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Title:

Theme:

Abstract:

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Project Period:
3rd semester

Project Group:
Group 310

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Copies: 1

Page Numbers: 1

Date of Completion:
November 15, 2022

Contents

1 Introduction

Getting a grip on the problem area - define the problem area - state how a new approach might be relevant - ends with the Initial Problem Statement

How can a virtual environment with a tailored player avatar help people with autism feel less emotional towards specific scenarios?

"Adolescents with AS often describe the computer as a comfortable and motivating medium." (kopieret fra en artikel, men man kunne finde og skrive noget om det her til intro måske)
Individuals with ASD tend to think in pictures rather than in words (god forklaring til hvorfor vi har tænkt os at bruge et virtuelt environment til scenarierne)

2 Analysis

Description of the problem - target group - a user study - related research/background work - state of the art (related commercial/academic work) - technical possibilities - how to evaluate/test (what methods do others use?) - early prototype test? - ends with the Final Problem Statement + Design Requirements

2.1 Initial research

2.1.1 Autism spectrum disorder

Autism spectrum disorder (ASD) refers to the disorder a person might have when showing impairments in social communication and repetitive behaviors or restricted interests. This person will often land somewhere on the autism spectrum, dependant on how the challenges a person with ASD might face, is expressed. Therefore, the disorder is highly specific to the individual and no two people will have the exact same perception of what is difficult or challenging, although there is bound to be overlaps between individuals. These challenges can range from mild to moderate to severe (Sandahl 2022). In addition to these core symptoms, nearly 75% of individuals with ASD suffer varying comorbidities from other psychiatric or neurological disorders such as anxiety, ADHD, depression, and others. A diagnosis is reached if an individual demonstrates symptoms of difficulties with social interaction and communication, limited interests and repetitive behaviours. These symptoms can come to light by obtaining a developmental history from the parents, and by observing the individual interact with others (Sharma, Gonda, and Tarazi 2018). Due to the neurological underdevelopment in individuals with ASD, they will experience struggles with social, emotional and daily living skills. One very common symptom in people with ASD is emotion dysregulation (Samson et al. 2015).

2.1.2 Emotion dysregulation

Emotion dysregulation is a term used to describe emotional responses which are poorly regulated - these could include problematic emotional responses such as tantrums, anger outbursts, disengagement in situations, anxiety, and elevated negative emotions. The intensified level of emotion may adversely impact the daily functioning, quality of life and long-term outcomes in the individual (Samson et al. 2015), and may lead to other disorders such as depression (Morgan, Izard, and Hyde 2014). Some coping mechanisms individuals with ASD rely on are maladaptive or idiosyncratic strategies such as avoidance and venting or defense and crying (Samson et al. 2015). Emotion dysregulation is not a criterion for ASD, however parents have noted these problems in their children with ASD (Samson et al. 2015). Additionally, clinical reports have provided evidence that more than 60% of youth with ASD exhibit behaviours of severe impairments in emotional functioning (Samson et al. 2015). Having regular emotional abilities are crucial for optimal functioning, because it enables an appropriate response in social interactions, and makes the individual able to cope with changing situations or stimuli (Samson et al. 2015).

Adults with emotion dysregulation will have a harder time regulating negative mood states and accessing strategies for regulation. However, research suggests that the ability to regulate one's emotions is not due to impairments in the individuals regulation abilities, but instead due to their own perceived lack of ability to produce the emotions they desire (Carthy et al. 2010). The problems associated with emotional deregulation in individuals with ASD lays the ground for exploring methods that could help ease such emotional responses in daily living situations.

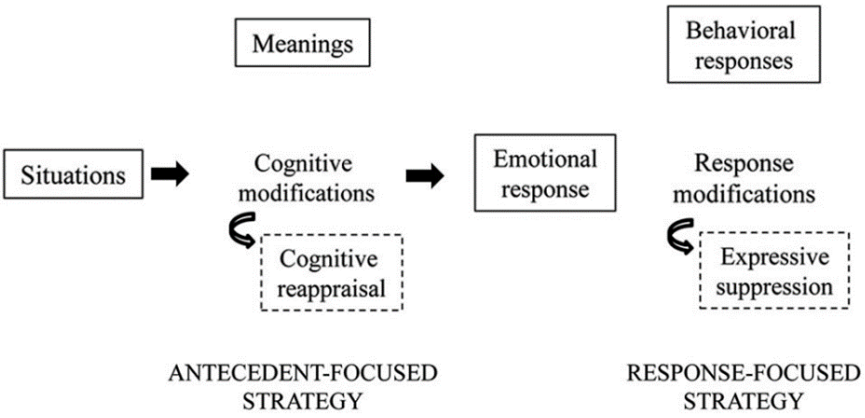

Figure 1: The process of emotion regulation. It can be divided into the components of situations, meanings, emotional response and behavioral response. The meanings of the situations can be changed by cognitive modifications, to change the emotion being produced. The behavioral response is influenced by response modifications. The strategy of cognitive reappraisal is used early in the regulation process Cutuli 2014

The process of regulating ones emotions can be seen in figure 1. The meaning of a situation is interpreted by the cognitive system and is influenced by cognitive modifications. After the meaning has been formed, the emotional response to the situation will be generated. The behavioral response is then based on the emotional response, in addition to response modifications. One strategy that can be used to change an emotional response is cognitive reappraisal. It is defined as an antecedent-focused strategy, meaning that it is applied as a cognitive modification, before the emotional response is generated (Cutuli 2014). Thereby emotional situations can be managed by modifying the emotional response, before it even has been generated. In contrast there are the response focused strategies, which are performed after the emotion has been generated. This happens late in the emotion regulation process, and only modifies the behavioral aspect of the emotional response, without reducing the subjective experience and negative emotion, thereby it can lead to the emotion continuing to linger and remain unsolved(Cutuli 2014). One such strategy could be expressive suppression which has been shown to be a common coping strategy for individuals with ASD (Samson et al. 2015)

Cognitive reappraisal has been shown to be the most effective way of regulating ones emotions, and is frequently used to reduce the negative ones (Uusberg et al. 2019). Cognitive reappraisal involves the process of recognizing the negative pattern of your thoughts, and changing the pattern to a more positive or neutral one. This is in practice done by examining a situation or activity again in order to make changes to ones emotions about it. Changing the course of thoughts can in turn change the course in emotions. Studies of emotion regulation suggest that reappraisal is often an effective mean for achieving emotion goals without side effects. Day-to-day reappraisal use has been found to correlate with higher levels of well being (Uusberg et al. 2019). It has also been found that Adults with ASD use cognitive reappraisal less frequently than others. Instead they tend to use strategies that suppress their emotions, which are seen as maladaptive in the long term, if it is the only coping mechanism used (Samson et al. 2015).

Carthy et al. (2010) created a way of determining the rate at which a person uses cognitive reappraisal as a coping mechanism. The method created was named the *Reactivity and Regulation situation* task, where 16 tasks were written out. The tasks created were all everyday-life situations that could potentially have a threatening meaning for the individual. Examples of the situations described were: *Your mother was supposed to return home from work but she is late, you are sitting in a group and your turn to introduce yourself is coming, your teacher hands you back your test and she says she is surprised, on your way to school you feel strange in your tummy.* The individual should then answer their first thoughts about the situation, rate their emotions on the negative emotion rating scale, and finally answer what they would do to calm themselves. Afterward, they were introduced to the idea of emotional reappraisal. Finally, the individual was given the same scenarios again with the instruction to reappraise it, now with the question "*Would reinterpreting the situation improve your feeling?*". To calculate the negative emotions in the situations, an index of negative emotional reactivity was calculated. This was done using the negative emotion rating scale to find the index. If a person responded negative appraisal in eight out of 16 situations, they would get an index of 0.5.
Due to this project focusing on individuals with ASD, it could be difficult for the individuals to picture themselves

in written out scenarios, as it has been found that individuals with ASD tend to think in pictures rather than in words while also lacking perspective taking abilities (Samson et al. 2015). Therefore, a different medium for the scenarios will be used.

