)

Figure A24.7: Explanation and references of the clocks and pictures

Icons are used to find the subjects fast, to remember information, for the illiterate and it looks playful and it improves the appearance. This will influence the patient emotionally by feeling positive and confident (Interaction Design Foundation, 2002).

The word 'My' is used through the whole flyer to underscore that the information is **personal**.

Open Sans has been chosen as **font** since it is the best to read when printed. It is sans serif which makes it easier to read (Vistaprint, 2018). The size of the font is 12 pt, which is a comfortable reading size for most people (Flyerzone, 2020).

The name of the surgeon as a **cue** for patients to inform themselves. This is a second adaptive skill (Lehti, 2016).

Practical information so the patient can always recall when the consultation has been.

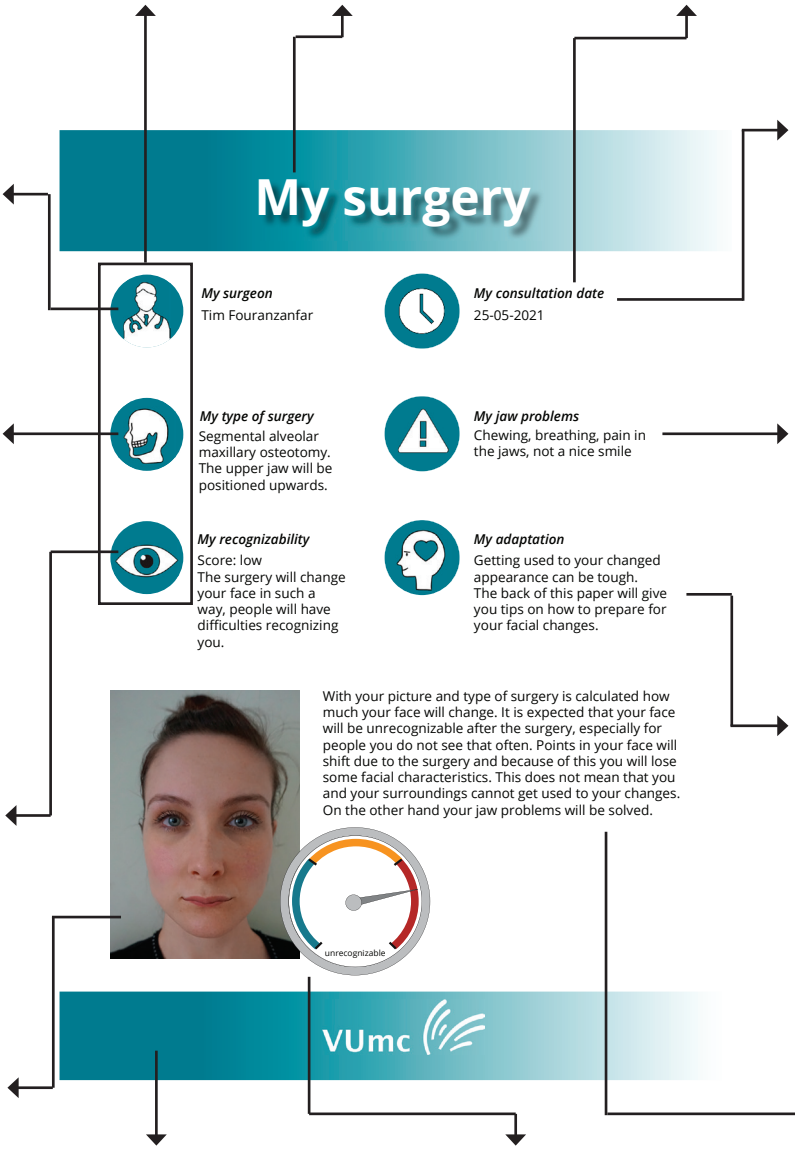
The medical term of the surgery as a **cue** for patients to inform themselves and an explanation of what it means. This is a second adaptive skill (Lehti, 2016).

To **remember** the patient why he chose to undergo the surgery. It can help to process information which is an adaptive skill (Lehti, 2016). Corresponds with tip 3.

The score and a short description of the **consequences**. For the doctor to explain fast to the patient.

Empathize with the patient. Referring to the back of the flyer. Provokes an emotional reaction of the patient which activates behaviour towards the surgery (Interaction Design Foundation, 2002)

The picture of the patient is shown which is used to calculate the similarity score. It gives the patient a feeling the information is **personal**. It can help to process information which is an adaptive skill (Lehti, 2016). It corresponds to tip 1 and 2.



This **colour** has been chosen because it gives a feeling of calmness and trust but also depth, expertise and stability (Color psychology, 2020)(Bruens, 2011, pp. 66-67). Patients do respond best when colours correspond with the intended results of the treatment (Bruens, 2011, pp. 66-67).

This **facial recognition clock** visualises the similarity score to make it understandable for patients.

This longer story gives an explanation of the outcome of the analysis, the consequences concerning recognition and jaw problems. It is a **summary** of the things the doctor should say during the consultation.

Figure A24.8: Design decisions flyer front page

The tips on the right support the tips on the left by using a key-word for describing the tip and by showing pictures of how to execute the tips. This can help remembering the information and it can help illiterate patients.

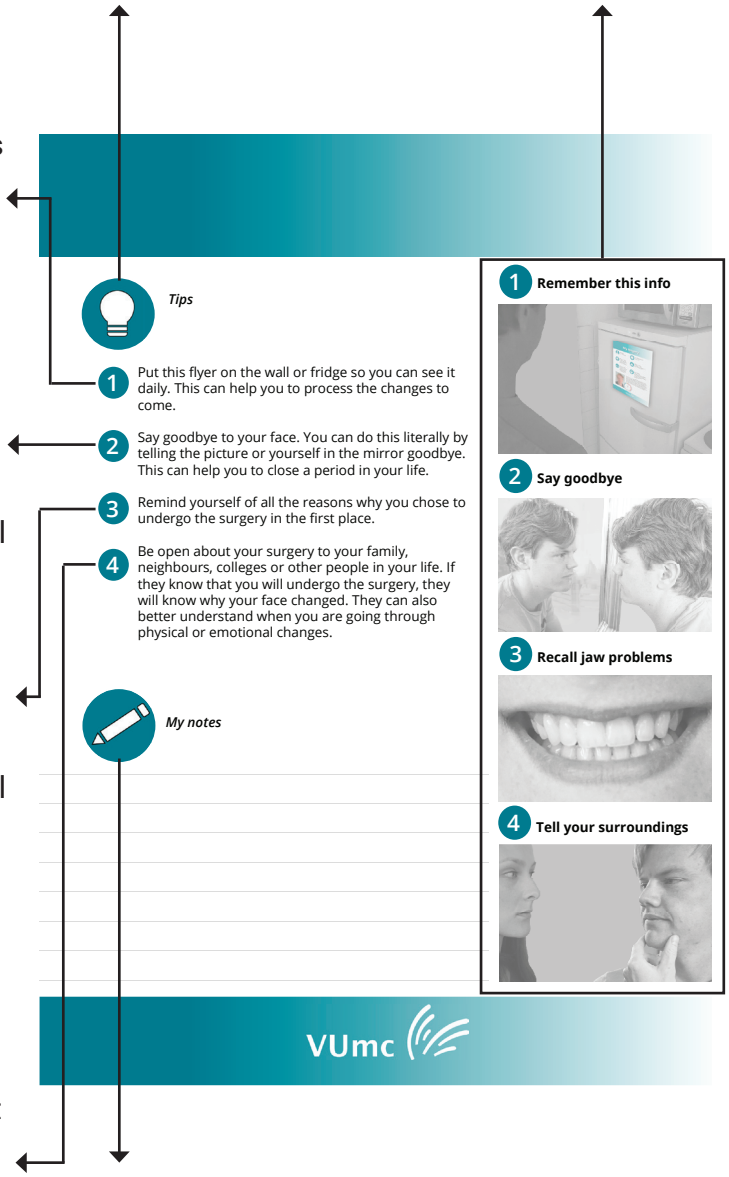
Tips are given to support emotional recovery when needed. Not every patient needs (all) the tips, depending on the mental state.

This tip **confronts** the patient with the results of facial recognition on the front page. It stimulates direct problem solving which is an adaptive skill (Lehti, 2016).

This tip **confronts** the patient with their own face and the changes which are about to come. It stimulates direct problem solving which is an adaptive skill (Lehti, 2016).

This tip helps the patient to put things in **perspective** by remembering the original reason he wanted to undergo the surgery. It stimulates information processing which is an adaptive skill (Lehti, 2016).

This tip helps the patient be **transparent** to the surroundings about the surgery. This can help to support the patient and to accept the facial changes. It stimulates mobilizing the social network. Which is an adaptive skill (Lehti, 2016).



The patient can use this space to write down any thoughts during emotional recovery. This stimulates information processing which is an adaptive skill (Lehti, 2016).

Figure A24.9: Design decisions flyer back page

Mijn operatie

Mijn chirurg
Tim Fouranzanfar

Datum spreekuur
25-05-2021

Mijn type operatie
Segmentale alveolaire maxillaire osteotomie. De bovenkaak zal naar boven verplaatst worden.

Mijn kaakproblemen
Kauwen, ademen, pijn in de kaken, geen mooie lach

Mijn gezichtsherkenning
Score: laag. De operatie verandert uw gezicht zodanig dat mensen het moeilijk kunnen vinden om u te herkennen.

Mijn acceptatie
Het kan lastig zijn om te wennen aan uw nieuwe uiterlijk. Op de achterkant van dit formulier staan tips over hoe u zich kunt voorbereiden op de veranderingen.

Aan de hand van uw foto en type operatie is berekend in welke mate uw gezicht zal gaan veranderen door de operatie. Waarschijnlijk gaat uw gezicht onherkenbaar zijn na de operatie, vooral voor mensen die u niet zo vaak ziet. Punten in uw gezicht zullen zo gaan verschuiven, dat sommige gezichtskenmerken verdwijnen. Dit betekent niet dat u en uw omgeving niet kunnen wennen aan uw veranderingen. Daar staat tegenover dat uw kaakproblemen worden opgelost.

VUmc

Figure A24.10: The front of flyer in the VUmc colour and in Dutch

Tips

1. Hang dit formulier ergens in huis op zodat u dit dagelijks kan zien. Dit kan helpen om aan de komende veranderingen te wennen.
2. Neem afscheid van uw gezicht. U kunt dit letterlijk doen door gedag te zeggen tegen uw foto of kijkende in de spiegel. Dit kan helpen om de periode voor de operatie af te sluiten.
3. Herhaal alle redenen waarom u heeft gekozen deze operatie te ondergaan.
4. Wees open naar anderen toe en vertel uw familie, buren, collega's en andere mensen in uw leven dat u een kaakoperatie ondergaat. Als ze weten dat u geopereerd wordt, dan weten ze waarom uw gezicht gaat veranderen. Ze kunnen u dan ook beter begrijpen wanneer u fysieke of emotionele problemen ervaart.

Mijn notities

1 Herinner deze info

2 Neem afscheid

3 Herinner kaakproblemen

4 Vertel uw omgeving

VUmc

Figure A24.11: The back of flyer in the VUmc colour and in Dutch

Appendix 25: Conceptualisation - The communication tool

Four types of flyers have been created:
1. Unrecognizable (page 112 - 113)
2. Slightly recognizable (page 114 - 115)
3. Recognizable (page 116 - 117)
4. Dutch translation of the unrecognizable flyer. Final version (page 118 - 119)

All of them have the scale 1:1. Flyers 1, 2 and 3 have a facial recognition clock matching the similarity score of the patient on the picture. The pictures which are shown on these examples are manipulated pictures which show the real belonging calculated score shown in the facial recognition clock. For each of these three flyers the text beneath 'my recognizability' is different per recognizability and the text next to the picture, which explains the meaning of the recognizability, is also different per recognizability.

My surgery

My surgeon
Tim Fouranzanfar

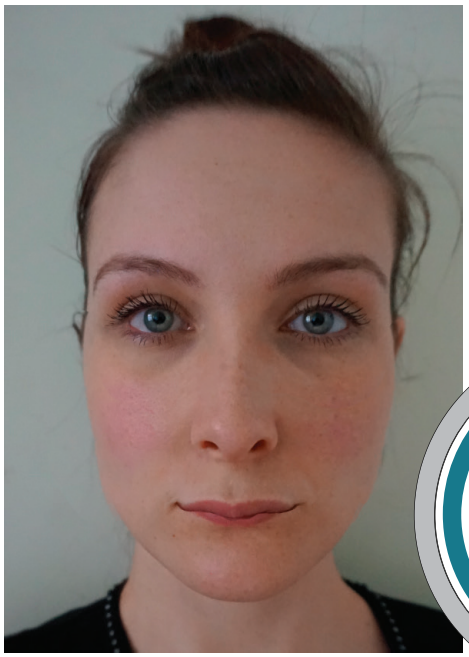
My consultation date
25-05-2021

My type of surgery
Segmental alveolar maxillary osteotomy. The upper jaw will be positioned upwards.

My jaw problems
Chewing, breathing, pain in the jaws, not a nice smile

My recognizability
Score: low
The surgery will change your face in such a way, people will have difficulties recognizing you.

My adaptation
Getting used to your changed appearance can be tough. The back of this paper will give you tips on how to prepare for your facial changes.



With your picture and type of surgery is calculated how much your face will change. It is expected that your face will be unrecognizable after the surgery, especially for people you do not see that often. Points in your face will shift due to the surgery and because of this you will lose some facial characteristics. This does not mean that you and your surroundings cannot get used to your changes. On the other hand your jaw problems will be solved.

VUmc

Tips

1. Put this flyer on the wall or fridge so you can see it daily. This can help you to process the changes to come.
2. Say goodbye to your face. You can do this literally by telling the picture or yourself in the mirror goodbye. This can help you to close a period in your life.
3. Remind yourself of all the reasons why you chose to undergo the surgery in the first place.
4. Be open about your surgery to your family, neighbours, colleges or other people in your life. If they know that you will undergo the surgery, they will know why your face changed. They can also better understand when you are going through physical or emotional changes.

My notes

1 Remember this info

2 Say goodbye

3 Recall jaw problems

4 Tell your surroundings

VUmc

My surgery

My surgeon
Tim Fouranzanfar

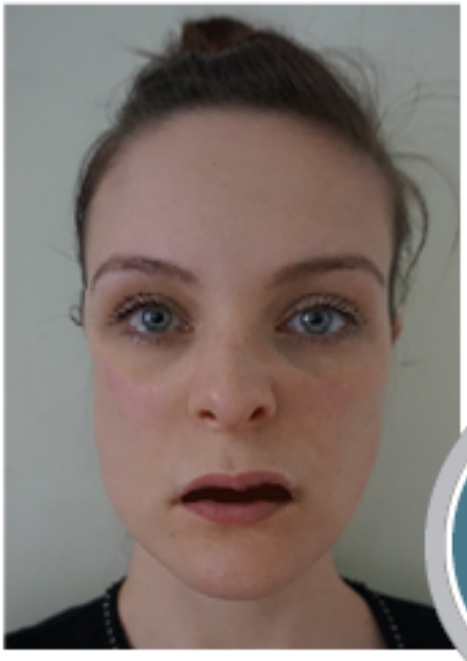
My consultation date
25-05-2021

My type of surgery
Segmental alveolar maxillary osteotomy. The upper jaw will be positioned downwards.

My jaw problems
Chewing, breathing, pain in the jaws, not a nice smile

My recognizability
Score: in between
The surgery will change your face but you will still be recognizable for most people.

My adaptation
Getting used to your changed appearance can be tough. The back of this paper will give you tips on how to prepare for your facial changes.



With your picture and type of surgery is predicted how much your face will change. It is expected that your face will only be unrecognizable after the surgery for some people, such as people you do not see that often. Your face will change, but not drastically. Points in your face will shift due to the surgery, which will change some of your facial characteristics. This does not mean that you and your surroundings cannot get used to your changes. Your jaws will fit nicely, and your jaw problems are solved.

VUmc

Tips

1. Put this flyer on the wall or fridge so you can see it daily. This can help you to process the changes to come.
2. Say goodbye to your face. You can do this literally by telling the picture or yourself in the mirror goodbye. This can help you to close a period in your life.
3. Remind yourself of all the reasons why you chose to undergo the surgery in the first place.
4. Be open about your surgery to your family, neighbours, colleges or other people in your life. If they know that you will undergo the surgery, they will know why your face changed. They can also better understand when you are going through physical or emotional changes.

My notes

1 Remember this info

2 Say goodbye

3 Recall jaw problems

4 Tell your surroundings

VUmc

My surgery

My surgeon
Tim Fouranzanfar

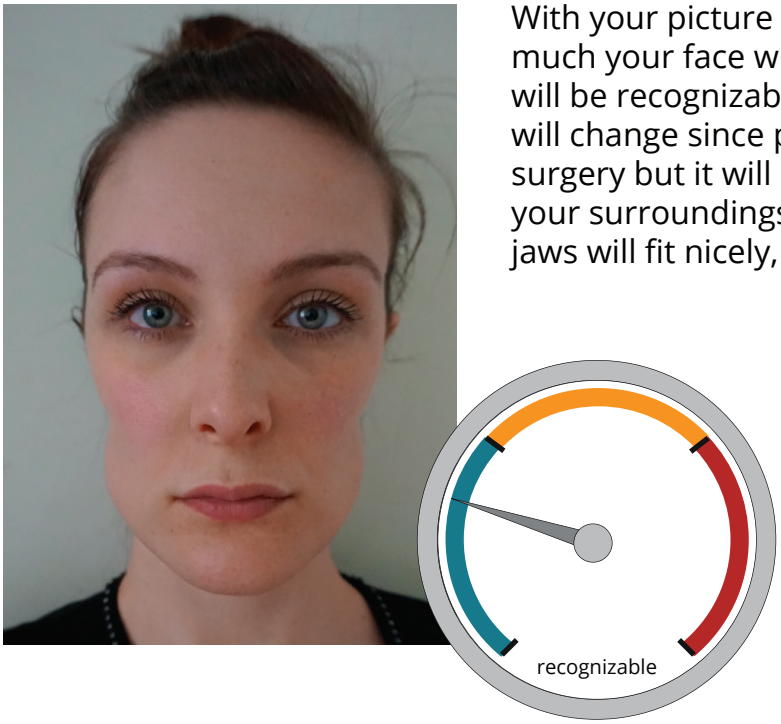
My consultation date
25-05-2021

My type of surgery
Surgically assisted rapid maxillary expansion. The upper jaw will be widened.

My jaw problems
Chewing, breathing, pain in the jaws, not a nice smile

My recognizability
Score: high
The surgery will change your face but you will still be recognizable.

