Together Apart: Exploring Mixed-Presence Social XR in Apple Vision Pro

BSc Creative Technology

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Abstract

Social acceptance is still a problem among Extended Reality (XR) devices, like the Apple Vision Pro (AVPro). This is influenced by social presence and safety, as it is important to be socially present and safe while using an XR device in the designated environment, both for the comfort and security of the user and the bystanders. To investigate these challenges, user studies were conducted on social acceptance around the AVPro in practice, to see what elements are challenging about the device. Findings revealed that bystanders are often curious about what the user is doing within the headset, which indicates that design elements need to be added to enhance the transparency of the AVPro from user to bystander. Based on these insights, a new design was developed to show a 3D model of the AVPro with new design elements introduced to it, that should enhance social acceptance within the social context of playing bluffing tabletop games. This model contributes to creating XR devices that are better suited for usage in social contexts.

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1. Introduction

In recent years, major tech companies like Apple and Meta have developed Virtual Reality (VR) and Augmented Reality (AR) devices. However, challenges remain around social acceptance (Vergari, 2021), as it does for the Apple Vision Pro, which is still seen as too bulky for everyday wear. To overcome this problem, it is essential to understand how people feel when using an AR or VR device in a social environment and how these feelings affect both users and bystanders.

The Apple Vision Pro (AVPro) is a new spatial computing headset from Apple (see Figure 1), which allows users to immerse themselves in the virtual and real world at the same time (Apple, 2024). This can be compared to AR or VR, but the overarching term is called Extended Reality (XR), which includes spatial computing as well as Mixed Reality (MR) (Tassinari et al., 2021).

Figure 1 – Apple Vision Pro with EyeSight function on. Obtained from Apple Vision Pro - Apple.

This thesis specifically explores how the AVPro, a new XR device, acts in social settings and influences social interactions and acceptability. In addition to this, the AVPro will be explored in user studies and redesigned to feel more natural and socially accepted in group settings, specifically during bluffing tabletop games. These types of games involve a high extent of social interactions, and the need to read the emotions or gestures from other players, which makes the investigation of social acceptance in this social context especially relevant. The paper dives into how wearing the AVPro affects not only the player but also the overall group dynamics and bystanders, especially in bluffing games where every facial expression and gesture can be important. This is especially relevant concerning the feature ‘EyeSight’ of the AVPro, which is a new aspect added to an XR device, as it shows live footage of the user’s eyes. By testing the device in the context of bluffing games, the study gathers insights into how different design elements, such as the feature EyeSight, impact the overall playing experience and how the AVPro might challenge or disrupt the game. Hence, the main research question is formulated as follows:

RQ: What design elements could be introduced to the Apple Vision Pro to increase social acceptance in the social context of playing bluffing tabletop games?

Through playtesting and feedback from user interviews, the research looks for ways to make the AVPro more socially acceptable. This will not be about changing the AVPro, but rather about conceptualizing additions or changes that could enhance the social acceptability of the device. This will lead to design sketches in a 3D model program, which are made with the information derived from the outcome of the user studies. To explore this issue, the research focuses on three key aspects that are explored through these sub-questions:

- SRQ1: What is social acceptability, and which factors influence it?
- SRQ2: How do people perceive the social acceptability of an XR headset in a group setting?
- SRQ3: What design features of the Apple Vision Pro currently challenge or improve social interactions in a group setting?

These questions will be answered by use of consecutively background research and user studies. When answers have been found a 3D model of the AVPro is made with new design elements that should enhance social acceptability in social contexts.

2. Background Research

To be able to answer the main research question and its sub-research questions, it is important to first dive into the already existing research. The focus of this research will lie on the impact of using Extended Reality (XR) devices, specifically the Apple Vision Pro (AVPro), in a social context and how this impacts social acceptability. But also how other technological devices impact social acceptability, to be able to see the differences between devices. Nonetheless, research will also be conducted on the important aspects of bluffing games, and how these games work as this will be important information to gain from existing research, before conducting the study. Lastly, the research looks into the state of the art, which will indicate which projects already exist relating to this topic.

2.1 Understanding Social Acceptability

Social acceptability is stated as an essential aspect while designing gesture-based devices, like the Apple Vision Pro, by several studies (Rico & Brewster, 2009; Rico & Brewster, 2010; Ahlström et al., 2014). However, the definition of social acceptability remains vague. When considering the topic of 'social acceptability' the first thing that comes to mind is the judgment of one individual over another. To have a clear definition of this topic it is crucial to look into how other researchers describe this.

Social acceptability is explained by Paliwoda-Matiolańska (2020) as the attitude of the public or society towards a particular problem. Additionally, the absence of negative emotions towards the user from its bystanders is described as social acceptance (Kelly & Gilbert, 2016), whereas Vergari et al. (2021) specifically looked into this topic. The researcher explains this topic further by utilizing the paper of Distler et al. (2018): "Social acceptability refers to a prospective judgment toward a technology or measures to be introduced in the future" (p. 1).

The researchers claim that safety concerns, both for the user and the bystanders, are a major factor influencing whether the XR device is socially accepted. For instance, devices that require large movements may create a safety risk in crowded places, reducing their acceptability in such settings. On the other hand, XR devices that limit the necessary physical movement while still providing interactivity are generally more socially acceptable. According to the research, the social environment plays a big role in how people accept and enjoy such technology (Vergari et al., 2021).

An example where XR technology usage is highly relevant is in planes; instead of using laptops or phones. This can be used for watching videos, gaming or even working. The AVPro is highly relevant for this, as it places a window inside the room to interact with, so the user is still able to see its surroundings. However, people might make unexpected moves while engaging with the headset. This might happen when the user is watching a scary movie for example or while playing an interactive game. Research was conducted on this problem, where the solution is found by having a physical ’doorbell’, that the people next to you in the plane could ring when they want to interact with you (Williamson et al., 2019). This is found instead of just tapping the person on the shoulder because that could potentially frighten them. Adding this feature, the use of XR in social settings should be more acceptable and may be used more often in the future (Williamson et al., 2019). This could certainly be an addition to the AVPro as the bystanders sitting next to you in a plane, cannot see if the user is busy or not and the user cannot see the users next to them as the headset has a limited field of view.

2.2 Factors influencing Social Acceptability among XR devices

The main focus of this thesis is the social acceptability of the AVPro, which can be influenced by other social factors like presence or interactions. The definition of social presence is difficult to formulate according to Kreijns et al. (2022), as one sees it as the perception that a user who is interacting through a technological device is together with another user, although they are both in separate locations. And another sees it as being ‘there’ with another person, independent of the environment. Where this last definition can be interpreted as being there with someone in the virtual space, as well as being there physically. This is very relevant for the level of social acceptance, as it is explained that a bystander tends to accept an XR user more when being socially present in their environment, which can either be in the virtual environment or the real environment. Social presence in the real environment is increased by the AVPro as the external display with the EyeSight function enhances the social contact and interaction between user and bystander, which could also lead to more acceptance (Lege, 2024). Furthermore, the AVPro enhances the social presence inside the virtual world as well, by its realistic avatars, spatial audio, and high-quality virtual and real-world environments (Apple, 2024).

Hence, research shows that feeling connected to others in both virtual and real-world environments is very important for social acceptance in these environments. According to Van Brakel et al. (2023), social VR platforms can give users a feeling of social presence, which is significant for the AVPro, as it not only provides virtual experiences but can also mix augmented and virtual reality (MR). The research claims that a strong connection is found between self-presence (the feeling of being the virtual body/avatar in the virtual space) and social presence. However, achieving this social presence depends on how immersive the virtual experience is, which can be enhanced by features of the AVPro like high-quality avatar interaction, body movement tracking, or spatial audio. Furthermore, the researchers suggest that spatial presence (explained by Yang et al. (2023) as “the feeling of being present in the virtual space” [p. 2]) does not have a direct impact on social support, but it can indirectly influence it by improving the feeling of social presence and/or self-presence.

Nonetheless, Riches et al. (2019) explained that the feeling of social presence fails when users become too aware of the physical aspects of the XR device, such as feeling the headset press on the head or any other physical discomfort like cybersickness (motion sickness caused by virtual environment). The researchers state that when users are too conscious of their bodies, the immersion into the virtual environment is less, which means that the feeling of social presence is also reduced. When a user experiences such discomfort social interaction is difficult. In contrast to these statements, Yang et al. (2023) offered insights on how this feeling of cybersickness might be reduced by having a higher level of social presence. This indicates that when the user feels more socially present, the discomfort of feeling cybersickness should be less. These findings suggest that the emotional and physical experiences of XR users are closely related to their environment.

Riches et al. (2019) investigated how certain aspects of VR (part of XR), such as head movements and hand gestures can influence social interactions. It is difficult for a bystander to interact when a user, for example, is waving his hand to swipe through the interface, because it actively shows that the user is busy. The user simultaneously will lose awareness of their physical surroundings because they are very immersed in the virtual world. This will lead to uncomfortable moments for the bystanders, as they have the feeling the user is not interested or able to create a real social interaction. Furthermore, the study of Koelle et al. (2020) has found that gestures that were described as subtle were more socially acceptable. This is further explained as gestures that do not invade or intrude the others' personal space. In addition to this, Ahlström et al. (2014) also investigated this topic in a practical matter, where studies were done in different public locations. As a result, people are very specific about the location and how the technology is used. So, were the acceptance rates higher in a home setting compared to a public setting such as in a bus or a museum. When the participants were asked about performing Around Device gestures (AD gestures), the acceptance rates were significantly higher around relatives and friends, compared to strangers.

The duration of gestures and distance from the device are important factors in public spaces, but the size of the movements and region are equally important. The researchers state that social acceptance drops when the gestures are made more than 30 centimetres away from the device, and when the duration of making movements is longer than 6 seconds. Linking this to the AVPro, the gestures made for this device are usually very short and do not require large movements, as the user only has to put their index finger and thumb together when looking at something. This indicates that the social acceptance for this particular device could be higher compared to other XR devices.

On the other hand, a study by Lege (2024) warns that while these virtual environments can improve emotional bonds, they may also lead to feeling isolated when used too much. They point out that XR devices should not only focus on the virtual side but also on keeping the users connected to their physical environment. The feature of seeing the user's eyes on the outer display of the AVPro could already be a step toward 'the right direction' given the theory of Lege (2024).

2.3 Social acceptability around other technological devices

2.3.1 Headphone usage

Additionally, while discussing social acceptability in XR devices, it is important to also consider more widely used technological devices to compare with, such as headphones. This type of device is also considered as an augmented tool like the AVPro, but then for audio. Audio augmentation is the concept where people interact with a digital environment using speech and sound in a different way that complements the visual, digital tools that are already out there, like virtual reality (Human, 2020). To give an example for this, a narrator could tell a story about which flowers and plants are blooming in a park, but the narrator explains things depending on what the wearer at that moment sees. This concept is relatively new however, headphones used for this event have existed for many years and therefore are likely to be more researched as they are more often used.

A common feature that is added to headphones nowadays is the ability to cancel out any noise from the environment, which is called Active Noise Cancellation (ANC) (Radun et al., 2024). This feature allows the user to focus better on a specific task while working in a busy office environment for example. However, the use of ANC headphones could lead to isolation for the wearer from their physical social environment (Schmalfuß-Schwarz et al., 2024). The wearer is easily excluded from conversations, as the bystanders are not attracted to start a conversation with them. The research of Schmalfuß-Schwarz et al. (2024) examined the use of headphones with autistic trainees. The study explains that it is still unclear which factors encourage or challenge the social acceptance of autistic workers in a social environment. Because of the common occurrence of total isolation, many headphones also have the option ‘ambient mode’ or ‘transparent mode’, which allows the user to easily engage in conversations. This feature can be easily compared with the EyeSight function of the AVPro as they both try to make social interactions easier, while still wearing the device.

2.3.2 Phone usage

Alongside the usage of headphones, smartphones are also commonly used in social settings. Whether individuals are on their own in busy environments or engaging in conversations with others, there are lots of social situations where one’s phone is more important than the people around them. Because this happens very often nowadays, it now has a specific term named “phubbing”. Derived from the combination of “phone” and “snubbing”, where the term snubbing refers to ignoring someone or something. Consequently, phubbing is defined as the act of ignoring someone in a social setting by focusing on their phone instead (Capilla Garrido et al., 2021). Research was conducted on the effect of phubbing on social interactions by Chotpitayasunondh & Douglas (2018). The outcome of this research revealed that phubbing could potentially harm social connections and relationships between individuals because people quickly feel undervalued or ignored by the person interacting with one's phone. The act of phubbing is seen as a morally wrong phenomenon by students of the study of Aagaard (2020), which is further described as both annoying and disrespectful, and thus could be concluded as not socially acceptable. The study by Leuppert & Geber (2020) adds more to the reason why people engage in the act of phubbing. In group settings, people tend to follow the descriptive norm, explained as what most people do, rather than the injunctive norm, explained as what is expected to be done (socially accepted). The study explains that phubbing is strongly related to descriptive norms, as people see others use their phones in a social setting, they might as well use theirs. Furthermore, the study suggests that people engage less in the act of phubbing when the descriptive norms of how phubbing is considered rude, are more noticeable. This could involve openly discussing how phubbing is disrespectful, which might encourage people to put their phones away during a social setting. To relate this to the use of XR devices in a social setting, the suggestion of openly talking about how XR devices are rude to use in a social setting is not equally relevant. The user might not even be doing something inside the glasses but is just wearing them and using them after the social interaction. For this, there must also be more awareness, which has been thought of a little more with the AVPro, as the bystanders can see if the user is busy or not because of the EyeSight feature.

2.5 Bluffing

To be able to understand the relation between the social acceptance among the AVPro, and the bluffing tabletop games, it is important to investigate what bluffing means and what the essential social aspects of bluffing are. Bluffing is described as when a person takes actions that deceive the other player(s) which leads to a benefit for themselves (Sobel, 2019). This act is often very unexpected, and therefore difficult for other opponents to predict. This makes the concept of bluffing very difficult to understand and it makes it hard to see on a player's face or body gestures. However, there are two different ways of thought concerning the concept of bluffing according to Hurwitz & Marwala (2007)): one field of research suggests that bluffing is only statistical, and another thinks it is only psychological. The researchers found with their study that learning Artificial Intelligence (AI) agents were able to predict the next steps of their opponent in a bluffing game. This implies that a bluffing game is rather statistical instead of psychological, which is an interesting finding, as bluffing is first explained as unexpected and not predictable.

When reading the word bluffing, the words deception or lying rapidly come to mind. In the article of (Kaufmann et al., 2017), bluffing is described as a form of deception, where the lies that are being told are acceptable (or as they describe it "palatable") to both parties. A study by Bond & DePaulo (2006) explains that people who deceive often try to hide the emotions of feeling guilt, anxiety, or shame. Research done by Pérez-Rosas et al. (2015) examined how this action of deception is visible in non-verbal and verbal responses. The conducted research suggests that bluffing can mostly be seen by non-verbal responses, such as facial displays and body movements. Yet, research has shown that bluffers can more easily hide their lies from their faces, but not from their bodies (Bond & DePaulo, 2006). This is because people tend to focus more on keeping a straight poker face than controlling tapping with their feet for example. To understand this in the context of social acceptability, with the hypothesis that bluffing can be more easily seen through body language instead of the face, the AVPro should not be an obstacle to determining if an opponent is lying.

In addition, bluffing is used in interrogation rooms by both the convict and the police. When the convict is guilty, they could choose to bluff to deny they committed a crime. While this often does not work out as evidence will be found, the police also use the bluffing technique to get convicts to confess, with deceiving the convict they have evidence of the crime. Perillo and Kassin (2010) specifically investigated this phenomenon, and it shows that the bluffing technique used in police interrogations often leads to innocent people committing crimes they did not commit. The bluffing technique involves telling suspects that evidence exists, like video footage, without presenting it. This makes innocent people think it is better to comply and confess to being out of the situation quickly, to explain their innocence afterwards. In this situation, the use of bluffing could be harmful, as the innocent could be wrongly convicted because a confession is made. Something that should help with this, is a detection system that could recognize facial cues or gestures that determine if a subject is bluffing or not. This was tested by Feinland et al. (2022), where the results were defined as reliable as the predicted bluffs and actual bluffs had a relative error rate of 20.31%.