Based on this, cognitive reappraisal will be displayed for the individuals with ASD, as the way of helping them feel less emotional towards certain scenarios. Some of the tasks represented in the Reactivity and Regulation situation tasks, will be used as inspiration for the scenarios to be displayed in the virtual environment. The approach of computing a negative emotion to a given scenario by using the negative emotion rating scale, will be used to asses the individuals emotions for each scenario before and after reappraisal.

2.1.3 Reasoning for video game as the medium

As people with ASD have been proven to think in pictures rather than words, we chose to look at video games as a more visual medium to affect the cognitive reappraisal of the target individual. A study done by Tréhin 2004, depicts 5 reasons for how and why a video game can be useful for people with cognitive or learning impairments:

- **A computer does not react like a person:** A computer's behavior is more easy to predict than a person for the individual with ASD.
- **A computer can be programmed to create very stable pictures:** It is possible to create environments with less visual clutter, and more clear pictures using objects, that is easier for the person with ASD to process.
- **A computer can be programmed to create very stable sounds:** Will not prove relevant to this project, but computers provide a platform to teach the spoken language which can be a complicated learning process for people with ASD.
- **A computer provides a wealth of input/output devices:** A computer is able to take and use input such as keyboard/mouse, touch, and the digital camera.
- **the computer is a mean of communication:** The computer provides a communication interface both on the internet as well as in video games that isn't as intrusive to the person with ASD as an in person conversation.

Due to the evident advantages that the video game has as a medium for an invididual with ASD, we will go ahead with the idea of developing a video game that can improve the cognitive reappraisal process of the target group. Further details into the relevant medium will be researched in the related research section of the report.

2.2 Target group

The development of emotion regulation skills starts from early childhood and carry on into adulthood. In these years the individual acquire a large range of emotion regulation strategies such as problem solving and cognitive reappraisal (Samson et al. 2015).However, if the strategies learned only focus on maladaptive strategies, this will lead to lower levels of well being in their daily lives. As stated above, this is a common problem in individuals with ASD.

In addition to this, the identified prevalence of children with ASD has been increasing over the past two decades with estimates from 2018 indicating that it affects 1 in 36 children (Sharma, Gonda, and Tarazi 2018), hence there is an increasing need for services that help support them in their daily lives.

Therefore, the target group for this project will be children to adolescents with ASD, as to help them learn coping strategies that they can carry with them into adulthood.

2.2.1 Meeting with Expert at MerVib

To get in contact with the target group, a meeting was conducted with the headmaster of Mervib, a residence for children with ASD-disorder. In cooperation with the estimated target group, the headmaster stated that there is a huge difference in the learning ability between children and young adults compared to grown adults. Hence for the testing of the developed game, it was determined to test on the residents in the age range of approximately 12-20 years old. For constructing the everyday-life situations the player should go trough, different

uncomfortable situations the children between 12-20 with ASD-disorder were dealing with was dived into. The headmaster explained that the children had different types of problems, and some could be outwardly responsive. The children presented different situations and explained why the situations made them uncomfortable. The situations were then categorized:

1. **Distractions when concentrating:** A reoccurring uncomfortable situation repeated by most of the children was the situation surrounding concentrating about something, when other sounds or distractions occur in the background. In this situation the children would get irritated, leading to them not being able to concentrate, and instead get angry. The situations mentioned were playing a video game and someone yelling outside, being at an exam where other people are tapping their feet or making other noises, not being able to fall asleep due to people talking.

2. **Confrontation:** Another uncomfortable situation that would frustrate some of the children was if another person did something that would frustrate them, causing them to having to confront the person about it, which would be nerve-racking. Examples of this included people at the residence not cleaning up after themselves, or if a person ate something from the fridge that was meant for someone else.

3. **Plans being ruined:** A different scenario which took place at a train station was described, here the individual was supposed to go on a train, however the train was delayed ruining the plans the individual had that day. The individual then had to figure out how to change their plans causing stress and anxiety.

4. **Bullying:** Some of the individuals at the residence have experienced being bullied, this leads to them feeling sad and like they aren't good enough.

In some of the situations mentioned it is possible to use the strategy of cognitive reappraisal to change the individuals emotions towards the situation. For example in the scenarios about confrontation the use of cognitive reappraisal could reinterpret the meaning of the situation. So instead of thinking that it is uncomfortable having to confront the person, the individual could think of it as being awesome that they now don't have to worry about that person being messy.

Another one of the situations in which cognitive reappraisal could be applied could be in the scenario of being bullied. Here instead of interpreting the meaning of why you are being bullied as not being good enough, instead you could think about the difficulties that has led to the other person bullying in order to gain an understanding and better relate to that person.

Finally

2.3 Game Design

2.3.1 Camera and controls

One of the most defining elements of a game is how the visual presentation is organized. Just like on a movie set, the game will be captured through a series of camera systems. How these systems are set up can make a critical difference for the outcome of your project. According to Senior Software Engineer Mark Haigh-Hutchinson, you should strive for a camera system that is almost unnoticeable by the player, however difficult that may seem (Haigh-Hutchinson 2005).

The changing nature of a game requires a system capable of presenting this in a precise and appealing manner. The multiple cameras present in a project should be interconnected, and the system should be able to switch between them fluently, as changes to the player and the environment occur. These camera switches could prove helpful in a game where you are meant to identify with a character by having interactive scenes and non-interactive cutscenes.

Camera Fundamentals
A game camera can be of different types - the simplest being the interactive and cinematic camera.
Interactive cameras respond to real time events, i.e. a player input or a game-specific event. As such, the camera behavior must compensate for the randomness and variability of these inputs (Haigh-Hutchinson 2005). This type of camera would therefore be used when the player is in control of the input that the camera has to adjust to.

Cinematic cameras can be compared to a virtual version of their real world counterparts, with whom they share common ground. They are often used to cue the player that they are not in control of their character during cutscenes - these scenes often emulate traditional film cameras, with the addition of being unrestricted by the physical rules present in a real world setting (Haigh-Hutchinson 2005). This type of camera can be used to show a certain state or specific details of the character that the interactive camera would not allow for.

How you want to present a given game world will be a defining factor for the characteristics of your camera's *presentation style*. This is commonly referred to as 2D, 3D, and the hybrid 2.5D cameras. Whichever you choose will determine the calculations and coordinate transformations on a programming and rendering level (Haigh-Hutchinson 2005), not to mention the distinct look associated with the chosen style.

2.3.2 Serious Games

With the growth the gaming industry has seen, the main purpose of many video games has been expanded to not solely entertain the player, but also to educate and train them. These types of games are known as "Serious Games", and can be applied as a medium for learning.

