HIDDEN IN PLAIN SIGHT

MAARTEN DE JONG - MASTER THESIS

AN INSTALLATION THAT CHALLENGES
POLARIZATION BY DISCOVERING THE
VALUE OF THE MIDDLE

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Master Thesis

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PREFACE.

This thesis marks the culmination of my master's program in Integrated Product Design and the conclusion of my journey at Delft University of Technology. Over the past seven years, this vibrant faculty has provided me with the skills, knowledge, and confidence to enter on my professional career.

The freedom within this project allowed for moments of boundless creativity, but also periods of tunnel vision and times when I could no longer see the forest for the trees. Navigating through this would not have been possible without the support of my graduation committee. I am thankful to Sylvia Pont and Charl Smit for guiding me through this project. Sylvia's boundless enthusiasm, theoretical expertise, and ability to offer critical insights at crucial moments, along with Charl's skill in asking the right questions and uncovering underlying challenges, were essential.

I would also like to express my heartfelt gratitude to my family and friends. My parents have always supported me in pursuing what I love. A special thanks to Davida for keeping me grounded and helping me maintain perspective. And to my roommates, Michiel and Timon, for yelling to close my laptop.

Above all, I am grateful to Him who created me as I am.

Maarten de Jong Delft, February 2025

AGAIN JESUS SPOKE TO THEM, SAYING, "I AM THE LIGHT OF THE WORLD. WHOEVER FOLLOWS ME WILL NOT WALK IN DARKNESS, BUT WILL HAVE THE LIGHT OF LIFE."

John 8:12

SUMMARY.

This thesis presents a design project that explores the role of visual perception in fostering empathy and addressing affective polarization. The research builds on insights from EyeSeeDifferent, a lighting installation developed for Highlight Delft, which demonstrated how lighting conditions influence perception. Expanding on this concept, the graduation project investigates how altering perception can enhance empathy within polarized societal contexts.

Affective polarization is increasingly prevalent, catalyzed by media coverage societal divisions. This project applies a polarization framework that identifies four distinct roles, with a particular focus on the Silent Middle and the Pushers. The Pushers contribute to polarization by reinforcing division, while the Silent Middle resists choosing a side despite experiencing pressure to do so.

Countering affective polarization requires enhancing empathy among the Pushers toward the Silent Middle.

Empathy is a dynamic and malleable concept, which can be enhanced through perspective-taking tasks. Research indicates that both visual and emotional perspective-taking activate the same brain regions, suggesting that engaging in a structured visual perspective-taking task may also stimulate empathy.

The primary design objective is to develop an installation that challenges polarization by emphasizing the value of the Silent Middle.

The resulting installation, Hidden in Plain Sight (dutch: Ik zie wat jij niet ziet), was developed through two major design iterations and

two user tests. The experience assigns participants to two roles: the Pushers, who have a limited visual perspective, and the Silent Middle, who integrate these fragmented perspectives to form a complete understanding. The Pushers shine red or blue filtered light through windows, creating opposing, partial views of a masked word due to a depth perception effect. The Silent Middle, located inside, can see both perspectives and decipher the full word: STILLE MIDDEN (English: Silent Middle). As a result, the Pushers leaves the interaction with a sense of dissatisfaction, while the Silent Middle experiences a sense of accomplishment and understanding. A debriefing session follows, where all visitors use a scale model and keyrings to further explore the installation from all perspectives. This step is designed to give meaning to the experienced interaction by connecting it to the polarization framework.

Prototyping and user testing provided critical insights that informed iterative refinements. The findings confirm that the intended emotional differences between roles are successfully conveyed. However, the connection between the interactive experience and the polarization framework requires further refinement.

This research contributes to the development of design strategies that can help reduce affective polarization by highlighting the value of the Silent Middle. By offering a tangible, interactive experience, the project demonstrates the potential of visual perception as a tool for promoting empathy in a divided society.

TERMINOLOGY.

Absorption is the process of converting light energy to internal energy of the absorbing molecules and eventually transfers it to the surrounding gas as heat. (Bond et al., 2006)

Transmission is the passage of light through a material without being absorbed or scattered.

Reflection occurs when light bounces off a surface, following the law of reflection, which states that the angle of incidence equals the angle of reflection.

Reflectance Is the function of wavelength that has been reflected or scattered from a solid, liquid, or gas. (Constants, 1995)

Scattering involves the random redirection of light in all directions when it interacts with small particles or irregularities in a medium.

Refraction is the bending of light as it passes from one medium into another with a different optical density.

Diffuse lighting refers to uniform and evenly distributed light across a surface, minimizing shadows and reducing glare.

Lighting distribution refers to the pattern or arrangement of light intensity across an illuminated area

Incident angle is the angle at which light or a ray of light strikes a surface. It is measured relative to the normal (perpendicular line).

Colour temperature is a characteristic of light sources, describing the perceived warmth or coolness of their emitted light. It is measured in Kelvin.

Hue refers to the attribute of colour that distinguishes one colour from another on the colour wheel. It is the quality that allows to describe colours.

Saturation, also known as chroma, represents the intensity or vividness of a colour. Highly saturated colours appear pure and vibrant, while desaturated colours tend to be more muted or pastel.

Luminosity is the perceived brightness of an object or colour, irrespective of its hue or saturation. It is associated with the overall lightness or darkness of an area and is often quantified in the CIELAB colour space.

Luminance is a measure of the amount of light emitted or reflected from a surface.

Illuminance is the amount of luminous flux per unit area

RGB stands for red, green, blue, and it is a colour model that represents colours by mixing these three primary additive colours.

CMYK is a subtractive model used in colour printing, where colours are created by subtracting varying amounts of Cyan (C), Magenta (M), Yellow (Y), and Key (K, black) ink from a white background.

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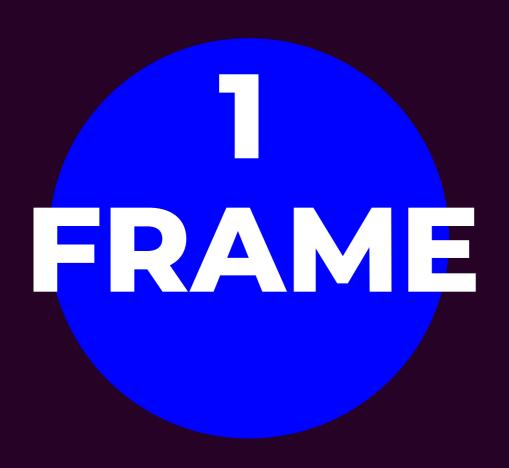
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THE DEBATE ON MASS POLARIZATION IS ITSELF POLARIZED.

Yphtach Lelkes (2016)

1.1.

STARTING POINT: EYESEEDIFFERENT.

This chapter serves as introduction to this thesis. It described the cause of the project; Highlight Delft 2024. The Chapter concludes with a design objective and an overview of the structure of the report.

- 1.1.1. EYESEEDIFFERENT - HIGHLIGHT DELFT

Our background, culture, education, etc., shape this perception of societal problems. Comparable, different conditions (like past experiences) alter the way our brains perceive a particular physical appearance. One such condition is lighting. The colour of light, the space light travels through and the material of the object it reflects on are examples of variables that have an impact on how we perceive a physical appearance. A sphere can be perceived as glossy green under one lighting condition and matt yellow in another. An example of this phenomenon is showed in Figure 1 & 2. This concept was developed for the Highlight Festival Delft during the course Lighting Design by Sarissa bakker, Brechtje Krijvenaar, Stijn Wiltingh, Esmee Treur and myself. The project showed that this interaction is an unprecedented experience for users. Visitors were invited to engage in two distinct space.

In the first space, participants experienced variations in perception by wearing different glasses, which allowed them to explore how individual interpretations can differ and to engage in meaningful discussions about these discrepancies. The second space illuminated

the impact of lighting on perception, employing illusions to amplify everyday phenomena. Utilizing chromatic tuning, the installation deliberately rendered certain elements visible or invisible to the human eye.

Due to the course's characteristics, we were unable to thoroughly investigate the foundational aspects of how altering visual perception can be used as an analogy to counter divides in society. In this graduation project, I will give an answer to the following question:

How can the interaction of altering perception contribute to increased empathy, facilitating depolarizing?

The overarching objective of this graduation project is to design an installation that validates this inquiry. Identifying an appropriate context for this exploration constitutes a critical component of the design process.

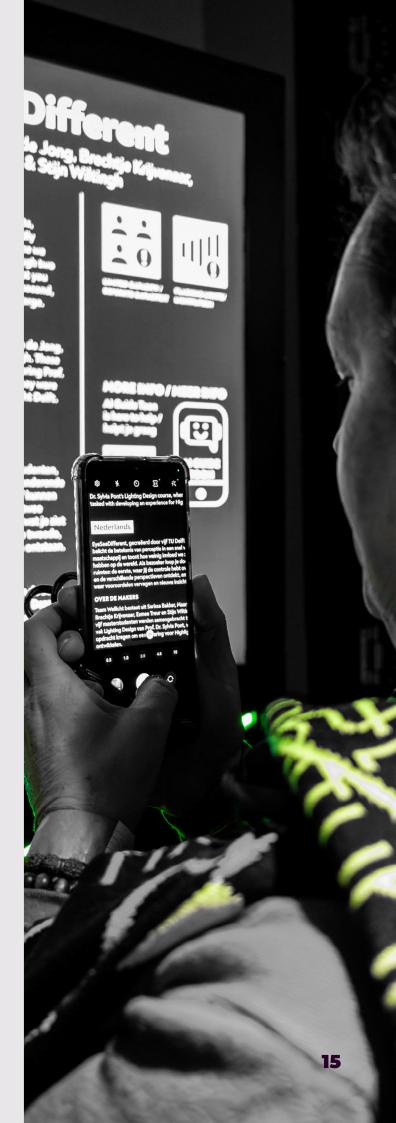
- 1.1.2. STRUCTURE OF THE REPORT

The report is structured to progressively unravel the key components of the design brief. The first chapter introduces a polarization framework, exploring how designing for perspective-taking can enhance empathy. It also provides an overview of how perception and sensation function. It also includes an of the context: Maker Faire 2025.

The second chapter synthesizes the theoretical framework, focusing on how visual perception can be altered. It then integrates the theories of empathy and polarization, narrowing down to a more specific design objective, which is followed by a list of design requirements.

The third chapter focuses on concept development, detailing two main iterations of the design, each followed by a user test. The first user test served to examine the interaction as a research-through-design exercise, while the second test integrated the user experience and also validated the technical aspects of the design.

The thesis concludes with a visual overview of the final design.



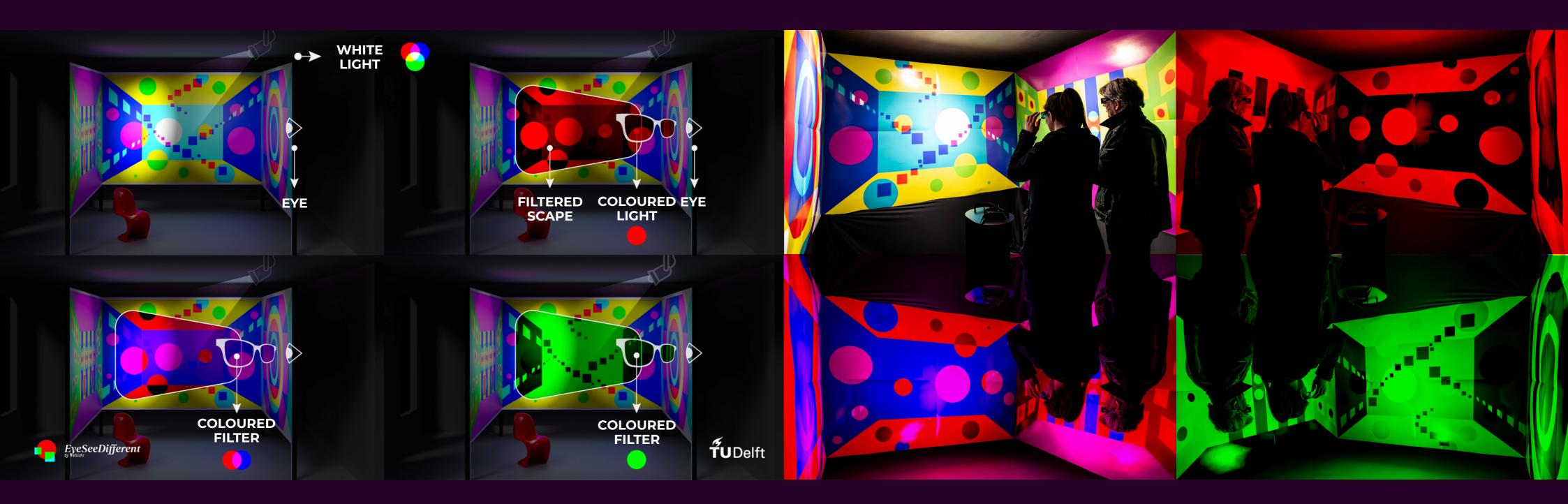


Figure 1. Schematic overview over the chromatic tuning principles utilized at the installation EyeSeeDifferent at Hightlight Delft

Figure 2. Result of the chromatic tuning principles through a red, magenta and green filter.

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1.2.

APPROACH.

This chapter outlines the methodology for executing the project, detailing the primary steps involved in developing the design. It concludes with a discussion on the distinctions between a traditional design process and the approach required for the project.

- 1.2.1. METHODOLOGY OF PROCESS

Conventional design processes typically begin with a client presenting a problem statement, which the designer then works to resolve, often guided by a set of client-provided requirements. This approach, as described in texts such as Productontwerpen, structuur en methoden (Roozenburg & J. Eekels, 1998), follows a structured framework. However, this project deviates from that model. In this case, there is no client, no concrete problem statement, and no predefined set of requirements. The process is instead structured to facilitate the exploration and validation of initial assumptions. To accommodate this, I used the methodological framework of a double diamond, indicating four key phases. The process is visualized in Figure 3.

 Discover perceptual working principles, contexts and design for empathy

A central objective is to determine the perceptual features that can effectively contribute to the intended interaction. Further exploration is possible for the installation exhibited during Highlight Delft. In order to achieve alignment between the perceptual features and the installation's context, these elements will be explored in parallel. Additionally, I will conduct research

into how design can contribute to depolarization through increasing empathy within a divided group.

2. **Define** list of requirements

Following the exploration phase, an analysis will be conducted to identify congruencies between the contextual elements, perceptual features and the research into empathy. This phase will enable the development of a preliminary list of requirements, serving as the foundation for conceptual ideation.

- 3. **Develop** concepts based on requirements
 With the requirements and contextual alignment established,
 potential concepts will be generated. These concepts must
 satisfy the list of requirements while resonating with the
 project's context, ensuring relevance and feasibility.
- 4. **Deliver** selection of the most feasible, viable, and desirable concept.

The final concept will be evaluated for feasibility, viability, and desirability. This selected concept will then be developed into an installation suitable for public display.

- 1.2.2. EXPERIENTIAL CHARACTER OF PERCEPTION EXPLORATION

When the circumstances get complex, light gets more and more unpredictable. Furthermore, human perception is inherently variable and subjective. Therefore, the interaction between light and perception necessitates an experiential approach to fully explore its potential impact. This approach involves experimentation with different combinations of elements to create meaningful interactions.

The Light Lab at the faculty of Industrial Design Engineering will serve as the primary environment for these experiments. Additionally, the digital tool Keyshot, conventionally used for rendering lighting in finished products, will facilitate early-stage experimentation by predicting how specific lighting conditions may be perceived. By employing Keyshot alongside physical prototyping in the Light Lab, this project will leverage both physical and digital experimentation to explore perceptual interaction.

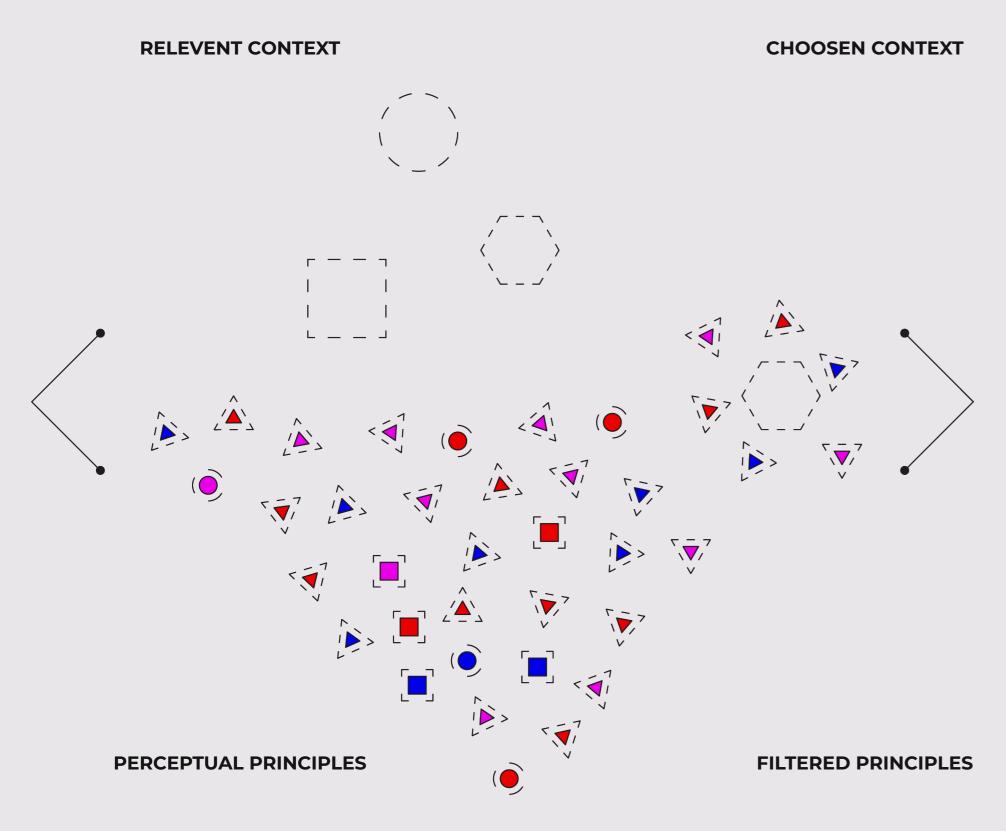
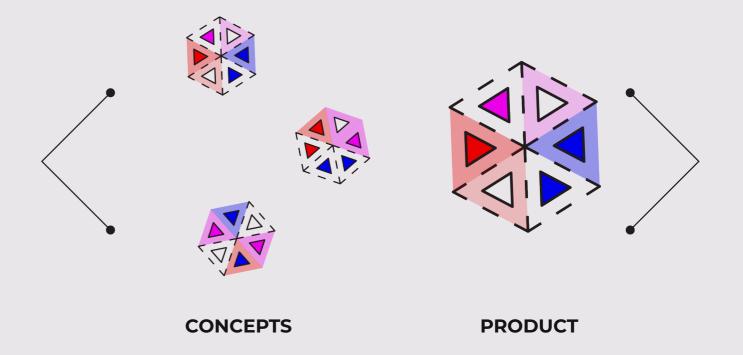


Figure 3. Visualization of the design process of this design project



1.3.

FRAMEWORK FOR POLARIZATION.

This chapter explores the multifaceted nature of mass polarization, distinguishing between ideological, perceptual, and affective forms. By examining a framework for depolarization, this chapter highlights the importance of strengthening the Silent Middle.

- 1.3.1. MULTIFACETED NATURE OF MASS POLARIZATION

Mass polarization is a multifaceted subject of research. We can make a distinction between three types of mass polarization. Ideological, perceptual and affective polarization (Quarterly, 2016). Where ideological polarization refers to which extent ideological ideas of partisans differ. Perceptual polarization is the degree to which the mass public perceives the parties and their follows to be polarized (Westfall et al., 2015). Affective polarization describes interparty hostility (Mason, 2015). It indicates how "warm" or "cold" people feel for another party.

Even though the topic of polarization is subject to debate in research, it is safe to say that ideological polarization did not increase (Quarterly, 2016). However, most people do feel like we drifted further apart. How is that possible?

Research shows that discussion on the topic of polarization increases over time. A study by Levendusky et al. (2016) shows that the word "polarization" has become more present in journalistic articles around political discord.

"Increasing perceptions of polarization cause people to moderate their issue positions while increasing interparty animosity." (Levendusky et al., 2016). So, depictions of a divided society through journalistic coverage can increase perceived polarization and affective polarization. At the same time, it moderates issue positioning. Perceived polarization exceed actual polarization by a factor of two (Westfall et al., 2015). So, it is true that we can feel like we drifted further apart, without it actually being the case ideologically.

In the context of depolarization, the challenge is to decrease perceived and affective polarization. Brandsma (2017) describes the problem as thinking of "us" vs "them". This is an indicator for affective polarization. He states that by focusing on the value of the middle, we can counter the depiction of a polarized society that ideologically does not actually exists.

- 1.3.2. FRAME OF REFERENCE POLARIZATION

Bransma formulated a framework to use in the practice of depolarization. This frame has proven to be successful in handling polarization all over the world. I will connect it with different complementary viewpoint.

Brandsma recognizes 5 key roles in the polarized debate (see Figure 4).

- 1. **Pushers** provide fuel to sharpen the division.
- 2. **Joiners** choose a side and support the Pushers. They like, retweet and support the pushers, but also show that they are more moderate than the pushers
- 3. **The Silent Middle** feel polarization pressure from the Pushers to choose a side, but continue to resist for various reasons.
- 4. **The Bridge Builder** positions himself above the poles and wants to create understanding in order to eliminate the polarization. Sometimes this provides more fuel and the bridge builder feeds polarization.
- 5. **The Scapegoat** When polarization is at its maximum, a scapegoat is sought. This can be the bridge builder or the silent middle.

Brandsma contends that there is an excessive focus on the Pushers in polarizing debates, particularly by journalists who adhere to the law of mutual hearing, which mandates a balanced presentation of opposing perspectives. While intended to provide objectivity, this approach inadvertently enables polarizing Figures to dominate the discourse, thus intensifying division rather than building the bridge. Consequently, the Silent Middle, individuals who either remain undecided or consciously avoid alignment with polarized stances, is marginalized. This group is of particular significance, as it holds the potential for offering nuanced and balanced viewpoints. These individuals may be in a state of indecision or may be deliberately maintaining neutrality. Brandsma's "gamechangers" aim to counteract polarization by strengthening this silent middle, thereby promoting a depolarized discourse that allows for diverse, yet moderate, perspectives.

- 1. Strengthen the middle instead of fighting or appeasing the poles.
- 2. Formulate the right issue for the middle and do not follow the rhetoric of the Pushers.
- 3. Do not stand above the parties, but provide a binding position, leadership in the middle.
- 4. In doing so, find the tone that binds. Not judgmental, but listening and empathetic.

I conclude that it is not most effective to build the bridge between the Pushers. However, the Pushers should empathize with the silent middle. The designed installation should move the focus form the Pusher to the viewpoint of the silent middle.

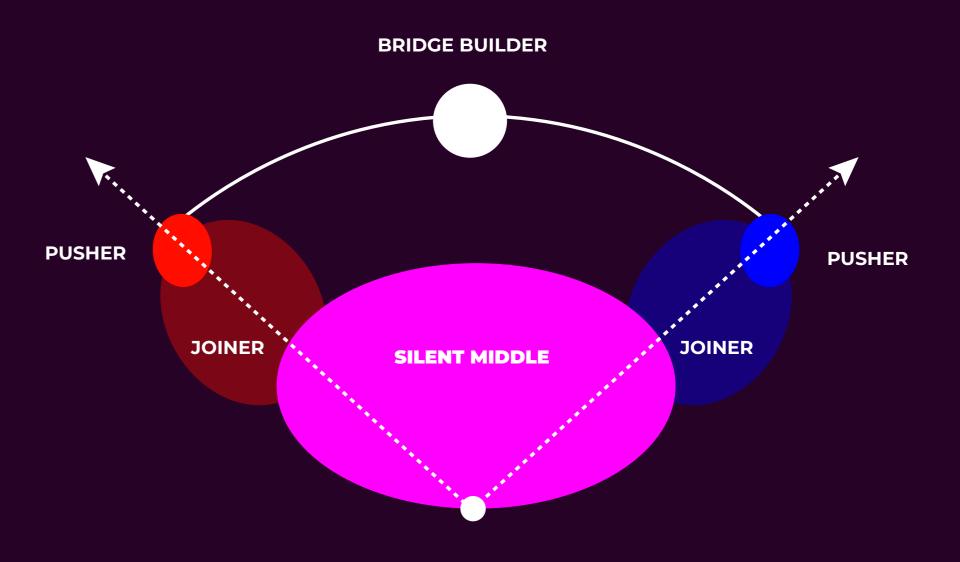


Figure 4. Denkkader Polarisatie (Brandsma et al.) — A framework highlighting the Silent Middle; a group that that feels polarization pressure from the Pushers to choose a side, but continue to resist for various reasons.

