

Bachelor Thesis Creative Technology,  
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Designing an interactive intervention to  
unconsciously steer residents of a dementia  
care facility away from the exit.

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## Abstract

Dementia care facility Bruggerbosch struggles with residents who keep coming to the exit of the residence with the intention to leave. Different environmental factors around the exit of Bruggerbosch have been identified through observations. These environmental factors include a contrast in light, stimuli from the receptionist close by the exit and the natural funnel like shape of the interior. Through literature research and interviews, information was collected about the processing of sensory stimuli in people with dementia. State of the art interventions for similar problems were discussed in order to create guidelines for the design for an intervention to steer residents of Bruggerbosch unconsciously away from the exit. Through an ideation process of generating and evaluating ideas, the concept of the Lost Puppy intervention was proposed. This concept consists of a stuffed animal in the shape of a puppy that is placed in the entrance hall, close to the exit. The intervention contains a storyline about the puppy being lost and needing help to find its way back to its mother that is laying in a basket somewhere else in the residence. The storyline is built up in four phases where 1) the attention of the resident is attained, 2) the interaction with the puppy is initiated and the task is explained, 3) the resident's attention is sustained while the resident is trying to find the puppy's mother, and 4) the resident succeeds by reuniting the puppy with its mother.

The intervention was evaluated using a realised prototype that was tested in the entrance hall of Bruggerbosch. It was observed that unfortunately no resident was able to complete the entire task of bringing the puppy back to its mother. It is therefore recommended to research further how to engage residents in prolonged interaction with the intervention. Suggestions to motivate interaction are to make the setting of the puppy more approachable and let the puppy provide more dynamic stimuli, such as a moving tail or head. However, it was also observed that the puppy generally raised positive reactions from residents and that it is possible to attract the attention of residents in the entrance hall with a puppy that uses both visual and auditory stimuli. The puppy stimulated social interaction amongst residents and provided visitors and employees of with an easy topic to start a conversation with residents.

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## 1. Introduction

In the Netherlands, more than 270.000 people suffer from dementia [1]. Dementia is a general term for the process of decline in a person's cognitive functions so significant that it affects their daily living [2]. There are many types of dementia, with the most common type being Alzheimer's disease. Dementia is most known for its effect on the memory, for example the disability to remember new events. But there are many more symptoms to the condition, such as impaired ability to focus, affected judgement, and disorientation of time and place. The symptoms are caused by the damaging of brain cells and affects people's everyday functioning. Therefore, people with dementia need special care which is provided by informal and/or formal care givers. In the early stages of dementia, it is common that family members of the person with dementia act as caregivers at home. When the workload of these caregivers gets too high, usually the person with dementia will get additional professional care or moves into a nursing home. Bruggerbosch in Enschede is such a nursing home, specialised in severe dementia care.

Everyday many residents from Bruggerbosch stroll through the building, with or without a purpose. Because residents of Bruggerbosch are in a far developed stage of dementia, most of them are not allowed to go outside without supervision. These residents therefore have a chip in their shoe that prevents the exit doors from opening when they stand in front of it.

However, during their stroll these residents often still end up at the door. It can be very confronting and confusing for the residents to discover that they cannot leave the residence. They can get upset, cause a scene at the entrance hall and even become aggressive towards caregivers. The receptionists at the entrance, and caregivers at work, then must step in to calm them down and take them somewhere else.

The problem at hand at Bruggerbosch can disrupt the calmness of the residence's entrance hall, the employee's work and cause discomfort for the residents themselves. But Bruggerbosch is not the only nursing home that encounters this problem. Solutions to residents wandering off have been presented before, such as the 'phantom bus stop' that a nursing home in Germany introduced to let residents patiently wait for a bus that will never arrive [3]. A different manner to divert residents' way is to use visual deterrents. Some manners more subtle, for example by using a life size sticker of a book closet to cover a door. And others more direct, such as yellow signs with the word 'stop' on it [4]. However, door stickers are not always applicable and stop signs are a very hard deterrent which can make the resident upset.

To help Bruggerbosch solve their problem, firstly the problems at the entrance hall of Bruggerbosch will be analysed in which the effect of the problem on both the residents and the staff will be studied. Together with the theoretical framework, that will contain an overview of the use of sensory stimuli in dementia health care, this will form the groundwork of the project. With this information and through extensive ideation, a concept will be proposed for an interactive intervention to unconsciously steer residents of Bruggerbosch away from the exit. Finally, this concept will be tested to evaluate whether the provided solution fulfils its goal of unconsciously steering residents away from the exit.

In summary, the following research questions will be answered:

- What is the exact problem with residents at the exit of Bruggerbosch?
- How can residents from Bruggerbosch be unconsciously steered away from the exit?
- Does the provided solution fulfil the goal of steering residents away from the exit at Bruggerbosch?

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## 2. Methods

This project is built up in various phases. The first phase is about orientation and then getting deeper into the presented problem. In this phase research was conducted about dementia as a condition and how it affects the people dealing with it. For this section literature from different databases was collected, scanned and thoroughly read for useful information. To better understand the exact situation at Bruggerbosch, observations were performed at the entrance hall, and interviews were conducted with occupational therapists, a receptionist and an activity manager of Bruggerbosch. For the literature study, multiple articles and studies were compared. The gathered information was used to discover and create design guidelines for designing for people with dementia that can be used as inspiration and provide overview for others working in this field. The second section, the ideation phase, is about generating ideas and evaluating them. The idea generation was started off with creating mind maps on a big white board about topics relevant to the problem at Bruggerbosch and from findings in literature. Then an individual brainstorm was performed with a restricted 3 x 5 minute time frame to keep the energy high in order to get at least 50 ideas. The performed brainstorm was in the form of a brainwriting pool. Ideas were all written in a few words on sticky memo's and stuck on the table for later evaluation. In between the 5-minute brain writing sessions was time to break and get inspired. The generated ideas were evaluated in four steps, using a ranking system based on different principles, assessment by experts in the field of dementia care and eventually weighing off pros and cons. The phase that followed ideation is the specification phase. In this phase the outcome of ideation is conceptualized in more detail with personas and user scenarios. The concept was split up in different parts of the story: 'attract', 'initiate', 'sustain' and 'succeed'. This was done to keep overview and to be able to pinpoint stronger and weaker points in the design that could guide future work. In the realization phase of the project, a prototype was made. The observation data was collected and analyzed for evaluation. With this evaluation, the research question of whether the proposed solution is successful in unconsciously steering residents away from the exit will be answered.

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### 3. Literature review

In this section, methods for information retrieval will be given, the literature review will provide an overview of the use of sensory stimuli when designing for people with dementia, and current products and interventions that use sensory stimuli will be discussed in the state of the art. Finally, based on this information design guidelines for design for people with dementia will be formed.

#### 3.1. Methods for literature review

To find relevant literature, several scientific databases were searched, including Google Scholar, UT Library, Chalmers Library, ACM, Scopus and PubMed. The articles were selected based the relevance of topics and research questions presented in the abstract. Thereafter, the selected articles were scanned for more specific subjects and thoroughly read to use them in the current literature review. The following keywords were used: dementia / sensory stimuli / technology / severe dementia / sensory reception / senses / Alzheimer's / stages of dementia / cognitive decline / wandering / vision / audition / olfaction / touch / intervention / cognitive impairment.

#### 3.2. Relevance of this research

It is regularly brought to the attention that the Dutch society is aging, with its associated aging diseases. A larger older population also means a larger group of people suffering from dementia.

The problem at the entrance hall of Bruggerbosch, of residents wanting to go out when they are not allowed to do so unsupervised, is both frustrating for the residents and the staff. Bruggerbosch is not the only nursing home that encounters this problem. It is relevant to search for ways in which the problem can be alleviated. Technology is an important part of health care and health care interventions nowadays and can also aid in care for dementia patients.

This chapter will be the groundwork for a dementia care intervention that uses sensory stimuli to lead residents of Bruggerbosch away from the exit. The goal is to give insight in how people with severe dementia receive stimuli through different senses and how these senses are currently used to stimulate the people. Then, it will be discussed how these findings can be used in an intervention.

Finally, current interventions will be discussed that aim at solving a similar problem or contain features that are useful for this study.

#### 3.3. Dementia

Dementia is an umbrella term for the deterioration of cognitive functions in elderly people caused by damaging of cells in the brain and connections between them. This brain cell damage obstructs communications between cells, which results in affecting the person's thinking, behaviour and feelings [2]. There are many different types of dementia, with the most common type being Alzheimer's disease, followed by vascular dementia, frontotemporal dementia, and Lewy Body dementia [5]. These types of dementia have different symptoms and characteristics, and each individual with dementia can experience it in a different way.

Dementia is a progressive condition and is often referred to in stages. Reisberg [6] describes the process in seven stages. The first three stages being pre-dementia stages, in which is spoken of non- to mild cognitive decline. From stage four to seven Reisberg speaks of moderate to very severe cognitive decline. These are the dementia stages. From stage five, described as moderately severe cognitive decline, the person with dementia can no longer survive without additional care or assistance.

The main symptom of dementia is the disability to remember new events and the disability to recollect old memories. People with dementia lose memory of the last few years before the onset of dementia. This is an ongoing process that causes a decline in the ability to recollect memories until a

person with dementia is mentally back in their teenage or childhood years. Van der Plaats [7] explains the human brain in four layers. Layer one and two are in the lower brain, and layer three and four are in the upper brain. In layer one, formed in the first year after someone is born, lie the most basic human functions, the primary vital functions such as hunger, pain and reflex. In layer two, formed between the ages two and five, lie impulses and mimicking behaviour. Then in layer three, all stimuli are formed into an image that is connected to memory, which gives it meaning. And lastly, in layer four, the situation is assessed and based on the assessment, a plan of action is made to be put into behaviour [7].

The lower brain contains the emotional brain. This is where spontaneous behaviour, based on emotions, comes from. The upper brain is the rational brain, that helps us consider and make decisions. The lower brain is also sensitive for dynamic stimuli, things that move or make sounds. The upper brain processes static stimuli, which is a harder task. In the deterioration process of dementia, the upper brain is affected first and the lower brain will keep its functions longer. When the upper brain is affected, people will lose the ability to perform tasks that require functions of the upper two layers of the brain. These functions are for instance the ability to plan ahead but also to be able to reflect on oneself.

### 3.4. Sensory stimuli

When using sensory stimulation in design for people with dementia, deterioration of the sensory abilities has to be considered. Senses are necessary tools to make sense of the world. The environment contains many cues that unconsciously tell us how to act or interact with what is around. These cues can address a single sense or multiple senses at the same time. Sensory stimulation is regarded as an important tool to stimulate people with dementia and engage them in activities. Although people can get dementia at an earlier age, the Alzheimer Association [8] found that most dementia cases occur with people who are over the age of 65. Both aging and dementia contribute to physical and cognitive decline and influence the way people receive stimuli through their senses. This change in sensory reception needs to be taken into account. The following sections will explain important aspects regarding the sensory stimulation of people with dementia. The sense of taste will not be discussed because it is considered not to be relevant for this study.

#### Vision

Vision can be used both actively and passively to diverse residents from the exit. Vision, or visual perception, is the ability of a person to see and interpret the visual information in their surroundings [9]. A visual stimulus can be anything that appears to the eye, such as light, images and colour. But also, materials with visible characteristics such as shiny metal [10]. Vision is often used in sensory stimulation therapy, including therapy for people with dementia. According to Jakob et al. [10], vision can be effective, but is often too much emphasized as a sensory stimulus for people with dementia. Too much sensory stimuli can be easily overwhelming. As described in Reisberg's [6] scale, people with dementia can experience affected ability to focus. This supports the advice by Jakob et al. [10], to de-clutter spaces and create visual focus points by for example lights that gradually change colour.

In order to guide certain behaviour, rather than just stimulating the mind, Habell [11] suggests visual cueing systems. As Habell cites Frascara in his study into specialised design for people with dementia: "Signs affect knowledge, attitudes and behaviour in general life" [12]. And if well used, they can be effective as visual guides in dementia care facilities. A visual cueing system might be colour coded sections or doors that are consistent through the residence. For example, using bright colours for bathrooms or communal areas that are accessible for residents, and using more dull colours for restricted areas.

A different visual cue is the gathering of other people in a certain place. Therapists from Bruggerbosch, and a receptionist, stated in an interview that residents are attracted by activity. Meaning that when a

group of caregivers are checking out of their shift at the same time at the reception, this attracts residents to the reception as well.

Rather opposed to Habell, Zeisel et al. [13] say that the important thing in order to obtain exit control, is unobtrusiveness of the exit possibilities. A feature is regarded unobtrusive when it is visually hidden and people are not aware of it. When exits are sufficiently unobtrusive, residents will not be aware of the fact that the exit is there and this will result in fewer attempts to exit the residence. Disguising the availability of an exit will therefore prevent frustration amongst residents and agitation for staff.

## Audition

Auditory stimuli have different functions and can act both deterring and enticing. However, people with dementia might not be able to detect auditory stimuli as well as other people. Hearing loss is a common occurrence in the aging process. Also, Uhlmann et al. [14] have found a correlation between hearing loss and the severity of cognitive dysfunction. The hearing loss significantly impacts the activities of daily living (ADL) [15]. This means that because of hearing impairment, people are not capable of performing certain tasks anymore. Therefore, hearing impairment needs to be taken into account when using sounds to attract the attention of people with severe dementia.

Music has proven to be a useful tool in stimulating people with dementia [15],[16]. It can be used as a way to comfort people but it also allows them to reminisce about earlier times since memory for music has demonstrated to be more tenacious while other abilities have already declined, as concluded by Spiro [17]. Music elicits curiosity and can be used to attract people into going to the place it is coming from.

Study into whether there is a relation between certain types of music showed that preferred music types, rather than a specific general music type, in music therapy helped improve cooperation in certain tasks and a decrease in aggressive behaviour [18]-[19].

Abstract sounds can elicit curiosity as well. Jakob et al. [10] support this, but also state that if the sounds are meaningless or too 'alien' they can cause confusion amongst residents. Abstract sounds that do have meaning, for instance, alarms, are more effective. Therefore, it is common that dementia nursing homes use door alarms at exits, which is the case at Bruggerbosch as well.

Employees of Bruggerbosch, an activity guide and a receptionist, stated in interviews (section 5.2) that the use of voice is very effective in instructing residents, especially when the resident are addressed with their name. They also stated that using personal information about the resident is effective when needing to change certain behaviour, such as attempting to exit the residence.

## Olfaction

Types of dementia and mild cognitive impairment (MCI) have shown to be correlated with deficits in olfactory functions [20]. It affects the detection threshold, discrimination and identification of smells. Smell is used as a sensory stimulus in for example aromatherapy but not yet as a deterrent or incentive. Smell has however, shown to have a strong connection with memory, according to a Bruggerbosch psychologist (section 5.2.3).

