UNIVERSITY OF TWENTE.

Wearable Robotics & Facial Identity Perceptions

Creative Technology
Bachelor Thesis

JULY 2023

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Abstract

Masks have been used throughout history and across different cultures as a way to take on different identities. However, what if a mask was not made to assume a singe identity, but multiple ones? This question, raised by Jonathan Reus, served as the starting point of this project, which explores the development of a theatrical mask that is capable of embodying multiple identities. The process started with a comprehensive background research on identity, its relation to faces, and on theatrical masks. This was followed by background research on face perception and related phenomena as well as a state of the art analysis. The findings were structured and categorized through a mind map, simultaneously serving as a foundation to generate the project's preliminary concept. This concept drew inspiration from a soft wearable robotic mask and used the critical features as its foundation, as modifications to these features was found to influence the perceived identity of faces. Thus, the concept was to use of soft wearable robotics to dynamically alter the mask's facial features and transform its identity. This initiated the prototyping process which facilitated the experimentation with various techniques, specifically silicone pneumatics and liquid injection, to inflate, deflate, and dynamically color the silicone facial prosthesis. Throughout the ideation phase, the project's focus shifted to the exploration of various mask designs and their impact on facial identity perception. To do so, a co-design workshop was conducted, where participants from diverse backgrounds facilitated the creation of various masks. These mask designs were showcased in a theatre space, where their effects could be observed and evaluated under varying lighting conditions. Different masks elicited various effects, such as defying expectations of body movement, embodying dual identities, and even deforming facial identity, which could set a path for further research. Moreover, while the initial goal of a mask with multiple identities was not fully realized, the insights gained from the process could benefit future endeavors.

Acknowledgements

First, I would like to give my sincere thanks to Edwin Dertien, my supervisor, for providing me with valuable feedback, inspiration, and overall guidance throughout this project. I would also like to thank Michaela Honauer, my critical observer, for her expertise and constructive feedback.
Moreover, I am very grateful to my client, Jonathan Reus, for providing me with the opportunity to explore and work on this topic.
I would also like to thank all the participants of the workshop for their active participation and vital contribution to the creation of such diverse designs.
Additionally, I would like to thank both Edwin and Jonathan for helping organize and facilitate the workshop.

Table of Contents

List of Figures

1 Introduction

For thousands of years and across different human cultures, masks have been used as a way to inhabit (or be inhabited by) the identity of others. However, what if a mask was not made to assume a singe identity, but multiple ones? This question is raised by Jonathan Reus, a transmedia artist whose work explores how hybrids of art and technology can lead to an uncanny perception and sensory delight in an audience.

From its origins in ritual and religious ceremonies, the theatrical uses of masks first emerged in Western civilization from the religious practices of ancient Greece and persisted throughout the years in a variety of theaters across different cultures [1]. Moreover, even nowadays, masks and other face-altering methods, such as makeup, have been featured in a variety of media.

Masks therefore have been a common and enduring part in theater and other forms of creative media. They work by concealing or modifying signs of identity, formally displayed by the actor, and present new values which represent the transformed person or an entirely new identity [2]. Besides disguising identity, with the use of certain techniques static masks have the ability to deceive the audience into thinking they're animated. In return, this has been shown to have an effect on the spectator's engagement [3].

However, nowadays, wearable electronics pose new opportunities to further explore the distortion of identities. This opens the door to the investigation of animating masks beyond simply deceiving the audience. Therefore, within this project, the goal is to design and develop a theatrical mask that is able to embody such an "unstable" identity.

1.1 Research Questions

In order to meet the goal of designing and developing a theatrical mask that is able to embody multiple identities, the following main research question needs to be answered:

Main RQ: *In a theatrical setting, how can wearable electronics in the form of a mask be used to embody multiple identities?*

Since this is a broad question to answer, it has been divided into four sub-questions. All of which need to be addressed to help the project towards its final goal. First, an overview of former and current uses of (theatrical) masks as well as installations and other forms of creative media that deal

with the topic of masks and identity will need to be provided. This should give an insight on the creative and historic aspects of masks and identities.

SQ 1: *In what ways and for which purposes are masks featured in creative media?*

This project also requires developing a basic understanding of face perception and related phenomena, such as facial identity perception markers, pareidolia, and predictive processing as these can aid in the development of a grounded deception method of the mask. Hence, the following sub-question:

SQ 2: *How can insights gained from face perception research be used to create a methodological approach for the mask's transformation?*

These two sub-questions will be answered through an extensive research process, where both background research and a state of the art analysis will be conducted.
Furthermore, considering the mask is intended to be used in a theatrical setting, the effects of various lighting techniques on the perception of the mask's face should be investigated. Understanding how lighting can influence the mask's facial appearance could provide valuable insights into enhancing the mask's morphing ability, leading to the following sub-question:

SQ 3: *In what ways can light and/or projections be used to enhance the identity changes of the mask?*

Adjusting lighting intensities and angles and observing their effects on the mask, the role of lighting variations will be explored. Finally, the perceptual experience of the mask will need to be evaluated to see whether its transformations have an effect on spectators and what that effect is.

SQ 4: *In what way and to what extent does the mask affect the spectators' experience?*

The answer to this sub-question, which is obtained through user testing, will determine the mask's effectiveness of influencing the spectator's experience and will allow to check whether the theory matches the prototype's results. Ultimately, by combining all the knowledge from answering the sub-questions, the main research question will be able to be answered.

1.2 Report Outline

This report describes the research towards the development of a theatrical mask, which is able to embody multiple identities. Since this project follows the Creative Technology Design Process, the report will be laid out accordingly [4]. First, to gain an understanding of the context of this project as well as to provide an overview of related works, the background research and state of the art analysis is described. These two topics comprise Chapter 2 and 3 respectively of this report. Afterward, in chapter 4, the methods and techniques applied to this project are described more thoroughly. Chapter 5 describes the Ideation phase of this project, in which through various prototypes a preliminary concept is developed into a final concept. The next phase of this project is the specification phase, which is described in Chapter 6. Here, the concept chosen in the previous phase is further expanded upon and specified in preparation its realization, which is described in Chapter 7. Its evaluation is detailed in Chapter 8. The outcomes of this research are outlined in Chapter 10, alongside a complete discussion, including limitations and future work. Chapter 10 will deal with the conclusion of this thesis.

2 Background Research

This chapter is dedicated to lay down the theoretical groundwork necessary for this project. To do so effectively it is split into two parts. The first part explores literature related to the topics of identity and masks. The next section provides an overview of research concerning face-perception and related phenomena.

2.1 Identity and Masks

This section aims to create an understanding of the topics related to this project. As such, it will lay out a definition of identity and the self to be used throughout this project. Moreover, since the mask is aimed to cover (a part) of the face, the relationship of faces and identity as well as the ability to recognize and interpret faces are explored and explained here. Lastly, this section discusses the definition and brief history of theatrical masks.

2.1.1 Definition of Human Identity and the Self

The exact meaning and definition of 'Identity' and 'the Self' can be hard to define since it can be viewed at and discussed through different lenses. Regardless, as identity plays a big role in this project, it is important to establish a rough definition that will be followed.

There is an overall agreement that identity can be categorized into personal identity and social identity. Personal identity refers to an individual's self-awareness in terms of their difference with respect to others. As such, it's shaped by internal factors and focuses on individual characteristics and experiences. Contrary to that, the social identity is shaped by external factors and fixates on social group membership. It refers to the fact that an individual perceives themselves as similar to others of the same background ("we") as well as the differentiation of that group from other groups ("them") [5]. Although related to identity, the self has a reflexive capacity. It refers to one's subjective experience of being a person and the subjective awareness of one's own individuality and existence [6]. Therefore, altogether, while identity describes how we see ourselves, show ourselves to others and how we fit in with society, the self refers to subjective self-awareness and individuality.

2.1.2 Faces and Identity

Faces are considered to be the portrait of Identity. They contain unique and recognizable features that can be used to distinguish individuals from one another. This coincides with the definition of

personal identity used within this project, i.e. that personal identity refers to one's self-awareness regarding their uniqueness from others.

The importance of the role of faces in social interactions is highlighted by the fact that studies have shown that newborns prefer looking at faces and images of faces, particularly those that are happy and open-eyed. This phenomenon is likely genetically inherent or instinctive [7].

In terms of processing faces, a study has found that the brain follows a specific mechanism. This process begins with a detection stage, which is highly non-linear and thus doesn't follow a simple pattern. Then, the brain measures different individual features, i.e., face variables, independently and linearly [8]. The fact that the brain recognizes faces as a combination of individual parts is highlighted by another study. Using primates and 50 categories of facial features based on 2,000 artificial faces, it was found that different neurons respond to different facial features. Moreover, these neurons were found to be able to recognize the same person under different viewing conditions, i.e., the same face from different angles [9].

Furthermore, facial appearance plays a vital role in interpersonal communication. Facial features are observably connected to perceptions of attractiveness, gender ethnicity and age. Moreover, they can even be categorized based on emotional states as exemplified by the fact that people often attribute personality traits to strangers solely based on their facial appearance [10]. While social traits, such as dominance and trustworthiness, are usually deduced from various facial features as well, it is worthy to note that through specific facial expressions this information can be concealed. Therefore, rendering it possible for individuals to manipulate how others perceive their social traits [11]. Regardless, faces depict the way we feel, how we look, and how we're perceived by others. Likewise, it can be implied that individuals infer parts of another's social identity, such as their ethnicity, age, and gender, solely from their face.

Thus, to conclude, faces are closely connected to an individual's identity, both personal and social, and play a significant role in social interactions.

2.1.3 Masks (in theater)

The following part provides a definition for a (face-) mask and outlines three examples of masks used in theater.

Definition of a Mask

Generally, a mask can be defined as a covering for either a part or the entire face and body, which has the potential to disguise, protect or transform the wearer [12]. Pollock [2], who offers a semiotic perspective on the concepts of masks, suggests that masks are both icons and indexes of identity. To

clarify, icons of identity are symbols that are widely recognized and associated with a particular group of identity. In contrast, indexes of identity are more subtle and indirect indicators of identity and as such are not as widely recognized. Pollock proposes that the mask functions by hiding or altering signs of identity and instead presents new values which represent a changed or entirely new identity. In addition to this, it is important to note that these signs of identity are dependent on social and cultural conventions [2].

Masks can be used as a proxy to displace identity and display a shift between the self and other, due to it possessing the characteristics of repeatability and separability [13].

In conclusion, masks can be seen as both icons and indexes of identity, that are able to conceal the identity of the wearer and project a changed or new identity by hiding or altering signs of identity and presenting new values instead.

Greek tragic Mask

The ancient Greek tragic mask was an essential part of the Greek theatrical experience and was used to convey the emotions of the characters to the audience. Since these masks were crafted using organic materials that were intended to decompose naturally and be offered back to the earth after use, the only available records of them are in the form of depictions on vases, paintings, and carvings. The mask featured exaggerated facial features, such as the eyes and mouth, which were designed to capture the attention of the audience and more vividly convey the emotions of the mask [3]. Moreover, Meineck [3], who explored the neuroscience behind this mask, identified a shared emotional experience between the audience and the actors. He pinpoints this to the theory of mirror neurons. which suggests that once observing an action, the brain mirrors that action and creates a similar emotional response.

Japanese Noh Mask

The Japanese Noh mask has a unique ability to change its expression depending on the angle at which it is viewed. Unlike human faces, the features of a mask are typically fixed, and the surface is hard and unyielding. However, the Noh mask creates an illusion of movement and expression through the use of exaggerated features, such as a protruding lower lip, and gentle shadows that are cast across its curved surfaces. As a result, the mask appears to be animated, and its facial expressions seem to change depending on the perspective from which it is viewed [3]. The difference in expression of an upward tilted and downward tilted Noh mask is depicted in Figure 1.

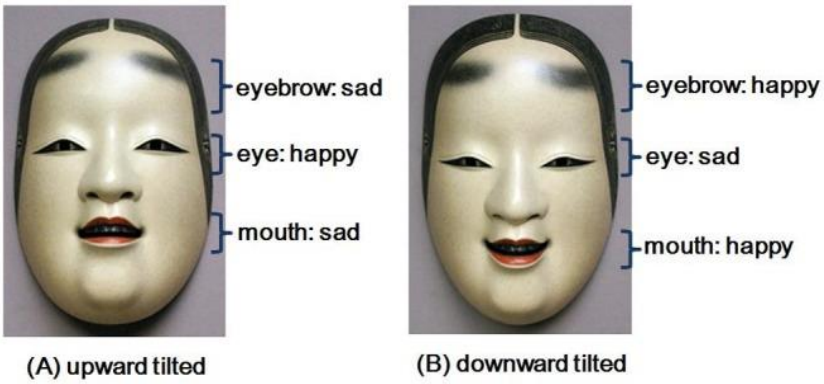


Figure 1: Emotions differentially represented by each facial part of the upward-tilted and downward-tilted Noh masks [41]

Notably, a study investigating the interpretation of the expressions conveyed by the Noh mask noticed a variety among the different cultural groups. In this case, the interpretations of a Japanese control group and the interpretations of a British group were compared [3].

Kwakwaka'wakw Mask

Often times, the Kwakwaka'wakw mask of the Indigenous people of the Pacific Northwest featured a special mechanism that allowed the mask to transform into another being.

Many of the Kwakwaka'wakw masks consisted of two layers that could display multiple aspects of a person's identity: the exterior layer and the inner layer. The outer layer represented the person's public identity, while the innermost layer symbolized their "'soul' or spiritual identity". The explanation of how these masks came to be stems from the culture's myth. According to the myth, the ancestors of the Kwakwaka'wakw shed their animal skins and emerged as humans, with their skins becoming the masks. By wearing these masks, the Kwakwaka'wakw people are thought to transform into their ancestor animals [2]. Moreover, by pulling hidden cords, these layers could be revealed, and the mask could be transformed [14].

Figure 2: Namgis. Thunderbird Transformation Mask, 19th century. Cedar, pigment, leather, nails, metal plate, Open: 31 x 45 x 47 in. (78.7 x 114.3 x 119.4 cm). Brooklyn Museum, Museum Expedition 1908, Museum Collection Fund, 08.491.8902. Creative Commons-BY (Photo: Brooklyn Museum, 08.491.8902_front_PS6.jpg)

2.2 Theoretical Tools

This section of the background research aims to identify relevant theoretical tools for face-related phenomena that could potentially be deployed in this project.

2.2.1 Facial Perception Identity Markers

Understanding human face recognition can assist in identifying facial perception identity markers, which are the specific facial features that enable individuals to recognize and differentiate between various faces. This process is crucial as it allows us to distinguish between individuals, even those who look similar or have altered their appearance. While humans are generally skilled at face recognition, research has revealed that there is a disparity between the face recognition for familiar faces and that for unfamiliar faces, with humans generally being better at recognizing familiar faces than matching unfamiliar ones. As such, multiple studies conducted by Abudarham et al. [16] aimed to investigate the critical features that contribute to face recognition. The first study focused on the identification of critical features for face identification. This was later expanded upon by another study which focused on familiar face recognition and whether there is a distinction in the critical features used for familiar and unfamiliar face recognition. The results of the second study indicate that the same features are critical for both familiar and unfamiliar face recognition, suggesting that there is no distinction between the features used for these two types of recognition. [16].

Identifying (un-)familiar faces

A subset of facial features known as high-PS features were identified as crucial for familiar and unfamiliar face recognition. High-PS features are facial features for which humans have high perceptual sensitivity to detect differences between different identities. As a result, systematic changes to these features were found to change the identity of faces. By contrast, systematic changes to features for which humans have low perceptual sensitivity (low-PS features) were found to not have an effect on the identity of faces. In addition to that, their findings suggested that the type of feature that was altered had a greater impact that the extent to which the features were modified. According to Abudarham et al. [16] examples of high-PS feature for unfamiliar face recognition changes are hair color, eyebrow thickness, eyes and lips. Examples of low-PS feature changes are skin color, face proportion, nose, and mouth [16]. In table 1 a list of the critical features as posed by Yovel, G. et al. [17] is provided. The table also outlines the scale that can be used to change these features and their perceptual sensitivity (PS) for the experiments of feature tagging and feature comparison.