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1.4.

DESIGN FOR EMAPTHY.

This chapter addresses the question: "What is the role of designing visual perception interactions in the context of empathy?" To begin, it is essential to ascertain whether empathy is a variable that designers can influence. This inquiry will be followed by a discussion of the perspective-taking process and the various interventions associated with it.

- 1.4.1. WHAT IS EMPATHY

Current research considers empathy as an essentially cognitive phenomenon, with the capacity for one person (an observer) to share and understand internal states of someone else (a target) (Wispé, 1986). Experiencing any emotional change themselves is not necessary. Empathy allows us to connect with one another.

It is generally accepted that all humans have certain characteristics that have the potential to influence empathic reactions. One of these is the biological capacity for empathy-related processes and outcomes (M. H. Davis, 2006). Exceptions exist when talking about autism or sociopaths.

- 1.4.2. MALLEABILITY OF EMPATHIC CAPACITY

An important question to answer is whether empathy is a skill that can be built, or that it is a fixed capacity. C. M. Davis (1990) claims that

it can be facilitated to occur, but the behavior of empathy cannot be directly taught as a skill. More specifically, feelings of anxiety, self-doubt, prejudice, and low self-esteem can make it difficult for people to be present for others and thus block empathy from occurring. The capacity of empathy seems to be stable. However, it can be facilitated and thus has a malleable characteristic. For example, research showed that people who hold a malleable mindset with regards to empathy (believing it can be developed), tend to expend greater empathic effort in a changing context than people who hold a fixed mindset (believing it cannot be developed) (Schumann et al., 2014).

- 1.4.3. PERSPECTIVE-TAKING PROCESS

Now we know that empathic reactions are malleable and can be facilitated, we have to see what makes these reactions. M. H. Davis (2006) structured the constructs surrounding the concept of empathy in his Organizational Model of Empathy-Related Constructs (Table 1). It states that the antecedents (the status of the persons involved and the situation) and the related process influence the intrapersonal or interpersonal outcomes. The antecedents entail the person's biological readiness, personality and learning history. These variables partially make for the malleability of the empathic reaction. Also, the strength of the situation (e.g., the nature of the target's emotion) and the similarity between the target and observer are relevant in predicting empathic reactions.

The particular process that generates empathic reactions is the second stage in the construct (Table 1). Davis based this distinction on the work of Kurtines & Gewirtz (2014). It says that empathic processes can be distinguished by the degree of cognitive effort and sophistication required. Noncognitive processes require almost no cognitive effort. These processes are often unconscious imitations of observers to the target's behavior, referred to as motor mimicry. Familiar processes like classical conditioning can be identified as simple cognitive processes. It has to do with associations with past experiences and labeling processes.

Lastly, and most relevant for the context of this project are advanced cognitive processes. This includes the process of perspec-

tive-taking. Perspective-taking makes the observer more likely to offer causal attribution for the target's behavior that resemble the target's own, that is, attributions that emphasize situational factors relative to dispositional ones. Situational factors explain how changes influence individuals' lives. Dispositional factors represent continuity (Harris & Teasdale, 2017). As we will explore later in the chapter, perspective-taking can be associated with specific neural structures. The way perspective-taking activities are conducted predicts the cognitive and affective outcome. For example, instructing observers to "imagine how the target feels" before exposing them to a distressed target and instructing to "imagine how you would feel" in the target situation both increase levels of empathy. However, contrary to the "imagine target" instruction the "imagine self" instruction also increase the personal discomfort of the observer (Batson et al., 1997). Relatively minor differences in perspective-taking instruction can produce significantly different outcomes.

The processes explained can generate cognitive outcomes, reflecting the degree to which the observer can produce accurate knowledge about the target, also referred to as interpersonal accuracy. Outcomes can also be affective. Parallel affective outcomes are when the observer not only is able to accurately label the internal state of the target, but also feels the same emotion. When the emotions of the observer do not match those of the target, but are a reaction to the target's situation, we talk about reactive affective outcomes. Perspective-taking commonly results in outcomes of parallel affection.

- 1.4.4. APPLICATION OF PERSPECTIVE-TAKING INTERVENTIONS

Now that we know where the perspective-taking process fits into the construct of empathy, the question arises as to why people do not show empathic behavior and for what reasons can perspective-taking interventions help to facilitate this?

There is a distinction between when an observer is not able, not ready or not willing to empathize (Simon-Thomas et al., 2017). This relates to the antecedence of the person and situation and the relation between these two. When an observer is not willing to empathize, there is no reason to offer another perspective, or to instruct to

Table 1. Organizational Model of Empathy-Related Constructs (M. H. Davis)

1. ANTECEDENTS	2. PROCESSES	3. INTRA-PERSONAL OUTCOMES	4. INTER-PERSONAL OUTCOMES
The person ► Biological readiness ► personality ► learning history	Non-cognitive ► motor mimicry ► simple cognitive	Cognitive Outcomes ► Interpersonal accuracy ► Attributional	Helping Behavior Reduced Aggresive Behaviors
The situation ► Strength of situation	Simple cognitive ► classical conditioning ► direct association	judgements ► cognitive representation	Social Behavior
► Observer-Target similarity	► labelling - Advanced cognitive	Affective Outcomes ► Parallel emotion	
	language-mediated associationelaborated cognitive	▶ Reactive emotion▶ Empathic concern▶ Personal distress	
	networks • perspective-taking	Motivational Outcomes ➤ Forgiveness ➤ Valuing other's outcomes	

imagine the situation of the target. In this situation the observer lacks motivation and not ability. Perspective-taking interventions can even backfire when applied in context where people are empathy avoiding and do not have the motivation to empathize. One should be cautious to recognize the underlying reason an observer does not show empathic behavior. Motivation based interventions were developed after this realization in literature. An example is actively changing the mindset of people from fixed to malleable (like discussed before). In research by Weisz et al. (2020), first year college students showed an increase in empathic behavior when exposed to the fact that empathy is a malleable concept. The same increase was found when they were told that empathy was the norm at this college. However, the increase was only found when measuring the positive accuracy of emotions. Approach motives for empathic behavior increased, but the avoidance motives did not reduce. Apparently reducing avoidance motives require a different intervention. This is why it is extremely difficult to design an intervention for highly polarized subjects that do not stem from the observer's ability to empathize but rather show empathy avoiding motives. An example for such a subject is the conflict between Israelis and Palestinians.

The conclusion is that an observer needs to be able and ready to empathize with a target for perspective-taking interventions to effectively facilitate it. They preferably show approach motives to empathic behavior.

- 1.4.5. CONNECTION TO VISUAL PERSPECTIVE-TAKING

Until this point, we have merely talked about verbal instructions when faced with a distressed target to accurately predict the internal state of a target (emotional perspective-taking). However, in the context of this project, we should focus on visual perspective-taking (VPT) (see Figure 5) . VPT is the ability to predict the visual experience of another agent (Michelon & Zacks, 2006). Michelon & Zacks (2006) found that perspective-taking encompasses at least two different computational processes. (1) Updating the viewer's imagined perspective. When an observer makes a judgement about a target's visual perspective, the observer mentally transforms their perspective to align it

with that of the agent. (2) An observer tracing the line of sight when asked about the visibility of a target.

Already from 36 months after birth a child is able to judge how others see the world when it differs from that of themselves (Moll & Meltzoff, 2011). They are even able to alter the perception of a target's colour perception after a production task.

Still there is a difference between visual perspective-taking and emotional perspective-taking. One is just geometrically imagining what the others see, the second is imagining what the other feels. Although, it happens that both tasks activate the same area in the brain. This part is often referred to as the Theory of Mind (ToM). It is the part of brain that is responsible for learning about self and other's emotional state (Leslie et al., n.d.). Schurz et al. (2015) tried to clarify the role of the Theory of Mind during visual perspective-taking. They found that a criterium for ToM activation was that the other should be a human Figure. Also, ToM was more stimulated when the self was seeing more than the other.

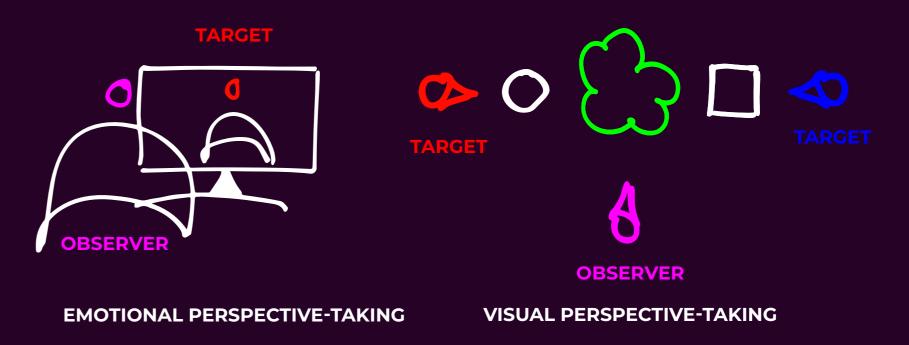


Figure 5. The left side of the Figure represents an observer taking the emotional pespective of an observer, while the right side illustrates an observer taking the visual perspective of the target to judge whether the square or circle are visible for them.

1.5.

UNDERSTANDING SENSATION AND PERCEPTION.

To understand the principles of visual perception, we must first explore the theory behind the process from emitted light to object perception. This involves examining how light interacts with materials, travels through space, and is received and processed by the eye and brain. Establishing this foundation allows us to analyze how changes in this sequence, from light source to perception, can alter our visual experience. This chapter begins with a story visualized in Figure 6.

Imagine stepping into a dark room. As your eyes adjust to the darkness, you start to rely on your other senses to make sense of the space around you. You reach out and run your hand along the wall, feeling its rough texture, maybe brick, you think. A faint chemical smell fills the air; the walls must have been freshly painted. Somewhere in the background, you hear low, rhythmic thudding, like the sound of drilling. Maybe someone is working nearby. Curious, you decide to flip on the ceiling light. Instantly, light floods the room, waves spilling out and traveling through space. When these waves reach the wall, they bounce back, and as they enter your eyes, your brain interprets them. From this input, you recognize the light as a warm, earthy red, rich with contrast that makes each shadow and texture pop. The colour, along with the roughness you felt, confirms your guess, the wall is indeed made of brick. Then, the drilling noise grows louder. With the room now illuminated, you realize that the person holding the drill is your dad, standing in the corner and focused on his work. Your brain effortlessly distinguishes him from the wall, recognizing him as family, not just another feature of the room. All the senses combined complete the picture, bringing this once-dark room to vivid life.

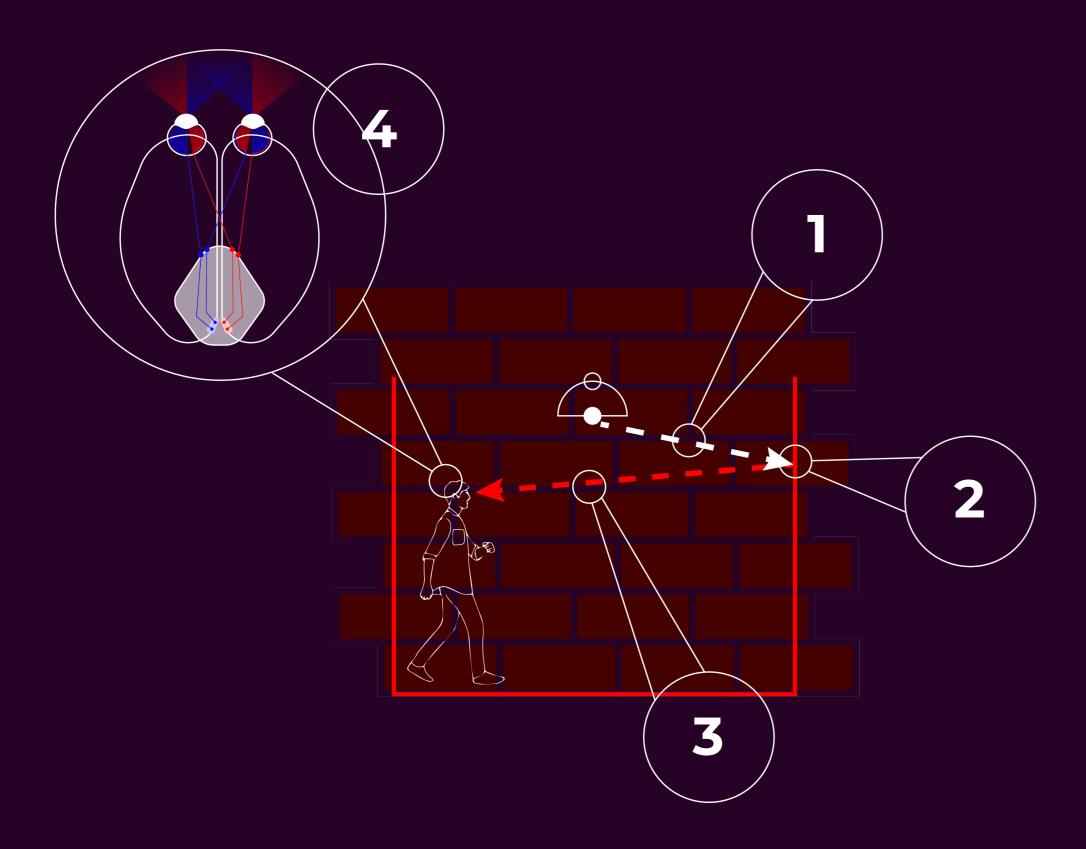


Figure 6. Illustration of fictional scenario. (1) Radiation spectrum of a fictional fixture, (2) the reflectance spectrum, (3) the spectrum that is a result of the light reflecting on the wall and (3) the wiring of the eyes to the brains. Numbers correspond with Figure 7.

- 1.5.1. DIFFERENTIATING SENSATION AND PERCEPTION

To understand the principle behind the previous example, it is essential to differentiate between several underlying processes, with a key distinction between sensation and perception. Detection is the physiological process of how light is processed by our eyes, with an electrical impulse as a result. The psychological process of the interpretation of this impulse into a perceived colour by our brain, is what is called perception.

Humans are capable of detecting electromagnetic waves within a specific range, from approximately 375-750 nm, which we perceive as visible light. A common misconception is that we directly detect colour. In reality our vision is based on four types of photoreceptors. These receptors lay in the light-sensitive layer of the tissue at the back of our eyes, called retina. There are four types of photoreceptors; rods and three types of cones. The rods help us see in a low light environment and have low spatial acuity. Rods are used for our scotopic vision. The cones become active in higher levels of light and have high spatial acuity. Cones make us able to see colour, called photopic vision. The three types of cones are sensitive to different parts of the light spectrum. Generally they can be divided into short (S), medium (M) and long (L) cones (see Figure 7). Short cones are most sensitive for visible blue, medium cones for green and long for red light. The excitement of the cones result in an electrical impulse of the cones. Depending on the spectrum of light hitting the retina, the three types of cones excite to a greater of lesser extent. The electrical impulses get send to the brain. The brain interprets these impulses. The result of this interpretation is our perception of light. The colour we see is dependent on the relative excitement of the different types of cones. However, the process of interpretation is also subject to psychological effects. These effects are composed of context, contrast, but also past experiences. Therefore, we do not perceive spectra, but colour.

- 1.5.2. FILTERING AND REFLECTING

Figure 7.1 shows the radiation emitted by the halogen lamp that is turned on in the example. The light travels through the room and hits

the wall. The wall has a certain reflectance spectrum. This Figure 7.2 tells what percentage of the energy is reflected, per wavelength. To see what the result of this reflectance is, the radiation spectrum of the lamp should be multiplied with the reflectance spectrum of the wall (see Figure 7.3). As this spectrum enters our eyes, the L and M cones get excited more than the L cones. The brain interprets this relative excitement. The spectrum in the Figure 7.1 may be perceived as red, but again, this is dependent on psychological factors too.

The process not only allows us to identify the wall's Colour as red but also enables us to interpret the subtle contrasts in light intensity on the wall, suggesting that it may be made of brick. Similarly, it allows us to distinguish the wall from the Figure of a person, our father, based on context and memory. Thus, the transition from sensation to perception is where cognition enriches our sensory experience, creating a comprehensive prediction of our surroundings.

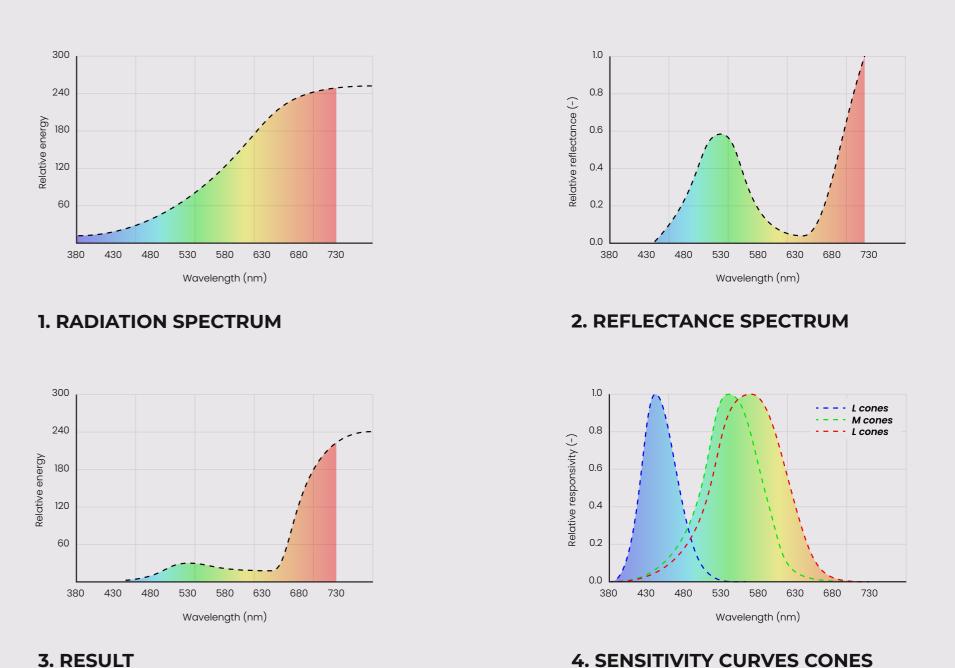


Figure 7. (1) Radiation spectrum of a fictional fixture, (2) the reflectance spectrum, (3) the spectrum that is a result of the light reflecting on the wall and (3) the sensitivity curves of the cones in our eyes. Numbers correspond with Figure 6.

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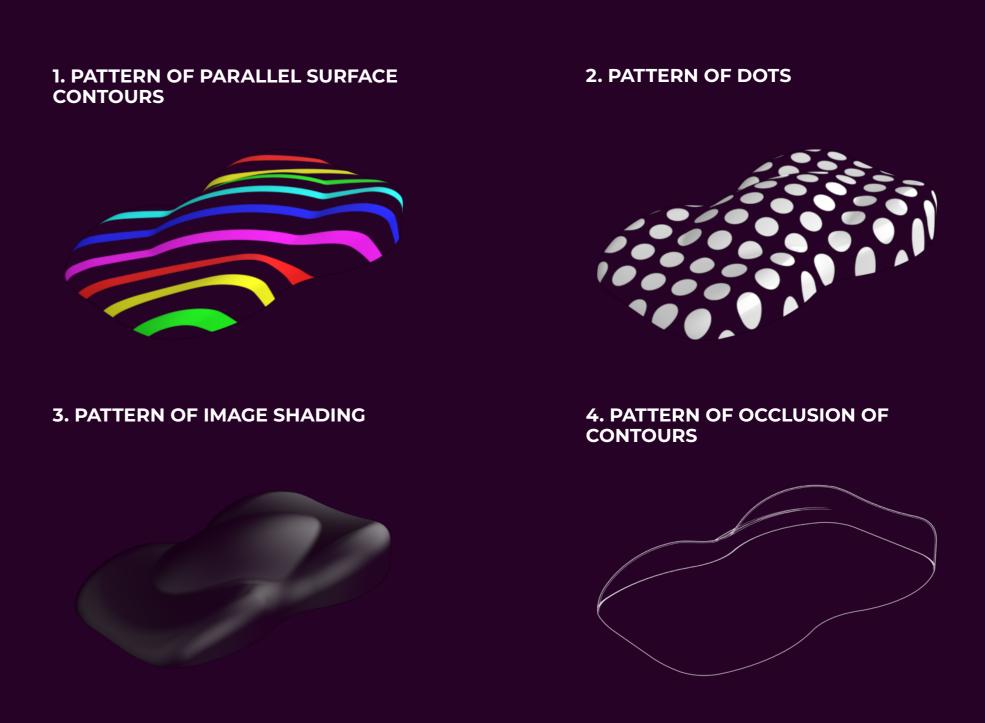
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- 1.5.3. DEPTH PERCEPTION

The visual image we are looking at gets projected on the retina. Each rod and cone on the retina provides information about the appearance we are looking at. We already discussed that the relative excitement of these photoreceptors makes it possible for us to perceive colour. The difference in excitement relative to the position of the photoreceptors translates to contrast in colour. Simply put, the appearance that we are looking at gets projected onto the retina (Ptito et al., 2021). The contrast in this information provides us information about the 3D shape we are looking at. There are multiple optical stimulations that provide this information. For example, the pattern in image shading, lines that mark an object's occlusion contours, gradients of optical curvature and gradients of texture from a pattern of parallel surface contours (see Figure 8.1) (Pizlo, 2007). These are examples for how we predict 3D shapes in still 2D images. When provided with multiple images, we can predict the 3D shape more accurately by the systemic transformations. We can process the disparity between the view of each of our two eye's. Also the deformations in the list of examples mentioned as a result of transformation provides information about the 3D shape.

Yet, with the information provided, an infinite number of possible 3D structures could be the source of this information. Therefore, we constrain the information by assuming likely predictions. In the example of the dot pattern in Figure 8.2, we assume that the shape is wrapped in circles.

Let's zoom in to the parallel surface contour example. Our eyes sense a set of lines. This set of lines could be a result of an infinite number of shapes. However, in the process from sensing to perception, we assume that the lines are a projection of parallel set of lines on a shape. We can create so called rulings that are constructed by parallel correspondence. When the rulings are perpendicular to the lines of the curvature, we are able to constraint the object's shape. This is how we go from an infinite number of solution to one.



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Figure 8. Optical depth perception stimulation methods (Pizlo, 2007)

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1.6.

CONTEXT: MAKER FAIRE 2025.

This chapter explores the intended context of the installation and the implications of further development.

- 1.6.1. SELECTING AN EFFECTIVE CONTEXT

The literature on empathy highlights several essential requirements for creating environments suitable for effective perspective-taking tasks. The most critical requirement is that participants must be both able and ready to engage empathically. Perspective-taking is an advanced cognitive task that demands focus and mental readiness. For example, highly trafficked public spaces are generally unsuitable, as visitors who are simply passing through are unlikely to take the time needed to engage fully in this type of activity.

I considered various potential contexts. In the end, I came in contact with the Science Centre at the TU Delft, which expressed interest in showcasing the installation at the Maker Faire 2025. This setting offers a more focused environment, where participants are likely to be receptive to interactive, reflective experiences, thus meeting the requirements established in empathy research.

- 1.6.2. THE CONTEXT: MAKER FAIRE 2025

"bringing together creators, innovators, and DIY enthusiasts to showcase their projects, share ideas, and present a vision of the future" (Maker Faire, n.d.). In Delft, the Science Centre hosts a local Maker Faire, with the most recent edition held in 2023. After a one-year hiatus, the Science Centre is planning the next Maker Faire for May 9, 2025, with an updated format to broaden its appeal.

This upcoming edition will shift from the previous two-afternoon schedule to an event starting in the afternoon and extending into the evening. The addition of a food court and live music is intended to give the event a festival atmosphere, attracting not only makers but also a wider audience interested in exploring new innovations and interactive experiences. This expanded, engaging format makes the Maker Faire a suitable context for this project, as it provides an environment where diverse participants are open to engaging with creative, thought-provoking installations. The location of the Maker Faire probably will be the area surrounding FREEZONE G.

- 1.6.3. TARGET GROUP

The target groups of the Maker Faire are amateur and professional makers. Additionally, the event is there to inspire children to work with technology. Therefore, a couple elementary school classes will join the event to experience the installations. This has implications for the content of the installation, but also for the ergonomical aspect of it. It is for this reason that it has been predicted that in the afternoon the audience will be younger than in the evening.

1.6.4. CONTEXTUAL REQUIREMENTS FOR THE MAKER FAIRE INSTALLATION

The context comes with certain practical constraints. Also, during a conversation with the organization, they expressed some elements that have implications for the requirements of the design of the installation. These requirements added to the list Chapter 2.3.