## Touch

The sense of touch can be used in a passive way and in an active way. Passively, to comfort people and make them feel safe, by providing soft or 'fluffy' materials. And actively, by providing people with dementia with objects with which they can interact in engaging ways. For example sensory cushions that contain different materials for a tactile experience and buttons and zippers to play with [21]. Touch

can be an effective stimulus, but in order to attract people with dementia and establish interaction, a touchable object should look inviting and meaningful [10].

### 3.5. Discussion and conclusions

As explained, the brain has upper and lower layers. The lower layers process dynamic stimuli and these functions are affected by dementia in the last stages. Based on findings from different sources, we can conclude that it is likely that dynamic visual stimuli are more effective in attracting the attention of people with severe dementia. Literature states that vision in general can be an effective sense to stimulate people with dementia and guide them in their behaviour. And that through visual cues, such as signs or colour coding, people can be assisted in their wayfinding through the residence. This can be used to steer residents away from the exit. Grouped social activity can also be a visual cue and attract residents to the place where this is happening. Taking this stimulus away from the area around the exit could therefore also be a useful way to the lower attractiveness of the exit. Disguising the exit as a whole, could possibly help prevent that residents attempt to leave the building as well. However, this is a solution that Bruggerbosch has already tried at one of their exits. Big stickers of life size bricks were stuck on a glass door to disguise that this was in fact an exit. Unfortunately, residents did still notice the exit and started peeling of the stickers from the door.

Auditory deterrents, such as alarms, can also be used to help prevent residents leaving the building. A downside to this is that it can be obtrusive and a less respectful way of keeping residents inside. When using sounds to attract people, sources show that meaningful sounds, especially music of the preferred taste of a person, are the more effective ways. Voice usage, with a personal approach can be effective as well.

Based on findings in literature that prove a correlation between the deterioration of the olfactory sense and dementia, a way to effectively use olfaction in sensory stimulation of people with dementia, could be to use stronger smells that are easy to distinguish.

When using touch as a way to attract the attention of people with dementia, it is recommended the tactile objects have multi-sensory properties to help establish interaction. It should for example, look visually appealing so that the resident feels invited to touch it. Soft, shiny or other textured materials could be used for this.

Overall, when working with sensory stimuli for people with dementia, the advice is to take care that there is no overstimulation. Overstimulation is caused by an overload of sensory stimuli from one or multiple senses. When an environment contains a lot of visual stimuli, such as different colours and materials, but also moving things such as people, the space quickly becomes ‘visually noisy’. If on top of that there is actual noise of people talking and walking around, the environment is even more imposing. When designing an intervention that uses sensory stimuli, it is recommended to make the design such that it fits within the environment and still manages to address senses and attract attention.

### 3.6. Design guidelines

To assist the design process of designing for people with severe dementia, below are elicited design guidelines that are related and relevant to this study. Based on findings and advice in various literature [10]-[11], the following things are advised:

#### 3.6.1. Environmental aspects

- The use of soft materials to make a resident feel safe and comfortable.
- The use of soft, indirect or diffused lighting.
- Creating visual focus points with:
  - Slowly changing colour of lights.

- Illuminated hand-held items.
- Video projections.
- Highlighting areas of attention.
- Bringing the feeling of outside inside with natural elements.
- The use of objects with meaningful properties.
- The use of objects that residents are familiar with.
- Creating sensory artworks that have a level of abstraction, yet are recognizable to residents.

### 3.6.2. Technology

- The use of multi-sensory technology.
- Combining the technological and the natural.
- Combining new things with familiar things.

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## 4. State of the art

In this section, relevant products and existing interventions to similar problems will be discussed. Both commercial and scientifically supported material will be considered and relevant aspects of the products will be used as inspiration for the intervention of this study.

### 4.1. Current commercial products

#### 4.1.1. OmiVista

The omiVista is an interactive projection system [22]. It projects images on surfaces and users can interact with it by moving around their hands, feet or entire body. There are different games that users can play, for instance popping balloons or playing a xylophone (Figure 1). The system is flexible and can be placed in varying environments. The use of the system stimulates multiple senses. It provides both audio and visual feedback and addresses the vestibular and proprioceptive senses as well. The two latter senses regulate body movement, direction and acceleration to maintain balance and sense the relative position of body parts. Relevant to this study is the flexibility of the installation and its large amount of possibilities for projecting stimulating images that in can be used as distraction or guiding tools at Bruggerbosch.



Figure 1 OmiVista in use with xylophone game [34].

#### 4.1.2. Bus booth

The bus booth is a solution that allows care givers to let residents wander off in a controlled way. It was thought of by dementia nursing home Benrath Senior Centre in Düsseldorf [3]. This nursing home experienced the same problem they do at Bruggerbosch. Residents attempting, and succeeding, to exit the residence and wander off. The solution they came up with is to place a bus booth just outside the residence (Figure 2). When residents exit, and see the bus booth, this appears as a convenience to them.



Figure 2 Phantom bus stop at Benrath senior centre[35].

The residents sit down at the bus booth and patiently wait for the bus to come. The bus booth functions as an assembly point and residents can easily be picked up from there. The bus booth provides the staff of the nursing home with the feeling of more control over their wandering residents and has alleviated the work stress that was caused by the problem. The solution has been implemented in several nursing home facilities around Europe and the US.

#### 4.1.3. Murals to disguise exit

A commercially offered solution to residents attempting to leave their care facilities is mural paintings or stickers that disguise the presence of the exit [23]. Dependent on the environment, murals can vary from bookshelves (Figure 3) to cupboards with dishware or knickknacks. To residents with dementia, the exit is not there anymore, but people with unimpaired cognition can look through the murals and still identify it as a door.



Figure 3 Mural in dementia nursing home [36].

#### 4.1.4. Alarms and signage

There is a number of web shops that offer different products to prevent wandering [4],[21]. These products include for instance, systems that consist of a tracker and sensors that send data to caregivers. Other products offered by these web shops are static visual deterrents, or in other words, signage. These can be for example, stickers to stick on doors that say ‘Do not enter’ or red signs that say ‘STOP’ (Figure 4). Although this might not be the nicest way to prevent residents from leaving the building, signage can be an effective way to help people with their orientation. Therefore, it is relevant to keep the use of signage in mind when trying to guide residents away from the exit.



Figure 4 Example of a visual deterrent [37].

### 4.2. Current scientifically supported products

#### 4.2.1. Ambient assisted living night time wandering system for elderly

This is a system developed by Radziszewski et al. [24] aimed at detecting the onset of wandering episodes at night. Besides this, it also provides assistance to meet the needs that are associated with the awakening, for instance going to the toilet or drinking water. Lastly, and most important in relation to this study, the system encourages the awoken person to go back to bed with visual cues.

The assistive functions of the system are driven by a personal profile of the user, formed during a monitoring phase. Based on this profile, the system can make assumptions about the resident’s behaviour, such as the need to go to the toilet at a certain time during the night. The system will assist



Figure 5 Visual cue to lead person to the bedroom [24].

the resident in meeting these needs by for instance turning on the light in the bathroom. After a while, the system will encourage the person to go back to bed. This is done by activating a light path on the ground that leads to the bedroom (Figure 5).

#### 4.2.2. PARO

PARO is an interactive therapeutic robot that resembles a small seal and appears as a stuffed animal. PARO was designed by Takanori Shibata and developed by AIST [25]. It is used as a companion for people with dementia in both private settings as well as nursing homes. According to studies by Wada et al. [25], PARO stimulates social interaction between residents and caregivers, but also has a positive effect on the residents' emotional state. The residents' improvement moods decreased the staff's workload and mental stress. PARO possesses different qualities that stimulate residents through multiple senses. PARO looks appealing to residents and is made of soft materials that invite petting and cuddling (Figure 6). It also gives audible feedback and can move as reaction to external stimulation. Relevant for this study is residents' engagement with PARO. PARO was used in group therapy, but also in situations where it was needed to calm down distraught residents or distract residents during certain routines that made them feel anxious [26]. Tests showed that PARO also had a positive effect on the ability to physically recover from stress.



Figure 6 Person interacting with PARO [38].

#### 4.2.3. Tovertafel

The Tovertafel (Figure 7) is a playful interactive projection system [27], much like the omiVista, but originally designed for people with dementia and based on research into their social and physical environment and the influence on movement. There is a number of games that promote multiple aspects such as physical movement, social interaction with others, stimulation of senses and reminiscence. The Active Cues design team, developers of the Tovertafel, work with a participatory design method to be able to accurately meet the needs and capabilities of people with dementia. From this method the researchers have learned that “light projections that are rich in colour, movement and detail, are most appreciated by the elderly.” [28].



Figure 7 People interacting with the Tovertafel [39].

### 4.3. Discussion and conclusions

The above-mentioned products and interventions have qualities that can be useful for finding a solution to the exit problem at Bruggerbosch. From several commercial solutions one can see that characteristics of dementia can be used in a positive way to prevent exit attempts or keep residents close. Namely by creating a comfortable illusion for residents with dementia, that people with healthy cognition can look through. This is both interesting and inspiring.

The scientific solutions provide thoroughly tested and evaluated solutions. The night time wandering assistant (Figure 5) shows that people with dementia can be drawn and guided into a certain direction by use of a light path. However, this system is aimed at usage during the night and therefore it is questionable whether it will work with daylight as well. The Tovertafel (Figure 7) proves that it is possible to engage people with dementia by use of dynamic projections on a surface. PARO (Figure 6) is also successful in engaging people with dementia and is being used in situations to calm or distract people as well. These are qualities that might be useful in finding a solution to the problem at Bruggerbosch.

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## 5. Ideation

In this chapter, the idea generation of the project is explained. Herein is included information acquired from the literature research, interviews with experts and personal experiences at Bruggerbosch.

### 5.1. Context analysis

Multiple observations were performed between different timeframes in the morning, midday and afternoon. The main findings from the observations were that weather conditions may have influence on the activity around the exit. Due to sunny and warm weather, many people went outside for a walk or to sit down in the sun. On average, about 55 people walked in and out through the door every hour on the observed hours (Appendix A). A receptionist of Bruggerbosch stated that a lot of activity occurs during the change from morning to evening shifts between two and three o'clock. Employees who worked the morning shift then come to the reception to hand in their work phones and say goodbye. These employees often stay at the reception for a little while to talk with their colleagues. To determine how influential this factor is on attracting residents towards the exit, an experiment was performed. For one day, employees of Bruggerbosch were instructed to use a side door instead of the main entrance of Bruggerbosch. However, during the day of testing, there was a heat protocol in action, which ordered care givers to keep residents in their living rooms as much as possible to stay cool. The results of this test did show a decreased amount of activity around the exit and also in exit attempts (Appendix B). However, this cannot be considered reliable evidence because the situation during the test was not representative for a regular day at Bruggerbosch.

It was observed that there are more factors in the environment of the exit that can be contributing to the reason why residents end up at the exit (Figure 8Figure 8).

First of all, there is a big contrast in light. Compared to the bright sunlight coming from outside, the inside of the entrance hall seems to be quite dark. Residents are therefore drawn to this sunlight. Where the building has a good design for visitors, who naturally feel where the exit is and where to go to ask questions, the same goes for the residents and therefore, the buildings design is not very favorable when it comes to the design for a dementia care facility with wandering residents.

Then there is the receptionist, who is a multi-sensory stimulus. She talks, moves and people gather around her which make her an auditory, visual and social stimulus that residents seem to be attracted to. Right before the exit, there is a small gift shop. This gift shop has items stalled and displayed outside of the shop, for example, shiny jewelry and things wrapped in squeaky plastic foil. It was observed that some residents are drawn to these products to look at and touch them. Finally, the shape of the furniture in the entrance hall creates a natural way directed to the exit. The rounded reception desk and gift shop create a funnel like path straight to door that is easy to follow by residents who are wandering.

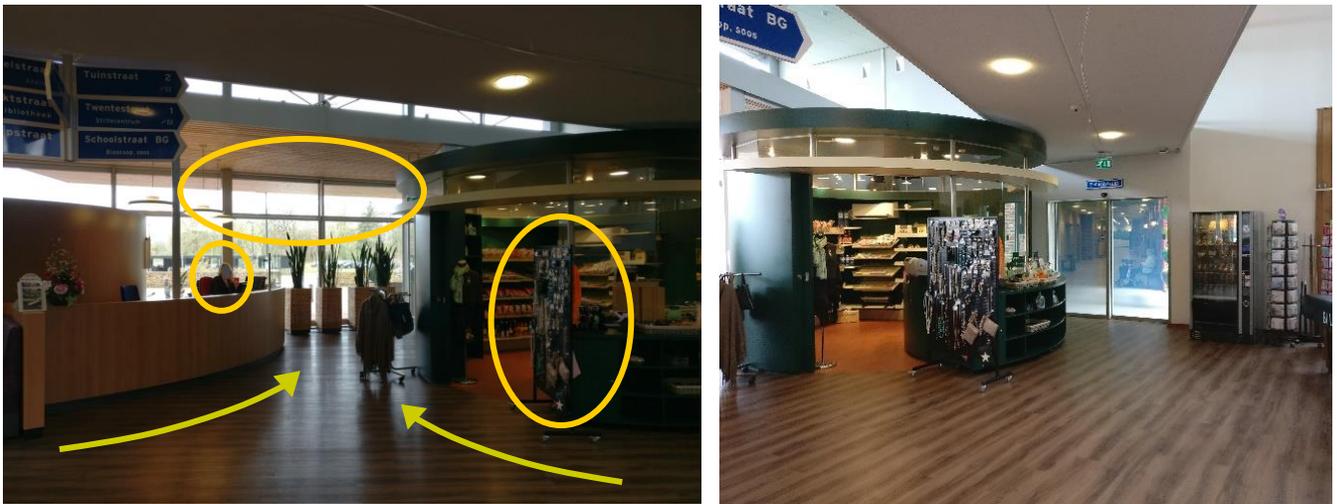


Figure 8 Entrance hall of Bruggerbosch (left); Gift shop (right).

## 5.2. Expert interviews

To get a more personal insight in the behaviour of residents of Bruggerbosch, the staff's experiences with them and feedback on some preliminary design directions, expert interviews were conducted with an activity manager, a receptionist and a psychologist of Bruggerbosch. The interview questions can be found in Appendix C.

### 5.2.1. Interview activity manager

The activity manager has been with Bruggerbosch for over ten years now and his tasks as an employee are to organize and manage activities for the residents with the focus on physical movement and engagement. These activities are meant to keep residents active and therefore they are mostly sports related activities in a playful way. For giving instructions to the residents, he states it is important to maintain the order of 'praatje, plaatje, daadje' (Dutch for 'talk, picture, deed'). Which means, explain, demonstrate and then let the them try it out themselves. Only words are not enough. He also mentions that the best way to reach residents, for him personally, is to use his humor. Making residents laugh makes them comfortable and relaxed and makes them more willing to participate. When residents are resistant, he tries to engage them by applauding and cheering them on with the other residents. But eventually things are always done from a perspective of the residents' needs and wishes.