Rank	Feature name + description	Scale	PS	
			Feature tagging	Feature comparison
1	Lip thickness	Thin – thick	0.8	0.75
2	Hair color	Light – dark	0.77	0.71
3	Eye color	Light – dark	0.75	0.73
4	Eye shape	Narrow – round	0.72	0.61
5	Eyebrow thickness	Thin- thick	0.71	0.63
6	Ear protrusion	Adjacent to the skull– protruding outward	0.71	0.60
7	Forehead height: distance between eyebrows and hairline	Short - long	0.65	0.69
8	Hair length	Bald – long hair	0.71	0.57
9	Eye size	Small – large		
10	Skin texture, incl. marks, scars, freckles, wrinkles	Smooth – textured	0.68	0.42
11	Jaw width	Narrow – wide	0.58	0.54
12	Eyebrow shape	Rounded – straight	0.58	0.47
13	Nose size: overall size	Small-large	0.49	0.60
14	Nose shape: Pointed and thin or flat and wide	Pointed -flattened	0.56	0.37
15	Skin color	Light – dark	0.45	0.57
16	Face proportion: Ratio between length (top to bottom) and width	Wide & short – symmetrical – narrow & tall	0.53	0.38
17	Cheek shape: Sunken and skinny cheeks or full and puffy	Sunken–puffy	0.41	0.57
18	Chin shape	Pointed–rounded–flat	0.54	0.12

		(square)		
19	Eye distance	Small–large	0.37	0.27
20	Mouth size	Small–large	0.34	0.21

Table 1: Perceptual sensitivity (PS) of features, for feature tagging and feature comparison experiments [17]

Furthermore, critical features (i.e. high-PS features) were found to be crucial for face identification since these features tend to remain the same even if there are some variations in the face's appearance. In contrast, less critical features (i.e. low-PS features) tend to change their appearance under different conditions, e.g. skin color varies under different lighting. Moreover, low-PS features can represent various appearances within the same identity. For instance, a person's face proportion not consistent and reliable cues to distinguish between identities can change due to weight gain or loss. Since low PS-features are they are less useful for identification [17]. However, despite being a relatively variable facial feature, hair was found to have a significant impact on familiar face recognition and to play a crucial and essential role in representing a person's identity.

Moreover, besides finding that that the same subset of facial features is used to recognize both familiar and unfamiliar faces, the study suggests and explains a relationship between the two. According to Abudarham et al. [16], since both familiar and unfamiliar face recognition use the same facial features, incoming face stimuli can be directly matched to representations in memory in order to determine if that face is familiar. Consequently, they suggest that the face processing systems learns which features are suitable for discrimination and generalization of familiar faces and applies these same features to match unfamiliar faces, thus basing unfamiliar face recognition on a lifetime of experience with familiar faces [16].

Overall, in both unfamiliar and familiar face recognition, high-PS features, such as eyes and lips, were found to be crucial due to them being more invariant and reliable cues to distinguish between different identities under different conditions.

2.3.2 Face pareidolia

The phenomenon of face pareidolia refers to the tendency to see faces in random patterns. It is assumed to be related to the previous-mentioned phenomenon of newborns' preference for looking at faces and images of faces. Consequently, it suggests that humans have an inherent mechanism that drives them to seek out faces, which is supported by the phenomenon of pareidolia [7]. A study showed that the extent to which someone experiences pareidolia is related to the level of face-specific activations in the right FFA (fusiform face area), which is a brain region involved in face processing. Therefore, it suggests that the right FFA plays a crucial role in the ability to detect and

recognize faces, even if those are not real, and that it plays an overlapped role in both top-down and bottom-up face processing. Additionally, the top-down component was found to be particularly strong in human face processing. This implies that the way people interpret and perceive visual information potentially containing a face relies on their prior knowledge and expectations about faces. Moreover, the strength of this component demonstrates that a face interpretation can already occur with the slightest suggestion of a face in sensory input [18]. Similarly, an experiment that aimed to induce pareidolia in participants investigated how little visual information is needed for an image to be perceived as a face. The findings of this study support the importance of both the eyes and mouth as crucial features for face detection in face-like inanimate stimuli [19].

2.3.3 Predictive Processing

Predictive Processing is a theory of brain function, which suggests that the brain relies on past information to guide sensory processes, creating thoughts and mental states that contain predictions, inferences and beliefs about future events. These predictions aid the brain in anticipating and getting ready for things that might happen and expect what is going to come. To interpret and understand new information using prior knowledge, the brain uses cues and context. The expectations of the brain depend on how much it has learned in the past and how well it can adapt to new situations [20].

When faced with something unexpected, like a face appearing in an unusual orientation or lighting, the brain shows more activity in specific parts responsible for processing visual information, called high-frequency gamma-band activity (GBA). This is believed to signal a prediction error (PE), which means that the brain's expectation was wrong compared to the actual sensory information present. Moreover, when the brain expects to see something under certain lighting conditions, there is an increase in GBA observed in brain regions responsible for attending to things remembered inside the mind. Thus, suggesting that the brain is focusing on specific features of a face, like the lighting, in order to guess what the face should look like [21].

Moreover, another demonstration of predictive processing is the discovery that when people had previous experience with faces, their brains displayed more low-frequency activity, which made it easier for them to anticipate what they were observing and identify faces more accurately [22].

3 State of the Art

The state of the art analysis serves as an overview of related works and relevant technologies. Subsequently, within the following chapter twelve projects and technologies related to the topic of this thesis are described. First, on the basis of two examples, two ways of interacting with identity and appearance are discussed. Then seven related works are discussed. Subsequently, an overview of three potential technologies is provided. All of these findings serve as inspiration for the Ideation phase of this project.

3.1 Software related to Identity and Appearances

3.1.1 (AR) Face Filters

The recent availability and accessibility of face filters has made it easier for more and more people to digitally alter the way they look. In the past, photo-editing technology was only available for celebrities. Beauty standards conveyed in media were as such portrayed by these celebrities while most of the general public was aware of the editing and altering that went into creating these images. Nowadays, through a range of filters offered by platforms such as Snapchat or Instagram, everyone can achieve that level of perfection and propagate beauty standards [23]. These apps allow users to distort their face, for instance by increasing the size of their eyes, and adding features, such as glasses, to their face in real-time. As these augmentations are mostly applied to the physical appearance of the person using it, AR filters are seen as a self-presentational technology [24].

3.1.2 Avatars

In social networks and video games, avatars have become a common feature, which serve to digitally represent the user within these environments Two concepts that dictate the degree of similarity between the player and their avatar are actualization and idealization. These concepts determine whether the avatar represents the actual user or an idealized version of them. [25].

3.2 Related works

3.2.1 On Illegibility, Yun Ingrid Lee, 2016-2018

The works of Yun Ingrid Lee focus on the ways in which our perceptions are filtered have an impact on how we construct and classify the concept of humanity, both constraining and broadening our approaches [26].

‘On Illegibility’, a lecture performance, focuses on exploring the use of biometric technologies (such as facial recognition) and the bias inherent in its algorithms. Moreover, it investigates strategies of concealment, masking, and ambiguity that are employed by "illegible" individuals to avoid detection. As such, during the performance, the performer wears a malleable mask of their own face and uses a facial recognition app to display demographics, such as age, sex, and race. Throughout the lecture, the performer alters their facial features until they are unrecognizable to both the app and the audience as a human face, as depicted in Figure 2 [42].

Figure 3: Performer wearing the mask (left) and the output of the facial recognition app (right) [42]

3.2.2 URME Surveillance, Leo Selvaggio, 2013

Similar to the previous work, URME Surveillance conceals identity from facial recognition technologies. Founded by Leo Selvaggio, this is a “Personal Surveillance Identity Prosthetic” aimed to protect people’s privacy from surveillance cameras. Rather than obscuring a person’s identity by for instance making it unrecognizable, this mask is a realistic 3D printed mask of the founder’s face. Wearing it will result in the person being recognized as Selvaggio by the algorithm, subsequently retaining their own identity from the surveillance cameras [27].

3.2.3 CV Dazzle, Adam Harvey, 2010

CV Dazzle, developed in 2010 by Adam Harvey, also aims to camouflage an individual’s identity from computer vision. Through makeup, hairstyling, and fashion accessories this camouflage strategy aims to break up the facial features that facial recognition algorithms typically use to identify people, such as the eyes, nose, and mouth [28]. Examples of three of the looks created by Harvey are depicted in Figure 4.

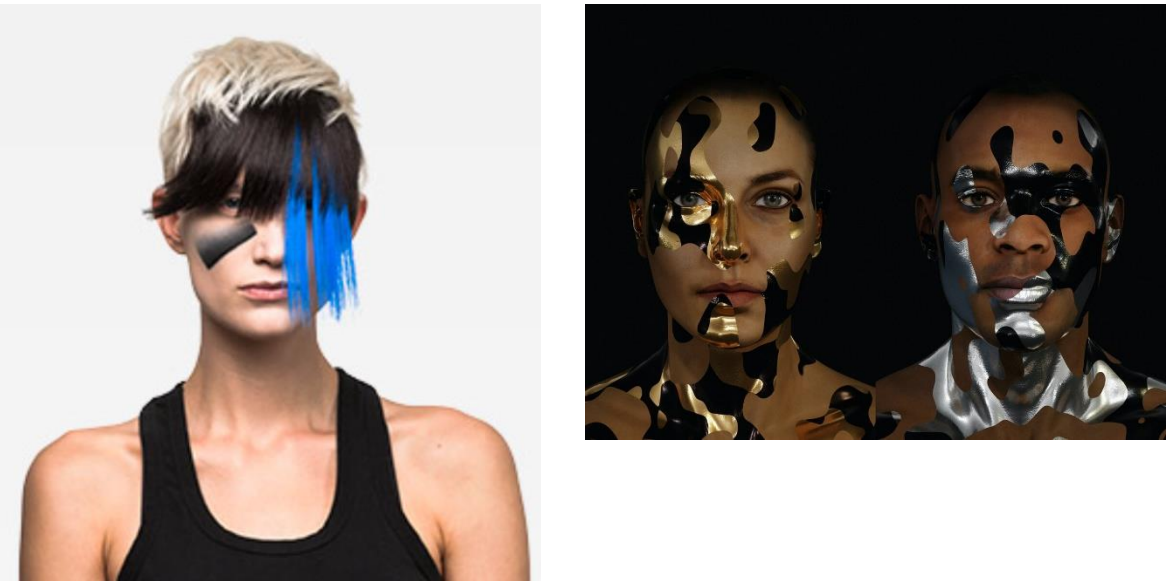


Figure 4: CV Dazzle Look 5 (left, 2013) and Looks 6 and 7 (right, 2020) [28]

3.2.4 Portrait of a Generative Memory, Indiara Di Benedetto, 2020

'Portrait of a Generative Memory', by Indiara Di Benedetto, focuses on subjective memory interpretation by exploring the specific aspects of a human face people are able to remember. By collecting, combining, and interpreting these aspects, unique and abstract portraits are generated [29].

3.2.5 Emoter, Tim Hawkinson, 2002

Hawkinson's 'Emoter' is a kinetic sculpture which was designed to mimic human emotions and facial expressions. It consists of a photographic collage of his own face and various mechanical components, which can animate different parts and features of the face [30]. These movements follow from a random input of signals and enable the sculpture to display a range of emotion. Two examples of which can be found in Figure 5 [31]

Figure 5: Hawkinson's Emoter [31]

3.2.6 Beautiful Minds, Steven West, 2021

This book by Steven West explores how brain imaging and personal stories can be used to address mental health stigma. He explores and discusses how people often wear a certain mask to present a certain image of themselves to others. Moreover, through the use of a PET/fMRI scanner, brain imagery is created and combined with classic portrait photography to provide a unique perspective on one's emotional identity and how it is presented to the world [32, 33].

3.2.7 INORI (prayer), Nobumichi Asai, 2017

INORI (prayer) is a collaborative work, initiated by Nobumichi Asai, that uses projection mapping technology to transform and animate the faces of two dancers. This technology is able to track the motions of the dancers' faces in real-time, project a new face or design onto it [34]. INORI uses "Super High Speed Face Mapping (1000fps)", which allows the animated designs to seamlessly interact with the dancers' performance [35].

3.3 Related technologies

3.3.1 Projection - Face Changing Projection Mask, Sean Hodgins, 2020

The Face Changing Projection Mask, created by Sean Hodgins, showcases the use of projection technology to project various identities onto a mask. The project consists of several components, including a miniature projector, which is mounted on the front of the 3D-printed mask, and able to project various images. The projected image is calibrated to the mask's shape and size, which allows it to seamlessly integrate with the wearer's face [36].

3.3.2 LEDs - Qudi, 2022

Qudi is a mask that is able to display a range of emotions through the use of smart LEDs. These emotions can be derived from the user shaking or nodding their head or selected in the app. Additionally, the mask can display text and adjust its animations based on the volume of the music using an equalizer mode [37].

3.3.3 Wearable Robotics - The Aposema Mask, Peng et al., 2017

The Aposema Mask is a type of soft robotic prosthetic that was developed by Sirou Peng, Adi Meyer, and Silvia Rueda and aims enhance the wearer's emotions. It recognizes facial muscle movements and is able to detect smiling or frowning. After this recognition, the sensor signals the mask to inject coloured liquid through the channels, enhancing the emotion detected by the sensor [38].

Figure 6: Aposema Mask [38]

4 Approach

As mentioned, this project follows the Creative Technology Design Process as posed by Mader and Egging [4], see Figure 2. This process consists of four phases: ideation, specification, realization, and evaluation. Through a feedback loop the designer is able to incorporate feedback and new insights into their design. As such, the final design is done through iterations.

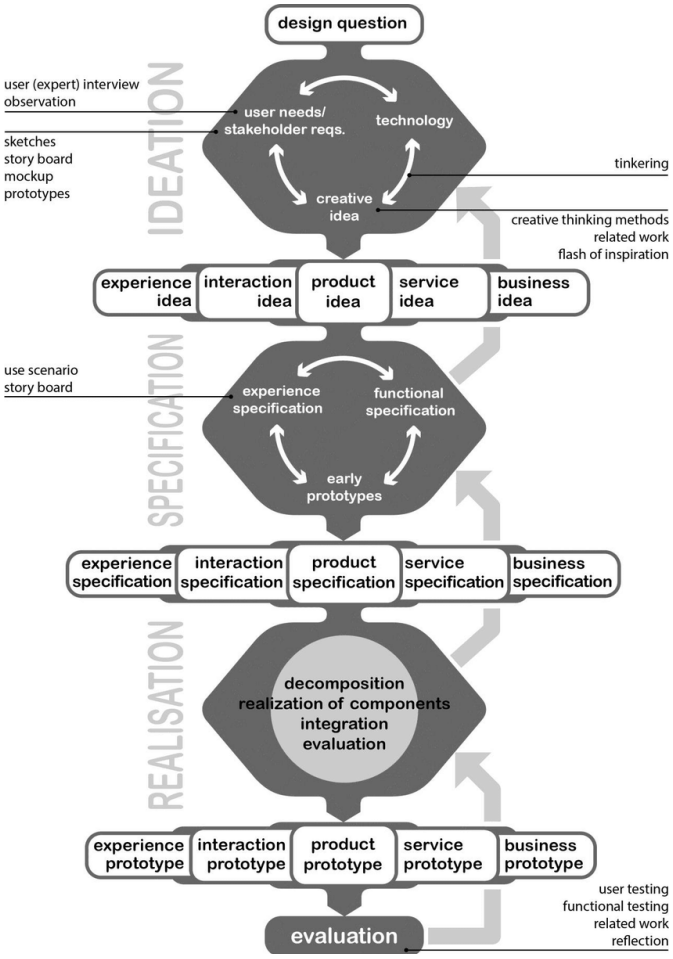


Figure 7: Creative Technology Design Process by Mader & Eggink [4]

Ideation

The starting point of this project was a client, namely Jonathan Reus, who requested a theatrical mask able to embody multiple identities. With that, the project entered the ideation phase. In this phase the topic of masks and identity was explored through background research. Moreover, more insight was gained on face perception and related phenomena. By conducting a state of the art analysis, works and technologies project related to masks, faces and identity were examined. To visualize, structure and categorize the findings, a mind map was created, which was presented and discussed in a meeting. Moreover, by combining and taking inspiration from the various findings presented, a preliminary concept was generated, which kickstarted the prototyping process. While

these prototypes identified possible designs in relation to the preliminary concept, they also led to the emergence of new ideas, leading to a shift in the projects focus. As a result, the final concept that was set up aims to explore and evaluate various designs by conducting a workshop.

Specification

In the specification phase the concept of the previous phase is further specified. In this phase, specific goals and objectives for the workshop are outlined, along with a clear structure for its execution. Moreover, a list of the necessary materials and equipment will be provided, and an evaluation plan will be developed to assess the outcomes of the workshop.

