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Developing interactive interfaces for people with developmental disabilities to be used in Snoezelen environments

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Abstract. Much of the equipment used in Snoezelen environments today is not interactive, and the equipment that is interactive can be hard for the user to access. By having interactive equipment in Snoezelen environments the user gets to experience and hopefully better understand the concept of cause and effect.

The purpose of this project has been to develop an interactive interface that can appeal to a wide range of users. By a small effort they should be able to get a response from the interface. To do this, different methods have been used, such as qualitative research methods and bodystorming. The work was developed following a user-centered design method and an iterative design process, where Snoezelen users in two different Snoezelen institutions in the Öresund Region participated.

The interactive interface is called Glownado. It is quite small and allows the user to interact in different ways, it can be approached, put into motion, and it has different tactile structure that the user can touch. This makes it easy to interact with Glownado, in a way that suits the user's needs and abilities. The feedback the user gets is in form of wind, sound and light, and creates a multisensory stimulation localized to one area. Depending on how the user interacts with it, it has different behaviors to respond to the specific action. It is important that the user gets an immediate response to their action, to understand that they are the ones making it happen. Wind has never been implemented in interactive Snoezelen equipment before. It creates a surprise moment, which makes the users curious to continue explore.

Keywords: Snoezelen, Interactive Design, Qualitative Research Methods

1. Introduction

The aim of this project was to design an interactive interface that can be used in Snoezelen environments. It should be manageable, meaningful and comprehensible. This makes it less confusing and reduces the insecurity of the user, which leads to exploration of senses. The interactive interface was supposed to have a direct and gradual response, and stimulate different senses. It was important to have some predictability but also a small amount of unpredictability. This is to make it understandable and increase the curiosity of the user, which leads the users to understand that their actions are the cause of the response given by the interactive interface. The users have participated in this study have a variety of abilities and disabilities. The goal has therefore been to make an interface that appeals to a wide range of users.

1.1. Developmental Disabilities and Sensory Deprivation

Developmental disability is a wide term, which describes many different chronic disabilities that can be cognitive, physical or even both [1]. Cognitive disabilities are commonly defined as, having problem with mental tasks and how to process them [2].

Sensory deprivation affects the human brain and can occur from abuse or neglect, or by severe sensory, cognitive and learning disabilities. As long as some part of the human brain is not stimulated, the specific part will wither. This can lead to rigorous life conditions in a way that it will affect the physical development, social and emotional functioning, the behavior, as well as how to communicate and learn [3].

Developmental disabilities, such as Down syndrome, fetal alcohol syndrome, severe autism, cerebral palsy, etc., can affect cognitive ability, physical functioning, and learning [4]. Children and adults with developmental disabilities will commonly be affected by sensory deprivation [3].

1.2. Snoezelen

Individuals with developmental disabilities are often limited in controlling the environment around them, which often leads to uncertainty, and also becoming withdrawn and therefore more helpless than they usually are with their disabilities.

Two psychologists, Cleland and Clark, developed a “sensory cafeteria” for people with intellectual disabilities [3]. This was further developed by Hulsegge and Verhaul to occupy the participants with intellectual and multiple disabilities. The environment where the participants experienced sensory stimulation was called Snoezelen. The word Snoezelen was created by combining two words in Dutch: “snuffelin” = to sniff, to snuffle and “doezelen” = to doze, to snooze. In the multisensory environment the individuals are supposed to experience having control over their surroundings, also get a feeling of independence [5]. The Snoezelen environment is stimulating and peaceful, and the idea is that the users are supposed to stimulate their senses in a non-demanding environment (snuffelin). However, it is also important, that users who are over-stimulated in the beginning can calm down by conditioning their surroundings (doezelen). One more advantage in those environments is that it’ll create a relationship between the users, the environment and the staff. Snoezelen rooms are supposed to stimulate different senses, and can be adapted to control the amount of stimuli to fulfill the needs of the user. Picture 1 shows a Snoezelen room.

Picture 1 A Snoezelen room, called the wind room. The user gets to experience the feeling of the wind. The fabric contributes to a visual effect, when flying around.

Snoezelen targets to both people with disabilities as well as without disabilities [5]. In this project, the focus has only been on people with developmental disabilities.

2. Method

2.1. User centered

In user-centered design the users are a part of the design process in one way or another. This can be done by e.g. letting the users test the product during the process. It can be hard for the designers to imaging every scenario and all the criteria that are important to the users. Placing the user in center ensures that the product or design is beneficial to the user. More advantages with user-centered design are that the product becomes more efficient and safe, and requires less redesigning [6].