My adaptation
Getting used to your changed appearance can be tough.
The back of this paper will give you tips on how to prepare for your facial changes.



With your picture and type of surgery is predicted how much your face will change. It is expected that your face will be recognizable after the surgery. However, your face will change since points in your face will shift due to the surgery but it will not affect your recognizability. You and your surroundings should get used to your changes. Your jaws will fit nicely, and your jaw problems are solved.

VUmc

Tips

1. Put this flyer on the wall or fridge so you can see it daily. This can help you to process the changes to come.
2. Say goodbye to your face. You can do this literally by telling the picture or yourself in the mirror goodbye. This can help you to close a period in your life.
3. Remind yourself of all the reasons why you chose to undergo the surgery in the first place.
4. Be open about your surgery to your family, neighbours, colleges or other people in your life. If they know that you will undergo the surgery, they will know why your face changed. They can also better understand when you are going through physical or emotional changes.

My notes

1 Remember this info

2 Say goodbye

3 Recall jaw problems

4 Tell your surroundings

VUmc

Mijn operatie

Mijn chirurg

Tim Fouranzanfar

Datum spreekuur

25-05-2021

Mijn type operatie

Segmentale alveolaire maxillaire osteotomie. De bovenkaak zal naar boven verplaatst worden.

Mijn kaakproblemen

Kauwen, ademen, pijn in de kaken, geen mooie lach

Mijn gezichtsherkenning

Score: laag. De operatie verandert uw gezicht zodanig dat mensen het moeilijk kunnen vinden om u te herkennen.

Mijn acceptatie

Het kan lastig zijn om te wennen aan uw nieuwe uiterlijk. Op de achterkant van dit formulier staan tips over hoe u zich kunt voorbereiden op de veranderingen.

Aan de hand van uw foto en type operatie is berekend in welke mate uw gezicht zal gaan veranderen door de operatie. Waarschijnlijk gaat uw gezicht onherkenbaar zijn na de operatie, vooral voor mensen die u niet zo vaak ziet. Punten in uw gezicht zullen zo gaan verschuiven, dat sommige gezichtskenmerken verdwijnen. Dit betekent niet dat u en uw omgeving niet kunnen wennen aan uw veranderingen. Daar staat tegenover dat uw kaakproblemen worden opgelost.

Tips

1. Hang dit formulier ergens in huis op zodat u dit dagelijks kan zien. Dit kan helpen om aan de komende veranderingen te wennen.

2. Neem afscheid van uw gezicht. U kunt dit letterlijk doen door gedag te zeggen tegen uw foto of kijkende in de spiegel. Dit kan helpen om de periode voor de operatie af te sluiten.

3. Herhaal alle redenen waarom u heeft gekozen deze operatie te ondergaan.

4. Wees open naar anderen toe en vertel uw familie, buren, collega's en andere mensen in uw leven dat u een kaakoperatie ondergaat. Als ze weten dat u geopereerd wordt, dan weten ze waarom uw gezicht gaat veranderen. Ze kunnen u dan ook beter begrijpen wanneer u fysieke of emotionele problemen ervaart.

Mijn notities

1 Herinner deze info

2 Neem afscheid

3 Herinner kaakproblemen

4 Vertel uw omgeving

VUmc

Appendix 26: Conceptualisation - Communication research

Communication between doctor and patient is complex and can be verbal and non-verbal and can be done with or without certain instruments (e.g. posters). The 3 main goals of doctor-patient communication are creating a good interpersonal relationship, facilitating exchange of information and including patients in decision making (Ha & Longnecker, 2010). Effective communication has a positive impact on important outcomes including patient satisfaction (Levinson et al., 2013). Patients have physical and non-physical expectations and understanding them can increase patient satisfaction. Psychological preparation for the treatment helps to prepare the patients for the post-surgery image. This can be achieved by the surgeon providing information, but also by talking to other patients who have undergone orthognathic surgery. Even if the surgical outcomes are ideal, it can lead to patient dissatisfaction when the psychological perspective has not been taken into account (Soh & Narayanan, 2013). The top priority of patients is information and shared-decision making (Schattner et al., 2006). The focus of the communication aspect of the tool will therefore lie on the information transfer and shared-decision making between doctor and patient in order to match the patients expectations with the outcomes.

Different type of patients undergo an orthognathic surgery, therefore, patient-centred healthcare is important to integrate in the tool. The better the way of communication between patient and doctor is, the more positive the health outcome will be. Patients need a tailored communication method to understand what the surgeon tells them about the changes of their face due to the surgery. This is also in line with research from Groeneveld et al., 2019 who concludes that user-centred design is needed to create tailored information provision to inform patients about the procedure and recovery of surgeries. However, this research also shows that in healthcare communication cannot be tailored for every individual patient and different patient roles can be created to use as design guidelines. Therefore, patient profiles for this project have been created (appendix 23). The rest of this chapter will show a brief description of the goals of shared-decision making and information transfer which are the goals for doctor-patient communication, the current consultation at the orthognathic department has been described and a description is shown of an analysis of how communication is done at the diabetes department in the VUmc.

Shared-decision making
Shared-decision making is dependent on a feeling of partnership between doctor and patient. Higher educated patients tend to have more partnership relationships with the doctor and they make decisions together more often. This has to do with a lower cultural difference between patient and doctor (Willems et al., 2005). A lower social class also predicted a lower preference for shared-decision making.

Information
Currently, the doctors communicate differently per patient according to observations from research and from the diabetes consultations in the VUmc (Ha & Longnecker, 2010; Ribbers et al., 2018; Willems et al., 2005). They adapt to the communication skills of the patient. Doctors give information in reaction of the responses of the patients and their questions. Also, the amount of information they give, depends on the personality of the patient. The more expressive and curious they are, the more information they get (figure A26.1). During diabetes consultations in the VUmc, the patients interviews showed that nurses respond differently from doctors. Doctors tend to be more pragmatic. Also according to the nurses and patients, the nurses give more tailored information. Where the doctor gives the patient numbers, the nurse would explain what the numbers mean.

Effective communication
It is important to know how patients process information the best, since they should process that their face will change in the process. The memory of medical information among patients is often poor and inaccurate. They remember simple and specific instructions better than general statements. Categorization techniques, like topics described in figure A26.5, can help to remember patients. Apparently, a test showed that with spoken medical instructions only 14% of the information was remembered correctly, compared with over 80% when visuals or pictograms were used. It works best if spoken information is supported with both written as visual material. Also, research does show that video or multimedia techniques do not improve memory performances (Kessels, 2003).

According to research done by the Victorian Quality Council (2010), the elements which are needed for effective communication are shown in figure A26.1. These elements should be taken into account when designing the communication tool.

Healthcare professionals desire flexible communication systems with patients that require only a few resources and both healthcare professionals and patient want to communicate in a fast and efficient way. The tools which can help the doctor and patient communicate should therefore be:
1. Technically efficient (fast, user-friendly, low-cost)
2. Secure in terms of confidentiality and privacy (ITACA-TSB, 2012).

Consultation in the VUmc
At the orthognathic consultations of the VUmc the time varies between 15 and 30 minutes depending on the type of consultation. Most patients have two consultations. The patient is referred to the hospital by the orthodontist where after he is having a consultation with the surgeon to evaluate the indication of the need of a surgery made by the orthodontist. Most of the time, the patient indeed needs a surgery. The surgeon tells the patients how long the process will take and in what time the surgery will take place. Closer to the surgery, the patient has a second consultation with the surgeon and the details of the surgery are discussed. The surgeon tells the patient about the type of the surgery and its technique, how long the surgery will take, the complications and how the functionality of the jaws will be improved. They also give the patient a brochure about this information. However, they do not tell anything about the outcome in appearance or facial recognition since they do not know anything about it. The patients are mostly young and the surgeons of the VUmc do not have problems in communicating with the patients about the information they currently tell (T. Fouranzanfar, personal communication, June 22, 2020). However, this information is from the view of the surgeons, it is unknown how patients experience the information transfer. Since literature shows that patients in other hospitals do have problems with shared-decision making and information transfer between patient and doctor, this will still be taken into account when designing the tool.

Communication in the VUmc
To get more inspiration for design of the tool and to know how to integrate the design into the current system of the VUmc, there has been looked into the way the VUmc communicates information to the patients now. Previous research at the VUmc has been done by Ribbers et al., (2018) about communication between doctor and diabetes patients and nurses and diabetes patients. This has been done at the department of internal medicine with the purpose of implementing a Value-Based Healthcare (VBHC) approach in the consultation room. During this research, patients have been interviewed about the hospital environment and information supply.
The most important outcomes of this research were:

- VBHC implementation: because of the implementation of VBHC the consultations are slowly changing and focusing more on the patients which is desirable for the patients. For example, a so-called 'menu card' with topics is given to the patient, which lets them indicate what they want to talk about during the consultation (figure A26.5). According to the nurses, this menu card works well especially with patients who immigrated and have a language barrier. It also provokes patients in asking questions or think about topics they did not think of at the moment of the consultation.

- Difference of attitude: between the doctors and nurses there are differences concerning their

Complete	It answers all questions asked to a level that is satisfactory to those involved in the exchange of information.
Concise	Wordy expressions are shortened or omitted. It includes only relevant statements and avoids unnecessary repetition.
Concrete	The words used mean what they say; they are specific and considered. Accurate facts and figures are given.
Clear	Short, familiar, conversational words are used to construct effective and understandable messages.
Accurate	The level of language is apt for the occasion; ambiguous jargon is avoided, as are discriminatory or patronising expressions.

Figure A26.1: Elements for effective communication (Victorian Quality Council, 2010)

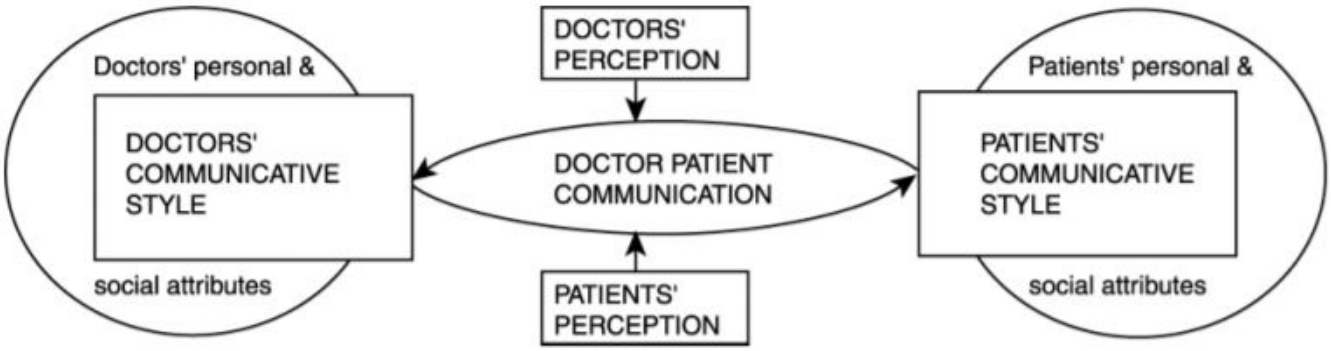


Figure A26.2: Influences on doctor patient communication (Willems et al., 2005)

attitude to the patients. On the one hand, the doctor often has a more distant relation with the patient and 'just' explains numbers and results to them. While on the other hand, nurses often have a more intimate relation with the patient and are really concerned with them.

- Lack of employees: at this moment there is a big shortage of employees in the VUmc. This results for example in nurses getting more administrative tasks and tasks like refilling the printer cartridge. These tasks have to be done all in between consultations, which sometimes results in nurses having too little time for patients.

- VBHC: the nurses think it is good the VUmc is implementing the concept of VBHC at the diabetes department. In this way patients know what their outcomes are for the consultation (what they get out of it). Because of this everything meets their expectations, which satisfies both nurses and patients and it results in the best tailored treatment for the patients.

Some similarities can be seen when comparing the diabetes department with the orthognathic department. Doctors in this department might also be willing to communicate numbers about facial recognition to patients (T. Fouranzanfar, personal communication, May 26, 2020) which might not be desirable or clear for the patients. What has been clear from conversations is that everything in the hospital must cost as little time as possible, it feels like they are in a hurry all the time. It is best for the VUmc to hire more staff, however, this might not be a possibility and can also not be solved by the tool. Therefore, the surgeon should be able to use the tool fast and easy. The surgeon should inform the patient in a clear and easy way. It could be a possibility to give information to the patient to take home which could be on paper or digital. Value-Based Healthcare is, among other things, about tailored healthcare and shared-decision making. According to the research, the VBHC approach leads to better outcomes because it matches their expectations. Both the nurses and patients are satisfied by this approach. Therefore, it is expected that it will also lead to positive results when it is applied to the consultations of the orthognathic department.

Information supply

Pictures have been taken from the waiting room and consultation rooms of the diabetes department. In the waiting room, flyers can be found in different parts of the room (figure A26.3). When walking in the consultation rooms, the rack with flyers can be seen right away on the right (figure A26.4). On the wall, posters with visual information can be seen, explaining things about diabetes. Also, during the consultation, a menu card is used to let the patient pick the topic to talk about. This is done with images and text. The reason visual information is used, because not every patient can read and the patients come from different social-economic classes. Also language barriers can be a problem. Therefore, the information should be presented in different ways, in order to tailor the type of information supply to the patients.

It is therefore desirable if the design:
- can be used fast by the surgeon
- can provide different type of information per patient
- can provide different amounts of information per patient
- uses visual information mainly, combined with text

Feedback about care

One strategy which improves communication between doctor and patient is asking the patients to evaluate the care (AHRQ, 2017). The diabetes department does this by handing out flyers and by placing tablets with questions in the waiting room. This way the care can be redesigned and the patients can speak out their concerns.

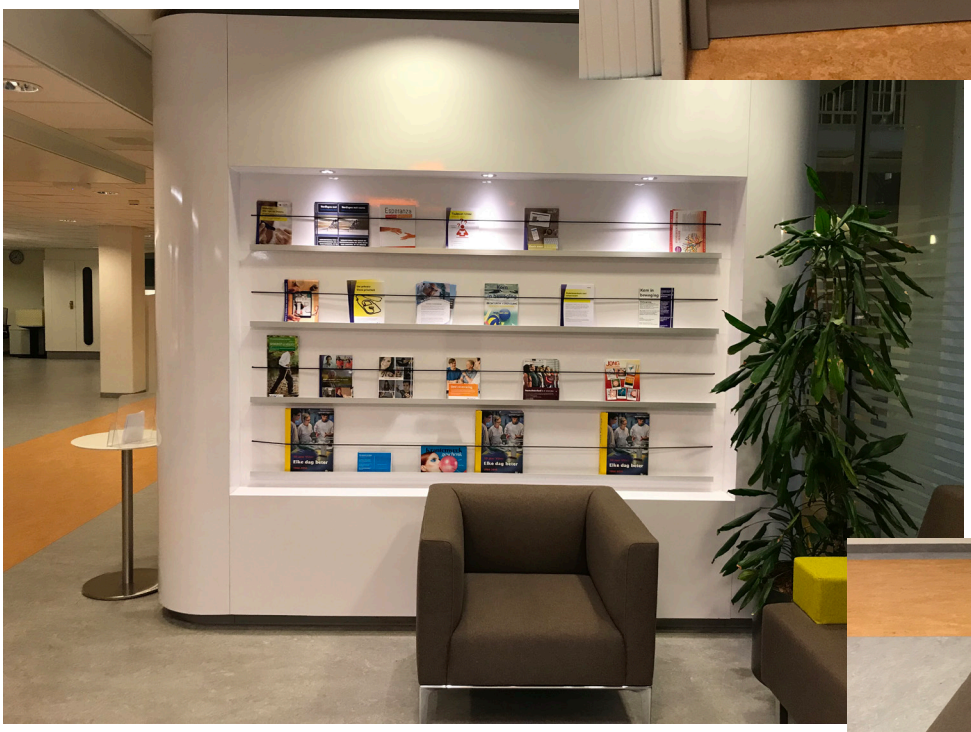


Figure A26.3 Flyers in the consultation room and waiting room at the diabetes department in the VUmc

Figure A26.4: Evaluation device and form to evaluate treatment and information posters on the wall of the consultation room at the diabetes department of the VUmc.

Mijn Diabetesjaargesprek

Zullen we eerst even samen de gesprekskaart bekijken?
Welke onderwerpen zijn op dit moment belangrijk voor u?

Factoren
HOE IS HET NU?

- **Wat wilt u vandaag zeker bespreken?**
- **Kunt u mij iets meer vertellen over dit onderwerp?**
- **Wat is er veranderd sinds onze vorige afspraak?**
- **Waar loopt u nog meer tegenaan; wellicht iets wat u moeilijk vindt te vertellen?**

Keuzes
WAT WILT U GRAAG?

- **Waar heeft u behoefte aan?**
- **Wat zou u graag anders willen zien?**
- **Welk doel wilt u bereiken?**
- **Wat is concreet haalbaar voor u?**

Afspraken
HOE PAKKEN WE DIT AAN?

- **Aan welke stappen denkt u zelf om weer vooruit te kunnen?**
- **Wat heeft u nodig om uw doel te halen en wie kan hierbij helpen?**
- **Heeft u het vertrouwen dat dit gaat lukken?**
- **Welke afspraak kunnen we hierover maken?**

› Hoe heeft u dit gesprek ervaren?

Lijf

Leefstijl

Welzijn

Zelfzorg

ndf nederlandse diabetes federatie
Personalized NDF Diabetes Care
Mede mogelijk gemaakt door: novo nordisk®

Figure A26.5: The 'menu card' used during diabetes consultations at the VUmc

Appendix 27: Conceptualisation - Emotional recovery

It is necessary to take emotional recovery of the patients after the surgery into account, because if they do not recover emotionally, they will never be satisfied with the outcomes of the orthognathic surgery and they even can get psychological problems. First has been looked into coping mechanisms with use of the theory of psychological adaptive modes, which describes how people deal with a big stressor like a surgery. After, this theory is applied to the communication part of the tool and design decisions has been made.

When circumstances change, people are forced to change their behaviour and their thinking patterns to adapt to these changes, coping mechanisms help with this. However, sometimes when more extreme situations occur, like a surgery, adaptation requires extreme changes which cannot be solved by the ordinary stress response coping mechanisms which ensure well-being under normal circumstances. When something like a surgery is happening, the resources of humans can be limited and sometimes resources should be found somewhere else. The ordinary stress response coping mechanisms should be temporarily shut down while other coping mechanisms are applied (Lehti, 2016).

