Daria

hydration by intuition

Improving the quality of geriatric life by managing water intake.

Daria: A product for hydration self-monitoring.

Graduation Report

Author
Tobias Strobel

Master Thesis
M.Sc. Integrated Product Design
Faculty of Industrial Design Engineering
Delft University of Technology

Academic supervisors
Chair | Dr. Elif Özcan Vieira
Mentor | Dr. ir. Marieke Sonneveld

hydration by intuition

Acknowledgements

First, I would like to express my deepest gratitude to my grandmother, whose personal experiences and insights inspired me to do this thesis. Her support, from helping me find participants to actively participating in interviews, was invaluable to the success of this research.

I am immensely thankful to my committee for their continuous support. Their guidance and encouragement were crucial in shaping this thesis.

A special mention belongs to the eight wonderful elderly individuals who shared their time and insights during our extensive interview sessions and user tests.

I would also like to extend my appreciation to my friend Patrick, who offered his office space for printing prototypes and project work.

Lastly, I cannot thank my partner Julian enough for his support, encouragement, and belief in my capabilities throughout this journey. His presence was a constant source of strength and motivation.

To all mentioned and the countless others who contributed in various capacities, thank you for being a part of this journey. Your support has been the backbone of this thesis.

Table of contents

Abstract

Dehydration is a common medical condition in the elderly. This deficit in body water increases the risk of illnesses and mortality. The human body has no way of storing water which makes consistent water intake crucial. Water plays a multifaceted role, from being the medium for all bodily chemical reactions to regulating temperature and ensuring organ functionality.

The challenges in the healthcare system emphasise the need for promoting independent ageing. With an increasing gap between the demand for caregivers and their availability, especially in countries like Germany, the healthcare system is on the brink of a crisis. The situation requires the development of solutions that empower the elderly to age independently, reducing the pressure on primary and secondary care systems. A significant observation is the decline in water intake with age. While younger generations have a variety of tools to monitor and motivate water intake, such products often overlook the elderly demographic.

This thesis introduces "Daria", a product designed for hydration self-monitoring among the elderly. The primary stakeholder for this project is the elderly population, specifically those above 65 years who live outside care institutions.

Context mapping was used to understand the elderly's daily routines and challenges related to fluid intake. Expert interviews provided insights into current medical practices and the nuances of hydration among the elderly. Functional prototyping was key in the design process, allowing for tangible testing and validation of design solutions.

Literature research revealed several challenges the elderly face in maintaining optimal hydration levels. Ageing results in a reduced renal concentrating ability, diminishing the kidneys' capacity to retain water. More importantly, a decreased thirst sensation in older individuals often leads to inadequate fluid intake. Other factors, such as urinary incontinence and social isolation, further contribute to hydration difficulties.

Various strategies have been explored to enhance hydration among older adults. While many interventions have been conducted in controlled environments like nursing homes, none have focused on home settings. Common strategies include verbal reminders to drink and providing a variety of beverages.

In conclusion, "Daria" aims to introduce a new product category to enable hydration monitoring for the elderly. By understanding their unique challenges and habits, this product aspires to motivate them to maintain optimal hydration levels and enhance their overall quality of life.

Keywords: water intake, elderly, dehydration, autonomous ageing, behaviour change

1. Introduction

1.1. Background

The Importance of Hydration in the Elderly
Dehydration is a common medical condition in the elderly (Bruno et al., 2021). Even though elderly homes are monitoring their patients it was found that 50-90% of elderly homes residents show insufficient fluid intake. Dehydration increases the risk of contracting a disease, staying sick and dying (Thomas et al., 2004). The human body stores energy in the form of body fat and muscles (Ferry, 2005). Compared to other nutrients the human body does not have a reservoir for water (Ferry, 2005). Because of that, a continuous intake of water is required (Ferry, 2005). Water is the medium in which all chemical reactions in the body take place. It also is the transportation vessel for nutrients and waste products (Ferry, 2005). Moreover, it is used to regulate the body's temperature via sweating, water is ensuring cell function and thus the function of all organs (Ferry, 2005). Lastly, water acts as a lubricant to ensure the safe flow of food, nutrients and waste products and absorbs shocks when a person is exposed to physical violence but also during normal physical activities (Jéquier & Constant, 2010).

Challenges in the Healthcare System and the Need for Independent Ageing
Insufficient water intake can lead to medical discomfort and eventually to dehydration. Current statistics show an increasing gap in Germany between people needing care and the number of caregivers resulting in staff shortages that will further worsen in the coming decades (Statistisches Bundesamt, 2021). In the near future, the waiting time for care will increase excessively and healthcare worker burnout will become widespread. Therefore, solutions must be developed to counteract a severe healthcare system crisis. Specifically, interventions should be proposed which promote independent ageing to reduce the pressure on primary and secondary care. Previous research shows that water intake is decreasing with age (Institute of Medicine, 2005). While younger people have a wide range of drinking aids available, the elderly are not targeted by these products or don't have access to them. To give some examples, there are smartphone apps to track and motivate water intake, innovative water bottles and IOT products to track hydration. These products are marketed within a healthy sporty lifestyle category aiming at high-paced generations.

Stakeholders
The main stakeholder in this project will be elderly people. For this context, the definition of the elderly by Orimo et al. is used, which describes this group as people above 65 years old (2006). Specifically, the target group will consist of elderly people who do not live in a care institution - neither medical nor geriatric care.

1.2. Scope

The aim of this thesis is to develop a product that supports elderly people in reaching their required water intake. The intervention aims at increasing the quality of life for geriatric persons by preventing health incidents and by promoting independent ageing. This is done by mapping the current context of elderly people and their drinking habits. Then possible solution spaces are explored to develop a product-based intervention aimed at preventing insufficient water intake.