Realization

As the project enters the realization phase, focus is put on preparing for and carrying out the workshop. Following the specifications, all the necessary preparations for facilitating the workshop are made, including gathering and organizing the required materials and equipment. Subsequently, the workshop is executed, during which multiple mask designs and their effect on facial identity are investigated.

Evaluation

The workshop is used as the primary means of evaluation for this project. During the workshop, the participants are invited to develop their own mask design. As a result, various designs can be explored and their effectiveness in morphing the mask's identity can be investigated. Each mask's showcase is accompanied by facilitated group discussions, during which the designs and their respective perceptual experiences are examined and assessed.

5 Ideation

In this chapter the several processes leading to the final concept are discussed. First, the process of generating the preliminary concept is presented, starting with the development of a mind map and its subsequent discussion during a meeting. That is followed by an outline of the preliminary concept, which simultaneously serves as the basis for the subsequent prototypes. The chapter concludes by presenting the final concept, which resulted from the prototyping and various brainstorming meetings.

5.1 Concept generation

Mind Map

In preparation for generating a concept, all the relevant findings from the background research were presented in a mind map. A small overview of the mind map is illustrated in Figure 8, while larger depictions can be found in Appendix A.

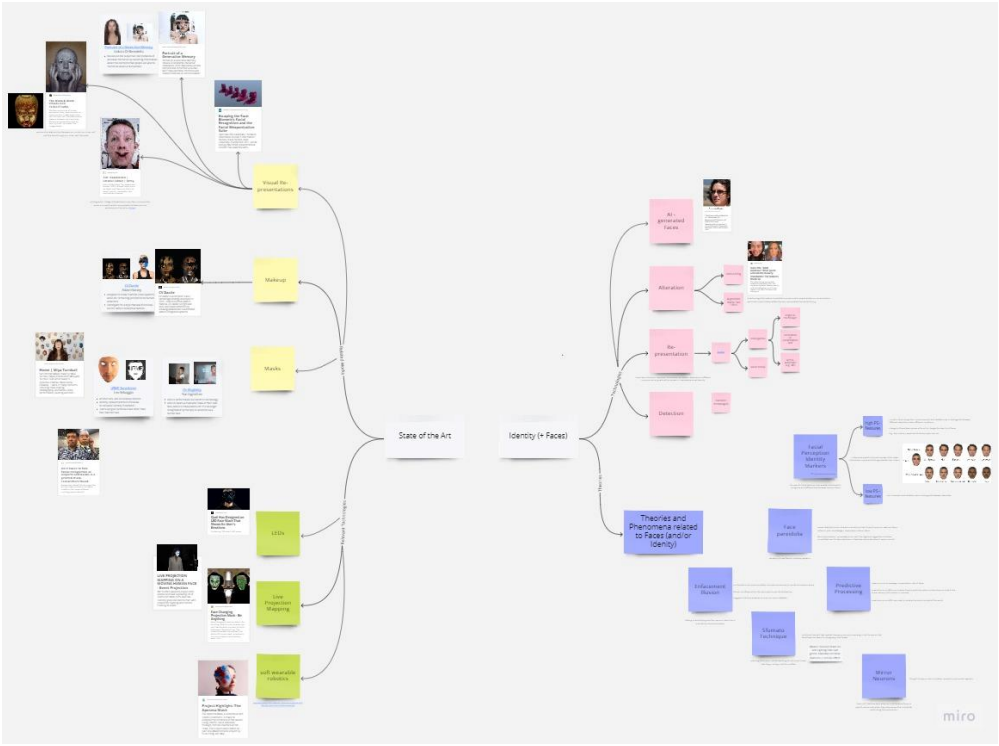


Figure 8: Mind Map depicting the results of the Background Research, separated into State of the Art (left) and Identity + Faces (right)

The mind map served as an overview of relevant works and concepts that were categorized and structured based on their theme or topic. By having such an overview, various aspects of different concepts could easily be identified and combined to form new ideas. The mind map was divided into two parts: Identity (+Faces) and State of the Art. The former explored the ways in which

technologies can be used to interact with one's identity (and face) and the theories and phenomena related to faces and identity. The latter focused on related works and technologies. Each overarching topic and theme were characterized with a particular color to make them easily distinguishable. First, I looked at the topic of Identity and Faces, which is illustrated in Figure 9.

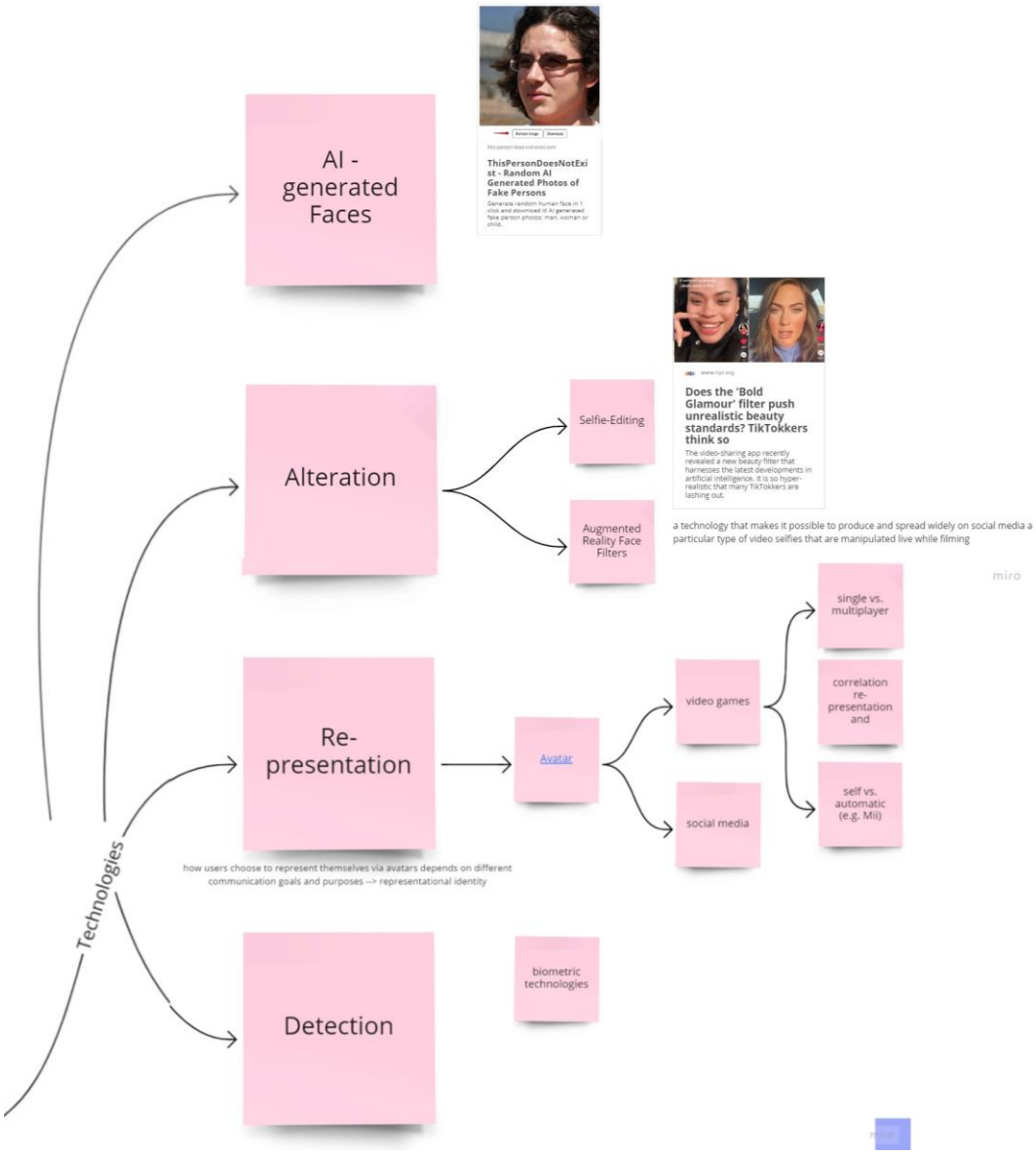


Figure 9: Technologies

Because my Literature Paper dealt with the ways technology can be used to interact with physical appearance and identity, one of the branches focused on that. Based on the interactions of these technologies, I have identified four categories: generation, alteration, representation, and detection. One example of a technology that falls under the category of generation is the website 'thispersondoesnotexist.com'. This site utilizes an algorithm to generate a new human face image each time the webpage is refreshed. Next, for the alteration category, technologies like selfie-editing

and augmented reality face filters can modify photos and videos of a user's face. The representation category involves the creation of avatars to depict one's appearance and identity. Lastly, biometric technologies, such as AI face recognition, can automatically detect or assume information about a person's age, gender, and sex. Therefore, these technologies were put under the category of detection.

Next, theories and phenomena related to faces were added to the mind map. As depicted in Figure 10, each theory and phenomenon was defined or explained, accompanied by additional details. For the sake of clarity, the high PS- and low PS-features of facial perception identity markers were further elaborated, along with a figure demonstrating the results of systematic changes to these features.

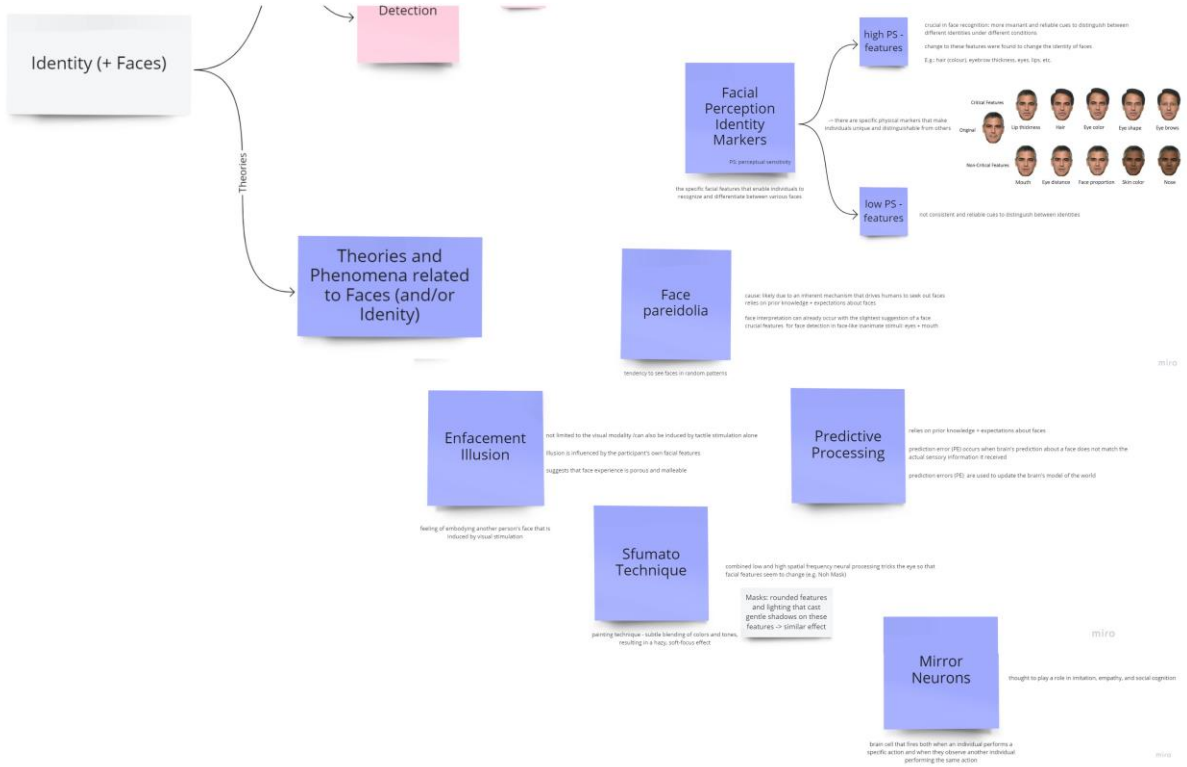


Figure 10: Face perception research and phenomena

The relevant works of the state of the art were further split into the approaches they used to deal with the topic of identity. These approaches included visual representations, makeup, and masks, which are outlined in Figure 11.

Each work was represented with a relevant picture and a brief summary of its most important information. By pasting the URL of some of the works, Miro, the software used to create the mind map, automatically displayed an appropriate image and summary. For the works that did not display correctly or only showed limited information, a short description and image were manually added for clarity.

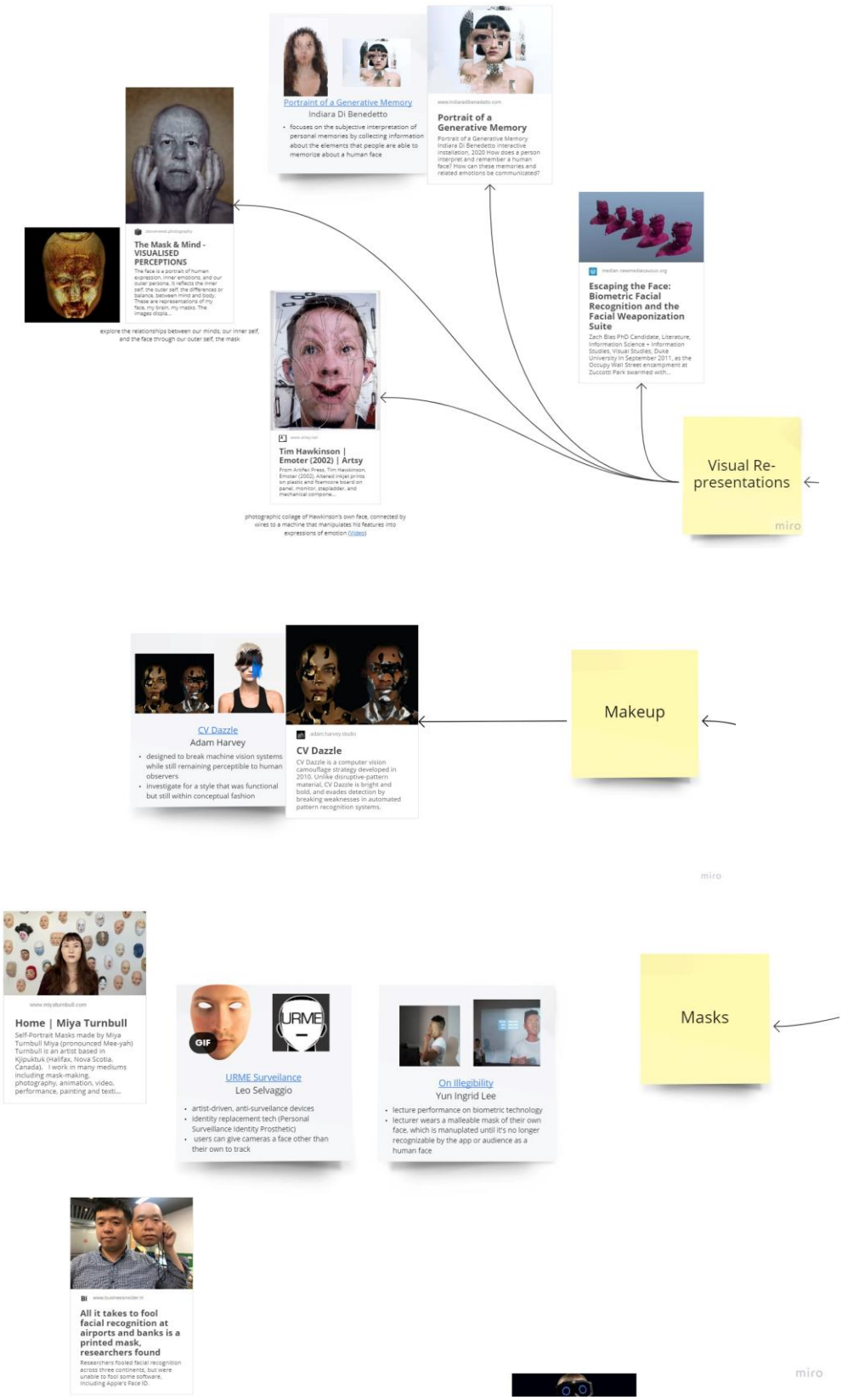


Figure 11: From top to bottom: Visual Representations, Makeup and Masks

Next, the relevant technologies investigated the many ways face concealment can be achieved through technologies. These included LEDs, Live Projection Mapping, and soft wearable robotics. As with the relevant works, examples or masks or face-related works featuring these technologies were provided.

The mind map helped to identify and combine relevant information from various references, providing an overview of the entire background research. As a result, these aspects and topics could easily be combined to create novel ideas. Therefore, the mind map functioned as a foundation for the concept generation, with each reference serving as a potential building block or source of inspiration.