Adaptive modes are used to describe a group of mental states affecting human behaviour and physiology. These are mental states which cannot be controlled like anxiety or depression, and these are activated when normal stress response mechanisms fail and people cannot cope with the stressor. However, adaptive modes are not per se negative since it is important for our survival and it can also allow people to think and plan things which would not be possible without them. Nevertheless, the adaptive modes are only beneficial if they are carried properly trough. The person is either enhancing the adaptation process or is consumed by it. Recourses like a psychologist or providing information, depending on the seriousness, can support adaptation. Figure A27.1 shows the flow chart of the theory of psychological adaptive modes. When a person activates the adaptive mode, he should use adaptive skills to overcome the adaptive problem. Adaptive skills are certain behavioural and thinking patterns. There are four types of first adaptive skills:

1. Direct problem solving (creativity, attacking)

2. Mobilizing the social network (asking for help, crying, showing sadness)

3. Information processing (iterating, conceptualizing, writing)

4. Enduring the stressor (denial, blaming others)

After the first adaptive skills, second line adaptive skills are used but this requires more cognitive processing, like planning a budget, looking for more information, having a serious conversation. A successful adaptation leads to raised well-being. Non successful adaptation leads to psychiatric disorders. It does not mean that all the four type of adaptive skills should be present to recover (Lehti, 2016).

When looking at orthognathic surgery as a stressor, the goal is to make the surgery a stressor which can be processed by ordinary stress response mechanisms so the patient will never get in the state of an adaptive mode. This can be done by matching expectations with outcomes and by informing the patient as best as possible. However, how the patient will cope differs per person and it is expected that there will be patients getting in the state of an adaptive mode, even if they are informed well. If the patient comes in the adaptive mode, extra support can be given by informing the patient how he can recover emotionally. This extra support can be the resource needed to cope with the stressor. For the design is chosen to implement the first three adaptive skills which are direct problem solving, mobilizing the social network and information processing.

The back of the information flyer shows four tips:

1. Direct problem solving. "Put this flyer on the wall or fridge so you can see it daily. This can help you to process the changes to come."

2. Direct problem solving. "Say goodbye to your face. You can do this literally by telling the picture or yourself in the mirror goodbye. This can help you to close a period in your life."

3. Information processing. "Remind yourself of all the reasons why you chose to undergo the surgery in the first place."

4. Mobilizing the social network. “Be open about your surgery to your family, neighbours, colleges or other people in your life. If they know that you will undergo the surgery, they will know why your face changed. They can also better understand when you are going through physical or emotional changes."

The back of the flyer also has space to write down thoughts, which is addressing the information processing.

The second adaptive skills are applied as well. The patients can use the flyer to look for more information. The flyer shows basic information like the name of the surgeon and the type of surgery without showing elaboration. The patient can search with these keywords themselves to get correct information, instead of searching with their own keywords which can give them incorrect results. The reason the information only consists of keywords and no further elaboration, is because at first the patients might not want this information if they are still in the first stage of adaptive skills. Also, not all patients are interested in this information and it can give them an overload of information which can cause stress which makes the surgery a bigger stressor.

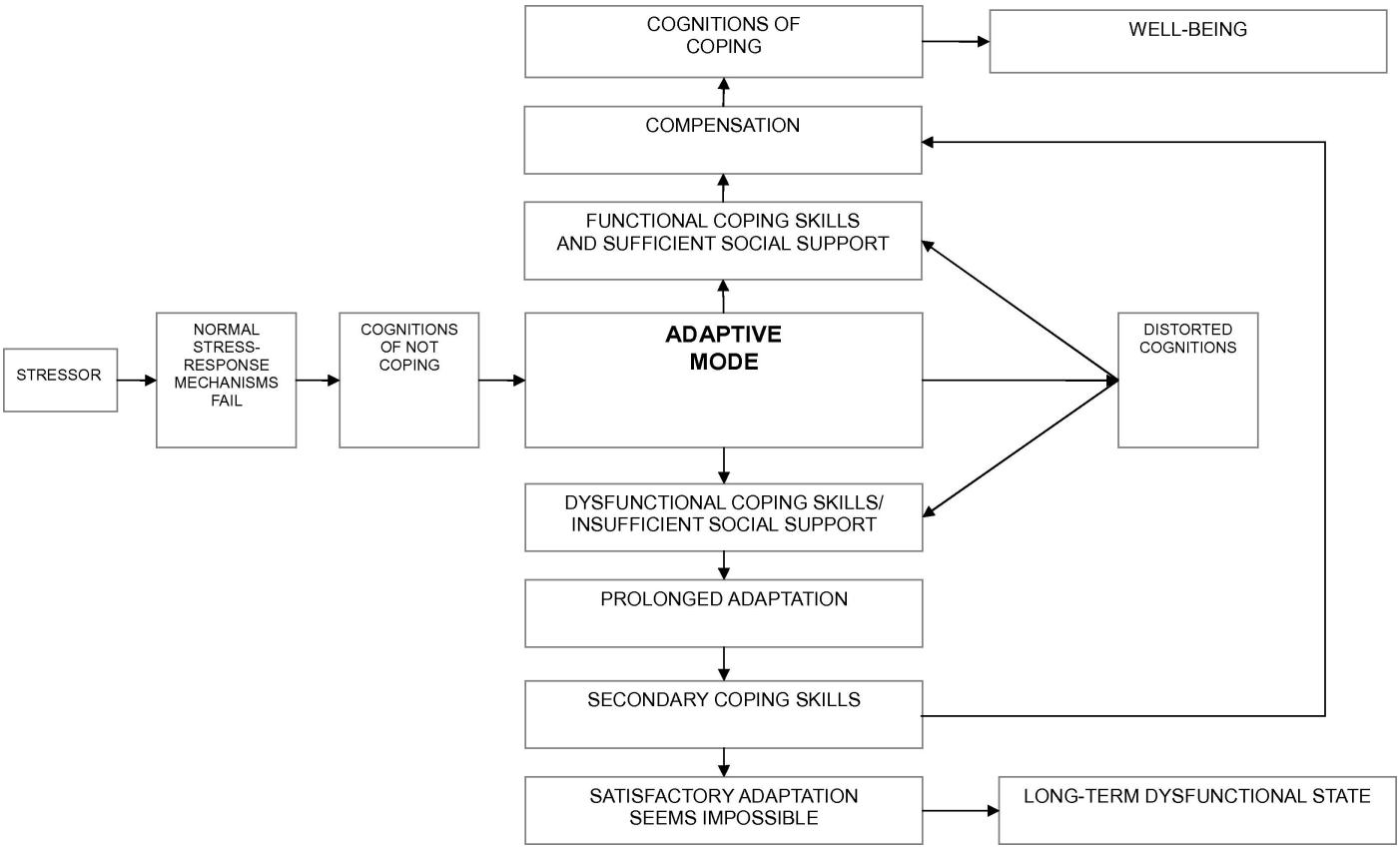


Figure A27.1: The theory of psychological adaptive modes (Lehti, 2016)

Appendix 28: User test - Guideline

Structure of the test
1. Explanation of the goal of the test and background of the project (1 minute)
2. Patient profiling (2 minutes)
3. Role play (5 minutes)
4. Interview (5 minutes)
The focus will be on facial recognition and the flyer, the other topics which are usually discussed during a consultation are skipped.

Patient profiling
Some questions are asked before the start of the test to see in what patient profile the participant would fit. Since the participants know the interviewer personally, the way they communicate is probably different when communicating with a doctor. Therefore it is valuable to know how they think they usually communicate with the doctor to estimate if the flyer works for them.
These questions are asked to the participant:
1. Do you remember you went to see a doctor?
2. Are you someone who usually asks a lot of questions during a consultation?
3. When you are going home from a consultation, do you often have the feeling everything is clear?
4. Do you write down things which are said during the consultation?
5. How do you prepare for a consultation?
6. How do you describe the communication with you and the doctor in general?

Script role play – user test (Dutch)

Uitleg rollenspel:
Interviewer: "We gaan een spreekuur naspelen waarbij we het vooral gaan hebben over gezichtsherkenning en de informatie op de flyer. U zult de patient spelen en ik de dokter. Als patient weet u dat u een kaakoperatie zult ondergaan omdat u last heeft van pijn in de kaken, van kauwen en ademen. Ook bent u niet blij met hoe uw lach er nu uitziet. De afspraak die u nu heeft met de dokter is een aantal weken voorafgaand aan de operatie."

1. Openen van het spreekuur
Dokter: "Welkom, hoe gaat het?"
Patiënt: "[zegt iets]"
Dokter: "[reageert op patiënt]"

2. Sturen van het gesprek
Dokter: "De vorige keer toen we elkaar hebben gezien hebben we afgesproken dat u een kaakoperatie zult ondergaan, we gaan vandaag de details van deze operatie bespreken."

Interviewer: "Normaal praten de dokter en patiënt hier over de operatietechnieken, de duur van de operatie, wat er qua functionaliteit veranderd met uw gebit en over de complicaties. Ook krijgt u een brochure waar alle praktische dingen instaan over de operatie. Nu komt er echter het nieuwe onderdeel, wat nog niet tijdens spreekuren wordt besproken".
3. Focussen van het gesprek
Dokter: "We hebben tegenwoordig een techniek die kan voorspellen hoe herkenbaar u gaat zijn na de operatie. Dit verschilt per persoon en per operatie. De foto die u voor dit spreekuur heeft laten maken is hiervoor gebruikt. De reden dat we dit met u bespreken is omdat uit onze ervaring blijkt dat patiënten

het moeilijk kunnen vinden om te wennen aan de veranderingen in het gezicht. We kunnen helaas niet voorspellen hoe u gezicht precies gaat veranderen, maar wel hoeveel. Als u dit van tevoren weet kunt u hier rekening mee houden.

Ik zal nu de resultaten hiervan met u bespreken. Uw bovenkaak zal naar boven worden geplaatst, waardoor uw gezicht zo erg zal veranderen dat u onherkenbaar zult zijn na de operatie. Deze score (wijs naar facial recognition clock) geeft aan in welke mate u onherkenbaar zult zijn. De reden dat u onherkenbaar zult zijn is omdat de operatie ervoor zorgt dat er zoveel punten in het gezicht verschuiven dat bepaalde gezichtseigenschappen veranderen. Er blijven ook gezichtseigenschappen intact, daarom zullen mensen die u vaker zien u beter herkennen dan mensen die u maar weinig ziet. Heeft u over deze informatie vragen?"

Patiënt: "[Geeft reactie]"
De dokter schrijft deze reactie op papier.
Dokter: "[Reageert op patiënt]"

4. Bespreken flyer en vervolg
Dokter: "De voorkant van dit formulier bevat informatie die ik u net heb uitgelegd over uw veranderingen. Het is belangrijk dat u beseft dat uw gezicht gaat veranderen zodat u erop voorbereid bent en zo na de operatie beter kan wennen aan uw veranderingen in het gezicht.
Op de achterkant van dit formulier staan tips die u als u wil kunt gebruiken om u voor te bereiden op de gewichtsveranderingen, dit is in zowel tekst als afbeeldingen uitgelegd. Heeft u hier nog vragen over?".

Patiënt: "[Geeft reactie]"
De dokter schrijft deze reactie op papier.
Dokter: "[Reageert op patiënt]"

Einde rollenspel

Interview
During the role play has been asked if the patient has any questions. These answers indicate if the first impression of the front page of the flyer was clear and if improvement is needed on this. After is asked to the participant to read through the whole flyer. Then questions are asked about the flyer (Dutch).
1. Welke informatie is na het lezen van de flyer, wel of niet duidelijk?
2. Welke informatie lijkt u overbodig?
3. Welke informatie mist u?
4. Hebt u verbeterpunten voor de uitstraling?

Op een schaal van 1 – 5 waarbij 1 zeer slecht is en 5 zeer goed:
1. Balans tussen hoeveelheid tekst en afbeeldingen
2. De hoeveelheid informatie
3. De kleurcombinaties
4. De toon waarop de tekst is geschreven
5. Algemene indruk van deze manier van communiceren

Appendix 29: User test - Measurements

Participant 1
Gender: Female
Age: 78
Profession: retired

Patient profiling
1. Do you remember you went to see a doctor?
Yes, 1 week ago
2. Are you someone who usually asks a lot of questions during a consultation?
I listen mostly, because I have the feeling the doctor never has time to answer my questions.
3. When you are going home from a consultation, do you often have the feeling everything is clear?
No I always go home with a lot of questions. For me it feels like the doctors never take enough time for older people. I also forget a lot of things which are said during the consultation.
4. Do you write things down during the consultation?
No
5. How do you prepare for a consultation?
By being on time and by bringing someone with me to the consultation. Sometimes when I know what the treatment is about I look on the internet beforehand.
6. How do you describe the communication with you and the doctor in general?
I let the doctor talk

This participants is an introvert patient

Role play
Comments of the participant:
- Explanation is very clear, I do not have any questions
- If the patients has problems with the jaw, the surgery just has to go on. If the jaw problems are not present than I do not think I would let the surgery continue because of losing facial recognition. It is quite a shock that you lose facial recognition.

Questions about flyer
1. What information is after reading the flyer not clear?
Everything is clear for me
2. What information seems unnecessary?
Nothing, everything seems important. It is not too much information.
3. What information are you missing?
Nothing
4. Do you have any tips for the appearance of the flyer?
I like how it looks, it looks calm and structured. The colours fit well.

On a scale from 1 to 5 (1 is very bad and 5 is very good)
1. Balance between amount of text and amount of images – 5
2. Amount of information – 5
3. Colour combinations – 5
4. Tonation of how the text is written – 5
5. This way of communicating, with a flyer during the consultation and by taking it home – 5

Extra comment: Is this you on the picture? I really did not recognize you! (the interviewee is the grandma of the interviewer, the interviewers manipulated picture was put on the flyer)
Participant 2
Gender: Male
Age: 62
Profession: Taxi driver
Remarks: colour blind

Patient profiling
1. Do you remember you went to see a doctor?
Yes, but it has been a long time ago I went for myself. But I did go with other people more recently.
2. Are you someone who usually asks a lot of questions during a consultation?
I do not ask questions, I just listen.
3. When you are going home from a consultation, do you often have the feeling everything is clear?
Sometimes it is clear when I am going home but it also happens it is not clear.
4. Do you write things down during the consultation?
No
5. How do you prepare for a consultation?
I cannot remember it that well, but I think I never prepared
6. How do you describe the communication with you and the doctor in general?
I let the doctor talk, but I never go home satisfied or calm. I am always still worried when I am going home.

This participant is an introvert patient

Role play
Comments of the participant:
- I think I would be really hesitant if I would still want to undergo the surgery. But on the other side with all the jaw problems, I should take the facial changes for granted.
- I think for me the changes would not bother me that much, but it is more for the surroundings that it would be bad for them

Questions about flyer
1. What information is after reading the flyer not clear?
Beneath the head of 'my facial recognition' it says 'low', this is clear but can be clearer that this is the score you get.
2. What information seems unnecessary?
Personally I do not care what surgeon will perform my surgery, if he can do the surgery and he is good than it is fine for me.
3. What information are you missing?
The information about the surgery itself, but if I get the brochure about this information as well, I do not miss anything.
4. Do you have any tips for the appearance of the flyer?
It gives me a nice overview and it is very structured. I like the front. On the back I think the images look pale, I like it more if they are sharper with the real colours. The overall blue colour looks medical and calm.

On a scale from 1 to 5 (1 is very bad and 5 is very good)
1. Balance between amount of text and amount of images – 5
2. Amount of information – 4
3. Colour combinations – 4
4. Tonation of how the text is written – 5
5. This way of communicating, with a flyer during the consultation and by taking it home - 4
Participant 3
Gender: Male
Age: 22
Profession: Video editor and cameraman
Remarks: colour blind

Patient profiling
1. Do you remember you went to see a doctor?
Yes, it was 1,5 week ago.
2. Are you someone who usually asks a lot of questions during a consultation?
I ask some questions, but not a lot.
3. When you are going home from a consultation, do you often have the feeling everything is clear?
Most of the time, questions pop up after the consultation. This does not always happen. It would be nice for

me to get a report home so I can read everything the doctor said because I cannot remember everything the doctor tells me.
4. Do you write things down during the consultation?
No
5. How do you prepare for a consultation?
When it is possible I search on the internet, I inform myself for what I am going to the doctor
6. How do you describe the communication with you and the doctor in general?
During the consultation I listen and I agree on everything the doctor says, but after the consultation I really start thinking and then it bothers me that I did not ask or say more because sometimes I do not agree.

This participant is an introvert patient, tending towards extrovert

Role play
Comments of the participant:
- I do not have any questions. Everything is clear. I have difficulties to empathize with the patient. But if you have jaw problems I think you should have a surgery no matter what facial recognition will be.

Questions about flyer
1. What information is after reading the flyer not clear?
Beneath the head of 'my facial recognition' it says 'low', this is not clear for me. What is this exactly?
On the back, tip 3 says 'repeat jaw problems', I think this can be formulated differently to something like 'remind jaw problems'. Further it is all clear for me. Sometimes at the doctor they use difficult words or flyers with a lot of text which can be annoying, but this flyer is easy to read and I understand everything.
2. What information seems unnecessary?
Not all tips are for everyone, I do not know if I would use the tips. But I guess that is why they are called 'tips', you can do with it whatever you want.
3. What information are you missing?
None
4. Do you have any tips for the appearance of the flyer?
It gives me a nice overview and it is very structured. I like the pale colour of the images on the back. It could be nice if you also make the patient picture in this colour because this looks better also with the green colour, but only if this is functional as well. I like the green colour though, it gives a relaxed feeling.

On a scale from 1 to 5 (1 is very bad and 5 is very good)
1. Balance between amount of text and amount of images – 5
2. Amount of information – 5
3. Colour combinations – 4
4. Tonation of how the text is written – 5
Comment: It is written in a transparent way, not too formal, just right.
5. This way of communicating, with a flyer during the consultation and by taking it home – 5

Participant 4
Gender: Male
Age: 20
Profession: Flower management

Patient profiling
1. Do you remember you went to see a doctor?
Yes
2. Are you someone who usually asks a lot of questions during a consultation?
No I never ask questions.
3. When you are going home from a consultation, do you often have the feeling everything is clear?
Sometimes I still have questions but most of the time everything is clear
4. Do you write things down during the consultation?
No
5. How do you prepare for a consultation?
I never prepare anything
6. How do you describe the communication with you and the doctor in general?

I listen to what the doctor has to say and I do what he says.

This participant is an introvert patient

Role play
Comments of the participant:
- I do not have any questions. Everything is clear. If you have jaw problems and it will be solved by this surgery, everything is fine and then I do not care about facial recognition.