2. Discover

2.1. Approach

2.1.1. Context Mapping

Context mapping is a research methodology in design that aims to understand user experiences within their natural environments, as described by Sanders & Stappers (2013). This approach focuses on observing and understanding users' behaviours, attitudes, needs, preferences and challenges in their daily activities. It uses techniques such as interviews, field observations, diary studies, and other user interactions.

Elderly individuals often have specific habits, routines and preferences that influence their fluid consumption. These patterns can be influenced by factors like their physical condition, living environment, daily schedule and social interactions.

For instance, an elderly individual might consistently drink a glass of water after each meal or might have a preference for certain beverages due to taste or habit. Physical limitations might also affect their ability to access or consume fluids.

By using context mapping, these patterns can be identified by observing elderly individuals in their usual settings, asking about their routines and preferences, and finding out about their behaviours throughout the day. This approach offers a detailed view of their fluid intake, habits and challenges.

In summary, context mapping provides essential insights into the experiences of the elderly, guiding the development of design solutions that meet their needs and respect their routines

2.1.2. Expert interviews

In this thesis, three experts were conducted to receive information about current medical practice and other professionals. In-text citations were marked as “personal communication”. The chosen experts are listed in the following.

Dr med. Antje Reiter
Dr Reiter is an experienced medical professional specializing in general medicine and palliative care in Munich, Germany (Laube, n.d.). With expertise in geriatric care, she is providing comprehensive healthcare services to elderly patients (Laube, n.d.). In addition, she serves as the deputy practice manager, contributes to the advancement of palliative medicine, and holds leadership positions in both a hospice facility and a nursing home (Laube, n.d.).

Joey May Gaßebner
J. Gaßebner is a caregiver in an elderly home in Biberach an der Riß, Germany. She is well-connected in the care home and has valuable practical experiences. J. Gaßebner knows details about recommendations, regulations and procedures in elderly homes (J. Gaßebner, personal communication, 15.04.2023).

Dr Jos Kraal
Jos Kraal is assistant professor of Behavioral Change at the Faculty of Industrial Design Engineering. His main research interests focus on design for behaviour change, physical activity promotion and the development of lifestyle interventions to prevent chronic diseases.” (*Kraal, J.J.*, n.d.)

2.1.3. Functional Prototyping and User Validation

Functional prototyping is a key method in the development process of this thesis, providing a practical and effective tool for testing, improving and validating the study's design solutions in a tangible and interactive way.

Functional prototyping serves as a tool for validating design solutions. Through testing the prototype in real-world conditions, the design can be evaluated to ensure it meets its objectives and that it functions correctly allowing to make any necessary adjustments before the final design is developed.

A significant advantage of functional prototyping is the ability to see how well the design works in practice. Users can be observed interacting with the prototype and can then provide insights about the design's usability, effectiveness, and appeal.

Lastly, functional prototypes are excellent tools for communicating and demonstrating ideas. They provide a tangible representation of the design concept that can be shared with users and the project team. By enabling people to engage with the design physically, prototypes can clarify concepts, illustrate functionality and evoke feedback in a way that written descriptions cannot.

2.1.4. Ethical Considerations

When designing for older adults, it's crucial to think about ethical implications. A key part of this is respecting their autonomy. Their right to make their own independent decisions about their life, health, and well-being must be respected.

A designer's role isn't to force certain behaviours, such as drinking more water, on elderly individuals. Instead, the aim should be to empower them with the tools and information they need to make their own decisions about their health.

This means that instead of designing products that push them to drink more, a focus should be put on creating tools that help them understand their hydration needs.

2.2. Literature Review

2.2.1. Aim

The primary aim of this section is to gather information about the significance of hydration, especially among the elderly population. By understanding the challenges they face in maintaining optimal hydration levels, the research aims to identify effective strategies and interventions to promote better hydration habits in this target group.

2.2.2. Research questions

Understanding Dehydration

- How is dehydration defined scientifically?
- What are its primary manifestations and implications?

Elderly Hydration Challenges

- What physiological and behavioural factors lead to dehydration in the elderly?
- How do social circumstances like living conditions impact their hydration habits?

Strategies and Interventions

- Which strategies have proven effective in improving hydration in older adults?

Public Recommendations

- What are the prevailing fluid intake guidelines for the elderly?

2.2.3. Method

To address the research questions, a comprehensive literature review was conducted. This involved:

Data Collection

Gathering peer-reviewed articles, studies and expert insights related to hydration, especially focusing on the elderly population.
Consulting with experts in the field to gain practical insights and perspectives.

Data Analysis

Analysing the collected data to identify patterns, challenges and effective strategies related to hydration in older adults.
Comparing and contrasting various studies to determine the most effective interventions and recommendations.

Synthesis

Compiling the findings into a cohesive literature research section, highlighting the significance of proper hydration, challenges faced by the elderly, effective strategies and public recommendations.

2.2.4. Results

2.2.4.1. Dehydration (including expert insights)

Sufficient hydration is important. Pross et al. (2014) showed that people that usually drink insufficiently felt more awake when drinking enough. People that usually drink sufficiently had an increase in negative emotions and a decrease in activity when asked to drink insufficiently. There is no sharp definition of what dehydration means scientifically. In general, dehydration means a reduction of the body's water content, which is influenced by many factors (Thomas et al., 2008). In literature, different methods are used to determine the hydration status of a person. In a systematic review different methods to determine dehydration were evaluated and measuring the salt content of a person's blood was set to be the gold standard (Hooper et al., 2015). This requires the collection of a blood sample. In current treatment practice, this gold standard test is not performed (Dr A. Reiter, personal communication, 04.05.2023). Hydration status is rather evaluated by observing symptoms of lack of body water such as dry lips and reduced skin turgor (Dr A. Reiter, personal communication, 04.05.2023). Three different kinds of dehydration are distinguished: Isotonic dehydration, hypertonic dehydration and hypotonic dehydration (Frühwald, 2009). These dehydration types are distinguished by the relation between water and salt loss. Healthy elderly people are mainly affected by isotonic dehydration which is a result of inadequate water intake without excessive sweating (Frühwald, 2009). Already a fluid loss of 2% of the body weight leads to increased stress on the cardiovascular system and impacts the thermoregulation of the body (Kenefick, 2018).