Meeting

To discuss the findings and ensure that the generated concept aligns with the client's requirement, an online meeting was scheduled. In that meeting the mind map was presented and concepts were discussed. As a result of this meeting, the initial direction of this project had been established and new aspects requiring research have been identified.

5.2 Preliminary Concept

The preliminary concept resulting from the meeting involves using wearable robotics to animate specific sections or facial features of the mask. This concept was inspired by a combination of topics and categories presented in the mind map, particularly wearable electronics showcased in the Aposema mask and the critical features of facial identification [16, 38].

Because the mask aims to embody multiple identities, the focus on changing the critical features of the mask was deemed particularly relevant, since changes to these features were found to change the identity of faces [16]. Moreover, the use of wearable electronics offers a dynamic approach, allowing for the critical features of the mask to change. This could involve the inflation or deflation of certain features or sections of the mask, as well as the movement of features and sections to increase or decrease the distance between them.

At the meeting, some questions were raised, and certain aspects were highlighted that may require further investigation. To address these questions and explore the highlighted aspects, I plan to conduct some prototypes. In preparation of these, the most important and relevant findings of the background research and state of the art analysis are outlined.

5.2.1 Critical features

Based on the background analysis, modifying critical facial features was identified as a potential method for changing identity [16]. Due to the fact that the mask primarily focuses on the face, ears and hair-related features were not considered at this stage. As a result of the critical features table for face identification [Table 1], the table below [Table 2] explains the features that can be modified, as well as the way and the extent to which they can be modified.

Critical feature	Alteration	Scale
Lip thickness	Alter the thickness of the lower and upper lip	Thin – thick
Eye		
Color	Switch or transition to another iris color	Light – dark
Shape	Adjust the curvature and contour of the eyelids and eye corners	Narrow - round
Size	Modify overall size of the eyes (in particular the eyeballs)	Small – large
Eyebrow		
Thickness	Increase or decrease the density and thickness	Thin - thick
Shape	Change into a different form	Rounded – straight
Face shape		
Forehead height	Change the distance between eyebrows and hairline by either raising or lowering it	Short – long
Jaw width	Adjust the width of the jawbone	Narrow – wide
Cheek shape	Alter the volume and contour of the cheeks	Sunken and skinny – full and puffy
Nose		
Size	Modify overall size of the nose	Small – large
Shape	Change curvature and contour of the nose	Pointed – flattened
Skin texture	Adding or smoothing out texture of skin surface	Smooth - textured

Table 2: Overview of categorized facial features, derived from [Table 1] [17]

In this table certain features such as the cheek shape, though scoring quite low in perceptual sensitivity, are still included. At this stage of the project, I consider the inclusion of these features as beneficial for prototyping and for determining which ones work well for this project and which ones do not. This is partially due to the fact that the study on critical features exclusively featured white

males, which may affect the generalizability of the findings [16]. Moreover, the study changed the features of 2D images, whereas the aim of this project is to create a mask that will be worn on a 3D face. As such, features that scored low in perceptual sensitivity in the study may have a different effect when altered on a 3D face.

5.2.2 Approaches for Modifying Features

In preparation for the prototypes, a table was developed to outline the possible actions and motions that could modify these features. The table below [Table 3] is derived from a combination of background research and meetings with my supervisor, who provided valuable advice and direction on what had been done in previous years and what new approaches could be explored.

Action/Motion	Description	Alteration
Inflation or Deflation	Silicone chambers can be inflated or deflated by injecting air	Increase or decrease thickness/volume
		Modify overall size of features
Colored liquids	Injecting liquid dyes into the silicone's air chambers	Change color
Strings (e.g., twist string mechanism or attached to air muscle)	Sections can be pulled apart or together	Increase or decrease distance
		Adjust width
Balloon inside rubber sleeve with slits	Inflating the balloon will result in change the shape from straight to curved	Change curvature

Table 3: Overview of various approaches for modifying features

However, before testing the various actions and motions that can alter critical facial features as outlined in Table 3, a paper prototype will be developed to explore how various interactions might change the structure of the face and whether these have an effect on identity. While a paper prototype is not very representative of a 3D prototype, it is a cost and time-effective way of exploring the various options. The paper prototype will explore the effects of motions such as inflation or deflation, for instance through increasing or decreasing the thickness of the lips.
By testing these motions and their expected outcome on a paper prototype, an initial design direction can be established, which can make later prototyping more time effective.

5.3 Paper Prototype

As outlined in the preliminary concept, the paper prototype aimed to explore the influence of different alterations on facial structures and identity. It serves as an initial exploration of face feature modifications and their potential effects. As the paper prototype involving the male faces was the most extensive, it is detailed in this section. Information on the prototype involving the female face is provided in Appendix B1.

5.3.1 Process

The paper prototype consisted of printing out two copies of the same face. The face selected for the prototype was sourced from a research article [43]. These images were chosen for their average shape. From one of the faces, the facial features were carefully cut out, following the principles of human anatomy.

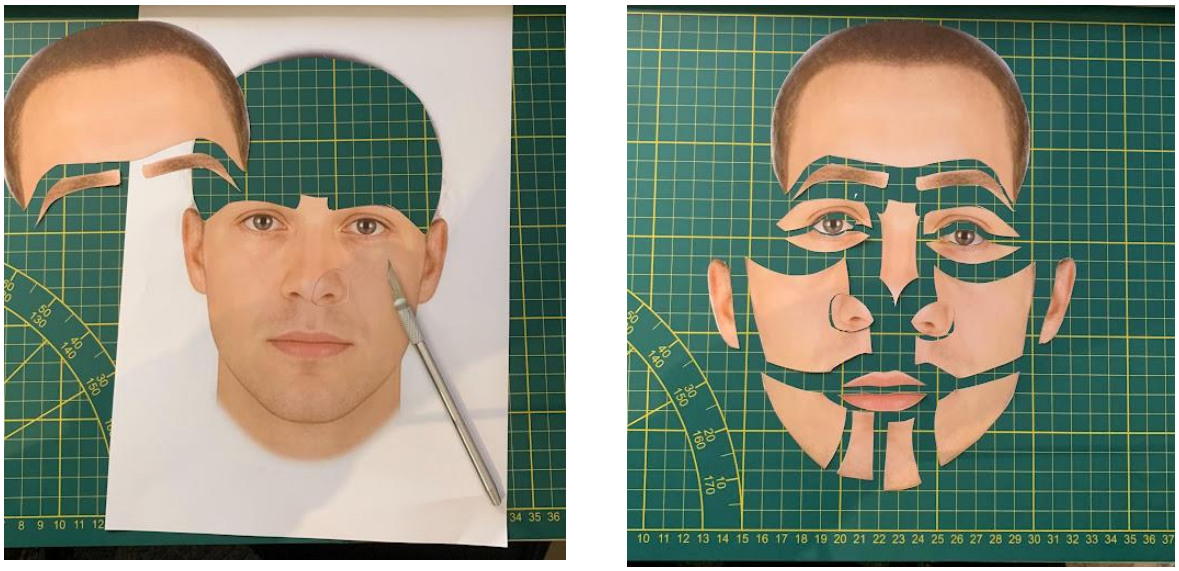
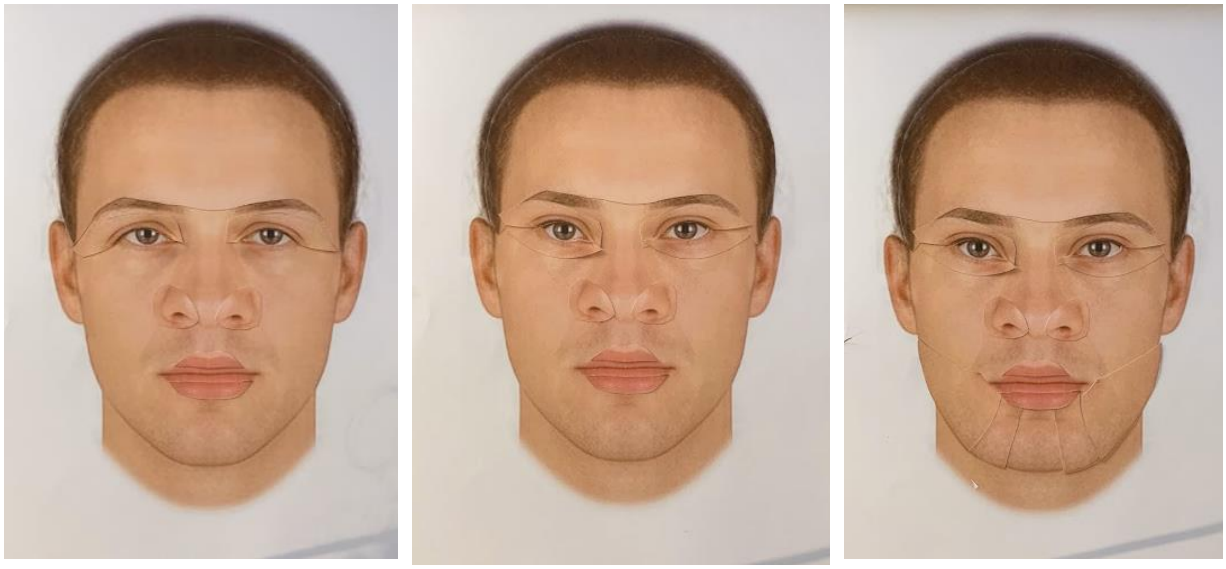


Figure 12: Process of cutting out facial features. Left: Work in progress with eyebrows and forehead cut out. Right: All feature snippets arranged to form a face

These cut-outs were then placed on top of the remaining face in different arrangements. By being able to easily shift and move the cut-outs, placements which seemingly altered the feature's appearance could be identified. Various arrangements representing various alterations to the face were created and documented so that their impact on the perceived identity of the face could be observed [Figure 13].



Variant #1 Variant #2 Variant #3

Figure 13: Three variants of faces made by different arrangements of the facial feature snippets. Details of the alterations made can be found in [Table 4]

Feature + Alteration	**Method**
Reduction of forehead height	By cutting out the forehead of the other image, it could be placed lower, thus reducing the height of the hairline, and appearing to change its size
Reduction of eyebrow thickness	The forehead was now covering the top part of the eyebrows, thus thinning them out.
Widening the nose (making it appear flatter)	Placing the nostrils further apart from each other (i.e., increasing the distance between de nostrils)
Changing the eye shape Variant #1: Downturned, Variant #2 and #3: Upturned	Changing the angle of the upper and lower eyelid
Increase jaw width (Variant #3)	Placing the jaw cut-out onto the image's jaw in a way that slightly exceeds it

Table 4: Changes made to the paper prototype faces

To ensure a more accurate comparison to the original face, one of the arrangements (Variant #1) was digitally edited to smoothen the edges and remove any shadows cast by the paper snippets [Figure 14].

Figure 14: Comparison of the original image (left) to the result of the paper prototype (right)

5.3.1 Results and Conclusions

Through this process, initial insights were gained regarding the potential effects of different interactions on the facial structure and identity. For instance, by adding eyebrows of the same shape above existing ones, the thickness of the eyebrows could be increased. Moreover, comparing the final modified paper prototype to the original face, and to the findings from the research on critical features [16], similarities between the prototype and the research could be identified. As with the research, modifications to critical features such as the lip thickness, had a seemingly greater impact on the morphing identity. Moreover, despite the paper prototype not being a perfect representation of a 3D prototype, it provided a cost-effective and time-efficient way to explore various design possibilities.

5.4 Silicone Prototypes

As outlined in Table 3 a significant number of the approaches for modifying the mask's facial features involve the use of silicone. Therefore, the primary objective of these prototypes was to gain familiarity with silicone and observe the impact of these actions and motions on the mask's identity. In contrast to the paper prototype, these prototypes can be used to observe and assess the changes in facial features in a three-dimensional context.

5.4.1 Pneumatics

This prototype involved using pneumatic actuation to inflate and deflate silicone facial prosthesis. Since its focus was to assess the effectiveness of specific techniques, minimal attention was given to the outer appearance of the silicone prosthesis. Later iterations of the prototype involved the use of improved molds and techniques.

Process

Among the reference materials obtained from previous years were silicones pneumatics and their corresponding molds. By examining these molds and observing the behavior of silicone during inflation, valuable insights into the process of inflating or deflating silicone were gained. The inflatable silicones consisted of two distinct layers, which I will refer to as the bottom and top layers. The bottom layer featured air chambers, while the top layer served as the visible surface. When inflated, both layers could expand and stretch depending on their thickness.

To explore the impact of various actions and manipulations on the mask's identity, lo-fi methods were employed for casting the silicone. These methods were chosen for their quick availability and easy replacement or disposal if needed.

The process began by creating the air chambers for the features that would utilize inflation. Using tie wire, a rough outline of the features was formed and filled with hot glue. Once the glue cooled and hardened, the outline was placed in a plastic (yogurt) lid. Next, equal parts (1A:1B) of the EcoFlex 00-35 FAST were mixed using a paper cup and popsicle stick. After a thorough but gentle mixing, the silicone was poured into the lid and left to cure for 5min [Figure 15].

Figure 15: Process of creating air chambers using tie wire

In later prototypes, this method was replaced by polymer clay. The air chamber was molded using clay and baked to harden. This was done so that the height and shape of the air chamber would be more manipulatable [Figure 16].

Figure 16: Process of creating an air chamber using polymer clay

After curing, the silicone was peeled out of the mold, and the air chamber was removed from the silicone. Another batch of silicone was mixed and poured into the same-sized lid, without any additional elements. Once cured, a thin layer of freshly mixed silicone was applied to bond the two silicone parts together, and an additional layer of liquid silicone was applied to the outer sections of both pieces to ensure an airtight seal.

Using tweezers or an X-Acto knife a small cut was made through the side necessary the silicone all the way to the air chamber. A tube was then inserted into the hole and, if needed, secured with more silicone to prevent air leaks. Excess silicone was trimmed with a knife or scissors. The features were then inflated to observe their appearance. Since observing the features on their own would not be an accurate representation, a plastic mask was used to serve as a base. The features were mapped onto the mask, and corresponding markings were cut out. To protect the silicone from potential sharp edges, the hollowed-out features were covered in cotton pads and tacky glue.

The result of inflating a silicone piece corresponding to the cheekbone can be seen in Figure 17, while Figure 18 showcases the effects of slightly inflating the upper lips.

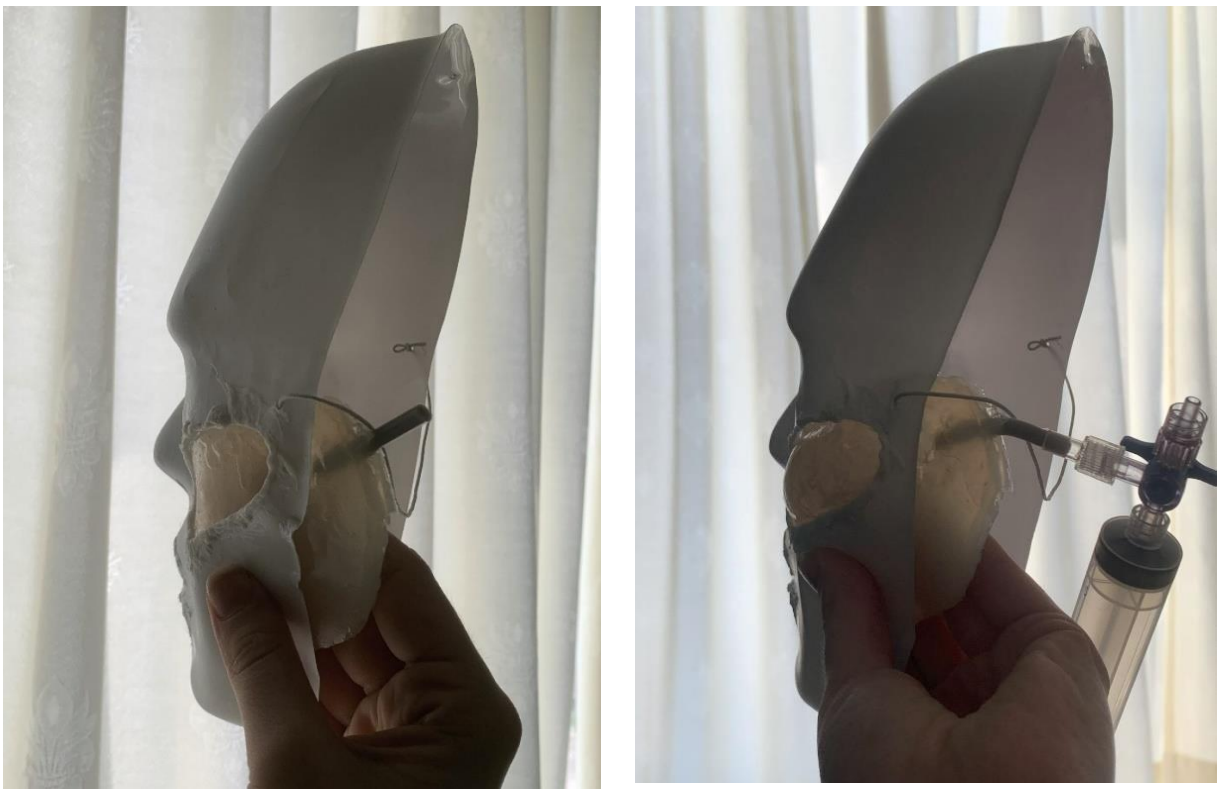


Figure 17: Effect of inflating the cheekbone

Figure 18: Effect of subtly inflating the upper lips

Results and Conclusion

Through the inflation and deflation of the silicone facial prosthesis, noticeable alterations in the appearance of various facial features were observed. Since it added volume to the silicone facial prosthesis, it was particularly suitable for altering features such as the lip thickness and cheek

fullness. Furthermore, as a result of the prototype, new potential approach was found, which aims to use the added volume to push specific features or sections of the mask.