2.6 State-of-the-Art

Several papers were found on the use of XR devices in social settings. First, Cocchia et al. (2024) test AR in different public spaces, to see how this affects social acceptability and interactions. The researchers of this study explore the difference between playing a team game or an individual game, in either a crowded or uncrowded place. It was found that people tend to experience a high level of social acceptance in team games, in an uncrowded place. When people play individually, players experience a lower level of social acceptance, because they are more focused on their environment than on the AR game (Cocchia et al., 2024). In addition to this, the study of Rauschnabel et al. (2016) explores the effect of wearing smart (AR) glasses in public. The researchers in the paper state that although there are several smart glasses on the market a very important question is still unanswered: “Are smart glasses, from the view of consumers, a type of technology, a fashion accessory, or both?”. Without having an answer to this question, it is difficult to understand how consumers perceive and react to such smart wearables as explained by Rauschnabel et al. (2016). The study explored if users see smart glasses as technology, fashion, or both (which is described as fashnology). The result clarifies that the majority of the users see smart glasses as both. This suggests that the biggest group of users recognizes both the complex nature of social interactions as well as the technological components of smart glasses (Rauschnabel et al., 2016).

Moreover, research by Profita et al. (2016) shows how the social acceptability of a wearable is influenced when the user utilizes it as an assistance device for a disability, such as blindness. The clear conclusion of this specific study is that social acceptability was higher when the user had a visible disability or if it was used for assistive reasons.

Further research on social acceptability was conducted by Nam & Lee (2020), where the results of smart apparel were analysed with the WEAR scale. This is a scale to measure the social acceptability among wearables. The WEAR scale in this research included fifteen items divided into four dimensions, which are very relevant to the fashion discipline. The four dimensions included: “design and aesthetics, self-expression, consequences, and reflection” (Nam & Lee, 2020). Considering that the AVPro is also a wearable device and could be included in the smart apparel field, the adjusted WEAR scale of fifteen items could be re-used for this research, however, this is not particularly focused on the social acceptance of the device.

2.7 Summary of Background Research

The chapter on background research investigates how XR devices like the Apple Vision Pro (AVPro) impact social acceptability, especially in group settings. The term social acceptability is explained as the attitude of the public or society toward a specific problem or item, whereas something is seen as socially accepted when negative emotions are absent towards a particular problem or item.

The most important factors here are safety, gestures, and social presence, described as the feeling of physically being together with others in a (virtual) environment. Spatial audio, body tracking, or realistic avatars, can make the immersion into the virtual space more real, which can lead to help people feel more connected to each other in the virtual space (Van Brakel et al., 2023). However, it is difficult to stay in that immersion when the physical aspects of the device make you realize it is not real, like discomfort or cyber sickness. If users become too aware of the headset or feel motion sickness, they are less likely to stay socially engaged (Riches et al., 2019). Features like the external eye display of the AVPro, which lets others see the user's eyes, help bridge the gap between virtual and real-world interactions, which improves social presence in the real-world environment and consequently may improve acceptability (Lege, 2024). But also, the subtle gestures of the AVPro reduce the risk of possible intrusive interactions. Research shows that people are more comfortable with technology that feels natural and does not draw too much attention to itself, especially in public spaces.

When comparing the AVPro to other technologies like headphones or smartphones in a social context, it highlights similar struggles with social interactions. Where research on phone usage (phubbing) explains that people tend to follow the behaviour of the people around them (descriptive norms), rather than doing the right thing (injunctive norms). Furthermore, noise-cancelling headphones can isolate users from the bystanders, but features like ambient or transparent mode, help to reduce this isolation, which is a similar idea to the EyeSight function of the AVPro. These additions show how design can encourage better social connections while using technology.

The research conducted on bluffing games gave insights that non-verbal cues are mostly more important than verbal, which makes it more difficult to analyse if someone is bluffing or not. Additionally, it is found that body language often reveals more than facial expressions in these games, XR devices might either make it more unclear or enhance these subtle signals (Bond & DePaulo, 2006).

When looking at the state of the art, studies on XR in public spaces show that social acceptability often depends on the setting and how the technology is used. For example, people tend to be more comfortable with team games in less crowded areas, whereas playing alone can make users more aware of their surroundings, which might reduce acceptance (Cocchia et al., 2024). Additionally, wearables like smart glasses are more socially accepted when the user has a (visible) disability, or if it is used for assistive reasons (Profita et al., 2016). Research on wearables like smart glasses highlights that many people see these devices as a mix of fashion and technology, or "fashnology." This means that both the design and working of the device are important and can really influence whether people feel comfortable using it in social settings (Rauschnabel et al., 2016). Additionally, the WEAR scale can help to provide a clearer picture of how social acceptability is measured and understood for wearables (Nam & Lee, 2020). This scale is redesigned multiple times to create a list of statements with a 7-point Likert scale.

Based on the findings in the related work and background research, I will now start with practical testing using the AVPro in a social setting. This will give more insights into how an XR device like the AVPro will act and influence social interactions and acceptance.

3. Methods and Techniques

In this chapter, the methods and techniques that will be used in this thesis will be explained in more detail. This will include the Creative Technology design cycle (method) and the plan for testing with the AVPro in a social context of playing bluffing tabletop games (technique).

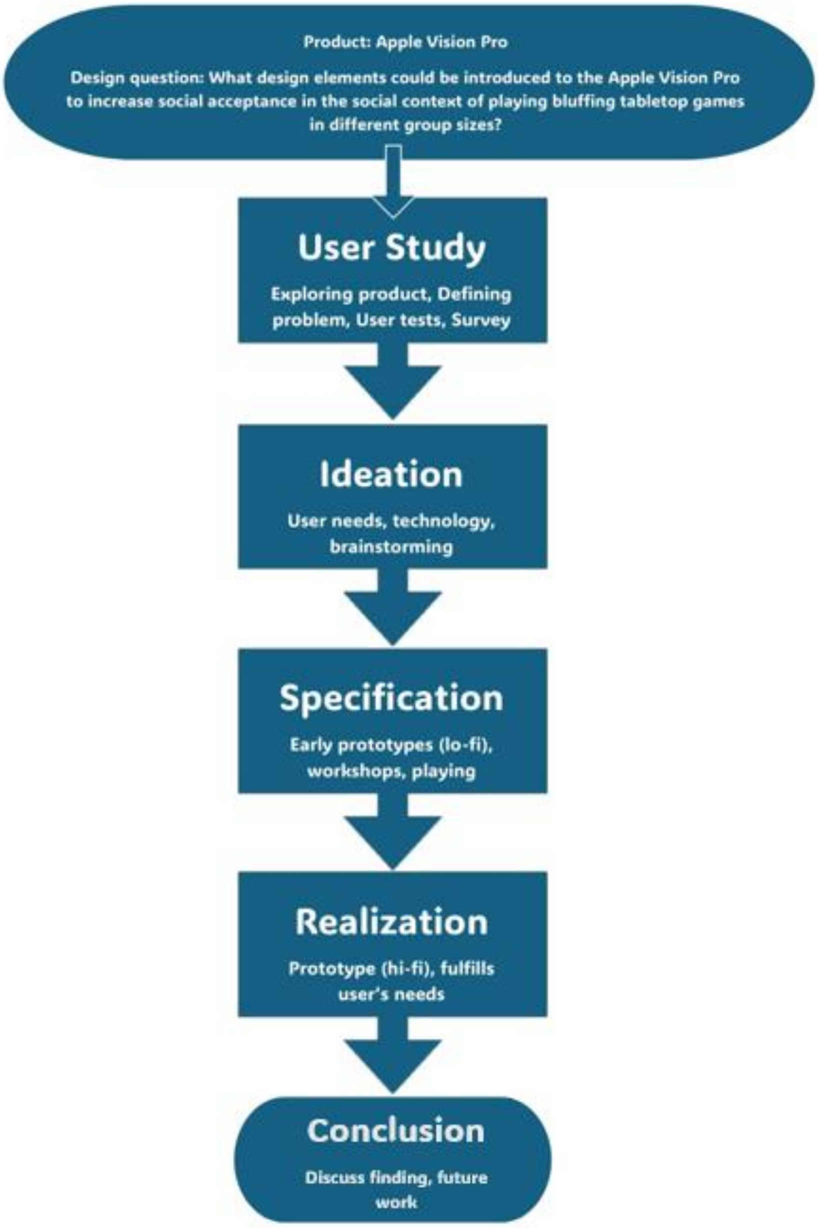


Figure 2 – Self-made version of Creative Technology design cycle applicable to my Graduation Project

3.1 Creative Technology Design Cycle

As this thesis is part of the Creative Technology (CreaTe) bachelor, the Creative Technology design cycle is a method that will be applied to this graduation project. This cycle is a design process, which consists of four phases including Ideation, Specification, Realisation, and Evaluation. To be able to understand this process better, the four phases will shortly be explained in more detail. However, because my project has a different structure, I will use the CreaTe design cycle as a starting point but will only use the first three phases. The reason for this is that I will not be evaluating the final product of the realisation phase but evaluating the starting product in the user study phase, which will be before the ideation phase (see Figure 2).

3.1.1 Ideation phase

The CreaTe design process may start with a design question, product idea or client request. What is known to be unique for CreaTe is that an idea around new or existing technology can be the motivation to start a project. To start with the ideation phase, people will brainstorm with the chosen technology, this action is known as tinkering. It involves exploring new ways to use existing or new technologies and relating them to the user's needs. The ideation phase has a spiral structure, including defining the problem, gathering information, and generating ideas. This approach is similar to other design structures.

3.1.2 Specification phase

The specification phase is for CreaTers to test several prototypes and explore all the available options with the chosen technology and idea. This allows the designer to test all the prototypes with potential users and see how they react to them. The feedback from these testing sessions can suggest necessary adjustments to the idea. This can come from either the feedback users give, or the observations the researcher makes. Prototypes that are made in this phase can easily be discarded, improved, or combined with others. This approach is very different from other engineering design structures, which typically focus on building and refining a single prototype until the final design is achieved. In the specification phase of Creative Technology, prototypes often target specific aspects of the user experience, which plays a crucial role in the design process.

3.1.3 Realisation phase

After the specification phase, the realisation phase will be followed with a step-by-step process for the design. This involves breaking the results of the specification phase into smaller parts, mixing them, and testing the final product. Two common models that follow these steps are the Waterfall Model and the V-model. These models are straightforward and allow the designer to go back and fix mistakes when needed as all the steps are built upon each other (linear model).

3.1.4 Evaluation phase (is not used)

The evaluation phase will check the build product from the realisation phase, to see if the model meets the set requirements from the ideation phase. The best way to test this is by user testing, as it checks if the decisions that are made meet the user's needs and create the intended experience. At this stage, comparing the created model to similar existing projects will help the designer to see where the results of the test fit within the bigger picture. Finally, reflection is an important aspect of both personal and academic growth. Where the designer thinks more deeply about the decisions that were made in the process and think of improvements for future engineers.

3.2 Method

The method of this study will include first conducting user testing and then continuing with the ideation phase. In the user tests, the functionality and design of the Apple Vision Pro will be explored by comparing them to a pair of headphones, while playing two different bluffing games. Following these tests and based on the findings, the ideation phase will begin, to see what design features currently challenge or improve social interactions in a group setting.

This explorative study will include users playing a bluffing tabletop game and I will observe them by taking notes and video- and audio-recording the studies. During the first round of the designated game, one player will wear the headphones and during the second round of the game, another player will wear the AVPro (randomized). This is played with two setups, where experiment one will include two players, while experiment two will include four to six players. This will give insights into whether and how the social acceptability of someone wearing the AVPro will vary in different group sizes, and how people perceive the social acceptability of the AVPro in a group setting compared to a familiar technology device, such as headphones.

3.2.1 Two different games

Cheat, or also called “Liegen” in Dutch, is a game played with a normal set of playing cards, without using the jokers. This game can be played by 2 players or more and is all about deception and tricking your opponents. The deck of cards will be evenly distributed among the players, to get rid of them as fast as possible. When the game begins, the first player will choose one of their cards and place it face down on the table while saying which card they are placing. The player could choose to tell the truth or lie about the card. The opponent(s) could either call someone’s bluff or say nothing. When one of the opponents, now called caller, says the player is lying the card will be revealed. The player who was wrong will have to take the pile of cards, which is a disadvantage as players want to get rid of their cards the fastest. This game is a combination of bluffing and strategic moves, where paying attention to non-verbal gestures is important and social interaction is necessary. The duration of this game is about fifteen minutes. Because of these aspects, the game is very suitable to use for this study.

Skull is a poker-like bluffing game where several players try to outsmart each other. All players have four coasters: three with flowers and one with a skull. The goal is to win rounds by flipping over coasters without revealing a skull. At the start of each round, players secretly choose one coaster to place face down. They take turns bidding on how many coasters they think they can flip over without showing a skull. If someone thinks the bid is too high, they can challenge the player. If a player is challenged, they must flip the number of coasters they bid. If they flip only flowers, they win the round. If they reveal a skull, they lose one of their coasters. The game continues until a player earns a set number of points. This game is a mix of bluffing and strategy, where reading players' non-verbal cues is an important aspect and social interactions are necessary. The duration of this game is about fifteen minutes. Because of these aspects, the game is very suitable to use for this study.

3.2.2 User Study Procedure

To set up the user studies, I will first recruit participants who are willing to take part in this study. They will either play the two-player Cheat game or the four to six-player Skull game. Before engaging in the study, they will receive a consent form together with an information letter that will inform the participant very thoroughly what the study is about. It will also explain the potential risks and the participant's rights. When the participant agrees to proceed with the study, I will randomize the order of the use of the headphones or AVPro first and accordingly to see which device will be used next. After this, the person who will be wearing the designated device will also be randomized by assigning numbers to each participant (Haahr, 1998). This is to prevent any preferences from the participants themselves towards a device and to exclude any biases made beforehand. The different types of technological devices are to see the differences between two different types of technology. The user of both the headphones and the AVPro will not hear or see anything on their devices;

hence it is purely for the perception of the other players and user, and how this influences the gameplay and consequently the social acceptability. During this session, I will observe the gameplay with a video recording and take notes, which is done with my phone. After each session with a device, a questionnaire will be handed out to the participants, specified to the role they had, user or bystander. This questionnaire will include simple questions with three themes: the interaction, the user, and the device (see appendix A.1 and A.2). This is to get a better understanding of how a gameplay experience with an XR device is, compared to one with using headphones. The questionnaires are identical so that the difference in social acceptance between the two technological devices can easily be compared. The questionnaire is retrieved and slightly adapted from three different studies: Profita et al. (2016), Schwind et al. (2018), and Eghbali et al. (2019). Where the last two are based on the first questionnaire, however, this study is about measuring the social acceptance of disabled people wearing XR glasses and therefore, it is slightly adjusted so that it fits more to this study. After the questionnaires are filled in by all participants, I will start the design discussion, which all individuals will be part of at the same time. This discussion will be audio-recorded and will be started by me, explaining that the thesis is about finding design elements that could be introduced to the AVPro to enhance social acceptance. Then the others are invited to come up with ideas or comments about the AVPro, to create a conversation on what could be improved and what are already good features. I will take notes on this but can also listen to the discussion afterwards if people have too many ideas at once. This is because the discussion needs to feel like a casual conversation instead of a very formal interview, so the individuals feel free to talk about their ideas or thoughts. The participants are thanked after the session, and I can begin by analysing the results of the user studies.