2.2.4.2. Fluid Intake of Elderly People (including expert insights)

Elderly people are at increased risk of insufficient hydration. The reasons for this are as follows:

Renal concentrating ability
When ageing the renal concentrating ability reduces, meaning that the kidney's ability to retain water while removing waste products declines (Institute of Medicine, 2005).

Reduced thirst sensation
In clinical practice, a reduced sense of thirst was reported, which is supported by findings in the literature (Institute of Medicine, 2005). When comparing the water intake and thirst in younger and older individuals, it shows that old age is connected to a loss in the body's ability to compensate for a lack of water (Phillips et al., 1984). Moreover, an older individual requires more time to recover from a dehydrating event than a younger individual (Phillips et al., 1984)

Urinary incontinence
With increased age, the incidence of urinary incontinence rises (Armstrong-Esther et al., 1996). The inability to hold in urine leads to some elderly people actively deciding to inadequately ingest fluids (Armstrong-Esther et al., 1996). Elderly patients report that they are knowingly not drinking sufficiently because they do not want to go to the toilet too often (Dr A. Reiter, personal communication, 04.05.2023). Dr A. Reiter also mentioned that the majority of her geriatric patients are fully aware of their lack of fluid intake and do not want to make changes in their habits. When comparing water intake habits to weight loss, Dr Reiter stated that her patients would rather

start using medication instead of changing their behaviour.

Elderly living alone

A study by Ferry et al. (2005) shows that 70% of the sampled elderly prefer bottled water over tap water. This restricts their water intake because 44% are not able to go grocery shopping by themselves.

Loneliness in the elderly is linked to insufficient hydration, mostly due to a lack of access to beverages (Ferry et al., 2005).

Stookey et al. (2005) analysed available data about the dehydration of elderly people living independently. Depending on the parameter used to determine dehydration, 0,5% to 60% of elderly people living independently are dehydrated. Assuming that acute dehydration prevalence is overrated in literature, elderly people still are at higher risk of dehydration caused by insufficient water intake (Hodgkinson et al., 2003).

Bennett et al. (2004) identified that almost half of the elderly people visiting a hospital's emergency department are chronically dehydrated.

2.2.4.3. Strategies to Improve Hydration in Older Adults

Numerous studies have explored interventions to enhance hydration in older adults. The majority of these interventions were conducted in controlled environments such as nursing homes or hospital wards. Notably, none of the studies focused on hydration interventions within a home setting. A common theme across these interventions is the combination of multiple strategies, often including verbal reminders to drink. This multifaceted approach makes it challenging to pinpoint which aspect of the intervention was most effective. However, it's evident that verbal persuasion and the availability of a variety of beverages positively influenced hydration levels.

Allen et al. (2014) investigated the use of straws for drinking among older adults with cognitive impairment and found a 7% decrease in fluid intake. In contrast, Bak et al. (2018) provided nursing home residents with more ergonomic drinking containers, resulting in a 47% increase in fluid intake during breakfast, equivalent to 70mL. Lin (2013) emphasised unrestricted access to beverages and encouraged residents to consume at least 1500mL daily. This approach led to an increase in fluid intake from 1449 mL to 1732 mL. Schnelle et al. (2010) offered a choice of beverages four times daily, combined with exercise and toileting assistance, which increased daily fluid intake by approximately 400mL.

Several studies, such as those by Simmons et al. (2001), Spangler et al. (1984) and Tanaka et al. (2009), incorporated verbal drinking reminders. These studies consistently reported positive outcomes with significant increases in fluid intake and reductions in dehydration rates among residents. Dunne et al. (2004) found that using high contrast red beverage containers as opposed to white ones led to an 84% increase in fluid intake among residents with severe cognitive impairment. However, not all interventions were successful. For instance, Holzapfel et al. (1996) observed no differences in hydration levels when a feeding assistant provided beverages in varying positions.

Robinson and Rosher (2002) combined verbal drinking reminders with a colourful drinking cart, leading to a reduction in dehydrated residents from 47% to 6%. Mentes and Culp (2003) implemented various strategies, including offering more water with medication and biweekly non-alcoholic happy hours, but observed no significant change in fluid

consumption. Smith et al. (2019) and Wilson et al. (2019) both reported positive outcomes from their multifaceted interventions, with the former noting a substantial increase in fluid intake from 1551 mL to 2225 mL among geriatric psychiatry residents.

Recommendations and methods to increase hydration in older adults

Beyond interventions there are established recommendations for enhancing hydration in the elderly. Thomas et al. (2008) emphasised the importance of educating caregivers about dehydration, increasing their awareness of risk factors and encouraging regular fluid offerings. They also highlighted the significance of providing suitable beverage containers, offering preferred beverages and involving family members in hydration goals. Similarly, Ferry (2005) recommended informing the elderly about the age-related decline in thirst sensation and promoting the consumption of water-rich foods. She also stressed the importance of distributing water intake throughout the day and ensuring easy access to beverages.

2.2.4.4. Thirst

Thirst can be described as an appetite for water that triggers the search for a source of water and eventually leads to water intake (Ramsay & Booth, 2012). It is not considered one of the 5 classical senses (Schmidt, 1980). Thirst is defined under general sensations which also include hunger, tiredness, air hunger (while suffocating) and sexual desire (Schmidt, 1980). All these sensations are influenced by multiple factors and triggers (Schmidt, 1980). In the following, the factors influencing, inducing and inhibiting thirst sensation will be elaborated.