2 SYNTHESIS

EMPATHY IS AN ANTIDOTE TO RIGHTEOUSNESS, ALTHOUGH IT'S VERY DIFFICULT TO EMPATHIZE ACROSS A MORAL DIVIDE

Jonathan Haidt

2.1.

PERCEPTUAL EXPLORATION.

This chapter discusses the two main perceptual principles that are explored in the first stage of the process. These principles are used in the concept development to meet the project's goal and requirements. The principles focus on altering perception.

- 2.1.1. DICHROIC MIRROR ALTERING PERCEPTION

In the theoretical framework, it has been explained how reflection and filtering works.

This section explores the mechanisms of reflection and filtering as they relate to materials with unique optical properties. Mirrors are defined by their high reflective index, meaning that the majority of the energy from spectrum is reflected rather than absorbed or transmitted. This is why we perceive reflection of objects positioned in front of the mirror.

In contrast, some materials allow partial transmission of specific wavelengths within the spectrum. For example, gel filters selectively transmit portions of light. Dichroic materials, derived from the Greek dikhroos (meaning "two-coloured"), exhibit the ability to both reflect and transmit distinct parts of the light spectrum. The transmitted and reflected spectrum are complementary. Dichroic materials are frequently used in decorative and artistic applications. These materials are available as adhesive films, vinyl, or nano-coatings on mirrors, such as those produced by Prinz Optics.

As part of this project, I investigated the potential of dichroic materials to alter perception. For example, consider the scenario depicted in Figure 9. When a lamp emits a "white" spectrum, the dichroic material reflects the cyan part of the spectrum while transmitting red. If the lamp's output is limited to the cyan, no light is transmitted, making objects behind the material that reflect red invisible. Conversely, when the lamp emits only red light, the dichroic material merely transmits, making objects that reflect cyan invisible in the mirror.

This phenomenon allows for dynamic manipulation of perception by altering the emitted spectrum. By doing so, one can instantly shift between emphasizing reflection (objects in front of the material) and transmission (objects behind the material), offering a method for altering perceptual experience.

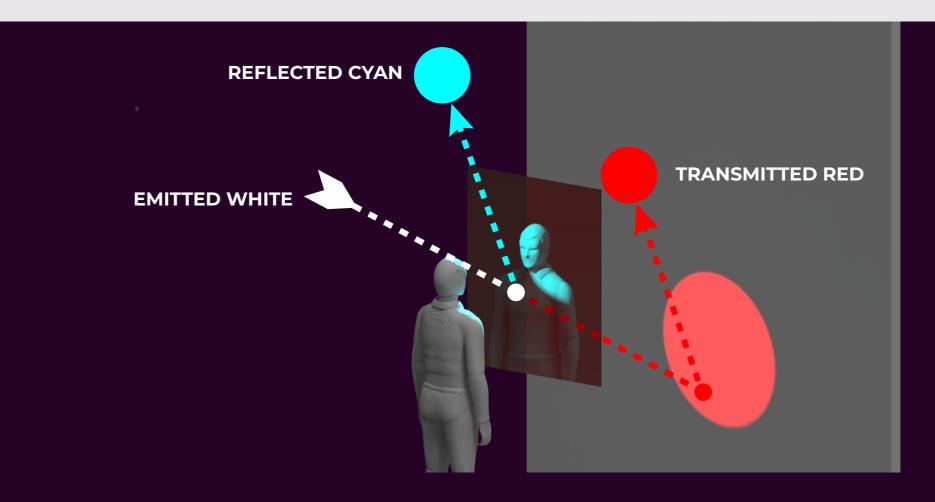


Figure 9. Schematic visualization of the principle of dichroic material, where the cyan side of the emitted gets spectrum gets reflected and red gets transmitted.

- 2.1.2. SHAPE PERCEPTION DISTORTION

A dichroic mirror allows us to manipulate the perception of transparency and reflection in materials. Chapter 1.5.2. explained the fundamentals of depth perception and how various factors and environmental circumstances influence it. Similarly to the dichroic mirror principle, depth perception can be altered by adjusting the conditions, such as lighting.

Car companies already leverage these principles to control depth perception. For instance, they carefully design a car's shape to reflect its intended personality. However, during public testing, this shape must remain concealed. To achieve this, they use specially designed wraps that distort depth perception. These wraps feature strong, random contrasts, often in black and white. This makes it challenging to discern the lines and details that arise from the car's actual shape.

The black-and-white contrast of these wraps is deliberate. Because what would happen if the pattern was coloured. What if we then could switch instantly between a patterned and plain surface by altering the lighting? The experiment shown on the right (Figure 10) illustrates this effect clearly. The object used is a piece of paper with a yellow pattern printed on it. Insights from the EyeSeeDifferent project revealed that by controlling lighting, it is possible to toggle between a plain and patterned appearance.

When illuminated with red light, the yellow pattern becomes invisible because yellow is a combination of red and green. In this lighting, all creases and subtleties in the paper are visible. Conversely, under blue light, the strong contrast of the pattern dominates, masking the creases, just like the wraps used on cars.

The next page shows the filter spectrum of the red and blue filters next to them. Looking through the filters to the yellow patterned wrinkled paper illustrates this perceptual principle. Make sure to be in a place with white light.



Figure 10. Experiment on altering depth perception distortion. (1) Printed paper under blue light, where the masking pattern is visible, leading to distorted depth perception. (2) The same printed paper under red-blue light, where the masking pattern becomes invisible, resulting in undistorted depth perception.

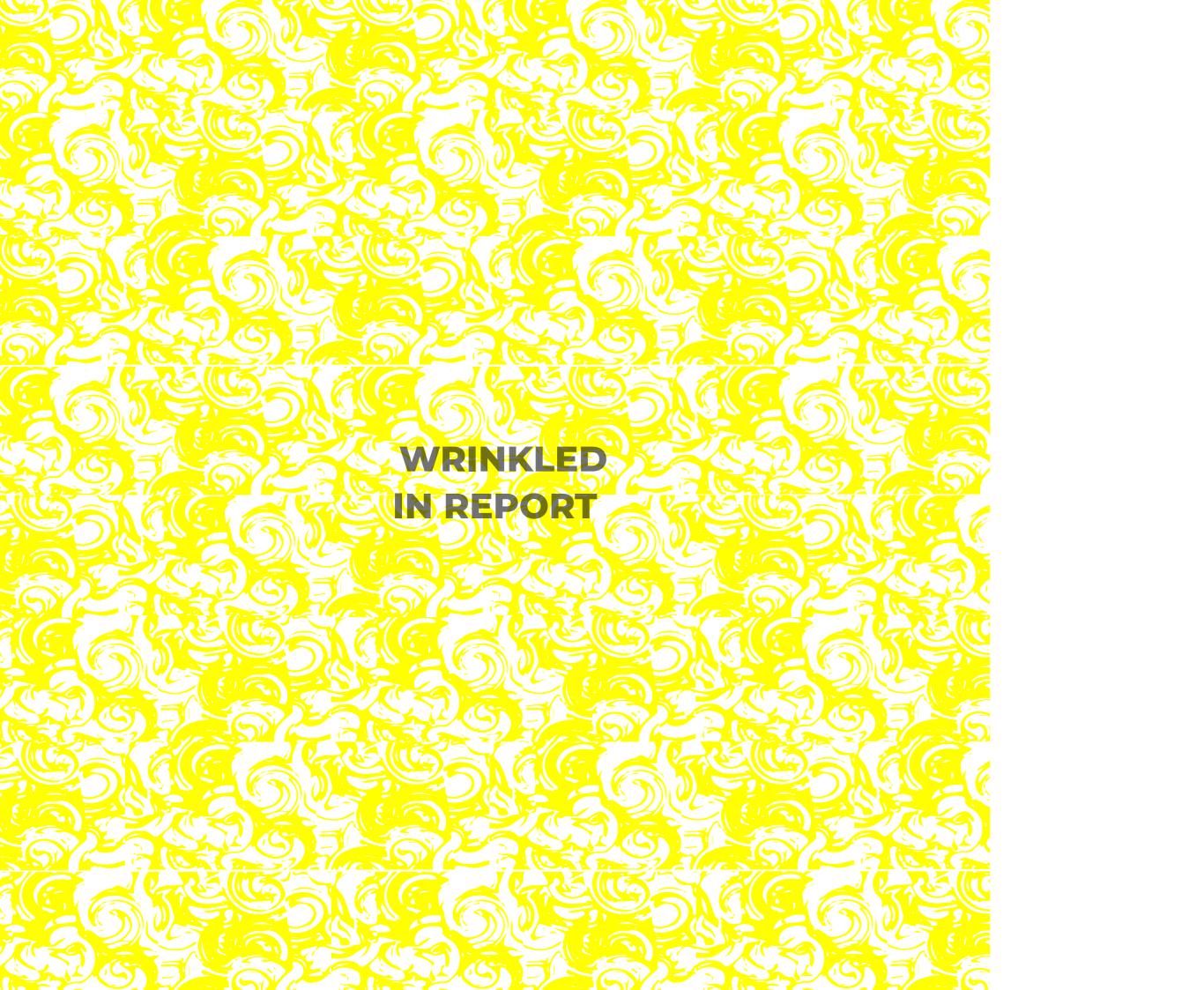
RED FILTER IN REPORT

BLUE FILTER IN REPORT

RED
FILTER IN
REPORT

BLUE FILTER IN REPORT





2.2.

CONNECTING POLARIZATION & EMPATHY.

In this chapter, I connect the polarization framework with theories of empathy and visual perspective-taking. The chapter concludes with an iteration of the design objective to guide the concept development stage.

- 2.2.1. POLARIZATION FRAMEWORK

In polarized discussions, Pushers represent opposing extremes, often constrained by a narrow focus on specific aspects of the issue. Their primary goal is to sway the Silent Middle toward their perspective. The Silent Middle, however, resists alignment with either extreme and maintains a more comprehensive understanding of the issue by considering both perspectives and (consciously) staying neutral.

- 2.2.2. VISUAL PERSPECTIVE-TAKING AND EMPATHY

As discussed in Chapter 1.4.5., visual perspective-taking, through the neural connection to emotional perspective-taking, is a cognitive task that increases empathic reactions. For example, in level 1 visual perspective-taking tasks (illustrated in Figure 11), an observer must determine whether a target can see the appearance. This requires cognitive effort to mentally adopt the target's visual perspective.

2.2.3. CONNECTING POLARIZATION AND VISUAL PERSPECTIVE-TAKING

When we connect these two concepts, we observe significant parallels. Consider the observer in a visual perspective-taking task as analogous to the Silent Middle in the polarization framework, and the target as analogous to the Pusher. The Pusher's limited vision mirrors their constrained perspective in polarized discussions. Conversely, the Silent Middle's broader understanding enables them to see beyond the Pusher's limited viewpoint. The Silent Middle can assess the situation holistically, potentially evoking the Pusher's curiosity about what they might be missing, causing them to take the effort to take the visual perspective of the Silent Middle. This enhances empathic reaction towards this Silent Middle.

2.2.4. TRANSLATING THE FRAMEWORK INTO AN INTERACTIVE REPRESENTATION

This interpretation can be embodied in an interactive installation:

1. Symbolizing polarized discussions

The subject of the polarized discussion is represented by a physical object or appearance. I decide not to implement a concrete subject to the design. This makes for an installation on which every individual can reflect a subject that is relevant to them onto the interaction. It also makes for easy translation into different contexts. The challenge is to keep the appearance abstract, but concrete enough that visitors get the message.

2. Pushers' limited perspective

Pushers perceive only partial aspects of the object, symbolizing their constrained viewpoint. This could manifest as Pushers seeing e.g. only the reflection of their light on the object or on a wall, or seeing just half of the object's form. This limited perception creates a sense of incompleteness and dissatisfaction.

3. Silent Middle's comprehensive view

In contrast, the Silent Middle perceives the full interplay of light and object, combining the perspectives of the Pushers. This results in a more holistic and satisfying understanding.

- 2.2.5. CONCEPT DEVELOPMENT QUESTIONS

This interpretation raises two key questions. (1) How can this interpretation of the framework be effectively translated into the layout of the installation, while adhering to the requirements outlined in chapter 2.3.? (2) What form will the object illuminated by the Pushers take, ensuring it aligns with the symbolic and interactive goals of the installation?

- 2.2.6. DESIGN OBJECTIVE

In summary the design objective that forms the starting point of the concept development can be described as: "Designing an installation that challenges polarization by highlighting the value of the middle. The experience involves two roles: the Pushers, who have a limited visual perspective, and the Silent Middle, who gains a complete understanding by integrating the fragmented views of the Pushers."

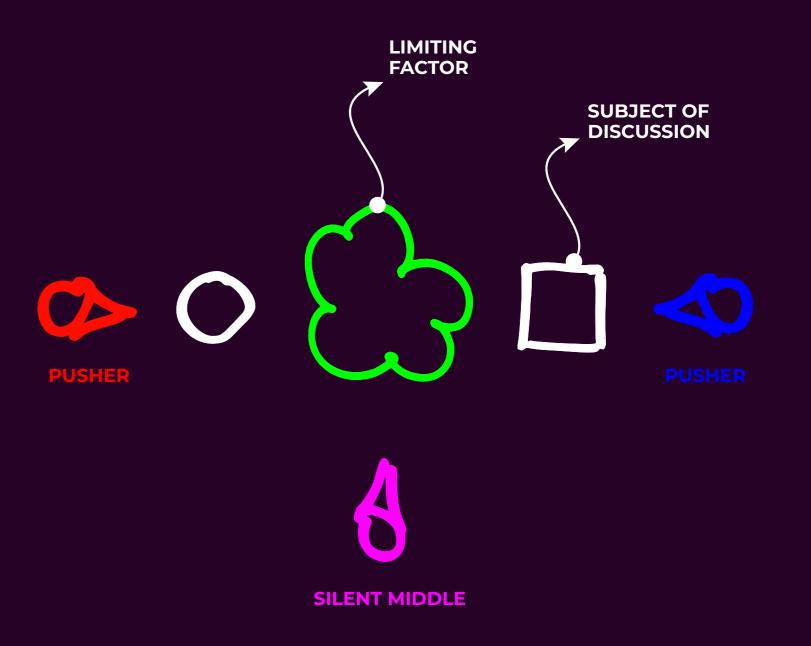


Figure 11. Combination of the polarization framework and visual perspective-taking task. The observer assumes the role of the Silent Middle, while the target takes on the role of the Pusher. The Pusher's perspective on the subject of discussion is restricted by an obstructive object.

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2.3.

LIST OF REQUIREMENTS.

This chapter outlines the list of requirements derived from the various aspects discussed in the prior chapters.

1. Design for empathy

- 1.1 Visitors are able and ready to empathize.

 This means that visitors are open to engage with a new interaction. Otherwise, visitors are less likely to react empathetically.
- 1.2 The installation must explicitly communicate that empathy is a malleable concept
- 1.3 This increases the likelihood of an empathetic reaction.
- 1.4 The installation must include two distinct roles: an observer and a target.
- 1.5 The interaction must allow visitors to take the perspective of the target, with the ability to switch roles during the experience.
- 1.6 The observer and target must perceive the installation's appearance differently, reinforcing the subjective nature of perception.

2. Representation of the polarization framework

- 2.1 The installation must include three distinct roles: two Pushers and a Silent Middle.
 - 2.1.1 The Pushers must have a limited visual perspective on the appearance.

- 2.1.2 The Silent Middle must see the complete appearance through the perspectives of the Pushers.
- 2.2 The installation must not depict a specific subject because the objective is not to reduce ideological polarization. It allows visitors to project their own interpretations.

3. Suitability for Maker Faire Delft

- 3.1 The installation must function effectively in both daylight and darkness.
 - 3.1.1 The installation must be weatherproof and able to withstand outdoor conditions.
 - 3.1.2 The interaction must provide an immersive experience.
 - 3.1.3 The installation must be of an architectural scale.
 - 3.1.4 The installation must fit in a 20-ft storage container.
 - 3.1.5 The installation must incorporate interactive, democratic, or participatory elements.
 - 3.1.6 The installation must function without reliance on digital or electronic components (i.e., it must be analog).
- 3.2 The installation should be accessible for elementary school children.
 - 3.2.1 The installation must be ergonomically accessible for elementary school children
 - 3.2.2 The installation must be visually and interactively engaging for elementary school children.
 - 3.2.3 The installation must be durable and resistant to rough, explorative handling by children.

4. Translation into different contexts

- 4.1 The installation should be physically adaptable to different contexts without compromising its functionality.
- 4.2 The language used in the installation should be easily translatable to ensure accessibility for diverse audiences.

3 CONCEPT DEVELOPMENT

WHAT YOU SEE AND WHAT YOU HEAR DEPENDS A GREAT DEAL ON WHERE YOU ARE STANDING. IT ALSO DEPENDS ON WHAT SORT OF PERSON YOU ARE.

C.S. Lewis

3.1.

CONCEPT
ITERATION 1.

This chapter examines the individual elements that form the first iteration of the integrated installation design. The concept addresses all requirements related to the intended interaction and concludes with a scenario that illustrates the initiated interaction.

- 3.1.1. LAYOUT ITERATION

The previous chapter initiated two questions. The first is: How can this interpretation of the framework be effectively translated into the layout of the installation, while adhering to the requirements outlined in Chapter 2.3.? To address the first question, I went through four distinct iterations (see Figure 12). In the first iteration, I disregarded the requirement for a storage unit. The Pushers direct a beam of light toward the Silent Middle using mirrors. The Silent Middle then redirects this beam onto the object, which reflects light onto the wall. For the Pushers, only the reflected light is visible, leaving them unaware of the object producing the reflection.

To reintroduce the storage unit requirement, I redesigned the layout in the second iteration. This design features a storage unit accessible from both short sides, maintaining the same interaction principle. However, I concluded that the unit would be too small to facilitate comfortable interaction with the installation. Additionally, the use of mirrors added unnecessary complexity to the interaction.

In the third iteration, I explored the differentiation of percep-

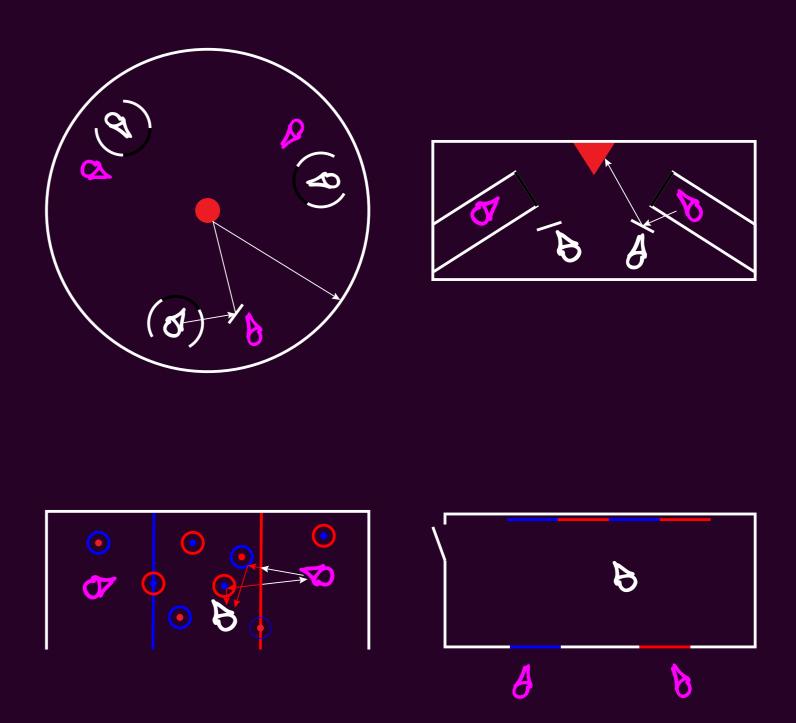


Figure 12. Visual representations of the iterations that led to the layout of the installation.

tion using red and blue filters. To simplify the design, I removed the mirrors and used objects made of holographic material. With this material, the same perceptual principle can be achieved as mentioned in Chapter 2.1.1.. Under red light or with red filters, visitors could only perceive certain objects. However, incorporating objects, filtered walls, and four visitors into the storage container resulted in overcrowding. Furthermore, keeping the long side open for safety made it difficult to ensure weatherproofing.

Ultimately, I chose to use an office unit for the final iteration. This solution features two windows with filters for the Pushers, who were positioned outside the unit. This approach tripled the available space for the installation and the Silent Middle. The office unit's design, containing a door, insulated white walls, and an electrical system is significantly more practical and functional than a standard storage unit.

- 3.1.2. OBJECT ITERATION

The question of what object the Pushers shine their light on was the focus of an extensive exploration. Figure 13 shows visual representations of this exploration. Ultimately, I decided to incorporate the depth perception masking theory discussed in Chapter 2.1.2.. The installation features letters that combine to form a word. When the righthand Pushers illuminate the letter "M" using red light, a pattern emerges that makes the letter not recognizable. Conversely, when the lefthand Pusher illuminates with blue light, the pattern disappears, leaving the surface plain. This allows shadows to reveal the letter "M," making it recognizable. Subsequently, Pushers perceive opposite halves of the letters. The Silent Middle, positioned inside the office unit are able to recognize all the letters through both the perspectives of the two Pushers.

- 3.1.3. GAMIFICATION

The installation is not intended to function as a traditional museum exhibit, where visitors passively observe and leave once they feel they have seen everything. Such an approach would, for example, present

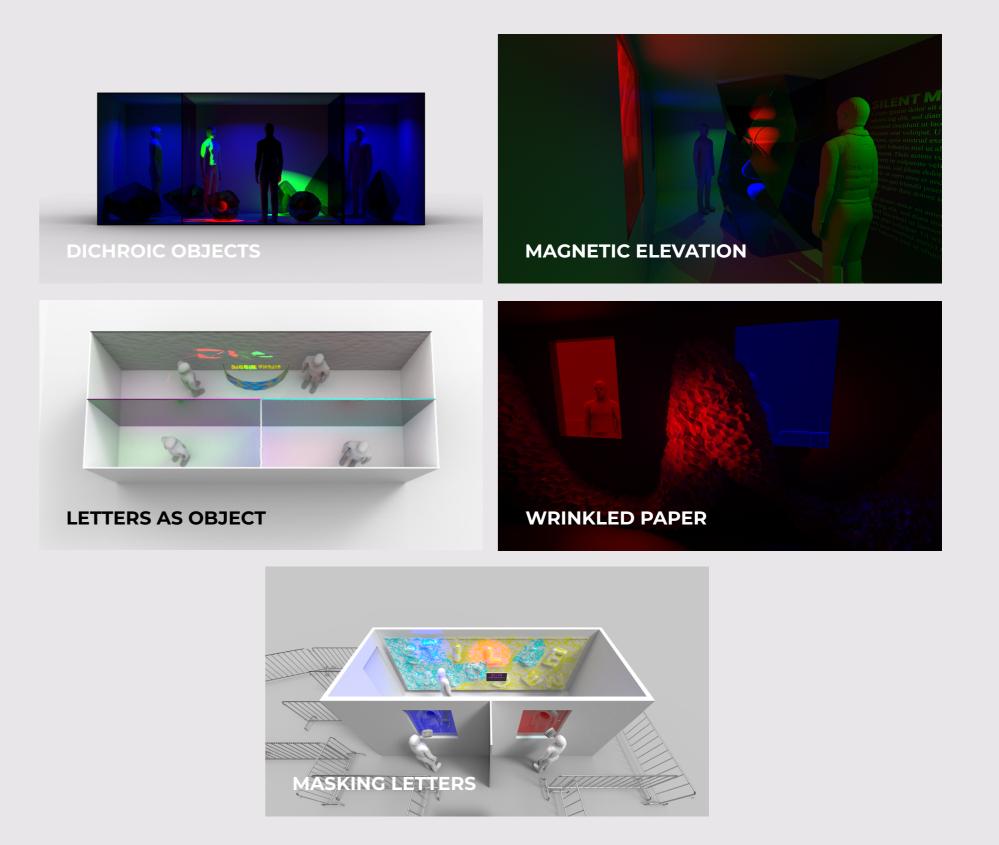


Figure 13. Visual representation of iterations on the object inside the container. The 'masking' letter iteration was selected for further development

challenges for managing crowd flow. Instead, visitors are required to take turns after a certain amount of time, which can be viewed as a constraint. However, this time limitation could also introduce a gamification element to the interaction, adding urgency to solve the challenge within the given timeframe.

This urgency enhances the emotional intensity of the experience. For example, if members of the Silent Middle successfully find the word just in time, they may feel a an increased sense of excitement and satisfaction. Conversely, Pushers who feel they only needed a few more seconds to complete the challenge may experience a stronger sense of dissatisfaction. This deliberate design choice amplifies emotional engagement and reinforces the polarization dynamics central to the installation's message.