3.3 Stakeholders

In order to have a clear overview of the interested parties and their power, it is good to conduct a stakeholder analysis. Because this project was set up by the university and not by a company, this section will be fairly short. See Table 1 for the identification of the stakeholders, together with their interest and their power.

Stakeholder	Description	Interest	Power
Maya Schuurmans (me)	The author of this thesis is a graduate student at the University of Twente.	High: wants to graduate and collect their Bachelor's.	High: is responsible for the whole project.
University of Twente (including Maro and Max)	Has set up this project together with the VU that this thesis contributes to.	High: wants to have more information on this topic and could further conduct research.	High: could choose to take me off this project.
Vrije Universiteit (including Dorothé)	Has set up this project together with the UT that this thesis contributes to.	High: wants to have more information on this topic and could further conduct research.	High: could choose to take me off this project.
Users	Users of the AVPro.	Medium: if they are not satisfied with the design of the device, they could contribute to this project.	Medium: could help with finding the necessary design elements for the device.
Bystanders	The bystanders around the users of the AVPro.	Medium: if they are not satisfied with the design of the device, they could contribute to this project.	Medium: could help with finding the necessary design elements.

Table 1 – Identification of stakeholders together with their interests and power

It is seen in Table 1 that there are five stakeholders identified, who are relevant or interested in this project, together with their power towards this project. From this, it can be concluded that I, the University of Twente, and the Vrije Universiteit have both the most interest as well as power. This is logical, as I am the one conducting this project commissioned by the UT and the VU. Furthermore, the users and bystanders are both a medium interested as well as power. This can be explained as the users and bystanders of the AVPro that are not satisfied with the device, can give input in this project to help me with finding the best design solution. However, in this project, I did not find anyone yet who owns the AVPro as well as being a bystander of it, and therefore, the power can also be interpreted as low.

3.4 Summary of Method and Technique

In this chapter, the method and technique are stated, which is derived from the Creative Technology design cycle, but slightly adapted. This includes, first the user studies, then the ideation phase, then the specification phase and finally, the realization phase. In the following chapter, the user studies will be handled that will give input for the remaining phases. These user studies are set up by two bluffing games, applicable for two players or four to six players. To be able to compare the social acceptance of the AVPro, a pair of headphones is used.

4. User Studies

After conducting background research, the AVPro will be researched with user studies in a social setting of playing bluffing tabletop games. This is necessary to measure the social acceptance of the device, compared to headphones. With these results, I can start the ideation phase to see what design elements could be introduced to the AVPro. Ideas for this will be found with the help of the participants and the results of the user study.

4.1 Pilot Tests

On the 11th of November 2024, the pilot test for the user studies was executed, to see how the testing procedure will go in real life. This is done with two players, playing a different game than described above. The game played was ‘Mr. Jack’, which was described as a two-player bluffing game. However, while playing the game in the pilot test, it became clear the game was more about strategy than bluffing. The procedure of the study took a bit longer than expected and the game was also harder to understand than I initially thought. Therefore, a new game was selected, which was ‘Cheat’. The results of this user study were not included in this thesis, as the game was different from the rest of the tests.

On the 21st of November 2024, the first real test was planned with four players, to play the game ‘Skull’. This game was tried beforehand with other people, to see if this game was suitable for the study, with the conclusion that it was (included bluffing aspects).

4.2 User Studies

The total number of conducted user studies without pilot tests is 6, divided into two groups of four, and four groups of two. This gives me a total of 16 participants in 6 different user study groups (see Table 2).

Number of User Studies	Game	Number of participants	Total
1	Cheat	2	16 participants were divided into 6 groups.
2	Cheat	2	
3	Cheat	2	
4	Cheat	2	
5	Skull	4	
6	Skull	4	

Table 2 – Layout of the conducted user studies.

According to Nielsen (2000), a user test with 5 participants is enough to find usability issues in a study. He explains that a test with three times 5 participants is much more effective than testing with 15 participants in one user study. In my case, I have tested with six user study groups, with at most 4 participants. Following this rule of thumb, the number of participants and user studies used in this study were just enough to find some of the possible usability issues. However, each participant in each user study has taught me something new, because all the user study groups included new participants with different group dynamics. Additionally, the user studies were also meant to get insights into the looks of the AVPro, and how this influences social acceptance, using interviews. This is not only focused on usability but more on the opinions and thoughts of the users on the device in this setting.

4.3 Results of User Studies

The user studies retrieve both qualitative and quantitative data, respectively from the design discussion and the Likert-scale questionnaires.

4.3.1 Qualitative results

Data from the design discussion (qualitative) is analysed using the Affinity Diagram method (Pernice & Krause, 2024). This method divides ideas, concepts, or findings into several themes. This will be a helpful tool in my case as I have input from sixteen participants divided into six different design discussions. Therefore, the design discussion audio of each session is listened to, and all the important comments or ideas are written down on a small document on the Miro board[1]. Consequently, five different themes are made where the ideas and comments of the first document are placed, and similar items are placed into the same theme. This was done by reading all the answers carefully and grouping them in my head by the same aspects, like functionality or looks. The outcome themes are Design Ideas, Functionality Ideas, Good aspects of the AVPro, Challenges of the AVPro, and Comments I should not forget (see Figure 3). Lastly, I have divided the ideas into things that could physically work, and ideas that can only be sketched. These inputs will be used in the ideation phase, to have a starting point for brainstorming further.

[1] Miro. (2024). *Affinity Diagram.* www.miro.com/app

Figure 3 – Affinity Diagram of design discussion results with the five different themes (more detailed version in Appendix B.1).

4.3.2 Quantitative results

The data of the Likert-scale questionnaires, retrieved and adapted from Profita et al. (2016), include twelve elements divided into three categories: interaction (six items), user (four items), and device (two items). This data is placed in an Excel sheet to have a clear overview of each participant using a person ID (anonymized), with all their data in one row. This includes the group number, the date, the group size, the order of using the device, their role in the first round, their role in the second round, their age, their gender, their education level, their interest in the device (two times) and then for each round (two), the Likert-scale values of all the statements (two times twelve statements) are put in.

When all the data was filled into the Excel sheet, the mean values could be calculated. To display this clearly, the mean data was put into a concise table, as shown below, and divided into three categories: interaction, user, and device (see Appendix C for all results).

Values that measure the interaction						
Elements	Awkward	Normal	Appropriate	Rude	Distraction	Uncomfortable
Mean	4,9	2,6	4,9	3,6	4,4	3,5
Variance	2,1	1,1	2,8	3,1	3,1	3,3
Standard Deviation	1,4	1,0	1,7	1,8	1,7	1,8

Table 3 – Table that displays the mean values of several elements about the interaction with the AVPro

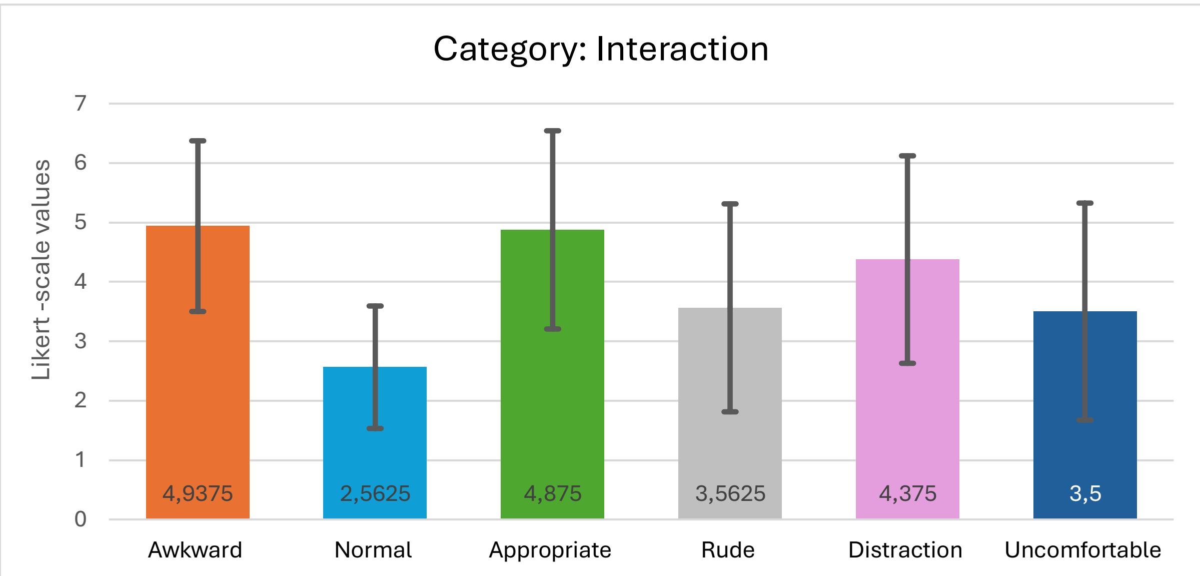


Figure 4 – Bar graph of Table 3 on the category of the interaction, displaying the mean and standard deviation.

Values that measure the user				
Elements	Curious	Isolated	Tech-savvy	Cool
Mean	5,9	4,4	4,8	3,9
Variance	1,3	3,1	2,4	3,0
Standard Deviation	1,1	1,7	1,6	1,7

Table 4 – Table that displays the mean values of several elements about the user of the AVPro

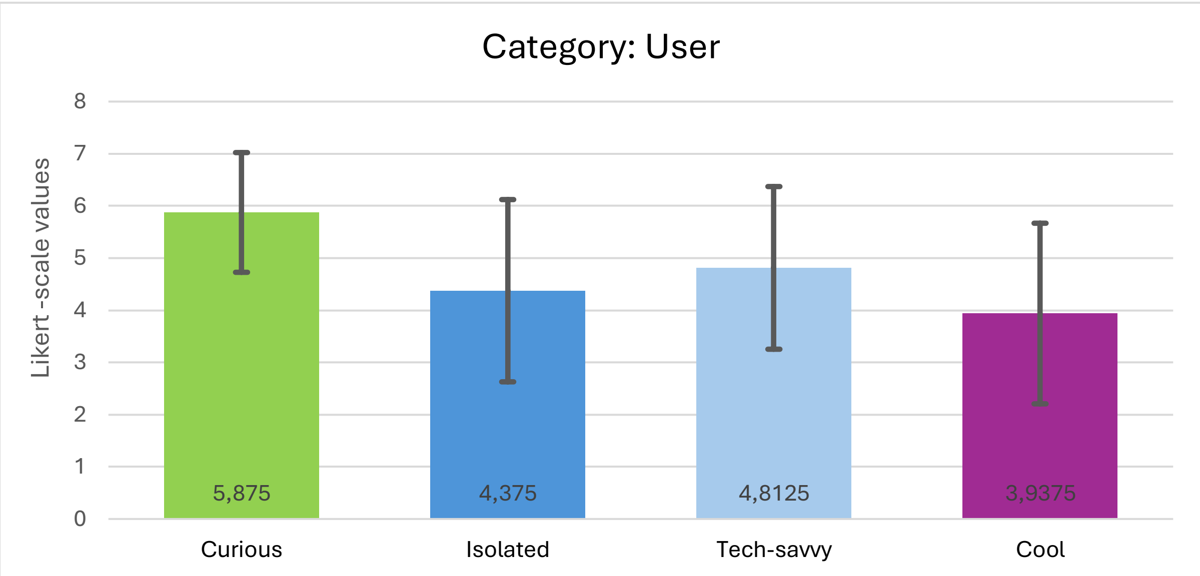


Figure 5 – Bar graph of Table 4 on the category of the user, displaying the mean and standard deviation.

Values that measure the device		
Elements	Useful	Unnecessary
Mean	2,3	5,9
Variance	1,4	1,5
Standard Deviation	1,2	1,2

Table 5 – Table that displays the mean values of several elements of the AVPro device

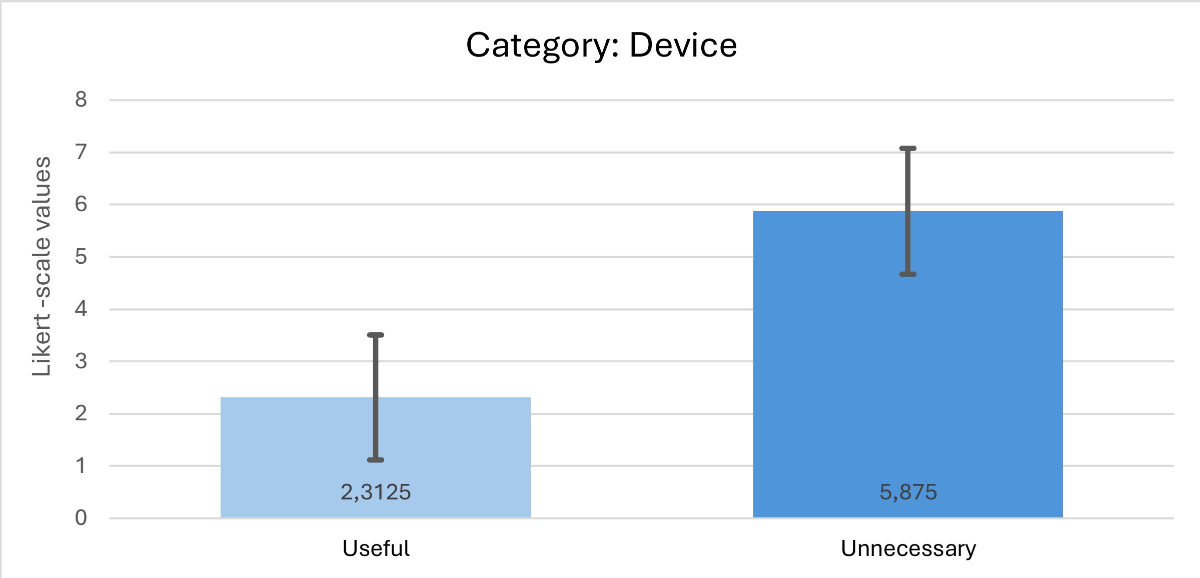


Figure 6 – Bar graph of Table 5 on the category of the device, displaying the mean and standard deviation.

When looking at the results of the Likert-scale questionnaires on the AVPro, it is clear that a few categories have a mean that is extremely high or extremely low. One of them is "normal", with a mean of 2.6 on a scale from 1 to 7 and a variance of 1.1. This indicates that most users do not experience the interaction with someone wearing the AVPro as normal. This is understandable as the device is new and far from familiar and thus normal. Furthermore, the category of "curious" has a mean of 5.9 on a scale from 1 to 7 with a variance of 1.3. This indicates that most of the people are very curious to know what is going on inside the AVPro. And lastly, both the categories on the device called "useful" and "unnecessary", scored extreme values with consecutively a 2.3 and 5.9 as mean on a scale from 1 to 7 and a variance of 1.4 and 1.5. This means that the device is considered useless and unnecessary in the setting of playing a game. This is understandable as the user did not have any benefits from the glasses, as they did not display anything to the user, like rules or cheat codes. So, therefore, these values will not be focused on. Additionally, it is seen that the difference between the small and large groups is not enough visible and reliable, as there are not enough data points to create a substantiated conclusion on the difference between these groups.

After analyzing the mean values, the reliability of the questionnaires needed to be checked using the theory of Cronbach's Alpha (*Cronbach's Alpha: Definition, Interpretation, SPSS - Statistics How To*, 2024). This is done using the first method mentioned in an article by Bashar (2024) on exceldemy.com, where an 'ANOVA test without replication' in Excel is executed, subsequently with the formula $1 - \frac{MS\ error}{MS\ rows}$, where MS stands for the Mean Square to calculate Cronbach's alpha. This is done for each set of statements, including the interaction (6 items), the user (4 items), and the device (2 items). The outcome of Cronbach's alpha will show how much the individual components measure the same thing in the mentioned categories. It is found that for the category of *interaction,* Cronbach's alpha has a value of 0.72, which is considered acceptable. For the category of the user, it is found that Cronbach's alpha has a value of 0.42, which is considered unacceptable. However, when removing the item of *isolation* in this category, the Cronbach's alpha value increases to 0.61. This is considered questionable, but the reliability is certainly higher than before. This is similar to the category of the device, where the Cronbach's value is 0.60, which is also considered questionable. However, when calculating the values separately for the AVPro setting and the Headphones setting, Cronbach's alpha values are consecutively 0.92 and 0.22. This indicates that the answers vary heavily between the two different settings of a user wearing the AVPro or wearing headphones. This suggests that people tend to agree on the usefulness and necessity of the AVPro in a social context, but not when someone is wearing headphones. An explanation for this could be, that some people find wearing headphones useful in a social setting as it could be used as an assistance device, as mentioned in the background research chapter, to cancel out any background noise and have more focus on your conversation partner.