Physiological Triggers

When the body loses 3% or more water, specialised neurons in the brain called osmoreceptors sense the increased osmolarity of the blood which leads to thirst sensation (Leib et al., 2016). Interestingly this thirst sensation can be immediately quenched by drinking water, even though the osmolarity remains high for at least 10 minutes after drinking (Leib et al., 2016). This is because the brain is sensing the ingestion of water in the throat and sends this signal back to the osmoreceptors (Leib et al., 2016).

Another physiological trigger of thirst is eating (Leib et al., 2016). Eating induces the release of body fluids needed for digestion (Leib et al., 2016). This would lead to dehydration, but this is mitigated by a yet unknown mechanism that activates the osmoreceptors while eating (Leib et al., 2016).

Mouth dryness can lead to the desire to drink which withdraws the dry feeling directly (Ramsay & Booth, 2012).

Perceptual Triggers

Maintaining sufficient hydration was shown to be a complex system in the human brain with many brain areas involved in the process that leads to drinking (Hsu et al., 2022). External perceptual triggers were also identified to influence thirst perception. For example, the colour of the glass used for drinking influences the thirst-quenching qualities of a beverage with cold colours such as blue being more thirst-quenching than warm colours (Guéguen, 2003).

2.2.4.5. Detecting Dehydration

Dehydration detection can be categorised into three distinct layers: hydration-linked events, signs of dehydration and methods for quantifying hydration. Each layer offers a unique perspective on dehydration, ranging from indirect observations to direct medical evaluations.

Hydration-linked events

Hydration-linked events are conditions or occurrences that, while influenced by various factors, have been observed as potential consequences of inadequate hydration (Bruno et al., 2021). These events, due to their multifactorial nature, cannot solely determine a person's hydration status. However, they provide insights into the severe implications of insufficient water intake. Medical professionals often utilise a combination of these events as a preliminary screening method for dehydration (Thomas et al., 2008; Hooper et al., 2015).

For instance, both Bruno et al. (2021) and Thomas et al. (2008) identified constipation, falls and urinary tract infections as potential hydration-linked events. Thomas et al. (2008) further highlighted weight loss, delirium, delayed wound healing, renal failure, dizziness, postprandial hypotension, respiratory infections, seizures, myocardial infarction, hospitalization, death and tachycardia as potential indicators. Anjo et al. (2020) and Ferry (2005) also noted exhaustion, muscle cramps and weakness as potential signs linked to dehydration.

Signs of dehydration

Direct signs of dehydration provide more immediate evidence of a person's hydration status. If these signs are present, it indicates existing dehydration with a need for immediate intervention.

Shimizu et al. (2012) identified several signs, including a dry armpit, dry mouth, sunken eyes, decreased skin turgor and delayed capillary refill time. Personal communications with consulted experts, Dr. A. Reiter and J. Gaßebner, added dry lips, increased urine odour, mouth infections and symptoms like confusion and hallucinations to the list. Thomas et al. (2008) and Ferry (2005) also pointed out urine colour, muscle cramps and weakness as potential dehydration indicators.

Methods for quantifying hydration

Quantifying hydration is crucial for a precise evaluation of a person's hydration status. However, as noted by Ferry (2005), there's a lack of a specific biomarker for hydration, given the body's continuous effort to maintain fluid balance.

The EFSA (2010) suggests body weight as a highly accurate method when measured frequently. The osmotic concentration of plasma is also reliable unless vomiting or diarrhoea are present. Plasma volume, while accurate, is challenging to determine (Senay and Kok, 1976). Urine volume, with an output of 100 mL/h, indicates sufficient hydration. Urine colour serves as a good indicator, but is not specific to hydration. Oppliger et al. (2005) found a high correlation with the osmolarity of urine, while the EFSA (2010) identified the specific gravity of saliva as another correlating factor.

2.2.4.6. Beverage Definition - What counts towards water intake

There are two main classifications of ingesting nutrients. Eating usually describes the ingestion of solid foods. Drinking usually describes the ingestion of liquids. But this differentiation is not very sharp. Some sources define soup as a drink as long as it is served without a spoon in a cup but a food when served with a spoon as a tool to ingest it (Conaboy, 2017). Another example is milk. Despite its liquid form, it is often not considered a beverage due to its high calorie and nutrient content. While it does contribute to overall fluid intake, it also contains macronutrients like proteins, fats and carbohydrates, making it more a food than a drink (Pereira, 2014).

Interestingly, some alcoholic drinks with low alcohol content are often considered as a contribution to daily water intake (Dr A. Reiter, personal communication, 04.05.2023). For instance, certain light beers and wines can consist of up to 95% water. However, it's important to note that alcoholic beverages can have a diuretic effect, which can lead to increased urination and potential dehydration, especially when consumed in larger quantities (Roberts, 1963).

It's also worth mentioning that other beverages such as coffee and tea, despite their caffeine content which has a mild diuretic effect, can also contribute to daily water intake. Numerous studies have shown that in moderate consumption, these beverages do not cause significant dehydration (Maughan & Griffin, 2003)

Ultimately, the classification of a liquid as a beverage should be clearly communicated to the user for them to know what counts towards their daily fluid goals and what should be excluded.

2.2.4.7. Influencing factors on hydration

As previously described there is no sharp definition of what dehydration is. In general, a person is not dehydrated if the water that is lost equals the water that is ingested (Jéquier & Constant, 2010). The intake of water only takes place through beverages and food. Some metabolic processes in the human body produce water as a side product (Jéquier & Constant, 2010). This can be neglected in this thesis as it is not possible to easily influence or increase this source of water. The numbers for water input are average values for individuals living in moderate climates and having a sedentary lifestyle (Jéquier & Constant, 2010). The human body loses water in four different ways - through urination, sweating (Skin), breathing and faeces (EFSA, 2010).