5.4.2 Coloring through liquid injection

This prototype was conducted to investigate the possibilities and effects of dynamic coloring of silicone facial prostheses.

The prototype used water and food coloring as the coloring agent. This liquid was injected into a transparent silicone inflatable piece using a syringe and rubber hose, as depicted in Figure 19

Figure 19: Colored liquid injection into a silicone piece. Left: Prior to injection, Middle: Complete injection of liquid; Right: Removal of liquid from silicone.

The injection of the liquid caused the silicone piece to inflate, while simultaneously adding color to the air chamber. Upon removing the liquid from the silicone piece, a certain amount of residue remained in the air chamber, which is probably due to insufficient pressure of the syringe. This was attempted to be addressed by using a non-Newtonian fluid, consisting of a mixture of water, corn starch, and food coloring, as the coloring agent. However, as can be seen in Figure 20, this alternative proved to be unviable as it left even more residue in the air chamber.

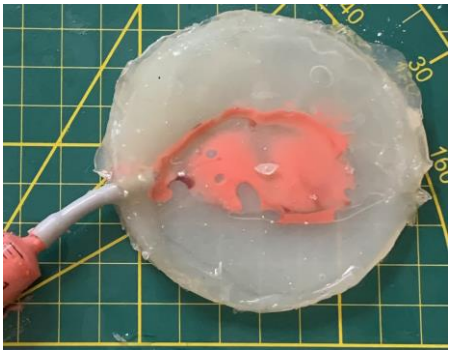


Figure 20: Residue left by the non-Newtonian fluid

Conclusion

Despite the challenges with residue from the water and food coloring, the prototype showcased the potential of coloring silicone through liquid injection as a means of altering the mask's features. The technique offers a way to add and remove color dynamically, which could for instance be used in features such as the cheeks to simulate blushing. Additionally, using this technique to add shadows and highlights to the face, along with the inflation, could emphasize the morphing of features. By applying the method learned from the previous paper prototype to the current prototype, the

potential to manipulate the thickness of mostly flat features, such as eyebrows, was found. Specifically, building on the concept of adding eyebrows of the same shape above existing ones, a consecutive eyebrow-shaped air chamber positioned right above the already visible eyebrow could be colored through liquid injection.

5.4.3 Coloring the rubber

This prototype served to find lo-fi ways of coloring the silicone rubber of the prosthesis. As can be seen in Appendix B2, it involved a series of tests and comparisons involving three different painting mediums, namely soft pastels, oil paint and acrylic paint, each added to uncured silicone. The outcomes of these experiments can be seen in Figure 21.

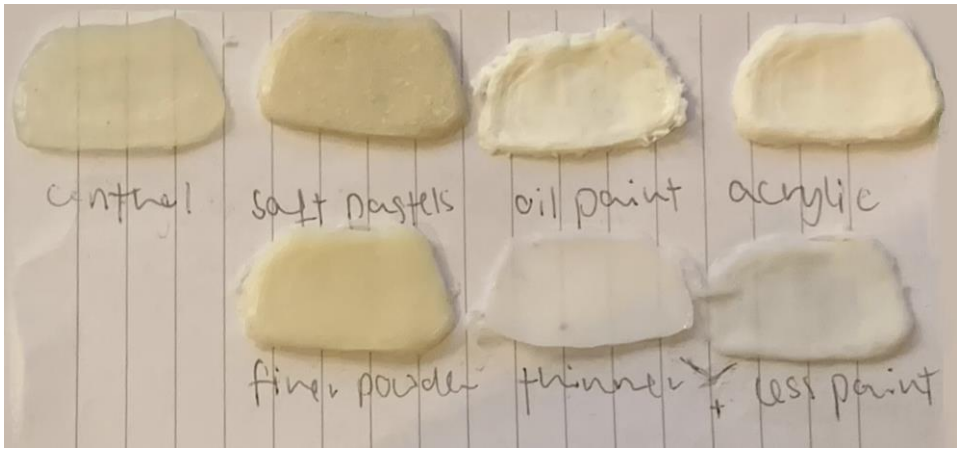


Figure 21: Series of tests involving various painting mediums. From left to right: control, soft pastels, oil paint, and acrylic paint

As a result, due to its adjustable opacity and its ability to evenly color the silicone rubber, acrylic paint emerged as the optimal lo-fi medium.

5.4 Final concept

Through prototyping and regular brainstorming meetings , more methods of designing and altering the mask's features were uncovered. Therefore, the final concept consists of conducting a co-design workshop, in which various designs can be explored and their effectiveness in morphing the mask's identity can be investigated.

6 Specification

This chapter aims to outline the structure of the workshop, including the necessary materials and equipment to facilitate it. This specification serves as the foundation for the realization of the workshop.

6.1 Overview of the Workshop

The main goal of the workshop is to explore various mask designs and their effect on morphing identity as well as to explore materiality, technologies, and performative aspects of the masks. Therefore, participants will be invited to conceptualize and realize masks that can play with the perceptions of facial identity. Through performance experiments, the perceptual experiences of each mask will be investigated.

The workshop will be organized and facilitated by three people. It aims to bring together participants from diverse backgrounds, including performers from theatre and dance, perception researchers, and artists. Those interested in participating were able to register through Google Forms, allowing them to be provided with further details about the workshop and enabling the organizers to plan for their participation.

6.1.1 Design and Research Goals

To outline and specify which aspects of the masks and performances should be explored and investigated during the workshop, a set of research and design questions are formulated. These questions include the comparison between realistic and exaggerated designs, the applicability of the critical features to the mask's design, the significance of the mask's visual appearance, and the role of lighting techniques. The full list of questions along with elaborations can be found in Appendix C.

6.1.2 Structure

The workshop is scheduled for an entire day, beginning at 9:00 and taking place until roughly 17:00h - with a lunchbreak from 12:30 to 13:30h. Participants of the workshop are not obligated to be present for the entire duration of the workshop.

The workshop will be divided into two phases: the design phase and the demonstration phase.

The design phase is scheduled from the start of the workshop until 14:30. In the design phase, the participants are introduced to the topic of the project through a short presentation.

After that, the participants are given the freedom to sketch and build their own facial prosthetics or masks. They will be given access to a wide range of materials so that they can experiment with them. Following the lunch break, participants will be given time to finalize their prototypes for the theatre stage.
The demonstration phase, which is scheduled from 14:30 until 17:00, focuses on the practical application and evaluation of the various masks. Through short theatrical sketches, the perceptual experiences associated with the different masks can be investigated and compared. At the end of this section a group discussion will be held in which participants can share their experiences, insights, and observations.

6.1.3 Materials and equipment

To ensure that there will be enough supply and variety for the anticipated number of participants, a list of the workshop's materials and equipment was made. The aim is to facilitate the creation of varying designs by having the workshop offer a diverse range of materials.
Some materials were chosen based on insights and experience gained from prototyping. For instance, a selection of acrylic paints was made available for processes like coloring silicones. Additionally, for more exploration, the list includes some new and untested materials, such as silicone paint base for painting silicone surfaces.
Furthermore, the workshop will provide materials and tools specifically beneficial to the mask-making process, including Styrofoam heads and standard cardboard masks. Various technologies, such as a mini projector and LEDs, are also included in the list, as well as a vacuum forming machine to quickly produce masks from face molds.

6.2 Evaluation Plan

To address the research and design questions outlined in Appendix C and summarized in 6.1.1, an evaluation plan has been formed. This plan incorporates a variety of methods, including interviews, observations, and group discussions. These structure and contents of the discussions and interviews use the research and design questions as their foundation.
During the design and creation session of the workshop, semi-structured individual interviews will be held to develop an understanding of their design choices. Along with the group discussion, this reflection and evaluation moment should contribute to answering the research and design questions formulated for the workshop, providing valuable feedback for further iterations and refinement.
A more detailed explanation of the evaluation plan is provided in Appendix D.

7 Realization

The realization of the workshop is split into two parts. The first part describes the preparations for facilitating the workshop, focusing on two specific design aspects. Subsequently, an overview of the workshop's execution is presented, including the introduction, design and demonstration phase, and a comprehensive overview of the showcased masks.

7.1 Preparations for the Workshop

In preparation for the workshop, the necessary materials and equipment were acquired. By having a comprehensive outline of materials which could be provided by the organizers and materials that needed to be obtained, the latter could be promptly ordered or purchased to ensure that it would be delivered on time for the workshop.
Moreover, preparations also involved the design of 3D-printed casting molds as well as the design of a vacuum forming mold using a 3D face scan. The following two sections will provide a more comprehensive overview of the respective design processes.

7.1.1 casting molds

To simplify the process of casting facial features out of silicone, various molds of facial features were designed. These molds were created using 3D printing, which allowed for precise results unlike the earlier lo-fi prototypes. Multiple variations of the same feature were made, so that various effects could be tested. Moreover, these molds could demonstrate some of the possibilities to the participants, and potentially inspire them to come up with their own unique mold.
The molds were designed using Adobe Illustrator and OpenSCAD.

7.1.2 custom vacuum forming mold

Through vacuum forming, a custom mold was to be realized which could be used to create quick replicas of during the workshop. The process began by using the Scandy Pro iPad application to create a 3D scan of my face. Using Meshmixer, the scan was cleaned up by filling any holes in the model and removing the parts unrelated to the face, such as the neck. Next, to prepare it for the vacuum forming process, the model was made solid, and the resulting backside was smoothed and levelled.

7.2 Workshop Execution

A total of 10 participants, excluding the three organizers, took part in the workshop. Due to scheduling constraints, not all participants were able to attend the entire duration of the workshop, with some arriving late, leaving temporarily, or departing early based on their availability.

The first half of the workshop was conducted in 'de Atelier', a large crafts studio at the University of Twente. Some of the tables in the room were positioned in a closed square formation at the center, with seats placed around them. Prior to the start of the workshop, at around 8:45, the necessary materials and equipment were set up.

After everyone was settled, a short introductory presentation was held to provide context and inspiration. The presentation began by briefly explaining the graduation project itself and providing an overview of the goals and agenda for the workshop. The presentation touched upon the main themes of the graduation project, presenting key findings from the background research related to masks and face perception. Additionally, it showcased some related works.

Following the presentation, each participant had an opportunity to introduce themselves and share their background. Furthermore, participants with a background in mask making, costume designing, and related fields elaborated on their previous works. They described the mediums they had worked with, showcased some of their creations and prototypes, and shared insights gained from their experiences, including valuable tips and lessons they learned from prototyping.

Figure 22:Presentation and demonstration of materials suitable for wearable mechanics.

For instance, a costume designer contributed their knowledge of wearable mechanics by presenting materials such as flexible plastics and strings that are suitable for constructing intricate mechanisms [Figure 22].

Another participant, with a background in sculpture and experience in theatre and mask making, brought their expertise in working with plaster and shared insights on its application in mask creation.
During this session, the process, results, and findings from silicone prototyping were also presented. Furthermore, each participant was given an information letter and consent form, which can be found in Appendix E.

7.2.1 Design phase

Following the introductions, the design and creation phase of the workshop was initiated. Some paper was distributed to allow participants to sketch their ideas, write down notes, and visualize their concepts.
Many participants started by exploring the various materials provided. Thoughts and thought processes were openly shared with one another. For some participants inspirations and ideas emerged from scanning through the available materials and examples provided. For instance, one participant inflated one of the provided examples of silicone pneumatics at varying speeds and compared the slow in-and deflating of the silicone with the movements of a frog's vocal sac.

Participants that were interested in using a specific mediums or techniques often sought advice and guidance from those with existing knowledge in them. This usually involved asking for reminders on how certain materials worked or how to best apply them to their specific design ideas. Additionally, some participants formed collaborations, brainstorming together to develop innovative mask designs, and working together to realize it.

One of the masks a participant was working on involved the process of casting a face in plaster. The initial application of the mask as well as a photo of its intermediate stage can be seen in Figure 23.

Figure 23: Process of casting a face in plaster; Left: Initial state -applying the plaster onto the face; Right: Intermediate state – mask split horizontally

Moreover, during the workshop a mini projector was used to project a face onto one of the Styrofoam heads. The distance, angles, and rotations of the projector were manipulated to observe the resulting transformation [Figure 24].

Figure 24: Observing the effects of distorted projections

After a lunch break, where sandwiches were provided, the design phase continued. While this phase was originally scheduled until 14:30 it was extended to 16:00.

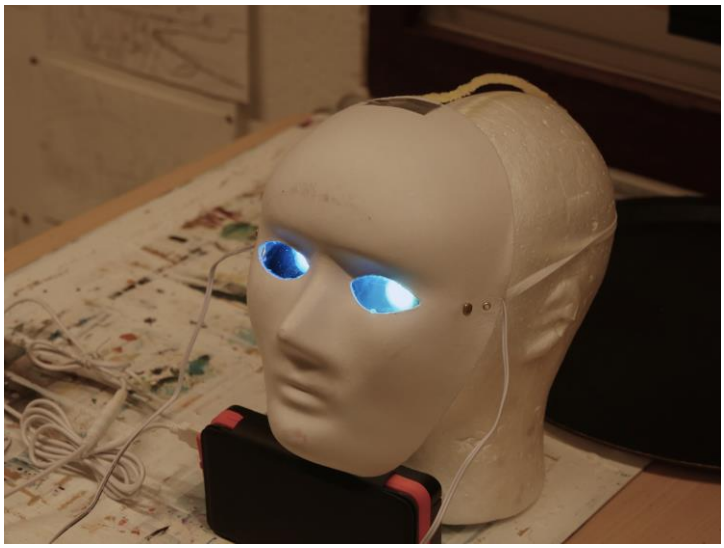


Figure 25: A finalized mask design incorporating LEDs as its eyes

This was to facilitate sufficient time for participants to finish up their masks, since the focus of the workshop was on exploration of designs rather than the performance sketches. One of the finalized mask designs can be seen in Figure 25.

7.2.2 Demonstration phase

The resulting masks from the design phase were brought to the 'Amphitheatre', a theatre space at the University. This space could be darkened, and two moveable and adjustable spotlights were available so that the effect of various lighting conditions on the masks could be examined.
Due to the extended duration of the design phase, the original plan of conducting short theatrical sketches was abandoned. Instead, the focus shifted to the visual presentation of the masks in the theatre space. Moreover, rather than conducting a group discussion at the end of the session to discuss the observations of each mask, these discussions took place during the showcase itself.

Figure 26: Presentation of one of the masks

As illustrated in Figure 26, at the beginning of each showcase, the participant(s) who created the mask presented it, by explaining its design and sometimes the construction process. Subsequently, the mask was worn by a performance artist, who engaged in a series of movements and actions. By maneuvering around the stage, and performing various body movements and head rotations, the masks could be observed and examined under various angles. Moreover, lighting settings and intensities were adjusted. If a particular location or movement elicited a visual effect, the performer was asked to repeat or emphasize similar movements so that this could be examined more in-depth. As the masks were showcased, participants shared their observations and sometimes even discussed potential future iterations of the masks. To document the results, the performer and the mask were filmed and photographed during the showcase.