Lastly, the results of the AVPro setting to the Headphones setting can be compared, which will be done by using a dependent t-test. This is because the same people execute two tests, one with an AVPro user and one with a headphone user, which could be themselves as it is randomized. Because of the varying Cronbach's alpha values, only the first category of the interaction can be compared as a group, but the categories on the user and the device, each item has to be separately compared.

For the interaction comparison between the AVPro and the headphones, I used the mean values of the six different items of the category for each device, so twelve items in total. There is said to be a significant difference in the interaction between the two when the P-value of the two-tail test is below the used alpha value, which was 0.05. The P-value is 0.51 so this is not the case and therefore can not speak of a significant difference between the AVPro and the headphones in the category of interaction (see Appendix E). Because the individual item of normal stood out in the mean comparison, also a dependent t-test was conducted on this item to see if there was a significant difference between the normality of the AVPro and the headphones. The P-value was found to be 0.17 with an alpha of 0.05, which is higher and therefore could not be concluded as a significant difference.

We now continue with the individual items of the category of the user, which includes four elements, namely curious, isolation, tech-savvy and cool. For the item of curiosity, also a dependent t-test is conducted where the P-value is 0.000053, which is very much below the alpha value of 0.05 and thus the difference is significant. This is also seen in the difference in the means, which is 2.4 (see Appendix E). This can be explained as that people are more curious to know what is going on inside the AVPro than what the headphone user is listening to.

The same procedure is executed for the rest of the items with a consistent alpha value of 0.05, where isolation has a P-value of 0.26 and tech-savvy 0.21, and therefore both do not have a significant difference. Conversely, the item cool has a P-value of 0.0015 and therefore has a significant difference, which means that it can be concluded that people find the looks of the AVPro cooler than the looks of the headphones (see Appendix E).

Lastly, the category of the device is looked at, with the items of useful and unnecessary. Both the items had a P-value higher than the alpha values, so there was no significant difference for these items (see Appendix E). This means that in the setting of playing a game, not one device seemed more useful or necessary than the other, as they were both considered useless and unnecessary in this setting.

4.4 Conclusion of User Studies

In conclusion, from the qualitative results, there are several ideas retrieved from the design discussions during the user studies, however, more brainstorming is needed to create more ideas upon the existing ones. However, repeated themes during the design discussion are that the AVPro is too bulky and that the eyes with the EyeSight feature look fake, as it seems like a video that loops itself and is not live footage of the user's eyes.

Furthermore, from the quantitative results, the item curiosity stood out both in the mean comparison and in the dependent t-test, with a significant difference between the AVPro and the headphones. This means that curiosity among the AVPro is a repeating theme and must be looked at further in the design process. Next, the item of normal stood out in the mean comparison but not when calculating the dependent t-test, and therefore is not seen as a priority. Finally, the item cool had a significant difference between the devices, where people tend to find the user of an AVPro cooler than the user of headphones. This is understandable as the AVPro is a new device and people are familiar with headphones. However, when looking at the mean and variance of the item of cool, this does not stand out from the rest. Therefore, the focus lies on the item of curiosity.

5. Ideation

In this chapter, the ideation phase of the project will be discussed, which is derived from the Creative Technology design cycle. The ideation phase will be the starting point to find an answer to the main research question and its sub-questions, where introducing new design elements to the AVPro has a central role in the upcoming chapters.

5.1 Research question

In the case of this thesis, the start of the ideation phase begins with a product and additionally a research question. This question, on the AVPro as a product, reads as follows: '*What design elements could be introduced to the Apple Vision Pro to increase social acceptance in the social context of playing bluffing tabletop games in different group sizes?*'.

5.2 Brainstorm

To make full use of the ideation phase, all the mentioned ideas in the affinity board must be discussed with others to retrieve more or different ideas derived from the ones presented. Therefore, a brainstorming session is planned with participants of the user studies, who are interested in creative thinking and helping further in this process. For this, the 'SCAMPER method' is used, which stands for Substitute, Combine, Adapt, Modify or Magnify, Put to another use, Eliminate, and finally Reverse (Parsons, 2024). This technique is very applicable after making an Affinity Diagram, as it encourages people to think broader than the already existing ideas.

5.2.1 Brainstorm Procedure

Ideally, 5 participants from the executed user studies are recruited for the brainstorming session, who are all willing to think outside the box and let their thoughts flow. The starting point of this session is the sticky notes from the Affinity Diagram. With these ideas in front of them, everyone is asked to individually write down as many ideas as they can in fifteen minutes, using the SCAMPER method on the created Miro board. When the time is over, a discussion is started with everyone, where each person explains their presented ideas. More ideas might come up from the discussion, which will also be written down. Finally, all the participants will conduct a dot voting (Gibbons, 2024), which is a method where each participant places a dot on their most liked idea. When all the participants have voted, the idea with the most votes will be chosen. This idea will be evaluated and specified in the next phase.

The brainstorming session was planned after the holiday break, with two other participants including myself as an expert on this topic. Before we started brainstorming, I explained to the participants how the SCAMPER method works and walked through the presented Affinity Diagram ideas, so everyone could start with the same knowledge. The fifteen minutes flew by, as everyone was very concentrated and had many ideas. After writing down all our thoughts, we had a discussion in which each person equally participated to explain their ideas better. After this, we all could vote on our most liked ideas, with the use of the method of dot voting. Because some of the former participants of the user studies, did not find the time to vote on the existing ideas, I contacted two people who were interested in participating. They received a link to the Miro board and could dot vote as well, but all the information they got was the ideas on the board and how many votes they were allowed to cast, which were five. Other than the information of what is discussed during the design discussions they participated in; they looked at the ideas with a fresh look.

5.3 Results of Brainstorm session

The outcome of the session, after all participants voted is shown below (Figure 7). In this picture, it is seen that two ideas had the most votes. These read as follows:

- Have glass that can turn transparent when the user is not doing anything

- Have an LED strip on the inside of the headband in combination with icons that show if the user is busy and changes colour accordingly.

Figure 7 – SCAMPER diagram, after Dot Voting.

6. Specification

This chapter specifies the design elements that will be introduced to the Apple Vision Pro. Therefore, together with sketching the options. This will be a short chapter as the brainstorming part is already done. Hence, only the design features chosen from the SCAMPER brainstorm session will be looked at, and how these correlate with the results of the Likert-scale questionnaires will be discussed.

6.1 Combine quantitative and qualitative results

In chapter four, the results of the quantitative data are shown. From these results, a few qualities stood out, namely: normal, curious, cool, useful, and unnecessary.

That most people do not find the use of the AVPro normal in a social setting, is very much understandable, as it is a new product that is noticeable on a user's face. This can be considered when designing, however, the size of the AVPro could not currently be reduced, as all the technology inside the headset is already extremely small. Additionally, the item of normal only stood out in the individual comparison, but when conducting both the individual t-test and category t-test, the item did not have a significant difference, and therefore will not have the highest priority.

Next, curiosity is an important item that keeps coming back, both in the quantitative results and in the design discussions. This is about what the user is doing within the AVPro headset. To make this clearer for the bystanders, it is important to create a feature that indicates what the user is busy with.

Furthermore, the item of cool stood out when conducting the dependent t-test between the two devices, which tells us that the AVPro is found to be cooler than the headphones. This is a positive affirmation, so making the design of the AVPro cooler is not a necessity.

Lastly, the elements of useful and unnecessary stood out, which is logical as the device did not help with the game in any way, as it was more to see what wearing such a device does to a social setting. This is therefore negligible for this research, as the focus lies on making the device more normal and eliminating the curiosity of the bystanders towards the user.

6.2 Specify the final idea

From both the qualitative and quantitative data, it becomes clear that curiosity and lack of normality are problems for social acceptance in a social setting. This correlates very well with the chosen ideas of the dot voting, as the focus lies on creating either visual or audible indications of the activity of the user and making the device more normal by making the glass transparent and really seeing their eyes through the AVPro.

To create the final idea, it is chosen to combine the most liked ideas from the brainstorming session. This will include changing the black display to a transparent display and including sound and visuals to communicate to the bystanders what the user is doing. If and how this will modify the AVPro technologically needs to be looked at and how this will have consequences for the design options will also be dived into.

6.2.1 Technology inside the AVPro

On the website of Apple, there is an exploded view displayed, where you can see the technology that is inside the glasses (see Figure 8). Most of the technology inside the glasses, is for the EyeSight function, as many cameras are built in to track the live eye movement. This also includes two lenses that make it possible to look at the display, without having the feeling of being very close to it. These lenses work very well for the user as it feels like not looking at a screen, however, when changing the front display to a transparent glass, the lenses will be visible to the bystanders. This will give a weird effect, as the lenses will transform the eyes and make them much bigger. However, other than seeing the exploded view, there is not much to find on what technology is exactly used and how this can be replaced.

Figure 8 – Exploded view of the Apple Vision Pro, from Apple Vision Pro - Apple

To get to know more about the inside of the AVPro it was clear that I had to search on other websites where other people were investigating how the device was built. A video of iFixit (2024) performs a teardown of the AVPro to see how it is made. This shows that there is so much more technology and complexity behind the display than only a few cameras and two lenses, which means making the glass transparent does not mean that you immediately could see the eyes of the user (even through the lenses).

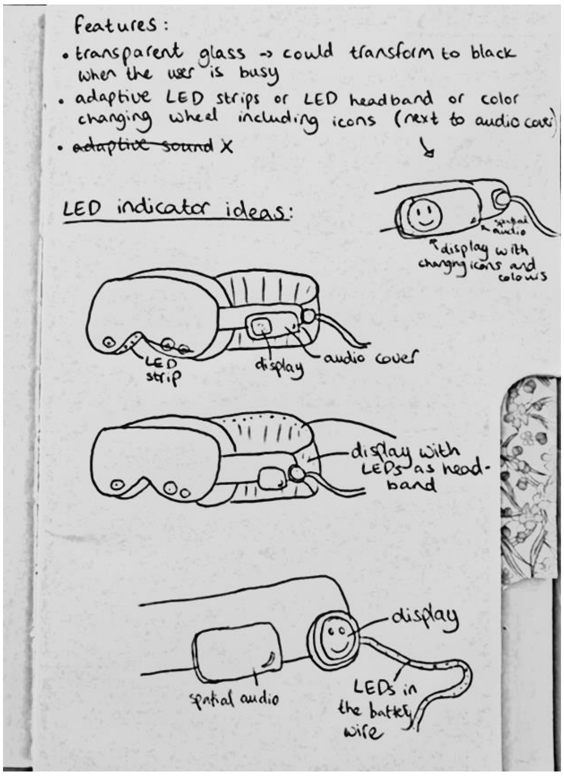
6.2.2 Possibilities for the design

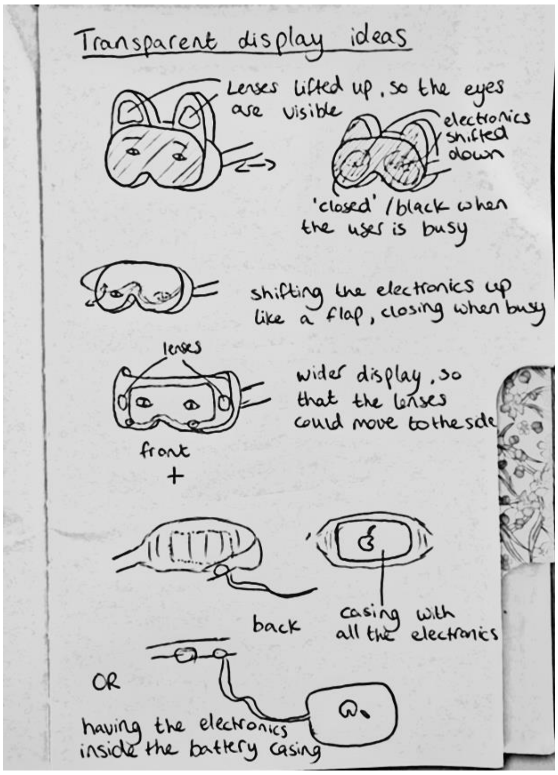
According to the findings, the electronics in front of the eyes are a big problem, because even when making the front display transparent, the bystanders would not see the user's eyes. Therefore, an option could be to place the electronics, like the computer(s), somewhere else, such as in the back, and only have the lenses and cameras in the front. This way, the lenses are the only thing blocking the eyes; hence they must be able to move. This is possible as the lenses are now already on a rail that can move horizontally since the lenses adjust to the position of the user's eyes. When changing the location of the electronics, this has consequences for the design, as there should be a case in the back and the lenses need to be able to move to the side, away from the user's eyes. Theoretically, this must be possible, because the connection of the electronics in the back can be the same as the battery connector. This works by creating wires going up and down between the elastics in the headband moving towards the connector part on the sides of the headset, just beside the battery connection point. The lenses can then be controlled by the computer inside the electronics case, by moving them along a curved rail in the front of the glasses. This rail has the same curve as the front display and will be made from transparent plastic, so it will not interfere with the front view of the user's eyes, just like the lenses do as they are moved to the side. The curving of the rail is possible, as the existing rail can only move the lenses horizontally, but they also should be able to move diagonally on the rail, as it allows this movement in the new design.

The other option is to remove this idea of making the glass transparent for my design, and only focus on the indicators to eliminate the curiosity of the users. Because the first option has the potential to improve the quality of the user experience and make the interaction between user and bystander easier, this will be included in the new design idea.

6.2.3 Sketches

To have a clear idea of what the 3D model would look like, sketches are made to vary with the ideas and see what the options are. For both features (state indicator and transparent display) several sketches are made, together with some small explanation text (see Figures 9 and 10).



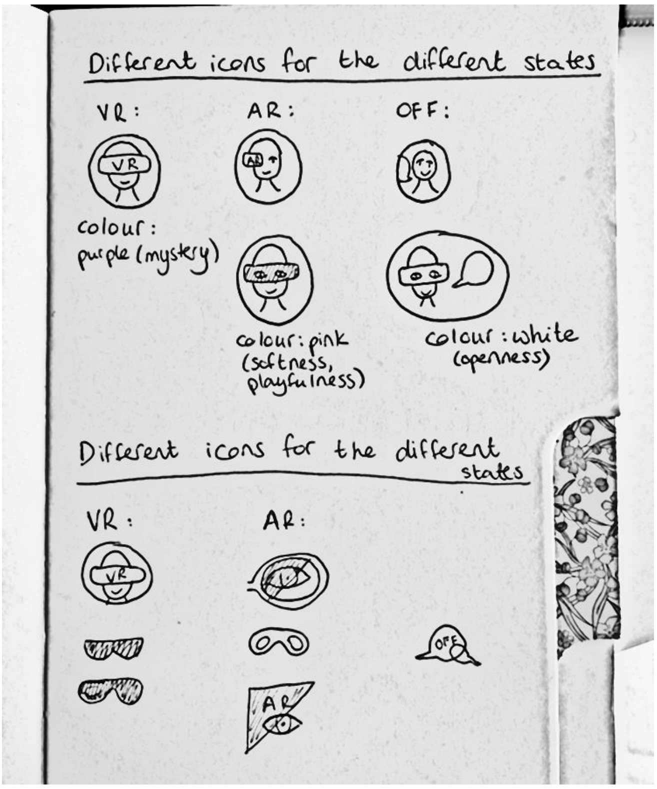


Figures 9 & 10 – Sketches for the state indicator and sketches for the transparent display

From these sketches, I have decided to choose the idea of having the display indicator on top of the battery 'hook' (bottom left), including LEDs in the battery wire. The display shows the user's state, and the LEDs will change accordingly. The sketches of the different options for the states are shown below (see Figure 11).