The activity manager says he has used technology in his activities with residents before, for example the OmiVista (Figure 1). In groups this system is not as effective, but for individual use it can be nice. They have also tried the Kinect, but this was not understood by residents because they did not understand the relation of their physical actions in combination with things happening on the screen. However, for the generation that grew up with technology it might be useful. When it comes to stimulating senses, he does not focus on a specific sense and did not notice one sense being more effective in stimulating than the other.

### 5.2.2. Interview receptionist

The interviewed receptionist has been working at Bruggerbosch for eight years now. Her task initially was to be a telephonist, but an important part of her job is also to interact with the residents that come to her desk or the exit. Although this is a large part of their job, the receptionists are not trained on how

to interact with people with severe dementia and some do not know what a good response is in the situations that often occur at the exit.

According to the receptionist, the most situations with residents at the exit occur after lunch, when the sun is shining right on the glass around the exit. She states residents end up at the exit for different reasons. Some end up there on accident as a result of their wandering, and some go there with a plan. She says for the latter group of residents it is hardest to change their mind or distract them. It is also common that residents in such a case get upset or aggressive.

To lead residents away from the exit, this receptionist uses a personal approach and states she feels this is most effective. She is not very confident about solutions to the problem, but if anything, she would try to take an important attraction stimuli away. Which are in her opinion the employees that loudly change shifts at the reception every day.

### 5.2.3. Interview psychologist

The interviewed psychologist of Bruggerbosch has been working in the field of dementia care for several years. She does neurological research on dementia and is involved with residents of Bruggerbosch. She looks at the severity of the dementia and a person's symptoms and behaviour to decide what the best care for this person would be.

She is familiar with the problem at the exit and frequently sees it happening herself. She has noticed the attraction of the large windows and the activity from employees going in and out as well. The exit is extremely visible for everybody, which makes sense but is not always convenient in the case of a nursing home for people with dementia.

The psychologist explains that there indeed is a spectrum of residents who accidentally end up at the exit or go there purposefully. She believes this is not directly correlated with the stadium of dementia, but more with the personality of the person with dementia and the type of dementia they have. Therefore, you cannot draw a line for all the people living at Bruggerbosch.

When asked about the utility and applicability of sensory stimuli in guiding residents away from the exit, the psychologist stated she can imagine it being useful. People with dementia have often difficulties with focussing and are easily distracted and attracted by stimuli. She strongly believes that providing a counter stimulus that is more attractive than the exit could help solving this problem. The olfactory sense is very much connected to memory. Also, music can be used to connect to a person with severe dementia. Besides providing sensory stimuli, a solution could also be to disguise the exit.

The psychologist explains that the time it takes to process sensory stimuli is different for people with dementia as opposed to healthy people. A person with dementia needs more time to process the same stimuli and therefore it would be important, if using sensory stimuli, to provide stimuli that last a little bit longer than it might have normally.

Dementia is a progressive disease that slowly takes away memories, starting with the things learned last and making its way back through time. People with dementia have a different perception of the world because they have lost memory of the things learned last, mentally they could be back 40 years. Therefore, the psychologist says, it would not be very natural for them to interact with for instance a touchscreen, since the use of touchscreens has only become common in the last decennium or so. Residents could even be scared to use it.

The psychologist feels that a combination of both an autonomous distraction from a technological intervention and a personal, human approach is desirable and probably most effective.

## 5.3. Requirements elicitation

With the gathered information about the residents of Bruggerbosch and designing for people with dementia, a list of user requirements was created. In Table 1, the first column represents a user's or a

proxy user's experience based on findings in literature, observations and statements in interviews. A proxy user represents a user that is not directly the target group of the intervention, but is connected to the group such that they have useful knowledge and can relate to the actual users. The second column denotes the source of the experience in the first column. In the third column of the table the value is stated that is connected to the experience, in order to take a step back and consider what is generally wished for in this situation. In the last column, the experience together with its related value is translated into a system requirement.

Users' experience	Source	Value	System requirement
"It is common that residents get upset or aggressive when they cannot go out the door."	Interview receptionist; section 5.2.2.	Comfortability	System should distract/attract the residents such that they do not mind the exit anymore.
Residents are attracted by the exit because of sunlight, presence of the receptionists and visitors/employees going in and out through the door.	Observations; section 5.1.	Stimulation	The system should provide stimuli that are noticed by residents more than the current stimuli present in the entrance hall.
"People with dementia lose memory of new products, such as touch screens and smartphones. A product or intervention intended for their use should therefore fit their perception of the world."	Interview psychologist; section 5.2.3.	Recognition	The system should be recognizable such that it invites interaction by residents.
People with dementia have deteriorated ability to remember new information.	Literature; section 3.3.	Ease of use	The system should not contain any features that require learning or memorizing.
PARO is used to calm people down or distract them in stressful situations.	Literature; section 4.2.	Comfortability	The user should feel safe and comfortable when using the system.
"Sometimes when I am busy and a resident tries to leave [...] it takes a while before caregivers are here to help."	Interview receptionist; section 5.2.2.	Control	The system should be able to entertain a resident for a while so that employees have time to take action.
"I try to use personal information to get their attention on something else."	Interview receptionist; section 5.2.2.	Recognition	The system should use information about the residents to make it more personal.

Table 1 User requirements.

## 5.4. Mind mapping

The ideation process was started by making mind maps to form a mental ‘ideation space’ and provide an overview of all things association with different subjects of the problem. The created mind maps can be found in Appendix D.

## 5.5. Brainstorm

A 3x5 minutes brainstorm was performed individually, in the form of a brainwriting pool. To prevent getting stuck or running out of ideas, the time was split up in 3x5 minute sessions with in between time to take a walk outside and get inspired again. All the produced ideas were written in a couple words or a short sentence on sticky notes and stuck on the middle of the table, together with ideas that were already thought of earlier in the project. In total these were about 50 ideas. Through four steps, all the ideas were evaluated. The evaluation process is explained in the following section.

### 5.5.1. Evaluation 1:

For the first evaluation, the ideas generated in the brainwriting pool were split into two categories. A category ‘immediate no’s’ (orange sheet) and a category ‘to be continued’ (green sheet). If an idea was too ridiculous, irrelevant or with an out of reach feasibility the memo would be stuck on the orange sheet. If the idea was worth thinking about again, the memo would be stuck on the green sheet of paper (Figure 9).



Figure 9 First evaluation of memo ideas.

### 5.5.2. Evaluation 2:

The green ideas were digitalized for the second evaluation. This second evaluation was performed in a matrix system (Appendix E). The ideas were then individually scored between one to five on the following six principles: feasibility, innovativeness, comfortability, distractibility/attractiveness, fits in environment and safety.

The feasibility was assessed based on assumptions about the amount of effort, time and money that would be spent on an idea. The innovativeness of an idea was scored based on state of the art interventions in the literature section and the overall use of certain techniques and technology. For comfortability was looked at the comfortability of all people involved, both residents of Bruggerbosch and receptionists and caregivers who may have to assist. The distractibility/attractiveness of the idea was based on theory about sensory stimulation and own observations. Fits in environment was scored based on observations and personal insight in the environment. Finally, the safety of an idea, for all people involved, was assessed based on meetings with the therapists from Bruggerbosch and common sense.

The scores were added to a total and ordered from high to low. This provided useful insights in which ideas would theoretically be better than others. The ideas with scores lower than 20 were stuck on a blue sheet of paper and the top thirteen were saved on the green sheet (Figure 10).

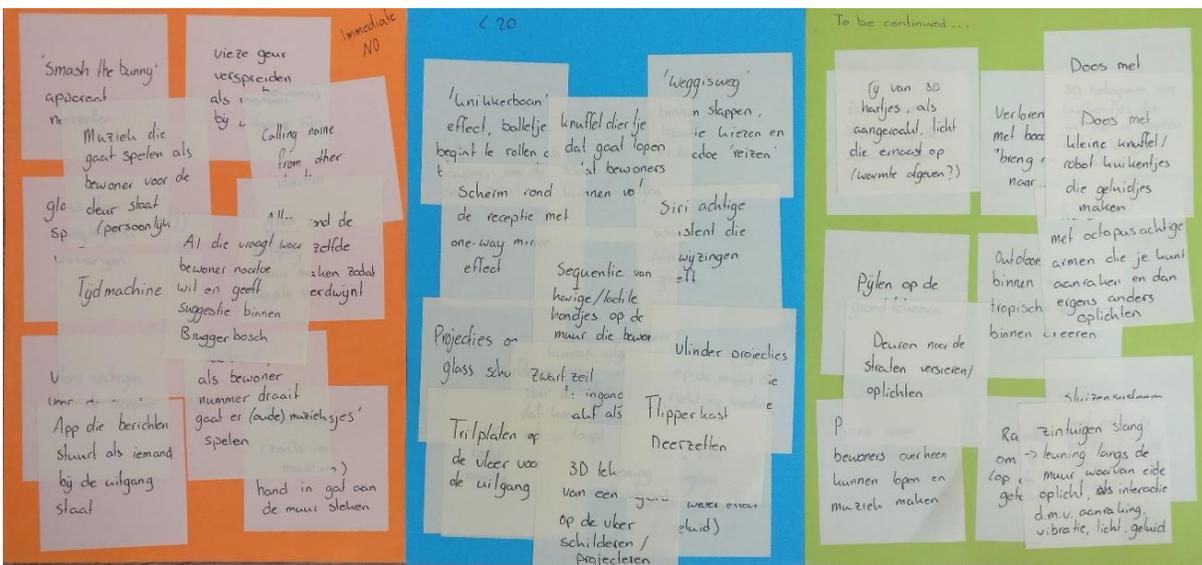


Figure 10 Second evaluation, extra category '<20' added.

### 5.5.3. Evaluation 3:

The ideas that scored higher than 20/30 were worked out in a few sentences so they could be evaluated with help of external parties. The eventual top thirteen ideas (Appendix F Appendix ) were each pitched to two occupational therapists of Bruggerbosch. The ideas were then thoroughly discussed, among other things, on their suitability for the residents and staff of Bruggerbosch and the effectiveness of the overall idea. Based on their feedback a new rank was formed (Appendix F Appendix ). The three ideas 'Lost Puppy', 'Box of chicks' and 'Illuminating row of 3D hearts' came out on top.

### 5.5.4. Evaluation 4:

In this fourth part the evaluation. The remaining three ideas are explained in more detail and the pros and cons for each idea are listed.

### Lost puppy with message

A stuffed animal, might be in the shape of a small dog or cat, is placed somewhere in the area of the exit. Residents would notice it due to its barking or meowing and pick it up. The barking/meowing by the animal can be activated by the receptionist or a sensor at the door. The animal has a note or maybe a voice message (upon touch) that says it's lost and wants to go back home. In one of the two adjacent hallways of the entrance hall (Dorpstraat or Schoolstraat) or another place in the residence, baskets are placed with a mother dog/cat where the residents can bring the animal.

Pro	Con
Gives purpose to aimless wandering.	Multiple dogs might be needed.
Can provide substitute satisfaction of need to go somewhere or do something.	Dogs need to be recollected and brought back.
(Stuffed) animals can provide comfort in situations of distress.	Assistance by receptionist is desirable.
Can stimulate social interaction to assist in goal reaching.	
Provides a multi-sensory experience.	
Provides meaningful sensory stimulation.	

Table 2 Pros and cons of the Lost Puppy.

### Box with chicks

A box as ones often sees in small animal gardens, standing somewhere rather close to the exit, filled with chicks that are hatching or just small. From the box come chick like sounds to attract the residents to the box. In the box are small stuffed animal chicks that can move around a little bit. Residents can either look at them or pick them up and play. The reception would have a collection of chicks behind the desk to give to a resident when they come to the exit. The receptionist can then ask the resident to bring the chick back to the box. The chicks cannot be fragile. No small loose parts either.

Pro	Con
Gives purpose to aimless wandering.	Short time of occupation.
(Stuffed) animals can provide comfort in situations of distress.	Multiple chicks needed.
Provides multi-sensory experience.	Assistance by receptionist is necessary.

Table 3 The pros and cons of the Box with chicks.

### Illuminative row of hearts

A sequence of heart shaped bolls of which one lights up if a resident stands in front of the exit. If the heart is touched, the one next to it lights up, this could go on in different patterns back and forth. The shape of a heart was based on a design guideline that it should somehow be meaningful to invite touching. A heart was considered more meaningful to touch than a sphere or a cube. The heart could be made of soft rubber or another material that is pleasant to touch. There could be a sign next to it that says 'Raak me aan' ('Touch me' in Dutch) to make it more apparent that the hearts can be touched. This idea might can work for people who are in a wandering state. This unobtrusive stimulus might then propose an interesting and stimulating activity to keep residents away from the exit. However, some residents are very determined to go out and come to the exit with a plan. For these residents, this might not pose enough of a distraction or stimulus to differentiate their plans.

Pro	Con
Can contain a game element.	Fairly meaningless stimulation.
Provides sensory stimulation for people with late stage dementia.	Location fixed.
Provides multi-sensory experience.	Location dependent for identifying the installation.
Assistance from receptionist not necessary.	Time of occupation dependent on user.

*Table 4 The pros and cons of the Illuminative row of hearts.*

After discussion with supervisors and weighing of the pros against the cons of the three top ideas, the idea of the lost puppy was selected as best idea to be made into a prototype and tested at Bruggerbosch.

The idea of the lost animal can give an aimlessly wandering resident a goal and a meaningful purpose. The system provides attractive stimuli that will distract a resident's attention away from the exit. Besides distracting the resident from the exit, the lost animal can give the resident interacting with it a feeling of responsibility. This responsibility and taking care of something can give a person so called ideo-pleasure, according to the pleasure model of anthropologist Lionel Tiger, that was applied to product usability by business psychologist Patrick Jordan [29]. Ideo-pleasure is pleasure that is linked to a person's ideals and values. For instance, a person that values environmental awareness would get ideo-pleasure from using a product that is made from recycled material. In this case, a resident could get ideo-pleasure out of helping someone else, here the small animal, because the resident values doing good to others.

Attraction of humans by animals might also be motivated by something called 'biophilia'. This can be described as the hypothetical affinity of human beings with and the tendency to connect with other living things in nature, such as animals [30]. This feeling is considered congenital and universally felt human beings.

The lost animal intervention can also give a person psycho-pleasure. In Jordan's pleasure model this entails pleasure that is created through satisfaction of the intellect. For example, by solving a puzzle. In the case of the lost animal, finding the animal's mother/home can give such pleasure.

The other two pleasures from Tiger's four-pleasure model are physio-pleasure and socio-pleasure. Physio-pleasure is derived directly from the senses and the sensory experience of a product in combination with associations with that product. For example, the smell of a new car. Socio-pleasure comes from products or services that facilitate social interaction or carry out a certain identity of a group that a user feels he or she belongs to [29].