2.2. Qualitative research methods

Qualitative methods are used to gather data about e.g. behaviors. In this project this method has been used, since it has been of importance to see how the user perceives the interface. The qualitative method that is used in this project is based on observations. It enables a better understanding of the interactive interface and how the users receive it.

The data from the observations, e.g. the reactions during the activity, can then be further analyzed after the session [7]. Video recording and observer's notes have been used in this project to gather information. Video recording is a good approach when working with users in a Snoezelen environment [5], since they are not often able to express their needs and wishes orally.

2.3. Bodystorming

Bodystorming is a way to broaden the perspective of how something is being approached or used, by actually participate in the interaction. To participate in the experience, the designer assumes the role of the participants and imagines different scenarios. This is to gain better understanding and empathy with the participants [8].

Bodystorming as embodied performing was used in this project. This means that designers or other people, brought into the session, will improvise as a participant to get the experience of the product or service [9]. This was used during the development of the interactive interface.

3. Pre-study

3.1. Snoezelen Institutions

It is of importance to the design process to understand what the users are able to do and what they are not able to do [7]. To make this possible the project was done in collaboration with two different Snoezelen institutions, *Snoezelhuset* in Gentofte, Denmark and *Safirens Upplevelsehus* in Malmö, Sweden.

The feedback from these visits had a major influence on the decisions regarding the design. There have been four visits to each of the Snoezelen institutions, to get to know the staff, and to get a better understanding of how the different Snoezelen institutions works and looks like. Also to try imagining, by some explanation by the staff, how the world looks and feels like when having sensory deprivation. On the visits the interaction between the user and the interactive interface were observed.

3.2. Participants

The target group involves adults with different grades of disabilities. Impaired vision has been a common factor, though the degree of impairment has been different for each user. The staff at the Snoezelen institutions selected five different individuals who participated in the study. Selection was done with regards to the individual's abilities, disabilities and interest. In this report, all the participants have been given fictitious names.

Bane has impaired vision, doesn't have the ability to talk and uses a wheelchair. Although he can't talk, he expresses satisfaction or dissatisfaction through vocalizing sounds. Despite his poor vision, he can notice very bright light, which is close to his face. He is able to move his arms and grab things with his hands, but having the arms close to his body. This makes small things more attractive to him. Small things are also easier to grab and interact with, in a way that he can decide whether he wants to have it close to his face or not. Ivy loves to talk in her own way, which is understandable for the staff, whom has been spending time with her. Her ability to talk makes it easier to understand, with some help from the staff, if she liked something or not. Ivy can move her arms and her hand. Her vision is impaired, but she can see lights and structures. Selina uses a wheelchair and can move her head and her hands, though she can only move her hands close to the body. She is able to spread her fingers, but not use them to grab things. Robin can move his arms, hand and fingers. He is very curious, he likes to use his fingers to fiddle with things and explore. He can walk, and walks away if the situations aren't appealing to him. Alfred is blind and uses a wheelchair. He can move his arms and hands and likes to have his hand close to the neck. He uses his fingers to explore. To have things close to the neck is an advantage in his case.

3.3. Interactive Snoezelen equipment

Even though it's not common, there is equipment in Snoezelen environments that are interactive. Making the Snoezelen environment interactive will hopefully engage the users to explore the outside world as well, since they might understand that they're making an impact on the surroundings. Some of the existing interactive equipment are push buttons or sound triggers. In this way the users can interact with the equipment by pressing a button or clap their hands, and thereby get a response. An example of existing interactive Snoezelen equipment with "push buttons" is interactive stepping stones, picture 2. The user uses the body to climb and press the stones to activate e.g. lights or bubble tubes [10].

Other equipment uses close interaction, which makes it easier for the user to access and understand. With close interaction the user get a direct response, compared to the push buttons where the response is given at distance. The interactive design in the SID project (Sinnlighet, Interaktion och Delaktighet translated Sensuousness, Interaction and Participation) uses close interaction. Examples of designs in the SID project are LivelyButton, HugBag, ActiveCurtain and MalleablePillow, picture 2. The LivelyButton

Picture 2 From upper left: Stepping stones [10], LivelyButton, HugBag, ActiveCurtain and MalleablePillow [11].

is a wooden box with rotating metal springs and fabric on the top. When the user approach or touches it, the color shifts and the box vibrates. The more proximal is the user, the faster it rotates and shifts color. HugBag is a big soft transparent ball fixed to a plastic base. When hugged, the ball changes color and makes sounds depending on the location and strength of the hug. The ActiveCurtain is a fixed and elastic curtain that is lightened up in a color spectrum. When the user pushes the curtain the image changes depending on the place and the strength of the push. MalleablePillow is a pillow filled with marbles and fabric that rustle. When touched and knead, the pillow emits light, the more it's kneaded the more intensive is the light [11].