7.2.3 Overview of Masks

Not every mask that was made during the workshop could be presented in the theatre space. Some participants had to depart prior to the start of the showcase, which prevented their mask design from being presented. Conversely, a few participants had multiple designs they wished to showcase. All in all, a total of nine masks were showcased during the demonstration phase, which will be outlined below. For an overview of all the photos of the showcased masks, refer to Appendix.

Mask #1: Plaster-Mask

The first mask that was showcased during the workshop was created by casting a face in plaster. The mask was split horizontally, with the dividing line positioned above the nose and below the eyelids.

The combination of the rough surface of the mask, the varying elevations caused by the features and the division of the mask evoked a resemblance to the earth's tectonic plates. Additionally, by casting a hand onto each half of the mask using plaster, a mold which served as a handle for the performer was created. As a result, each half of the mask could be moved conveniently and independently of each other, as is demonstrated in Figure [27].

Figure 27: Mask#1 showcased with differing placements of the lower mask half

From the movements of the mask's plates various effects could be observed.
For one, the overall structure of the face, including the arrangement of the nose and lips to the forehead, could be manipulated. For instance, by increasing the vertical distance between the two halves, the perceived face was elongated. These movements elicited a resemblance to shifting landscapes, highlighting the initial tectonic plate comparison. Moreover, at certain angles and placements, glimpses of the performer's eyes could be seen.
Furthermore, from viewing the mask at various angles, the effect of various lighting could be observed. Most notably, it could be observed that at certain angles the mask seemingly lost its resemblance to a face. Instead, it was remarked to resemble a mound of clay.

Mask #2

The second mask was created by heating and molding a Worbla thermoplastic sheet over the plaster face mask (Mask #1). A bit of silicone was incorporated in between the plaster base and the plastic. This silicone layer could be inflated, causing the plastic sheet to lift.

Figure 28: Mask#2 Demonstration of the mask's inflation

Mask #3

The third showcased mask used one of the provided cardboard face masks as its base. It featured two LEDs as its eyes with clear blue plastic covering the eye holes to emit blue light [Figure 29].

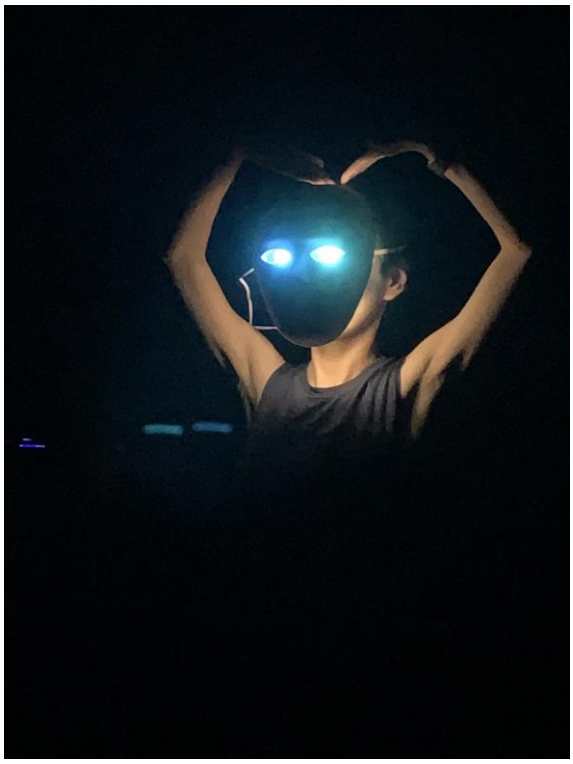


Figure 29: Mask#3 showcased in the dark

The participant who created the mask mentioned that to create the illusion of the 'eyes' following you the LEDs were placed slightly further into the eyeholes. The placement of the LEDs also resulted in a slight offset between the mask and the performer's face. This, combined with the illumination of the wearer's face by the light emitted from the LEDs, created a floating effect, which was particularly noticeable when the entire theatre space was darkened. Moreover, when viewed from the side, both the mask's face and the performer's face were simultaneously visible [Figure 30]. It was speculated that increasing the offset between the mask and its wearer could further enhance the visibility of both faces.

Figure 30: Mask shown from the side

Figure 31: Mask worn backwards in a darkened theatre

Furthermore, as demonstrated in Figure 31, when the mask was worn backwards while the room was darkened, the expectations of body movements could be defied.

The visibility of the mask's face despite the darkness of the room created the assumption that the performer and the mask were facing the same direction. However, arm movements occurring near the mask revealed glimpses of the performer's body and various movements which contradicted the expectations.

Mask #4

This mask was created by heating and molding clear blue plastic over a Styrofoam head. The back of the mask consisted of a standard face mask, while an LED positioned at the center illuminated the mask from within. While the mask was not wearable, the performer could carry and move it, allowing it to be observed from various angles. The transparency of the blue plastic combined with

the internal LED illumination, resulted in the mask's backside being visible from both front and back [Figure 32 and 33]. This led to the mask being compared to the hollow mask illusion.

Figure 33: Mask#4 backside

Figure 32: Mask#4 side view

Furthermore, the cuts made to the mouth and duct tape covering the eyes of the basic mask, resulted in the expression of the mask being perceived as horrific.

Figure 34: Mask#4 back side view

Mask #5

The fifth showcased mask consisted of two types of plastic, black and clear. Due to the light reflecting off the mask, it took on a wet appearance.

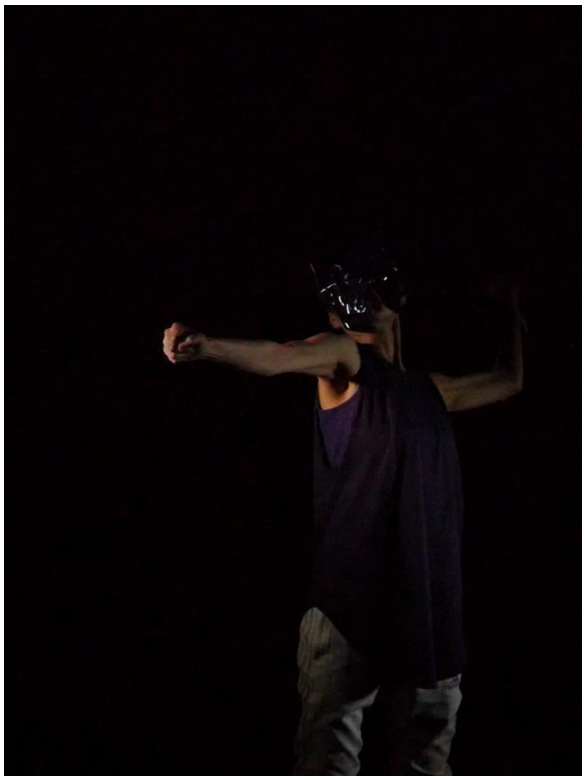


Figure 35: Mask#5 being showcased

Mask #6

The sixth mask that was showcased was a composition of multiple cardboard face masks. It consisted of a central mask that was surrounded and extended by horizontally and vertically split halves of other masks, all the same type.

The mask was constructed by splitting one cardboard mask in half, with each half attached to either side of the center mask. Additionally, another cardboard mask was carefully cut just below the nose, extending over the top of the center mask. The last mask was horizontally split at the height of the

Figure 36 Mask#6 being showcased

lower line of the eyehole, positioned just below the upper lip of the central mask.
During the showcase, the performer rotated her body, while spinning the mask at a faster speed. The rotation stopped once the mask was oriented towards the audience while her body faced the opposite direction. As with the third showcased mask, many body movements made in this counterposed position defied the expectations.
Furthermore, the side profile of the mask was significantly influenced by the presence of all the noses. For instance, the nose of the mask placed just below the upper lip was lined up in a way that created the illusion of a pointy chin when viewed from the side [Figure 38].
Moreover, when the performer faced opposite to the light and was viewed from the side, the side mask was illuminated from behind. Due to the light subtly bleeding out the seam connecting the side mask to the central mask, causing it to stand out from the rest. This created the illusion of the side mask being a separate entity [Figure 37].


Figure 38: Mask#6 side view


Figure 37: Mask#6 illuminated from behind

Mask #7

The seventh mask featured a large wearable mechanism consisting of various materials, including strings and spring steel. This mechanism allowed the mask to open and close with the simple pulling of a string, as illustrated in Figures 39 and 40.


Figure 40: Mask#7 closed


Figure 39: Mask#7 open

Moreover, at certain angles, the shininess of the sheets used in the mask, reflected a subtle glimpse of the wearer's face. During discussions, it was conceptualized that by using a shinier material, such as mirrors, a greater reflection of the performer's face could be achieved, thereby enhancing the effect.

Another concept that was explored involved the use of separate facial features within the mask. When the mask is closed, these individual features could come together to form a complete face.

Figure 41: Mask#7 showcase

Mask #8

The eighth showcased mask was a plastic mask designed to resemble the face of one of the two Styrofoam heads. The process involved cutting off the face from the Styrofoam head to be used as a mold for vacuum forming.

Moreover, this mask is connected to an identical Styrofoam head by a few strings on one side of each head. While the mask is worn on the head of the performer, the Styrofoam head attached to it is positioned on one of the shoulders and secured into place by fastening the steel ribbon.

Figure 42: Mask#8 showcase

Figure 43: Mask#8 showcase

Mask #9

The last mask that was showcased was specifically designed to be used in a choir. It featured a unique exterior design with the goal of promoting more individuality among the members. Moreover, the top section of the mask was able to be lifted, creating an open space around the mouth area. This was down to ensure that the wearer's voice remained unobscured and allowed for vocals to be accentuated through the mask.

During the mask's presentation it was conceptualized how future iterations could enhance the accentuation of vocals. For instance, by incorporating features such as vibrations, lights, and fur, which could be synchronized with the wearer's voice.

Figure 45: Mask#9 showcase

Figure 44: Mask#9 showcase

8 Evaluation

In this chapter the masks that resulted from the workshop are evaluated by presenting the observations shared during their showcase. First, however, the changes made to the evaluation plan are discussed.

8.1 Changed Evaluation Plan

While the evaluation plan initially aimed to conduct interviews after each mask had been showcased, instead, the evaluation of the workshop's outcome in relation to its design and research question is primarily based on observations and group discussions that occurred during the showcase of each mask. Additionally, it includes observations from experiments, such as the effect of a distorted face projection conducted during the design phase of the workshop.
To document the workshop's process and the discussions that took place, written notes were taken, which were later categorized and structured according to the design and research objectives.

8.2 Evaluation of the Workshop's Outcomes

The evaluation of the workshop's outcome in relation to its design and research question is primarily based on observations and group discussions that occurred during the showcase of each mask. Additionally, observations from experiments, such as the effect of a distorted face projection conducted during the design phase of the workshop, are also included.
To document the workshop's process and the discussions that took place, written notes were taken, which were later categorized and structured.

Projections

During the design phase a face was projected onto a Styrofoam head, and its projection was distorted by manipulating the distance, angle, and rotation of the projector to observe the resulting transformation. When the projector was manipulated in a way that distorted the projected face, while aligning the shadows of the projected face with the natural contours of the Styrofoam face, it elicited the illusion of the projected face merging with the physical features of the Styrofoam face. For instance, as depicted in Figure 46, where the projected face has been rotated 180 degrees and the sides of the nose are lined up.

Figure 46: Two projected faces, with the projection of the face on the right being distorted

Deformation of facial Identity

During the performance sessions, adjustments were made to the lighting intensity and angles to observe and discuss their effects on various mask designs.

Trough these adjustments an influence of lighting variations on the perception of the facial appearance of Mask #1 could be observed. From certain angles, it was observed that the mask no longer resembled a face, but instead it was perceived as a mound of clay. As a result, through the use of various lighting techniques the facial identity of the mask was deformed, shifting between a face and a non-face resemblance.

Dual identity

Moreover, the influence of light on the overall perception of the mask was demonstrated during the showcase of Mask #6. Despite all the masks being attached and connected, the lighting could make one of the masks on the side stand out in a way that made it appear as though it was a separate entity. Likewise, the visibility of two distinct identities was also exhibited in Mask #1, where certain angles and placements of the mask's halves revealed glimpses of the performer's eyes.

Similarly, in Mask #3, the illumination of the mask caused both the mask's face and wearer's face to be simultaneously visible.

Defying expectations of movement

Furthermore, the mask's illumination dictated the mask's viewing direction even in a darkened theater space. Therefore, when worn backwards, any body movements occurring near the mask that did not align with the viewing direction of the mask, contradicted the assumption of mask and wearer facing the same direction and thereby defying some expectations of body movements. Despite not having its own light source, Mask #6 was able to create a similar effect when worn backwards in minimal lighting.

Intensity of alteration

Moreover, when comparing mask designs, it was noted that there were variations in the intensity of the alterations. For instance, the alteration featured in Mask #2, i.e., the slight lifting of the mask caused by the silicone inflatable, was perceived as subtle in contrast to designs like Mask #1, where the two halves of the mask could be moved freely and independently.

The ability to shift and manipulate the two mask halves significantly affected the overall perception of structure of the face. For instance, by increasing the vertical distance between the two halves, the face could be elongated, showcasing the potential for more dramatic transformations.

9 Discussion

The initial goal of the thesis was to design and develop a theatrical mask, that uses wearable robotics to dynamically change its facial features in a way that transforms its facial identity. However, as a result of prototyping and various brainstorming sessions, the focus gradually shifted to exploring various designs and their effect on facial identity in relation to lighting conditions and viewing angles. While this led to various findings and new insights, time constraints prevented these from being incorporated into a final prototype.

Consequently, this chapter aims to outline these findings and discuss how they could be incorporated into the mask design. It will delve into various aspects related to the research and design process, while also discussing the limitations encountered during the study. Additionally, this chapter will provide recommendations for potential future directions.

9.1 Outcomes and Main Findings

Despite not meeting the project's initial goal of developing a mask able to embody multiple identities, several insights gained from the background research, workshop and prototyping can be used to formulate a potential final mask design.

As design's aim is to transform the mask's facial identity from one face representation to another, it should focus on altering the critical features, as systematic changes to these features were found to alter the identity of faces. However, considering the limitations of the study, such as the use of 2D images and male faces, it is recommended to explore more low PS-features, such as cheek shape.

To alter these features dynamically, the mask could incorporate soft wearable robotics, particularly silicone pneumatics, and liquid injection. During prototyping, silicone inflatables were shown to be an effective method of adding and removing volume to features. As a result, it could dynamically alter the appearance of various features, such as lip thickness or cheek shape. Additionally, one of the designs showcased during the workshop demonstrated how silicone inflatables could be used to lift a section of the mask. Moreover, as demonstrated during prototyping, liquid injection offers additional possibilities by dynamically changing the color and appearance of features while potentially inflating them simultaneously. For instance, by adding blush to the cheeks, a sense of life could be added to the mask. Feature changes could also be accentuated through this method by for instance adding contour and highlight to the mask. Additionally, this method could be used to alter the appearance of eyebrows.

To emphasize the changing features, a combination of various lighting effects should be used. The workshop demonstrated the potential for lighting to transform the perception of the mask's facial

appearance. By altering the angle of the lighting, more contrast can be added to the face, potentially highlighting the changing features.

Moreover, during the workshop a variation in the intensity of mask alterations was observed. Designs that incorporated elements like silicone inflatables were perceived as more subtle in their transformations. This subtlety was also present in the silicone prototypes, with the changes staying within realistic boundaries.

In theory, however, the subtlety observed to the modification of the critical features should not pose as an issue. The findings from the research indicated that the type of feature being altered had a greater impact on the perception of identity than the extent to which the features were modified. Therefore, even subtle changes in critical features could significantly influence the perceived identity of the mask. Furthermore, while some designs demonstrated the potential for more dramatic transformations, subtle changes in masks, as for instance seen in the Japanese Noh mask, may still be effective even in a theatrical context. However, considering that the Noh mask's transformations are related to facial expressions and that facial expressions and facial identity are distinct aspects, the effectiveness of these subtle changes may not be applicable to the proposed mask design.

9.2 Limitations

(Paper) Prototype and critical features

While the paper prototype allowed for initial exploration of facial features alterations and their effect on the facial identity, time constraints limited the inclusion of multiple types of faces to ensure more diversity. Therefore, while the results coincided with the critical features outlined by the background research, both the prototype and the study were based on white male faces. Additionally, while this project used the critical features as it's guide to which features to prioritize for alteration, the use of 2D Images in the critical features research raises questions about the full applicability of the findings to 3D faces. Moreover, the focus on white male faces in the research limits the generalizability of the results to a more diverse population.

Workshop Process

While every participant had access to the same selection of materials and equipment, the masks that made during the workshop each varied from the other. Due to these variations, the effects of different designs could be observed and examined. However, the workshop took place over the course of a single day. Within this timeframe, participants were introduced to the topic of the research, brainstormed, developed their prototypes, and subsequently presented their results.