Questions about flyer
1. What information is after reading the flyer not clear?
For me it is all clear.
2. What information seems unnecessary?
It is all short and clear. I never read long texts, but I can read this easily and fast. The tips are clear too.
3. What information are you missing?
None
4. Do you have any tips for the appearance of the flyer?
It gives me a nice overview and it is very structured. The icons make it also clear in one view what every little text is about. The blue colour is nice and looks really calm.

On a scale from 1 to 5 (1 is very bad and 5 is very good)
1. Balance between amount of text and amount of images – 4
Comment: The text next to the patient picture is longer than the rest although I see it summarizes the outcome of the facial recognition.
2. Amount of information – 5
3. Colour combinations – 5
4. Tonation of how the text is written – 5
Comment: It is written in a transparent way, not too formal, just right.
5. This way of communicating, with a flyer during the consultation and by taking it home – 5
Participant 5
Gender: Female
Age: 22
Profession: Student communication

Patient profiling
1. Do you remember you went to see a doctor?
Yes
2. Are you someone who usually asks a lot of questions during a consultation?
Yes I ask a lot
3. When you are going home from a consultation, do you often have the feeling everything is clear?
Sometimes I still have questions but most of the time everything is clear
4. Do you write things down during the consultation?
Yes
5. How do you prepare for a consultation?
I write down all my questions and already look on the internet
6. How do you describe the communication with you and the doctor in general?
It is a partnership relationship, we always decide together

This participant is an extrovert patient

Role play
Comments of the participant:
- My mom also had a surgery because her lower jaw was too far forward, she changed a lot so I understand why facial recognition is important. She changed in a good way though, I saw pictures of her before the surgery and it looked not comfortable and she looks better now.
- It is super nice I can take this home

Questions about flyer
1. What information is after reading the flyer not clear?
For me it is all clear.
2. What information seems unnecessary?
It is all short and clear. The text is short which is nice to read and the icons make it easy to find back the information. The clock is also nice and represents the information in a clear way. I like that the things which are discussed during the consultation are written down. For me it is nice that the date of the consultation is shown so I can always look back how long it has been. Also the name of the surgeon is nice so I can search for his expertise on Google.
3. What information are you missing?
None. During the consultation it could be nice to show already that it is possible to write things down on the back of the flyer.
4. Do you have any tips for the appearance of the flyer?
No I like all of it. The colour is a nice calm colour. In the clock the red space where you are unrecognizable can feel like it is bad since red is associated with 'bad'. But I also see that it can make patients aware of the changes which are going to happen.

On a scale from 1 to 5 (1 is very bad and 5 is very good)
1. Balance between amount of text and amount of images – 5
2. Amount of information – 5
3. Colour combinations – 4
4. Tonation of how the text is written – 5
Comment: It is written in a polite way, no too formal, just right.
5. This way of communicating, with a flyer during the consultation and by taking it home – 5

Participant 6
Gender: Female
Age: 49
Profession: Barber

Patient profiling
1. Do you remember you went to see a doctor?
Yes
2. Are you someone who usually asks a lot of questions during a consultation?
I always listen.
3. When you are going home from a consultation, do you often have the feeling everything is clear?
Most of the time it is not clear.
4. Do you write things down during the consultation?
No
5. How do you prepare for a consultation?
I write down my questions .
6. How do you describe the communication with you and the doctor in general?
We talk together about it and we decide together

This participant is an introvert patient tending towards extrovert

Role play
Comments of the participant:
- But will I look better after the surgery?
Answer interviewer: Your face will be more in proportion and your mouth will look healthier. But what people perceive as beautiful is different per person.

Questions about flyer
1. What information is after reading the flyer not clear?
Everything is clear.
2. What information seems unnecessary?
For me tip 1 is unnecessary. I think it would not be so sentimental for me because I would be annoyed with my face before the surgery because I would probably not like it. So I do not want to be remembered by my

face before the surgery.
3. What information are you missing?
None.
4. Do you have any tips for the appearance of the flyer?
I like it, it looks professional. I like all the images and icons, it makes it more clear and it looks nice as well.

On a scale from 1 to 5 (1 is very bad and 5 is very good)
1. Balance between amount of text and amount of images – 5
2. Amount of information – 5
3. Colour combinations – 5
4. Tonation of how the text is written – 5
5. This way of communicating, with a flyer during the consultation and by taking it home – 5

Extra comment: Is this you on the picture? I really did not recognize you! (the interviewee is the aunt of the interviewer, the interviewers manipulated picture was put on the flyer)

Participant 7
Gender: Female
Age: 56
Profession: Lab secretary Radboud UMC

Patient profiling
1. Do you remember you went to see a doctor?
Yes, half a year ago
2. Are you someone who usually asks a lot of questions during a consultation?
I ask questions
3. When you are going home from a consultation, do you often have the feeling everything is clear?
I always still have a lot of questions
4. Do you write things down during the consultation?
No, but I put on the voice recorder
5. How do you prepare for a consultation?
I already look on the internet if I know for what I am going
6. How do you describe the communication with you and the doctor in general?
When I had a consultation for my orthognathic surgery I only listened but for other things try to discuss the treatment together

This participant is an extrovert patient

Role play
Comments of the participant:
- Clear, no questions.
- It is a shock to become unrecognizable. But will I become prettier? Why can you not tell me what happens to my face exactly?
Answer interviewer: Your face will be more in proportion and your mouth will look healthier. But what people perceive as beautiful is different per person. How your face changes exactly cannot be predicted since the soft-tissue of each patient will change differently.
- The images can work well for people who cannot read that well

Questions about flyer
1. What information is after reading the flyer not clear?
For me it is all clear.
2. What information seems unnecessary?
Nothing, I think it should all be on there.
3. What information are you missing?
About the surgery itself, but I understand in real life we already talked about it.
4. Do you have any tips for the appearance of the flyer?
No it looks professional. It is all clear and the images are good and clear. Is this the VUmc colour? Maybe you

can change it to their colour. Altough the colour looks medical and calm, which fits the purpose.

On a scale from 1 to 5 (1 is very bad and 5 is very good)
1. Balance between amount of text and amount of images – 5
2. Amount of information – 5
3. Colour combinations – 5
4. Tonation of how the text is written – 3
Comment: There are some small things you can maybe rephrase a bit like the word 'erg' (in Dutch), I think you can write this more subtle because for the patients it can feel like they change in a bad way. I will email you the things I would rephrase.
5. This way of communicating, with a flyer during the consultation and by taking it home – 5
Participant 8
Gender: Male
Age: 52
Profession: Former graphic designer, owns a webshop now

Patient profiling
1. Do you remember you went to see a doctor?
Yes, 2 weeks ago
2. Are you someone who usually asks a lot of questions during a consultation?
Yes do ask questions
3. When you are going home from a consultation, do you often have the feeling everything is clear?
I always go home with a lot of questions still
4. Do you write things down during the consultation?
No
5. How do you prepare for a consultation?
I go through all the questions in my head. Sometimes I look on the internet what it could be. But most of the time I go to the consultation and forgot to prepare.
6. How do you describe the communication with you and the doctor in general?
Before the consultation I sometimes already have in mind what it could be and I already searched information about it on the internet. I discuss my founding with the doctor. It is a partnership relationship, we always decide together.

This participant is an extrovert patient

Role play
Comments of the participant:
- Wow I think becoming unrecognizable is really a problem. But do you know if I will become more beautiful?
Answer interviewer: Your face will be more in proportion and your mouth will look healthier. But what people perceive as beautiful is different per person.
- For me it is really a problem that my face will change so much, maybe for younger people it is easier but for me in this stage of life I do not know if I would continue with the surgery.
- When you really have problems with your jaw I can see that the surgery is necessary and I see it is worth it then

Questions about flyer
1. What information is after reading the flyer not clear?
For me it is all clear.
2. What information seems unnecessary?
Nothing is unnecessary. But I think tip 2 about saying goodbye to your face is quite a shock, I would really have difficulties with this.
3. What information are you missing?
None.
4. Do you have any tips for the appearance of the flyer?
When I look to it with a graphical eye it looks good. The colour is not my taste but it is a calm and medical colour. I would change the flat images about the tips to colour images, I think this will be more clear. For me the A4 format could be improved to something which looks more luxurious. Let it print somewhere else on nice paper and make it foldable so it has some more volume. I think a surgery costs a lot of money so the

hospital can also invest money to make a more luxurious flyer.

On a scale from 1 to 5 (1 is very bad and 5 is very good)
1. Balance between amount of text and amount of images – 5
2. Amount of information – 4
Comment: You could make it look like more information by making it foldable
3. Colour combinations – 4.5
4. Tonation of how the text is written – 5
5. This way of communicating, with a flyer during the consultation and by taking it home – 5

Appendix 30: Dimension test - Steps

1. The scale of the face should be created. The face in real life (so not on the picture) in frontal view has been measured (figure A30.1).
- Height, from chin to hairline is the easiest to measure, 170 mm
From this the scale of the picture has been defined. If the height in the picture is 150. The scale is 170:150 = 1:0,9
- Width mandible line, defined with the scale which matches the real measure, 84 mm
- Width maxilla line, defined with the scale which matches the real measure, 98 mm

2. A grid has been made, with a distance of real-life 5mm. With this grid, manipulations of landmark positions can be easily done while using real dimensions (figure A30.3)

3. Photoshop has been used to create the manipulations. The photoshop file should always start with the three layers containing the face, separate landmark specified for the face and the grid. The size of the face layer and grid layer may never change, because this will influence the scale.

4. Position the grid on the landmark to change so you can measure the change in dimension. In this example, the mandible plane landmarks since the manipulation will widen the mandible.

5. Manipulate the face with the warp tool in Photoshop, explained in appendix 11, one by one according to the dimensions of figure A30.2.. 5 millimeter are the sides of one box from the grid (A30.4).
The same has been done with the picture in the frontal-lateral (FL) view and a new scale has been created. The height has been used again, from chin to hairline, which is 170 mm. The scale has been determined, this

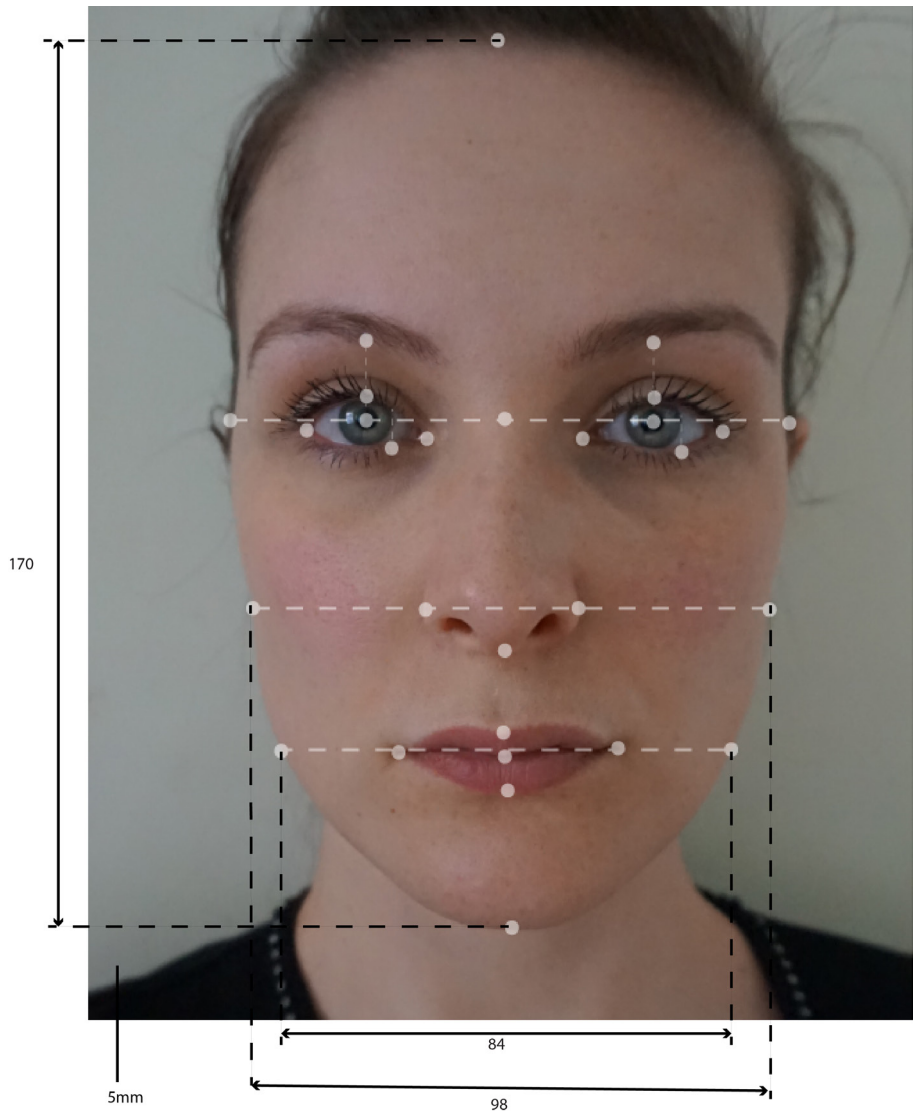


Figure A30.1: The measurements in mm of the face when the real-life scale is applied

differs per screen size. A grid has been made (figure A30.7), the sides of the boxes are 5mm in real-life. Also, landmarks and the maxilla and mandible plane have been created for this picture (Figure A30.8)

Instead of moving the landmarks straight up/down left/right, the FL view picture is manipulated oblique from one corner of a box to another in an angle of 45 degrees (Figure A30.5).

Optimizing manipulation

There has been chosen for the narrowing and widening manipulations on the mandible to not only move the outer landmarks on the mandible plane but also two outer points on the mandible, moved 3 boxes lower in the grid from the two outer landmarks. Since a orthognathic surgery would also widen/narrow the whole jaw and not only a part of it. This also gives more natural results instead of a sharp mandible.

More realistic comparison

A problem existed that the similarity score was not exceeding the threshold when single (extreme) manipulations were done while the patient data belonging to these type of manipulations did exceed the threshold.

The 'before' picture to compare with has been changed. Since the pictures in the patient data were not the same pictures and made on another day, the angle of the faces are never the same. Therefore, another picture of the same person wearing the hair almost the same was made on another day in an angle which is slightly different.The frontal picture which is used for manipulations has been compared with the new picture made (figure A30.9). They show a similarity score of 0.35. Same has been done with the frontal-lateral pictues (figure A30.10) showing a similarity score of 0.26. They are therefore seen as the same person, but the faces are not completely similar when comparing the pictures which is logical, since the angle is different and so is the expression. The same has been done with person 2.

Dimensions too big

For the up mandible (2c) manipulation, the 4th dimension of 20 mm was not possible since it was too big to fit.

Manipulation step	1	2	3	4
Dimensions of landmark movements [mm]	5	10	15	20

Figure A30.2: The manipulation steps

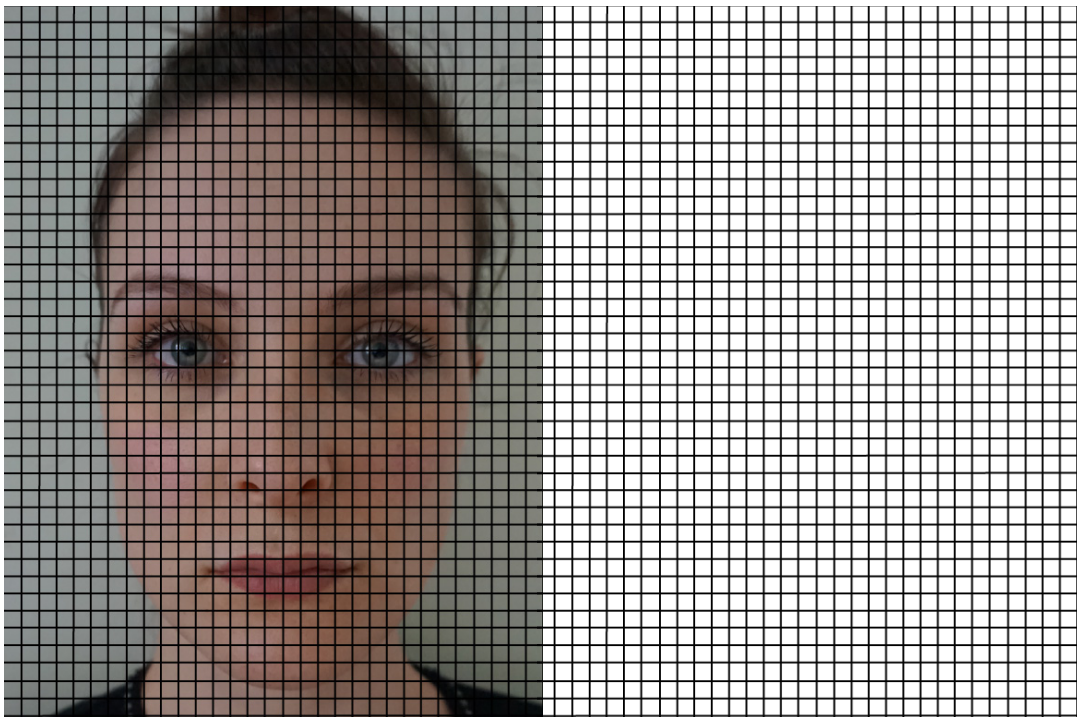


Figure A30.3: The grid with a distance of 5mm between the boxes in real life

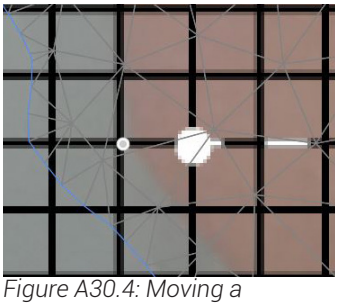


Figure A30.4: Moving a landmark 5mm to the left in the frontal view picture

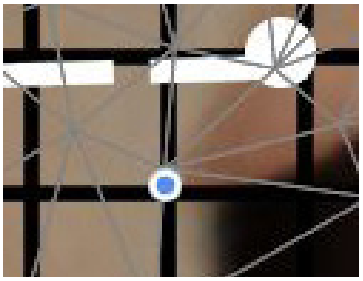


Figure A30.5 Moving a landmark 5mm to the left in the lateral view picture

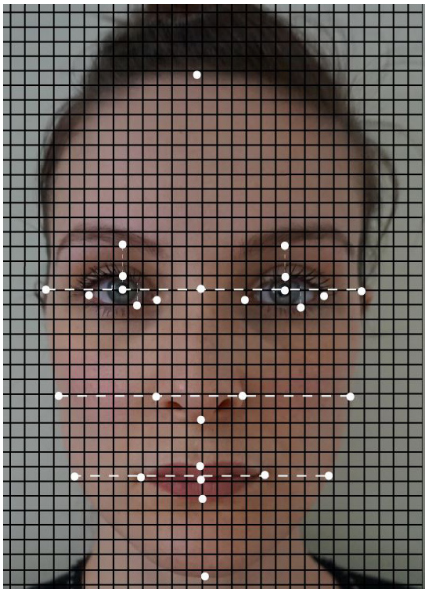


Figure A30.6 The three layers combined in Photoshop

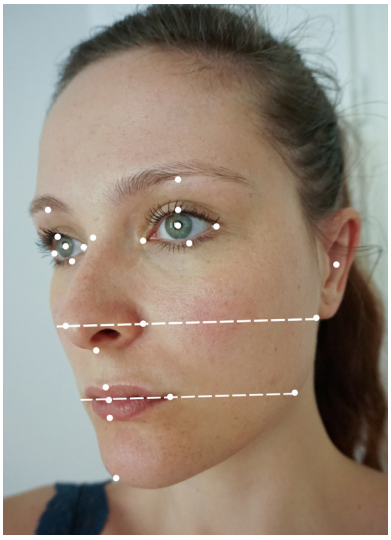


Figure A30.7: landmarks created for FL view, based on combination of frontal and lateral landmarks.