A study by Laamarti, Eid, and El Saddik 2014 delves into which areas serious games can be applied to and what specific elements of media and game design, a serious game consists of. Serious games' appliance is wide and includes education, training, well-being, advertisement, cultural heritage, interpersonal communication, and health care (Laamarti, Eid, and El Saddik 2014). Five principles to look at when attempting to analyze or make serious games are as follows:

- **Activity:** The way the player is meant to handle the game. A game meant for weight loss might have the player do physical activity, whereas a game meant for people with anxiety is meant to mentally challenge the play.
- **Modality:** How the game communicates a message to the player, be it a challenge or general knowledge. Laamarti, Eid, and El Saddik 2014 describes it as "*Most research agrees that digital serious games contain different media, which can be a combination of text, graphics [29], animations [30], audio [31], haptics [27, 32], and so forth.*". When making a serious game, it's important to utilize the medium's many ways of communicating.
- **Interaction Style:** What kind of input the game is built for. For a normal game on the computer the standard interaction style is either mouse or keyboard using WASD for movement or both. For VR games, the player would need a VR controller alongside a VR headset. For old consoles, a simple joystick would be the norm. This can also be affected by the target group, and what they're capable/familiar with using.
- **Environment:** A video game can be either 2D or 3D, first person or third person. Furthermore, a game can be set in a mixed or augmented reality. Additionally, a game's environment might be dictated by whether it's a singleplayer or multiplayer game.
- **Application Area:** The reason that the game is being built. There are too many application areas to mention all but a few examples include if the game is about combating obesity, then the application area would be health care and well-being. If the game is meant to teach school kids how to calculate, then the application area would be education (Laamarti, Eid, and El Saddik 2014). This principle defines what the game is meant to accomplish.

With these design principles, a serious game should be able to convey a message or enhance the player in some way applicable to the real world.

2.3.3 Principles for designing games for individuals with ASD

As the focus of the game is to help down regulate negative emotional responses in individuals with ASD, some guidelines for the design must be adhered to. Carlier et al. (2019) examined how to make a game that eases stress and anxiety in children with ASD. In this regard, they gather useful suggestions to include in the game, from other studies. The guidelines mentioned were:

- **Customizability:** The game should be customized to the person playing.
- **Evolving tasks:** The motor and cognitive-related tasks in the game should increase in difficulty.

- **Unique goal:** There should be a goal to reach during the game.
- **Instructions:** The game's goals and tasks should be clear to the player and understood without too much text and language.
- **Reward:** Good performance in the game should be rewarded with music and animations
- **Repeatability and predictability:** When learning a new skill, repeatability is very important and creates predictability for the goals in the next gaming session.
- **Transitions:** The transition time between different scenes in the game should be short and simple so the player does not lose concentration.
- **Minimalistic graphics and clear audio:** The graphics and the audio in the game should be kept simple, without too many unnecessary colors and impressions.
- **Dynamic Stimuli:** Animations and music can keep the player's focus, whereas static visuals should be avoided.
- **Serendipity:** Visual and audio feedback are good for increasing satisfaction in the game but should be consistent and predictable.

This project will aim to implement as many of these principles as possible, with some proving more relevant than others. Specifically, customizability should be implemented in order to cater to the individual playing the game. Furthermore, Rewards, Instructions, minimalistic graphics, and clear audio should be implemented as basic game elements which both eases and motivates the player.

2.4 Story telling

Humans, as a species, have been telling stories for millennia – in the beginning, the huntsman's tale of scouting suitable prey for days, leading to the cornering and final kill, would entertain and educate other tribe members. The greatest stories would be retold throughout generations, birthing legends, myths, and fantastic tales. Whether the stories sought to entertain, educate or enlighten, they have been a key factor in shaping our world and our way of thinking. Today, stories are more widespread than ever, appearing everywhere from the books on our shelves to our favorite shows on television. The available supply has steadily increased from our humble beginnings to a nearly endless supply of both the mundane and the legendary. Naturally, our ability to sort the quality stories from the boring has increased along with it, making it exponentially more difficult to develop an interesting and immersive narrative (Lebowitz and Klug 2011).

Enter video games – a nascent medium, providing opportunities for different approaches to storytelling. Despite its young age, some of the most intriguing, accomplished, and iconic tales have unraveled within these digital worlds of wonder. From the 1981 title *Donkey Kong*, widely considered to be the first story-based video game, to today's elaborate and deep open-world RPGs, such as *Fallout: New Vegas, The Witcher 3, and World of Warcraft*. The medium provides an element that is difficult to reproduce in other storytelling media – user interaction. Providing the player with the ability to interact with the world presented to them lets them experience the story in a whole new way.

2.4.1 Narration and navigation in video games

Narration means telling a story. It can be meant both literally, where a person or character narrates a story, or more figuratively, where the story is told through the medium's design choices, setting, or the decision-making of the characters. Even though *ludologists* and *narratologist* are in a fundamental disagreement whether or not video games in general, have a narrative, both parties can accept that at least some video games do have narratives (Domsch 2013).

In video games specifically (that contain some form of narrative), narration can be applied in many different ways to tell the stories and intricacies of characters, as well as the decisions and the situations they find themselves in. Since a video game includes a player, the decisions and/or actions of the player should enforce the narrative, the game is trying to convey. Since the game designer would be able to tailor the game so that the outcomes of any choice the player might make would reinforce the overall story, this should be fairly easy to (somewhat) successfully execute. If a player is forced to choose between different options that will progress

the story, optimally, the consequences of the chosen option should make itself known in the story afterwards. This principle is also known as "Chekhov's gun" (Tikhonov and Yamshchikov 2021), a term which origins from theater back in the late 1800s. In its essence it translates to: "*if a gun hangs on a wall in the first act, it must be fired in the last act*" - or in other words - there is no reason to include something, that is not going to be used later. This has been translated to several different storytelling media since, and is a way of making important details or the decisions of the characters involved in the story, clear and streamlined for the audience/player. In role-playing-games, this often leads to non-linear (branching) stories, where actions early in the game might have decisive outcomes later in the story (i.e. Skyrim's choice between the Imperials or the Stormcloaks or choosing who to side with in Fallout: New Vegas).

A game does not necessarily need an actual narrator to guide the player into these choices, but the game's environment and the characters inside the world can lead the player into a call to action (Bloom and Hobby 2009). With that said, actual narration - either by *a* or *several* non-playing-character(s) (henceforth NPC(s)) or an all-knowing narrator (Buckland 2020) can be an enormous asset to the story, since it allows clear guidance throughout the medium's environment. It can be used to paint a clear picture of the actions of the characters within the world, give the player the context needed to understand the world, ease or thwart (whatever is required for the story) the decisions of the players and generally make the world as easy to understand and dive into as possible. An all-knowing narrator can be an important character for the story if need be, but even if it is not, it can ease the burden of taking on an entirely new world for the first time.

2.4.2 Building a story

In both film, TV, theater and video games writers and creative directors will use *moodboards* to get an idea of the environment of a scene. Moodboards are essentially several different images that help sculpt the scene. These are usually made relatively early in a project to underline important features or "moods" that the scene needs to fulfill. An example of a moodboard could be a scene in a film, that plays out in the courtyard of a castle but they can be used for many different projects that requires some sort of visual outcome (Bakalchuk et al. 2022). For everybody to follow the same vision of what the castle should look like, different images of castle courtyards and castle exteriors are gathered into one image, so that the people of the project do not imagine the scene differently. This also has the benefit of helping the location scouts, decorating teams, the director and the cinematographers to figure out how to use what they have, to get the result they are looking for visually. Moodboards and concept art are both used in video games as well for the same reasons. Depending on the size of the project, the team might not have decorators or location scouts, but instead artists that sculpt the world and its environment, whom will have a much easier time making the world feel coherent with itself if the shared vision for the project is already visualized.