Splitting the workshop over multiple days could facilitate its participants with more time to reflect on their design ideas, which could potentially lead to more designs or creative concepts. Moreover, this would facilitate more time to realize and touch up the final prototype, perhaps resulting in more hi-fi or detailed designs. Furthermore, this could reduce the duration of the workshop's session, which could help reduce fatigue, particularly during the afternoon.

The evaluation

Each showcased mask design and perceptual experience was evaluated based on the observations shared by the participants. Due to the fact that these sessions were not audio recorded, the evaluation relies on written notes. Unlike with audio recordings, written notes may not capture all that was discussed, potentially resulting in the absence of relevant information. Thus, the lack of an audio recording can potentially impact the validity of the evaluation.

Moreover, while the evaluation plan initially aimed to conduct interviews after each mask had been showcased, these were eventually disregarded. This was due to the evaluation plan not accounting for the possibility of certain phases taking longer than scheduled.

9.3 Future Work

Despite not meeting the project's initial goal of developing a mask able to embody multiple identities, several insights were gained from the background research, workshop and prototyping which could be further explored.

Firstly, the exploration of lighting effects on various mask designs during the workshop showed the potential for lighting to transform the perception of a mask's facial appearance. Though the deformation of the mask's facial identity observed during the workshop deviated from the initial goal of transforming facial identity, it does demonstrate the influence of lighting on the perception of the mask. Future work could further explore this relationship to identify ways in which lighting can be used to influence the perception of a mask's facial identity.

Moreover, the focus on white male faces in the critical features research presents an opportunity to broaden the scope and increase the diversity of the study's participants. Extending the research to include faces from various ethnicities, genders, and cultural backgrounds will enable a more comprehensive understanding of how masks interact with different facial identities.

Additionally, as the research used 2D images as stimuli the applicability of the findings of the critical features research to 3D faces should be investigated.

Furthermore, while the prototypes of this project focused heavily on silicone pneumatics, future work could delve deeper into exploring a diverse range of techniques and materials to further

transform facial identity perception. For instance, building upon the projection experiment conducted during the workshop, where a distorted face projection onto a Styrofoam head created the illusion of the projected face merging with the physical features of the Styrofoam face when its shadows aligned with the natural contours.

10 Conclusion

This thesis set out with the initial goal of designing and developing a theatrical mask that is able to embody multiple identities.

Literature research indicated a strong connection between faces and identity, emphasizing the significance of the eyes and mouth in face detection. Moreover, critical features were identified as crucial for familiar and unfamiliar face recognition, and modifying these features was found to result in changes to the perceived identity of faces.

By drawing on the knowledge gained from the research, meetings and inspiration from related work, the preliminary concept of using soft wearable robotics to dynamically modify the mask's facial features and transform facial identity was formulated. Prototyping served as a means to experiment with various techniques, such as silicone pneumatics and liquid injection for inflating and deflating, and dynamically coloring silicone respectively.

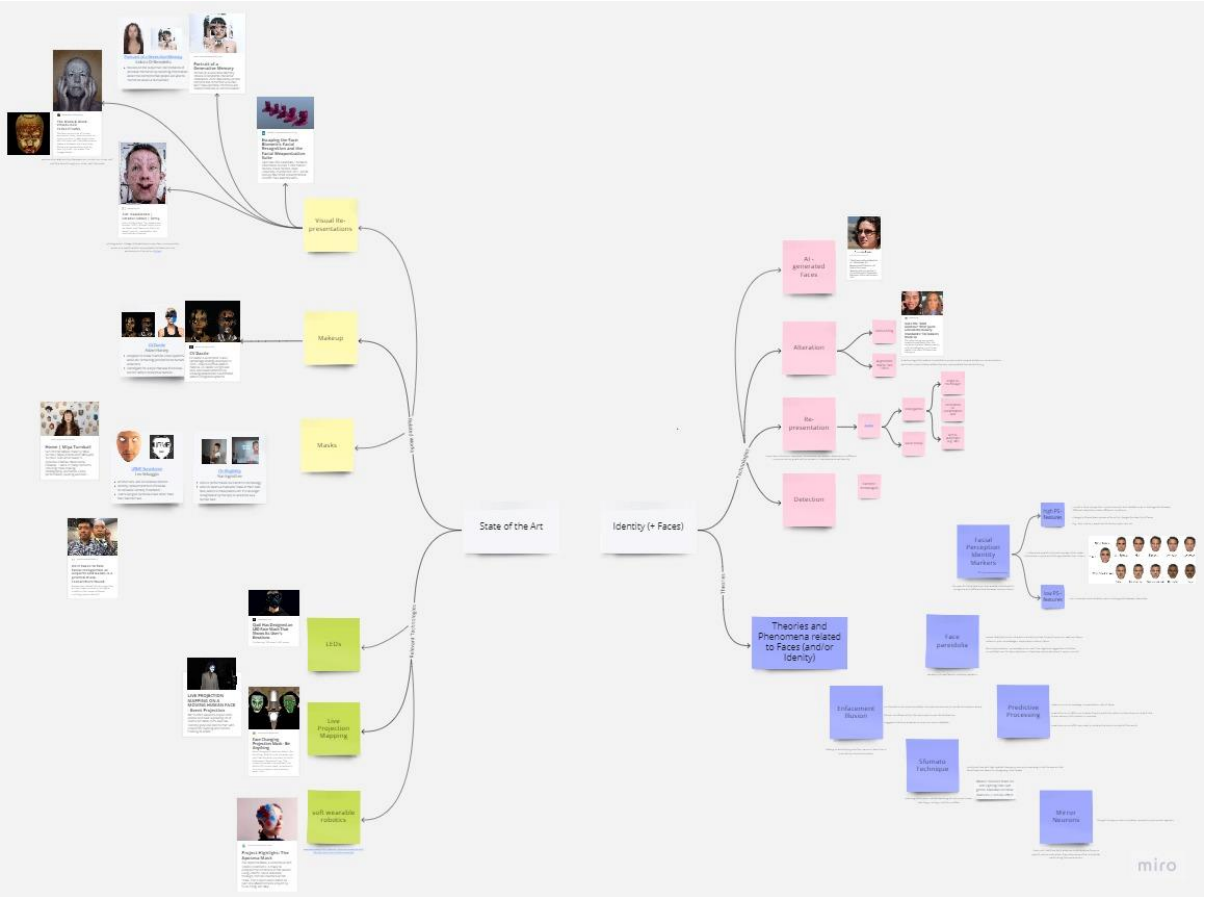
However, as a result of the prototyping and various brainstorming sessions, the focus gradually shifted to exploring various mask designs and their influence on facial identity with a specific emphasis on the influence of lighting conditions and viewing angles. To realize this exploration, a co-design workshop was conducted, inviting participants from various backgrounds to create masks that play with the perception of facial identity.

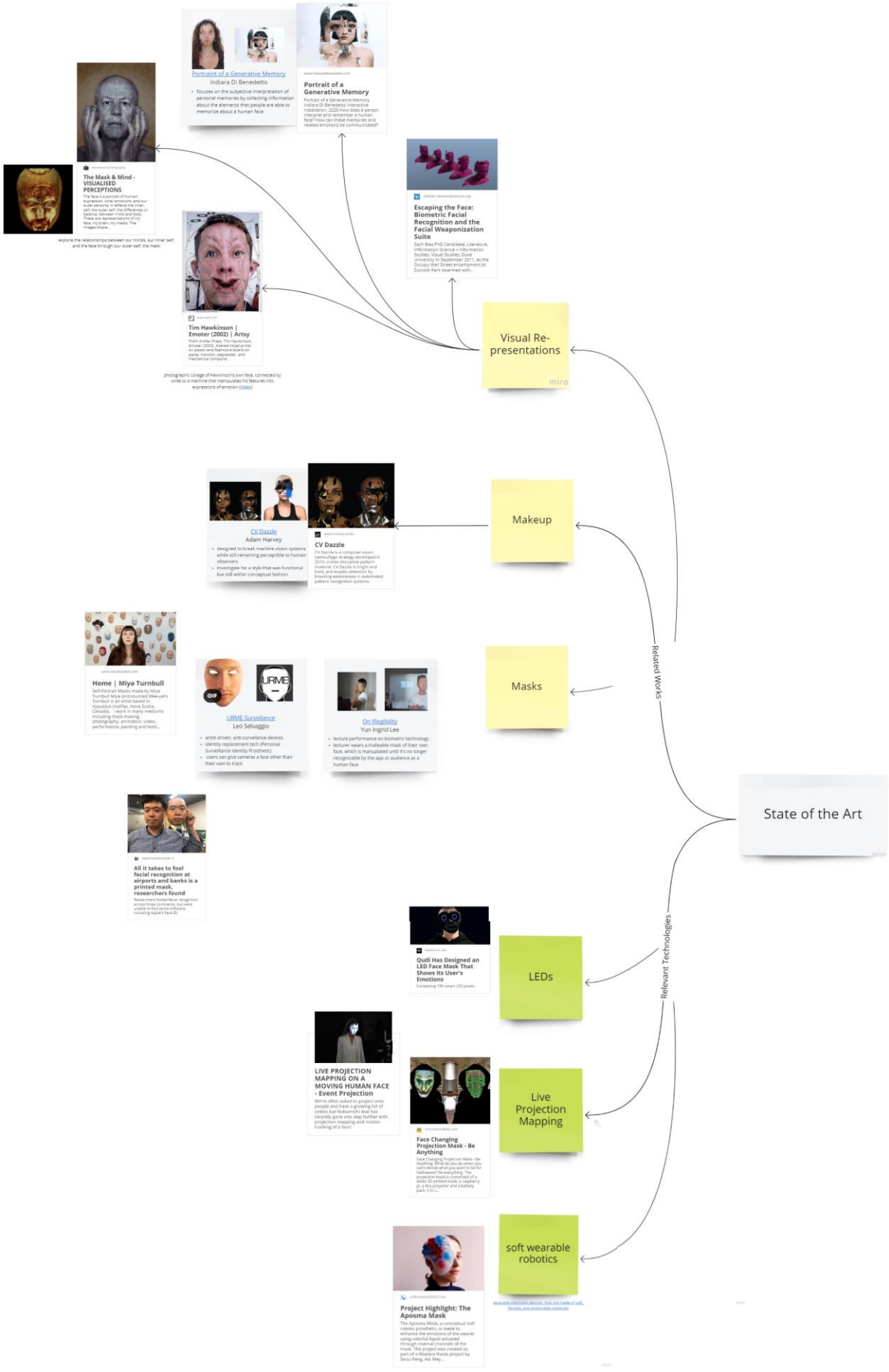
During the workshop's showcase in a theatrical setting, the masks' effects were observed and assessed in their intended context. Notably, different effects could be observed particularly when manipulating lighting and angles: some masks defied expectations of body movement, some other masks embodied dual identities, and one mask was able to deform facial identity.

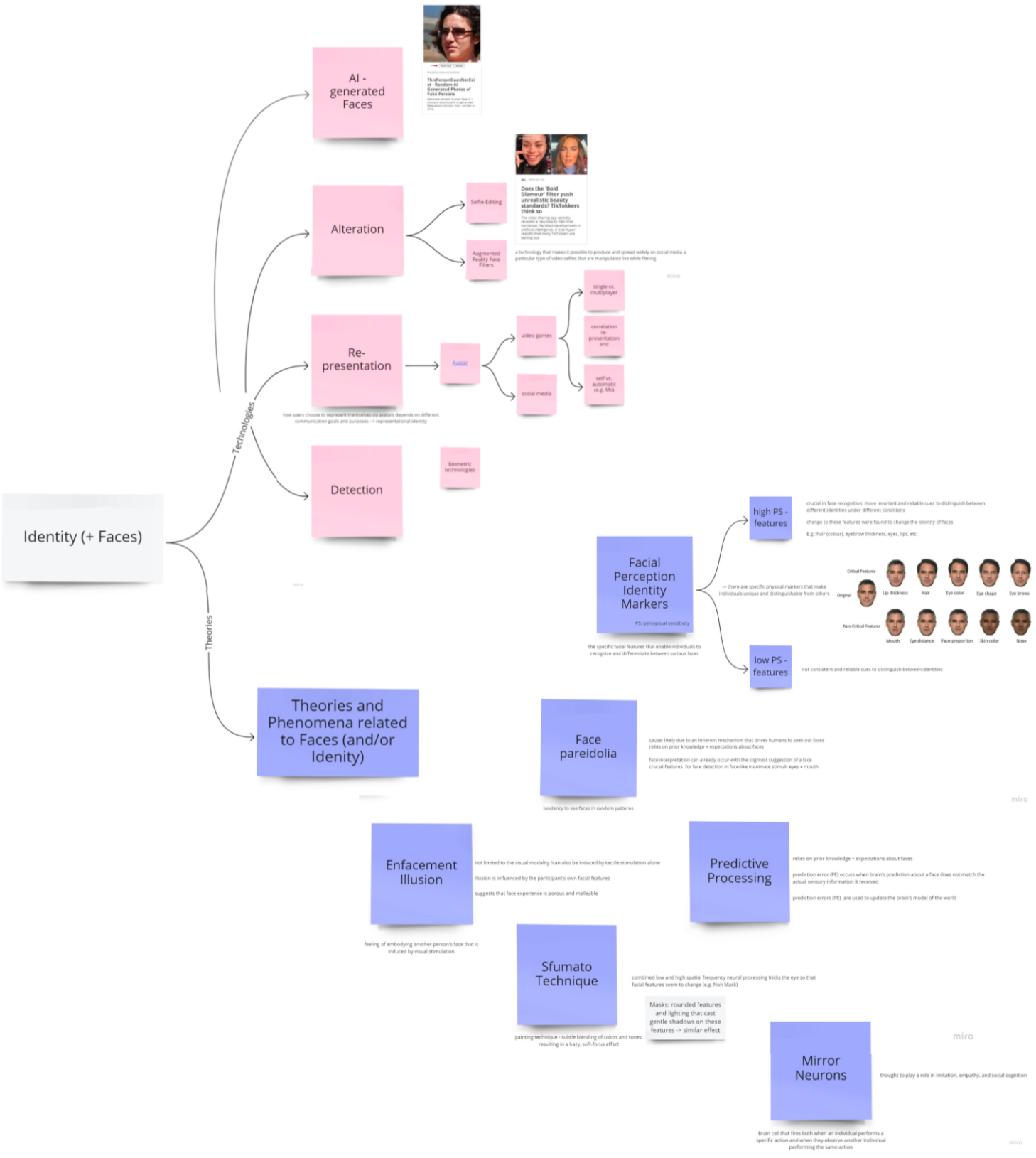
While the project's initial goal of a mask with multiple identities was not met, the insights gained from the background research, prototyping and the co-design workshop set a path for further research.