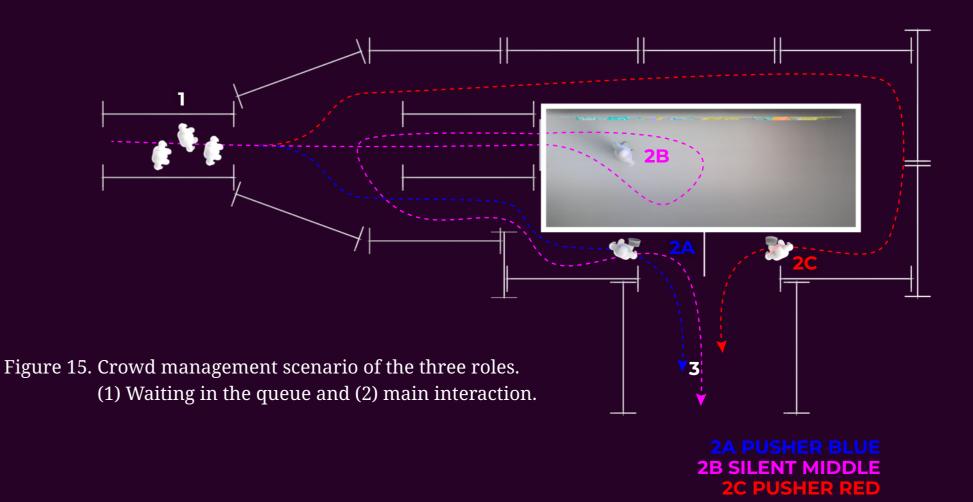
Gamification scenario

The following sections make for the gamification scenario of the installation.

- 1. Visitors waiting in the queue observe a display mounted on the exterior of the office unit. This display shows a countdown timer, a riddle providing a hints to the answer, and placeholder dashes corresponding to the word to be found (see Figure 14). These visual cues are designed to make visitors aware that the challenge is to identify a word within a limited timeframe.
- 2. Once the previous group exits the installation, the new visitors enter. The Silent Middle initiates the interaction by pressing a start button located inside the office unit, which activates the spotlight outside. This display shows the same riddle and placeholder dashes as the one outside. The Silent Middle can input letters into the display, which appear in a magenta Colour surrounded by white. These letters are invisible to the Pushers because of their red and blue filters.
- 3. After three minutes, the countdown timer reaches 00:00, signaling the end of the session. At this point, the spotlight turns off, and visitors are prompted to leave the installation, making way for the next group.



Figure 14. The first step of the interaction begins in the queue. A display shows a countdown, a riddle, and place-holder dashes.



- 3.1.4. CROWD MANAGEMENT

With the positioning of visitors during the test defined, the next step is to determine how they reach these spots. This process must adhere to two primary requirements, rooted in the concept of reflecting the polarization framework:

- 1. There must be a single queue that divides into three distinct pathways.
- 2. The left and right pathways lead to the Pusher spots, while the middle pathway directs visitors into the office unit, representing the Silent Middle.
- 3. All visitors must exit the installation through the same point, creating an opportunity for them to exchange experiences.

Through an iterative design process, I evaluated various approaches to crowd management. Ultimately, I concluded that the layout depicted in Figure 15 is the only configuration that satisfies all the criteria.

3.1.5. MAKING THE LEAP FROM INTERACTION TO POLARIZATION FRAMEWORK

The design choices were deliberately selected to minimize the conceptual leap from the abstract interaction to the polarization framework. Features such as the choice between the left, middle, or right path, the riddle displayed on the screen, the use of red and blue filters, the spotlight, and the gamification elements all contribute to reinforcing this connection. Collectively, these elements aim to guide participants toward understanding the intended message of the installation.

These design elements evoke distinct emotional responses: Pushers feel dissatisfaction, while the Silent Middle experiences satisfaction. However, additional measures are necessary to effectively bridge the gap between the interaction and the polarization framework. Simply leaving participants with a sense of dissatisfaction does not suffice.

First, it is essential for all participants to share and articulate their emotional responses, thereby highlighting the discrepancies in their experiences. Second, participants need an opportunity to un-

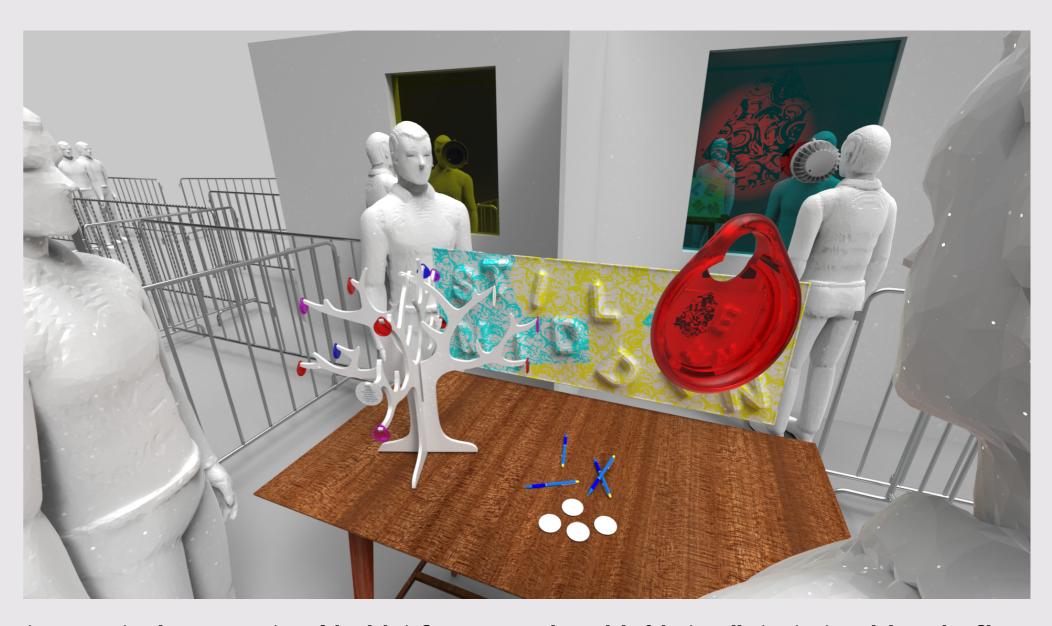


Figure 16. Visual representation of the debriefing step. A scale model of the installation is viewed through a filter keyring (in this case, red). The keyring can be kept after the participant writes a message on a Post-it.

derstand what others have perceived, even if this understanding is less immersive than the initial interaction. Consistent shapes should be used throughout the installation to tie these elements together visually and conceptually.

All visitors exit the installation via the same path, which provides an opportunity to deliver supplementary information. Here, visitors can write down their experiences of the installation on a piece of paper, which they can exchange for a keyring. This keyring serves as a token that enables participants to revisit the installation in the roles of all parties involved. A scale model of the installation facilitates this exploration, encouraging former Pushers and Silent Middle to exchange their experiences. The keyring remains with the participant as a lasting reminder of the installation's message. Figure 16 illustrates this step of the experience.

A poster with text and a visual combining the shape of the keyring (and the installation's modules) and the polarization should explicitly makes the connection between the two (see Figure 16).

HIDDEN IN PLAIN SIGHT AN INSTALLATION THAT CHALLENGES POLARIZATION BY DISCOVERING THE VALUE OF THE MIDDLE

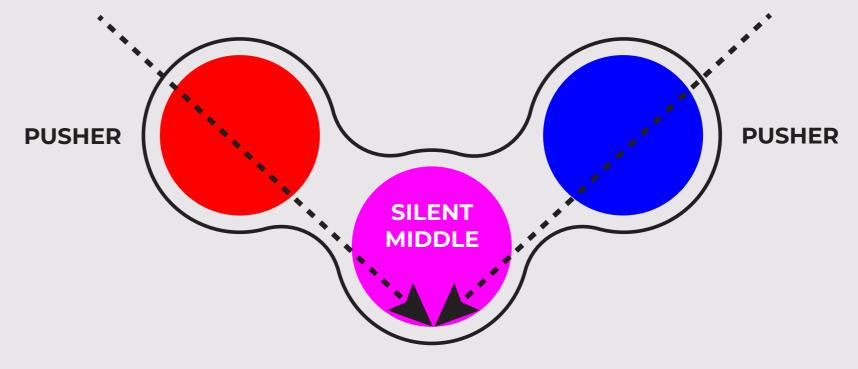
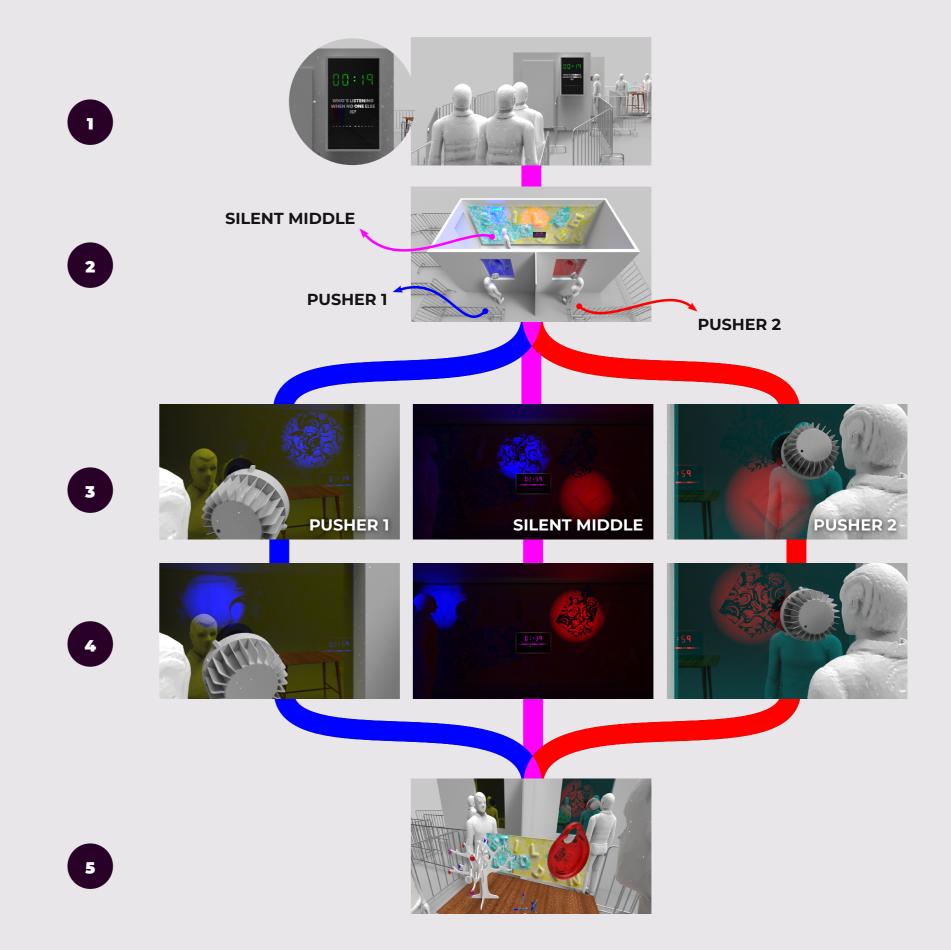


Figure 17. Poster displayed during the debriefing step of the interaction, aimed at connecting the interaction with the polarization framework.

- 3.1.6. INTEGRETED USER EXPERIENCE SCENARIO

The following steps outline the integrated user scenario for the installation's interaction. These steps correspond to those in the scenario on the next page.

- 1. Participants begin their journey by choosing one of three lanes, their curiosity piqued by a display showing a countdown, a riddle, and hints for a word. Anticipation builds as they prepare to engage with the installation.
- 2. Inside the unit, the Silent Middle presses a button to start the countdown, triggering two spotlights outside. The two Pushers, standing outside, direct their coloured spotlights through a window onto an appearance inside the unit. This setup creates a playful challenge, immersing everyone in the task.
- 3. The Pushers and the Silent Middle collaborate to collect all the letters needed to form a word, the ticking countdown heightening their sense of urgency. The coloured depth perception pattern ensures each Pusher can only see half of the letters.
- 4. As the Pushers observe the Silent Middle filling in letters they cannot see, their curiosity deepens. This prompts them to consider the Silent Middle's perspective. Despite their attempts, the Pushers end with incomplete or nonsensical words. However, by combining the perspectives of both Pushers, the Silent Middle can solve the riddle in time, leading to a mix of emotions; a sense of accomplishment for the Silent Middle and a feeling of dissatisfaction for the Pushers.
- 5. Upon exiting the installation, participants encounter a table where they exchange a note reflecting their learning for a key ring. As each participant contributes, the "experience tree" grows, symbolizing collective insight. The key ring, featuring a coloured filter, allows participants to revisit the installation from all roles and discuss their experiences. Beyond the installation, the key ring serves as a keepsake, reminding them of the interaction and its lessons in daily life.

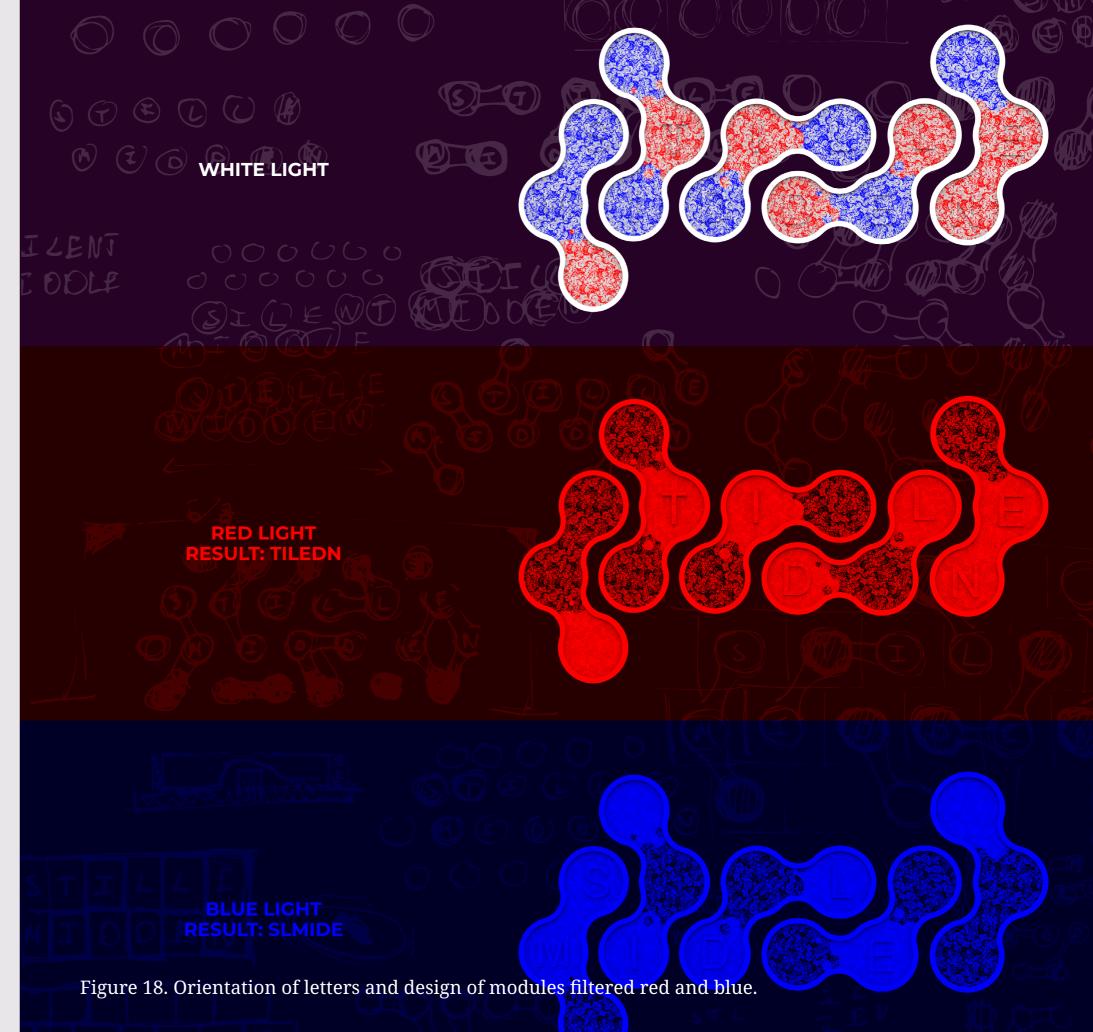


- 3.1.7. ORIENTATION AND COLOURS OF LETTER

Ideally, the word chosen for the installation would divide into two meaningful words for the Pushers. However, after extensive exploration, I concluded that achieving this with sensical words was not feasible. Consequently, I decided to feature the phrase Silent Middle, which reflects the core rationale of the installation. While this phrase lacks standalone meaning, providing context before and after the interaction is essential to ensure visitors understand its significance.

Thanks to the masking pattern, the Pushers perceive opposite letters of the phrase Silent Middle. To maintain a sense of plausibility, each Pusher is assigned two of the four vowels of the word Silent Middle. This ensures they retain the impression that forming a complete word is possible. Additionally, due to the geometrical limitations of the righthand Pusher (red), letters far to the left (S, M, and I) are designated as blue. The same goes for the lefthand Pusher.

Taking these constraints into account, the ideation process produced the configuration shown in Figure 18. The design features 5 individual modules each consisting of 3 circles. Splitting the letters makes the installation modular, meeting the requirement of easy translation to different contexts. It also enables one piece of paper to wrap around 3 letters, increasing feasibility. The modules' shape visually reflects the polarization framework, 2 Pushers on each end and a Silent Middle in the middle. This consistent shape serves as a recognizable common thread throughout the scenario, e.g. the keyring. The design incorporates two circles at the top and one at the bottom without letters. These elements increase the gamification challenge while maintaining consistency in the module's shape.



- 3.1.8. SCALE OF MODULES

After this iteration on the layout of the letters and surrounding design, I can make a step of exploring the scale of the installation. There are a couple constraint for this choice.

- 1. The scale of the letters is essential to enable the Pushers to perceive them when they are not masked. Simply put, the bigger width and length of the letters, the better. This makes the interaction of searching for a letter more engaging. When a letter is unmasked, a bigger will more likely to be recognized.
- 2. The inner dimensions of the long wall of the office unit are 5860x2340 mm (see Appendix A for the dimensions of the office unit). The installation should not exceed this. Also, the visitors should be able to comfortably enter and leave the office unit.
- 3. So each module should be wrapped with one piece of paper. The wrapping cannot be split into different pieces of printed paper, because of the unpredictability of the winkles. The printer at the faculty of Architecture prints on paper role of max 900 mm wide. After printing, the paper will be wrinkled and placed over the letters. The needed margin for this is 50 mm on each side. This is why I choose for the dimensions for the module shown in Figure 19.

Figure 19. Scale of the models compared to the printed paper that will be wrapped around them

- 3.1.9. DESIGN OF THE KEYRING

As outlined in Chapter 3.1.5., the initial concept for the keyring was to contain a single red, blue, or magenta filter. However, I have since concluded that for visitors to fully understand the dynamics of the installation, they must have the opportunity to revisit it from all three roles. This realization led to the decision to design the keyring in a way that incorporates all three filters, enabling participants to view the installation through the perspectives of all roles.

The design of the installation modules also reflects this three-fold concept. Each module features a circular structure divided into three sections. For the keyring, each circle can house one of the filters. This way the keyring's design is consistent with the design of the installation, reflecting the visual of the polarization framework. See Figure 20 and 21 for the result of the redesign.

- 3.1.10. DEPTH OF LETTERS

The depth of the letters is a compromise between the ability to mask it and the ability to make it clearly appear when not masked. Furthermore, a thicker letter will make it significantly more difficult to wrap the paper around it. After testing different depths of the letter, I used a depth of 6 mm on a letter that is 90 mm tall. I also tested this thickness on a full scale letter (see Figure 22). This made it too difficult to read at a distance. There is not enough shadow to reveal the shape. I assume that the thickness of the letters should be scaled with the height of the letter in a ratio of +/- 1:15. This should be validated in the next iteration.

- 3.1.11. MASKING PATTERN

Throughout this iteration, I used a pre-existing masking pattern, which proved effective. For the next iteration, I could consider designing a custom pattern, although this should remain a lower priority.

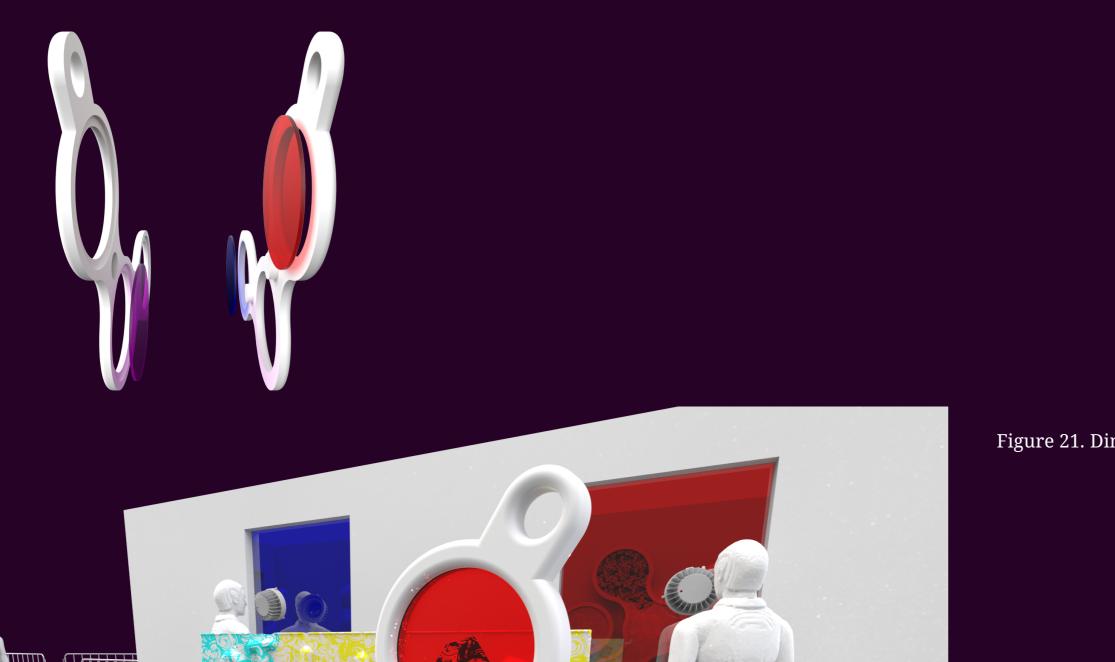


Figure 20. Redesign of the keyring in contex

d set explod

70 2 3 57

Figure 21. Dimensions keyring (mm).



Figure 22. Experiment to test the depth of the letters for achieving the optimal masking effect.

- 3.1.12. SPECTRAL TUNING VARIABLES

To optimize the switch between a high-contrast masking pattern and a plain surface, it is crucial to fine-tune the relevant spectra. The Pushers must experience opposite visual perceptions, achieved by separating the spectra as much as possible to prevent overlap. Red and blue were chosen as filter colours because they are positioned at opposite ends of the visible spectrum. Figure 23 illustrates the implementation of the relevant variable spectra.

The Holographic film

The holographic film introduces a mysterious quality to the interaction. It reflects cyan or yellow of the daylight spectrum (the visitors see their own filtered reflection) while primarily transmitting red or blue. However, the transmitted spectrum from the film is relatively broad, resulting in overlapping spectra between the two Pushers.

The Lee Filters

The Lee filters play a critical role in minimizing spectral overlap between the Pushers. They refine the broad spectrum transmitted by the holographic film into narrower bands. Deep Blue and Primary Red Lee filters (see Appendix B for transmissions spectra) were selected because their spectra have minimal overlap while maximizing transmission. By doing this, the power output of the spotlight needed to sufficiently perceive what is inside the office unit can be minimized.

The spotlight

Since the Lee filters effectively separate the spectra, the emitted spectrum of the spotlight could be broad, as the filters narrow it to their respective spectra. While the spotlight in the figure emits white light, in the concept the lights are either red or blue. This enhances the impression of distinct perspectives. Because of the narrow spectra of the filters, the emitted spectra of the spots must match the spectra of the filters or have a broader spectrum. For the test in Chapter 3.3., I use 2 flashlights that transmit a white light. Participants were not able to see the light of the other Pusher, validating the choice of the filters.