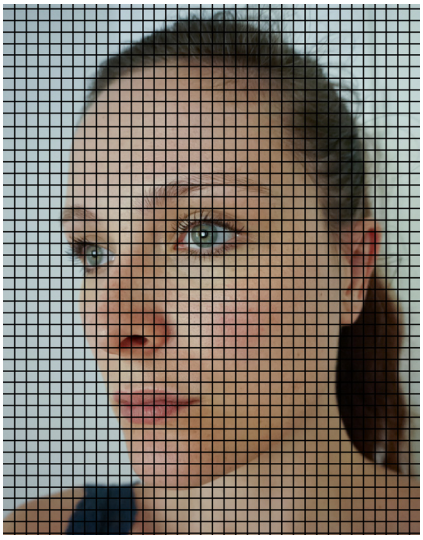


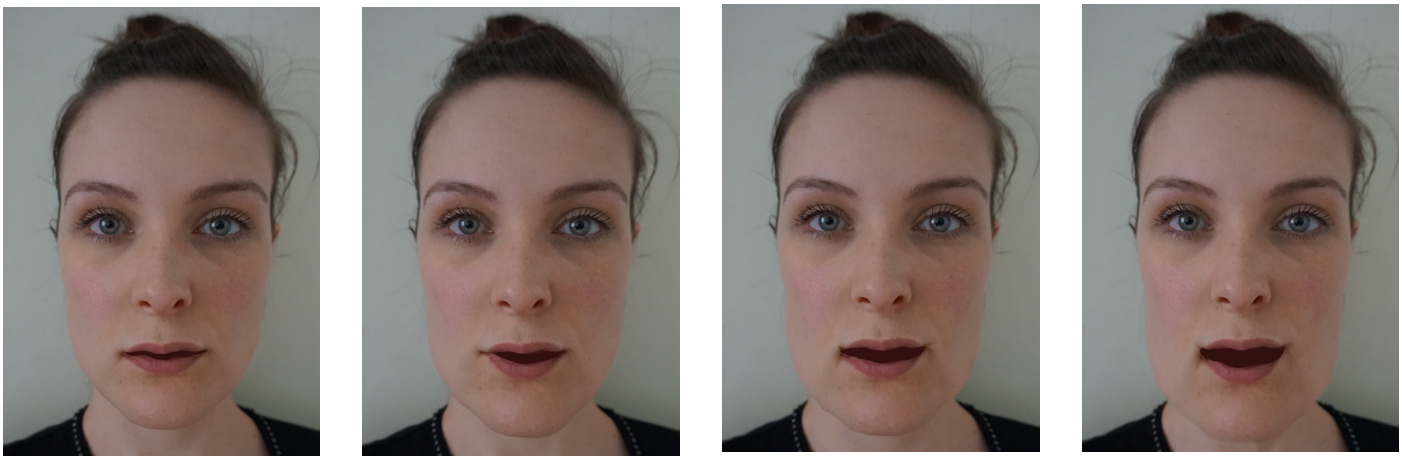
Figure A30.8 The grid of the frontal-lateral picture

Figure A30.9: On the left, the F picture used for the manipulations. On the right, the F picture used for comparing the similarity score. The similarity score of these two pictures is 0.35.

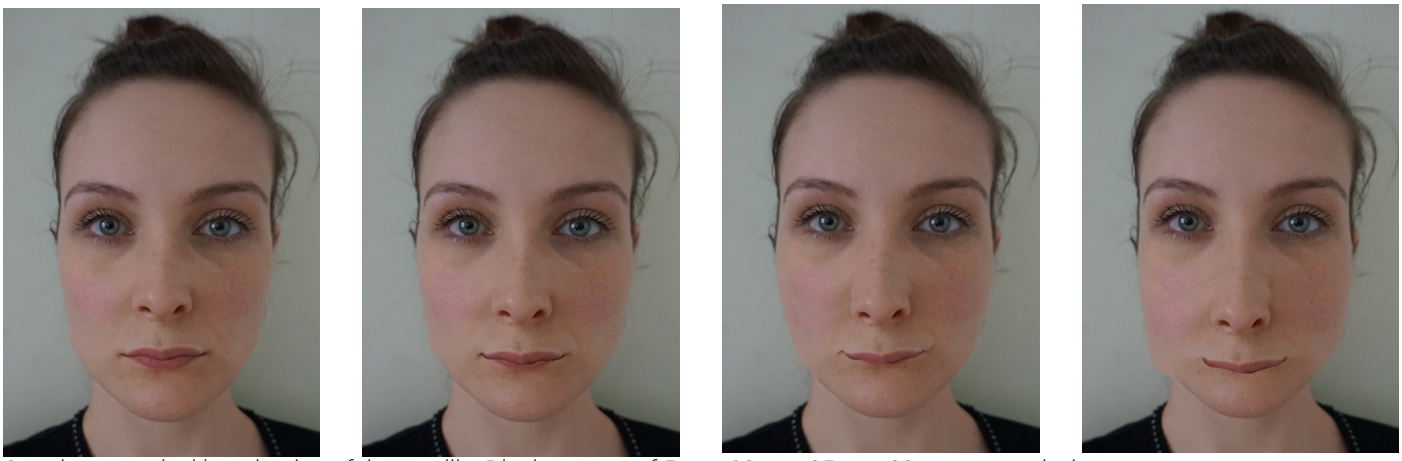
Figure A30.10: On the left, the FL picture used for the manipulations. On the right, the FL picture used for comparing the similarity score. The similarity score of these two pictures is 0.26..

Figure A30.11: Pictures of another person. On the left, the F picture used for the manipulation. On the right, the F picture used for comparing the similarity score. The similarity score of these two pictures is 0.36.

Appendix 31: Dimension test - Manipulations

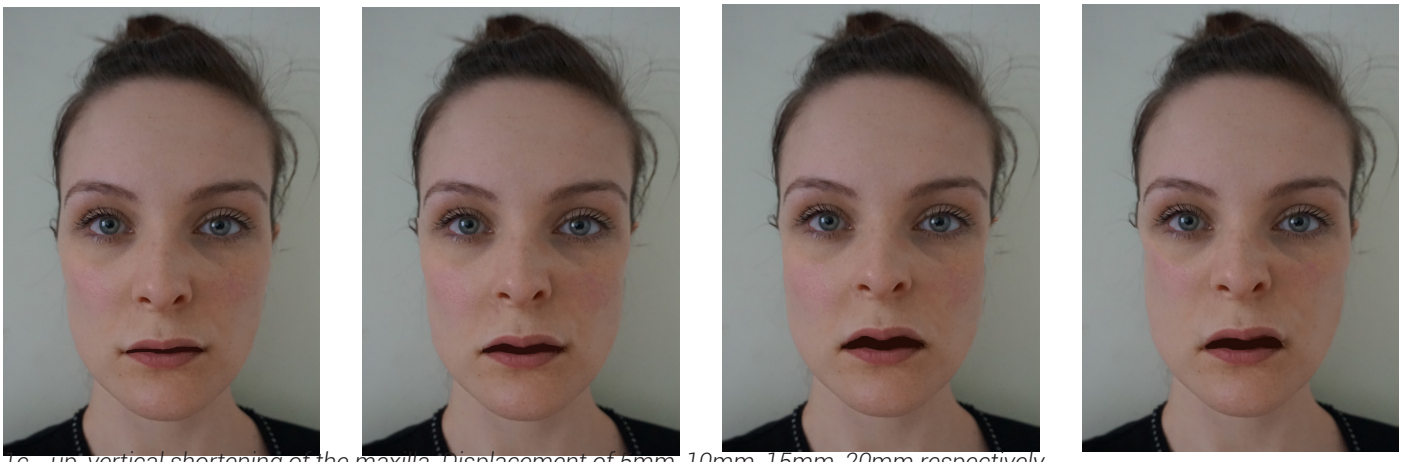


2c - down, vertical lengthening of the mandible. Displacement of 5mm, 10mm, 15mm, 20mm respectively



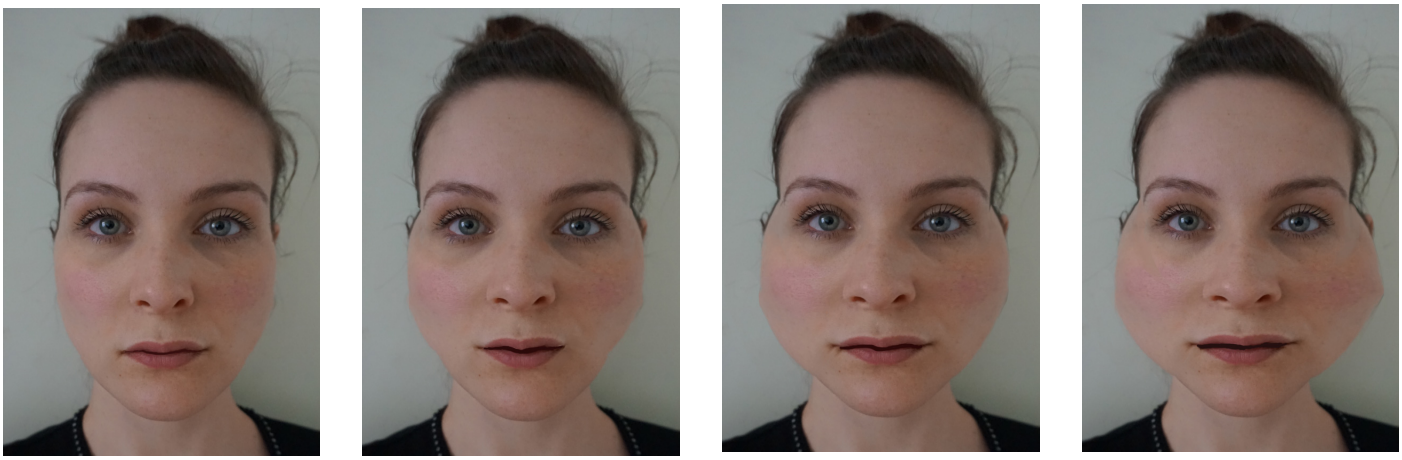
1c - down, vertical lengthening of the maxilla. Displacement of 5mm, 10mm, 15mm, 20mm respectively

2c - up, vertical shortening of the mandible. Displacement of 5mm, 10mm, 15mm, 20mm respectively

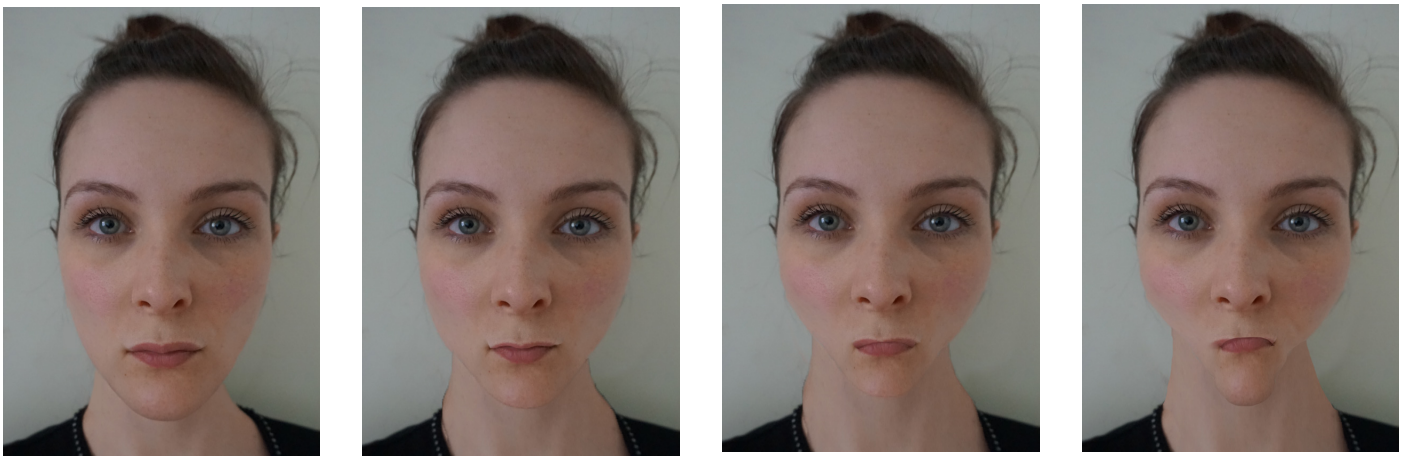


1c - up, vertical shortening of the maxilla. Displacement of 5mm, 10mm, 15mm, 20mm respectively

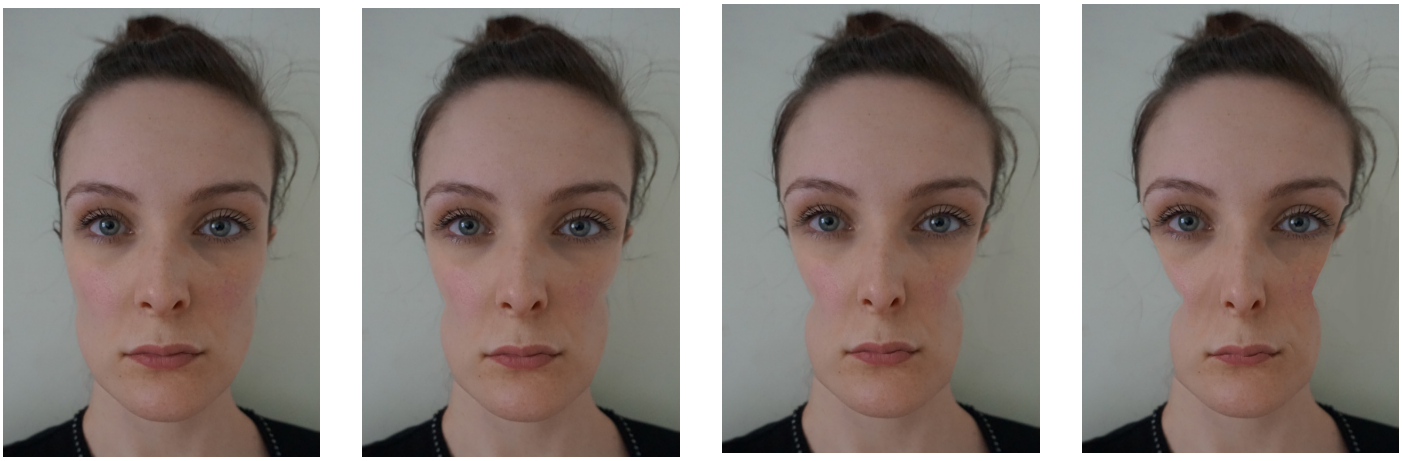
2b - widening, widening of the mandible. Displacement of 5mm, 10mm, 15mm, 20mm respectively



1b - widening, widening of the maxilla. Displacement of 5mm, 10mm, 15mm, 20mm respectively



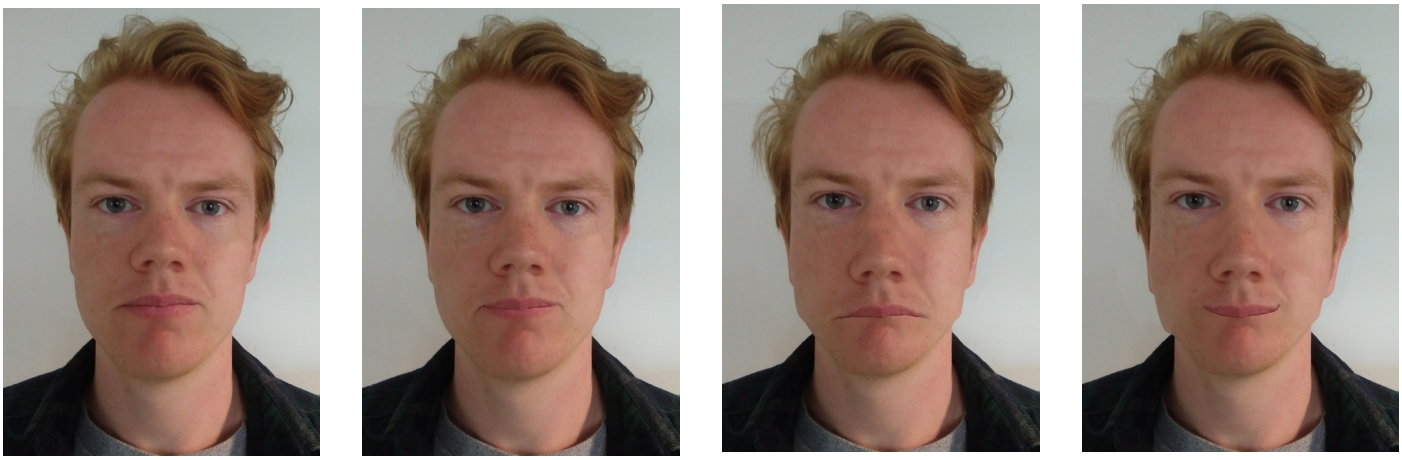
2b - narrowing, narrowing the mandible. Displacement of 5mm, 10mm, 15mm, 20mm respectively



1b - narrowing, narrowing the maxilla. Displacement of 5mm, 10mm, 15mm, 20mm respectively

1a - lengthening, horizontal lengthening of the mandible. Displacement of 5mm, 10mm, 15mm, 20mm respectively

2a - lengthening, horizontal lengthening of the maxilla. Displacement of 5mm, 10mm, 15mm, 20mm respectively



1c - down, vertical lengthening of the maxilla. Displacement of 5mm, 10mm, 15mm, 20mm respectively.
Picture of another person for comparison between different people.