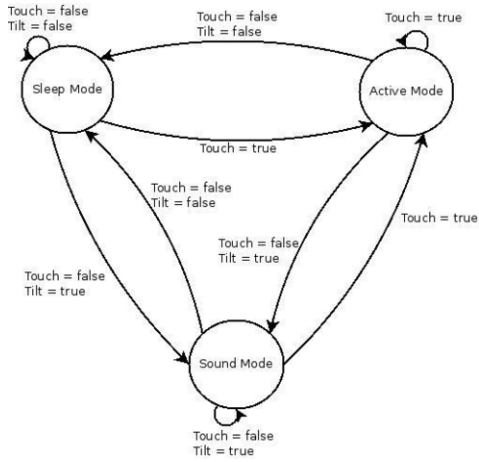
4. Glownado

The word Glownado was composed by the words glow and tornado. The main inspirations came from the wind room at Safiren in Malmö. Here they used wind as a tactile element. Bane was also a major inspiration, he held a color changing egg in his hand and moved it back and forward close to his face to experience a visual effect.

Glownado, picture 3, is a quite small design with a fan that blows air towards the user while interacting. The bottom is rounded, which make it possible to put it in motion. The interface has different sensors that can be controlled gradually. The sensors detect the user's action. To get a response from those actions the interface generates different types of outputs, in form of light, wind and sound.

The controller used in this project is an Arduino board, which is an open source platform. With different sensors connected to the input pins, the Arduino can control different actuators on the output pins.

Picture 3 Glownado has a rounded bottom. It has small holes, to provide airflow to the fan. It's black to avoid attraction. The top is white with light inside to attract the user to the fan. It has brown strips of conductive fabric that creates an aura around it. The rings around Glownado prevents it from tipping over. A fan cover is used at the top to prevent fingers and other things from falling into the fan.



Picture 4 The state machine shows how the different modes are set by the inputs, touch and tilt.

In a truly interactive environment, there can be different responses to various actions in different situations. In the same way, Glownado should react in different ways depending on how the user interacts with it. Implementing this, different modes were set to control the behavior of Glownado. The modes were *sleep mode*, *active mode* and *sound mode,* picture 4.

4.1. Sleep Mode

In this mode, the interface is standing still without any interaction, and this is the most important mode because in this mode it has to attract the user's curiosity, which leads them to investigate. The fan is off in this mode. To attract the user to start interact, a *sleep light* was implemented. The *sleep light* is on medium intensity and shifts color slowly in a spectrum of light from red to white. Having it on medium intensity it'll be even more evident when the modes are changing. The impression of Glownado being in a resting stage is given by shifting colors in a slow pace. It is important that the pace is not too fast, since that can negatively affect people with epilepsy. To attract users with impaired vision a *sleep sound* was implemented. The notes and volume are fixed values with a constant delay between the notes. This was chosen to fit the behavior of the light. There are two different sound types for the *sleep sound*, to make it appeal to a wide range of users. One sound type was chosen to be more arousing and the other more smoothing.

4.2. Active Mode

The *active mode* is active when Glownado is sensing a touch, meaning it will always be active as soon as the capacitive sensor detects an approach or a touch. A capacitive sensor detects the distance between the interface and the human body, by reacting to differences in the electricity. An external control box is used to set the threshold for when the capacitive sensor should activate. In this mode the fan activates, the speed will increase while the distance to the capacitive sensor is decreasing. The light changes from *sleep*

light to *active light.* The shifting of colors, from the *sleep* light, will stop, and the current color will increase the intensity to its maximum. This is to get a response from the action, in form of light. An *active sound* was also implemented to give a response, in particular to people with impaired vision. The volume of the notes are controlled by the fan speed, since the noise from the fan increases with the fan speed, the sound gets more noticeable when the volume of the sound increases with the fan speed. The tilting magnitude sets the notes, the larger the tilting magnitude, the higher the note. This makes it predictable, the notes will always increase with the tilting magnitude, but yet unpredictable, since it's hard to predict the notes, which might arouse the curiosity to explore. When held in the same position the delay between the notes will increase. Like in *sleep sound, active sound* has two different sound types.