The specification of the lost animal concept will be explained in the next section.

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## 6. Specification

In this section, the lost animal idea that was the result of the ideation phase, will be further specified and conceptualized.

### 6.1. Choice of animal

Initially, the idea was based on a lost puppy or kitten. An assumption was made that many people enjoy puppies and kittens. However, people are often familiar with cats and dogs and might make assumptions about their behaviour, which can be negative. This was also one of the reasons that the designers of PARO chose to use a baby seal instead [31]. People know baby seals just enough to find them cute, but don't know exactly how a baby seal behaves which makes it easier to simply enjoy their companionship.

The psychologist of Bruggerbosch also stated in the interview (section 5.2.3.) that because dogs and cats are so easy to come in contact with, there is a bigger chance that people have had negative experiences with them, and perhaps even trauma's, than for example in the case of a seal. However, the same goes for positive experiences. Dogs and cats are popular animals in Dutch households and many people may have positive memories about them. Familiarity and recognition are important aspects when it comes to designing for people with dementia and therefore it was decided to still go with a dog or cat for this project.

It was consciously decided that the animal should be a 'baby' form. Meaning a puppy or a kitten instead of a grown dog or cat. This adds to the setting of them being helpless and lost, in need of help to find their way back to their home. To motivate this there is also the baby schema: *'The baby schema (Kindchenschema), as proposed by ethologist Konrad Lorenz, is a set of infantile physical features perceived as cute and motivates caretaking behavior in other individuals, therefore providing the fundamental function of enhancing offspring survival.'* [30]. This means that certain physical properties of the puppy, for example their fluffy hair and big round eyes, will stimulate a feeling of care and responsibility amongst residents.

It was decided to use a puppy instead of a kitten to make it more natural to use a slightly bigger animal that would be easier spotted by residents and practically to be able to store a speaker inside of it. Also, cats are usually more independent animals and therefore it is less likely for them to get lost. To make the situation easier to understand a dog was the more logical choice.

### 6.2. Location of the puppy

The location of the puppy was decided based on tests that were performed earlier in the project. The test set up and execution can be found in Appendix GAppendix . For the test, a stuffed animal, in the shape of a small dog was put at different locations in the entrance hall of Bruggerbosch. For the course of an hour for each location, observations were performed to observe whether the dog would be spotted or not. The most reactions were when the dog was put on top of a pool table that had a black cover on it (Figure 11Figure 11 Location test set up.). This created a big contrast between a large black canvas and a light coloured fluffy animal. Based on this test it was decided to take this as the



Figure 11 Location test set up.

location for the puppy (Figure 12). But since the pool table should be able to be used, the puppy will be put on a moveable cart in front of the pool table.

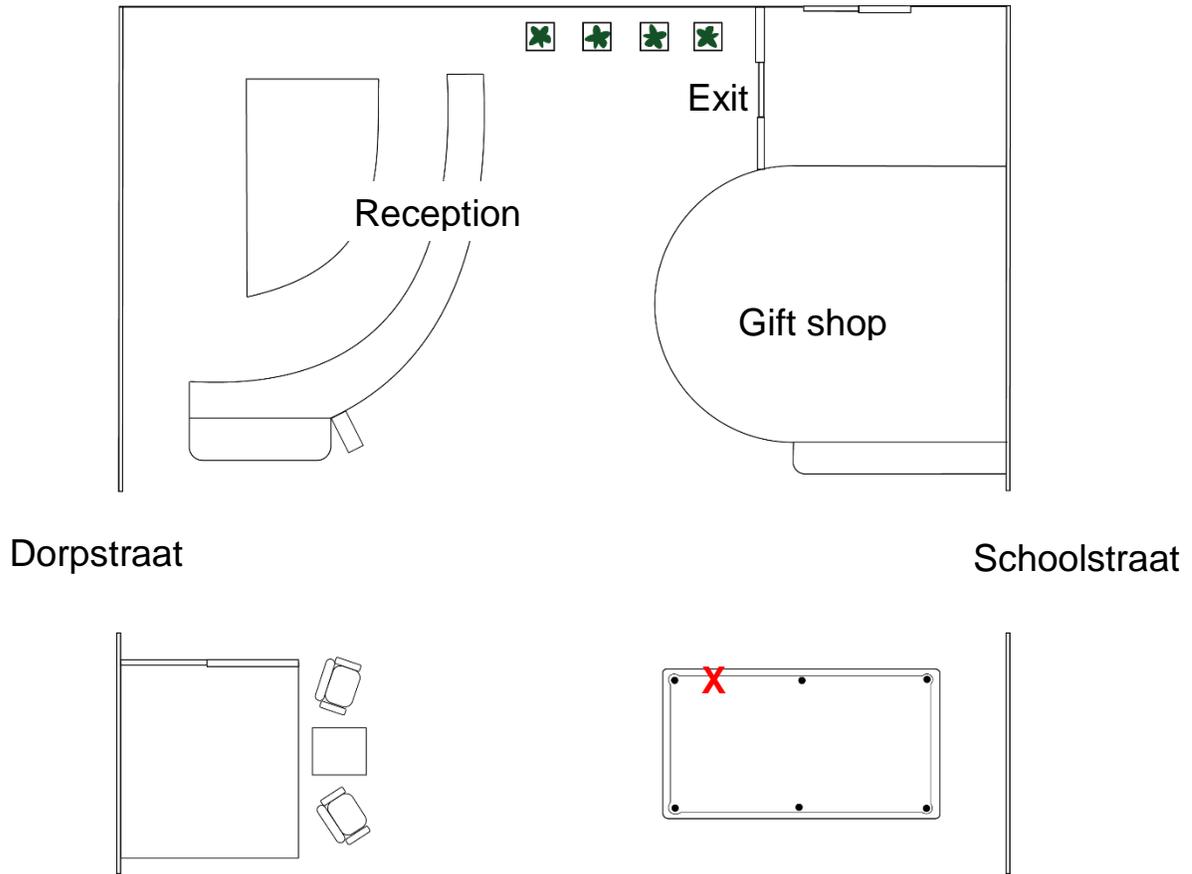


Figure 12 Map of the entrance hall of Bruggerbosch; Red X depicts the location of the puppy.

### 6.3. Concept specification

The concept of the lost puppy consists of the four phases: ‘attract’, when the resident’s attention is drawn to the puppy, ‘initiate’, when the interaction between the resident and the puppy is initiated, ‘hold’, is the period where the attention of resident is sustained, and finally ‘succeed’, where the resident completes the task of reuniting the puppy with its mother.

#### A. ATTRACT

In this phase, the resident’s attention is captured by use of visual and auditory stimuli. Visually, the puppy will be present and laying on hip height to make it easier to be spotted by residents. The puppy will also have a dark background to create contrast and let the puppy stand out more. Upon approach, a light will go on that gradually changes colour to form a dynamic stimulus and capture the attention of a resident. According to literature (section 3.3.) dynamic stimuli are processed by a part of the brain that deteriorates last in the progression of dementia and would therefore be more effective in attracting attention.

## **B. INITIATE**

In this phase, emotional and physical interaction is initiated with use of visual and auditory cues. To initiate interaction the puppy is made of visually soft material that invites touching and petting. The puppy will bark and whine to indicate it wants attention. Also, infantile physical features (section 6.1), for example the puppy's big eyes, will stimulate care giving by residents.

## **C. HOLD**

In this phase, the resident's captured attention is held and intended action is directed by use of visual, tactile and proprioceptive stimuli. Through a note that is attached to the puppy's collar, it is made clear that the puppy is lost and needs to be brought home, including where this is. Paw prints on the floor indicate the direction in which the resident needs to go. While looking for the basket, the resident's attention is on the puppy that they are holding. The resident is being stimulated through the tactile properties of the puppy and proprioceptive stimuli that cause the resident to hold on to the puppy and not let it fall.

## **D. SUCCEED**

In this phase the resident is supported in succeeding in the 'task' that was directed by use of visual and auditory cues. With the paw prints that were used during the HOLD phase, the resident can reach the basket in which a mother dog lays to indicate the puppy's home. The same colour changing lights will be present there to attract the resident's attention and make an (unconscious) connection to when the puppy was found. When the resident with the puppy approaches, the puppy starts barking in a happy way, indicating it recognizes that it is home. The resident can then lay the puppy with its mother.

## 6.4. Personas

To be able to envision the possible users better and create a use case scenario, two personas was created. The characteristics of persona 'Brecht' and 'Andrea' are based on experiences, interviews and conversations with people at Bruggerbosch.



Figure 13 Elderly woman [41].

### Brecht van Diepen

73 years old, married, one daughter

Brecht is a 73-year old woman who has been diagnosed with Alzheimer's disease six years ago. She has been living at Bruggerbosch for two years now. Before, her husband was taking care of her at home, but since she started showing wandering behaviour and the workload became too much for her husband it was better for Brecht to live at Bruggerbosch. Brecht and her husband have one daughter together. Brecht still recognizes her husband and daughter.

#### Stage of dementia

Stage 5/6, Alzheimer's disease

#### Symptoms

- Memory loss
- Disorientation of place and time
- Wandering
- Agitation and sometimes aggressiveness

#### Former job

Teacher at an art academy

#### Hobbies/interests

- Art
- Painting
- Animals

#### Personality

- Caring
- Mood changing
- Socially withdrawn but good with kids

#### Daily activities

- Participates in activity classes organised by Bruggerbosch.
- Her husband visits twice a week.
- Her daughter visits together with husband on Sundays.
- Enjoys interacting with small children who come and visit the residence.
- Wanders through the building.
- Drinks coffee frequently in the canteen.

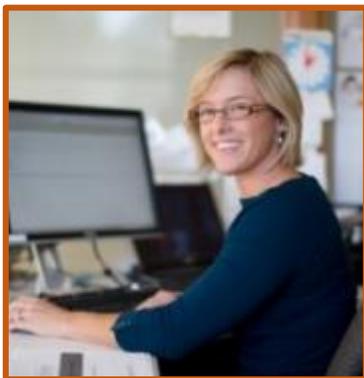


Figure 14 Receptionist [42].

### Andrea Scholtens

42 years old, married, two daughters

Andrea is a 42-year old receptionist of Bruggerbosch and has been working there for eight years now. She has studied communication management and Bruggerbosch is the first healthcare facility for which Andrea has worked. She has been married for seven years and has two daughters of ten and six years-old. She enjoys working with elderly people and through the years has developed skills to communicate with people with dementia.

## Study

Communication management

## Job

- Former: assistant at a research company
- Current: receptionist at Bruggerbosch

## Job responsibilities

- Serve reception desk and inform people
- Answer phone calls
- Keep an eye on residents at the exit
- Interact with residents

## Personality

- Patient
- Empathic
- Organised

## Hobbies/interests

- Playing piano and going to piano concerts
- Crafting with her children
- Organising trips with the school trip board of her children's school
- Playing squash with her husband

## 6.5. User scenario

### Brecht, the resident

*'Brecht has been a resident of Bruggerbosch for the last two years. She has stage five dementia Alzheimer's disease and has difficulties with her orientation. She often forgets that she is married but when her husband comes to visit her, she recognizes him. Brecht's husband recently came to visit her and they had lunch together outside in the courtyard because the weather was nice. After her husband left, she went back to her room to have a coffee. When Brecht finished her coffee, she started walking through the building. First upstairs in the hallway and then she took the elevator to the ground floor. Brecht exits the Schoolstraat and enters the entrance hall. She waves at Andrea behind the reception desk and then she walks towards the exit. As she walks, barking sound start coming from her left and she notices a blue light. Brecht turns to her left and sees a puppy sitting on a small table. She walks to the puppy and the puppy makes a sad whining sound. Brecht reads the note that is attached to the collar of the puppy. The note says the puppy is lost and the mother dog is in the Dorpstraat. She then pets the puppy and picks it up. Brecht finds paw prints on the floor and asks the puppy out loud whether they are from the puppy. She follows them and enters the Dorpstraat. Some meters into Dorpstraat, Brecht finds a basket with a bigger dog on the floor and the puppy starts barking. Brecht asks herself if this is her mother and lays the puppy in the basket next to the dog.'*

### Andrea, the receptionist

*'Andrea has been receptionist at Bruggerbosch for eight years. She studied communication management and has learned to interact with people with dementia through the years she has worked at Bruggerbosch. Today she has started her shift after the lunch break. She has been filing some room reservations and answering phone calls. Because the weather is nice, she needs to keep track of care givers and visitors taking residents out for a walk. Andrea notices Brecht waving at her and she greets her. Brecht walks towards Andrea without noticing the puppy barking and paces in front of the reception desk for a while. Andrea points to the puppy and tells Brecht she thinks it's lost because the puppy is supposed to be with its mother in the Dorpstraat. She suggests that Brecht gives the puppy some attention. Brecht walks to the puppy and the puppy starts barking, she sees coloured light coming from its direction. Brecht pets the puppy and then picks it up. Andrea then suggests that Brecht brings the puppy home to its mother in the Dorpstraat. Brecht asks where the Dorpstraat is. Andrea points to Dorpstraat and says to go in there. Brecht walks into the Dorpstraat.'*

## 6.6. Use case scenario

Basic flow of events:

1. Brecht walks out of Schoolstraat into the entrance hall.
2. Brecht's movement is picked up by the sensor.
3. The puppy starts barking and the light is showing different colours.
4. Brecht walks towards the puppy.
5. The puppy makes a barking and whining sound.
6. Brecht pets the puppy.
7. Brecht reads the note on the collar of the puppy.
8. Brecht picks up the puppy and pets it.
9. Brecht notices paw prints on the floor.
10. Brecht holds the puppy and starts walking in the direction of the paw prints.
11. Brecht walks into Dorpstraat.
12. Andrea takes another puppy from her desk and places it on the finding spot in the entrance hall.
13. Brecht reaches the basket with the mother dog.
14. The puppy starts barking.
15. Brecht lays the puppy besides the mother dog.
16. Later, Andrea collects the puppy from Dorpstraat and stores it at the reception desk.

Alternatives flows:

- 7a. Brecht does not read the note on the puppy's collar.
  - 7a.1 Andrea tells Brecht that the puppy is lost and needs to be brought home to the Dorpstraat.
  - 7a.2 Brecht asks where the Dorpstraat is.
  - 7a.3 Andrea points Brecht towards the Dorpstraat.
- 9a. Brecht does not notice paw prints on the floor.
  - 9a.1 Andrea tells Brecht that she has to go to the right and enter the Dorpstraat.
  - 9a.2 Brecht goes to the right and into the Dorpstraat.
- 11a. Brecht does not walk into Dorpstraat.
  - 11a.1 Brecht walks into the canteen.
- 11b. Brecht does not walk into Dorpstraat.
  - 11b.1 Brecht walks into the Schoolstraat.
- 14a. Brecht does not lay the puppy with the mother dog.
  - 14a.1 Brecht keeps holding on to the puppy.
  - 14a.2 Andrea gets another puppy from her desk and places it on the findings spot in the entrance hall.