Appendix 32: Patient consent to use pictures

A consent was given to patient 1 for using her pictures in chapter 12 for predicting the similarity scores.

I hereby give permission to Tamara Ribbers to use the pre- and post-surgical pictures of me in her graduation thesis.

Name: [redacted]
Date: 01/06/2020
Answer: Yes

Appendix 33: Regulations

Before the tool can be developed to implement it at the orthognathic consultations, tests with patients should be done first. This is needed to proof if prediction of the similarity score does match the actual similarity score of the pre- and post-surgical pictures. Chapter 12 shows it works on two patients, but more tests are needed to see if it works on a bigger amount of patients. After this, the tool can be either optimized or developed and implemented. The test plan for the tool can be found in chapter 13. However, patient pictures are needed to do this test and the METC (Medical Ethical Review Committee) committee of the VUMC should approve the test before it can be done. This is done to insure the well-being of the patients (T.Fouranzanfar, personal communication, June 22, 2020; VUmc, 2019). When the tool is developed, patient data including pictures need to be saved and used for the facial recognition analysis as well. Therefore, in this chapter has been looked into general regulations, METC regulations and regulations according to saving patient pictures.

General regulations
When researching, multiple regulations the hospital should follow can be found at the KNMG (Koninklijke Nederlandsche Maatschappij tot bevordering der Geneeskunst) (2019). Some of important regulations regarding implementation of the concept are:

- WGBO (Wet Geneeskundige Behandelovereenkomst): covers regulations about the starting or ending a treatment agreement, informed consent, secrecy and access to the medical records, rights for minors and incapacitated patients and good care.

- NEN 7510:2011 and 7513: Regulations about how EMR's have to be secured and protected against unauthorized use.

- AVG (Algemene Verordening Gegevensbescherming): These are regulations not only for healthcare about processing personal data.

- EGiz (Gedragscode Elektronische Gegevensuitwisseling in de Zorg): Regulations for safe electronic exchange of patient data.
All these regulations are mostly about patient data. The VUmc uses Epic as EMR (Electronic Medical Records) for saving patient data (chapter FIXME) and Epic follows the General Data Protection Regulation, (EU) 2016/679 (Epic, 2020). It is therefore assumed that their EMR does meet the other regulations for saving patient data as well. The software which should be developed for the tool and integrated in Epic should follow these regulations as well.

METC
When tests are performed by the VUmc to develop the concept, the METC regulations should be taken into account and they should review the test. Therefore, a test protocol should be written for the METC when the VUmc will perform tests. The most important regulations for testing for development of the concept are summarized. Tests at the VUmc can be divided into WMO (Scientific Human-related Research) or without WMO. Since the test requires pictures taken from the patients and since the tool will be tested as well, it will be a WMO. The METc wrote a policy procedure (appendix 34). The most important norm in this particular test from this procedure is the Norm HRP.3 ME3 part of article 12 of the WMO, which means the requirements include that sponsors protect the privacy and confidentiality of the subject data. Since data will be used in this test, this norm is important. To summarize this norm, there are three things which should be taken into account:

1. Most data will be handled in coded or anonymous form. If a researcher wants to diverge from that criteria, it must be motivated to the committee why less private forms of data handling and storage are necessary for the research.

2. Data transfer abroad is only allowed when researchers have explicit consent from the research subjects for this transfer and data sharing and data processors agreements are present.

3. The human subject information form (PIF) also needs to contain information about the privacy legislation and how the sponsor protects their privacy

The tool is not a medical device, so the CE quality marks do not have to be taken into account. These are the key-points of the policy procedure which are relevant for the tool:
- The privacy and confidential data of patients is protected
- The researcher is qualified to perform the test
- The researcher is responsible for the design,

implementation and completion of the research.
- Financially and logistically it should be feasible.
- The recourses and facilities that support the research program are identified
- Patients are informed about the research, test, privacy and consent is asked.
- VUmc employees are permitted to participate
- Requirements for managing conflicts of interest, both financial and non-financial should be followed
- All medical science research should be reviewed

Patient pictures

When pictures of people who are recognizable are made and saved online, the AVG regulations apply. The photographer should ask consent to the photographed person. This also applies to patients in the hospital (Nederlandse Vereniging van Journalisten , 2018; KNMG, 2019). When the concept is tested or implemented, the picture is made where after it is saved online all the regulations from this chapter need to be applied. Unfortunately, it is not known how the VUmc deals with recognizable patient pictures. In the past, their pre- and post-surgical patient pictures of the orthognathic department were printed and saved physically in an office, the same happened with paper patient reports which are now digitalised. To show how other medical facilities treat online recognizable patient pictures, personal experiences are shown and some research has been done at other medical facilities.

It is known by searching and by personal experiences, is that orthodontists in the Netherlands do make patient pictures. Because of the COVID-19, some orthodontists ask patients to make pictures of their whole face themselves and to send it to them via email (Opdebeeck Orthodontie, 2020). It is unknown if this is happening according to regulations. Personal experiences in the hospitals of Reinier de Graaf, Rijnstate and Utrecht UMC in the Netherlands, show that these hospitals do save patient pictures. Reinier de Graaf saves one picture in their digital system and prints it on the patient pass to identify the patient. Rijnstate did save patient pictures digitally before and after the surgery at their orthognathic department in 2008. Utrecht UMC did make patient pictures at the plastic surgery department and saved it digitally in 2009. It is expected that surgeries or treatments where the face is involved (e.g. orthodontists, orthognathic surgeries, plastic surgery) do need patient pictures to obtain enough information to perform the treatment or surgery, also at these departments in the VUmc.
The information at the VUmc about the EPD (Elektronisch Patientendossier), called EVA in the VUmc (Dorresteijn. 2015), which is the digital patient report, does not mention anything about patient pictures (VUmc, 2019). However, other hospitals like Groene Hart Ziekenhuis (n.d.), mention the EPD could contain patient pictures which are made during the treatment. It is therefore expected that regulations allow hospitals to save patient pictures in their EPD.

Appendix 34: Regulations - METC

RESEARCH REVIEW PROCESS POLICIES METC VUMC – based on JCI standards

Of all standards in which the Medical Ethical Review Committee (METc) of VUmc is involved the role and policy of the METc VUmc is described. This document will be used to write a Dutch Standard Operating Procedures (SOP) document that describes the entire process of a research review by the METc VUmc. This document is still under construction.

THE JCI STANDARDS

Norm HPR.1 ME4 → Hospital leadership assumes responsibility for patient protection irrespective of the sponsor of the research

The Hospital Board is responsible for all scientific research involving human subjects that is carried out at VUmc. VUmc researchers and physicians remain responsible for their actions and protection of the patients, regardless of who the sponsor of the research is. The principle investigator is responsible for the design, implementation and completion of the research (according to articles 8-12 of the Medical Research Involving Human Subjects Act (hereafter WMO)).

Norm HRP.1.1 ME1 → Hospital leadership recognizes and establishes mechanisms for compliance with all regulatory and professional requirements related to research.

According to the WMO all research with humans that subjects persons to research actions or interventions or that impose behavior, should be reviewed by an accredited committee. According to this legal task the METc VUmc reviews research proposals. In addition to her legal task, the METc also fulfills an advising role; she helps researches to comply with regulatory and professional requirements by advising through her website, e-mail, phone or personal contact, see website METc.

Norm HRP.1.1 ME2 → Hospital leadership has a process for budgeting to provide adequate resources for effective operation of the research program

The METc considers research that cannot be performed or that cannot be completed unethical, she wants to ascertain that the research is financially and logistically feasible. Therefore, she requires a signature of the department head as well as the business manager of the concerning division on the submission letter. With their signature, they acknowledge that the department has adequate facilities to carry out the research. If research involves medical imaging, the department of Radiology and Nuclear Medicine needs to sign the submission letter or research protocol as well to assure that scanning costs are covered and scanning time and personnel is available

Resources: *- submission letter (see website)*

Norm HRP.1.1 ME3 → Hospital leadership provides or ensures that there is adequate indemnity insurance to compensate patients participating in clinical research who experience and adverse event

The WMO specifies that a 'WMO-research subject insurance' must be taken out for research. The insurance must provide coverage for any unexpected injury or adverse event resulting from the research. Since 15 July 2015, it is the responsibility of the sponsor (initiator) of the research to take care of the 'WMO-research subject insurance' for all participating centres in the study. Researchers need to submit information about the 'WMO-research subject insurance' to the METc (according to article 7 of the WMO). Under certain conditions, exemption from the 'WMO-research subject insurance' is possible. When the researcher has the opinion that the research involves no or minor risks, they can request the METC to grant exemption from the 'WMO-research subject insurance' (according to article 7, clause 5 of the WMO). The committee will decide whether exemption is allowed. The certificate of the 'WMO-research subject insurance' needs to be submitted to the METC. If a commercial partner (e.g. pharmaceutical industry) is the sponsor of the research, the

policy conditions must be added. At all times, a liability insurance needs to be present for all participating centres (locations).

Resources: - *insurance policies VUmc by Centramed (see website)*
- *website METc VUmc: verzekeringen*

Norm HRP.2 ME2 → Hospital leadership identifies the facilities and resources that support the research program

The METc belongs to the staff service 'Research support' of VUmc. The METC reviews protocols from her legal task and advises researchers from her supportive task.

Norm HRP.2 ME3 → Hospital leadership identifies the qualifications of staff permitted to participate in the research program as principal investigator or other members of the research team.

Norm HRP.2 ME4 → There is documentation of the qualification of staff permitted to participate in the research program

According to the WMO, research must be conducted in appropriate institutions and by, or under the supervision of, persons with appropriate training in scientific clinical research, of whom at least one is an expert in the procedures that will be carried out in or with the human subject (according to article 3, clause f; article 13, clause c and d of the WMO). The METc VUmc assesses if the researcher(s) are competent in carrying out the research that is being reviewed on the basis of their curriculum vitae (CV). Furthermore, the METc VUmc checks if every researcher involved in the research protocol has a BROK certificate, in accordance with the NFU advice "Kwaliteitsborging mensgebonden onderzoek 2.0".
Information about the BROK needs to be indicated on the submission letter. CV's and submission letters become part of the METc file and stored conform METc VUmc requirements.

Resources: - checklist 'indienen WMO', see website METc
- submission letter WMO, see website METc
- BROK, see website METc

Norm HRP.2 ME5 → Hospital leadership identifies those circumstances in which staff can serve as research subjects

VUmc employees cannot participate as healthy subjects or as patients in scientific research carried out by their own department because of dependence in the work relation and impossibility to ensure consent is given freely. VUmc employees are permitted to participate in scientific research of other departments under the condition that there was no undue inducement or relationship of dependence between the employee and the researchers and the employee in question was free to decide on participating in the research (according to article 5 of the WMO). In cases like this, the METc VUmc therefore demands an open passive recruitment strategy, for example by posters. The incentive to participate must lie with the employee.

Norm HRP.3 ME2 → The requirements include that sponsors use research teams that are trained and qualified to conduct the research

For sponsored research the METc VUmc demands the same requirements as for investigator initiated research (see HRP.2 ME3 en ME4). In addition, a VUmc researcher has to be involved in research performed in VUmc, otherwise the METc VUmc and Hospital Board will not allow the research (to be performed in VUmc).

Norm HRP.3 ME3 → The requirements include that sponsors protect the privacy and confidentiality of the subject data

policy conditions must be added. At all times, a liability insurance needs to be present for all participating centres (locations).

Resources: - *insurance policies VUmc by Centramed (see website)*
- *website METc VUmc: verzekeringen*

Norm HRP.2 ME2 → Hospital leadership identifies the facilities and resources that support the research program

The METc belongs to the staff service 'Research support' of VUmc. The METC reviews protocols from her legal task and advises researchers from her supportive task.

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Norm HRP.2 ME4 → There is documentation of the qualification of staff permitted to participate in the research program

According to the WMO, research must be conducted in appropriate institutions and by, or under the supervision of, persons with appropriate training in scientific clinical research, of whom at least one is an expert in the procedures that will be carried out in or with the human subject (according to article 3, clause f; article 13, clause c and d of the WMO). The METc VUmc assesses if the researcher(s) are competent in carrying out the research that is being reviewed on the basis of their curriculum vitae (CV). Furthermore, the METc VUmc checks if every researcher involved in the research protocol has a BROK certificate, in accordance with the NFU advice "Kwaliteitsborging mensgebonden onderzoek 2.0".
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Resources: - checklist 'indienen WMO', see website METc
- submission letter WMO, see website METc
- BROK, see website METc

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Norm HRP.3 ME3 → The requirements include that sponsors protect the privacy and confidentiality of the subject data

Norm HRP.4 ME3 → Hospital leadership specifies the requirements of entities outside of the hospital that provide all or a portion of the research review function, such as a contract research organization

Research initiated by VUmc or primarily performed in VUmc must be submitted for review to the METc VUmc. If clinical research involving human subjects is initiated by a sponsor other than the VUmc and there are more participating centres than VUmc, the initiating party is free to choose a different recognized METC. After approval of a recognized METC, the research needs the permission of the Hospital Leadership.

Norm HRP.4 ME4 → Hospital leadership ensures research that is exempt from the research review process is identified

Hospital leadership has decided that all medical scientific research that is initiated by VUmc or performed primarily in VUmc, must be reviewed. Depending on the nature of the research, WMO protocols are reviewed by the CCMO or by a recognized METC. Research that is reviewed by a different recognized METC will need the permission of the VUmc Hospital Board to be performed in VUmc. This permission is given with a 'lokale uitvoerbaarheidsverklaring', which - at the request of the Hospital Board – is provided by the METc VUmc. Requests to start a collection of patient material for future research and the release of this material for actual research questions, is reviewed by the Review Committee for Biobanks (TcB) of VUmc. All other research with humans is called 'non-WMO research' and is reviewed by the Executive Board of the METc, according to relevant laws and regulations such as the GDPR and Medical Treatment Contracts Act (WGBO). Therefore, no research is exempt from review, only different review procedures are followed. Criteria for WMO research, biobanks and 'non-WMO research' are provided by the METc.

Resources: *'Beslisboom niet WMO-onderzoek', see website METc*
'Flowchart Biobank', see website METc
'niet-WMO onderzoek' see website METc
'Biobank', see website METc

Norm HRP.4 ME5 → Hospital leadership specifies the requirements for documentation of the activates of the research review function

With the exception of the CCMO, there is no party that can impose requirements with regard to which documents needs to be documented by the METc VUmc for WMO research. Documenting the research file of WMO research review is a requirement of the Dutch Archives Act and the 'Basis selectielijst METC's'. It determines the documents that need to be stored, the way the documents need to be stored and the duration of storage. Documenting the file of a local feasibility (lokale uitvoerbaarheid LU) request, biobank research and non-WMO research is a request of the Archives Act, the GDPR, and the VUmc Hospital board. All documents that are related to a review of WMO research, non-WMO research or biobank by the METc VUmc, TcB VUmc or EB of the METc VUmc, are filed in the METc's document management system: Corsa.

Norm HRP.4 ME6 → Hospital Leadership provides for a review of all research review processes at least annually

The METc VUmc is an independent review body. With the exception of the CCMO, there is no party that can impose requirements with regard to the research review processes of the METc VUmc. By law, the CCMO is responsible for the supervision of the tasks, composition, and working procedure of the METc VUmc. Accordingly, the METc submits its annual report and revised official regulations to the CCMO. The METc registers information about its reviews via Toetsing Online (national accessible internet portal of the CCMO). The CCMO uses this information to continually monitor the activities of all recognized committees. The CCMO also performs audits to randomly monitor the activities of recognized committees. The METc VUmc annually sends an overview of her review activities to the Hospital board. Twice a year the METc conducts a self-evaluation and asks all its

members to fill in an evaluation form. Additionally, the METc asks researchers to evaluate the experiences with METc VUmc on a continuous basis. The METc VUmc uses these two evaluations to improve her procedures, her advisory role and the information she offers.

Norm HRP.6 ME1 → The research program is a component of the hospital's processes to report and act on sentinel events adverse events of other types and the processes to learn from near misses

In accordance with article 10 of the WMO and the GCP, all Serious Adverse Events (SAE's) and Suspected Unexpected Serious Adverse Reactions (SUSAR's) must be reported to the METC according to the procedures stated in the protocol. The sponsor must report the SAE's to the METC within 7 days of first knowledge for SAE's that result in death or are life threatening followed by a period of maximum 8 days to complete the initial preliminary report. All other SAE's must be reported within a period of maximum 15 days after the sponsor has first knowledge of the SAE, unless otherwise stated in the protocol. In Investigator initiated research, the SAE's and SUSAR's must be reported through ToetsingOnline. The researchers need to submit an annual progress report and for drug studies additionally an annual safety report, to the METC. When, during the research, there are good reasons to assume that continuation of the research would lead to unacceptable risks for the subjects, the sponsor of the research shall suspend the execution of the research until a further positive judgment has been obtained from the METC. When a DSMB is installed for the research, the METC needs to be informed about interim analyses and other relevant decisions of the DSMB. In case monitoring by the CRB leads to a second 'inadequate' monitoring report conclusion, the METc VUmc is informed by the CRB to come to a mutual action plan.

Resources: *Voortgangsrapportage, see website METc*
Veiligheidsrapportage, see website METc
SOP 'Opschalen CRB naar METc VUmc en RvB', see Kwaliteitsnet CRB

Norm HRP.6 ME2 → The research program is included in the hospital's programs for hazardous material management, medical equipment management, and medication management

A clinical physicist (who is a member of the METc VUmc), reviews the research protocols on the basis of the medical device directive with a focus on the safety of the medical device. Research involving medical devices that do not have a CE quality mark or will be used for purposes other than the intended use (off-label), must meet the following requirements:

1) *the researchers need to deliver an Investigational Medical Device Dossier (IMDD) to the METc Vumc.*
2) *the researchers need to have approval from the medical technology department of the VUmc to use the medical device.*
3) *the researchers must register the medical device with the inspection health care and youth (IGJ).*

Researchers submitting a research protocol involving medical devices that do have a CE quality mark need to provide evidence of the CE quality mark to the MEC.

A pharmacologist (who is a member of the METc VUmc), reviews the research protocols on the basis of the medicine directive with a focus on the safety of the medicinal product. The pharmacologist reviews the drug labels and production licenses for every drug used in the research protocol. Research involving non-registered drugs or drugs that will be used for off-label purposes, must meet the following requirements for product information:

1) *the researchers need to deliver an Investigational Medical Product Dossier (IMPD) to the METC.*

2) *the researchers need to deliver an Investigator's Brochure (IB) to the METC. The IB includes, among other things, information on the dose of the study drug, the frequency of dosing interval, methods of administration and safety monitoring procedures.*

For research involving registered drugs, the researchers need to deliver a Summary of Product Characteristics (SPC) to the METC. The SPC is a specific document required within the European Commission before any medicinal product or biocidal product is authorized for marketing.