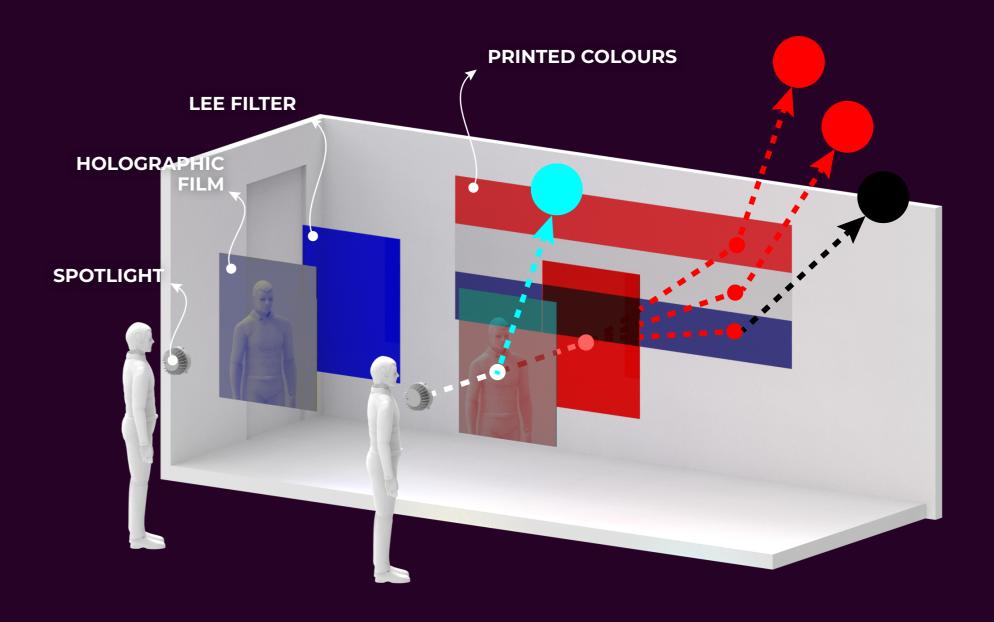


Figure 23. Schematic overview of the components influencing spectral tuning. Emitted light travels through the dichroic film, reflecting cyan and transmitting a broad spectrum of red. It then passes through a red filter, narrowing the spectrum, and is reflected by the printed paper. In this example, the red and white pigments reflect red, while the blue pigment absorbs red light.

The printed colours

The final variable is the reflectance spectra of the printed red, blue, and white colours on the installation. Light can be described using an additive colour model. Starting from black and combining red, green, and blue to produce the full visible spectrum (with equal combinations resulting in white light). Printing utilizes a subtractive colour model.

In the subtractive model, pigments are applied to a white substrate (e.g., paper), absorbing specific wavelengths of light and reflecting others. For instance, adding cyan pigment reflects cyan while absorbing other colours. Adding more pigment darkens the resulting colour. The subtractive model typically uses cyan, magenta, yellow, and key (black) pigments to create colours. Its Colour gamut (range of available colours to be produced) is narrower compared to the additive model. Advanced printers, however, expand the gamut by incorporating additional pigments.

Printer choice

I selected the HP DesignJet Z9+dr 44-in printer, located at the Faculty of Architecture. This choice was based on my familiarity with the printer, its availability on campus, and its capability to support rapid iterative testing. The printer uses nine pigments (cyan, magenta, chromatic red, yellow, matte black, photo black, chromatic green, chromatic blue, and grey), which broaden its colour gamut. For future iterations, I remain open to exploring printers with different specifications if needed.

Testing and adjustments

I conducted tests using a printed PDF featuring RGB blue and RGB red patterns. Ideally, illuminating the print using the flashlight through the red Lee filter would make the printed red and white areas appear as a uniform colour. However, due to the subtractive nature of printing, this is not the case. In practice, the printed red appears darker than the white, creating unintended contrast.

To address this, I introduced a percentage of black pigment to the printed white areas. This adjustment reduced the contrast of the pattern when illuminated with blue light, balancing its visibility. I determined that a 12% grayscale for the white spaces in the pattern

provided the optimal compromise. This level minimizes the pattern's visibility under one colour while maximizing its contrast under the other, ensuring a clear and effective interaction for the Pushers.

Daylight implications

The Maker Faire takes place during daylight hours, a factor that significantly impacts the visibility of the installation, particularly for the Pushers situated outside. To ensure optimal functionality, the design must minimize the amount of daylight entering the windows through which the Pushers interact with the installation.

To address this, the office unit will be oriented so that the windows face north, preventing direct sunlight from entering. This strategic positioning eliminates the risk of glare or unwanted reflections. Daylight remains a critical consideration for the next iteration.

3.2.

PROTOTYPE 1.

I developed a prototype for the first user test, which focuses on the integrated interaction of the design. A full-scale, technically integrated model is not required for this test.

- 3.2.1. REQUIRED MATERIAL

The following elements are needed for the planned user test:

- A 1: 2.5 scale model of 2 modules with 6 (MIDDEN) of the 12 letters.
- A scale model of the long wall of the office unit with 2.
- 2 flashlights with small beam angles (<10°).
- A laptop with countdown, riddle and placeholder text (magenta).
- A printed poster of Figure 17.
- For the debriefing table:
- o A 1:5 scale model of 2 modules with 6 (MIDDEN) of the 12 letters.
- o 3 keyrings filtered red and blue.

- 3.2.2. BUILDING SCALE MODEL OF MODULES

The module's design lends itself well to laser cutting. Each module consists of two laser-cut layers that clamp the printed paper securely in place using nine M4 bolts (see Figure 24). This design allows the printed paper to wrap around the letters. The letters and printed paper can be easily replaced, offering flexibility for iterative design adjustments. Also, this way the letters can be replaced, combining a

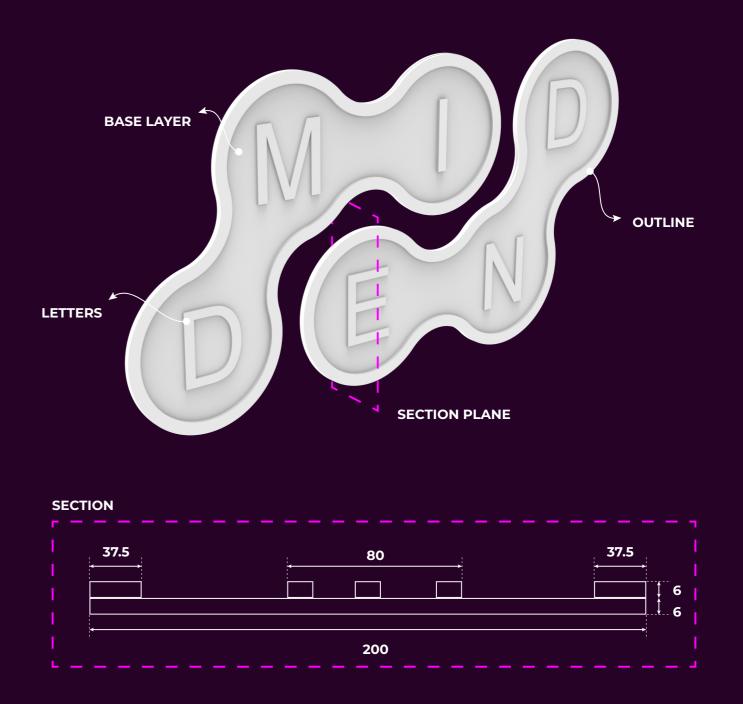


Figure 24. Section view and dimensions of modules (mm).

different word (for example Silent Middle instead of Stille Midden). For testing purposes, the 1:2.5 scale model was suspended from a door using nylon fishing line. Figure 25 shows the assembling process of the prototype.

- 3.2.3. INSIGHTS WHEN BUILDING THE PROTOTYPE

Figure 26 and 27 illustrate the result of this prototype in context. When building the prototype, I came across a couple of issues that need attention in the next iteration of the concept.

Wrapping process

The paper used to print the pattern is 190 gr/m2. Which means it is stiffer than the paper used in previous testing. This made it more difficult to wrap it around the letters. This will get easier for the full scale model.

Glare of paper

The prototype used satin-finished paper, which showed visible glare when illuminated by the spotlights. This glare revealed the shapes of the letters, even when the masking pattern was visible. This issue arises due to the parallel surface contour principle discussed in Chapter 1.5.2., where parallel lines highlight the shape of a surface.

To address this issue, I increased the angle between the installation inside and the windows. By ensuring that the glare does not directly reflect back toward the visitors, the glare's visibility is significantly reduced. In the next iteration, material selection will be revisited to identify a finish that minimizes glare while maintaining the clarity and effectiveness of the masking pattern.

Separating beams

The full-scale installation inside the office unit spans an area of 8.5 m², allowing the beams from the spotlights to remain sufficiently separated. In the 1:2.5 scale model, with only six letters, the beams merge more significantly. This decreases the clarity of the experience and reduces the engagement for all participant roles.

Additionally, the room used to test the scale model in was not com-



Figure 25. Prototyping process of the 1:5 scale model for the debriefing step.



Figure 26. The result of the 1:5 scale model for the debrieding step.

pletely blacked out, which introduced another challenge. Scattered and reflected light made the letters partially visible even when the spotlights were not directly aimed at them. This issue is expected to reduce in the full-scale version due to the larger spatial separation of beams. This did not influence the test results.

To further mitigate this problem, I would need to cover the interior of the office unit with blackout fabric. This will absorb excess light and minimize reflections, ensuring that the letters are only visible under the intended conditions.

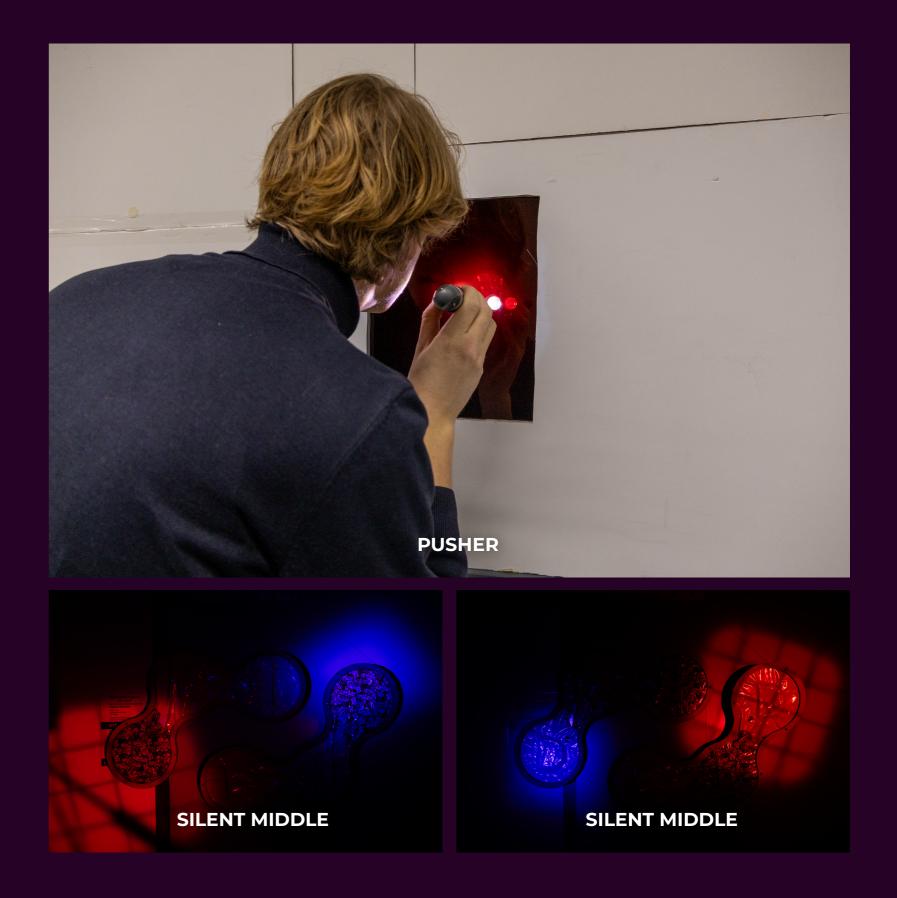


Figure 27. 1:2.5 scale model in context of the test setup.

3.3.

USER TEST 1.

Now an integrated concept has been developed, that is designed to meet the goals for the interaction, it should be tested. This chapter discusses the test setup, the prototype built for the test and the insights following the test.

- 3.3.1. RESEARCH OBJECTIVE

This test is developed to validate the intended emotional sequence of each of the roles. This can be done by measuring the emotional state of the participants. It can be compared to the intended emotional states to see if these align.

- 3.3.2. METHODOLOGY

Emotion questionnaires can be quite challenging to fill out. Therefore Desmet et al. (2019) developed the so called PrEmo card set. This is a pictorial emotion scale. Half of the emotions are negative and half are positive. The 14 emotions represent a cross-section of the human repertoire (see Figure 29).

The number of participants involved in this test will not result in significant quantitative data. Consequently, merely asking to pick a card from the set after each section is not sufficient. The PrEmo cards will be used as a tool to visually recognize the emotions of the card and compare it to the participants emotions. Subsequently the participant is better prepared to describe his or her emotions and their

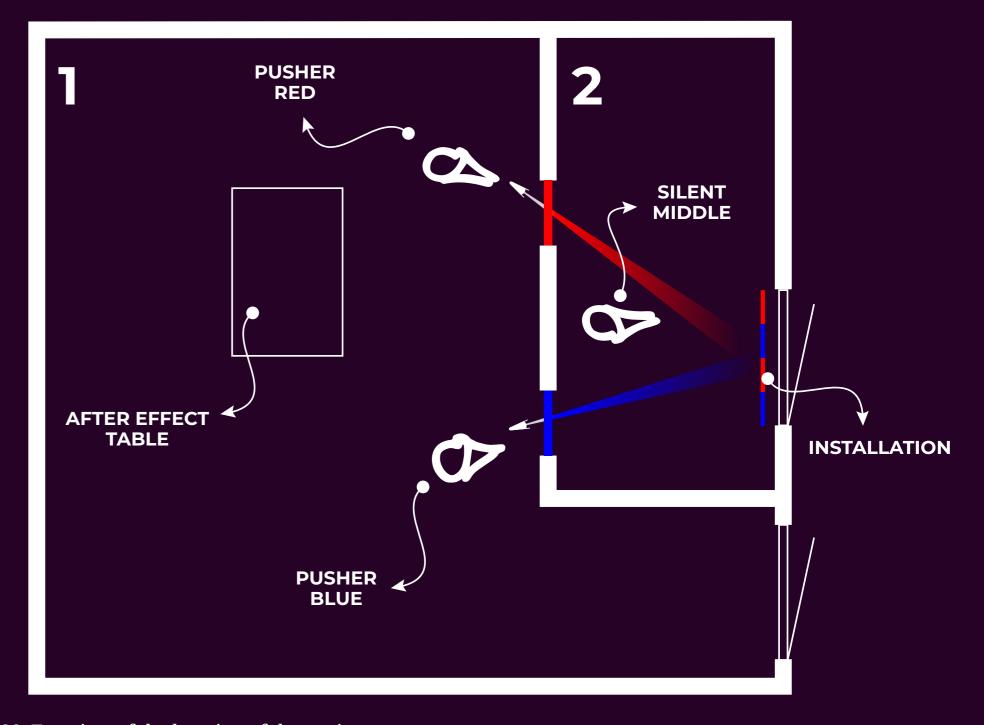


Figure 28. Top view of the location of the testing setup.



Figure 29. PrEmo cards (Desmet et al., 2019) used for testing of emotional sequence.

cause. I will provide both male and female cards in order to not be a restrictive component.

- 3.3.3. PROCEDURE

The test setup consists of four distinct sections. Participants begin by completing a consent form (see Appendix C). After each section, they are asked to fill out a section of the corresponding form (see Appendix D). The complete procedure is attatched in Appendix E. See Figure 28 for a top view of the location and positions of participants.

- 3.3.4. PARTICIPANTS

Like mentioned in Chapter 1.6.3., the target group of the Maker Faire can be divided into three different clusters: professional makers, amateur maker and elementary school children. All participants of this test are students or employees of the TU Delft. They can be defined as professional/amateur makers. This limitation is a time consideration. It is essential to test with children in the future, because it is assumed that they react significantly differently to these kinds of interactions.

- 3.3.5. INSIGHTS

After the first two tests, I concluded that the concept's elements were not sufficiently tested to validate the intended emotions. As a result, I shifted to a research-through-design approach, making minor adjustments between tests. This iterative process allowed me to identify what worked and what did not, making it an effective exercise.

Word searching cue

The designed cues to make participants aware of the fact that they must search for a word, is not convincing enough. The cues contain the riddle, placeholder dashes and the countdown sign on the display at the outside wall of the office unit (in the test represented by a printed render). This has major implications for the following sections of the interaction. The letters on the installation have a level of indistinctness, as a compromise to the masking. Assumed is that when participants are not aware that they are searching for letters, they do not recognize the letter as fast. The testing showed that this results in unwanted confusion amongst all roles (Silent Middle and Pushers).

In the next design iteration this cue should be made clearer. After the second test, the participants were told that they should be searching for a word. This way, the rest of the elements of the design could be tested.

Organizing letter into word

During the design of the installation, it was assumed that participants would organize the letters into words by reading from left to right and top to bottom, following conventional reading patterns. However, testing rejected this assumption. The findings suggest that the colour of the letters serves as a stronger cue for clustering than their spatial orientation. For instance, a participant from the Silent Middle group formed the word "MEDDIN" by grouping all red letters (MED) and all blue letters (DIN), demonstrating a colour-based rather than orientation-based organizational strategy. A possible solution to this problem is bring the shape of the installation without colours back in the displays on the exterior and interior.

Physical ergonomics

The height and dimensions of the window in the office unit is fixed, so was the window during the test. During the test, a participant was not tall enough to comfortable interact with the installation. She needed a step for this. During the Maker Faire, primary school kids will also interact with the installation. It is essential to take this element of physical ergonomics into account during the next iteration.

Visual perspective-taking

After interacting with the installation, participants were asked whether they thought about what another participants might have

seen and when this would have occurred. Observations during the test combined with the answer to this question suggest that this is a conditional step. The conditions appear to be that (1) participants are (partially) done with becoming aware of their own visual cues and (2) they realize that they see something else than the other participants. A participant that is constantly confused about what they are looking at, will not be likely to take the step of perspective-taking. Furthermore, a participant that does not know that the other has another perspective (e.g. red instead of blue filter) is also not likely to take this step. Participants also establish this awareness when they realize that they do not see the spot of the other Pusher.

Perceived collaborative function of the spotlight

The test indicates that participants perceive the task of finding the word as a collaborative effort. However, it also reveals that participants occasionally struggle to discern the function of the spotlight in locating the word. Notably, some participants assumed that combining the red and blue light on a letter would make it visible to the Silent Middle. This misconception occurred exclusively when Pushers were permitted to communicate during the interaction. Ironically, combining the spotlights on a letter actually makes it more difficult for the Silent Middle to perceive it. Whether this sense of collaboration is desirable remains open to debate. Ideally, the Pushers should feel a sense of urgency to independently identify the word rather than collaborating solely to enable the Silent Middle to discover it.

Debriefing table

The cues on the debriefing table work sufficiently to discover what each role saw during the test. Also, all participants picked up the key ring in order to discover this. However, convincing the connection to the framework needs more information. It needs to be explained what the Silent Middle means. This term does not stand on its own. Only connecting it to the word Pusher is not sufficient. This is why I have to redesign the poster used. This poster should contain a clear visual about what is happening during the interaction. Also I am considering designing a flyer that contains the technical working principles (educational) and background information.

Language inconsistencies

I wanted to have the opportunity for international people to also participate in the test. Therefore, the form of the test, the debriefing poster and the riddle were written in English. However, the word of the installation was Dutch (Stille Midden). In the end, only Dutch speaking people participated. One participant said that he was confused because he assumed that he should have been looking for an English word. For the Maker Faire, all provided information will be in Dutch. The installation is designed in a way that the word and provided information can easily be translated to accommodate English speaking visitors.

3.4.

CONCEPT
ITERATION 2.

Building on the insights gained from the proof of concept, a second iteration was developed. This iteration aims to address not only the requirements for the interaction but also the practical and technical requirements.

- 3.4.1. BUDGETING

It is confirmed that my installation will be exhibited at the Maker Faire on May 9th. However, the specific form of this exhibition depends on the available funding. I applied for a Fast Fund Ambitious Project Grant, a subsidy program for TU Delft students undertaking ambitious projects outside their regular curriculum. In my case, the exhibition itself is not part of my graduation project assessment.

The project has been awarded a grant of €4000. With this budget, I should be able to exhibit at the Maker Faire. I plan to use media coverage from this exhibition to apply for participation in a second event with broader reach of public, making it possible to exhibit twice within the allocated budget.

The design for this iteration must remain within the allocated budget. As a result, careful consideration is given to whether to purchase or rent materials. Renting can be relatively costly due to the multiple planned exhibitions. The budget overview is presented in Appendix F.

- 3.4.2. EMBODIMENT OF MODULES

The modules are not complex objects. They consist of a base layer. The letters are sticked on this base layer. A piece of printed paper is wrapped sticked on this base layer and wrapped around the letters. An outline of the base layer is bolt onto the base layer as top layer. This last part makes sure the paper can be easily cut around the edges

Material base and top layer

Due to the scale of the installation, minimizing workload for production, processing, detailing, and assembly is essential. Therefore, the base and top layers are designed for laser cutting, ensuring precise tolerances, fast production, and easy assembly.

Material selection is crucial for feasibility. Laser cutting has thickness limitations that vary by wood type. For example, MDF consists of compressed wood particles bonded with glue, making it harder to cut than softer materials like plywood.

To optimize light absorption, all materials, except the printed paper, should be as matte and black as possible. High-quality black MDF was chosen for the base and top layers due to its matte finish, eliminating the need for post-processing. This material is also more durable than standard MDF and commonly used in interior design. Additionally, its cost is not significantly higher than alternatives.

As established in Chapter 3.1.10., a letter depth of 9 mm is most suitable for masking. Therefore, 9 mm MDF is used for the base layer, top layer, and letters. Using a single plate thickness minimizes material waste and therefore costs.

The base and top layers are secured using 8 mm hexagon socket head bolts with a countersunk head. The countersunk design allows the bolts to sit flush with the MDF surface, ensuring a smooth and seamless finish.

Bolt cover cap

The socket heads are galvanized, making them highly reflective. To prevent them from drawing visitors' attention, black cover caps were added. Purchasing these caps would cost approximately €50, so I designed and 3D printed them instead. For optimal 3D printing, I used chamfers instead of fillets, reducing the visibility of layer lines.

The caps snap into the socket heads securely. Achieving the right fit required six iterations of tolerance adjustments.

Matte finish printed paper

During prototyping for the first user test, I discovered that the paper produced significant glare. This glare increased the visibility of masked letters, compromising the intended effect. While printing on matte paper could reduce glare. However, it also causes the pigment to penetrate the paper more than on satin paper, resulting in desaturated colours.

To address this issue, I explored post-processing methods to minimize glare while preserving colour vibrancy. I tested a transparent matte acrylic spray, which proved highly effective. This method allows for the colour properties of the satin paper and the reflective properties of matte paper. To prevent craquelure and cracks, the spray is applied after the paper is wrapped around the letters.

Splitting the modules for laser-cutting

The modules exceed the 700x1200 mm bed size of the laser cutter at IDE. Rather than scaling down the installation, I chose to split the modules at logical points. The division lines ensure that the base and top layers interlock for structural integrity. However, the top layer is relatively more vulnerable than the base layer. During the upcoming prototyping stage, it should be tested whether additional support is needed at the back of the base layer to enhance integrity.

- 3.4.3. DESIGN OF THE SUPSPENSION CONSTRUCTION

Now I know how the modules will look like, I can start thinking of a construction to hang the modules on to. The following requirements apply to the design of this construction, following the MoSCoW method (Kravchenko et al., 2022):

Must have

1. It has low impact on the visual appearance of the installation. The only visual element of the installation that should grab attention is the printed paper.

- 2. The construction fits through the door of the office unit (875x2125mm).
- 3. The budget for the construction is \in 600 for 2 execution.
- 4. The construction support the 150 kg installation.

 The 5 modules weight approximately 150 kg, assuming that it is going to be made of (high density) wood.

Should have

- 5. The construction is modular.

 The construction should be stored somewhere in the time between the Maker Faire and the second exhibition. For this
 - between the Maker Faire and the second exhibition. For this, it is desirable to be able to divide it into small pieces.
- 6. The construction should withstand forces that visitors apply to it.
- 7. Elementary school kids should be able to lean onto it.
- 8. The construction can be bought instead of hired.

 Often, purchasing a product like this is profitable after multiple execution. The amount of executions is insecure. Therefore, the preferable option is to purchase goods.
- 9. The installation is 2.0x3.7m. The construction should accommodate these dimensions.
- 10. The installation should be hung 20cm from the ground.

Could have

- 11. The weight is of the construction is limited.

 This is not a crucial requirement, because weight can also add to the constructive integrity.
- 12. The construction is easy to produce, process and assemble.

Choosing a construction system

I have to design an construction system which is detached from the office unit. This is because of the fact that I hire the office unit. It is not allowed to hang anything on the walls. After ideating on the manufacturing method of the construction, three option arose. A wooden construction, a truss construction and a scaffolding tube construction. The pros and cons of all three are listed in Appendix G. I assume that all three options have the potential to meet the *must have* requirements.