## 6.7. Technical requirements

- Must have**
- No sharp objects or edges.
  - Puppy must be light enough to carry around.
  - The puppy must start barking as a reaction to movement in the near environment.
  - Visual cues that indicate direction of the goal.

- Explanation that instructs the user in what to do.
- Should have**
- Multiple puppies so that the installation is never empty.
  - Light that transitions in colour so that the installation changes appearance regularly.
  - Different sounds for different interactions.
  - Different lights for different interactions.
- Could have**
- Multiple locations with a basket and a mother dog.
- Won't have**
- Puppies with RFID chips for reaction to its environment.
  - Puppies that can move their head and eyes.
  - Personalized reaction based on information about the user.

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## 7. Realisation

In this section, the specified concept is realised into a prototype and the tools used for this will be described.

### 7.1. Prototype design

To start off the realisation of the intervention, first an overview of the installation was made to list all separate elements needed (Figure 15).

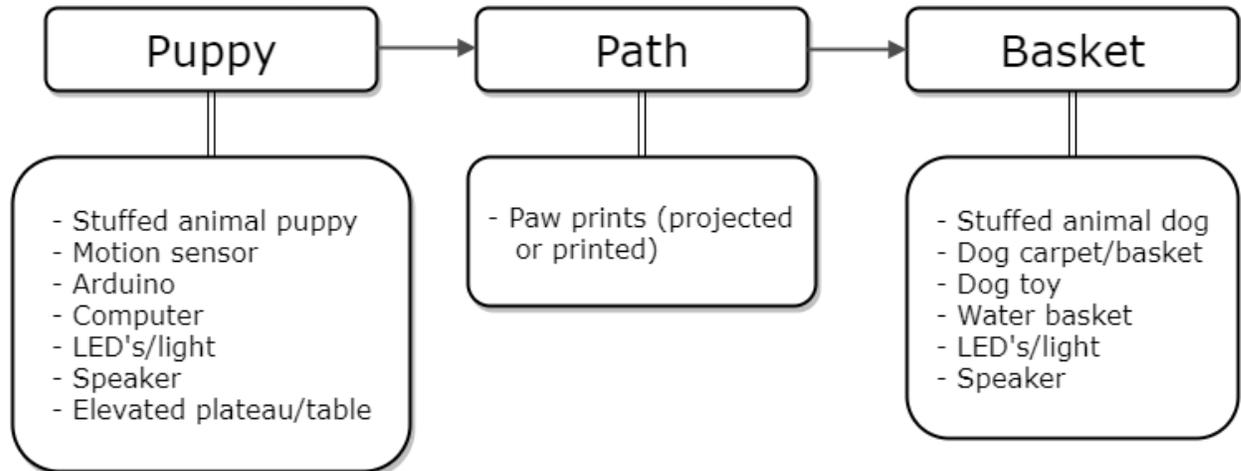


Figure 15 Overview of components in the prototype.

### The puppy

The stuffed animal that represents the lost puppy was selected based on several factors. The puppy must be of a manageable size that is possible for the residents to hold with one hand. For this was estimated to be a maximum of around 35 centimetres long, 15 centimetres wide and 15 cm in height, excluding paws and tail. The puppy should also be light enough to carry around for a while, as stated in the technical requirements. This is because residents might not have as much strength anymore due to ageing. Therefore, it was decided not to put the speaker inside of the puppy but in the environment around the puppy and possibly the mother dog. Multiple stuffed animal puppies were collected but it was decided to go for the puppy that looked the most realistic (Figure 16). For the location experiment this puppy was also used and residents reacted positively to the puppy. The other puppies had a high 'cuteness' factor, but their physical properties were enhanced such that it made them look too unrealistic and perhaps childish (i.e. extremely big round eyes, and very smooth fur). The note attached to the collar of the puppy says 'Lost:



Figure 16 Selected puppy for the intervention.

*bring me to the Dorpstraat.*’ This was done in handwriting instead of a typed message, to make it appear more familiar to the residents.

From the location experiment it was learned that the puppy was spotted most when laying on a big pool table in the entrance hall. The pool table had a big black cover over it and that created a contrast between the puppy and its surroundings that made the puppy most likely stand out more to the residents. However, the puppy in this intervention cannot always be put on the pool table because the pool table is used every now and then. The puppy should therefore be put on a separate, smaller table next to the pool table, preferably on wheels so that it is mobile and can be rolled away in case the pool table needs to be used. The smaller table for the puppy is also of a dark colour. For this purpose, a box was made that could store the technology and wiring inside and the puppy on top of it. The design of the box was made in the software program CorelDraw[32] and the box was cut out of wood with a laser (Figure 17).



Figure 17 Box to place the puppy on.

To incorporate lighting in the system, Philips Hue lights are used (Figure 18). The Philips Hue lights are controllable from a distance through a mobile application and via the computer, and can show different colour patterns and brightness's.

As stated above, the speaker through which barking sounds are played, is placed unobtrusively underneath the puppy so that it still looks as if the sounds are coming from the puppy itself. To control when the barking sounds are played, a motion sensor is included in the installation.



Figure 18 Philips Hue bridge and lamps [40].

The passive infrared motion sensor detects motion up till about six meters. As soon as motion is detected, the Arduino to which the sensor is connected (Figure 19), will send this data to a computer that is placed in the installation as well. There are different types of barking sounds that can be played. Some sounds are more of a sad and whiney character, to aid to the story of the puppy being lost and wanting attention. And other sounds are more excited to generally stimulate residents. The sounds in this prototype are played randomly but for future development it would be interesting to see if it would make a difference to play certain sounds according to the interaction.

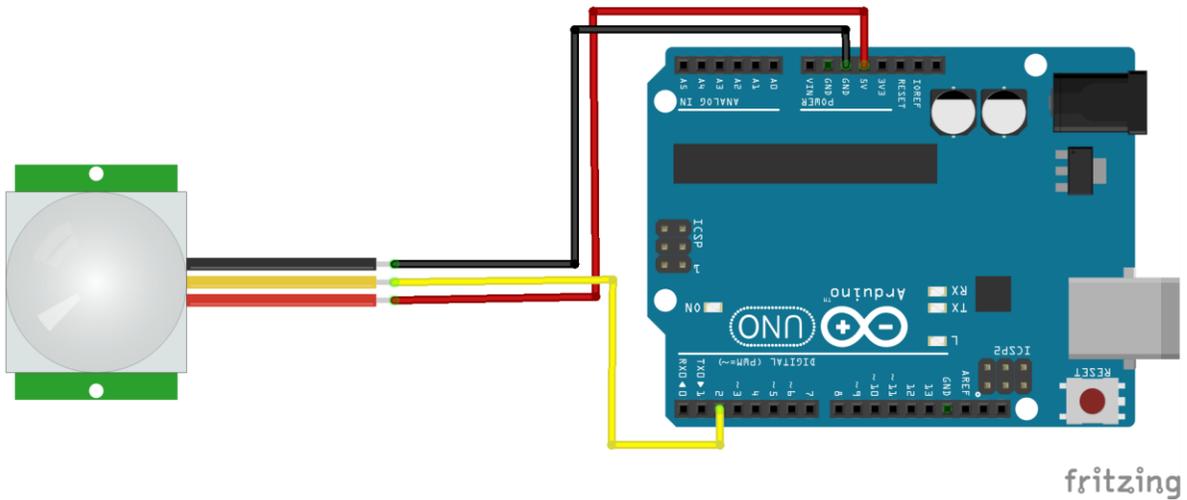


Figure 19 PIR motion sensor connected to Arduino. Made in Fritzing.

### The path

To indicate the direction to go in after taking the puppy, paw prints are placed on the floor. The paw prints are cut out of material to make removeable stickers. They were then stuck on the floor in such a way that they lead towards the basket with the mother dog in the Dorpstraat (Figure 20). It might make more sense to make the paw prints in the opposite direction, because then they show how the puppy came to that place. However, to make it more relatable for residents and remove this extra thinking step, the paw prints are put in the direction from the puppy towards the Dorpstraat.



Figure 20 Paw prints leading from the puppy to the basket in Dorpstraat.

## The basket

The mother dog will be represented by a bigger stuffed animal in the shape of a mature dog. This dog was borrowed from Bruggerbosch (Figure 21). This dog is a robot dog, but unfortunately did not work properly anymore. Therefore, it was not turned on during testing and was merely a passive element of the installation.



Figure 21 Mother dog, placed in the Dorpstraat with paw prints leading to it.

For the basket, a dog carpet was used that has the same paw prints on it as the stickers that lead from the puppy to the mother dog, to create a visible connection between the two parts. To make the scene appear more realistic, a water bowl and a dog toy were added.

In the Dorpstraat, where the basket with the mother dog is located, a Philips Hue light will be placed to emit colour changing light and let the setting stand out more to residents (Figure 22). The light will change colour in the same way as the light where the puppy was found so that residents can make an (unconscious) connection between the two places.

Both locations of the puppy and the basket are shown in Figure 23 below. As stated in section 6.2, the location of the puppy was decided based on performed tests. Around the corner in Dorpstraat was chosen to be the location of the basket because the psychologist of Bruggerbosch stated in an interview (section 5.2.3) that people with dementia can have trouble focussing and generally have a shorter attention span. Initially the basket would be placed about 50 meters further into the Dorpstraat, around another corner. But because of the short attention span, this was considered to be a too large distance from the entrance hall. The risk of the resident getting distracted, or forgetting what they were doing would be too big. The distance between the finding place of the puppy and the basket in Dorpstraat is now about 20 meters. But to maintain the exploring element of the intervention, the basket was not placed within a direct line of sight from the puppy, but around the corner.



Figure 22 Philips Hue in glass lamp shade next to the basket.

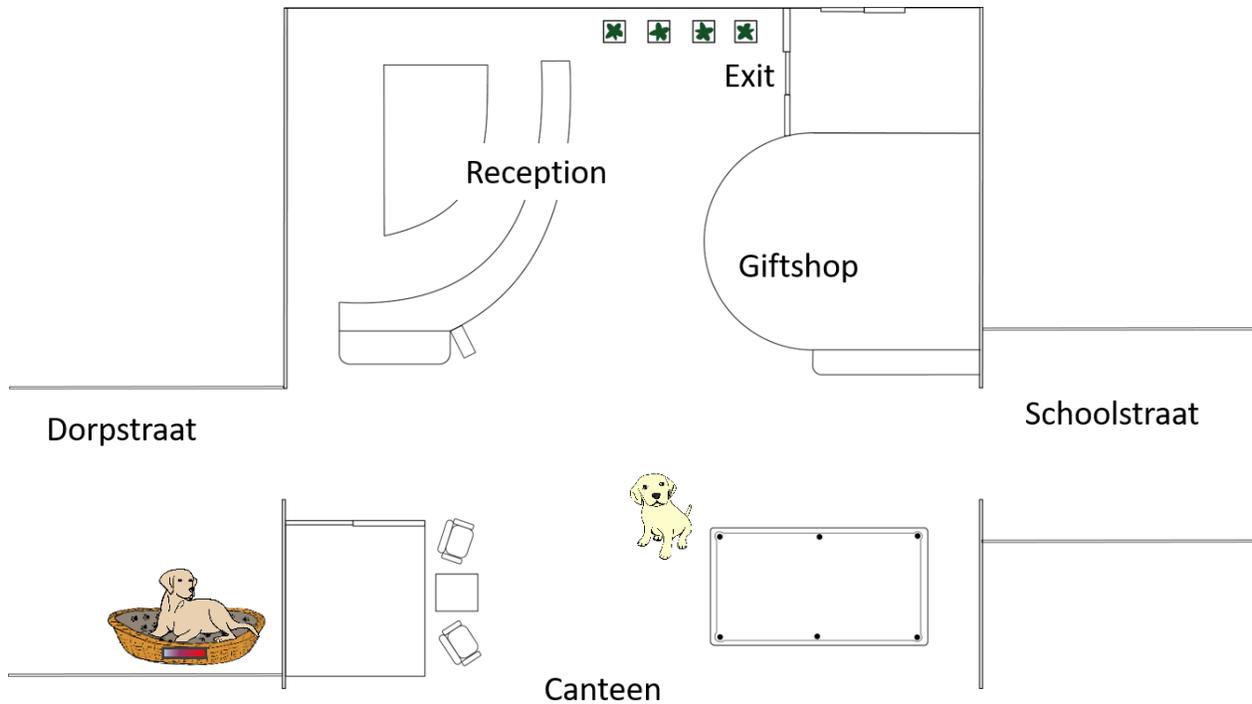


Figure 23 Map of the entrance hall of Bruggerbosch with locations of the puppy in the entrance hall and the basket in the Dorpstraat.

## 7.2. Software

To control the barking of the puppy, a motion sensor is included in the system. The sensor is connected to an Arduino. To program when the sounds should be played, code was written in both Arduino and Processing. Arduino is an open source platform to create interactive prototypes using both hardware and software. To read out sensor values Arduino was used and connected to Processing, an integrated development environment (IDE) for the open source programming language that is also called Processing. In Processing a script was written to determine when sounds should be played and stopped. The code of both Arduino and Processing can be found in Appendices F and G.

To control the Philips Hue, an application was used named Huetro for Hue. This application connects to the bridge that comes with the Philips Hue system. Through the application, it is possible to change and play different colour patterns.

# EVA LUA TION

## 8. Evaluation

In this section, the evaluation process of the concept and created prototype will be explained and the results will be discussed.

### 8.1. Evaluation methods

The goal of the observations was to gain insight in how effective the intervention is and whether it is indeed possible to distract the attention of residents from away from the exit. The evaluation was split up into four tests to be able to reflect more specifically on what aspects of the intervention can be considered successful or require further investigation. The tests were performed continuously. Every 1,5 hour another element would be added to the system. Participants did not need to be recruited for the test because the goal of the test was to see whether the intervention attracts users on its own. The intervention was evaluated by doing observations and an interview with the receptionist who was working during testing and agreed to play a role in giving instructions to the residents. The receptionist has been working for Bruggerbosch for about one year. In a previous job, some years ago, she also worked in a care facility for people with dementia.

The observations were performed over the course of in total seven hours. People with dementia are a rather vulnerable user group and therefore a pilot test was first performed for one hour, to discover any major flaws and be sure that no dangerous situations could occur during testing. This pilot did not show any indication of this.

### 8.2. Results

The following sections will describe the results of the tests performed at Bruggerbosch.

#### Test 1

During the first test, the puppy was placed on top of the box, with the motion sensor active and the Philips Hue turned on and programmed to gradually change colour constantly (Figure 24).

Residents in the entrance hall did notice the puppy and some approached it. The exact numbers of the people were not kept because observations were done from several points of view and the exit was not always within sight. However, special attention was paid to the interaction residents had with the entire intervention. One resident walked by the puppy, when the puppy started barking, the resident said to the puppy “It’s going to be fine”. Later the same resident walked by again and responded to the puppy’s barking “calm, calm”. The resident stood next to the puppy for a couple of minutes but did not pet or pick up the puppy.