Furthermore, the idea of having the lenses move to the sides and the electronics inside the front of the glasses move to the back is chosen (middle right). This approach is the most feasible way to create ‘real’ eye contact between the user and the bystander. This is very meaningful, and therefore, this idea will be implemented in the 3D model.

Figure 11 – Sketches of different options for the different states



6.2.4 Colour Theory

To choose matching colours with the icons, it is important to know which colour is appropriate for each state. The Colour Theory is a powerful helping tool that explains what emotion or vision each colour evokes (Stevens, 2024). For each colour there are several themes or things stated that are most common to associate the colour with. To give an example, some statements behind the colour purple are: “royalty, nobility, glamour, mystery, luxury” (Stevens, 2024). This indicates that people see purple as a rich colour with some mystery behind it. When looking further, another author explains that purple is also about imagination and creativity, which is also fitting for this state (Olesen, 2024). For the state of being in AR, it is fitting to have a colour that symbolizes playfulness but is also open to the world. When looking at all the different colours in the article of Olesen (2024), where the colour salmon represents this. This is a form of pink, which is often associated with playfulness and softness, and also the feeling of being approachable. Lastly, when the device is off this still needs to be addressed by a colour and icon, which is associated with openness. When looking at both the article of Olesen (2024) and Stevens (2024), the colour white represents this together with simplicity and emptiness. The icons below will show the different states, which are created with the Word icons (see Figures 12, 13, and 14).

Figure 12 – VR state icon

Figure 13- AR state icon

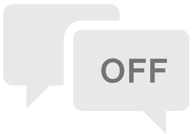


Figure 14 – OFF state icon

7. Realisation

In this phase, the final idea will be realised using a 3D sketching program to show the new design for the AVPro, as it is not possible to change this device physically. Inside this 3D program, the model will also be worn by a person, to show how the new design will look like on a person. Lastly, the interaction with the new device will be displayed by a storyboard.

7.1 Final idea

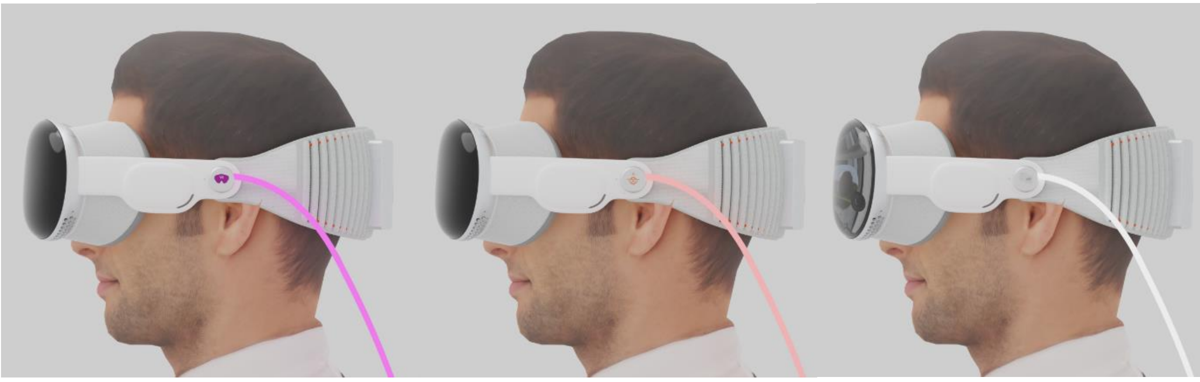
Two design elements will be introduced to the device to make the Apple Vision Pro more socially acceptable in social group settings. These are the state indicators, including the LED wire toward the battery and the transparent display with moving lenses, including moving the electronics to the back of the headset inside a case.

7.2 3D model

The starting point for the 3D model was to search for existing models of the AVPro as this would save me much time. Someone had made a model in the program Blender, which is nice 3D modelling software that I already was familiar with, as we had used it in the CreaTe bachelor. The credits of this model are stated below including additional features that were necessary for my model which were made by others. Additionally, the link to the website of the AVPro model also shows what the 3D model looked like before I adjusted it.

In Figures 15 and 16, renders of the newly designed AVPro are shown. In Figure 15 the transparent mode is on, and in Figure 16 the VR mode is on. Then in Figures 17, 18, and 19, the different modes are shown including the changing displays (state indicators) and the change in colour in the battery wire. In Figure 20 the back of the model is shown, where the electronics are moved inside a casing, that looks similar in design to the battery of the AVPro (see Figure 21). And finally, in Figure 22 the lenses that shift to the side are shown from the front.

Figures 15 & 16 – AVPro model in Blender with OFF mode on and with VR mode on



Figures 17, 18 & 19 – Close-up to see the VR-mode, AR-mode and OFF-mode indicators on the LED display and in the battery wire.

Figures 20 & 21 – On the left the back of the AVPro is seen with the electronics casing mounted on the back of the headset with a curve to match the shaping of the headband, together with the design of the AVPro battery on the right (Apple, 2024).

Figure 22 – The lenses that slide to the side, when using the transparent mode

In Figure 22 the lens shifting is seen, which is a feature which already has been implemented in the existing AVPro, but this mechanism can not be seen from the outside. The working of this in the existing device is that it can only move on a rail from left to right, but in the new design, the lenses can also move from the back to the front. This mechanism is possible as the rail is curved in the shape of the headset. When the user switches to OFF mode, the lenses will move along this curved rail, which will reveal the user's eyes. However, the look of this person's eyes is not exactly how one looks at another without a device in between, as the glass slightly deforms the eyes. This weird effect will be seen by the bystander towards the user, which raises the feeling of finding the person funny. If this is positive or negative must be found out by further user tests.

7.2.1 Credits 3D models

"Apple Vision Pro" (https://skfb.ly/oIDrM) by pravinvamp is licensed under Creative Commons Attribution (http://creativecommons.org/licenses/by/4.0/). Apple Vision Pro - Download Free 3D model by pravinvamp (@pravinvamp) [08217e6]

"Apple Logo" (https://skfb.ly/6xOQR) by MysteryPancake is licensed under Creative Commons Attribution (http://creativecommons.org/licenses/by/4.0/). Apple Logo - Download Free 3D model by MysteryPancake (@mysterypancake) [ec021e3]

"Eric Rigged 001 - Rigged 3D Business Man" (https://skfb.ly/6SC6z) by Renderpeople is licensed under Creative Commons Attribution (http://creativecommons.org/licenses/by/4.0/). Sketchfab

7.3 Storyboard

To clarify the usage of the AVPro in real life, I have made a storyboard to show the interaction step by step (see Figure 23). A storyboard gives the designer more possibilities to explain their idea in more detail, by creating a hypothetical story that could occur in real life when the device is fully developed. In this storyboard, Jack is thought of as the user of the new

AVPro and Emily is the bystander. The scenario describes how Jack interacts with the device in the AR mode, but then would like to switch to OFF mode as he wants to speak to Emily.

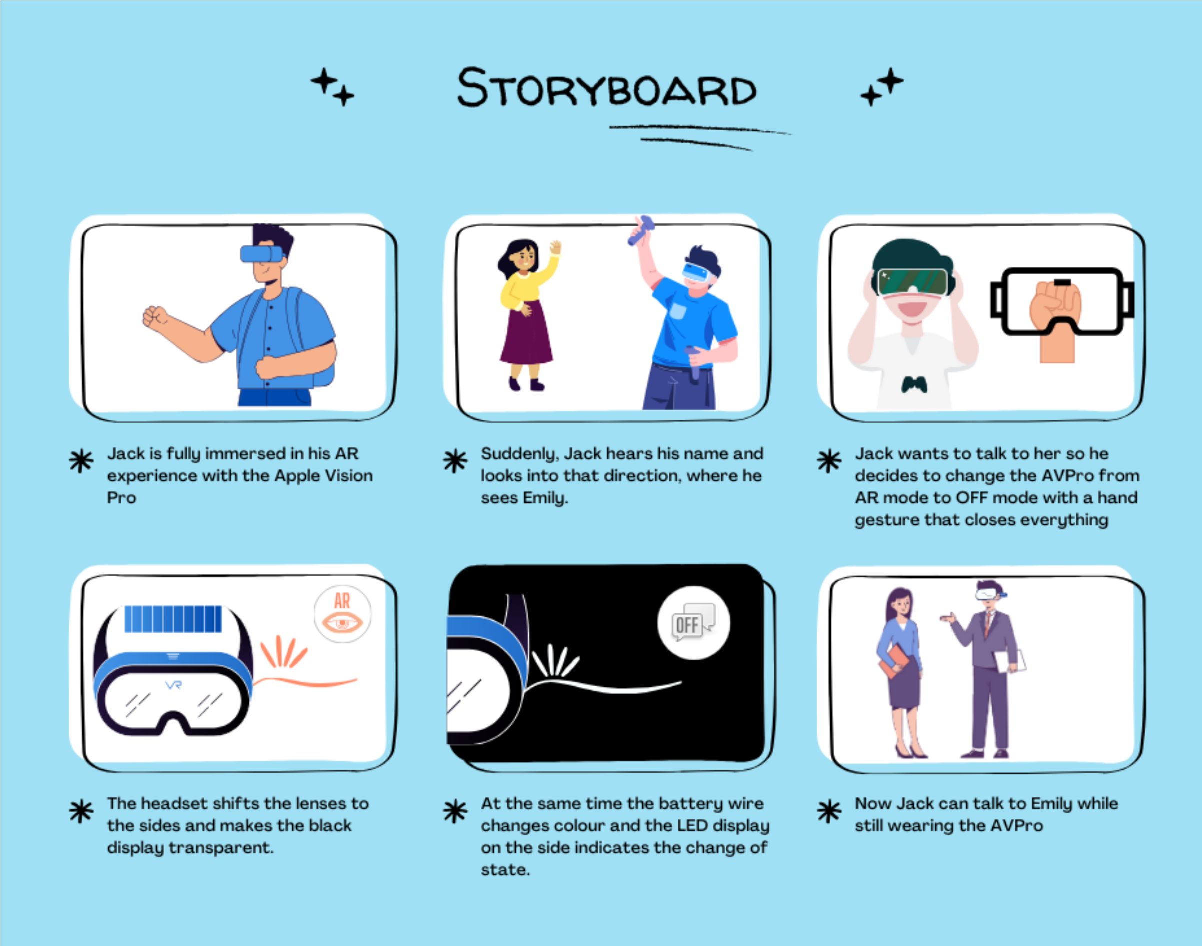


Figure 23 – Storyboard on the interaction with the AVPro with the new design elements

Making this storyboard has helped me to see if the design idea was fully thought out, or that I still had to make crucial design decisions. While creating the transition of Jack switching between AR to OFF mode, I realized that I had not thought about the hand gesture yet. This was important, as this got the transition between the states started. To decide which gesture was suitable, I thought that it must be an easy, small, straightforward, and not repetitive gesture as the user must not accidentally switch states. From these requirements, I thought making a fist was appropriate, as this small gesture looks closed off, is simple and is not already used for another function inside the headset.

7.4 Conclusion on Final Design

With this newly designed Apple Vision Pro people the contact between the user and bystander will be more visible, through state indicators and a transparent mode. However, the look of the transparent mode is still a bit deformed by the glass, which creates a funny look on the user. To see how this would further impact social acceptance and if this is a better design than the existing model, has to be decided by further user tests.

8. Discussion and Future Work

This chapter discusses the results and the interpretations of these outcomes, moreover, it discusses the encountered challenges and limitations, in addition to what could be improved for future work or development.

8.1 Summary of Findings

The aim of this thesis was to explore what could be improved on the Apple Vision Pro to enhance social acceptance in social settings, like playing bluffing tabletop games. Through user studies, it was found that the curiosity of bystanders about what the user is doing within the headset was the most important aspect. Therefore, the focus on redesigning the AVPro lies in finding elements that reduce the curiosity of bystanders towards the user. This is done by adding a state indicator on the battery connector, including a colour-changing battery wire, with additionally a front display that could switch between black (VR or AR mode) and transparent glass (OFF mode).

8.2 Interpretation of Findings

These findings indicate that the view of people wearing something in front of their eyes awakens curiosity from their bystanders, even when the eyes of the user are visible with the EyeSight feature. Therefore, it is found in both the qualitative and quantitative results that for social interaction people want to maintain real eye contact and not look at a screen that displays the so-called live footage of the user's eyes, as it seems fake. This also correlates with the findings in the background research on social presence. When a user is wearing an Extended Reality (XR) device, it is crucial to still be socially present in the environment of the people around them, which is not the case with the existing XR devices, even the AVPro. Hence, seeing the eyes of the user through the device will most likely enhance social presence, and therefore social acceptance. In addition to this, the state indicator also contributes to this, as it actively shows that the user is aware of their surroundings, and switches states when having a social interaction.

8.3 Limitations and Future Work

During the work of this thesis, there were some limitations with knowledge, resources or time. To start off the Likert-scale questionnaires were not reliable enough to conduct t-tests comparing the different categories between the two devices. To improve this the questionnaires had to be tested first with various pilot tests, to see if they are reliable and test the same category. Hence, when calculating Cronbach's alpha of the measurements in this project, it was seen that only the first category had a high enough value to be seen as reliable. To improve this more items needed to be added to the two categories to be able to double-test on items that measure the same thing in order to be more reliable.

Next, the number of participants in the user studies was enough to give insights into the design of the AVPro, but not if there were real outliers in the Likert-scale values. This means that while making scatter plots, all the values were very widely distributed, as the data set was small. When the tests were done with a larger data set, it would be clear which people were giving notable answers. These people could either be eliminated from the results or interviewed on why they gave these striking answers. Also, it would show a better indication of the mean and standard deviation of all items, as more people would most likely have the same opinion. Lastly, it would give a better indication of the difference in social acceptance between the small and large group settings.

Finally, there were also limitations with the end design, as the redesigned AVPro could not be evaluated during the period of this project. Ideally, it would be good for the reliability of this research to see if the redesigned AVPro would have a higher social acceptance level than it did before. However, then the new design elements must work together with the existing device and that would be almost impossible, as I did not have access to the total functioning of the AVPro and how to add items to this. Moreover, this would take a very long time to make, as Apple took many years to make this model. Another option was to build a 3D model of the outside of the AVPro displaying the new features that work with the Wizard of Oz technique (Rosala & Paul, 2024), to be able to test the difference in social acceptance. Only by testing the AVPro with the new features, it can be checked if the social acceptance level lies higher than it did before. Something that could come up from this evaluation testing, which I did not think about while making the final model, was that the glass of the front display deforms the eyes a bit. The look of this is a bit funny, and therefore could either have a positive or negative impact on the social acceptance. Adding something that would correct this deformation, would most likely make the device more heavy and costly, which might lead to the conclusion that the idea of making the front display transparent is not the ideal solution.

9. Conclusion

To have a clear answer to the main research question of this thesis, a conclusion is made using the sub-research questions.

9.1 What is social acceptability, and which factors influence it?

The use of Extended Reality (XR) devices, like the Apple Vision Pro (AVPro), in a social context still has the challenge of maintaining social acceptance. Social acceptance, described as the absence of negative emotions towards an item or problem, is influenced by mostly social presence and safety.

9.2 How do people perceive the social acceptability of the Apple Vision Pro in a group setting?

To find out how the social acceptability among the AVPro was seen in a group setting was tested in user studies, where it was mentioned that the device was too bulky for everyday use. Besides, the device was very new and not seen as normal to wear in public social settings.