Other than moodboards, "*storyboards*" are used in creative processes as well. The purpose of these are not necessarily to project a shared vision of the visual outcome of the project, but instead to create a visual representation of the storyline and arcs of the story (Vinke 2016). These usually come in form of a "sketchy" comic-strip, where each window represents a key shot in the project, however, storyboards can in principle be any visual representation of important points in the story's progression, depending on what the creative process is and what is necessary. In video games, storyboards can be used to represent the progression of the story's important scenes. Both moodboards and storyboards help creating and sharing a vision of a project - both story-wise, visually and in regards to the mood of the scenes. They serve to reduce the workload on the project by reducing the amount of work being made that contradicts the rest of the project, and thereby help formulating thoughts and ideas.

2.5 The effect of avatar appearance on player behaviour

Due to this project focusing on the process of cognitive reappraisal, it could be useful to know how the player of the game can better relate to the scene they're placed in. Therefore, an exploration of how the player avatar affects the behavior of the player would seem relevant, as the player avatar is the element of the game that the player should feel the most connected to when playing.

Numerous studies have been made in cognitive physiology, proving that behavioral realism can be used in a VR environment to help users improve skills. This report focuses on assessing if the physical realism of the player avatar and environment has the same effect, on improving their cognitive reappraisal. For the user to improve upon their emotional responses to certain situations, they would have to portray the same behavior in the virtual environment as they would in real life. For this, research has been been made suggesting that the player

avatar has an effect. Yee and Bailenson 2007, elaborate upon the reason why the appearance of an in-game avatar affects how we behave in the virtual world. They argue that one possible reason for this can be due to behavioral confirmation. Behavioral confirmation is referred to as the process whereby the expectations of the perceiver, causes the target to behave in ways which confirm the perceiver's expectations (Yee and Bailenson 2007). Thus, it is the perceiver's expectations that cause a change of behavior in the target.

However, another reason for the shift in behavior may also stem from self-perception theory which suggests that people observe their own behaviors to understand what attitudes may have caused them (Yee and Bailenson 2007). So, the behavior of the player may change solely depending on the way the avatar is being presented, independent of how it is being perceived by others. This theory was delved into in a study by Frank and Gilovich (1988). Here, subjects that wore black uniforms behaved more aggressively than subjects in white uniforms. Frank and Gilovich explained this phenomenon by the following *'Just as observers see those in black uniforms as tough, mean, and aggressive, so too does the person wearing that uniform'* (Yee and Bailenson 2007). Hence the subjects adhere with their new identity by becoming more aggressive. This effect has also been recreated in a virtual environment, where users given avatars in a black robe expressed a higher desire to commit antisocial behaviors than users given avatars in a white robe. Yee & Bailenson showed in their study that users will unknowingly and unwillingly adapt their behaviors to the appearance of their avatar (Ferstl, Kokkinara, and Mcdonnell 2018). They named this phenomenon the Proteus effect, which is a conjunction of the previously stated theories.

2.5.1 Avatar identification

When it comes to the proteus effect in games, Anna Praetorius & Daniel Görlich (2020), showed that it is closely linked with the concept of avatar identification, as the proteus effect is integrated with the concept of self-identity (Ferstl, Kokkinara, and Mcdonnell 2018). In a study by Sabine Trepte & Leonard Reinecke (2010), it is shown that for character development the player goes through estimates of the gameplay before it even happens. In that evaluation the player tries to determine how the character should look and act in order to make the character fit the story, the player wants to create based on their own prerequisites, which shows the connection to the proteus effect in a game environment. Player avatar identification (PAI) is a term that was introduced in a study by Dong Dong Li & Albert Kien Liau & Angeline Khoo (Li, Liau, and Khoo 2013), here it was used to encourage the player to experience appeal and alluring emotions towards a character to achieve identification through the character in order to make the player experience emotions. Another aspect of PAI is that it is used to merge the player's self with compelling and fascinating characters and different personalities. PAI, was in a study by Van Looey described as one of three dimensions of identification, with the sub-component of self-similarity (Ferstl, Kokkinara, and Mcdonnell 2018).

- **Self-similarity** uses the assumption that similarity with oneself, will lead to a higher self-relevance since personal information can be used to adopt the expected behavior of the avatar. Therefore Self-similarity is seen as the most important component of player avatar identification.

As the self-similarity aspect is seen as the most important aspect for PAI, it is important to measure which outer characteristics are important when creating the tailored avatar. In an article by Ducheneaut et al. 2009, players were asked questions about their interaction with avatar creation systems across three popular virtual world games: *World of Warcraft, Maple Story, and Second Life*. In the survey, participants were asked if they use some of their physical features when creating an avatar. Only 32 percent of the participants answered that they did. The players were also asked to weigh different physical traits based on how important they are when customizing their avatar, on a scale from 1, meaning not important, to 5, indicating essential. Across the three games, the most important traits were:

1. Hair style and color
2. Facial characteristics
3. The body

The least important features were skin tone and shoes. When discussing the reasons for hairstyle and color being seen as essential physical features, the authors mention how much hair can affect a person's identity, including their style, personality, and occasionally ethnicity. Hair is also often very visible. Especially in games using third-person perspectives (Ducheneaut et al. 2009).

Another study which focused on the affects of character identification was by Katheryn R. Christy & Jesse Fox (2016). This study determined if the player experiences, presence and immersiveness in a video game, is affected by identifying with the character through a narrative perspective. The identifying process was measured through different parameters like Wishful identification, Self-presence, Social presence, Physical presence, and Sex. What they mean with a narrative perspective is that the player is able to interact with the video game's own environment and not mainly the interaction with the retold story presented through the environment. Trepte and Reinecke (2010) divide the player's presence in the game into three different subsections: Self-presence, social presence, and physical presence.

- **Self Presence:** Involve the feelings in which the user experience their virtual self as if it were their actual self. This corresponds to the self-similarity aspect explained by Van Looey.
- **Social Presence:** Feelings that involve the NPC's in the environment. Mostly the question of whether or not they are authentic, and closely represent real-world actors. As an example this could be done by including NPC's in the game who represented family members of the individual with ASD. Or by having the NPC's model the behavior of real life individuals- such as their movement.
- **Physical Presence:** Refers to the degree in which the user feels that they can interact with objects in the virtual world as they would with actual objects (Christy and Fox 2016). Hence for each scenario, the physical objects in the scene should match the way the scenario would play out in real life.

Each of these points positively related to identification with one's own avatar. For this to make sense, the avatar that is used inside of the game, should in some way be forced to look like the individual playing. This is due to the fact that not everybody makes character that is in align with their own physical characteristics. Hence when creating the virtual environment, the techniques used for creating the tailored player avatar will revolve around getting an input image of the user, and then transferring it into an avatar by using techniques from computer vision.

2.6 Computer vision

Computer vision involves the process of extracting information from images or videos, by an automated procedure (Erik Solem 2012). These procedures cover a wide range of possible usages, such as object recognition or detection, grouping and searching image content, the creation of 3D models etc. The advancements within the field has made it possible to integrate computer vision into systems, making it possible to increase what can be achieved.

As the aim of this project is to create an avatar based on computer vision, object detection will be explored, by using image analysis. Here the goal is to find objects of interest and then extract some parameters of the objects (Moeslund 2012). The general framework for image analysis consists of five procedures:

1. **Image acquisition**: Involves everything surrounding the setup and the camera. This could e.g. be that the person must stand at a certain distance from the camera.
2. **Pre-processing**: Involves the things done to the image before the processing begins, e.g. resizing the image.
3. **Segmentation**: The information of interest is extracted from the image, in the case of creating a tailored player avatar, this could be extracting the face of the user from an image.
4. **Representation**: The objects extracted are represented in some manner. The face could then be represented by it's bounding box.
5. **Classification**: Examines the information produced in the previous block, and then classifies each object as an object of interest.