Comparing the pros and cons of the three option shows that the

scaffolding tube construction is the most suitable option. This is mostly due to the high visual impact and bulky wooden construction and the inability of the truss construction to reach higher than 2m. Designing and assembling the scaffolding tube construction requires relatively low work load.

Designing the scaffolding tube system

The construction is based on a banner frame, which consists of two horizontal tubes, two vertical tubes, and two base tubes. These tubes are connected using links. To facilitate the attachment of modules to the structure, six additional vertical tubes are incorporated. The outer vertical tubes of the banner frame are fixed with a T-link, while the added vertical tubes can slide along the horizontal tube (using the link in Figure 30.1). Consequently, modules are not attached to the outer tubes to preserve the ability to adjust the position of the sliding tubes. This adjustability allows for compensation for the system's rough tolerances.

The banner frame is originally designed for supporting banners, which requires a lower level of structural integrity than this application. To enhance stability, a diagonal tube was added. This modification is particularly necessary because the center of mass is not aligned with the depth of the frame, as the modules are suspended in front of it.

A total of 13 links are used to secure the modules. See Figure 30.3 for the design of these links. Each module contains seven sets of holes, enabling multiple orientation options. This design allows for the composition of the installation to be modified after executions, making it possible to change the displayed words as needed.

Scaffolding systems are available in various diameters. For this iteration, a diameter of 48 mm was selected. Accurately estimating the forces exerted on the structure and the structural integrity of the links is complex. Therefore, a conservative approach was taken by selecting the safer option. Prototyping the installation should validate this choice. See Figure 31 for an impression on the designed construction.

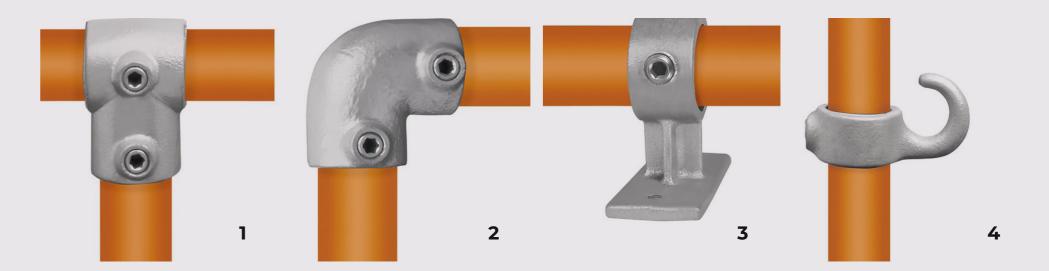


Figure 30. Final design of the construction system using scaffolding tubes.

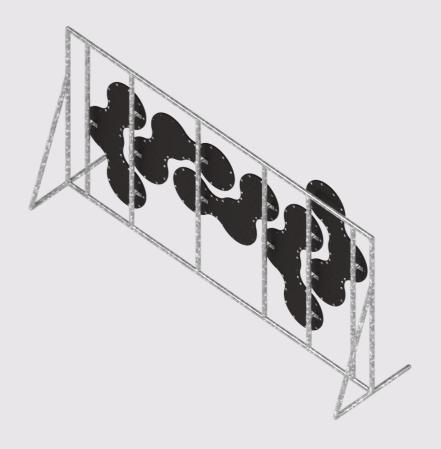


Figure 31. Scaffolding tube links used in the construction design.

- 3.4.4. SELECTING THE FIXTURE

THis section explores the requirements for a fixture and compares different type to select one.

Setting a list of requirements

After the first test, I concluded that a flashlight is the most suitable form factor for a fixture. This allows the visitors to intuitively work with the spot. Choosing the right flashlight depends on the following criteria.

Must have

- 1. The beam angle can be set to +/- 10 degrees.

 This way, at a distance of 2.3 meter the light spot is 50 cm in diameter. This is the height of a letter in the installation.
- 2. The flashlight can produce 1500 lux at a distance of 2.3 meter with a 10 degree beam angle.
 Determining the precise illuminance required on the letters to optimize the effectiveness of the perception principle is challenging due to the variability of daylight conditions in the installation's context. To facilitate the search for suitable flashlights, a target illuminance of 1500 lux was established.
- 3. The power output is variable.

 As discussed in Chapter 1.5.1., the short cones in our eyes are less sensitive than long cones. We perceive blue as less intense than red light. This is why the energy (irradiance) going through the blue filter should be higher to compensate for this phenomenon. This is why the flashlight should have a variable power output.
- 4. The flashlight has solid build quality.
 Considering the fact that enthusiastic visitors are going to interact with it, the build quality of the flashlight should be solid. This probably means a metal housing.
- The flashlight should not produce excessive heat.
 Tactical flashlights tend to get warm quickly. With children interacting with the flashlights, this should be avoided at any time.
- 6. The budget for one flashlight is €100.

I have to assume that the flashlights will get damaged. That is why I should have 1 spare. Spending more than €300 on the flashlights would not be suitable considering the budget.

Should have

- 7. The flashlight should have a replaceable battery.

 On maximum power, most flashlights are dead in one hour.

 That is when it should be replaced with a fully charged one.

 Preferably, the flashlight has a replaceable battery, so an array of fully charged batteries can be available.
- 8. The beam angle can be locked
 This acoids visitors adjusting it.

Could have

- The power output can be locked.
 This avoids changing the output half way through the interaction.
- 10. The flashlight has a hole to wire a steel cable through.

 This steel cable can be attached to the office unit. This way the Pushers are not able to shine in each other's eyes. Also, this prevents theft.
- 11. The housing is IP rated.

The visitors will be positioned beneath a canopy, which mitigates the need for the flashlight to be weather-resistant. However, there is a possibility that moisture could reach the flashlight due to leakage, making weather resistance a desirable feature, though not a critical one.

Testing flashlights

Measurements conducted with flashlights available in the Light Lab revealed that their actual output was significantly lower than the manufacturer-listed power ratings. As a result, a flashlight with a higher rated power than theoretically required to achieve 1500 lux on the letters was necessary. Additionally, the listed power typically represents the maximum output, which is often not sustainable for extended durations.

During this process, I found that most flashlights do not specify a rated beam angle, and many lack a variable focus. Initially, I

purchased the Brennenstuhl LuxPremium flashlight (rated at 430 lumens) as it appeared to meet most of the criteria. However, it only produced approximately 1000 lux at a distance of 2 meters with a beam angle of 12 degrees, and its output declined rapidly over time. Since the measured output did align with the rated power, I conducted spectral measurements using a spectrometer at a distance of 2.3 meters with a 12-degree beam angle. I measured the direct beam (radiation spectrum) as well as red and blue filtered beams (filtered spectrum) using Lee Filters previously selected for the project (see Figure 32). The transmission spectra of the filters can be calculated by dividing the filtered spectrum with the radiation spectrum. The calculated transmission spectrum closely matched the rated spectrum provided by Lee Filters , displayed in Appendix B.

Testing multiple available flashlights revealed that their radiation spectra were similar, exhibiting a typical LED spectrum with a relatively high intensity on the blue side, indicating a high colour temperature. This could help compensate for the fact that our eyes are less sensitive for blue light as compared to red.

Consequently, I sought flashlights with a rated power between 1000 and 1500 lumens and identified Ledlenser as a suitable manufacturer. Ledlenser produces flashlights with variable focus, which was a key requirement. I tested two models: the P7R and the P7R Core, both of which lacked a rated beam angle. The P7R has a power output of 1400 lumens with a measured minimum beam angle of 12 degrees, but its focus mechanism cannot be locked. The P7R Core has a power output of 1000 lumens with a measured minimum beam angle of 8 degrees, and its focus can be locked. Both models produced sufficient illuminance, but the ability to adjust focus ultimately led to the selection of the P7R.

Specifications Ledlenser P7R

Beam angle: min 8 degree (can be locked)

Battery: 18650 3.7V

Temperature: 6000-8000 kelvin

CRI: 65

Power output: 1000 lumens Weather resistance: IP54

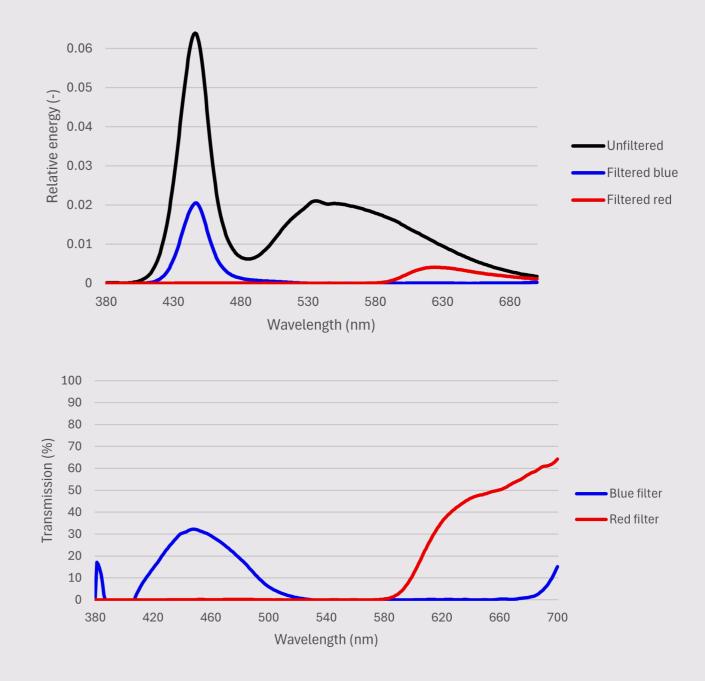


Figure 32. Top: The radiation, filtered blue, and filtered red spectra of the Brennenstuhl LuxPremium in combination with Lee Filters. Bottom: The percentage of energy filtered.

- 3.4.5. DEBRIEFING POSTER ITERATION

The debriefing section should establish a clear connection between the interaction visitors have just experienced and the polarization framework. The first user test indicated that this connection was not sufficiently clear. The interaction using the keyring and scale model effectively replicated the roles of the experience, so this aspect remains unchanged.

To improve clarity, the poster has been redesigned. The revised version explicitly presents what each role perceived in the installation, alongside the role names, the installation's title, and its objective. This approach ensures a stronger connection between the roles in the framework and those within the interaction. Figure 33 is the result of this iteration.

- 3.4.6. KEYRING ITERATION

The use cues of the keyring work like intended. However, the keyring should be produced more than 100 times and the filter should be better secured. That is why I redesigned the housing of the keyring and the shape of the filters. The shape of the filters are now squared instead of circled. This allows for quick cutting. It makes the housing a bit bulkier to allow for the square to fit. I bought a 3mm hole puncher. I also 3D printed a part that hold the filter in place while cutting through the slots in the part. See Figure 34 for the result of this iteration.

- 3.4.7. REMOVING HOLOGRAPHIC MATERIAL

I decided to remove the holographic material from the windows of the Pushers. This decision is based on insights from user testing, which highlighted that visitors' realization of the Pushers having different filters is essential for establishing a connection to the framework. The mysteriousness of the holographic film does not contribute to this. Therefore, only red and blue filters will be used.

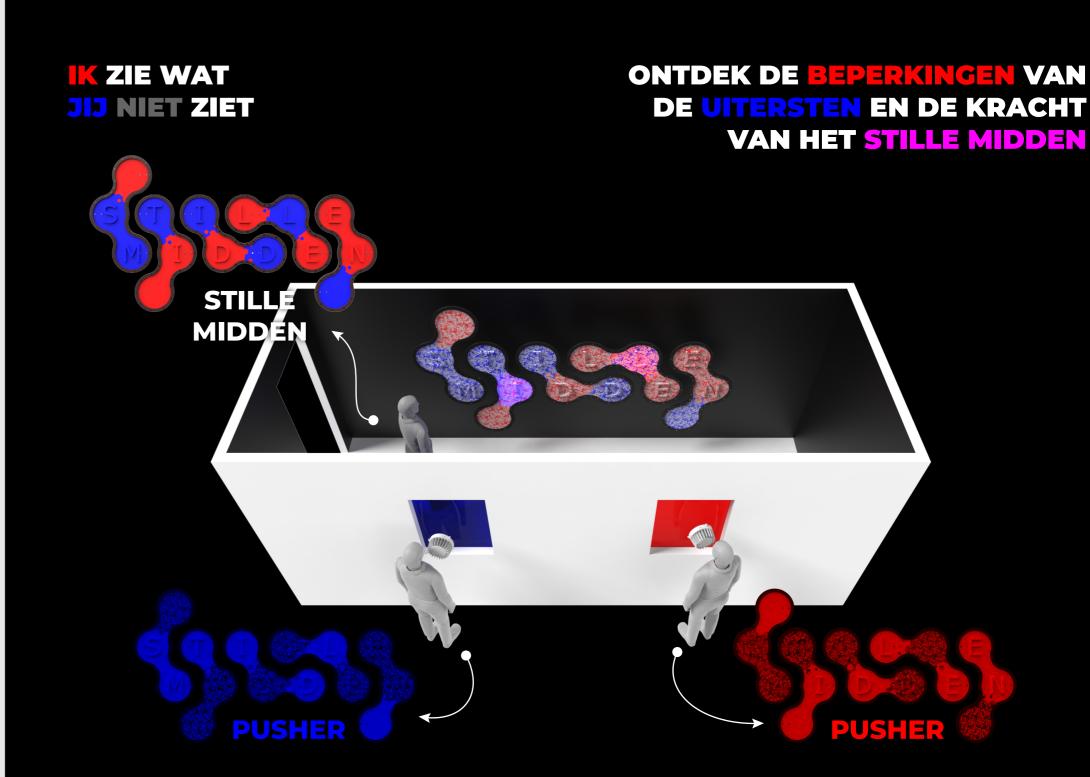


Figure 33. Iteration of debriefing poster.

- 3.4.8. LIMITING SCATTERED LIGHT

As previously mentioned, all elements except for the printed paper should absorb as much light as possible. This is essential not only to ensure that attention remains focused on the modules but also to minimize scattered light from the beams. The interior of the office unit is white. This is why covering the walls with a black backdrop would be preferrable.

Since the backdrop must be detached to the office unit, several solutions were explored. A pipe-and-drape system would provide full coverage with minimal spatial impact. However, at an estimated cost of €250 per exhibition, this option is not financially viable. Instead, I opted to hang a backdrop curtain with loops on hooks attached to the construction. This solution is significantly more cost-effective while still covering the most critical area (where the spotlights directly shine) thereby effectively reducing light scattering.

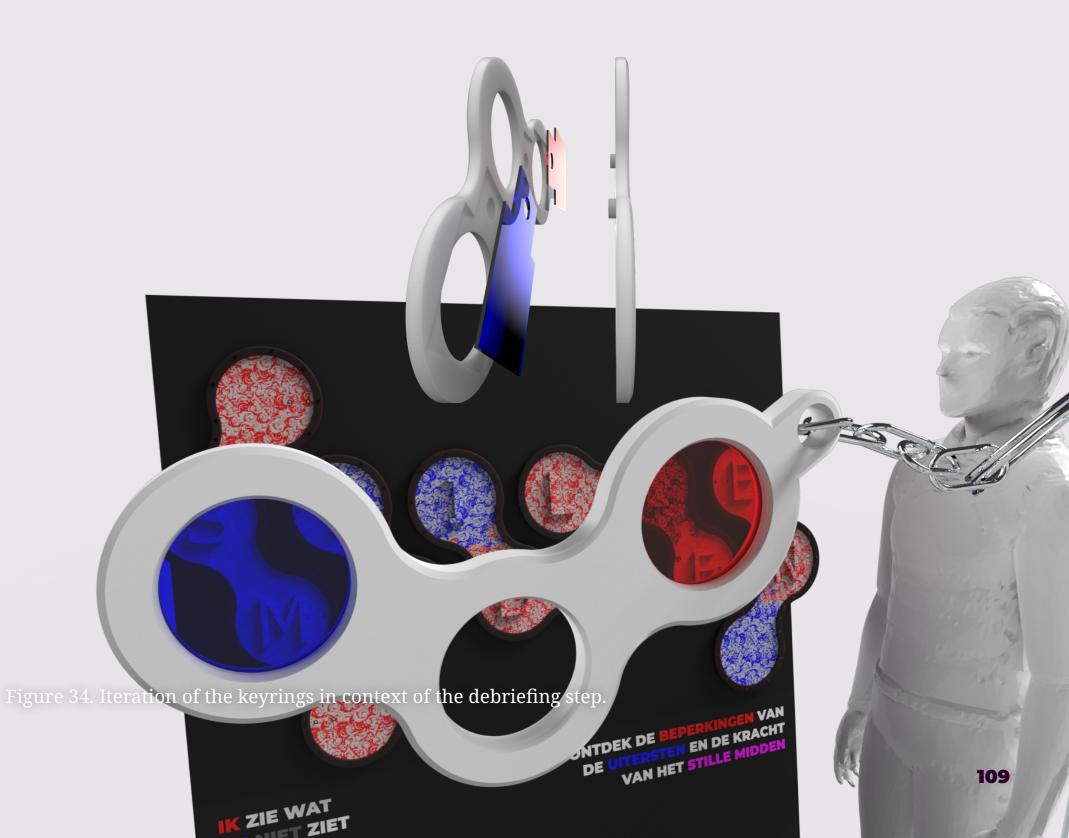
- 3.4.9. ORIENTATION OF MODULES

The first user test revealed that participants struggled to form a word even after identifying all the individual letters. I hypothesize that this difficulty is partly due to the letter M not being positioned as the leftmost letter, which may have disrupted the expected reading order. To address this, I reoriented the modules so that M is the first letter visitors encounter. This required mirroring the installation along the horizontal axis.

As a result, the blue Pusher can now perceive the letters S, T, I, L, M, D, while the red Pusher sees L, E, I, D, E, N. The word "Leiden" is a Dutch word, which could enhance the element of surprise during the debriefing.

- 3.4.10. DEALING WITH DAYLIGHT CONDITIONS

Daylight conditions significantly influence the perceptual interaction with the installation. The contrast between a sunny and a cloudy day has substantial implications for the experience. To ensure



optimal conditions, minimal daylight should enter the office unit. This prevents unintended scattering of light, ensuring that the Silent Middle perceives the installation only through the Pushers' flashlight. Additionally, reducing daylight enhances the contrast between illuminated and non-illuminated letters, thereby increasing the intended depth perception effect.

To control the variability caused by changing daylight conditions, two measures will be implemented:

- 1. Orientation of the office unit The unit will be positioned with its long side with windows facing north to prevent direct sunlight from entering through the windows at any time of day.
- 2. Use of light blocking tents— A 6x3 meter black Easy Up tent will be placed in front of the windows. These tents can be fully enclosed, providing a simple yet effective solution to eliminate uncertainties related to daylight exposure.

By implementing these measures, the impact of external lighting conditions will be minimized, ensuring a controlled and consistent perceptual experience.

- 3.4.11. ENHANCING WORD RECOGNITION WITH WORKSHEET

The initial user test revealed that participants did not immediately recognize that their task was to search for a word. Additionally, they encountered difficulties in orienting the letters to form a coherent word. To address this, I designed an A5 worksheet where participants can record the letters they identify, structured as a representation of the installation. Figure 35 shows the worksheet consisting of the visual representation of the framework, the name of the installation and the question "What word do I see?". This adjustment is expected to facilitate better word recognition and serve as a discussion point during the debriefing. Furthermore, incorporating this feature eliminates the need for screens and software, ensuring that the installation remains entirely analog.



3.5.

PROTOTYPE 2.

This chapter introduces the second prototype, which serves as a technical proof of concept for the installation. It validates design and construction choices and will be tested in the second user test. This prototype is also intended for the final Maker Faire installation, using reusable scaffolding components. The chapter details the prototyping process, material testing, and key insights gained.

- 3.5.1. PURPOSE OF THE PROTOTYPE

The second prototype serves two key purposes: (1) validating design choices related to construction and embodiment of the modules and (2) functioning as the installation to be tested in the second user test. Similar to the previous prototype, two modules will be constructed. This time, they will be built at a 1:1 scale. This full-scale approach allows for a thorough evaluation of the connection and interaction with the construction. Additionally, these two modules are intended to be incorporated into the final installation showcased at the Maker Faire. All scaffolding tube components used in the prototype will be reusable in the final installation.

- 3.5.2. PROTOTYPING PROCESS

The following steps where undertaken to build the second prototype. The steps correspond with steps in Figure 36.

1. **Material testing** – A 48 mm scaffolding tube and two links

were purchased. A sample plate was used to test the margin of the laser-cut holes designed to connect the modules to the links. Additionally, a test was conducted on laser-cutting 9 mm black MDF. Although MDF can be challenging to laser cut, the process was successful. However, the high power required resulted in a wider cutting line, necessitating adjustments to the margins.

- 2. **Material purchasing** After confirming that the wood and laser-cutting process were suitable for the application, materials were ordered for all five modules to minimize transportation costs. To optimize material use, the required plates were mapped out in Adobe Illustrator.
- 3. **Laser cutting preparation and execution** Laser cutting files were prepared, and cutting began for the two modules. The plates for the debriefing model were not cut, as the previous test model would be reused.
- 4. **Component validation** The alignment of the base layer and top layer was tested, ensuring they fit together correctly. The same validation was conducted for the scaffolding link
- 5. **Detailing and finishing** To refine the modules, the visible edges were milled with a 2 mm radius. The holes for the 8 mm bolts were countersunk.
- 6. **Module assembly** The two modules were assembled, and the construction process was tested. It was observed that assembly is more efficient when performed by two people, a recommendation for future executions.
- 7. **Base structure implementation** The prototype features a wooden base, attached using the same links that connect the modules.
- 8. **Letter preparation** The sharp edges of the letters were trimmed to prevent cracking the paper.
- 9. **Letter attachment** The letters were surrounded with removable double-sided carpet tape.
- 10. **Paper wrapping** The paper was carefully wrapped around the letters.
- 11. **Final assembly** The top layer was placed on the base layer and secured with 8 mm bolts. Once the bolts were tightened, the excess paper was trimmed along the edges, completing the module.

- 3.5.3. INSIGHTS OF PROTOTYPING PROCESS

Structural Evaluation of the prototype

The prototype was partially developed to validate the structural integrity of the construction, and the results confirm that the design effectively serves its intended purpose. While the structure becomes relatively heavy, this does not present an immediate issue. However, I recommend testing the length of the base tubes prior to the Maker Faire, as adjustments may impact the available space for movement for the Silent Middle.

Structural calculations indicate that, for the prototype with a base tube length of 0.25 m, a force of approximately 300 N (~30 kg) applied to the upper horizontal tube is sufficient to initiate rotation. However, significantly more force is required to cause the structure to tip over. With a total weight of approximately 300 kg and a base width of 0.5 m, the final installation would require 650 N, almost equivalent to the weight of an average person, to initiate rotation.

While safety remains a top priority, unnecessary reinforcements should be avoided where possible. Therefore, I recommend varying the tube length in preliminary tests to determine the optimal balance between stability and interactive functionality.

Dealing with highlights

In the previous chapter, I tested the use of transparent matte spray to eliminate highlights on masked letters. This method proved effective. However, in the prototype, where the paper is not tightly wrapped around the letters, highlights still appeared. For instance, the letter I was rounded, which caused persistent highlights on vertical edges, regardless of the incident angle.

I recommend selecting a font with letterforms that facilitate smoother and more uniform wrapping. This could improve the effectiveness of the masking technique.

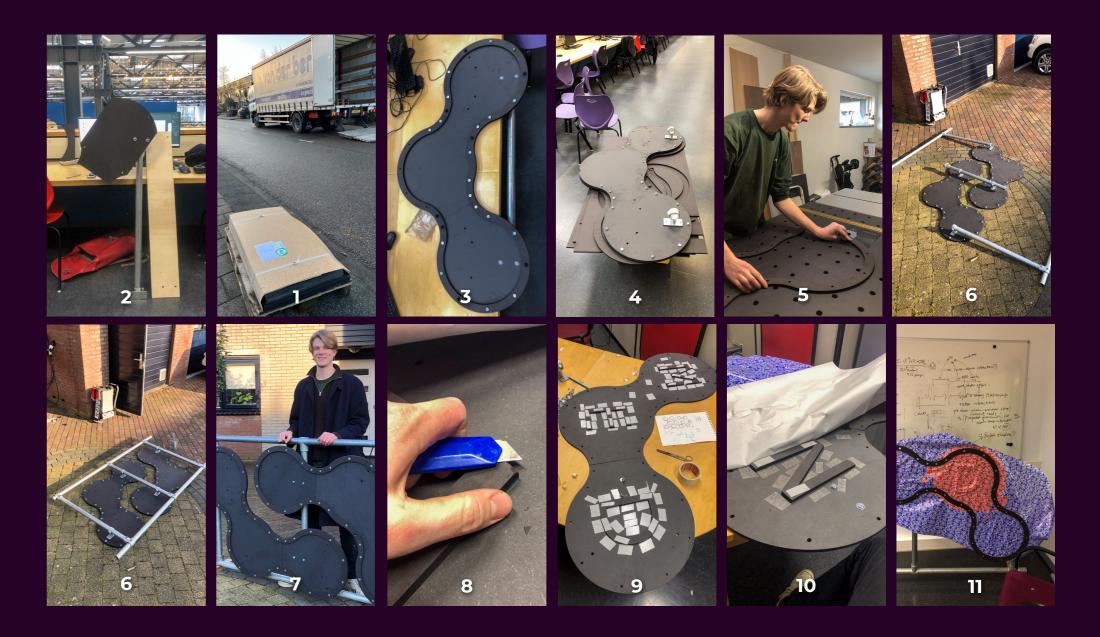


Figure 36. Steps for producing the second prototype, intended to prove the concept of the technical aspects and to test the integrated interaction scenario.