Water Input

Water source	Average water input (mL/day)
Beverages	1575
Foods	675
Metabolic water	300
Total	2550

Table 1: Average data on fluid intake (Data from EFSA, 2010)

Water Output

Water loss location	Average water output (mL/day)
Urine	1600
Skin	450
Respiration	300
Faeces	200
Total	2550

Table 2: Average data on fluid output (Data from EFSA, 2010)

2.2.4.8. Public Recommendations (including expert insights)

Recommendations are usually determined from experimental values and describe the overall fluid intake that is required to adequately hydrate as a healthy individual (Jéquier & Constant, 2010). The recommended fluid intake of elderly people is the same as for adults (EFSA, 2010). Including beverages and food 2000 mL is recommended for females and 2500 mL for males (EFSA, 2010). Elderly people lose less water through physical activity and reduced body functions, but they require more water because their kidney function is reduced as well hence the same fluid recommendations as for healthy adults (EFSA, 2010). It may seem surprising that recommendations are given as a fixed value with biological gender being the only differentiation, but the values recommended are usually higher than required in most adults. This is because water intake can be much higher than actually needed, but not much lower for a longer period of time (DGE et al., 2021). Surprisingly the maximum daily water intake that is expected to not cause negative health consequences is 10 litres per day (DGE et al., 2021). However, this value was determined in young males and other findings suggest that due to reduced organ function, elderly individuals are at risk of overhydration and should not be pushed to drink much more than required (Mack et al., 1998).

A more personalised approach is the recommendation of fluid amount per body

weight such as 30 mL per kg body weight (Nordic Council Of Ministers, 2012). For a person that weighs 50 kg, this would mean an intake of 1500 mL per day and for a person weighing 80 kg, this equals a total daily water intake of 2400 mL. However, Löwik et al. (1989) recommend a minimum total water intake of 1700 mL.

Another common recommendation for total water intake is correlating it to the energy consumed which represents 1 mL of fluid per consumed kcal (Phillips et al., 1984).

In an elderly home in Germany, the minimum fluid intake goal excluding foods is 700 mL whilst individual factors are considered (J. Gaßebner, personal communication, 15.04.2023). This means that height and body weight are taken into account when monitoring the hydration habits of the residents.

Fluid intake recommendations might be confusing to elderly people because they remember a mentioned value but are unsure if water intake from food is included and what sort of liquids count. A common misunderstanding is that coffee doesn't count towards fluid intake. But a table with an overview of fluid intake recommendations could help the elderly to have an idea of how much they should drink.

2.2.5. Conclusion

The literature clearly highlights the importance of proper hydration, especially among the elderly. Dehydration generally refers to a decrease in the body's water content, influenced by multiple factors. Although measuring the salt content in blood is considered the best method to assess dehydration, it's not commonly used in practice. Instead, symptoms such as dry lips and reduced skin turgor are more frequently observed.

Elderly individuals face specific challenges that increase their risk of dehydration. These include a reduced ability of the kidneys to concentrate urine, a diminished sense of thirst, urinary incontinence and social factors like living alone.

Various strategies have been explored to improve hydration in older adults, mostly in controlled settings like nursing homes. Some interventions, like verbal reminders and using ergonomic drinking containers, have shown positive results, while others have had mixed outcomes. Recommendations for fluid intake differ, with some suggesting fixed amounts based on gender, and others recommending personalised amounts based on body weight or energy intake. However, misconceptions such as not counting coffee as part of fluid intake can confuse these guidelines for the elderly.

In conclusion, while the need for hydration is well-understood, there's a clear need for straightforward and consistent strategies and guidelines to help the elderly maintain proper hydration levels.

2.3. Market Analysis

2.3.1. Hydration products

In the following, the current market landscape for hydration-related products will be analysed. Four main categories of products have been identified: direct hydration monitoring, self-monitoring, reminders/schedules and flavour enhancement.

Figure 1: Examples of products for direct hydration monitoring.

Direct Hydration Monitoring

Direct hydration monitoring products are typically high-tech wearable devices that track the user's hydration status in real-time. They often provide data on the user's hydration level, alerting them when they need to drink more water. While these products offer a high level of precision, they can be expensive and only target people actively exercising. Furthermore, they often do not consider personal habits, routines and preferences of elderly users.

Figure 2: Examples of products for self-monitoring hydration.

Self-Monitoring

Self-monitoring products are tools that help users keep track of their water intake manually or assisted by technology. These can include water bottles with measurement markings, hydration tracking apps or smart water bottles. These products rely on the user's motivation and discipline to accurately track their water intake. While they are typically more affordable and accessible than direct hydration monitoring products, they require active participation from the user and may not be as accurate.

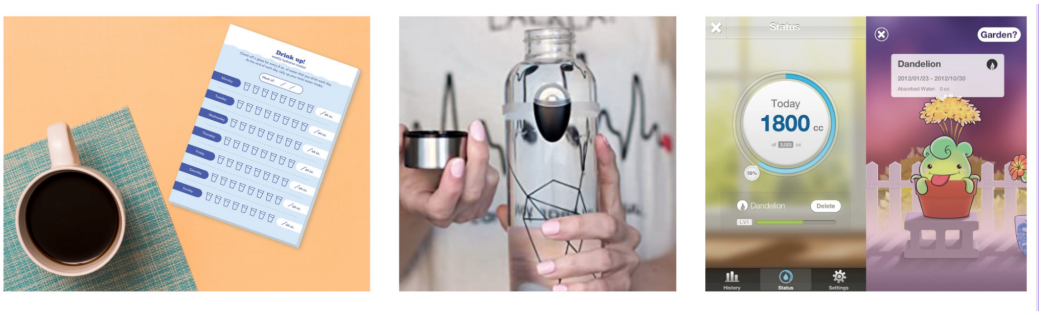


Figure 3: Examples of a hydration schedule and a hydration reminder.

Reminders/Schedules

Reminders and schedules are features often found in hydration apps, smart water bottles or even simple paper-based logs. They provide timely prompts to the user to drink water, often based on a pre-set schedule or the user's estimated hydration needs. These products can be useful for individuals who forget to drink water or who have difficulty recognizing their body's thirst signals. However, they may not be flexible enough to accommodate the user's changing hydration needs throughout the day, and they may not integrate well with the user's existing routines and rituals.