Figure 24 Test 1 with the barking puppy and the colour changing light.

Some residents walk in small groups through the building, and when passing by the barking puppy, they would giggle or laugh at each other and say “look at that”. They did not approach the puppy and from their reaction it was clear that they did not think the puppy needed help in any way.

There was one resident who asked how the system actually worked and wanted to know the technical details of it. She did not think that the puppy was real but she did pet the puppy and seemed to be amused by the whole system for quite a while. This was a resident that is usually quite active around the exit and regularly attempts to leave the residence unsupervised.

There were also residents that walked or drove by the puppy without noticing the puppy or its barking. It slowly became busier in the entrance hall because lunch hour was approaching, therefore the barking was sometimes hard to hear. The receptionist therefore suggested to turn up the volume of the barking.

## Test 2

For the second test, the pawprints leading to the Dorpstraat were added and the basket with the mother dog was set up in the Dorpstraat as well. A Philips Hue lamp was placed behind the mother dog and turned on with the same colour changing program as the light at the puppy in the entrance hall (Figure 25).

The paw prints immediately gained attention from residents. Residents stopped to look at them and made comments such as “how funny”. One resident in the entrance hall had already noticed the puppy, also noticed the paw prints. He even followed the paw prints for a little while, but not far enough to spot the mother dog around the corner in the Dorpstraat. However, this resident might have noticed a connection between the puppy and the paw prints.

A group of residents and visitors walked by the puppy together and one of the visitors suggested to approach the puppy. The group seemed to be very amused and delighted by the puppy and its barking and one of the residents left a little flower with the puppy.

There were also residents coming from the Dorpstraat, walking towards the entrance hall. These residents walked past the mother dog and almost all residents seemed to notice the dog. Largely these residents responded by smiling and some reacted verbally in both social and individual cases. But this did not result in any physical interaction with the dog.

There was no resident that seemed to have made a connection between the puppy, the paw prints and the mother dog in the Dorpstraat.



Figure 25 Additions to the installation for test 2.

### Test 3

The only element added for the third test was the note that said *'Lost: bring me to the Dorpstraat.'* (Figure 26).

This note was not noticed by many residents. There was one resident who noticed the note by herself, she did not engage in further interaction and therefore it was not clear whether she had understood or actually read the note.

There were several groups of residents with visitors. Usually the visitors reacted with most enthusiasm to the puppy and encouraged the residents to approach and pet the puppy. It then created a social situation of which the puppy was central. They would stand around the puppy, listen to its barking and some also pet the puppy. The visitors that were with the residents noticed the note attached to the collar, but also the visitors did not seem to be confident that they were allowed to pick up or take the puppy and therefore did not encourage the residents to do so either.



Figure 26 Puppy with note.

### Test 4

For the fourth test, no physical elements were added to the system anymore, but the receptionist working was asked to assist. She was informed about the tests before the testing started. During the day she had already seen things happening and had a good idea of what was going on. She was instructed to point residents towards the puppy when they would come to the exit and explain that the puppy was lost and had to be brought back to Dorpstraat. The receptionist was able to use the information in a natural way when she talked to residents.

With the receptionist's assistance, residents seemed to approach the puppy more than without the encouragement of the receptionist. Some residents walked to the puppy upon her instructions, but when they arrived at the puppy they would look at it and then walk away again. Some residents did not immediately follow up on the receptionist's instructions but when she physically guided them they would go with her. The receptionist would show the note and suggest to the resident to bring the puppy to the Dorpstraat. But the residents then did not show interest in doing it and said things like "No, it is dead" or "I have to pee first". There was one resident that day who came to the exit with the intention to go out, and when the receptionist suggested to go to the puppy, the resident responded to receptionist that the puppy on top of the box was fake, but that there was a dog inside of the box (because that is where the barking came from). However, the resident did not care to seek this out. She did continue a conversation with the receptionist and then decided to sit down.

The receptionist that assisted in giving instructions to residents stated that the puppy provided a natural topic to talk about with residents and that she did not feel uncomfortable to do so. She said this also has to do with being able to empathise with the perception of a resident. There is a good chance a resident will think the puppy is real, and to be able to connect with residents you have to join in on their perception of the world.

The receptionist stated that she did not see a change in the behaviour of the residents during testing. She believes that most of the residents are too 'faded' to be able to grasp the idea of a lost puppy. She did see that the residents noticed the paw prints on the floor and refused to step on it. She suggested to place them directly in front of the exit.

In her previous job as a receptionist at a dementia care facility, she noticed there were a lot more people who were already carrying stuffed animals or dolls themselves. She says this is less common at Bruggerbosch and thinks the puppy might have appealed more to the people who already have affinity with stuffed animals.

It was observed that the lights did not seem to make much impact on residents due to bright daylight that made it hard to see the lights. Therefore, an iteration was made during this fourth test. The colour pattern of the lights was changed from slowly transitioning colours to a combination of gradually transitioning and faster flickering. However, there was still no clear indication that the lights drew attention.

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## 9. Discussion

This section provides an evaluation of the results of the intervention in combination with earlier findings from this study that were translated into requirements. The set of requirements are discussed one by one.

### 9.1. Discussion of the requirements

*'The system should distract/attract the residents such that they do not mind the exit anymore.'* Whether the intervention was able to distract the residents and divert their way away from the exit is hard to tell. From this evaluation, it cannot be known if the residents who interacted with the intervention would have ended up at the exit if the intervention was not there. This would require more control observations and also a much longer evaluation period to be able to compare and evaluate whether there is a significant difference in the amount of exit attempts by residents.

*'The system should provide stimuli that are noticed by residents more than the current stimuli present in the entrance hall.'*

It is difficult to evaluate whether the intervention's sensory stimuli stood out from the other stimuli present in the entrance hall of Bruggerbosch. This is also not a measurable factor since the processing of sensory stimuli is different for every person. One person can have hearing impairments and the other deteriorated eye sight, especially for elderly people it is difficult to find a setting that works well for all users. However, the observations showed that there were moments that residents reacted to the barking of the puppy, or the puppy itself, making the puppy in that moment the most outstanding stimuli.

*'The system should be recognizable such that it invites interaction by residents.'*

Largely residents seemed to recognize the stuffed animal as being a puppy and reacted positively to this. Residents showed laughter, verbal reactions and social interaction as a reaction to the puppy. There was one resident that mistook a mailbox for being the puppy when he was appointed to the puppy. Which stage of dementia this resident was or what type of dementia he had is unknown, but this shows that for this resident, the intervention did not fulfil this requirement.

*'The system should not contain any features that require learning or memorizing.'*

What was not thought of earlier in the process, during ideation, was that the intervention does contain a memorizing feature. Between finding and taking the puppy, to arriving at the basket (the 'HOLD' phase) the resident needs to remember what they are doing, namely, bringing home the puppy to its mother. The resident receives visual cues by means of the paw prints on the floor, but when a resident has forgotten about the goal, they might also lose connection to the paw prints. However, because no resident picked up the puppy to bring it to the basket, this could not be tested. The first part of the interaction ('ATTRACT' and 'INITIATE') did not contain any learning or memorising elements.

*'The user should feel safe and comfortable when using the system.'*

During testing residents did not show any indicators of them being scared or afraid of both the puppy and the bigger dog in the basket. The psychologist stated in the interviews (section 4.2.3.) that some people might have negative associations with dogs. It was still decided to use a puppy, because puppies are generally perceived more positively because of the baby schema (section 5.1). There was one visitor, a daughter of one of the residents, that said her mother did not really like dogs, but together they still approached the mother dog in the basket and looked for a while. The resident did not seem afraid and even more to enjoy herself.

*'The system should be able to entertain a resident for a while so that employees have time to take action.'*

When making this requirement, it was not stated how long 'a while' exactly had to be making this a requirement that is difficult to evaluate. The residents were generally not entertained for longer than a minute or two. However, the residents were then not in a situation that would require the assistance of a care giver. Also generally, when a resident would be entertained by the system for a longer while, and they are on their way to bring the puppy to the mother dog, there is no need any more for a care giver to be called in for assistance. This requirement was created before noticing that as long or as soon as a resident is occupied with something other than the exit, there is no need for caregivers to come and assist. Therefore, this requirement should not specifically address the time that the resident is entertained by the system, but rather the location that it leads the resident. Which would be away from the exit.

*'The system should use information about the residents to make it more personal.'*

This requirement was not fulfilled by the intervention itself, but more by the receptionist that supports the system. The receptionist was able to talk about and appoint the puppy in a natural way to the residents. She did use the names of the residents and they responded to this. It was expected that this personal aspect would increase the motivation of residents to go and interact with the puppy. However, it did not seem to make a difference in the way they interacted with the puppy or the rest of the intervention. Maybe even more personal information could be used to let the intervention appeal to the residents more. For instance, talking about the dog that a resident might have had when she still lived independently. But this information is hard to come by and very hard to remember for the receptionists.

## 9.2. Discussion of the prototype

There were also some practical matters that could have been of influence on the effectiveness of the intervention. The puppy was pet by residents and sometimes also by their visitors. It was easy to pet the puppy because it was on an elevated plateau. The mother dog was lying on the ground and was pet less than the puppy. This might be due to the mother dog lacking a bit of the 'cuteness' factor, but might also be because people, especially elderly, are less likely to bend down all the way to the ground.

Another practical matter was the lighting. The lighting was hardly visibly due to bright daylight. Therefore, the lights did not seem to be noticed by anyone. The goal of the colour changing lights was so that residents could make an (unconscious) connection between the two locations. But because it was barely visible this cannot be considered an influential element of the intervention.

The resident did not engage in any physical interaction other than petting the puppy. Sometimes residents would stand in front of the puppy and look at it for a while, and then leave again. When standing still in front of the puppy, the motion sensor will not detect motion anymore. Therefore, the puppy will not bark. When standing close to the puppy, the colour changing lights are also not very visible anymore. In this case, the puppy turns into a static stimulus. It does not move, it does not make sounds, it is only laying there. This could cause the resident to lose attention or interest in the puppy. Therefore, it might have been better to put the lights somewhere that they are constantly visible to residents, or to make the puppy itself more dynamic by letting the head or the tail move.

For residents, the connection between the three parts of the intervention seemed to be unclear. The basket with the mother dog was standing around the corner in Dorpstraat, not in a direct line of sight. It could be argued that putting the mother dog in a direct line of sight from the puppy's findings place would help the resident to make a connection between the two parts.

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## 10. Conclusion

In this section answers will be provided to the individual research questions set at the beginning of this project.

· *RQ1: What is the exact problem with residents at the exit of Bruggerbosch?*

Nursing home Bruggerbosch struggles with residents coming to the exit, wanting to leave the residence unsupervised. A spectrum of residents was identified, with goal oriented residents on one end, and aimlessly wandering residents on the other. Due to environmental factors around the exit and the stimulation of residents' senses hereby, residents are often drawn towards the exit. When these residents realise that the exit does not open for them or they are being told that that cannot leave, the residents may get frustrated and angry. When residents get upset, the receptionist and caregivers can feel uncomfortable assisting the resident away from the exit. The situation at the exit therefore creates a problem for both residents and employees of Bruggerbosch.

· *RQ2: How can residents from Bruggerbosch be unconsciously steered away from the exit?*

Literature shows that sensory stimulation can be used to attain the attention of a resident and stimulate them mentally. There are different ways to incorporate sensory stimulation into an interactive intervention to unconsciously steer residents away from the exit. For example, through visual cues such as signage. In this study an intervention is proposed that uses a stuffed animal puppy that is placed in the entrance hall, close to the exit. The storyline connected to the intervention tells that the puppy is lost and should be brought home to its mother somewhere else in the residence. By using barking sounds the intervention will address the auditory sense. Visually the residents will be stimulated by colour changing light, pawprints on the floor and the appearance of the puppy itself. When interacting with the puppy, the resident's sense of touch is stimulated. By walking the puppy home also the proprioceptive sense is addressed because the resident coordinates walking and holding the puppy at the same time. Because the residents are stimulated by the sensory aspects of the intervention and motivated by the storyline connected to them, residents will be unconsciously steered into a different direction than the exit.

· *RQ3: Does the provided solution fulfil the goal of steering residents away from the exit of Bruggerbosch?*

The solution proposed as the Lost Puppy intervention can attract the attention of residents walking through the entrance hall. When noticed, the presence of the puppy and its barking sounds, the paw prints on the floor, and the mother dog in the basket did seem to have a general positive effect on the residents and the atmosphere in the entrance hall. However, the intervention does not sustain the attention of residents for a long time and residents were not able to grasp the connection between the three different parts of the intervention, nor did they complete the suggested task to bring the puppy to its mother. The intervention did not prevent residents who purposefully wanted to go outside from going to the exit. From this evaluation, it is not possible to say whether residents who did not end up at the exit during testing, were steered away by the intervention or because of other reasons.

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## 11. Future work

In this section recommendations will be discussed that can be used as guidelines for future research into this topic.

### 11.1. Improvement of the prototype

For future work, there are several aspects of the prototype that can be adjusted in order to better research the effect of the intervention.

First, the setting of the puppy. The puppy was placed on top of a large box in the entrance hall. To some people this made the puppy less approachable, as if the puppy was exhibited and they were not allowed to touch it. Therefore, it is recommended to place the puppy on something that makes it more accessible and store the technology and the wiring in a different way that is either still mobile, or can be permanently placed somewhere in the entrance hall.

The evaluation showed that the puppy stopped barking when someone was standing still for a while in front of the puppy. Recommended would therefore be, to add another sensor, that can sense the proximity of a person in front of the installation and based on this play the barking sounds to keep a resident stimulated.

The receptionist and caregivers at work during testing stated that the sounds were sometimes too soft when there was noise in the entrance hall. Therefore, it is recommended to provide the receptionist with the possibility to turn the volume of the barking sounds up and down from behind the reception desk. It is also recommended to provide the receptionist with an on and off button to easily switch off the installation when there are activities in the entrance hall, for instance, a children choir performance.

In the ideal case that a resident takes the puppy and brings it to the basket in Dorpstraat, there needs to be a new puppy available to be placed in the entrance hall. The receptionist could be involved in this, having a storage of some puppies behind the desk and keeping an eye on residents taking away the puppy. Every now and then, the puppies also need to be recollected and brought to the reception desk to be stored there. One of the receptionist said that if this place is close, this would not be a problem if the effect of the intervention is that less residents go to the exit.

Based on the findings in this study, it is recommended to look further into the use of a robot puppy instead of a stuffed animal. A robot puppy can provide even more stimuli. For example, a moving tail or a moving head might make the puppy come across more natural and realistic to the residents, and can encourage residents to interact with the puppy. However, one needs to take care that this does not make the puppy fragile because it needs to allow cuddling by residents and a possible fall when a resident drops the puppy.