9.3 What design features of the Apple Vision Pro currently challenge or improve social interactions in a group setting?

What additionally challenges the use of the AVPro in a social context, is found to be the curiosity of the bystanders towards the activities of the user inside the headset. To reduce this, new design elements are introduced to the AVPro to enhance social acceptance in the social context of playing bluffing tabletop games. This social context is chosen, as bluffing games require a high need for social interactions and focus on facial expressions or gestures, as the AVPro has the EyeSight feature this is highly relevant. The findings of these user studies indicate that bystanders have a strong curiosity about the activities of the user inside the headset. This curiosity is natural, as the device is new and high-tech looking, however, it may also lead to disconnection or discomfort between the user and bystander. The solution that is found to this problem is indicating the state of the user by changing icons on the battery connector together with a colour-changing battery wire. When the user changes states from AR or VR to OFF mode, the black front display will simultaneously turn transparent, together with lenses that shift to the side. The consequence of this design is that the technology inside the front part of the headset is moved to the back inside a casing that is similar to the battery casing. Adding these features, the user and bystander can maintain real eye contact when the user indicates they have no activities inside the headset.

However, limitations and challenges remain, with the solution of having a state indicator together with a transparent display, it is believed that social acceptance of the AVPro is enhanced in the social context of playing bluffing tabletop games and potentially other social settings.

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11. Appendix

A. Questionnaires used for User Studies

A.1 Questionnaire used for the User

(Obtained from a mix of previous studies of Profita et. al. (2016), Schwind et al. (2018) and Eghbali et al. (2019)https://trepo.tuni.fi/bitstream/handle/123456789/26840/Eghbali.pdf?sequence=4).

Section 1: Statements about Your Interaction with the Device

For each statement, please indicate how strongly you agree or disagree.

Statement	Strongly Disagree	Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Agree	Strongly Agree
1. I felt uncomfortable using the wearable device in this setting.	☐	☐	☐	☐	☐	☐	☐
2. It felt awkward to use this device in this setting.	☐	☐	☐	☐	☐	☐	☐
3. Using the wearable device in this setting felt normal to me.	☐	☐	☐	☐	☐	☐	☐
4. It felt appropriate to use the wearable device in this setting.	☐	☐	☐	☐	☐	☐	☐
5. I felt rude to use this wearable device in this setting.	☐	☐	☐	☐	☐	☐	☐
6. I felt that using the wearable device	☐	☐	☐	☐	☐	☐	☐

distracted me from interacting with others.							

Section 2: Statements about How Others Perceive You as a User

For each statement, please indicate how strongly you agree or disagree.

Statement	Strongly Disagree	Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Agree	Strongly Agree
7. I think I looked cooler with this wearable device than others.	☐	☐	☐	☐	☐	☐	☐
8. I felt tech-savvy while using this device.	☐	☐	☐	☐	☐	☐	☐
9. I felt that others were curious on what I was doing with the device.	☐	☐	☐	☐	☐	☐	☐
10. I felt more isolated from the rest while wearing the device.	☐	☐	☐	☐	☐	☐	☐

Section 3: Statements about the Device's Role in Social Interactions

For each statement, please indicate how strongly you agree or disagree.

Statement	Strongly Disagree	Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Agree	Strongly Agree
11. The wearable device felt	☐	☐	☐	☐	☐	☐	☐

useful in this setting.							
12. The wearable device felt unnecessary to use in this setting.	☐	☐	☐	☐	☐	☐	☐

Section 4: Participant Background and Demographics

1. Were you previously familiar with the wearable device used during the session?
    - Yes
    - No
2. If so, have you used it before?
    - Yes
    - No
3. How interested are you in using the wearable device?
    - Strongly Uninterested
    - Uninterested
    - Somewhat Uninterested
    - Neutral
    - Somewhat Interested
    - Interested
    - Strongly Interested
4. What is your opinion on the wearable computing device? (Please write your answer here)

____

____

5. Gender: ________________________
6. Age: ________________________
7. Level of Education: ________________________

A.2 Questionnaire used for the Bystander

(Obtained from a mix of previous studies of Profita et. al. (2016), Schwind et al. (2018) and Eghbali et al. (2019)https://trepo.tuni.fi/bitstream/handle/123456789/26840/Eghbali.pdf?sequence=4).

Section 1: Statements about the Interaction

For each statement, please indicate how strongly you agree or disagree:

Statement	Strongly Disagree	Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Agree	Strongly Agree
1. It looked awkward when this person was using the device in this setting.	☐	☐	☐	☐	☐	☐	☐
2. It looked normal when this person was using the device in this setting.	☐	☐	☐	☐	☐	☐	☐
3. It was appropriate for this person to use the wearable device in this setting.	☐	☐	☐	☐	☐	☐	☐
4. It was rude for this person to use the wearable device in this setting.	☐	☐	☐	☐	☐	☐	☐
5. I felt uncomfortable watching this person use the wearable device in this setting.	☐	☐	☐	☐	☐	☐	☐
6. I felt distracted by the user of the device, which caused me to have a harder time interacting with them.	☐	☐	☐	☐	☐	☐	☐

Section 2: Statements about the User

For each statement, please indicate how strongly you agree or disagree:

Statement	Strongly Disagree	Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Agree	Strongly Agree
7. I am curious to know what the user is doing or listening to.	☐	☐	☐	☐	☐	☐	☐
8. I think the user is isolated from the rest of us.	☐	☐	☐	☐	☐	☐	☐
9. This person looked cooler than the others.	☐	☐	☐	☐	☐	☐	☐
10. This person looked tech-savvy wearing the device.	☐	☐	☐	☐	☐	☐	☐

Section 3: Statements about the Device

For each statement, please indicate how strongly you agree or disagree:

Statement	Strongly Disagree	Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Agree	Strongly Agree
11. The wearable device seemed useful in this setting.	☐	☐	☐	☐	☐	☐	☐
12. The wearable device seemed unnecessary to use in this setting.	☐	☐	☐	☐	☐	☐	☐

Section 4: Participant Background and Demographics

1. Were you previously familiar with the wearable device used during the session?
   - Yes
   - No
2. If so, have you used it before?
   - Yes
   - No
3. How interested are you in using the wearable device?
   - Strongly Uninterested
   - Uninterested
   - Somewhat Uninterested
   - Neutral
   - Somewhat Interested
   - Interested
   - Strongly Interested
4. What is your opinion on the wearable computing device? (Please write your answer here)

____
____

____
____

5. Gender: ________________________
6. Age: ________________________
7. Level of Education: ________________________

B. Affinity Diagram

Quotes and ideas from audio recordings of the design discussion on the AVPro

- "99 precent of the time I have no idea where you were looking at with the AVPro on"
- "same for me (user), because I have a sort of tunnel vision while wearing the headset"
- "the EyeSight is a good addition to the AVPro, but it still needs some work"
- "it feels like talking to someone with sunglasses on"
- <u>wider view is nice for both user and bystanders; panorama view</u>
- "when someone is wearing the headset it already looks like they would not want to be disturbed, the same for someone wearing earbuds or headphones as you have the feeling they have different things to do than interacting with someone."
- "the more it looks like normal glasses, the more the feeling of being able to interact with the user"
- **the AVPro is too bulky not subtle (7x)**
- "you would not wear it when you are not using it"
- it stands out too much
- <u>idea of having the headset only for one eye instead of two</u>
- <u>idea of having an indicator on the outside to see if the user is busy; color change (but give indication what each color means; icons</u>
- <u>more attractive colors on the outside, personalize the AVPro (2x)</u>
- not intimidating, but a bit weird as the eyes look like a screen and not really as eyes; more of an illusion
- <u>have the eyes always visible, because when not looking at the someone the eyes "go out"</u>
- <u>idea of having the color around the eyes as the skin color, instead of black around the eyes (3x)</u>
- good feature that the bystanders can hear the same audio as the user
- <u>have the side profile also visible, so people can still see your facial expression</u>
- have more subtle movements, no hand gestures, only eye tracking
- idea of placing the features on a table, or other flat object to tap on them instead of in the air; more intuitive
- <u>"it is nice to see the eyes on the display, which is missing with headphones as you can not see the ears then and it immediately looks like you can not hear the rest as you can not see the sense"</u>
- <u>idea of having transparent glass (3x)</u>
- "it is nice to have transparency, so you actually can see the eyes, but that will then mean that the functionality is less"
- "when the glass is transparent it looks like diving glasses, which might be even weirder than this"
- "to wear it everyday it is too big, because you can not casually use it"
- "or maybe when everyone will wear it is normal"
- <u>idea of seeing more features of the face instead of only seeing the eyes, better seeing the eyebrows or the nose</u>
- <u>idea of having a little screen next to the glasses to see what the user is seeing</u>
- <u>idea of seeing an indicator when you are or are not recording</u>
- "the headset already looks isolating; impersonal"
- "it looks like the eyes is just a video and not really the live footage of the eyes"
- "the skin color simulating also brings ethical issues, as the person might not match with the colors available"
- idea of having an app that connects to the AVPro so the bystander can see what the user sees

Design Ideas

Dot Voting

Ideas

- Wider view, for both the user and the bystanders, maintain more possible eye contact
- only having the apple vision for one eye instead of two, so you can see the other eye
- having an indicator on the outside to show if the user is busy or not
- be able to personalize the headset to your liking, with colors in the eyesight display
- have the skin color around the eyes instead of black, makes it more blend into the face
- have transparent glass instead of black
- seeing more from the face instead of only seeing the eyes and a bit of the eyebrows
- having a little screen on or next to the headset to see what the user is doing

Questions

- does that work with lens correction etc.?
- only with colors, or also with icons, or text to explain what the color means?
- maybe also personalize with clips or accessories? (physical things)
- ethical issues?
- is that possible with all the technology inside the glasses?
- would that not be more distracting?

Functionality Ideas

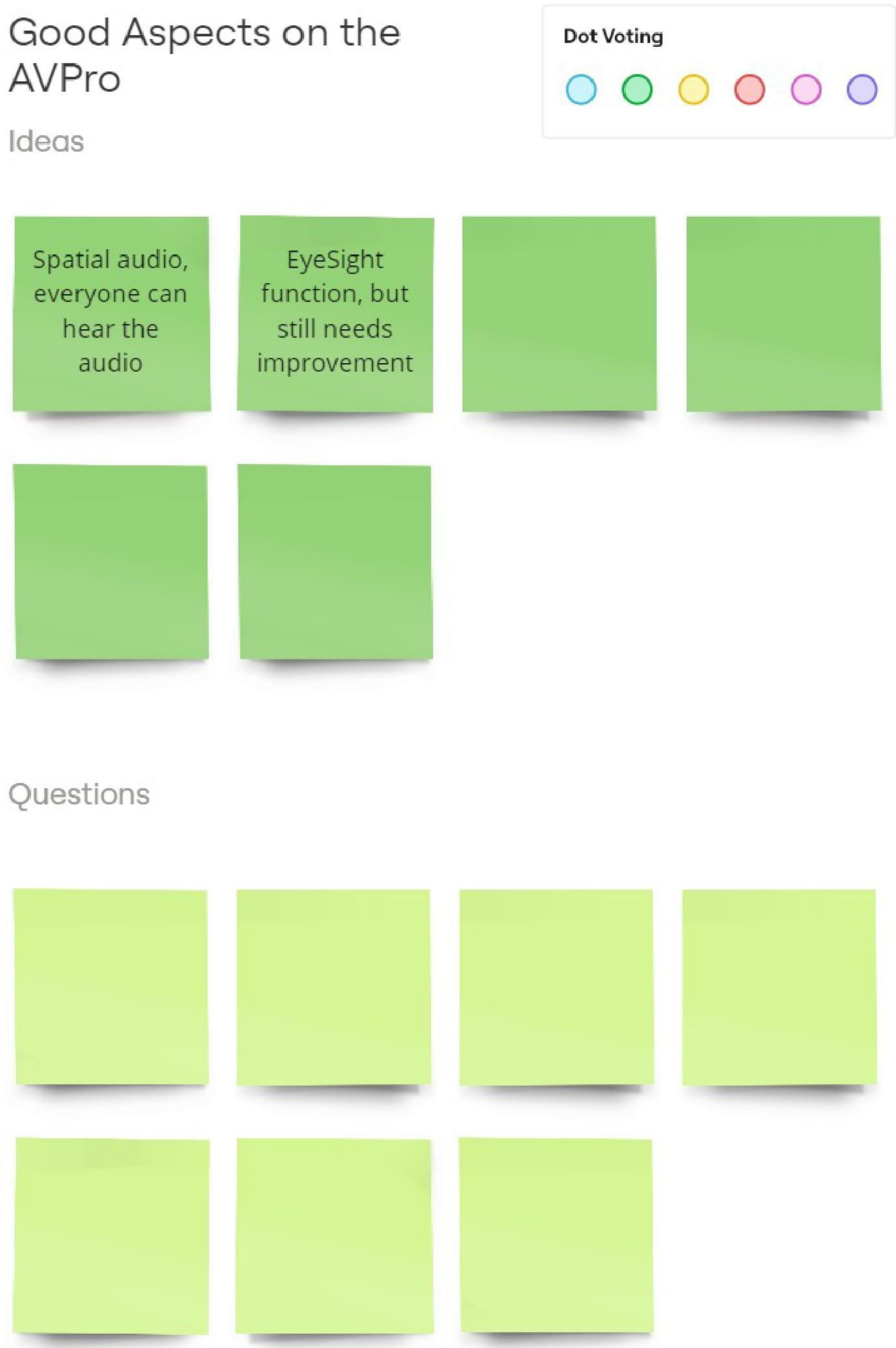
Dot Voting

Ideas

- wider view for the user, so there is no more tunnel vision
- have more subtle movements, no hand gestures, only eye tracking
- idea of placing the features on a table, or other flat object to tap on them instead of in the air; more intuitive
- indicator of when the user is recording or not
- having an app to see the users view

Questions

- isn't that already on the apple vision?
- would not work when the bystander does not know the user, which is where i am designing for


Good Aspects on the AVPro
Ideas
Dot Voting
Spatial audio, everyone can hear the audio
EyeSight function, but still needs improvement
Questions

Challenges on the AVPro

Dot Voting

Ideas

- Tunnel vision, small view
- Too bulky, not casual or subtle
- The eyes look like an illusion or video and not real
- The eyes sometimes "go out" when not looking at someone

Questions

Comments I should not forget

Dot Voting

Ideas

"it feels like talking to someone with sunglasses on", as you can sometimes see through and see the eyes

"when someone is wearing the headset it already looks like they would not want to be disturbed, the same for someone wearing earbuds or headphones as you have the feeling they have different things to do than interacting with someone."