A radiation expert (who is a member of the METc VUmc), reviews every protocol that involves radiation with a focus on radiation safety. The radiation expert reviews the research protocols on the basis of the medical exposure directive and on the basis of the European radiation protection guidelines. These guidelines include the following documents:

1) *Radiation Protection 102: Implementation of the "Medical Exposure Directive" (97/43/Euratom).*
2) *Radiation Protection 116: Guidelines on education and training in radiation protection for medical exposures.*
3) *Radiation Protection 109: Guidance on diagnostic reference levels (DRLs) for medical exposures.*
4) *Radiation Protection 100: Guidance for protection of unborn children and infants irradiated due to parental medical exposures.*
5) *Radiation protection 118: Guidelines for referral to imaging research.*
6) *Radiation protection 91: Criteria for the acceptability of equipment for Radiology (including Radiotherapy) and Nuclear Medicine.*
7) *Radiation protection 97: Radiation protection after iodine-131 therapy (exposure by outpatients or discharged clinical patients).*
8) *Radiation Protection 136: European guidelines on radiation protection in dental radiology (the safe use of radiographs in dental practice).*
9) *Radiation Protection 154: European Guidance on Estimating Population Doses from Medical X-ray Procedures.*
10) *EUR 19793: Optimisation of Protection in the Medical Uses of Radiation*
11) *EUR 16260 EN: European Guidelines on Quality Criteria for Diagnostic Radiographic Images.*
12) *EUR 16261 EN: European guidelines for quality criteria for diagnostic radiographic images in paediatrics.*
13) *EUR 16262 EN: European Guidelines on Quality Criteria for computed tomography.*
14) *EUREF, 2001: European Guidelines for Quality Assurance in Mammography Screening (Third edition).*

(see:https://www.rivm.nl/Onderwerpen/M/Medische_Stralingstoepassingen/Trends_en_stand_van_zaken/Wetgeving_en_richtlijnen/Europese_Aanbevelingen).

The METc VUmc demands that the radiation is described in the ICF, in a comprehensible and honest way, conform the CCMO format.

Resources: - *Proefpersoneninformatie en toestemmingsformulier', the CCMO format for the ICF, see website METc*

Norm HRP.7 ME1 Patients asked to participate are informed about the research, duration of patient's participation, procedures to be followed, and who to contact with questions about the research

Norm HRP.7 ME2 Patients asked to participate are informed about the expected benefits, potential risks, and alternative treatments and procedures that might help them

Norm HRP.7 ME3 Patients asked to participate are informed about the extent to which confidentiality of records will be maintained

Norm HRP.7 ME4: Patients asked to participate are informed about the compensation or medical treatments available if injury occurs

Norm HRP.7 ME5: Patients asked to participate are assured that participation is voluntary and refusal to participate or withdrawal at anytime will not compromise care or access to hospital services

Norm HRP.7 ME6: Through the research review function the hospital establishes and implements how consent for participation will be obtained and documented and under which circumstances consent will be obtained again during the research

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All JCI required elements are also legal requirements of the WMO. The METC reviews the Human Subjects Information Form (PIF) and the Consent Form (CF), together called the Informed Consent Form (ICF). According to article 6, clause 5 of the WMO, the METC has to approve the ICF before it can be used. The METC also needs to approve all recruitment material and other information that possible participants will see.

The CCMO has provided a format ICF (see http://www.ccmo.nl/nl/standaardonderzoeksdossier-1). The METc VUmc insists that researchers use this format. According to article 6, clause 5 and article 9 of the WMO, the PIF is legally required to include the following information: 1. The purpose, the nature and the duration of the research; 2. The risks that the research would entail for the health of the research subject; 3. The risks that an interim termination of the research would entail for the health of the research subject; 4. The burden that the research could have on the research subject. In compliance with the guideline for Good Clinical Practice (GCP), the ICF is required to state the following:

(a) That the trial involves research.

(b) The purpose of the trial.

(c) The trial treatment(s) and the probability for random assignment to each treatment.

(d) The trial procedures to be followed, including all invasive procedures.

(e) The subject's responsibilities.

(f) Those aspects of the trial that are experimental.

(g) The reasonably foreseeable risks or inconveniences to the subject and, when applicable, to an embryo, foetus, or nursing infant.

(h) The reasonably expected benefits. When there is no intended clinical benefit to the subject, the subject should be made aware of this.

(i) The alternative procedure(s) or course(s) of treatment that may be available to the subject, and their important potential benefits and risks.

(j) The compensation and/or treatment available to the subject in the event of trial-related injury.

(k) The anticipated prorated payment, if any, to the subject for participating in the trial.

(l) The anticipated expenses, if any, to the subject for participating in the trial.

(m) That the subject's participation in the trial is voluntary and that the subject may refuse to participate or withdraw from the trial, at any time, without penalty or loss of benefits to which the subject is otherwise entitled.

(n) That the monitor(s), the auditor(s), the IRB/IEC, and the regulatory authority(ies) will be granted direct access to the subject's original medical records for verification of clinical trial procedures and/or data, without violating the confidentiality of the subject, to the extent permitted by the applicable laws and regulation and that, by signing a written informed consent form, the subject or the subject's legally acceptable representative is authorizing such access.

(o)That the records identifying the subject will be kept confidential and, to the extent permitted by the applicable laws and/or regulations, will not be made publicly available. If the results of the trial are published, the subject's identity will remain confidential.

(p) That the subject or the subject's legally acceptable representative will be informed in a timely manner if information becomes available that may be relevant to the subject's willingness to continue participation in the trial.

(q) The person(s) to contact for further information regarding the trial and the rights of trial subjects, and whom to contact in the event of trial-related injury.

(r) The foreseeable circumstances and/or reasons under which the subject's participation in the trial may be terminated.

(s) The expected duration of the subject's participation in the trial.
(t) The approximate number of subjects involved in the trial.

Resources: *ICF CCMO format, see website METc*

7.ME1: Conform the WMO, the ICF must include information about the research that will be executed, the duration of the participation, procedures that must be followed and who can be contacted with questions about the research.
7.ME2: Conform the WMO, the ICF must include information about the expected benefits of the research, possible risks of the research and alternative treatments and procedures that may also benefit the research subject.
7.ME3: Conform the WMO, the ICF must state to what extent patient files and data will remain confidential during the research. The PIF must state and explain to which extent data will be coded and what the retention period of the data is.
7.ME4: Conform the WMO, the ICF must include information about compensation for injuries that occur on account of the research. If the research needs an WMO subject insurance, an insurance appendix needs to be included in the ICF.
7.ME5: Conform the WMO, the ICF must state that participation is voluntary and that refusal to participate or termination of participation at any time, never jeopardizes the quality of care the patient receives and the access the patient has to the services of the hospital.
7.ME6: The METC reviews how the consent procedure is carried out and keeps in mind the legal requirements and ethical aspects. The consent procedure must be documented in the research protocol and the ABR-form. If any changes are made to the study protocol by the researchers, an amendment must be submitted to the METC and the METC reviews all revised documents (as established in the WMO, article 13k). If any changes are made to the study protocol that have consequences for the demands or stress imposed on the research subject or the research subject's safety or if additional information becomes available that could influence the participation of the research subject, the researcher must submit an amendment of the protocol and ICF to the METC. Changes cannot be carried out without approval of the amendment.

Norm HRP.7.1 ME1 → Patients and families are identified and informed about how to gain access to clinical research, clinical investigations, or clinical trials relevant to their treatment needs.

The METc VUmc always considers the recruitment strategy to ensure every eligible patient has access to the study and no bias can arise.

Norm HRP.7.1 ME2 → Through the review function, the hospital established and implements safeguards to protect the safety, rights, and well-being of vulnerable patients, including children, prisoners, pregnant women, persons or are mentally disabled, persons who are economically or educationally disadvantaged, and other who may be at risk for coercion or undies influence

Article 4, 5 and 6 of the WMO set out the requirements that research with above-mentioned vulnerable groups must comply with. Research with incompetent subjects (e.g. children under the age of 16 years, people with advanced dementia or some mentally disabled people) is forbidden unless the research therapeutically beneficial to the subject or it needs to be impossible to carry out the research without cooperation of these subjects (group affiliation, 'groepsgebondenheid'). In the case of non-therapeutic research involving incompetent research subjects, there are additional requirements of minimal risk and burden in comparison to the standard treatment and the subject does not resist during the research (articles 4 and 6 of the WMO). The METC evaluates whether the protocol and other documents meet these requirements and evaluates the arguments to include the specific group of research subjects, the 'groepsgebondenheid'. Incompetent research subjects are entitled to receive information appropriate to their level of comprehension and, when possible, their assent must be obtained. When scientific research can only be carried out in emergency

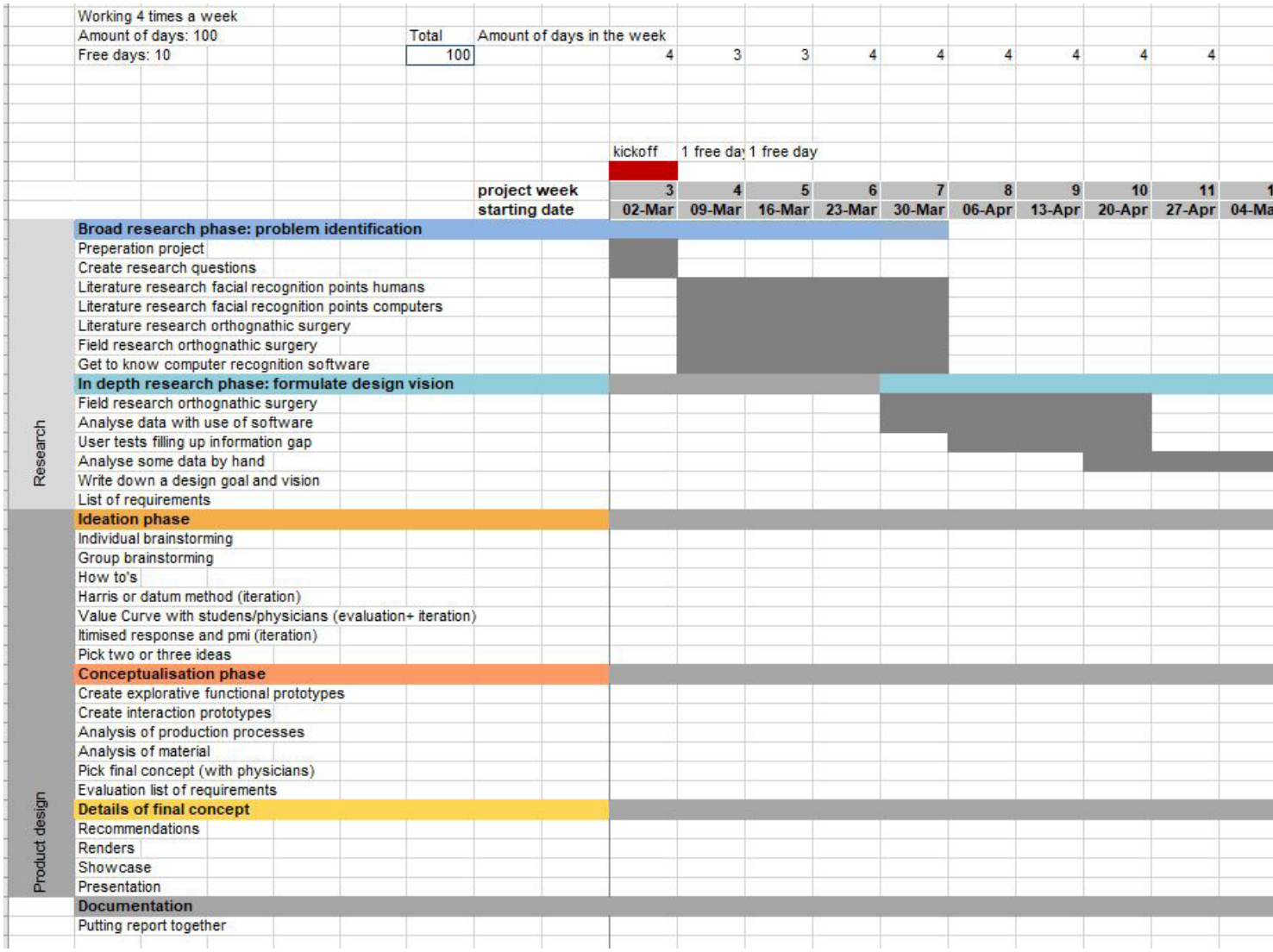
situations in which consent required cannot be obtained and the research can benefit the person who is in the emergency situation, the research may be carried out without consent of the research subject as long as the circumstances prevent the researchers from obtaining consent (according to article 6, clause 4 of the WMO). That means that explicit written consent from the research subject is requested when the research subject becomes competent during or after the research. In all cases, a legal representative must give permission for the participation of the incompetent subject. Incompetent subjects must be distinguished from other vulnerable subjects such as those who have a relationship of dependency with the researcher who takes care of the recruitment, the researcher that performs the research or the sponsor. Research subjects that have a relationship of dependency are, for example: soldiers, prisoners, research subjects that are recruited by their attending physician, students who are recruited by a professor or employees of a particular company or a particular organization recruited by a supervisor. The WMO has similar demands for this group of subjects (WMO, article 5). In addition to the WMO, the GDPR states that there needs to be a fundamental base to use data for research. Normally, consent is a valid base, but in the case of a relationship of dependency, it cannot be proven that consent was given freely. Therefore, consent is no fundamental base for the inclusion in research in the case of relationship dependency. The METc VUmc is especially critical when the research under review involves these kind of groups. She evaluates the burden for the research subjects, how voluntary the participation of the research subjects is, the apprehension level of the research subjects, and the extent of the dependency of the relationship. The METc VUmc will always carefully consider whether the expected benefits of the research are in proportion to the expected risks and burden for the research subjects and if the PIF is completely clear about the (non-) therapeutic nature of the research. The CCMO reviews all non-therapeutic intervention research that involves incompetent research subjects or children.

Norm HRP.7.1 ME3 → Through the review function, the hospital establishes and implements safeguards to protect the safety, rights, and well-being of hospital staff who may be at risk for coercion or undue influences.

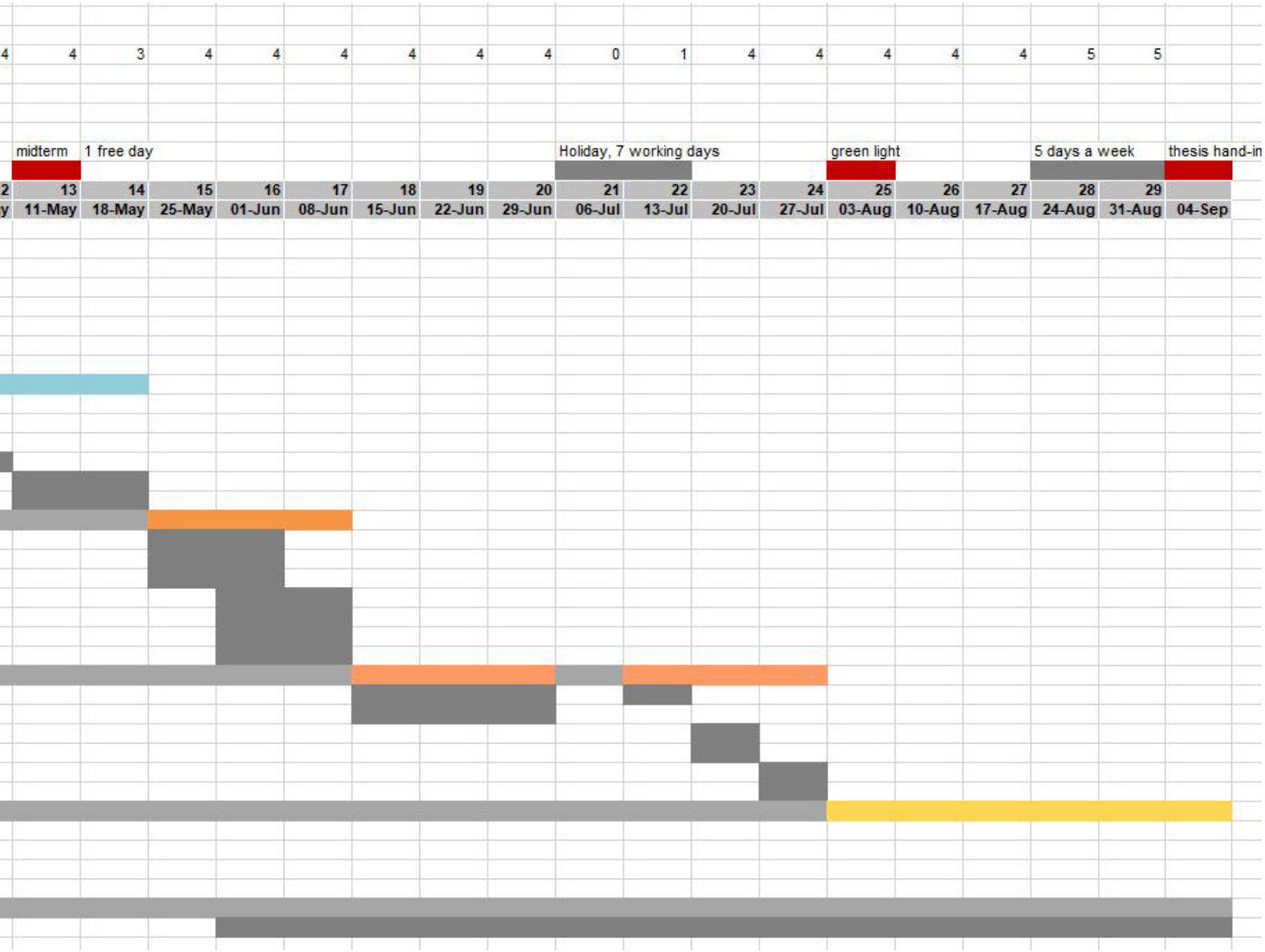
The METc reviews the independence of the research with respect to sponsor and research integrity and the possibility for hospital staff to refuse participation. VUmc employees cannot participate as healthy subjects or as patients in scientific research carried out by their own department. VUmc employees are permitted to participate in scientific research of other departments on the condition that the recruitment is passively and informed consent is obtained (according to article 5 of the WMO). Researchers may not actively approach potential research subjects, but can use passive recruitment strategies such as leaving leaflets in the VUmc. Subsequently, the potential subjects needs to show initiative, e.g. contact the researcher, to participate.