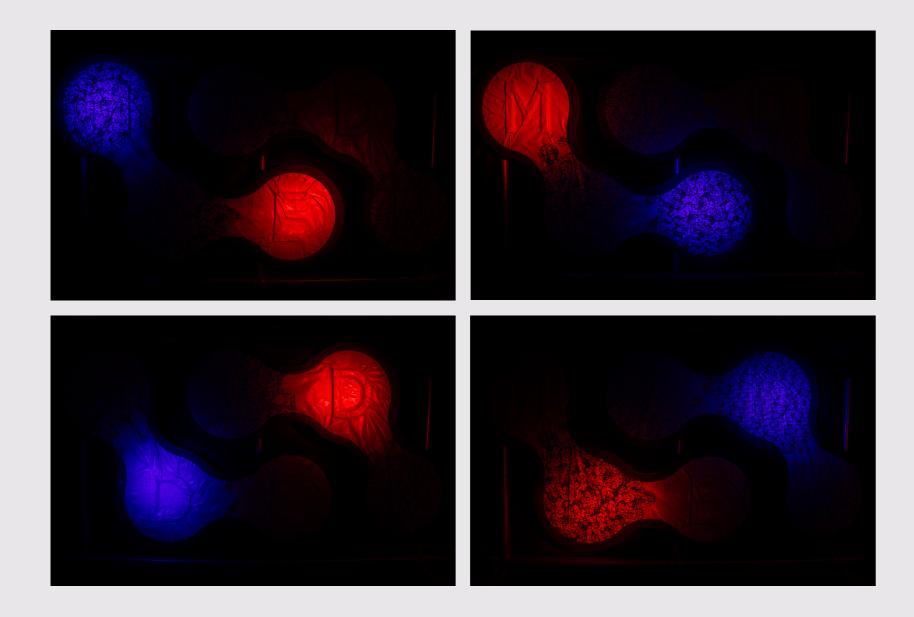


Figure 37. Proof of depth perception distortion principle in second prototype.

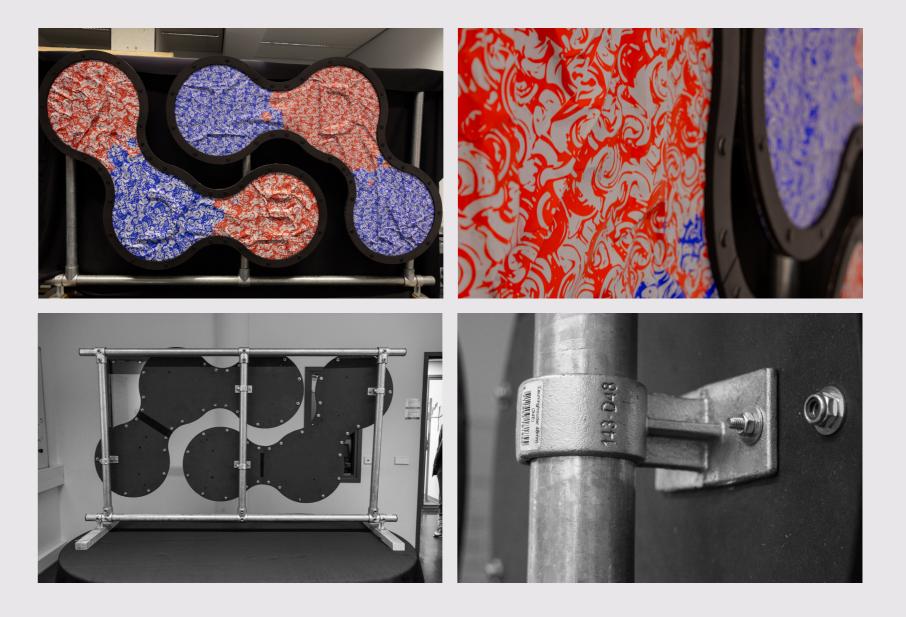


Figure 38. Proof of technical aspects of the design in the second prototype.

3.6.

USER TEST 2.

This chapter outlines the final validation of the emotional sequence, visual perspective-taking task, and the installation's ability to communicate its intended goal. It concludes with the final recommendations for development ahead of the Maker Faire.

- 3.6.1. RESEARCH OBJECTIVE

The proof of concept outlined in Chapter 3.3. was originally intended to validate the expected sequence of emotional transitions throughout the interaction. However, early testing revealed that the concept was not yet fully developed and that the prototype lacked the necessary refinement for a meaningful evaluation. Despite these initial limitations, the combination of the intended emotional sequence and the perspective-taking task remains a fundamental aspect of the design's effectiveness. Through further development, the concept has now reached a stage where systematic testing can be conducted to assess its impact more rigorously. In this user test the following aspects are validated:

- The intended sequence of emotional transitions.
- The ability of the interaction to let visitors adopt the visual perspective of others.
- The ability of the installation to convey the connection between the interaction and the polarization framework.

- 3.6.2. HYPOTHESIS

The following hypotheses will be evaluated during the validation process:

- 1. During the interaction, visitors adopt the visual perspective of other visitors.
- 2. While waiting in the queue, curiosity is evoked.
- 3. Visitors assigned the Silent Middle role transition from a state of curiosity in the queue to a state of satisfaction following the interaction.
- 4. Individuals assigned the Pusher role transition from a state of curiosity in the queue to a state of dissatisfaction following the interaction.
- 5. After the debriefing, visitors do not leave with a negative emotional state.
- 6. After the debriefing, participants are able to connect the roles of the interaction to the roles of the polarization framework.

- 3.6.3. PARTICIPANTS

The poule of participants is the same compared to the previous test, based on the same rational. 10 sessions were conducted, in which I played the role of blue Pusher twice (session 3 and 5).

- 3.6.4. METHODOLOGY

The methodology is equal to the previous user test. The same form was used (see Appendix D).

- 3.6.5. PROCEDURE

The test setup consists of four distinct sections. Participants begin by completing a consent form (see Appendix C). After each section, they are asked to fill out a section of the corresponding form (see Appendix D). The complete procedure attatched in Appendix H.

- 3.6.6. RESULTS

Participants completed the forms, describing their emotional state. This qualitative data was labeled, identifying the primary emotion expressed. Some participants mentioned multiple emotions, which is why each section in Table 2 has two columns. A table with all labelled emotions is attatched to Appendix I. This also includes the number of correct letter per role. The emotions are colour-coded:

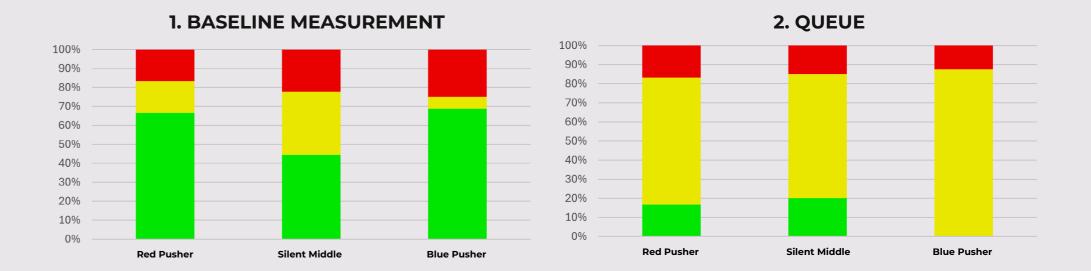
- **Green (positive)** represents emotions with an explicitly positive connotation, such as enthusiasm, satisfaction, accomplishment, and pride.
- **Yellow (ambiguous)** represents emotions with an explicitly negative connotation, such as confusion, annoyance, or disappointment.
- **Red (negative)** emotions in this study represent states that are neither explicitly positive nor negative but rather ambiguous or exploratory. These emotions often indicate engagement, openness, or cognitive processing rather than a clear sense of satisfaction or dissatisfaction. These neutral emotions are categorized separately because, within the context of the installation, they serve a distinct role. A transition in emotional state, such as moving from curiosity to satisfaction, should be clearly visible in order to validate the assumptions.

- 3.6.7. CONCLUSION

In this section, the hypothesis will be evaluated according to the collected data.

1. During the interaction, visitors adopt the visual perspective of other visitors.

The installation effectively encourages visitors to take on the visual perspective of others. Notably, 22 out of 28 participants adopted another participant's viewpoint at any point during the main interaction.



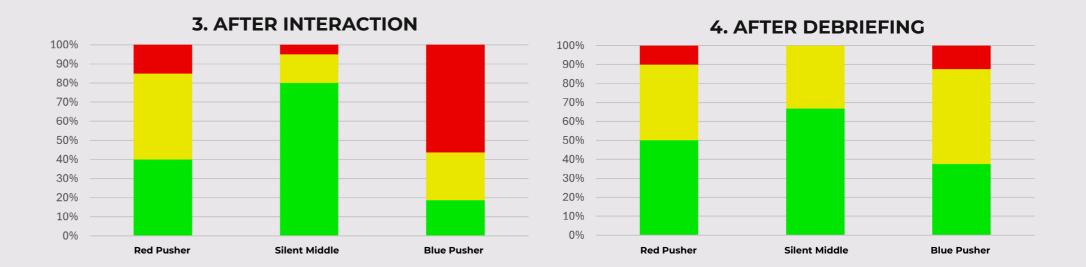




Figure 39. Results of testing the emotional sequence of participants at each step of the test.

curiosity is evoked.

Comparing Figure 39.1 with Figure 39.2 shows a shift to mostly yellow emotions. It exhibits a shift of the participants' emotional state between section 1 and 2. The differences between the emotion categories also is smaller, where yellow emotions have the upper hand. Participants' emotions transitioned from predominantly positive (green) to a more neutral or ambiguous state (yellow), indicating heightened curiosity.

3. Visitors assigned the Silent Middle role transition from a state of curiosity in the queue to a state of satisfaction following the interaction.

Participants assigned the Silent Middle role transitioned from yellow emotions in the queue (section 2, Figure 39.2) to green emotions following the interaction (section 3, Figure 39.3). Their emotional state shifted from predominantly curiosity to emotions such as accomplishment, pride, or confidence.

4. Individuals assigned the Pusher role transition from a state of curiosity in the queue to a state of dissatisfaction following the interaction.

Participants assigned the Pusher role did not exhibit explicit frustration after the main interaction (section 3) but retained a sense of curiosity or confusion after the interaction (yellow emotions). This is on the condition that Pushers did not see al letters. In cases where Pushers were able to see all the letters (e.g., sessions 1 and 9 of red Pusher), their emotional state aligned with that of the Silent Middle, reflecting pride and confidence.

When comparing these findings to the previous conclusion, a distinct difference in the distribution of emotional categories between the Silent Middle and Pushers emerges (see Figure 39.3). The Silent Middle exhibited more emotions associated with satisfaction compared to participants assigned the Pusher role.

5. After the debriefing, visitors do not leave with a negative emotional state.

The minimal presence of red emotions in Figure 39.4 suggests that participants rarely left with a negative emotional state following

the debriefing session. Instead, their emotions were predominantly positive (green), characterized by feelings of surprise, pride, or satisfaction, or ambiguous (yellow), reflecting a sense of interest.

6. After the debriefing, participants are able to connect the roles of the interaction to the roles of the polarization framework.

After the debriefing, participants demonstrated an understanding that the installation relates to differing perspectives and the limitations of individual viewpoints. Many concluded that collaboration is necessary to construct a complete picture. However, they did not explicitly connect the roles within the interaction to the polarization framework. Notably, the role and meaning of the Silent Middle remained unclear to participants.

- 3.6.8. DISCUSSION

Unlike the first user test, this iteration enabled an assessment of the sequence of participants' emotional states, leading to conclusions that can inform the final design iteration.

This final iteration will be conducted after graduation and prior to the Maker Faire and is therefore not included in this thesis. The following recommendations are provided for its development.

Connecting the interaction to the polarization framework

The measured emotional states of participants largely aligned with the intended emotional sequence. Zooming in to section 4, most participants left with either a positive or ambiguous emotional state. However, observations during the test suggest that this outcome was primarily driven by participants' understanding of the interaction itself rather than their ability to connect it to the polarization framework. While participants recognized that the installation related to differing perspectives, they consistently failed to grasp the role and significance of the Silent Middle.

Participants were unable to articulate the meaning or value of this group within the framework, even when reflecting on the interaction. The critical cognitive step, from recognizing the installation's

emphasis on perspectives to understanding the function of the Silent Middle, was not convincingly made. Furthermore, the explanatory poster did not effectively facilitate this connection, as the term Silent Middle held no clear meaning for participants.

To address this gap, I recommend explicitly defining the Silent Middle within the context of the polarization framework. In combination with the existing visual representation that directly links this concept to the interaction it may provide the necessary clarity.

Timing of countdown

Participants were given 30 seconds to identify six letters. However, the effectiveness of this time constraint is dependent on how well the letters are masked. Initial tests suggested that extending the time limit would increase the likelihood of Pushers recognizing all letters, thereby reducing the intended challenge and diminishing the effectiveness of the interaction.

To maintain the intended balance of difficulty, I recommend adjusting the countdown timer dynamically during the Maker Faire, based on real-time observations of participant performance.

Provided information in the queue

When participants were provided with the clipboard, they also received additional instructions. This included the challenge of identifying a word within 30 seconds and the ability to record the letters they had identified on the clipboard. However, the phrasing of this instruction introduces a subtle but important distinction. Stating, "You have to find a word in 30 seconds," can be interpreted as a shared challenge, whereas "Each of you have to find a word in 30 seconds," emphasizes an individual challenge.

The latter phrasing is preferable, as it encourages participants to personally engage in the task, reinforcing the idea that they are relying on their own limited perspective. This realization is crucial for the intended learning outcome, that their viewpoint was incomplete and needed to be reconsidered. In contrast, the first instruction may lead participants to assume that collaboration is expected from the outset, which could decreases the intended impact of the interaction.

Presenting the instructions in a way that emphasizes individual responsibility ensures that participants experience the challenge from

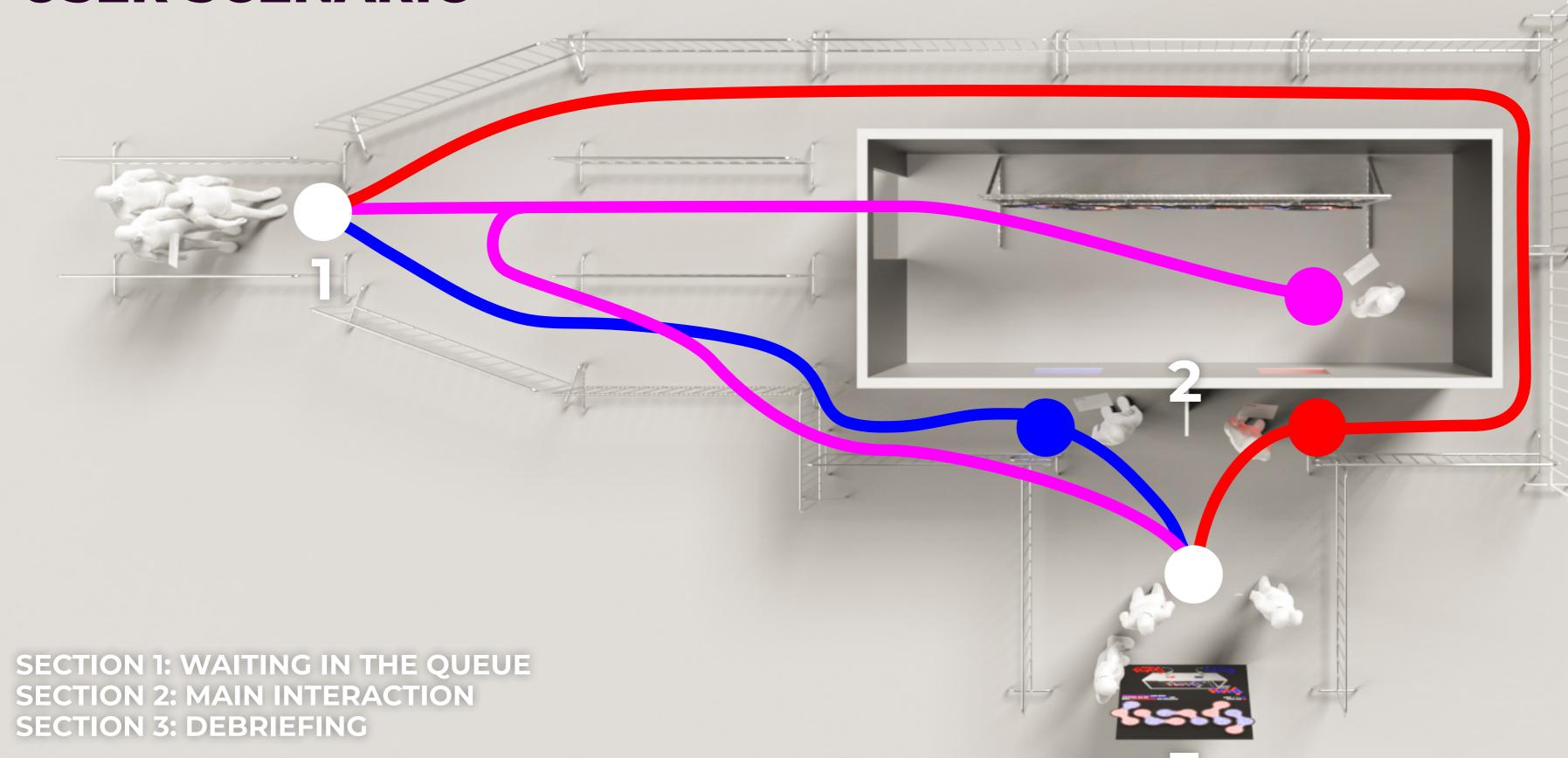
their own perspective before recognizing its limitations.