Figure 4: Examples of products that enhance water flavour.

Enhance Flavor

Flavor enhancement products aim to make water more appealing to drink by improving its taste. These can include flavour drops, infusion bottles for fruit and herbs or even flavoured water products. While these products can make water intake more enjoyable, they do not address the core issue of monitoring and maintaining adequate hydration levels.

In conclusion, while the current market offers a variety of hydration-related products, there appears to be a gap in products that are focused specifically on the needs and preferences of the elderly.

2.3.2. Water Advertisement

Companies selling bottled water put a lot of effort into marketing their products. By analysing their advertisements, strategies developed to evoke a desire for hydration and refreshment may surface. Some of the most popular mineral water brands in Germany are Gerolsteiner, Volvic, Adelholzener and Evian (VuMA, 2020; Herrmann, 2016). In the following, advertisements from these brands will be compared and common features will be identified. This was performed by extracting colour palettes from advertisement material of the water brands using https://coolors.co.

Figure 4: Adelholzener advertisement (Seiler, 2020).

Adelholzener (Figure 4) focuses on freshness and is associating their water with the "pure strength of the Alps". In addition to water droplets on the glass bottle, there are some ice crystals visible, emphasising the refreshing properties of the product. Adelholzener's chosen colour palette is only incorporating shades from dark blue to white in the visualisation of the crisp sky and snowy mountain tops. Interestingly the chosen visuals do not show any water in its liquid state.

Figure 5: Gerolsteiner advertisement (Gerolsteiner Brunnen: Frische Marken-Identity, 2020).

Gerolsteiner is showing their product in a scene composed solely of water. The water in the composition is flowing intensely which is emphasised in the written text "Real power originates from nature". Compared to Adelholzener, Gerolsteiner focuses more on the hydrating and thirst-quenching properties of their product. With shades of blue the colour pallet is similar to Adelholzener, but each of the blues contains a portion of green making the ad more connected to nature and seem more alive.

Figure 6: Volvic advertisement (Volvic, 2020).

Volvics' marketing strategy focuses on environmental aspects. With the green-dominated colour palette, they target the market's need for environmentally friendly products. Water droplets on the plastic bottle indicate a cooled product representing freshness. A closeup shot of a flowing river and a vivid green vulcanic landscape represent the natural origin of the product.

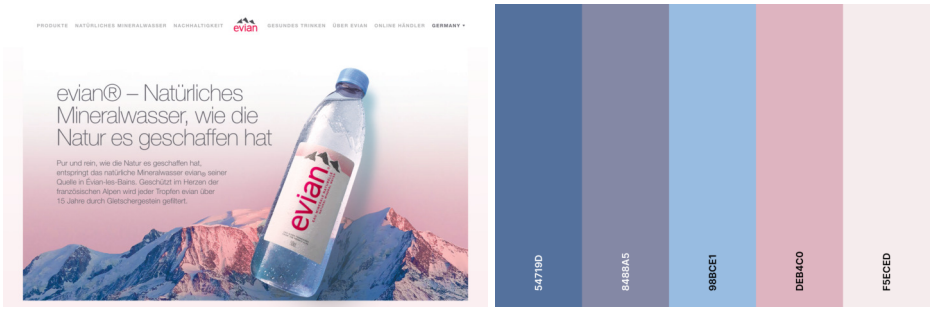


Figure 7: Evian advertisement (Kialka, 2022).

Evian follows a similar approach as Adelholzener by choosing the Alps to represent their water. However, instead of referring to this depiction as strength, Evian uses it to embody purity. Although some condensation droplets are visible on the plastic body, freshness and thirst-quenching properties seem not to be the focal point of Evians' marketing strategy. The composition reminds more of a cosmetic product, which leads their product to be perceived as a lifestyle luxury product rather than a basic human need. The Cold blue colour palette is complemented with a warm pink tone depicted as morning dawn.

The insights of this water advertisement examination can be utilised for the product development of this thesis. Especially colour, material and finish can be developed based on these insights. Light cold colours can be used to create an intention of freshness. A brighter warm colour can be used as a contrast colour and to create brand identity such as Evian accomplishes with the colour pink. Transparent or translucent materials can be used to convey a sense of freshness and purity.

2.3.3. Conclusion

Diverse product landscape
The hydration product market is diverse, spanning from high-tech wearables to simple flavour enhancers. Each category addresses different aspects of hydration, from monitoring to motivation.

Elderly-specific needs
Despite the variety of products available, there's a noticeable gap in solutions tailored specifically for the elderly. Many existing products either require active user participation or do not align with the daily routines and preferences of older individuals.

Advertisement insights
Water brands emphasise nature, purity and freshness in their advertisements. The use of specific colour palettes, imagery and messaging is strategic, aiming to evoke feelings of refreshment, environmental consciousness, or luxury.

Future opportunities
Given the gaps identified in the market and the insights from water advertisements, there's a clear opportunity to develop hydration products specifically for the elderly. Such products could combine the best features of existing categories, be tailored to the elderly's needs and utilise branding strategies that resonate with the target audience.

2.4. Context Mapping

2.4.1. Research aim

To enable the development of a meaningful product-based intervention that facilitates hydration awareness and behaviour change, the context of the target group was explored. By creating a connection with the target group, information about their hydration habits was determined. The research questions were:

What are the habits of elderly people regarding water intake?

Sub-Questions
What motivates elderly people to ingest fluids?

How does water intake take place in their daily life (Drinking, Eating, Type of beverage eg. Tea, Juice, Water etc.)?

Is fluid intake related to certain habits/structures/beliefs/triggers?

Are there habits/structures/beliefs/triggers that stop elderly people from ingesting fluids?