Others

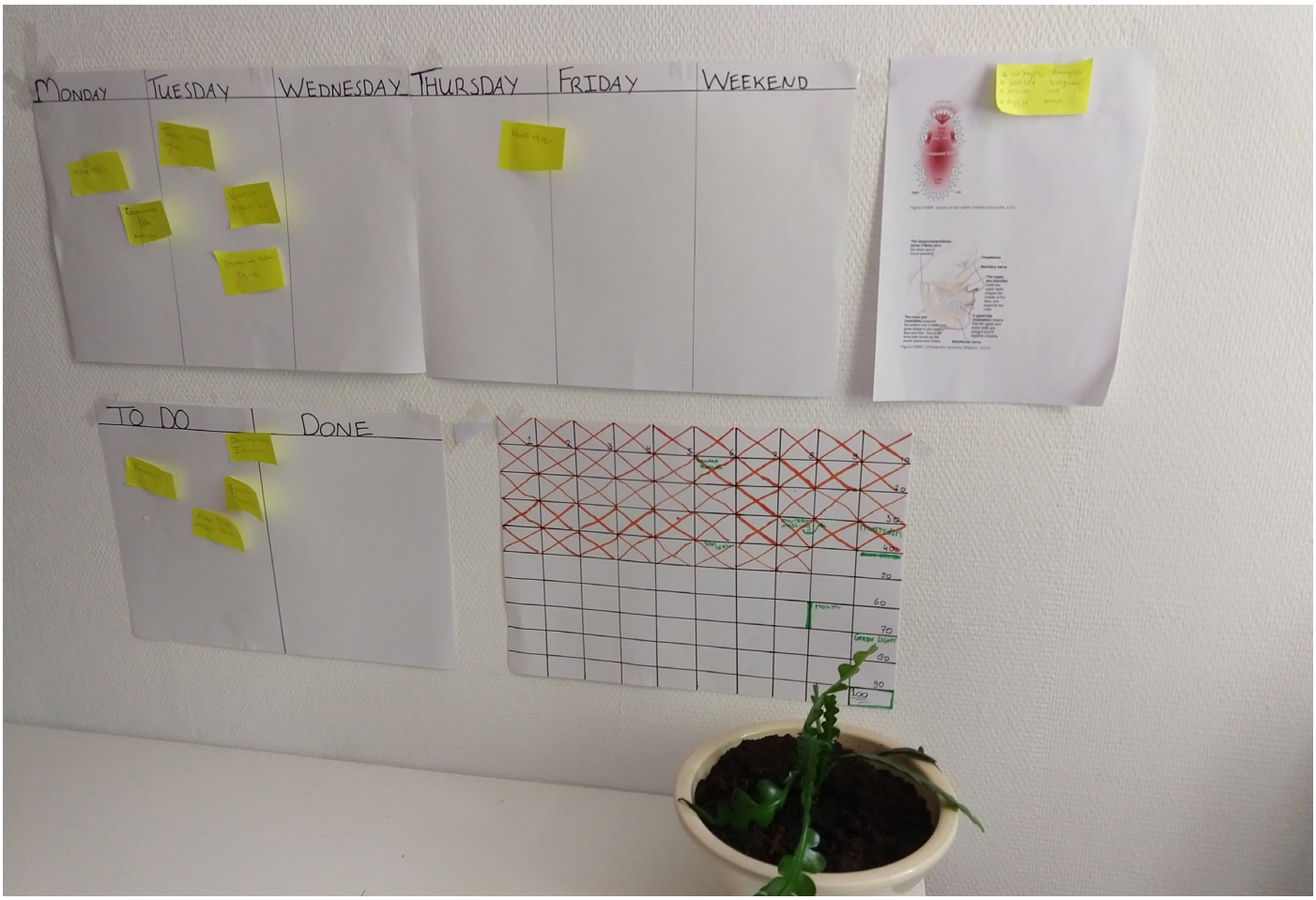
Appendix 35: Overall-planning



	Working 4 times a week													
	Amount of days: 100	Total	Amount of days in the week											
	Free days: 10	100		4	3	3	4	4	4	4	4	4		
				kickoff	1 free day	1 free day								
			project week	3	4	5	6	7	8	9	10	11		1
			starting date	02-Mar	09-Mar	16-Mar	23-Mar	30-Mar	06-Apr	13-Apr	20-Apr	27-Apr		04-Ma
Research	**Broad research phase: problem identification**													
	Preperation project													
	Create research questions													
	Literature research facial recognition points humans													
	Literature research facial recognition points computers													
	Literature research orthognathic surgery													
	Field research orthognathic surgery													
	Get to know computer recognition software													
	In depth research phase: formulate design vision													
	Field research orthognathic surgery													
	Analyse data with use of software													
	User tests filling up information gap													
	Analyse some data by hand													
	Write down a design goal and vision													
	List of requirements													
Product design	**Ideation phase**													
	Individual brainstorming													
	Group brainstorming													
	How to's													
	Harris or datum method (iteration)													
	Value Curve with studens/physicians (evaluation+ iteration)													
	Itimised response and pmi (iteration)													
	Pick two or three ideas													
	Conceptualisation phase													
	Create explorative functional prototypes													
	Create interaction prototypes													
	Analysis of production processes													
	Analysis of material													
	Pick final concept (with physicians)													
	Evaluation list of requirements													
	Details of final concept													
	Recommendations													
	Renders													
	Showcase													
	Presentation													
	Documentation													
	Putting report together													


4 4 3 4 4 4 4 4 4 0 1 4 4 4 4 4 5 5
midterm
1 free day
Holiday, 7 working days
green light
5 days a week
thesis hand-in
13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29
11-May 18-May 25-May 01-Jun 08-Jun 15-Jun 22-Jun 29-Jun 06-Jul 13-Jul 20-Jul 27-Jul 03-Aug 10-Aug 17-Aug 24-Aug 31-Aug 04-Sep

Appendix 36: Week-planning



Appendix 37: Project brief

Procedural Checks - IDE Master Graduation

TU Delft

APPROVAL PROJECT BRIEF

To be filled in by the chair of the supervisory team.

chair R.H.M. Goossens date 10 - 3 - 2020 signature

CHECK STUDY PROGRESS

To be filled in by the SSC E&SA (Shared Service Center, Education & Student Affairs), after approval of the project brief by the Chair.
The study progress will be checked for a 2nd time just before the green light meeting.

Master electives no. of EC accumulated in total: 27 EC

Of which, taking the conditional requirements into account, can be part of the exam programme 27 EC

List of electives obtained before the third semester without approval of the BoE

(✓) YES all 1st year master courses passed

( ) NO missing 1st year master courses are:

name date 17-3-2020 signature

FORMAL APPROVAL GRADUATION PROJECT

To be filled in by the Board of Examiners of IDE TU Delft. Please check the supervisory team and study the parts of the brief marked **.
Next, please assess, (dis)approve and sign this Project Brief, by using the criteria below.

- Does the project fit within the (MSc)-programme of the student (taking into account, if described, the activities done next to the obligatory MSc specific courses)?
- Is the level of the project challenging enough for a MSc IDE graduating student?
- Is the project expected to be doable within 100 working days/20 weeks ?
- Does the composition of the supervisory team comply with the regulations and fit the assignment ?

Content: (✓) APPROVED ( ) NOT APPROVED

Procedure: (✓) APPROVED ( ) NOT APPROVED

comments

name Monique von Morgen date 30-3-2020 signature MvM

Personal Project Brief - IDE Master Graduation

TU Delft

A tool for improving orthognathic surgeries — project title

Please state the title of your graduation project (above) and the start date and end date (below). Keep the title compact and simple. Do not use abbreviations. The remainder of this document allows you to define and clarify your graduation project.

start date 02 - 03 - 2020 — 04 - 09 - 2020 end date

INTRODUCTION **

Please describe, the context of your project, and address the main stakeholders (interests) within this context in a concise yet complete manner. Who are involved, what do they value and how do they currently operate within the given context? What are the main opportunities and limitations you are currently aware of (cultural- and social norms, resources (time, money,...), technology, ...).

Around 5% of the population undergoes an orthognathic surgery to correct jaw problems (Posnick, 2013). Since the population in the Netherlands exists out of 17,4 million people (CBS, 2020), 870 thousand of these people undergo orthognathic surgery in their life. This project will be done for the orthognathic surgeons of the VUmc hospital. They are specialised in reconstructive surgeries.

A big problem within orthognathic care is the conflict of interest between patients and surgeons. The patient cares about the aesthetics of the face while the surgeon cares about the functionality of the jaw (figure 1). Also, their perceptions of aesthetics differ (Bonanthaya & Anantanarayanan, 2013). According to research done in Sweden, the reason why male and female patients perform orthognathic surgery is mostly the functional indication, however, aesthetics is one of the primary motivations for surgery for patients (Andrup, 2015). The surgeons at the VUmc apply standard 'beauty protocols' when performing surgery, so they know what to do to make a face aesthetically attractive. However, some patients are still dissatisfied after the surgery, since they lose their facial characteristics (T. Fouranzanfar, personal communication, March 2, 2020).

Surgeons in the VUmc warn the patients before the surgery since their face may drastically change after the surgery (figure 2). Also, screening is done at the VUmc to screen out people with mental problems like the Body dysmorphic disorder, which is already 7-18% of the patients, seeking orthognathic care because of aesthetical reasons (Cadogan & Bennun, 2011; Vulink et al., 2008; T. Fouranzanfar, personal communication, March 2, 2020). Although some patients and their surroundings can get used to the changes of the patient's face, some patients cannot get used to their different face which leads to identity problems (Bellucci & Kapp-Simon, 2007). Also, the social influence on the patient of being unrecognizable can lead to severe mental problems (T. Fouranzanfar, personal communication, March 2, 2020).

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introduction (continued): space for images

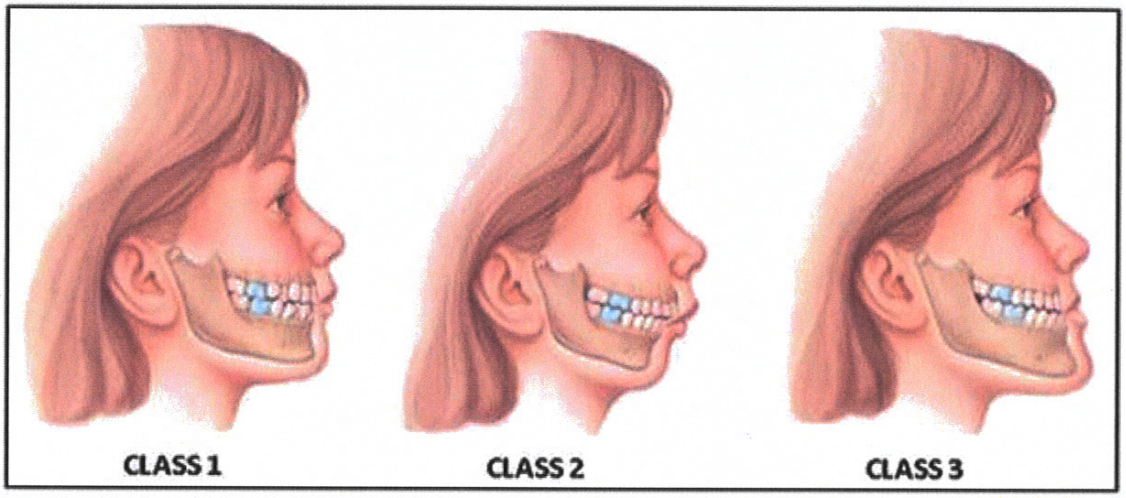


image / figure 1: Example of functional jaw problems. The three types of malocclusions (Fagu, 2016).

image / figure 2: Frontal view of before and after orthognathic surgery (dr. Antipov, 2017).

PROBLEM DEFINITION **

Limit and define the scope and solution space of your project to one that is manageable within one Master Graduation Project of 30 EC (= 20 full time weeks or 100 working days) and clearly indicate what issue(s) should be addressed in this project.

The expectations of the patients cannot be aligned by prediction of the surgery because this is inaccurate even when using prediction software. After all, the interaction between the soft- and hard tissues are different per patient and can only be determined during the surgery (T. Fouranzanfar, personal communication, March 2, 2020). The patient's perception and expectations about the surgery should align with the treatment plan, if not, this should be resolved before proceeding the treatment (Bellucci & Kapp-Simon, 2007). If the surgeon could promise the patients that they would be recognizable after the surgery, it is meeting the 'before' image or perception of the patients of their face after the surgery, as well as meeting (part) of the expectations. Not being recognizable after a functional orthognathic surgery happens often at the VUmc. However, they do not know how to change the orthognathic surgery to keep people recognizable.

There is a need for optimizing the orthognathic surgery to make patients recognizable after the surgery. Since there is a knowledge gap in facial recognition between humans and the link between facial recognition and functional orthognathic surgeries, this knowledge needs to be obtained.

ASSIGNMENT **

State in 2 or 3 sentences what you are going to research, design, create and / or generate, that will solve (part of) the issue(s) pointed out in "problem definition". Then illustrate this assignment by indicating what kind of solution you expect and / or aim to deliver, for instance: a product, a product-service combination, a strategy illustrated through product or product-service combination ideas, ... In case of a Specialisation and/or Annotation, make sure the assignment reflects this/these.

Design a physical tool that can assist the surgeon, before and during the surgery, in recognizing the facial recognition points of the patient's face. These recognition points can be used as a guideline through the surgery to keep the face recognizable.

The physical tool the surgeon will use will be personalized per patient since each patient will have facial recognition points at different spots. For example, the tool can be a mask of the patient's face, which shows the facial recognition points.

Design approach
The design process will be done by following the Double Diamond shape. To design the tool, information about facial recognition points needs to be obtained first. An information gap exists in facial recognition points from the humans perspective and the link between these points and orthognathic surgery. 4000 coloured pictures including scans of patients before and after the surgery are available at the VUmc and will, therefore, be used during the research phase. The information about facial recognition points will be obtained by explorative and focused research:
1. Literature research of facial recognition points from a humans perspective
2. Literature research of facial recognition by computers
3. Analyzing data with the use of recognition software (Matlab, Amazon rekognition)
4. If information of facial recognition points from humans perspective is missing or needs further exploration, user tests with data will be done.

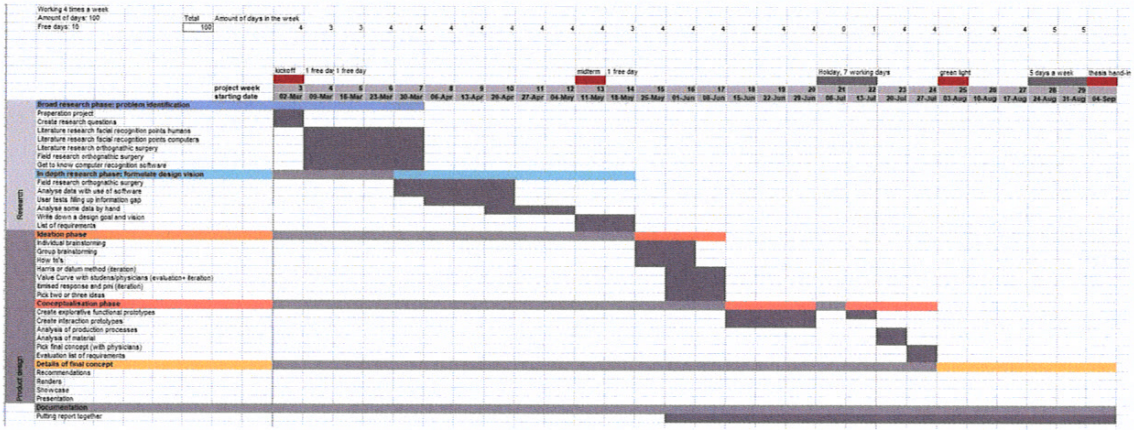
This information will be used to determine facial recognition points which are important for orthognathic surgeries which can be used as input for the tool.

PLANNING AND APPROACH **

Include a Gantt Chart (replace the example below - more examples can be found in Manual 2) that shows the different phases of your project, deliverables you have in mind, meetings, and how you plan to spend your time. Please note that all activities should fit within the given net time of 30 EC = 20 full time weeks or 100 working days, and your planning should include a kick-off meeting, mid-term meeting, green light meeting and graduation ceremony. Illustrate your Gantt Chart by, for instance, explaining your approach, and please indicate periods of part-time activities and/or periods of not spending time on your graduation project, if any, for instance because of holidays or parallel activities.

start date 2 - 3 - 2020

4 - 9 - 2020 end date



MOTIVATION AND PERSONAL AMBITIONS

Explain why you set up this project, what competences you want to prove and learn. For example: acquired competences from your MSc programme, the elective semester, extra-curricular activities (etc.) and point out the competences you have yet developed. Optionally, describe which personal learning ambitions you explicitly want to address in this project, on top of the learning objectives of the Graduation Project, such as: in depth knowledge a on specific subject, broadening your competences or experimenting with a specific tool and/or methodology, ... Stick to no more than five ambitions.

This project makes me enthusiastic because I see lots of opportunities in the medical field and also in this field of orthognathic surgeries. Also, I know people who went through orthognathic surgeries, from which I am one. Therefore, I can relate with the patients and I feel a connection. I have some medical competences: I did an internship at the Antoni van Leeuwenhoek hospital, where I designed a product for the tracheostoma of laryngectomy patients. I also did a short internship for Dental Robotics, a start-up developing a toothbrush. Next to this, I have done two projects in the medical field, one for the VUmc, for them I created a product for teenagers with diabetes type 1, based on Value-Based Healthcare. In the other project, I developed a gaming controller add-on for an exoskeleton for children with Duchenne. Furthermore, my Medisign specialization contained the subjects 'health psychology' and 'experience and persuasion', the psychology I learned in these courses could be of use in this project. I obtained some extra technical knowledge during my Mechanical Engineering pre-master which could be of use when creating simulations or explaining the jaw movements.

In this project, I would like to gain medical knowledge by talking to specialists in the hospital. I am interested to gain more knowledge in the field of orthognathic surgery. Because of the information gap in facial recognition points and the link with orthognathic surgery, I am really curious in what information I can find and I am excited to analyze the big amount of data which is available by using literature and software. I always had difficulties asking others for help, so I want to challenge myself to ask specialists, teachers and other students for help. Also, creating a physical product is something I would like to achieve in the end. Experimenting with modelling tools is something I would like to use while creating the product.

My learning goals summarized:
- Gain medical knowledge of orthognathic surgery
- Filling the information gap by analyzing literature and data
- Ask others for help when needed
- Create a physical tool by using modelling tools

FINAL COMMENTS

In case your project brief needs final comments, please add any information you think is relevant.

Because of personal circumstances, I will work on the project for 4 days a week.