The classification will then be used to map between the person and the avatar. System-defined mappings between an input photo and an output can be defined as a "semiotic morphism" (Kao and Harrell n.d.). A morphism is a mapping that preserves the structure of one set of data to another. The concept of mapping can be used to represent certain characteristics of a user. To do so however, information about the user's characteristics will firstly need to be extracted. Information about the characteristics of the human face, such as the size of the nose, eyes and mouth, can be gathered by 2 steps. Firstly using face detection to locate a human face in the input image and return the bounding box. Secondly after locating the position of the face, important points can be located inside of the rectangle.

2.6.1 Facial Detection

Face detection algorithms are an integral part of facial analysis systems. These algorithms can detect the human face part of an image. There are many challenges in the problem of face detection such as pose variation, illumination, expression variation , facial hair, image resolution etc. (Jadhav et al. 2021). There are several different approaches to creating a face detection algorithm such as *Cascade classifier, MTCNN, Dlib HOG, Dlib CNN, etc.*

The Dlib HOG model was originally created with the purpose of detecting humans in an image, but is now one of the most widely used models for face detection (Jadhav et al. 2021). It is based on the Histogram of Oriented Gradients (HOG), which is a feature descriptor for the purpose of object detection (Axis College of Engineering and Technology, Joseph, and Pradeep 2017). The idea behind HOG is to describe the structural shape and appearance of an object, and then give that information to a classification algorithm. Dlib uses the SVM or support vector machine algorithm for simplicity and speed, which is a linear model for classification and regression problems. SVM can then asses if a an object with the structure of interest is present in a region or not. (Jadhav et al. 2021)

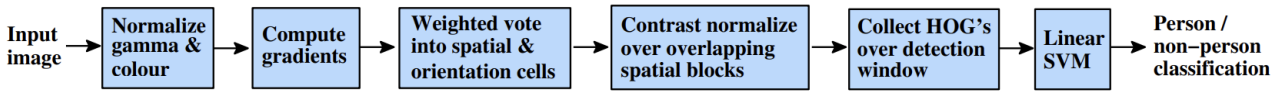

Figure 2: The Dlib HOG feature extraction and object detection chain. The detector is tiled with a grid of overlapping blocks where Histogram of Oriented Gradient feature vectors are extracted. The combined vectors are then fed to SVM for object classification (Dalal and Triggs 2005).

The reason for computing the HOG is that local object appearance and shape can often be characterized by the distribution of edge directions (Dalal and Triggs 2005). The Dlib HOG face detection algorithm follows an object detection chain which can be seen in Figure 2. The steps of the chain will be descried below:

Normalize gamma and color
As a pre-processing step, gamma-mapping can be used to increase or decrease the luminance in dark and light levels of an image individually. This is a useful step when dealing with images that have bad illumination. For the color representation it was found that RGB and LAB color spaces have the highest efficiency (Dalal and Triggs 2005). It should be noted that this step in the detection chain is not always done, as it only has a modest effect on performance (Dalal and Triggs 2005).

Compute gradients
The next step is to calculate the gradient for every pixel in the image. The gradients of the image are computed since, they provide the additional information of edge directions, compared to only computing the edges of an image. The gradient can be defined as the slope of the curve at some point. Each point of an image have a gradient in the x-direction, and the y-direction. These two gradients span a plane (The tangent plane), which intersects the point. The resulting gradient is then defined as $\overrightarrow{G}(g_x, g_y)$ which is the direction.

Correlation is used to compute the all of the gradients of the image, by applying a 1×3 kernel to each pixel. The kernel is applied in both the vertical and horizontal direction, to detect the gradients of both x and y. Dalal et al. (Dalal and Triggs 2005) found that a centred $[-1, 0, 1]$ mask works the best.

Constructing the HOG
Steps 3, 4 and 5 in the feature extraction chain (figure 2) are all a part of building the histogram and will therefore be explained together in the following section.

When constructing the HOG, the image should be divided into 8×8 cells, therefore in practice, the image should be resized to a 1:2 ratio in the pre-processing step. The HOG of an image is then computed by dividing the image window into small regions called “cells”, to make the HOG more robust to noise. Then a HOG is computed for each cell.

This is done by estimating the direction of a gradient in a certain region, a histogram of $8 \times 8 = 64$ values is build of the gradient directions and their magnitudes (64 values). The categories of the histogram, correspond

to angles of the gradient from 0 to 180^o where 9 categories are defined $0^o, 20^o, 40^o, ..., 180^o$.

Then the 2 values of Direction Magnitude are found.
The direction is then used to figure out which of the 9 categories, the magnitude of the pixel gradient should contribute to. There are 3 subcases when building the HOG:

1. The angle is $< 160^o$, and not directly in the middle of 2 classes. For this case the magnitude will be added to the right category of the HOG.
2. The angle is $< 160^o$, and directly in the middle of 2 classes. For this case the magnitude will be contributed equally to the 2 nearest classes, and the magnitude will be split in 2.
3. The angle is $> 160^o$. For this case, the magnitude contributes proportionally to 160^o and 0^o.

After this process, the HOG features of each cell are now created. However, these gradients are sensitive to the overall lighting. This means that some portions of the image could be very bright compared to others. For better invariance to illumination, each histogram of each cell should be contrast-normalized. This contrast normalization can be done by accumulating a measure of local histogram "energy", over larger spatial regions denoted "blocks". Now when combining each of the descriptors from the blocks, the HOG of the entire image is created.

Linear SVM
After collecting all of the data, the SVM classifier can then be trained.

2.6.2 Facial landmark detection

After getting the bounding box of the location of a person's face in an image, it is possible to identify the locations of important regions inside of it, such as the nose, eyes, mouth etc. This process is called facial landmark detection. As a standard, facial landmark points normally provide 68 (x, y) coordinates.

Vahid Kazemi and Josephine Sullivan (Kazemi and Sullivan 2014) created the *One Milisecond Face Alignment with an Ensemble of Regression Trees* which they confirmed produced the highest quality predictions, of facial landmarks, while being more efficient than the best previous method (Kazemi and Sullivan 2014). Therefore the basics of this algorithm will be looked into.

The proposed algorithm is a Regression-Based method, and utilizes a cascade of regressors. The idea of the algorithm is as follows - In an image I, $x_i \in R^2$ facial landmarks can be defined, where the x_{ith} facial landmark has the coordinates x, y. The vector $\mathbf{S} = (x_1^T, x_2^T, ..., x_p^T)^T \in R^2$ denotes all of the facial landmarks in the image I. The vector **S** is also referred to as the shape. The shape is computed by using the regressors. Every regresssor $r_t(.,.)$ in the cascade of them, predicts a vector from the image and adds the prediction to the current shape estimate, thus resulting in an improved estimate of the shape. Hence, if $\widehat{S}^t$ is the shape estimate at the current time then:

$$\widehat{S}^{t+1} = \widehat{S}^t + r_t(I, \widehat{S}^t)$$

The regressor r_t makes the prediction based on features such as intensity values from I, which are then indexed relative to the current shape $\widehat{S}^t$. Each regressor r_t is then trained using an algorithm. The process is done when each r_t combined, provides sufficient accuracy.

2.6.3 Object detection with ML

The detection of objects in video or images is a computer vision task that in recent years have been influenced by progress made in Machine learning. A subset of machine learning is deep learning, and works by simulating the human brain. It learns from data, by using algorithms to train a neural network.
A neural network is a series of algorithms undertake the task of recognizing relationships in sets of data. A neural network can be trained to recognize numbers, images, voice etc.