### 11.2. Improvement of the evaluation

To better evaluate the concept, or an improved version thereof, several changes to the evaluation method are recommended.

The evaluation of the prototype in this study was done for seven hours, including a pilot test. It is recommended to extend this period of testing to be able to observe from different points of view. This will allow for getting a general idea of the interaction between residents and the intervention first, and then to observe the exact numbers of residents being attracted to the exit and attempting to leave. These numbers can then be compared to control observations and a more solid statement can be made about the effectiveness of the intervention.

Another recommendation is to research whether separating the interaction in different parts is cognitively too demanding for people with dementia and whether it is more effective to combine the

parts into one. From the evaluation in this study, it was observed that not one resident completed the task of bringing the puppy to the basket in the Dorpstraat. It seemed as if it was not possible, or at least very difficult to grasp the connection between the three parts of the intervention, but the cause of this was not clear. Therefore it recommended to research how residents can be supported in connecting these different parts or that it is necessary to simplify the storyline.

To make it easier to follow up and evaluate requirements in a later stage, it is recommended to create requirements that are measurable to a certain extent.

Finally, it is recommended to keep searching for ways to stimulate people with dementia living in care residences and to establish playful interaction that will engage residents enough to prevent unsupervised exits. It is recommended to use dynamic stimuli and elements that appeal to residents' curiosity and therefore motivate interaction. Interventions such as the Lost Puppy and possible future variations on it or other playful interventions can provide such stimulation and are worth looking into as solutions to the exit control problem.

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## 1. Appendix A

Observations.

To get more insight in the behaviour of residents, observations were performed in the entrance hall of Bruggerbosch. For residents who actively attempted to exit the residence, observations about their behaviour was written down.

Timeframe: 10:56 – 14:10

Day: Friday 24/03

- How many unique residents from Bruggerbosch end up at the exit?

Resident	Time	Notes
1	13:02	Succeeds. Seemed as if the door opened for him, receptionist still called him back.
2	13:06	Fails.
3	13:15	Succeeds.
4	14:00	Fails

Resident 1

Question	Observation
How long does it take to realize that they cannot go through the door?	Does not realize.
How long do people spend in front of the exit?	Walked straight through the door, door opened for him.
What are the residents' physical reactions?	None
What are the residents' verbal reactions?	None
Do the residents search for a solution to open the door?	No
→ If yes, how do they search for a solution and what do they come up with?	-
How much time do employees spend on getting a resident away from the exit?	About 5 seconds
What techniques do the employees use to get a resident away from the exit?	The receptionist called him back. Second time she lets him go outside and calls staff.
What type of environmental cues/stimuli seem to attract people's attention? And why?	Resident seemed quite determined to go outside.
What are the weather conditions?	Sunny and dry.
What are the receptionists doing?	Working, movement is minimal.

Resident 2

<b>Question</b>	<b>Observation</b>
How long does it take to realize that they cannot go through the door?	Until receptionist calls him back.
How long does the resident spend in front of the exit?	About 20 minutes.
What are the residents' physical reactions?	Seems surprised, stops immediately.
What are the residents' verbal reactions?	Surprise "ohh".
Do the residents search for a solution to open the door?	Yes
→ If yes, how do they search for a solution and what do they come up with?	Waiting for other people to go in or out.
How much time do employees spend on getting a resident away from the exit?	About 5 seconds
What techniques do the employees use to get a resident away from the exit?	Receptionist screamed "Nee!"
What type of environmental cues/stimuli seem to attract people's attention? And why?	Receptionist was big environmental stimulus. Resident seemed intrigued by the activity around the reception desk.
What are the weather conditions?	Sunny, dry.
What are the receptionists doing?	Working, talking to people.

Resident 3

<b>Question</b>	<b>Observation</b>
How long does it take to realize that they cannot go through the door?	After first attempt. He still wants to go out, tries again and succeeds. Receptionist calls staff but residents stays close to the door and receptionist keeps an eye on him. Residents comes back inside by himself.
How long do people spend in front of the exit?	10 minutes
What are the residents' physical reactions?	He walks back and forth between desk and exit.
What are the residents' verbal reactions?	Talks to the receptionist.

Do the residents search for a solution to open the door?	Yes
→ If yes, how do they search for a solution and what do they come up with?	He waits until someone comes in.
How much time do employees spend on getting a resident away from the exit?	+/- 5 minutes, when talking with him.
What techniques do the employees use to get a resident away from the exit?	She talks with him and keeps him in sight.
What type of environmental cues/stimuli seem to attract people's attention? And why?	The receptionist
What are the weather conditions?	Sunny, dry.
What are the receptionists doing?	Working, making phone calls, typing on computer.

#### Resident 4

<b>Question</b>	<b>Observation</b>
How long does it take the resident to realize that they cannot go through the door?	After the first attempt, resident appeared to be quite goal oriented and walked straight towards the exit. This took about one minute.
How long does the resident spend in front of the exit?	In total about 10 minutes.
What are the resident's physical reactions?	He turns around as if he is going to walk away from the exit but as soon as attention fades he turns back to the door and tries to exit again.
What are the resident's verbal reactions?	He refuses to accept that he cannot go outside and says 'No'. He repeats this a couple of times.
Do the residents search for a solution to open the door?	Yes
→ If yes, how do they search for a solution and what do they come up with?	He waits for someone to enter the building so that the door opens and he can go out while it is.
How much time do employees spend on getting a resident away from the exit?	Approximately 10 minutes, about the whole time that the resident tries to exit. They have to keep paying attention to what he is doing and where he is going.
What techniques do the employees use to get a resident away from the exit?	The receptionist says with a loud voice 'Mr ... No, you cannot' and repeats this until he listens.

What type of environmental cues/stimuli seem to have attracted the resident's attention to go to the door? And why?	This was not clear from the scene.
What are the weather conditions?	Sunny, bright.
What are the receptionists doing?	Typing on a computer and talking to people.

## 2. Appendix B

Set up and results of the exit experiment.

### 1. Research question:

How does changing the location of the exit for employees from the main exit to the side exit impact the attraction of residents towards the main exit?

### 2. Hypothesis/positive prediction:

If employees (quietly) use the side exit instead of the main exit, the activity around the reception will decrease, resulting in less attraction of residents to the exit and thus fewer exit attempts.

### 3. Experiment

#### 3.1 Control observations

Observations between 13:00 – 16:00. In this experiment, no changes are made to the environment and employees are not informed about the observations.

What to observe:

- How many people go in/out through the main exit?
- How many unique residents go to the main exit?
- How many of these residents actively attempt to go through the exit?

#### 3.2 Experiment

Observations between 14:30-17:00. It was later decided that this would be a better time to observe because the change from morning to evening shift is between 15:00 and 16:00 for most employees. In this experiment the employees are informed about the experiment. First by email and then on the day of the experiment at the beginning of their shift (07:00) they will receive a note (attached to a small chocolate bar) that asks them to use the side exit to leave the building after their shift has ended. During the morning shift, employees will be reminded by going through the building and telling them again.

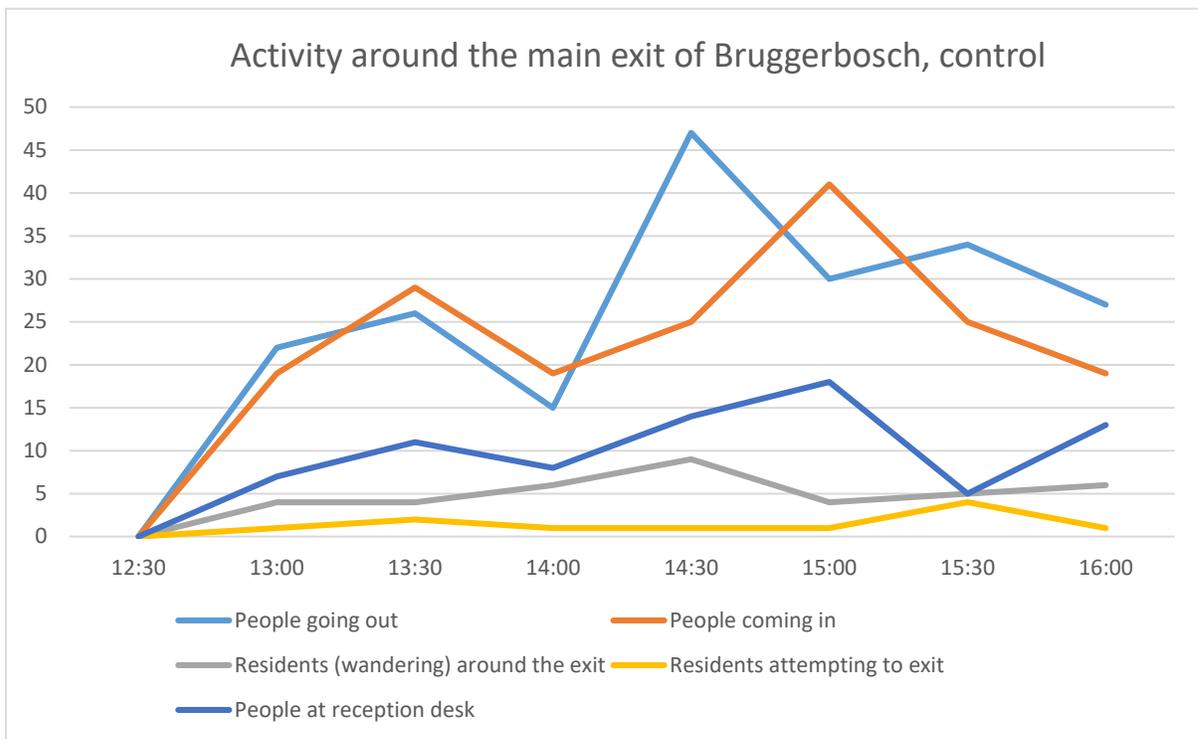
What to observe:

- How many people go in/out through the main exit?
- How many unique residents go to the main exit?
- How many of these residents actively attempt to go through the exit?

## 4. Results

### 4.1. Control observations

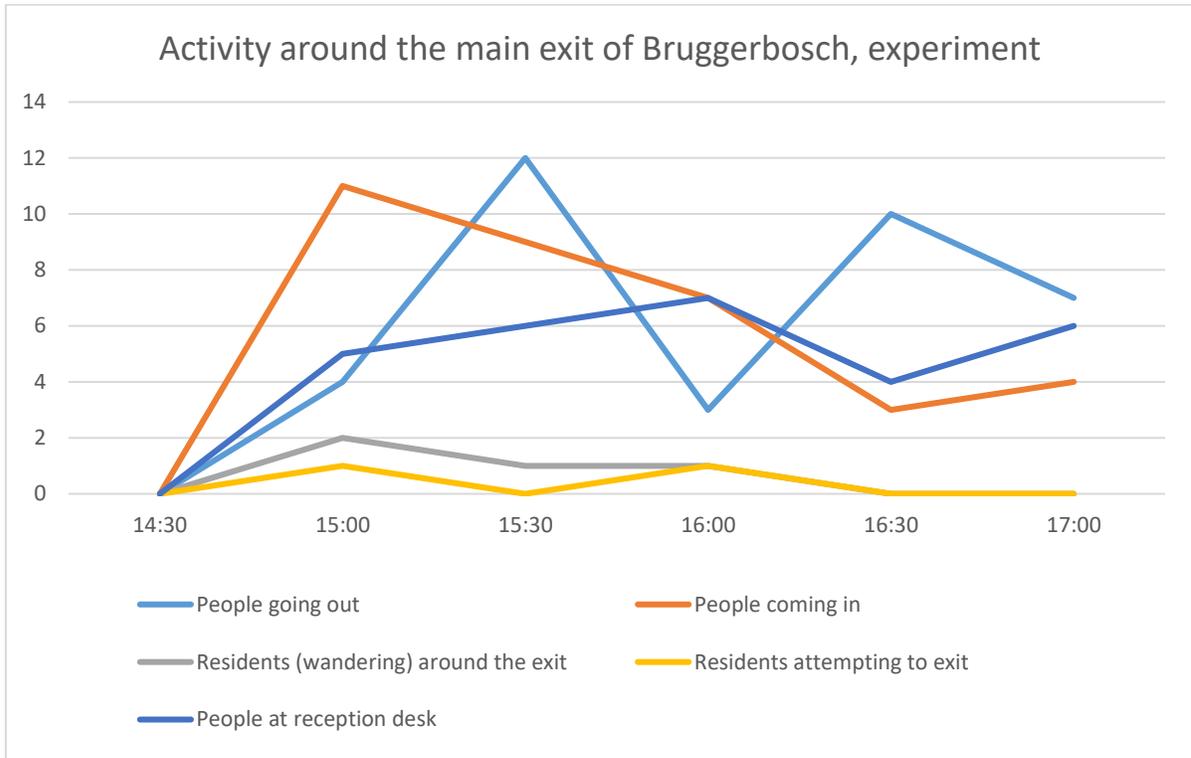
Score at	12:30	13:00	13:30	14:00	14:30	15:00	15:30	16:00
People going out	0	22	26	15	47	30	34	27
People coming in	0	19	29	19	25	41	25	19
Residents (wandering) around the exit	0	4	4	6	9	4	5	6
Residents attempting to exit	0	1	2	1	1	1	4	1
People at reception desk	0	7	11	8	14	18	5	13



### 4.2. Experiment

Score at	14:30	15:00	15:30	16:00	16:30	17:00
People going out	0	4	12	3	10	7
People coming in	0	11	9	7	3	4
Residents (wandering) around the exit	0	2	1	1	0	0
Residents attempting to exit	0	1	0	1	0	0

<b>People at reception desk</b>	0	5	6	7	4	6
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## 5. Conclusion

During the experiment there was a heat protocol active. Therefore, no conclusion are drawn from the performed observations.