4.3. Sound Mode

The *sound mode* is triggered by the tilt, meaning that it activates when the user set Glownado in motion, and an accelerometer is activated. This occurs when the user touches the lower part of Glownado or the rings around it, or when Glownado continues to wobble after being pushed. The *active sound* is activated in this mode, which is explained in active mode. The fan is off and the *sleep light* is activated.

5. Results

5.1. Observations in Snoezelen environments, part 1

For the first user observation, only the fan and the light were implemented. The main focus was to observe how the participants would react to the power of the wind produced by the fan, to see whether Glownado was sensitive enough to respond to a gentle touch and also to investigate if the light attracts the user to start investigating.

The users interacted with the design in different ways. Selina, placed the back of the hand against it. By doing this, she could feel the vibration the fan was producing through her body. When the fan was strong she lent her head back to avoid the wind. Selina seemed to like it and was investigating it. Selina could probably not see the light from Glownado. Alfred was laying in the waterbed and had Glownado placed either close to his neck or in front of him were he could reach it with his hand. The light was not beneficial for him, since he is blind he couldn't see it. He used his fingers to touch and investigate the fan cover. Ivy used her hands to push Glownado away when the fan caught her by surprise. She also seemed to like it since she started to investigate it more, pushing it around.

5.2. Observations in Snoezelen environment, part 2

For this observation, the sound was implemented and it was important to investigate if it was attractive. As before, the power of the wind, the influence of the light and the mobility of Glownado were observed.

Bane used both his hands and arms when interacting with Glownado. It seemed that the light wasn't bright enough for him to notice. During this visit, the sound was not acting as intended. The notes were random and there were no distinction between the

sounds i.e. both of the sounds, *sleep sound* and *active sound*, acted at the same time and provided a mix of the two sounds. It seemed liked Bane was fond of the wind and the vibration from the fan, since he kept his hand on Glownado for a long time. He got focused when interacting with Glownado. Bane had problem setting Glownado in motion. The roundness of the bottom was not enough to respond to his gentle push.

5.3. Observations in Snoezelen environment, part 3

An additional light source was added, to increase the intensity. The bottom was made more rounded to respond to a gentle touch. As before the mobility of Glownado, power of the wind, light and sound was observed.

Robin interacted with Glownado, sitting on a hard bed. He got curious and calm, and started to touch it with his hands. Robin was touching Glownado everywhere, the fan cover, the fabric, the small holes in the bottom and the rings. He was shaking it, tilted it, and held it tilted in a fixed position. If something changed he stopped in that position and thought about what was happening. During Robin's interaction, the power cord suddenly got unplugged, it was clear that he wondered what had happened and he stopped interacting with Glownado. When the power cord was plugged in again he directly started to interact. After interacting with Glownado for a while, he stopped and gave the impression that he was finished, but as soon as he sat up he started to interact with it again. This time he wasn't that active, he was more thoughtful and had Glownado in the same position for a while. The sound was turned on and off to see whether he seemed to like the sound or not. Robin didn't act any different when the sound was off or when it was on, it was then hard to come to any conclusion. It was also hard for him to understand that the notes and the volume changed when he moved Glownado, since the changing of the notes were too slow. Robin could notice the light from Glownado and he seemed to like the strong wind.

5.4. Observations in Snoezelen environments, part 4

Changes were made in the code for the *active sound*, to give a quicker response to the action. A lightweight fabric was attached to the fan cover, to provide a visual effect and attract the user to the fan, since wind is not visible the lightweight fabric will reveal the wind and to arouse curiosity. The purpose of this test was to observe, the power of the wind, if the light was strong enough, and to see how the user responded to the sounds. Also to see if the lightweight fabric had an influence. The mobility of Glownado was going to be observed, as well.

Bane held a steady grip of Glownado during the whole interaction. This time he could set Glownado in motion. The capacitive sensor wasn't behaving as intended, it was random when it was activated, which turned the fan on and off randomly. For this session it was a good thing, since he held it close to his face the fan became too powerful. Bane couldn't see the lightweight fabric, but when the wind started to blow the fabric was set in motion and tickled him on the nose and the cheeks. The different sound types and settings were tested. It was hard to tell if he liked the sounds, but according to the staff he probably liked the more smoothing sound type. A good way to make the sound more noticeable for him was to turn it on and off. Bane then became thoughtful and more aware that there was sound. It seemed like he could notice the light on Glownado, since he focused his eyes on it once in a while. It was hard to tell if Bane liked Glownado, but he was holding it all the time and didn't want to let it go.