2.4.2. Method

Participants

Inclusion parameters:

- Elderly people (65+ years)
- No diagnosed or known signs of dementia
- Has lived in Germany for the majority of their life
- No major disease especially regarding renal function
- Living in an independent accommodation (not a care institution)

The demographics of the participants are as follows:

Gender: Of the eight participants, six were female and two were male.

Age: The ages of the participants ranged from 74 to 86 with a median age of 82.

Location: All participants were socialised in South-West-Germany.

Family Status: Three participants were married, four were widowed, and one was single.

Household Size: The household sizes of the participants varied between one and three people.

Housing Type: Seven participants resided in houses, one in an apartment.

Tools & Equipment

- Audio recorder
- Physical notebook
- Printed interview questions
- Printed accompanying questions for Context mapping assignments.
- Context mapping assignments

Stimuli

1. Semi-structured-interview questions

Aim: The interview is supposed to create a positive, open and welcoming environment. It is also meant to direct the participant's thoughts towards the topics of hydration and fluid ingestion. They are encouraged to answer important questions regarding their connection to fluid consumption.

2. Context mapping assignments

Presenting the participants with stimuli will likely enable them to reflect on a more in-depth level about the area of fluid intake and connecting behaviours. Therefore, the participants will be presented with the following material:

Stimulus 1: Context mapping assignment 1 - Typical Day

Aim: This stimulus is used to make the participant reflect on their typical daily habits. It's up to them how they structure their day on the piece of paper. The only indication and guiding visual they are provided is a line on the DIN A4 sheet representing a timeline from what they define as the start of their day to what they define as the end of their day. Several different coloured writing/drawing materials are offered.

Stimulus 2: Context mapping assignment 2 - Free associations based on images

Free associations based on images:
Showing seemingly random images to participants is a method of cognitive activation. Throughout the whole exercise, the participant is asked to speak out loud about what they think. First, the participants are asked to describe what they see in each of the images. Then, they are asked to tell what image speaks to them the most and why. The images for this assignment were chosen to activate memories and experiences in the participants. In the following, the reasoning behind the image selection will be described.

Image 1: In this image a typical lake with standard German vegetation is visible. This image is supposed to evoke memories of being in nature and find out about feelings that being close to water induce.

Image 2: This image depicts a characteristic German tradition of “Kaffee und Kuchen” which translates to “Coffee and Cake”. It is a social gathering that happens between lunch and dinner around 3 pm. The image is meant to be in the view of the elderly person that sees a young relative sitting opposite of them using a smartphone. With this image, the social aspect of fluid intake is touched. Additionally, the presence of the distracting

element, such as a smartphone, is supposed to trigger the participant to speak out towards their opinion about technology.

Image 3: This image shows a person sitting on the ground watering a houseplant after repotting it which is indicated by dirt on the ground and the presence of a hand shovel. This image is a representation of water as a necessity to life. Plants cannot survive without water and need regular watering. From initial conversations with younger people about their elderly relatives it arose that the elderly tend to water their plants very regularly and care a lot about them while forgetting to care about themselves and not ingesting enough fluids. The depiction of a gardening activity might enable the participant to talk about their potential passions for living organisms and how they care about them.

Image 4: The last image shows an elderly person standing hesitantly behind a table with an almost full bottle of water and an empty glass in front of them. This image was chosen to enable the participants to share negative emotions connected to drinking and to talk about the pressure they feel surrounding the topic. Elderly people are being shamed and blamed by their younger relatives when they get told to drink more and that they aren't drinking sufficiently. With this image composition, such feelings might be triggered and hopefully, specific details about them shared aloud.

Procedure

The estimated duration for each research session was approximately 1 hour and 35 minutes, with a scheduled time of 2 hours per participant to allow for a 25-minute buffer.

The sessions began with an introduction, where the informed consent sheet was reviewed and the procedure explained. Once consent was obtained, the audio recording was started.

The session was divided into three phases:

- Semi-structured interview (15 minutes)
- Context Mapping assignment 1 - "Typical day" (20 minutes)
- Context Mapping assignment 2 - "Free associations based on images" (30 minutes)

2.4.3. Results

Beverage containers

During the semi-structured interview the participants were asked to show the contaminants they usually use to consume fluids. This revealed that most participants drink from cups and glasses. Seven participants drink bottled water, some additionally drink tap water.

Table 8: Beverage containers presented by users

Beverage preferences

Half of the participants mentioned water as one of their favourite drinks. Coffee was a preferred beverage for three participants, and the same number also expressed a liking for alcoholic beverages, such as beer or wine. In terms of dietary habits, traditional dishes from South-West-Germany were mentioned, while three emphasised the significance of consuming fresh, regional and seasonal foods.

Health and hydration awareness

Three participants knew someone who had received treatment for dehydration or related complications. Five participants linked thirst to physical activity or warmth. Notably, half of them observed a change in their sense of thirst as they aged, with mentions of reduced thirst or increased awareness of the need to hydrate. The importance of water was universally acknowledged, with five participants linking it to life or naming it the "elixir of life."

Daily routines and habits

Daily structures among participants varied. Three had a very structured routine, two had a more flexible routine and the rest had a combination of fixed habits and flexible time. Common daily activities were taking medication after waking up, eating meals at fixed times and doing household tasks or hobbies. For five of the participants, physical activity played a large role in their habits. Most of them mentioned going for long walks as their preferred exercise. Five participants mentioned specific times during the day when they would typically consume water or other beverages.

Perceptions and associations with images
The lake image was favoured by six participants, who often related it to nature, relaxation or personal memories. Conversely, the coffee image, particularly due to the presence of a smartphone, was least favoured by three participants, as it evoked aversions to distracting technologies.

Product ideas and technology use
Five participants expressed curiosity for a product that could help in monitoring or enhancing their water intake. Four were open to advice or suggestions, as long as they sensed genuine care and intention behind them. In terms of technology, half of the participants used computers, of which only one additionally used a smartphone.