INDSÆT FIGUR
A neural network primarily consists of an input layer, an output layer and hidden layers between the 2. A deep neural network is defined as having more than one hidden layer.

- **The input layer** uses large amounts of data to build the neural network. For the application of this report, the data will be in the form of images.

- **The hidden layer** processes data by complex computations. This layer carries out feature extraction, and passes the value to the output layer.
- **The output layer** uses activation functions that decide which neurons should be activated. This will decide whether the neurons input is important in the prediction or not. It then outputs a predicted output that can be a numeric or categorical value.

Hence for the purpose of recognizing e.g. the shirt of a person, The output could be a binary classification with the number one classifying a shirt.

2.7 State of the Art (intro skal lige rettes når hele sota er færdigt :))

To be able to create a game where the player would be able to handle difficult situations regarding ASD-disorder, it is important to look at what has worked in previous studies. A lot of different opportunities were able to pick out, since there is a lot of different games made for people with ASD-disorder, but in this study, it is necessary to pick out other studies where the focus was on decision making and other cognitive aspects like emotional training and partially social skills and behavior skills.

2.7.1 Mindlight

Mindlight is a single-player PC-game from 2020 which was created to help children with anxiety symptoms. It focuses on cognitive and behavioral training and has been used in other studies for children with ASD-disorder as a game in the Serious Game category. Even though Mindlights purpose is focusing on anxiety disorder, ASD-disorder is often followed with anxiety and depression traits. In (Wijnhoven et al. 2015) they discovered that children in the age of 8-16 years old are showing a decreased amount of anxiety levels in the expanded over 3 months compared to the children that were under controlled conditions. Therefore, Mindlight turns out to be an effective tool to train the ability to control anxiety levels for children with ASD-disorder.

Mindlight is working with multiple evidence-based approaches like relaxation and mindfulness strategies. It allows the player to be immersed and do different tasks throughout the game while being exposed to neuro-feedback training. In (Wijnhoven et al. 2015) the study shows that through neurofeedback training the player is experiencing exposure techniques. The player is exposed to different anxious components to be inhabited with at different anxiety levels and furthermore becoming more comfortable with situations that can increase anxiety for the player. The game also provides visual tools to stimulate the automatization of daily tasks that would normally occur in life. Mindlight falls under the category Serious Games because it has been developed as therapy for children with anxiety disorder. Thus, the application area can be speculated to be that of health care and well being. Besides the fact that Mindlight helps the player tackle their anxiety through exposure techniques, it also provides the player to gain focus on the positive aspects of the game, for example the setting.

In Wijnhoven et al. 2015 the main purpose of the study is to investigate if the serious game MindLight can reduce different types of symptoms of anxiety for children with ASD-disorder. What they discovered was that the children with ASD-disorder that have played Mindlight over a time span of 3 months, had decreased anxiety symptoms after a 3-month period. The reason why the children showed lower anxiety symptoms could be a result of being trained in neurofeedback training through exposure techniques and being provided with different visual aids to be better prepared for different obstacles in daily life.

What is interesting is how Mindlight is proven effective to help with cognitive behavioral therapy (CBT), the topics that can be drawn from this game lies between exposure techniques and relaxation training to give the player effective tools to cope with different anxiety traits. For example, Mindlight does not actively tell the player how to cope with anxiety, but the player will be trained by doing different tasks in the game in a playful manner. For that matter, the player will go through subconscious training and the purpose is to motivate the player to keep practicing different tasks to calm themselves when they are experiencing anxiety related emotions. Schoneveld et al. 2016. Another thing of note is that the game is based on different environments where the player is able to manipulate or modify these as a type of puzzle game. In detail the game takes the player through threatening situations with monsters but receives positive stimuli through the environment and active decisions. Wijnhoven et al. 2015. To sum up, it is essential for Mindlight to be a serious game and a game that is supported by cognitive training. The fact that it contains the aforementioned puzzles makes it so

that the player take decisions in possibly terrifying situations and is able to receive emotional stimuli through positive and possibly terrifying situations.

Figure 3: Mindlight: The relaxing game where the player works with bias puzzles through neuro-feedback training

2.8 Related Work

In order to have an optimized workframe when designing a game meant for people with ASD, other studies with the same target group could prove a valuable resource. Therefore, the approach of 2 specific studies was examined where one focuses on a longer testing of the emotional response of people with ASD to certain scenarios written down, whereas the latter focuses on immersive gaming experiences of people with ASD.

Samson et al. (2015) did a study for gaining a better understanding of emotional regulation in children with ASD. Where they measured the extent to which individuals with ASD were capable of using emotional reappraising once it was learned. Additionally, they measured if reappraising in a threatening situation yielded a reduction in levels of experienced negative emotion. The study was conducted on 22 people with ASD, and a control group of 22 individuals without it. The participants were asked to reflect on 16 different daily life scenarios that they might see as scary or nerve-racking. The 16 specific scenarios were from the Reactivity and Regulation- situation task created by (Carthy et al. 2010). This test was used to assess their emotional regulation. The situations were potentially nerve wracking regarding the aspects of *family, social, performance or physical.* The scenarios would be described by a few sentences on a computer and written using *"you"*, to encourage self-reference. Some of the sentences include examples like: *"You enter a store and the employee stares at you," "You are about to go out somewhere with a lot of people,"* and *"You hear a knock on the door and when you open it, you see a person you do not know."*

Then, the participants were told to read aloud one of the sentences and then reflect on what they would think if that scenario occurred and how worried they would feel from 1 - not at all, to 5 - very much. The scale was represented with circles of increasing size and redness - 5 represented a large red unhappy face. The five choices were also visualized with red circles increasing in size and color intensity. They were then asked, "what would you do to calm yourself down." They would do this for each of the 16 scenarios.

In order to assess which emotion regulation strategy was used for each scenario, the initial reaction the individual had to a scenario were used. The statements were then categorized into one of the following categories: *Avoidance, problem solving, distraction, cognitive reappraisal, suppression, relaxation, no regulation and not codeable*. To asses their emotions, the five item scale was used.

Afterward, the participants would be taught the idea of cognitive reappraisal and given examples thereof. It was explained in simple terms as a way people can change emotions, by changing the way they think about what is happening or has happened to them. One such example was a scenario where they should imagine that they are sick. Here the participant could focus on being able to stay at home and do stuff that they normally would not have time to do, instead of concentrating on being sick. The participants then had the chance to

practice “thinking differently”, once the participant was able to give an example of cognitive reappraisal, they were asked to use this strategy for each scenario.

Lastly, the participants were asked to go through each of the scenarios again, but this time they were encouraged to think differently about the scenario, and then rate their amount of anxiety from 1 to 5 again (Samson et al. 2015).

The study showcased that individuals with ASD benefited from the strategy of using reappraisal as a coping mechanism. However, they had a harder time using it than individuals without ASD. Furthermore, the individuals with ASD were able to use cognitive reappraisal to down-regulate their emotions to the same extend as the control group.

The study notes that several limitations were present in terms of describing the scenarios. The scenarios were described in a way that involved the process of reading and language, as well as perspective taking abilities. For individuals with ASD, it might be difficult to picture themselves in the situations when described through text (Samson et al. 2015). Reports suggest that they tend to think in pictures rather than in words, which might have impacted the accessibility of the written scenarios.