Appendix

Appendix A: Mind Map



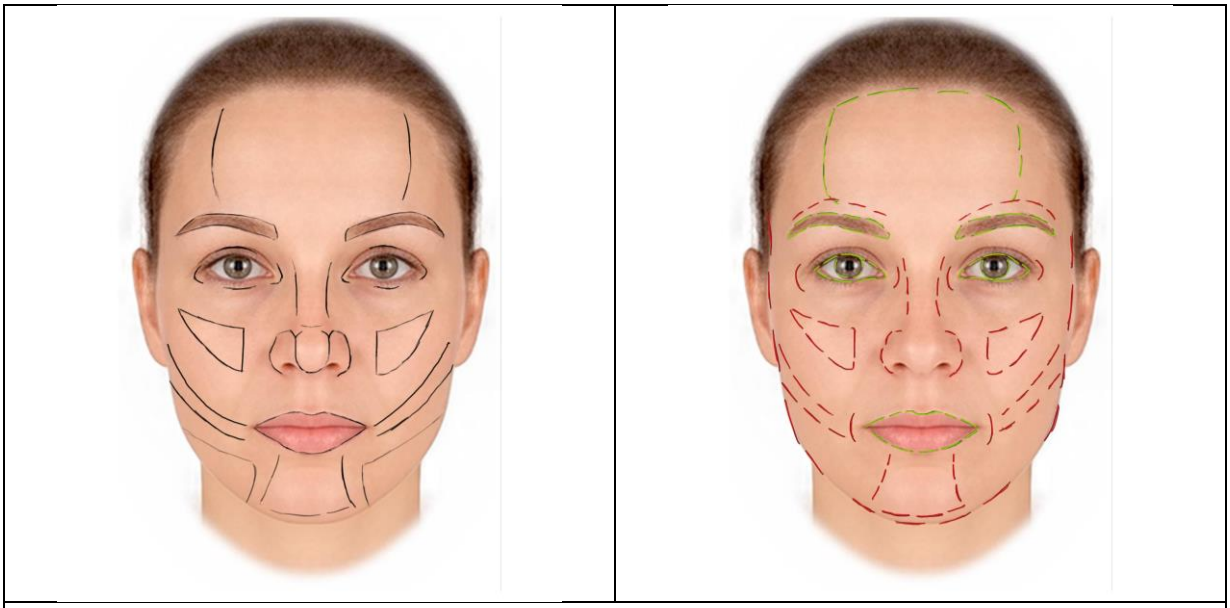

Portrait of a Generative Memory
Indiara Di Benedetto
focuses on the subjective interpretation of personal memories by collecting information about the elements that people are able to memorize about a human face
Portrait of a Generative Memory
The Mask & Mind - VISUALISED PERCEPTIONS
explore the relationships between our minds, our inner self, and the face through our outer self, the mask
Escaping the Face: Biometric Facial Recognition and the Facial Weaponization Suite
Tim Hawkinson | Emoter (2002) | Artsy
photographic collage of Hawkinson's own face, connected by wires to a machine that manipulates his features into expressions of emotion (Video)
Visual Re-presentations
CV Dazzle
Adam Harvey
designed to break machine vision systems while still remaining perceptible to human observers
investigate for a style that was functional but still within conceptual fashion
CV Dazzle
Makeup
Home | Miya Turnbull
URME Surveillance
Leo Selvaggio
artist-driven, anti-surveillance devices
identity replacement tech (Personal Surveillance Identity Prosthetic)
users can give cameras a face other than their own to track
On Illegibility
Yun Ingrid Lee
lecture performance on biometric technology
lecturer wears a malleable mask of their own face, which is manipulated until it's no longer recognizable by the app or audience as a human face
Masks
All it takes to fool facial recognition at airports and banks is a printed mask, researchers found
Related Works
State of the Art
Relevant Technologies
Qudi Has Designed an LED Face Mask That Shows Its User's Emotions
LEDs
LIVE PROJECTION MAPPING ON A MOVING HUMAN FACE - Event Projection
Face Changing Projection Mask - Be Anything
Live Projection Mapping
Project Highlight: The Aposma Mask
soft wearable robotics


Identity (+ Faces)
Technologies
Theories
AI - generated Faces
ThisPersonDoesNotExist - Random AI Generated Photos of Fake Persons
Alteration
Selfie-Editing
Augmented Reality Face Filters
Does the 'Bold Glamour' filter push unrealistic beauty standards? TikTokkers think so
a technology that makes it possible to produce and spread widely on social media a particular type of video selfies that are manipulated live while filming
Re-presentation
Avatar
video games
social media
single vs. multiplayer
correlation re-presentation and
self vs. automatic (e.g. Mii)
how users choose to represent themselves via avatars depends on different communication goals and purposes --> representational identity
Detection
biometric technologies
Facial Perception Identity Markers
PS: perceptual sensitivity
the specific facial features that enable individuals to recognize and differentiate between various faces
high PS - features
crucial in face recognition: more invariant and reliable cues to distinguish between different identities under different conditions
change to these features were found to change the identity of faces
E.g.: hair (colour), eyebrow thickness, eyes, lips, etc.
--> there are specific physical markers that make individuals unique and distinguishable from others
Critical Features
Original
Lip thickness
Hair
Eye color
Eye shape
Eye brows
Non-Critical Features
Mouth
Eye distance
Face proportion
Skin color
Nose
low PS - features
not consistent and reliable cues to distinguish between identities
Theories and Phenomena related to Faces (and/or Idenity)
Face pareidolia
cause: likely due to an inherent mechanism that drives humans to seek out faces
relies on prior knowledge + expectations about faces
face interpretation can already occur with the slightest suggestion of a face
crucial features for face detection in face-like inanimate stimuli: eyes + mouth
tendency to see faces in random patterns
Enfacement Illusion
not limited to the visual modality /can also be induced by tactile stimulation alone
illusion is influenced by the participant's own facial features
suggests that face experience is porous and malleable
feeling of embodying another person's face that is induced by visual stimulation
Predictive Processing
relies on prior knowledge + expectations about faces
prediction error (PE) occurs when brain's prediction about a face does not match the actual sensory information it received
prediction errors (PE) are used to update the brain's model of the world
Sfumato Technique
combined low and high spatial frequency neural processing tricks the eye so that facial features seem to change (e.g. Noh Mask)
painting technique - subtle blending of colors and tones, resulting in a hazy, soft-focus effect
Masks: rounded features and lighting that cast gentle shadows on these features -> similar effect
Mirror Neurons
thought to play a role in imitation, empathy, and social cognition
brain cell that fires both when an individual performs a specific action and when they observe another individual performing the same action
miro

Appendix B: Prototyping Notes

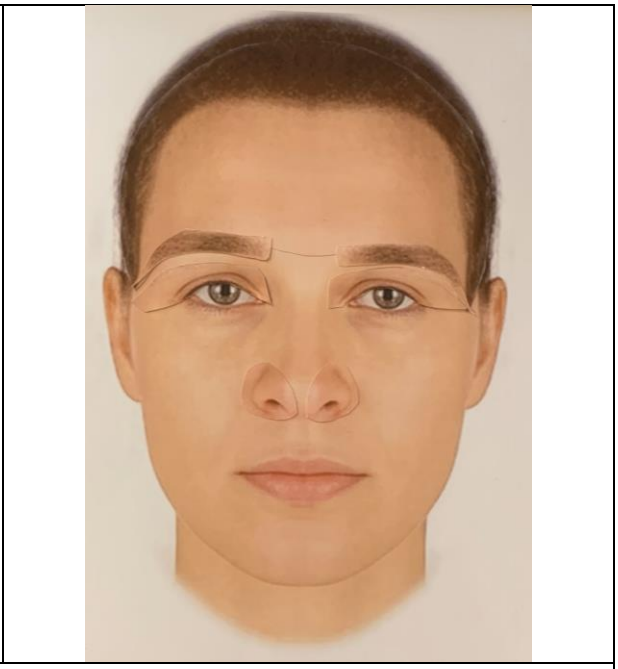
B1: Paper Prototype – Female Face

As a first step in the prototype, the face regions of one image were marked to distinguish where one feature ends and another begins. Following the guide, high PS-features were marked in green, and low PS-features were marked in red. The table listed a total of 20 features [Table...], which I categorized into rank 1-10 as high PS-features and rank 11-20 as low PS-features. I've left out certain features, such as hair length, as they aren't included in the mask design.



Left: Face Regions, Right: Marking high-PS features (green) and low PS-features (red)

As I was lacking sufficient printouts of female faces, the male cutouts were used to modify the female face. The result of that prototype can be seen in Fig… and an overview of the all the present in the prototype in table …

Left: Original, Right: Altered Face

Feature + Alteration	**Method**
Reduction of forehead height	Placing the male forehead lower than the female forehead, thus reducing the height of the hairline, and appearing to change its size
Increased eyebrow thickness	Placing the male eyebrows (which were thicker) over the female eyebrow
Widening the nose (making it appear flatter)	Placing the nostrils further apart from each other (i.e. increasing the distance between de nostrils)
Changing the appearance of the eyes	Placing the male upper lid (which has less noticeable lashes) on the original upper lid

B2: Coloring Silicone Rubber - Notes

Test: Add various painting mediums (soft pastels, oil paint, and acrylic paint) to uncured silicone (right before mixing Part A and B) Later, observe what happens when changing other variables such as amount of paint added.

Mat 1: soft pastels

- Test 1: Scraped with a knife and added directly to the uncured silicone
    - Lots of chunks
    - silicone cured as normal (did not change the texture, etc.)
    - opaque
- Test 2: powder crushed using a mortar and pestle into a finer texture
    - fewer chunks
    - opaque
    - Despite being the pastel being white, the silicone appeared more off-white compared to the other materials

Mat 2: oil paint

- Test 1: adding a drop
    - Extremely opaque (maybe due to the amount of paint added)
    - seemingly changed the consistency of the cured silicone -> silicone was less firm, as though it wasn't cured yet
      possible causes:
        - too much paint added
        - incorrect ratio (silicone)
        - oil paint didn't fully set (usually takes 6-8 hours to dry)
- Test 2: less paint and thinner silicone cast; Goal: reduce opacity (make the silicone clearer)
    - less opaque (and less matte than acrylics)
- Test 3: let dry for at least 6 hours (as opposed to 5mins from previous iterations) Goal: see if a difference can be observed + whether the consistency of the silicone is still affected.
    - when lifting the silicone from the mold it constantly stuck to itself, causing it to clump up and be extremely difficult to smooth out again
    - texture is still affected even after having dried for 6 hours

Mat 3: acrylic paint

- Test 1: adding a drop
    - opaque (maybe due to the amount added)
    - no cracks, even when stretching out the silicone
- Test 2: less paint and thinner silicone cast; Goal: reduce opacity (make the silicone clearer)
    - less opaque (but still more opaque than oil)
    - more matte than oil
- Test 3: let dry for at least 6 hours (as opposed to 5mins from previous iterations) Goal: see if a difference can be observed (particularly if it cracks or not)
    - no cracks & didn't affect the silicone texture

Results

when silicone is still uncured, acrylic paint is a suitable lo-fi way of coloring it.

- cheap + doesn't crack (even coloration of silicone) + adjustable opacity

Appendix C: List of Research and Design Questions

RQ 1: *How does the choice between a realistic design, i.e. one that changes the mask's facial features within realistic bounds, and an exaggerated design, i.e. one that alters the facial features beyond realistic bounds, impact the mask's effectiveness in changing its identity?*

In a theatrical setting, where the mask will be observed from various distances, it may be worthwhile to explore the effect of an exaggerated design, since that may make the mask's alterations more observable from a higher distance.

By observing the morphing capabilities of both realistic and exaggerated masks from different viewing distances, their effectiveness can be assessed.

RQ 2: *To what extent can the findings from the research on critical features for face identification (by G. Yovel and L. Shkiller) be applied to the 'morphing mask'?*

While the research on critical features for face identification provides valuable insights, its applicability to the creation of the morphing mask needs to be explored (Considering the experiments of this research only featured 2D images of white male faces). Therefore, the question aims to investigate whether the findings of the research can be generalized to the mask's design or if notable deviations or adaptations are necessary. (For instance, while the research did not emphasize cheek size as a critical feature, could it become significant in creating masks resembling female or feminine faces?)

By also manipulating features outside of the critical features identified by the research and examining their effect, this question can be answered.

RQ 3: *Does the type of motion of the changing features impact the audience's experience?*

This question investigates whether the type of motion, such as rotation, expansion, contraction, etc., and the speed of the feature changes in the mask influence the audience's perception of identity transformation.

By comparing performances in which the features are altered in various ways and potentially at different speeds, it is possible to observe and compare their respective effects.

RQ 4: *What role does the visual appearance have on the mask's identity transforming capabilities?*

This question investigates the influence of visual appearance, including painting styles and variations, on the effectiveness of the mask in transforming its identity.

By exploring different visual appearances of the mask's face, such as realistic, cartoonish, or abstract, this question aims to investigate their influence on the mask's performance and audience's experience.

RQ 5: *In what ways can light and/or projections be used to enhance the identity changes of the mask?*

This question explores the role of lighting techniques, such as contrasting light and shadows, and projections in enhancing and highlighting the identity changes of the morphing mask.

During the workshop various projector and lighting equipment will be provided, so that various lighting setups and techniques can be experimented with.

Appendix D: Evaluation Plan

Plan: Using a combination of individual interviews and group discussions to gather feedback from participants. Gathering information during the design and building section of the workshop, as well as in between and after the performances could be most useful.

Individual interviews:

Conducting semi-structured interviews with individual participants.
During the design and creation session of the workshop, participants can be asked to reflect on their design choices. That way, insights can be gathered on the participants' thought process when it comes to creating a morphing mask. Moreover, they could be asked what their expectations on their mask's effect is.
Potential Questions:

- Which features did you focus on in your design? How do you plan to change them? (These results can e.g. be compared to the research on critical features)

Moreover, if participants consent, their design process could be visually documented.
After or in-between the performance experiments, some participants could be interviewed individually to see how they perceived the effects of the various masks (and mask designs). While the plan is to hold a group discussion, additionally conducting individual interviews could provide a more in-depth understanding of their experiences.
Potential Questions:

- How do you perceive the effectiveness of the mask in transforming its identity? Did the choice between realistic and exaggerated designs have any noticeable impact?
- Were there any facial features or transformation methods you deemed particularly effective in transforming the mask's identity?
- How did the abstract methods of changing the mask's features affect your experience as a creator and observer? Did you notice any uncanny valley effects?
- Did the fluidity and speed of feature changes in the mask influence your perception of identity transformation?
- How did the visual appearance of the mask impact its identity transforming capabilities? Did different painting styles and variations alter the mask's effectiveness?
- In what ways did lighting and projections enhance the identity changes of the mask? What lighting techniques or setups had the most significant impact?

Group discussions:

Facilitating group discussions where participants can share their experiences, insights, and observations and provide feedback to each other. Questions and prompts need to be open-ended to encourage discussion.
Examples of questions/prompts:

- How do you perceive identity?
- Where do you see the future of morphing masks research?
- Most surprising insights from the workshop?

Appendix E: Information Letter and Informed Consent form

Information Letter

Enschede, 27-06-2023

Facial Robotics & Perceptions Workshop -

Information Letter

In this workshop, materiality, technologies and performative aspects of wearable robotics masks will be explored as part of my bachelor's thesis. As a result, the goal of this workshop is to experiment with making wearable robotic masks for performance that play with perceptions of facial identity.

Workshop Details:
The workshop is divided into two parts. In the morning, we will begin with a short presentation on face perception, followed by some quick introductions. The rest of the morning will focus on creating prototype/experimental mask designs. After a lunch break, we have some time allocated to continue to work on and to finalize the masks. In the afternoon, we will move to the theater space to conduct performance experiments. The workshop will conclude with an evaluation and wrap-up session to reflect on the perceptual experiences of the masks.

The rough schedule for the workshop:
9:00 participants arrive / workshop start
9:15 short presentation on face perception & quick introductions
9:30 sketching / building of facial prosthetics/masks
12:30 lunch
13:30 finishing up masks
14:30 performance experiments in the theater space
16:30 evaluation & wrap up
17:00 done

Participation in this workshop is completely voluntary. You have the right to leave the workshop at any time without giving a reason.

Data collection
The information gathered from (group) discussions and interviews that will be used for the report will be used anonymously. Throughout the workshop, photos and videos will be taken to document the process and outcomes. The outcomes of this workshop and the data associated with it may be kept and reused in future research.

Researcher
Lot van der Galiën
l.vandergalien@student.utwente.nl

Enschede, 27-06-2023

Contact Information for Questions about Your Rights as a Research Participant
If you have questions about your rights as a research participant, or wish to obtain information, ask questions, or discuss any concerns about this study with someone other than the researcher(s), please contact the Secretary of the Ethics Committee Information & Computer Science: ethicscommittee-CIS@utwente.nl

Facial Robotics & Perceptions Workshop -

Consent Form

YOU WILL BE GIVEN A COPY OF THIS INFORMED CONSENT FORM

Please tick the appropriate boxes

	Yes	No
Taking part in the workshop		
I have read and understood the workshop information dated [27/06/2023], or it has been read to me. I have been able to ask questions about the workshop and my questions have been answered to my satisfaction.	☐	☐
I consent voluntarily to be a participant in this workshop and understand that I can refuse to answer questions and I can leave the workshop at any time, without having to give a reason.	☐	☐
I understand that throughout the workshop photos and videos will be taken to document the process and outcomes of the workshop.	☐	☐
Use of the information in the study		
I understand that information I provide will be used for the evaluation of the concept and that my answers and results may, anonymously, be used in the report belonging to this study.	☐	☐
I understand that personal information collected about me that can identify me, such as [e.g. my name or where I live], will not be shared beyond the study team.	☐	☐
Consent to be Audio/Video Recorded		
I agree to be audio/video recorded.	☐	☐

Signatures

_____	_____	_____
Name of participant	Signature	Date

I have accurately read out the information sheet to the potential participant and, to the best of my ability, ensured that the participant understands to what they are freely consenting.

_____	_____	_____
Lot van der Galiën	Signature	Date

Study contact details for any further information: Lot van der Galiën, l.vandergalien@student.utwente.nl

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