"the more it looks like normal glasses, the more the feeling of being able to interact with the user"

"you would not wear it when you are not using it"

"it is nice to see the eyes on the display, which is missing with headphones as you can not see the ears then and it immediately looks like you can not hear the rest as you can not see the sense"

Questions

"when the glass is transparent it looks like diving glasses, which might be even weirder than this"

Evaluate

most possibility of physically working:

- having an indicator on the outside to show if the user is busy or not
- be able to personalize the headset to your liking, with physical things like badges or stickers
- having a little screen on or next to the headset to see what the user *doing* is using the Wizard of Oz method *(in AR mode, in VR mode).*

ideas that are possible in sketches but not in reality:

- Wider view, for both the user and the bystanders, maintain more possible eye contact
- only having the apple vision for one eye instead of two, so you can see the other eye
- be able to personalize the headset to your liking, with colors in the eyesight display
- have the skin color around the eyes instead of black, makes it more blend into the face
- have transparent glass instead of black
- seeing more from the face instead of only seeing the eyes and a bit of the eyebrows
- having a little screen on or next to the headset to see what the user is *seeing*

Most liked idea:

- having an indicator on the outside to show if the user is busy or not

C. Quantitative results

C.1 Entire table of results, divided per person

ID	Group	Date	GroupSize	Order	role_time1	role_time2	age	gender	education
0,1	0 (PILOT)	11/11/2024 00:00	2	AVP_HP	AVP	bystander	23	male	
0,2	0 (PILOT)	11/11/2024 00:00	2	AVP_HP	bystander	HP	20	male	
1	1	21/11/2024 00:00	4	AVP_HP	AVP	bystander	29	male	master
2	1	21/11/2024 00:00	4	AVP_HP	bystander	bystander	20	female	bachelor
3	1	21/11/2024 00:00	4	AVP_HP	bystander	bystander	22	female	master
4	1	21/11/2024 00:00	4	AVP_HP	bystander	HP	22	female	bachelor
5	2	27/11/2024 00:00	2	AVP_HP	AVP	bystander	19	female	bachelor
6	2	27/11/2024 00:00	2	AVP_HP	bystander	HP	21	female	bachelor
7	3	28/11/2024 00:00	4	AVP_HP	AVP	bystander	22	male	master
8	3	28/11/2024 00:00	4	AVP_HP	bystander	bystander	22	male	bachelor
9	3	28/11/2024 00:00	4	AVP_HP	bystander	bystander	23	male	bachelor
10	3	28/11/2024 00:00	4	AVP_HP	bystander	HP	21	male	bachelor
11	4	02/12/2024 00:00	2	HP_AVP	HP	bystander	21	female	bachelor
12	4	02/12/2024 00:00	2	HP_AVP	bystander	AVP	22	male	bachelor
13	5	05/12/2024 00:00	2	HP_AVP	HP	AVP	20	female	hbo
14	5	05/12/2024 00:00	2	HP_AVP	bystander	bystander	17	female	havo
15	6	05/12/2024 00:00	2	HP_AVP	HP	AVP	22	female	bachelor
16	6	05/12/2024 00:00	2	HP_AVP	bystander	bystander	19	female	hbo

education	interest_1	awkward_1	normal_1	appropriate_1	rude_1	distraction_1	uncomfortable_1	Column1	curious_1
master	5	2	3	4	6	3	2		
bachelor	1	6	2	2	1	5	1		
master	5	7	1	3	5	4	5		
bachelor	4	5	3	3	2	5	4		
bachelor	7	3	3	6	2	5	5		
bachelor	7	6	2	1	6	7	6		
master	6	4	3	2	3	4	5		
bachelor	7	4	3	6	2	2	1		
bachelor	6	3	5	2	4	2	3		
bachelor	6	5	3	3	2	5	4		
bachelor	5	5	3	3	6	5	7		
bachelor	5	5	2	2	3	4	2		
hbo	7	5	5	2	5	1	2		
havo	3	3	3	3	4	2	2		
bachelor	6	6	3	2	4	6	6		
hbo	7	3	3	4	2	1	1		

curious_1	isolated_1	tech-savvy_1	cool_1	Column2	useful_1	unnecessary_1	Column3	interest_2	awkward_2	normal_2
3	2	5	5		2	6		3	2	5
7	5	4	6		2	6		5	2	6
6	6	3	3		2	6		5	5	3
6	5	6	2		5	4		6	4	2
7	5	6	6		3	5		6	5	3
7	6	4	2		3	6		7	2	5
5	5	4	4		2	7		3	6	2
6	2	7	2		2	7		3	6	2
6	2	5	4		2	6		3	5	3
6	5	6	6		2	7		5	6	2
2	5	5	3		1	7		5	6	3
5	5	2	1		1	5		7	4	3
2	2	4	2		6	6		2	6	1
3	5	4	4		3	5		6	6	1
4	7	3	3		2	7		7	6	2
4	6	2	3		1	7		3	6	3

normal_2	appropriate_2	rude_2	distraction_2	uncomfortable_2	Column4	curious_2	tech-savvy_2	isolated_2	cool_2	Column
5	5	2	4	2		3	5	1	4	
6	5	2	2	2		3	4	2	2	
3	2	6	4	4		5	1	5	1	
2	3	5	5	6		3	4	6	1	
3	2	6	5	4		6	2	6	3	
5	3	4	2	7		6	5	6	2	
2	1	4	5	5		4	2	5	1	
2	2	2	2	5		1	1	5	1	
3	2	5	3	5		1	1	5	1	
2	5	3	3	6		3	2	6	1	
3	2	6	7	4		7	5	6	1	
3	6	2	2	2		7	7	3	6	
1	1	6	6	7		6	1	7	2	
1	3	3	5	5		5	6	3	4	
2	2	4	6	7		4	5	2	5	
3	4	3	2	3		6	7	6	5	

curious_2	tech-savvy_2	isolated_2	cool_2	Column5	useful_2	unneccesary_2	Column6
3	5	1	4		4	6	
3	4	2	2		2	6	
5	1	5	1		2	5	
3	4	6	1		3	6	
6	2	6	3		1	7	
6	5	6	2		1	7	
4	2	5	1		2	7	
1	1	5	1		1	6	
1	1	5	1		2	6	
3	2	6	1		2	1	
7	5	6	1		1	7	
7	7	3	6		5	3	
6	1	7	2		1	7	
5	6	3	4		2	5	
4	5	2	5		2	5	
6	7	6	5		1	7	

C.2 Tables that show the mean, variance and standard deviation of the AVPro

Values that measure the interaction						
Elements	Awkward	Normal	Appropriate	Rude	Distraction	Uncomfortable
Mean	4,9375	2,5625	4,875	3,5625	4,375	3,5
Variance	2,0625	1,0625	2,783333333	3,0625	3,05	3,333333333
Standard Deviation	1,436140662	1,030776406	1,668332501	1,75	1,74642492	1,825741858

Values that measure the user				
Elements	Curious	Isolated	Tech-savvy	Cool
Mean	5,875	4,375	4,8125	3,9375
Variance	1,316666667	3,05	2,429166667	2,995833333
Standard Deviation	1,147460965	1,74642492	1,558578412	1,730847577

Values that measure the device		
Elements	Useful	Unnecessary
Mean	2,3125	5,875
Variance	1,429166667	1,45
Standard Deviation	1,195477589	1,204159458

C.3 Tables that show the mean, variances and standard deviation of the Headphones

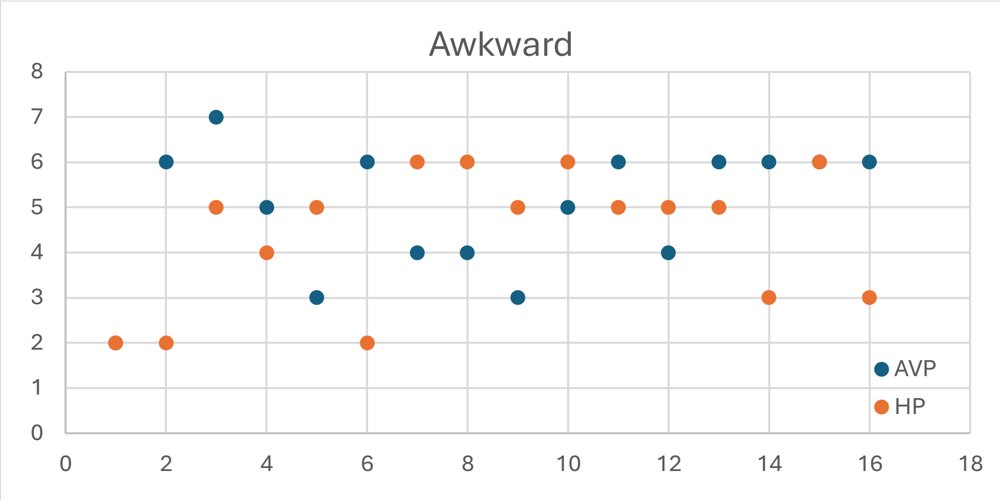
Values that measure the interaction						
Elements	Awkward	Normal	Appropriate	Rude	Distraction	Uncomfortable
Mean	4,375	3,25	2,875	3,9375	3,375	4,125
Variance	2,25	1,6666667	1,5833333	2,1958333	2,5166667	4,1166667
Standard Deviation	1,5	1,290994449	1,258305739	1,481834449	1,586400538	2,028957039

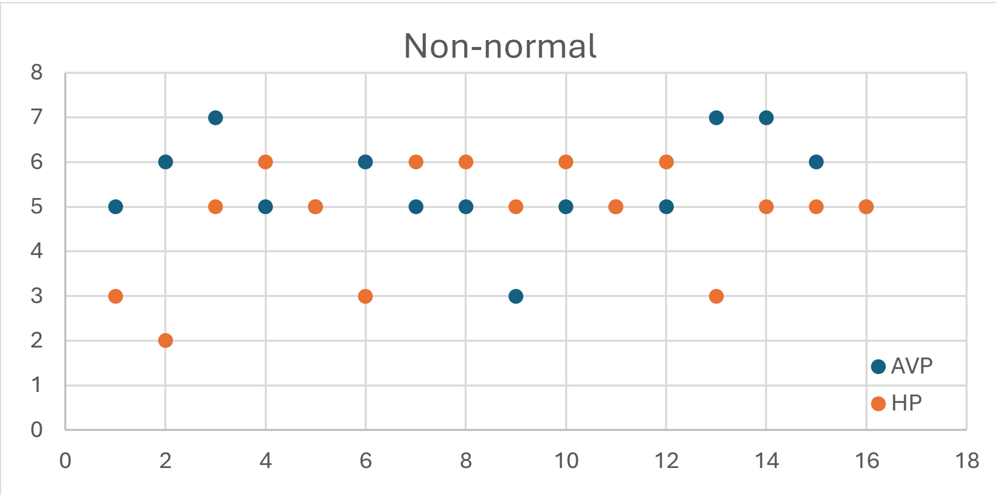
Values that measure the user				
Elements	Curious	Isolated	Tech-savvy	Cool
Mean	3,4375	3,5625	4,1875	2,0625
Variance	2,395833333	3,8625	2,829166667	1,2625
Standard Deviation	1,547847968	1,965324401	1,682012683	1,123610253

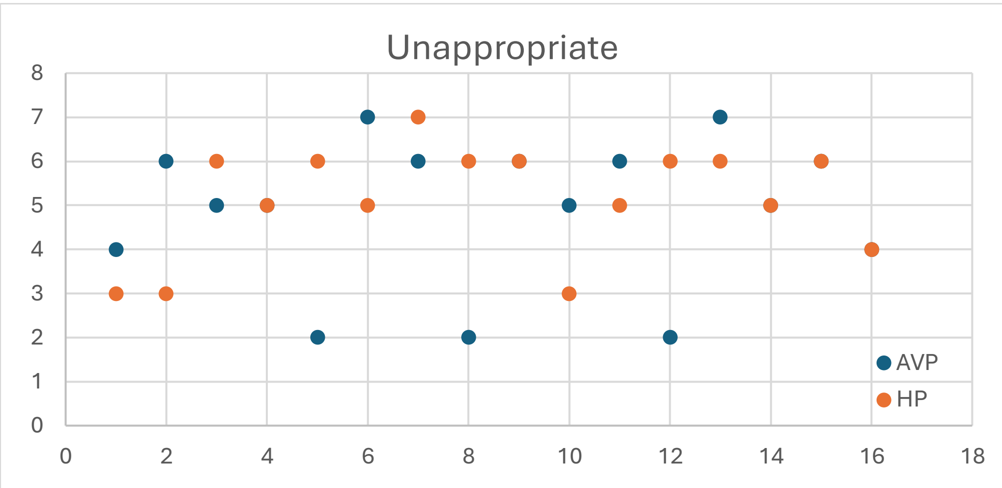
Values that measure the device		
Elements	Useful	Unnecessary
Mean	2,125	5,875
Variance	1,85	2,25
Standard Deviation	1,360147051	1,5

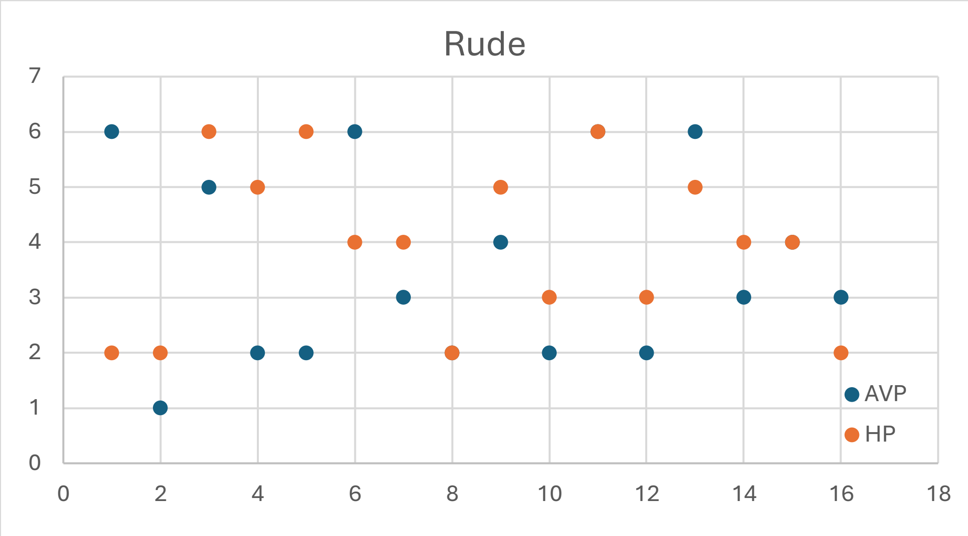
D. Plotted quantitative results

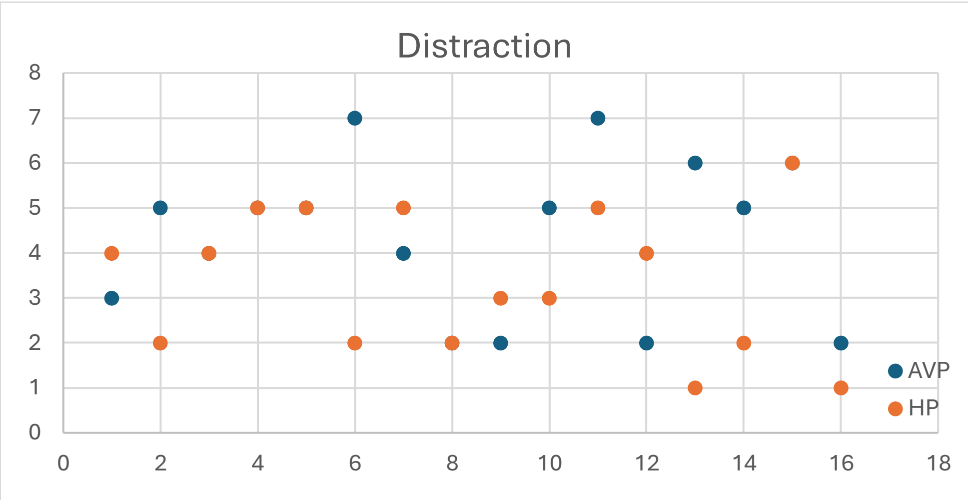
Category: INTERACTION with Cronbach's alpha of 0.72