This study can however be used to showcase that cognitive reappraisal can be used as a way of helping individuals with ASD showcase less negative emotions to certain scenarios.
Walshe et al. (2003) have explored how an immersive game can treat anxiety and phobia of driving. The study required that the participants' rating increased by >3 on the Subjective Units of Distress Scale (SUDS) or that they experienced an increase in heart rate >15 beats per minute during a driving simulation.

The SUD scale goes from 0 to 10 and is used for subjectively measuring the intensity of experienced anxiety or distress. The scale can be used to assess a person's starting point or to measure a difference in the amount of distress after therapy sessions (Kiyimba and O'Reilly 2020).

The participants were exposed to the driving simulation during up to 12 weekly sessions lasting 15 minutes. During the game, they were asked to do a few tasks such as overtaking another vehicle, avoiding obstacles, and entering an accident situation. After the sessions, the heart rate and SUDS score of the participants were measured again. A non-parametric test was made to see the difference between the heart rate and SUDS score, among other measurements, before the treatment sessions and after. The level of significance was decided to be set to $p < 0.05$ (Walshe et al. 2003).

2.9 Analysis Conclusion

Based on the initial research it was discovered that Autism spectrum disorder (ASD) is correlated strongly with conditions like anxiety, ADHD and depression. Therefore, people with ASD will have difficulties with developing a useful skill set when it comes to their daily living. One factor found to lead to these difficulties is a symptom called emotion dysregulation, which is a term that describes poorly regulated emotional responses. Therefore, a strategy is needed to lessen the impact of emotion dysregulation. One such strategy was found to be that of *Cognitive Change* and a sub strategy called reappraisal. The goal of this strategy is to positively alter a person's thought about themselves or a specific scenario and thereby achieving a higher level of well being. This is done by examining a situation closely multiple times after it has happened in order to get a better understanding of what triggers negative/unwanted thoughts, and gaining an understanding of how to work around it. Due to people with ASD being visual thinkers, we looked into how video games can be useful as a medium of learning and entertainment. It was found that people with ASD have an easier time with computers and virtual worlds rather than people, due to the computer and the video game being more predictable and less intrusive as opposed to interacting with a person directly.

In accordance with our initial research, our target group was deemed to be adults with ASD in the age range of 18-40. Consequently, interviews were done with members of the target group to get a grasp of which specific types of situations could be difficult, and to understand how technological tools could help in the daily lives of people with ASD. Therefore, the interview will prove crucial in determining in-game scenarios in accordance with the game design section.
The game design section was used to explore how to lay the foundation of a game using 3 principles being *player, communication and appeal*. Additionally, it delves into the differences between the usage of interactive

and cinematic cameras in video games which we can apply when working with interactive and non-interactive scenes. Lastly, for the design of Serious games specifically for people with ASD, 5 principles and 10 guidelines for designing games were examined in order to support our work with serious games. Here, 2 of the principles being Modality and Environment could prove especially useful when making a game meant to teach the player the process of cognitive reappraisal and communicate it effectively. Moreover, of the 10 principles at least 4, could prove to be relevant for this project. The 4 are customizability, rewards, instructions, minimalistic graphics and clear audio in order to cater to the individual playing the game as people with ASD are spread across a wide spectrum meaning that a singular anxiety provoking design could prove troublesome.

In order to make a game featuring difficult scenarios, storytelling and narration in the medium was looked into. Here, a point of focus was how the environment and the characters inside of it, can be used to tell a story and point the player in a direction. This led to the exploration of how the characters and more specifically, the player avatar should look. Research indicated that a player avatar that resembles the player's physical characteristics would affect the realism of the player's behavior. Therefore, the point of this section became to look into how the proteus effect and the self-perception theory affects the players behavior inside of a game. It also had the purpose of finding the physical characteristics that is able to be modified/adjusted in most games, where you create your own character. This will lay grounds for questionnaire featured in the design section of the report.

For the game to feature a player avatar that resembles the player, image analysis and computer vision was chosen as the technique to identify the player and materialize the avatar. One important aspect of the player's characteristic is their facial features. The framework for the detection of the face was found to be the dlib HOG method, followed by facial landmark detection. It was found that other aspects of the player can be categorized by creating a neural network that has the purpose of recognizing some aspects, and then categorizing them. The categorizations then leads to a mapping of the person to the avatar.

The state of the art section of the report was useful in finding a game called mindlight that also focuses on training cognitive and behavioral deficiencies in people with ASD or suffering from anxiety. The game was built on the principle of neurofeedback and exposure techniques that helps the player be better prepared for similar real life situations.
Lastly, the related work section sought to optimize the workframe of the project by looking at how two prior studies have dealt with testing difficult scenarios related to ASD and anxiety. Techniques such as monitoring heart rate or filling out scales such as the SUD scale was found to be a reliable way to measure anxiety. Additionally, this section widened the amount of scenarios that could prove helpful for players of the game to be exposed to by looking at the Reactivity and Regulation- situation tasks. It also examined how cognitive reappraisal can be taught which could prove useful inside the game.

The findings of the analysis allows for the problem to be narrowed down into the final problem statement.

"*How does a video game that portrays the coping mechanism of cognitive reappraisal, and utilizes a tailored player avatar, help adolescents with ASD feel less emotional in nerve racking everyday-situations?*"

2.10 Design Requirements

Based on the theoretical framework and the initial target group interviews, the following functional and non-functional design requirements have been formulated:

Table 1: The functional design requirements

Design Requirements
Functional
The game must run on a computer
The game should include different everyday-scenarios based on the situations mentioned in the interview with the personnel and residents at MerVib
The game should include an all-knowing omniscient in-game narrator to guide the player
The game should include ambient noises and music to satisfy the dynamic stimuli of the player
The graphics and audio should remain simple and clear
The game should utilize an interactive camera for interactive scenes and cinematic cameras for cutscenes
The game should utilize computer vision to costumize a player avatar
The game should use dlib facial detection and facial landmark detection to compute the area of the user's facial features
The game should use a Neural Network to categorize the shirt and pants of the user

Table 2: The non-functional design requirements

Design Requirements
Non-Functional
The narrator should use cognitive reappraisal in the difficult everyday-situations
The goal of each scenario should be communicated effectively
The game should enhance the self presence component of player avatar identification by creating a tailored player avatar from an image of the user
The game should enhance the physical presence component of player avatar identification by creating an interactable environment with ovjects that match objects of the real life scenario
The game should enhance the social presence component of player avatar identification by making an interactable environment with NPCs, that is designed similarly to the character and that fits the individual situations
The game should should be able to offer neurofeedback training trough exposure techniques that acclimate the player to real-life situations

3 Design

3.1 Player Avatar Questionnaire

The following section will introduce the questionnaire meant to determine which physical characteristics to focus on implementing for the player avatar. The sampling method used was that of convenience sampling, as there is no reason to believe that people with ASD define their appearance differently to people without ASD.