6. Conclusion

In general Glownado got many positive feedback from the staff at the Snoezelen institutions. They had common opinion that it wasn't age dependent, due to the pure design with its simplicity, the natural choice of colors and its shape.

The goal of this project has been to make the interface appealing to a wide range of users. In existing interactive Snoezelen equipment this is often not possible, since they require a bigger effort from the user to interact. In other words the user needs to be able to move quite a lot to interact with the interface. For example, the LivelyButton in the SID project can be accessible to a wide range of users, since it can be used with many body parts, and the sensitivity can be adjusted, but it is quite big. Without help from the staff or the carer the user is sometimes not able to reach the surface of it, to interact with it. In this project it has also been of importance that the interactive interface allow the user to explore their senses, and make them understand that their actions have an impact on their surroundings. Glownado was implemented to give a gradual response, for the users to understand that they're the ones that affect the environment. The conclusions from the observations shows the importance of giving a quick response to the users' actions, since many of the user hasn't been able to understand the effect of the gradual response. Glownado opens up many possibilities for the user to explore and interact in different ways, since it can be approached, put into motion, and it has different tactile structure that the user can touch.

By making Glownado small and take advantage of the users' abilities to interact with it, it gets accessible to a wider range of users. With a capacitive sensor, that creates an aura around Glownado, the user gets a response from the wind, the light and the sound as soon as they approach it. It doesn't require much effort from the user to get a big response to their actions from Glownado. The aura makes Glownado accessible in many different ways, from the sides and from the top. To have the ability to change the threshold of the capacitive sensor, it can be adjusted to a wide range of users. The users who participated in this study used their hands to interact with it, but there are many ways to do it, with the feet or the head. During bodystorming these options were tried out. By placing the head against Glownado the vibrations and the wind in the face are perceived. Making the conductive fabric as strips was good. They created a bigger aura when they weren't completely attached to the fabric. For users, who can use their fine motor skills, it invited the user to explore, when fiddle with the fabric, or maybe even pull it.

Having Glownado small makes it easier to place it where the user benefit from it the most. It would have been even better if no cables were connected to Glownado, to improve the movability. With this design it was not possible, since the fan runs on 1.14A. The Arduino board can only supply the fan with 200mA [12], which means that the fan needs an external power supply. Batteries might be possible, but might drain too fast because of the high power consumption of the fan. Moreover, the capacitive sensor element works better when connected to physical ground.

The shape creates a lot of opportunities of the mobility, it is possible to spin, make it wobble or having it in a fixed position. Having all these options, Glownado can be adapted to the user's needs and abilities. According to the staff the mobility also inspires to team play.

The fan cover was used as a protection, but it also gave the user, with fine motor skills, more opportunities to explore Glownado.

The feedback from the staff was that the light had a good speed when shifting between the colors and it was a good way to create an interest to Glownado. Having shifting colors is a better way to create an interest to start explore, than to only use one color. Although, the gradual shifting between the colors might not be noticed by some users. If the user has impaired vision, the option to activate sound was good to lure and tell the user where Glownado is, to enable the user to start interact. By having a sound in the active mode provides an extra sensory stimulation to the user. This extra sound can be confusing for the user, since both the sound and the noise stimulate the hearing at the same time. During the observations this was never noticed as a problem. How a person reacts to different sounds is very individual. One person may associate one sound to something negative, while for another it can be something positive. By having the possibility to choose different sound types or even turn the sound off makes Glownado appeals to a wide range of users.

The option to add lightweight fabrics on top of the fan, to provide a visual effect, might arouse the curiosity of the user and lure them to the wind. During the observations it was noticed that this feature was also of significance for users with visual impairment. In this case it gave a tactile impression and boosted the feeling of the wind.

To make the fan interactive contributes to an innovation, since this hasn't been used in interactive Snoezelen equipment before. The wind provides a different tactile effect, when it is not visible. The sudden gust of wind was surprising and took the user off guard for a second, but after realizing what happened it was fun, exciting and adventurous. The surprise moments made the users curious to continue explore. A concern was if the noise of the fan was too loud. According to the staff, this was not a problem. The sound created by the fan can give the user a feeling of security, since the motor sound reminds of something familiar, e.g. a car.

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