### 3. Appendix C

#### Interview questions

##### C.1. Interview Activiteitenbegeleider Bruggerbosch

- Voorstellen.
  - Uitleg over bachelor opdracht en reden voor het interview.
  - Consent vragen om geluidsopnames van het interview te maken.
- 

1. *Hoe lang werkt u al als activiteitenbegeleider?*
2. *Welk soort dementie hebben de bewoners waar u mee werkt?*
3. *Wat is uw taak als activiteitenbegeleider?*
  - a. *Welke activiteiten doet u met bewoners?*
  - b. *Hoe reageren bewoners op activiteiten met geluid?*
  - c. *Hoe reageren bewoners op activiteiten met licht?*
  - d. *Hoe reageren bewoners op activiteiten met tactiele objecten?*
  - e. *Hoe reageren bewoners op activiteiten met geuren?*
  - f. *Wat voor voorwerpen gebruikt u bij activiteiten?*
  - g. *Wat gaat er vaak mis bij activiteiten?*
4. *Wat denkt u dat over het algemeen stimulerend werkt voor bewoners?*
5. *Welke activiteiten heeft u in het verleden geprobeerd en sloegen niet aan?*  
➔ *Wat denkt u dat de reden hiertoe was?*
6. *Welke activiteiten heeft u in het verleden geprobeerd en sloegen goed aan?*  
➔ *Wat denkt u dat de reden hiertoe was?*
7. *Stimuleren de activiteiten sociaal contact tussen bewoners?*
8. *Verlaten bewoners activiteiten weleens?*
9. *Hoe houdt u bewoners betrokken bij de activiteiten voor langere tijd?*
10. *Wat zijn belangrijke dingen om rekening mee te houden als het gaat om activiteiten organiseren voor mensen met dementie?*
11. *Maakt u gebruik van media en/of technologie bij de activiteiten?*

##### C.2. Interview questions receptionist Bruggerbosch

- Voorstellen.
  - Uitleg over bachelor opdracht en reden voor het interview.
  - Consent vragen om geluidsopnames van het interview te maken.
- 

1. *Hoe lang werkt u al als receptioniste bij Bruggerbosch?*
2. *Wat is in uw taak bij de receptie van Bruggerbosch?*

3. *Hoe vaak denkt u dat het op een dag voorkomt dat een bewoner probeert het gebouw door de uitgang te verlaten?*
4. *Zijn het verschillende mensen, of altijd dezelfde die dit proberen?*
5. *Uit welke richting komen deze bewoners meestal?*
6. *Lopen bewoners bewust naar de uitgang of belanden zij er 'per ongeluk' tijdens het dwalen?*
7. *Merkt u dat het probleem invloed heeft op de bewoners? Lijken zij bijvoorbeeld gestrest of angstig wanneer zij voor de uitgang staan en niet verder mogen?*
8. *Wat voor technieken gebruikt u om te voorkomen dat bewoners door de deur gaan of hen eventueel weer terug te halen?*
9. *Wat denkt u dat mogelijke oorzaken zijn dat bewoners bij de uitgang terecht komen? (Noem evt. voorbeeld zonlicht, winkeltje etc.)*
10. *Heeft u weleens een bepaald patroon opgemerkt in het gedrag van bewoners rond de uitgang?*
11. *Welk moment zou u identificeren als een cruciaal punt tussen het 'rondhangen' bij de uitgang en het daadwerkelijk door de uitgang willen gaan?*
12. *Heeft u zelf ideeën of suggesties voor oplossingen?*
13. *Wat denkt u dat absoluut niet effectief zal zijn om dit probleem op te lossen?*
14. *Wat is de invloed van het probleem op uw werk?*

### **C.3. Interview questions psychologist Bruggerbosch**

- Voorstellen.
  - Uitleg over bachelor opdracht en reden voor het interview.
  - Consent vragen om geluidsopnames van het interview te maken.
- 

1. *Hoe lang werkt u al als psycholoog in de dementiezorg?*
2. *Wat is uw taak als psycholoog bij Bruggerbosch?*
3. *Wat zijn volgens u belangrijke aspecten om rekening mee te houden bij het ontwerpen voor mensen met dementie?*
4. *Bent u bekend met het uitgangsprobleem bij Bruggerbosch?*
5. *Wat zijn volgens u de belangrijkste oorzaken van het probleem dat bewoners bij de uitgang terecht komen en (zonder toezicht) het gebouw willen verlaten?*

6. *Hoe ervaren bewoners dat zij niet door de uitgang mogen? Geeft dit hen bijvoorbeeld stress, boosheid, angst etc.*
7. *Wat is het verschil tussen de prikkelverwerking bij gezonde mensen en mensen met dementie?*
8. *Is hierin ook nog verschil in de verschillende stadia van dementie? En hoe uit zicht dat?*
9. *Denkt u dat sensorische stimuli onderdeel kunnen vormen van een oplossing voor dit probleem? En zo ja, of wat voor manieren?*
10. *Geluidsprikkel d.m.v. stem vanuit een box o.i.d. eventueel effectief?*
11. *Denkt u dat een teveel aan prikkels een negatieve invloed kan hebben op het gedrag van bewoners?*
12. *Eerdere oplossingen: het kleurverschil in de vloer. Waarom denkt u dat deze oplossing niet het gewenste effect had bij Bruggerbosch?*

#### 4. Appendix D

Mind maps, made in Coggle [33].



## 5. Appendix E

### Matrix evaluation.

Idea\value	Feasibility	Innovativeness	Comfortability	Distractibility	Fits in environment	Safety	Total (max 30)
Lost puppy	5	4	4	3	5	4	25
Forrest/tropic plants painting	4	2	5	3	4	5	23
Arrows on the floor	5	1	4	2	5	5	22
Box with (holographic) chicks	3	3	5	4	3	4	22
Row of hearts that light/warm up	4	3	5	3	3	4	22
Light up/decorate doors to streets	4	3	4	3	4	4	22
Piano floor	4	3	4	3	4	3	21
Interactive senses snake	3	3	5	4	3	3	21
sluice with gates in shape of a bush	3	4	4	4	3	3	21
Interactive octopus installation	3	4	4	4	2	3	20
Black window stickers on glass	5	1	3	3	4	4	20
Interactive) rainbow route on the floor	2	3	4	4	4	3	20
Knikkerbaan	3	2	4	2	3	5	19
Pet to follow	2	3	5	4	3	2	19
Vibrating floor	2	4	2	4	4	3	19
Pinball box	3	3	4	3	3	3	19
Voice assistant device	2	2	3	3	5	3	18
Telephone booth music dial	2	4	4	2	2	4	18
AI guide to suggest alternate plans	1	3	3	3	4	4	18
3D painting of abyss	3	2	3	4	3	3	18
One-way mirror for reception	2	1	2	4	3	5	17

'Vanishing cabinet'	4	4	2	2	3	2	17
Black/blue plastic sail in front exit	5	1	2	3	3	3	17
Butterflies/birds flying to canteen	2	3	4	3	2	3	17
Replace glass with mirrored glass	2	1	2	4	4	3	16
Sequence of hairy/tactile animals	2	1	4	2	2	4	15

## 6. Appendix F

Top thirteen ideas.

### **Ideas good enough for continuation**

#### *1. Lost 'puppy' with message*

A stuffed animal, might be in the shape of a small dog or cat, is placed somewhere in the area of the exit. Residents would notice it due to its barking or meowing and pick it up. The barking/meowing by the animal can be activated by the receptionist or a sensor at the door. The animal has a note or maybe a voice message (upon touch) that says it's lost and wants to go back home. In Dorpstraat or Schoolstraat, or another place in the residence, baskets are placed with a mother dog/cat where the residents can bring the animal.

#### *2. Box with chicks*

A box as ones often sees in small animal gardens, standing somewhere rather close to the exit, filled with chicks that are hatching or just small. From the box come chick like sounds to attract the residents to the box. In the box are small stuffed animal chicks that can move around a little bit. Residents can either look at them or pick them up and play. The reception would have a collection of chicks behind the desk to give to a resident when they come to the exit. The receptionist can then ask the resident to bring the chick back to the box. The chicks can not be fragile. No small loose parts either.

#### *3. Row of hearts that light up*

A sequence of heart shaped bolls of which one lights up if a resident stands in front of the exit. If the heart is touched, the one next to it lights up, this could go in different patterns back and forth. The heart could be made of soft rubber or another material that is pleasant to touch. There could be a sign next to it that says 'Raak me aan' to make it more apparent that the hearts can be touched. This idea might can work for people who are in a wandering state. This unobtrusive stimulus might then propose an interesting and stimulating activity to keep residents away from the exit. However, some residents are very determined to go out and come to the exit with a plan. For these residents, this might not pose enough of a distraction or stimulus to differentiate their plans.

### **Ideas that contain useful elements but are not strong enough ideas on their own**

#### *4. Black window stickers on glass*

To disguise what's behind and make it less attractive to go to the exit.

#### *5. Arrows on the floor*

Straightforward idea, based on literature about signage. Could be an addition to another idea.

#### *6. Interactive octopus installation*

Artwork like installation with arms that have different interaction possibilities. E.g. one arm changes colour when touched, another arm can be moved/changed position, another makes a sound when touched etc. This could work if the system had different modes that could be changed every week/month. Otherwise it becomes a part of the environment for residents and they will not notice it anymore. In the system would allow for easy update/extensions it would be a plus.

*7. Light up/decorate doors to the streets*

Creating interesting ports to the streets that make it appealing to walk towards the streets. Lights, coloured materials or plants could be used. To make this work, the space behind the doors should be made attractive as well. By for instance, creating artificial sunlight so that residents are drawn to the light behind the doors.

*8. Interactive senses snake*

Could lay along the reception desk. The snake is made of soft or crunchy material that residents can squeeze or pet. Snake can light up in several places on the snake to attract people to that direction. Snake make sounds upon interaction, e.g. squeezing.

*9. Extra row of sluice gates*

Placing an extra row of gates between reception and giftshop to create an extra control point. Gates at hip high, naturally shaped to make it less obtrusive, e.g. with bush like properties or clouds.

**Ideas considered not good enough for continuation**

*10. Forest/tropic plants painting*

Paintings or stickers on the glass of the exit doors that disguise that it is a door. The painting of plants create a more natural feeling barricade that is less obtrusive. → This could work if the entire door was covered with real plants and an actual oase is established.

*11. Piano floor*

Placing projected of physical piano keys on the floor that residents can walk over and make sounds. This would only work if it is constantly playing by itself or someone is constantly playing it. Otherwise residents will not understand that what the system does or how it works.

*12. Interactive rainbow route on the floor*

Projected rainbow on the floor that created path in front of resident, guiding their direction away from the exit.

## 7. Appendix G

### Location test set up.

Experiment – Testing different locations of a sensory stimulus in the form of a test object in the entrance hall of Bruggerbosch

#### 5. Research question:

What is the most effective location for the placement of an installation to attract residents in the entrance hall of Bruggerbosch?

#### 6. Hypothesis/positive prediction:

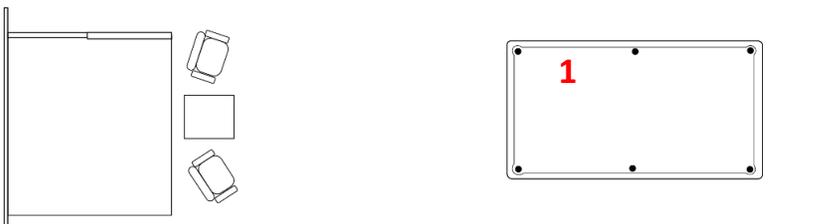
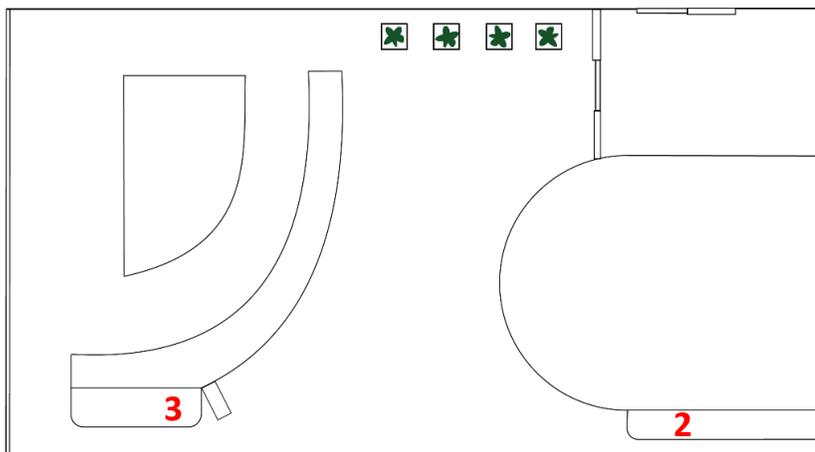
If the test object is placed directly besides the exit doors it will be seen and interacted with the most.

#### 7. Experiment

Observations in the entrance hall of Bruggerbosch. The test object, in the form of a stuffed animal dog, will be placed in different locations in the entrance hall. For each location, the behaviour of residents and their interaction with the test object will be observed. For each location, observations will be done over the course of one hour.

What to observe for every location:

- How many residents are wandering through the entrance hall or going to the exit?
- How many residents have spotted the test object?
- How long does the test object occupy the resident?



## 8. Appendix H

Arduino code.

```
//Yacintha Aakster
//05-06-2017

int ledPin = 13;
int inputPin = 2;
int pirState = LOW;
int val;

void setup()
{
  pinMode(ledPin, OUTPUT);
  pinMode(inputPin, INPUT);
  Serial.begin(9600); // initialize serial communications at a 9600 baud rate
}

void loop()
{
  val = digitalRead(inputPin);

  if (val == 1) {
    digitalWrite(ledPin, HIGH);

    if (pirState == LOW) {
      Serial.print("yes");
      Serial.print('\t');
      //Serial.print(string.length);

      pirState = HIGH;
    }
  } else {

    digitalWrite(ledPin, LOW);
    if (pirState == HIGH) {
      Serial.print("no");
      Serial.print('\t');
      pirState = LOW;
    }
  }
}
```

## 9. Appendix I

Processing code.

```
//yacintha Aakster  
//05-06-2017  
//Code based on:  
//https://www.wired.com/2012/09/using-motion-detectors-with-an-arduino/  
//https://stackoverflow.com/questions/26000592/wav-file-in-minim-plays-too-fast
```

```
import cc.arduino.*;  
import org.firmata.*;  
import processing.serial.*;  
import ddf.minim.*;  
  
Minim minim;  
AudioPlayer[] dog;  
Boolean playing = false;  
Serial myPort;  
String val;  
  
void setup() {  
  size(200, 200);  
  minim = new Minim(this);  
  
  String COM3 = Serial.list()[0];  
  myPort = new Serial(this, COM3, 9600);  
  
  dog = new AudioPlayer[5]; //array of audiofiles  
  dog[0] = minim.loadFile("barkingDog1.mp3");  
  dog[1] = minim.loadFile("barkingDog2.mp3");  
  dog[2] = minim.loadFile("barkingDog3.mp3");  
  dog[3] = minim.loadFile("barkingDog4.mp3");  
  dog[4] = minim.loadFile("barkingDog5.mp3");  
  
  //player.play();  
}  
  
void draw() {  
  int num = int(random(0,4));  
  
  if ( myPort.available()>0 ) //Check for data
```

```

{
  val = myPort.readStringUntil('\t');    // read it until tab and store it in val
}

if (val==null) { //prevent null pointers
  val = "0";
}

println(val);

if (val.contains("y") && playing==false) { //value yes and soundfile currently not playing
  dog[num].play(); //play one of the soundfiles
  int wait = dog[num].length();
  delay(wait); // wait with reading data until fragment finished
  playing = true;
} else if (val.contains("n") && playing == true) { //of there is no motion detected, pause playing and
rewind
  dog[num].pause();
  dog[num].rewind();
  playing= false;
}
}

void stop() {
  // dog[num].close();
  minim.stop();
  super.stop();
}

```