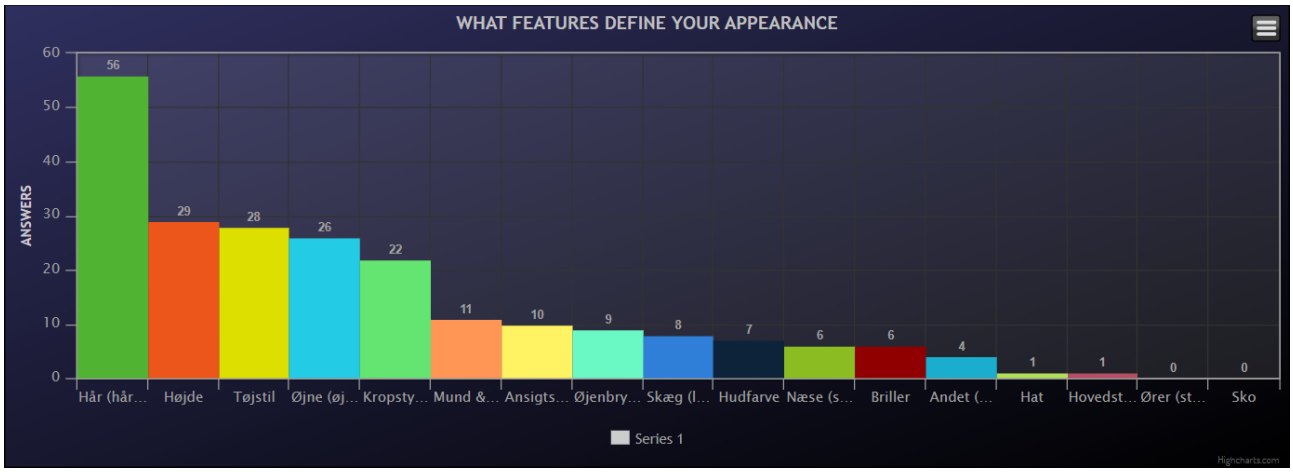

Figure 4: Diagram showing answers gathered from the Player Avatar Questionnaire. The sample size was that of $\boldsymbol{n} = 84$.

In total, 84 participants took the questionnaire and each participant was able to pick up to 3 characteristics. This theoretically means that the total picks could've gone up to a maximum of 252. However, only 226 picks were received meaning that a fair amount of people either only picked 1 or 2 options. All in all, the characteristic that received the most picks was that of hair which includes hair type, hair length and hair color. The 4 next most frequently picked options were height, style of clothing, eye size/color and body type. All of these 4 picks were picked by 26-34% of respondents, whereas the next highest picked option was that of mouth and lips, which was only picked by by 13% of respondents. Therefore, the implementation of hair style and hair color will be prioritized, and the rest of the options, will be implemented in the order they were picked in the list. To sum up, a prioritization list should look like the following:

Must be implemented first:

- Hair style and hair color

Should be implemented into the game:

- Height
- Style of clothing
- Eyesize/color
- Body type

These features were used as a baseline for the features that should be implemented into the initial design of the character creation.

3.2 Prototypes of initial design

3.3 High fidelity Character creation menu

A high fidelity prototype was created of the character creation process within the game.... This prototype was created for assessing whether the individual felt high self presence with the character created. The prototype takes two images of the player as input, one of the face of the player, and one of the body. The image of the face was used to asses the hair color and the eye color as these were important features found in the questionnaire. Additionally, based on the face image the skin color was categorized, and the size of facial features such as the

jaw width and eye size was computed. The sizes of the facial features were not used in the output, as a standard for categorizing the sizes should be determined. This will be gathered in the testing of the initial creation to get an idea of each individuals interpretation of the size of each feature, compared to the size the program computes.

The image of the individuals body was used to compute the color of the shirt, and the color of the pants. In the final prototype, this picture should also be used to categorize each clothing piece the person is wearing to map it to the avatar.
The image acquisition involved using an outline in each of the pages where the user should take an image of themselves. For the facial image this was done, as the computation of the facial features are relative to the distance the participant is to the camera, hence in an ideal situation each individual should be in the standing the exact same distance away from the camera.

The outline for the body image was used to determine where the individuals shirt and pants where placed in the image.

Some of the characteristics from the initial questionnaire such as the hair type, and the body type was implemented by letting the user pick these aspects, due to limitations of ...

3.3.1 Testing the character creation

As one of the non-functional requirements stated that *The game should enhance the self presence component of player avatar identification by creating a tailored player avatar from an image of the user* (2), a structured interview was conducted to figure out if the user felt that the character created did represent them. In addition to this, the character creation menu should have high learnability, as this task is indented to be done rarely. Therefore a think aloud test was conducted before the structured interview, to get a sense of the usability of the creation. For conducting the think aloud test a procedure was read out loud for the participant (see appendix A), afterwards they were given the task to *Create an avatar*.

After the think aloud test, the structured interview was conducted which focused on 4 main topics, the first was concerned with the usability of the application:

1. How hard or easy was the process of creating a character?
2. Did you have enough information on each page to know what to do?

The next set of questions were concerned with the computer vision part of the character creation:

1. Does the gender of the character match your gender?
2. Does the color of the characters eyes match your eye color?
3. Does the color of the characters skin match your skin color?
4. Does the color of the characters hair match your hair color?
5. Does the color of the characters shirt match your shirt?
6. Does the color of the characters pants match your pants?

Additionally the participants were asked if they felt certain features of their face were big, small or medium sized. These questions were then compared to the size that were computed from the facial landmark detection, such that a standard for small big and medium features could be set within the game:

1. Would you define the the size of your eyes as small, big or medium?
2. Would you define the the width of your mouth as small, big or medium?
3. Would you define the the size of your jaw as small, big or medium?
4. Would you define the the size of your eyebrows as small, big or medium?
5. Would you define the the length of your nose as small, big or medium?

Finally the last question was asked to asses the self presence component of player avatar identification:

1. Do you feel the character represents you?
    - If not: Which characteristics of your appearance would the character need to be a representation of you?

3.3.2 Test results

The test was then conducted on 11 participants from medialogy at Aalborg university. The data gathered was then analysed using the thematic content analysis, to asses problems found from the participants. In the process of creating the avatar 3 problems were found. The first was that 6 of the participants did not notice that they had to press "*Space*" to capture a picture of themselves, they would instead press the "*Next*" button without having captured the picture. They did mention that after reading the instructions on the screen, they figured out that they had to press space, however most did not read the instructions at first. The second problem found was mentioned by 5 of the participants. When having to take a picture of the body, the person should then wait 10 seconds after pressing space, for the picture to be captured. In the 10 second time frame it was mentioned by the 5 participants that a timer would be helpful. The final problem was that 4 of the participants did not place their face directly in the outline, which would mess up the data calculated of their facial features as the distance to the camera is now further away.

Information was then gathered
All the test persons had trouble with the system's mechanics because of not reading the text on the screen. But once they found them, they all agreed that the directions were easy to follow. For our next implementation, we should make the instructions stand out more.

All four of the test persons also found it more or less difficult to insert their face or body correctly in the outline. Especially the full body outline was hard to find the correct distance and angle to stand in. Two people also mentioned that a timer could prove helpful so they don't have to count 10 seconds themselves. We should therefore make it more clear where the person should place their face and body and place a timer when taking the full body picture.

4 Implementation

4.1 Implementation of Character creation

Development of the solution – prototyping

5 Methods

What overall strategy will you use to answer the FPS?

6 Results

Purpose of the test, test setup, procedure, results, discussion of results

7 Discussion

Answering the FPS – findings – importance of the work

8 Conclusion

Summing up – future directions

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List of Figures

A Test Procedure in original language, danish

“Hej vi er igang med at teste funktionaliteten af vores system som skaber en karakter, på baggrund af et billede af dig. Til det vil vi have dine tanker om brugbarheden af det mens du tester den. Derfor vil du få en prototype af systemet, mens du bruger det, skal du sige alt hvad du tænker, med henblik på navigation og brugbarhed af systemet. Vi vil gerne nævne, at vi udelukkende tester appen og ikke dig, derfor beder vi dig om at være helt ærlig omkring, hvad du synes. Efter det vil vi holde et interview om den skabte karakter. Er det i orden, at vi optager testen med lyd? Er instruktionerne klare for dig?”