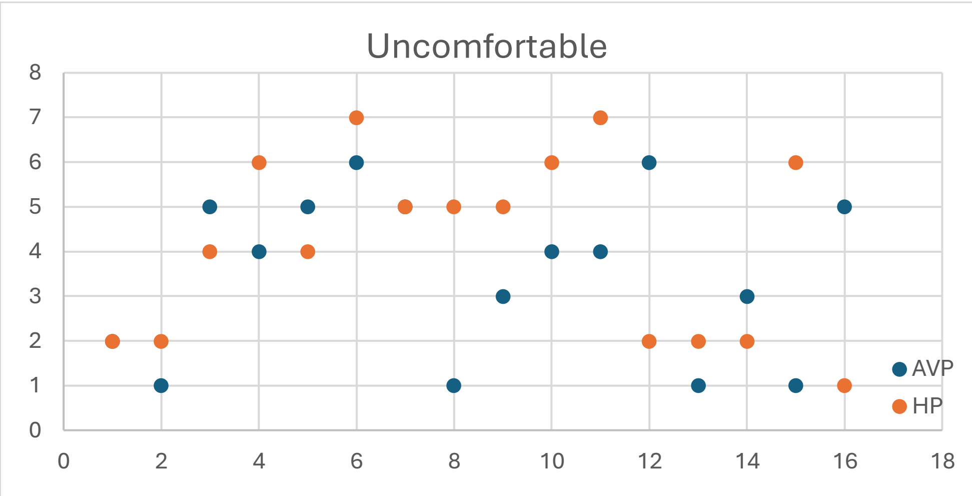




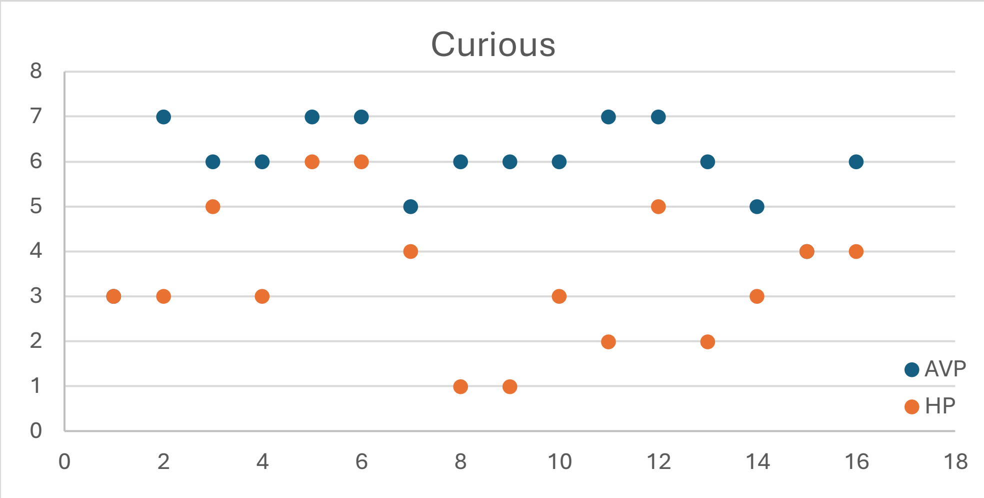


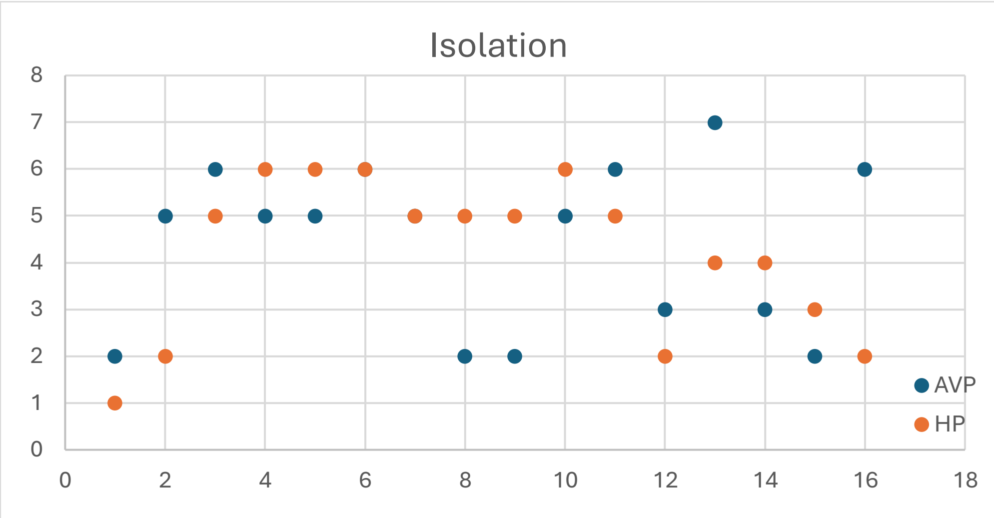

Rude
7
6
5
4
3
2
1
0
0
2
4
6
8
10
12
14
16
18
AVP
HP

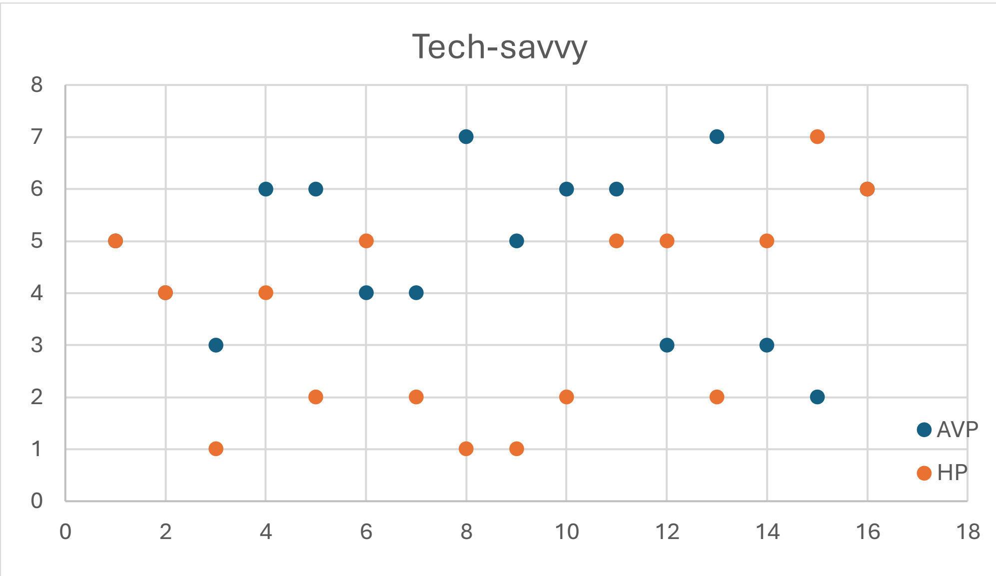

Distraction
8
7
6
5
4
3
2
1
0
0
2
4
6
8
10
12
14
16
18
AVP
HP

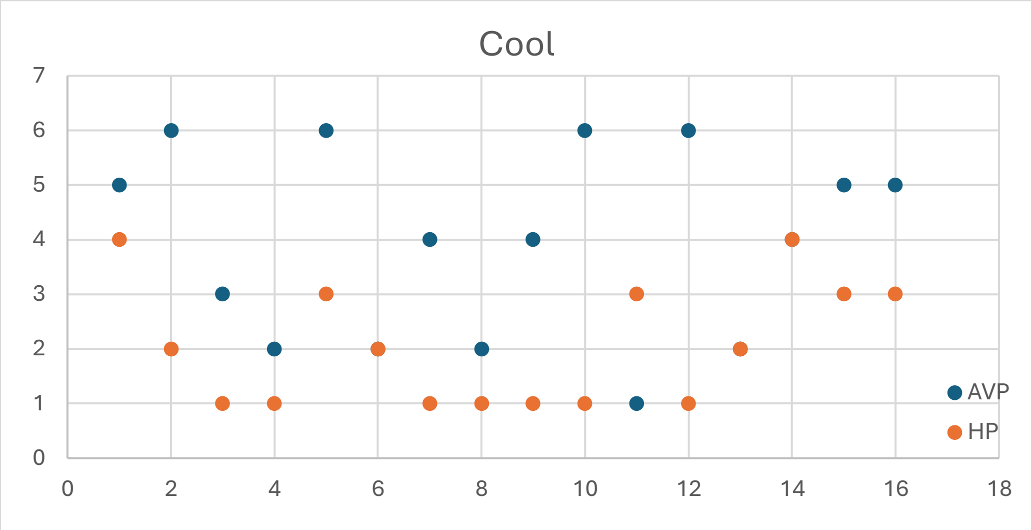

Uncomfortable
8
7
6
5
4
3
2
1
0
0
2
4
6
8
10
12
14
16
18
AVP
HP

Category: User, with Cronbach's alpha of 0.42 (when removing isolation 0.62)

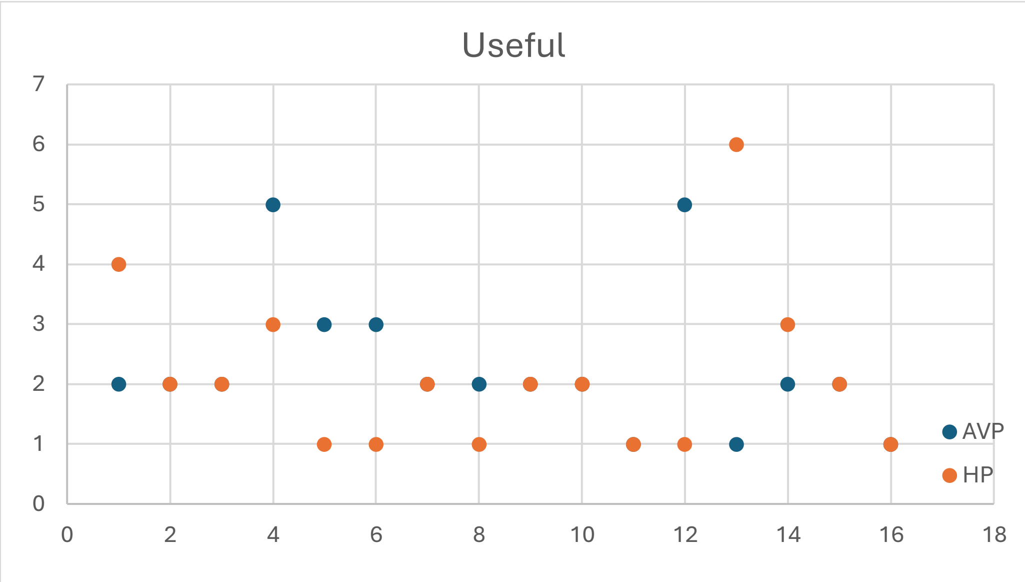


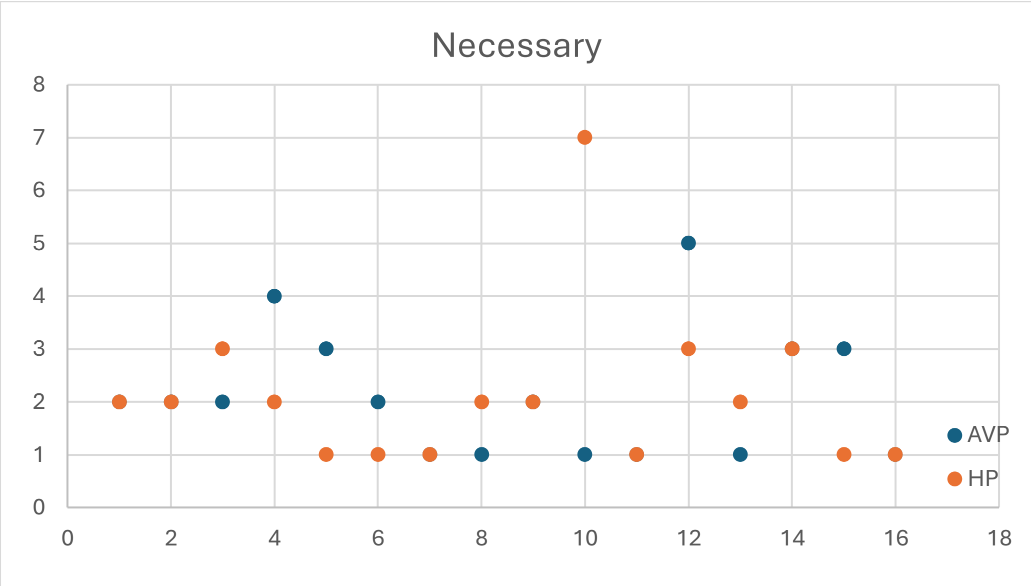






Category: DEVICE, with Cronbach's alpha 0.60





E. Dependent t-test of AVP vs. HP

INTERACTION		
t-Test: Paired Two Sample for Means		
	Variable 1	*Variable 2*
Mean	3,96875	3,65625
Variance	0,857422	0,333984
Observations	6	6
Pearson Correlation	0,041608	
Hypothesized Mean Difference	0	
df	5	
t Stat	0,714772	
P(T<=t) one-tail	0,253362	
t Critical one-tail	2,015048	
P(T<=t) two-tail	0,506725	
t Critical two-tail	2,570582	

USER: CURIOUS		
t-Test: Paired Two Sample for Means		
	Variable 1	*Variable 2*
Mean	5,875	3,4375
Variance	1,316667	2,395833
Observations	16	16
Pearson Correlation	0,182986	
Hypothesized Mean Difference	0	
df	15	
t Stat	5,571429	
P(T<=t) one-tail	2,67E-05	
t Critical one-tail	1,75305	
P(T<=t) two-tail	5,34E-05	
t Critical two-tail	2,13145	

USER: ISOLATION		
t-Test: Paired Two Sample for Means		
	Variable 1	*Variable 2*
Mean	4,375	3,5625
Variance	3,05	3,8625
Observations	16	16
Pearson Correlation	-0,1044	
Hypothesized Mean Difference	0	
df	15	
t Stat	1,176643	
P(T<=t) one-tail	0,128837	
t Critical one-tail	1,75305	
P(T<=t) two-tail	0,257673	
t Critical two-tail	2,13145	

USER: COOL		
t-Test: Paired Two Sample for Means		
	Variable 1	*Variable 2*
Mean	3,9375	2,0625
Variance	2,995833	1,2625
Observations	16	16
Pearson Correlation	0,13926	
Hypothesized Mean Differe	0	
df	15	
t Stat	3,890312	
P(T<=t) one-tail	0,000725	
t Critical one-tail	1,75305	
P(T<=t) two-tail	0,00145	
t Critical two-tail	2,13145	

DEVICE: USEFUL		
t-Test: Paired Two Sample for Means		
	Variable 1	*Variable 2*
Mean	2,3125	2,125
Variance	1,429167	1,85
Observations	16	16
Pearson Correlation	-0,18962	
Hypothesized Mean Difference	0	
df	15	
t Stat	0,37998	
P(T<=t) one-tail	0,354643	
t Critical one-tail	1,75305	
P(T<=t) two-tail	0,709286	
t Critical two-tail	2,13145	

USER: TECH-SAVVY		
t-Test: Paired Two Sample for Means		
	Variable 1	*Variable 2*
Mean	4,8125	4,1875
Variance	2,429167	2,829167
Observations	16	16
Pearson Correlation	0,294037	
Hypothesized Mean Difference	0	
df	15	
t Stat	1,296771	
P(T<=t) one-tail	0,107152	
t Critical one-tail	1,75305	
P(T<=t) two-tail	0,214304	
t Critical two-tail	2,13145	

DEVICE: UNNECESSARY		
t-Test: Paired Two Sample for Means		
	Variable 1	*Variable 2*
Mean	5,875	5,875
Variance	1,45	2,25
Observations	16	16
Pearson Correlation	-0,00923	
Hypothesized Mean Difference	0	
df	15	
t Stat	0	
P(T<=t) one-tail	0,5	
t Critical one-tail	1,75305	
P(T<=t) two-tail	1	
t Critical two-tail	2,13145	

F. Plagiarism and AI

During the preparation of this work the author used Grammarly in order to improve the clarity and readability of the text, by enhancing the read flow. After using this tool/service, the author reviewed and edited the content as needed and takes full responsibility for the content of the work.

During the preparation of this work the author used Zotero in order to make citation easier and have the correct APA structure for each citation. After using this tool/service, the author reviewed and edited the content as needed and takes full responsibility for the content of the work.

During the preparation of this work the author used ChatGPT in order to guide with the start of writing and by enhancing the read flow of the text and additionally, to ask questions or clarify assignments. After using this tool/service, the author reviewed and edited the content as needed and takes full responsibility for the content of the work.