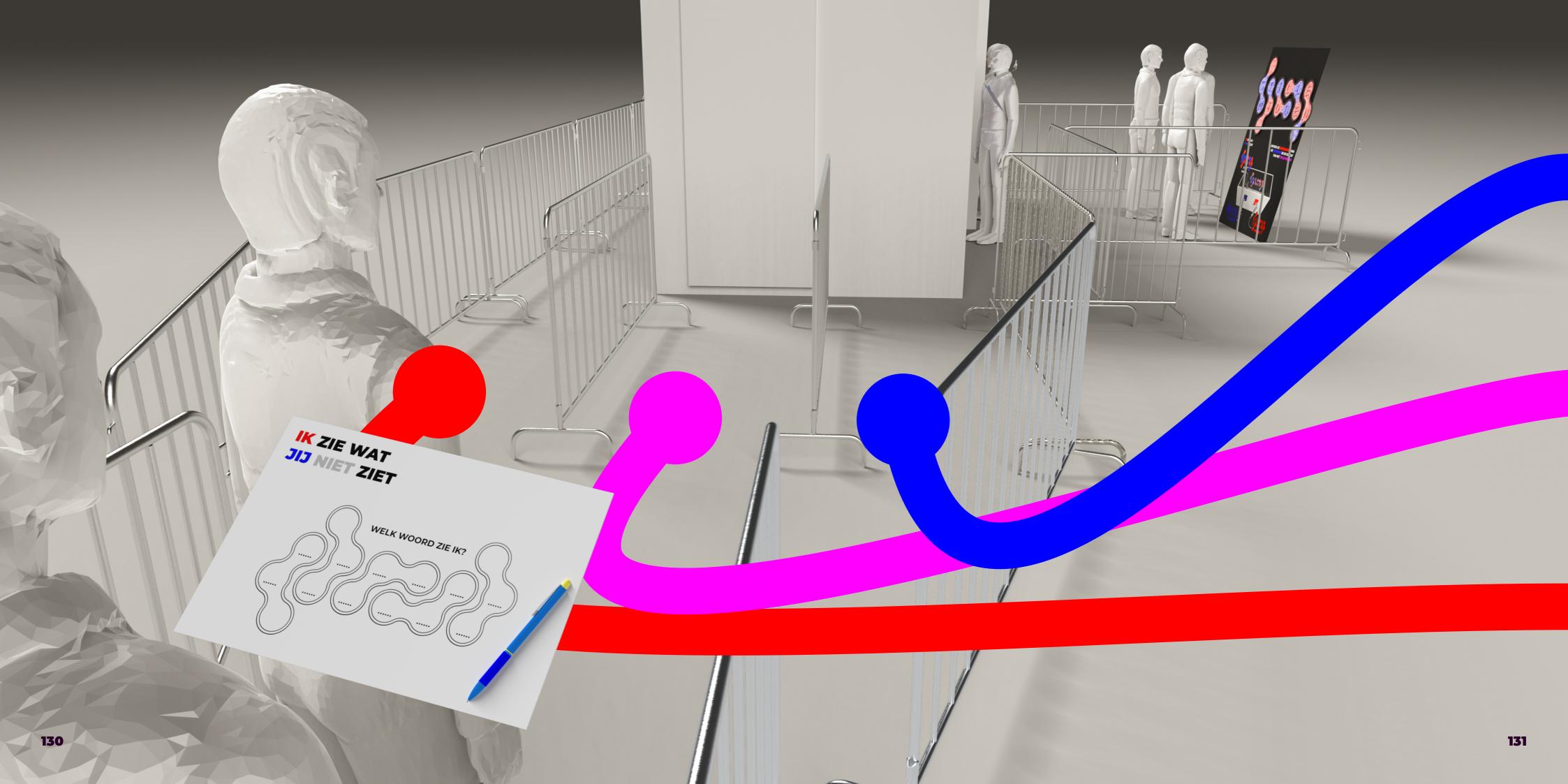


LIMITS OF HIS OWN FIELD OF VISION FOR THE LIMITS OF THE WORLD

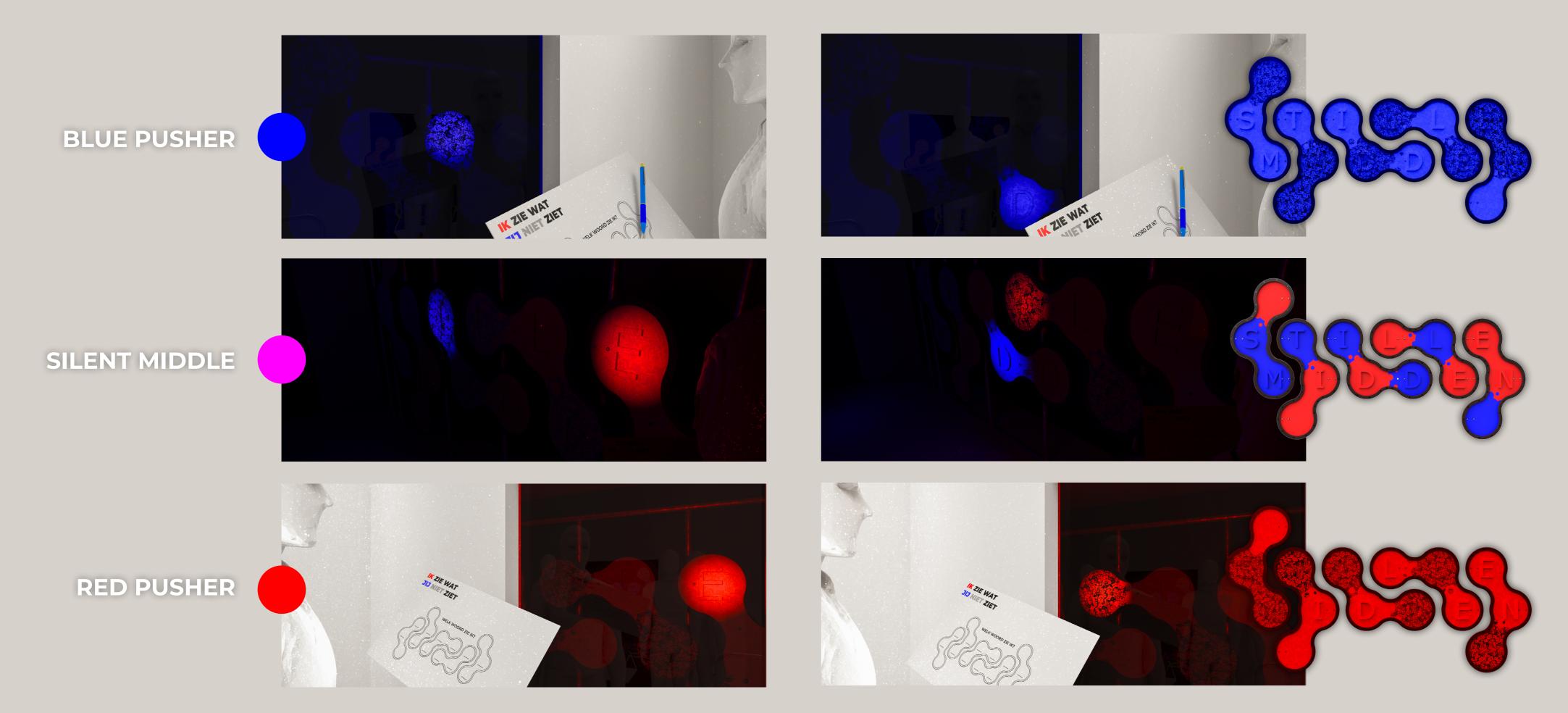
Arthur Schopenhauer

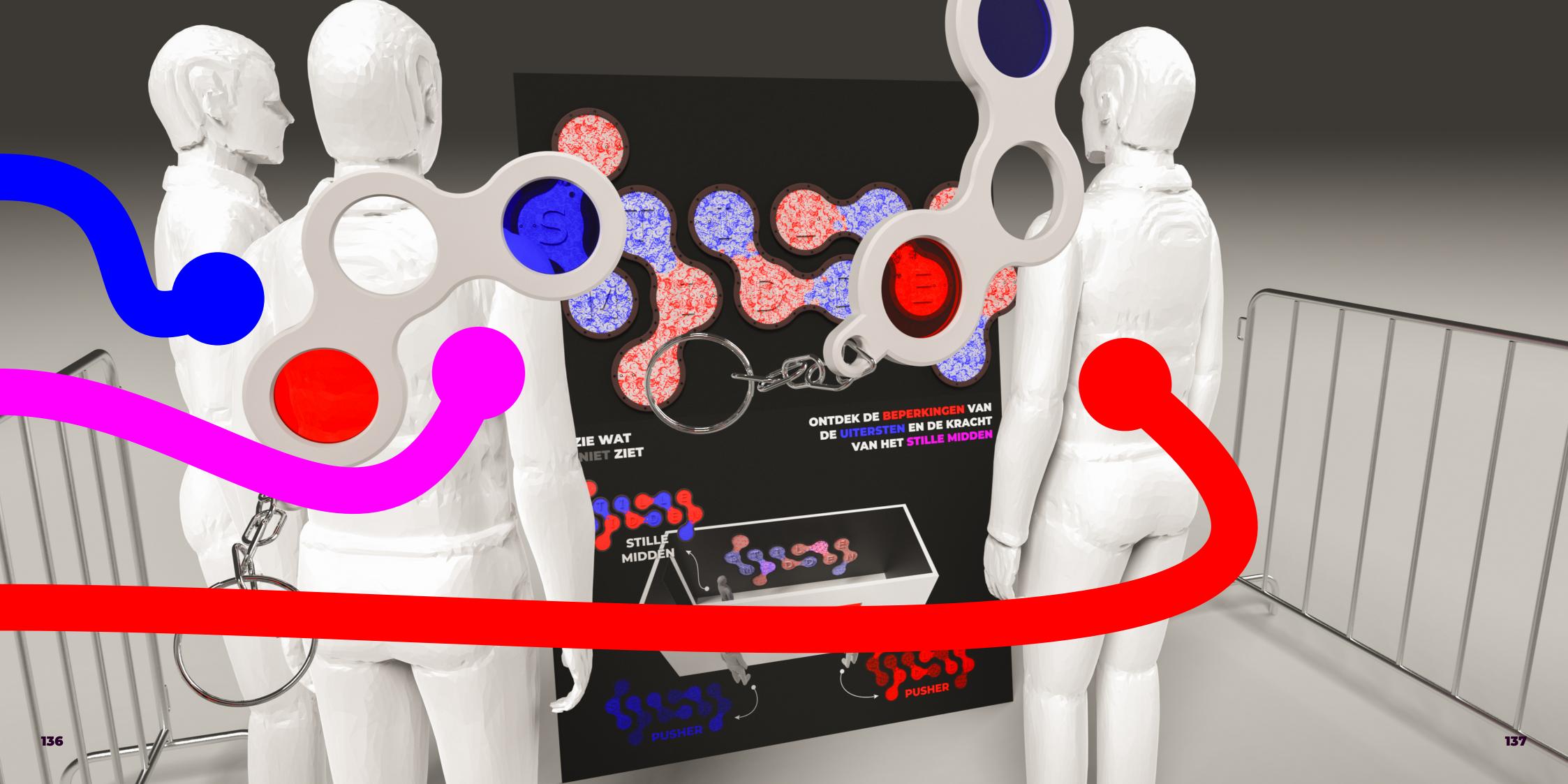
USER SCENARIO





SILENT MIDDLE RED PUSHER BLUE PUSHER 132





EXPLODED VIEW



M6 WASHER

M6 NUT

COMPONENTS PER MODULE:

26 X

13 X

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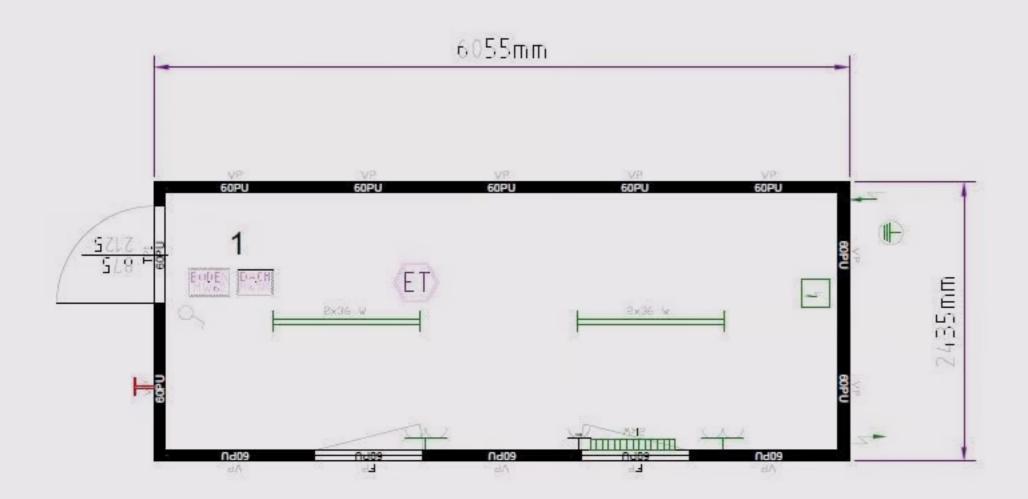
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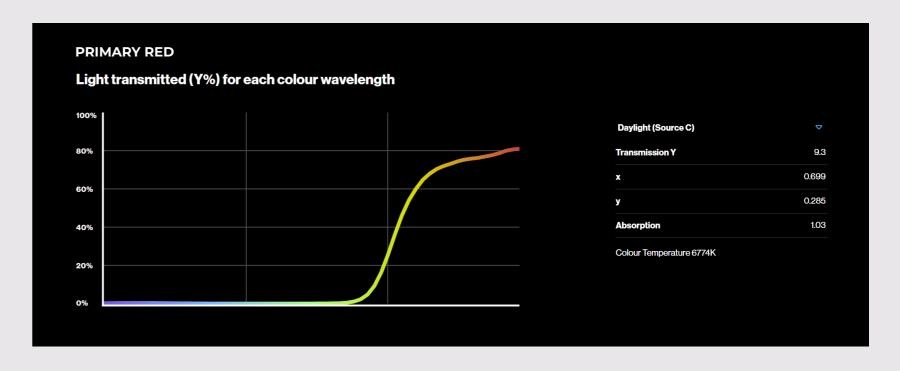
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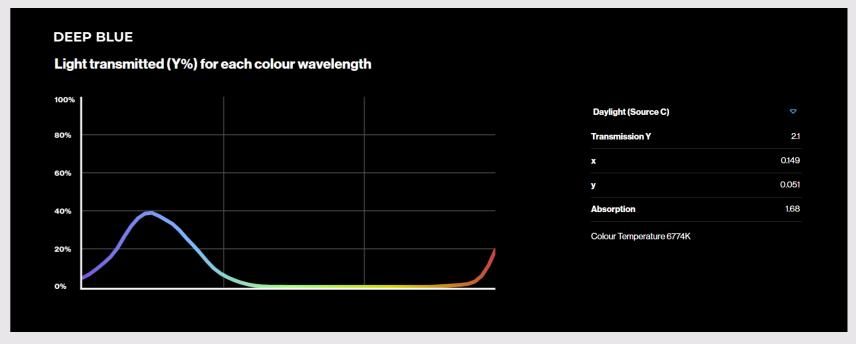
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APPENDIX A: OFFICE UNIT DIMENSIONS



APPENDIX B: SPECTRA LEE FILTERS





APPENDIX C: CONSENT FORM

Hidden in Plain Sight

This research is conducted as part of the MSc study of Integrated Product Design at the faculty of Industrial Design Engineering at Delft University of Technology.

Research contact

Maarten de Jong

Informed consent participant

You are being invited to participate in a research study titled "proof of concept *Hidden In Plain Sight*". This study is being done by Maarten de Jong from the TU Delft.

The purpose of this research study is to proof the concept of the installation called *Hidden In Plain Sight*, and will take you approximately 15 minutes to complete. The data will be used for a thesis publication. We will be asking you to interact with the installation in steps and fill out a form after each step, which is focussed on your emotional state.

I am aware that data will be collected during the research. I give permission to collect this data during the research. The data will be processed and analysed for this master thesis only. At the end of this project (February 2025) this data will be made accessible to the public, through the repository of the TU Delft. Any personal identifiable information will be destroyed after the project is completed. Before this date, the personal data (the consent form) will be locked away by the researcher and the supervisory team of the project, and the experimental data statistics will be analysed and published anonymously.

I give permission to store the data I provide in the TU repository after completion of this research and use it for educational and research purposes.

I acknowledge that no financial compensation will be provided for my participation in this research.

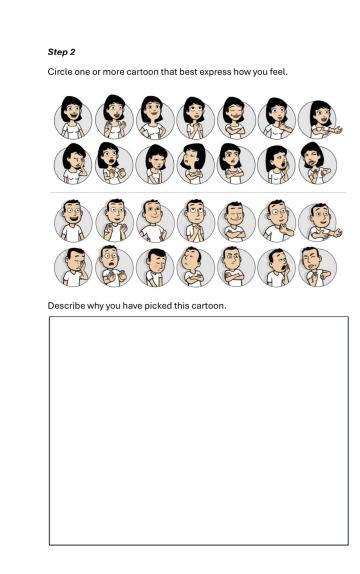
With my signature, I acknowledge that I have read the provided information about the research and understand the nature of my participation. I understand that I am free to withdraw and stop participation in the research at any given time. I understand that I am not obliged to answer questions which I prefer not to answer and I can indicate this to the research team.

Signatures		
Name of participant [printed]	Signature	Date

APPENDIX D: TEST FORM

Roll:	Step 3
Step 1	Circle one or more cartoon that best express how you feel.
Circle one or more cartoon that best express how you feel.	
Circle one or more cartoon that best express how you feel. Describe why you have picked this cartoon.	At any point during this step, did you think about what another participant might see? If yes, when did this occur, and whose visual perspective did you consider?

APPENDIX D: TEST FORM



				To the second	
escribe why	you have picked t	his cartoon.			
Vhat do you t	nink the message	of the install	ation is?		
Vhat do you tl	nink the message	of the install	ation is?		
Vhat do you ti	nink the message	of the install	ation is?		
Vhat do you ti	nink the message	of the install	ation is?		
Vhat do you ti	nink the message	of the install	ation is?		
	nink the message			re?	

APPENDIX E: PROCEDURE TEST 1

1. Baseline measurement

a. To determine what effect the interaction has on the emotional state of the participant, I ask them to express their current emotional state before the start of the interaction.

b. Participants fill out section 1 of the form.

2. Waiting in the queue.

a. A render of the queue scenario is shown to the participants. This illustrate the cues that are offered to the visitors in the queue. These cues are the countdown, the riddle, the scale of the installation and the 3 pathways.

b. Participants fill out section 2 of the form.

3. Main interaction.

a. The researcher tells that there are 3 pathways that each lead to different places. Participants are asked to discuss who is going in each of the directions.

b. From this point all participants are told to be silent.

c. The researcher asks the Pushers to enter room 1. The flashlights are given to the participants. They are asked to stand in front of the windows. They can light the flashlight when they see that the countdown in room 2 starts and dim them when the countdown is over.

d. The researcher tells the Silent Middle to enter room 2. They are able to fill in the word. They are asked to start the countdown when the researcher leaves to room.

e. After 2 minutes, when the countdown is over, the Silent Middle is asked to enter room 1. They fill out section 3 in silence.

4. Debriefing

a. The item on the debriefing table are revealed. The researcher tells that after the interaction they all come across this table and that they are allowed to talk about their experience.

b. Participants fill out section 4 of the form. Thereafter, the researcher is able to ask reflective questions.

APPENDIX F: BUDGET

Material		X	p/x	Total		
Lighting material						
Flashlights	Purchase	2	€ 90,00			
LEE Filters	Purchase	2	€ 15,00	€ 30,00		
			Total	€ 210,00		
Practicalities						
Office unit	Hire	1	€ 700,00	€ 700,00		
Crowd barriers	Hire	16	€ 13,00	€ 208,00		
Easy up tent	Hire	1	€ 116,00	€ 116,00		
Backdrop	hire	1	€ 50,00	€ 50,00		
			Total	€ 1.074,00		
Installation						
Door en door zwart MDF	Purchase	1	€ 340,00	€ 340,00		
190 gr satin 900 mm	Purchase	136	€ 2,10	€ 285,60		
Mounting material	Purchase	1	€ 100,00	€ 100,00		
Scaffolding tube frame	Purchase	1	€ 550,00	€ 550,00		
Debriefing prints	Purchsae	1	€ 100,00	€ 100,00		
Contingency costs	Purchase	1	€ 100,00	€ 100,00		
			Total	€ 1.475,60		
Marketing						
Photo and video	Once			€ 200,00		
			Total	€ 200,00		
						Content-related deliverable
Purchased			Milestone 1	€ 1.865,60	Purchased materials	Photo's of installation (1:1 scale)
			Milestone 2	€ 1.274,00	Hired goods execution 1	Result of execution at Maker Faire (professional video
			Milestone 3	€ 1.074,00	Hired goods execution 2	Video of installation on site
			Total	€ 4.213,60		

APPENDIX G: PROS AND CONS CONSTRUCTION

Wooden construction

In this option, a "second wall" is constructed where the modules are hung onto.

Pros

• There is a lot of form freedom when working with wood.

Cons

- A wooden construction gets bulky quit quickly, increasing visual impact and weight.
- Building, processing and detailing of a wooden construction takes a lot of work load.
- Designing a wooden construction that is modular takes a lot of work load.
- It is complex to estimate the cost of a wooden construction before a proper design is made.

Truss construction

The truss system would create a bow. With steel cables, the modules could be hang onto the horizontal truss. A quote of this option was around €300 (incl. taxes) per execution (€600 for two execution).

Pros

- The construction is standardized and thus modular.
- Hanging the modules on steel cables instead of screwing it onto a wall is visually more attractive.
- A bow made of a truss system is constructively integer.

Cons

- Due to the standardized character of the system, it is not able to reach higher than 2m (outside dimension). The installation should be scaled down in order for it to fit.
- The truss system is too expensive to purchase. It should be hired.
- Hanging the modules on steel cables would make it vulnerable for movement. Dynamic forces on the module creates complex constructive challenge.

Scaffolding tube construction

For this option, I would use a banner frame of 2.3x4m. In this frame I add vertical tubes to support the modules. The costs for a second hand construction is approximately €550.

Pros

- The construction is standardized and thus modular.
- The construction has relatively low visual impact.
- The construction can be bought second hand, reducing the costs significantly.

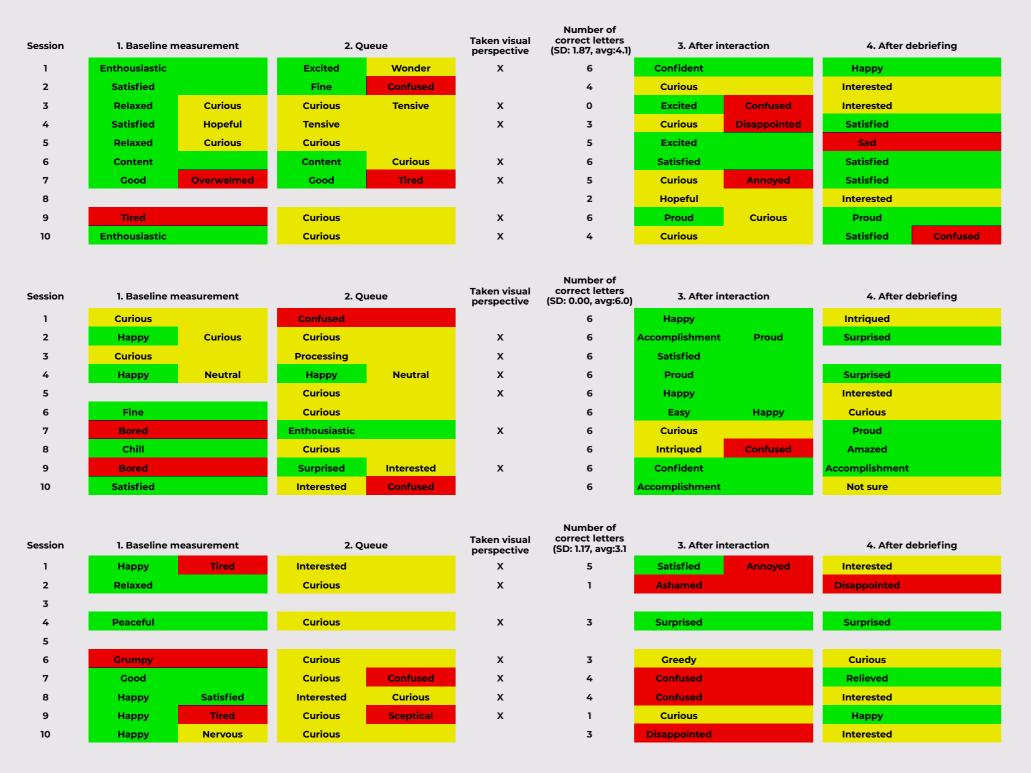
Cons

- The construction is relatively heavy. This could add to the constructive integrity.
- The base tubes should be 0.5 on each side of the modules. This reduces the room to move for the Silent Middle.
- The tolerances of the scaffolding tube system requires thorough testing.

APPENDIX H: PROCEDURE TEST 2

- 1. Baseline measurement
- Participants fill out section 1 of the form.
- 2. Waiting in the queue.
- Participants are introduced to the scenario in the queue. Participants get a clipboard with the worksheet.
- The researcher informs the participants that, during the interaction, they will have 30 seconds to guess a word, which they can write down on the clipboard.
- The researcher informs that there are 3 pathways that each lead to different places.
- Participants fill out section 2 of the form.
- 3. Main interaction.
- Participants are asked to divide rolls.
- The researcher tells the Silent Middle to enter room 2 and stand in front of the installation. The door closes.
- The researcher provides the Pushers with the flashlights. They are asked to stand in front of the windows. They can light the flashlight when the researcher tells them the countdown starts.
- After 30 seconds, when the countdown is over, the Pushers are asked to turn of the flashlights.
- Participants fill out section 3 of the form in silence.
- 4. Debriefing
- The item on the debriefing table are revealed. The researcher tells that after the interaction they all come across this table and that they are allowed to talk about their experience.
- Participants fill out section 4 of the form.
- The researcher can ask reflective questions.

APPENDIX I: RESULTS USER TEST 2



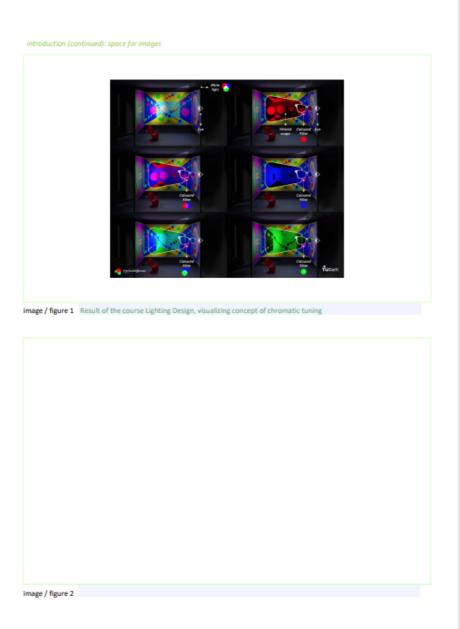
APPENDIX J: GRADUATION BRIEF

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APPENDIX J: GRADUATION BRIEF







Personal Project Brief - IDE Master Graduation Project

roblem Definition

What problem do you want to solve in the context described in the introduction, and within the available time frame of 100 working days? (= Master Graduation Project of 30 EC). What opportunities do you see to create added value for the described stakeholders? Substantiate your chaice.

In the current society, there is a tendency towards polarisation. This is evidenced by the apparent disappearance of a nuanced political centre, with attitudes on the flanks of the spectrum becoming more prevalent. This phenomenon can be attributed, at least in part, to a decline in the willingness to empathise with others. The effort required to understand one's peers has become less of a priority.

Countering this problem starts with the actual realization that people look differently at situations. This is the specific aim of this project.

Assignment

This is the most important part of the project brief because it will give a clear direction of what you are heading for. Formulate an assignment to yourself regarding what you expect to deliver as result at the end of your project. (1 sentence) As you graduate as an industrial design engineer, your assignment will start with a verb (Design/Investigate/Validate/Create), and you may use the green text format:

The objective is to create an experiencial installation that will assist visitors in empathizing with their peers by altering their perception on a physical appearance through the use of chromatic tuning of light.

Then explain your project approach to carrying out your graduation project and what research and design methods you plan to use to generate your design solution (max 150 words)

The complete project hinges on the critical elements that make for the altering of the perception of a physical appearance. This is why this is the driver of the project. In parallel with the exploration of these elements, a context for application is being sought in q1. This process makes sure that the manifestation in the specific context is effective. The process of this project can be identified as a typical double diamond.

1 Discover: The first few weeks will be used to explore the critical elements that maximize the concept of altering perceptions with chromatic tuning. Parallel to this, possible applications/contexts will be explored. 2 Define: This exploration should lead to a list of perceptual elements. At this stage, a relevant application or context and the linked constraints and requirements will be defined. 3 Develop: With the selected perceptual elements, I will create concepts that effectively apply to the chosen context. They should all align with the constraints and requirements that follow from the user scenario. 4 Deliver: The final stage of the process is to select one concept and develop it into a feasible and viable installation.

Project planning and key moments

To make visible how you plan to spend your time, you must make a planning for the full project. You are advised to use a Gantt chart format to show the different phases of your project, deliverables you have in mind, meetings and in-between deadlines.

Keep in mind that all activities should fit within the given run time of 100 working days. Your planning should include a kick-off meeting, mid-term evaluation meeting, green light meeting and graduation ceremony. Please indicate periods of part-time activities and/or periods of not spending time on your graduation project, if any (for instance because of holidays or parallel course activities).

Make sure to attach the full plan to this project brief. The four key moment dates must be filled in below



Motivation and personal ambitions

Explain why you wish to start this project, what competencies you want to prove or develop (e.g. competencies acquired in your MSc programme, electives, extra-curricular activities or other).

Optionally, describe whether you have some personal learning ambitions which you explicitly want to address in this project, on top of the learning objectives of the Graduation Project itself. You might think of e.g. acquiring in depth knowledge on a specific subject, broadening your competencies or experimenting with a specific tool or methodology. Personal learning ambitions are limited to a maximum number of five.

(200 words max)

- Light and lighting have always fascinated me, leading to it being a subject in several of my design projects throughout my education. As I transition into the professional field, I am eager to continue working in this field However, aside from the 'Lighting Design' course, my knowledge in this area is limited. I view this Graduation Project as a valuable opportunity to deepen my understanding of lighting theory, serving as a foundation to kickstart my career.

- The process of this Graduation Project is unique because it doesn't start with a specific application. Instead, the application will be discovered alongside the exploration of how light conditions can alter perception. This approach makes the initial exploration limitless, introducing some uncertainty into the process. My goal is to navigate this uncertainty effectively.