2.4.4. Discussion

The findings from this research provide valuable insights into the hydration habits and needs of elderly individuals. Several key themes emerged that have implications for the design and implementation of a hydration aid for this target group.

Occasion-based intentional dehydration
Especially when doing activities that involve other people such as relatives, some elderly perceived the need for frequent toileting as a burden to others and deliberately decide to interrupt water intake before these activities start.

Physical activity
Contrary to common stereotypes about the elderly, this research showed that the participants were more physically active than expected. This was evident in their daily routines, which often included regular exercise, active hobbies and a general commitment to maintaining a healthy lifestyle. Physical activity can increase the body's demand for water, making hydration even more critical for the participants than for less active individuals of the same age.

“Working hours”
Another key finding is that the participants typically completed their chores and tasks by around 3 pm each day. This structured approach to daily activities suggests a preference for routine and order. A product to assist with hydration could make use of this. For example, reminders or prompts to drink could be timed with the completion of certain tasks or chores, making hydration a natural part of the daily routine.

Routines
Routines play an important role in the lives of the participants. They provide structure, predictability and a sense of control, all of which are particularly valuable in the context of ageing. This suggests that a successful hydration aid should fit seamlessly into existing routines, rather than requiring the user to adopt new ones. It should be intuitive and easy to use, with minimal disruption to the user's daily life.

Rituals as enjoyable routines
In addition to routines, the participants' responses also underlined the presence of rituals in their lives. These rituals are activities that are done in a certain way or at a certain time, often for symbolic or emotional reasons. They are not just tasks to be completed but are a source of enjoyment and meaning. This finding suggests that a hydration aid could be more than just a practical tool; it could also enhance the user's daily rituals, making the act of drinking water more enjoyable and meaningful. For example, the design could incorporate aesthetic elements that appeal to the user's senses, or features that make the act of drinking feel special or ceremonial.

Curiosity and uncertainty about fluid intake
One of the most important findings from this user research was the curiosity that elderly

individuals expressed about their fluid intake. Many participants expressed an interest in understanding more about their hydration habits, including how much fluid they consume in a day or how their fluid intake compares to recommended amounts. This curiosity suggests a willingness to engage with tools or strategies that could provide more insight into their hydration habits.

However, this curiosity was often accompanied by a degree of uncertainty. Despite their interest in understanding their fluid intake, many participants were unsure whether they were consuming enough fluids each day. This uncertainty was not always due to a lack of knowledge about recommended fluid intake amounts. Instead, it often originated from difficulty in tracking their fluid intake throughout the day as most of the participants drink intuitively.

These findings suggest a need for tools or strategies that can help elderly individuals monitor their fluid intake more accurately and easily. Such tools should not only track the amount of fluid consumed but also provide feedback and education to help individuals understand whether their fluid intake is adequate.

2.4.5. Limitations

The recruitment of context-mapping participants took place within the social circle of the authors' grandmother. This approach allowed for an open and trusting interview environment. Some participants mentioned - without being asked - that they would have never agreed to such research if approached differently. While this recruitment method allowed for a deep understanding of the participants' water intake habits and needs, it is also expected to bias the research. Only participants were chosen that are cognitively and physically in good condition and relatively open-minded. Very lonely people with little or no social circle are excluded by this recruitment method as well. As all participants are residents of the same city - a small village in the southwest of Germany - the results may not be directly applicable to the urban population.

2.5. Household interactions

In this section, products that elderly people interact with will be analysed. The aim of this analysis is to find common themes and features that increase a product's usability. A special focus will be laid on products that have physical interaction interfaces and products that convey information to the user.

2.5.1. Temperature indicators

Figure 9: Thermometer.

Thermometer with minimum and maximum indicator
This thermal expansion thermometer shows the temperature using a numbered scale and the liquid level inside the glass tube. Additionally, two blue needles float on the liquid. The right blue needle is pushed up when the temperature rises and the left needle is pushed up when the temperature decreases. This indicates the maximum and minimum temperature reached. The button in the centre of the two glass tubes opens an air valve which resets the blue needles to the current temperature. The negative values are visualised in the colour red and the positive values in the colour black. This could be confusing to users as red is not just associated with negative values but also with heat. A more precise colour scheme would be blue for negative and red for positive temperatures.

Figure 10: Circular Thermometer

Circular thermometer
This thermometer uses a circular scale. The current temperature is shown by an indicator similar to an analogue clock. The scale is numbered in decimal increments. Negative temperatures are depicted with a dash.

Figure 11: Clinical thermometer.

Clinical thermometer
The interaction of the digital clinical thermometer consists of a button and an LCD display. The button combines three functions. Pressing it turns on the thermometer and starts the temperature measurement. A long press turns off the thermometer. An acoustic signal from a piezo speaker accompanies the use phases: turn on/start of measurement, end of measurement and turn off. The LCD screen and push button are visually separated from the rest of the device by using a plastic inlay in a contrasting colour.

2.5.2. Weight Indicators

Figure 12: Kitchen Scale.

Analog kitchen scale with tare function
The mechanic scale uses a semi-circular scale and a red indicator to show the current weight. The scale can be moved which is visualised by ripples along the edge of the scale for better grip. Moving the scale does not move the indicator. This allows to tare weight the scale for example when several ingredients need to be added.

Figure 13: Body scale.

Battery-free body scale
This body scale uses a button dynamo to generate energy for the weighing process. After pushing the dynamo button the person can step on the scale and the weight is shown on an LCD display. Conventional body scales are battery-powered. There is no need to turn them on with a button. Stepping on them turns on the scale and initiates the weighing process. After stepping off the scale, it automatically turns off using a timer.

2.5.3. Time Indicators

Figure 14: Water filter with digital interface.

Water filter change indicator

The water filter screen depicts four bars each representing a week of available usage of a filter cartridge. With each week that passes one bar disappears. After four weeks all bars are gone and an arrow appears which indicates the change of the filter. After changing the filter cartridge the bars can be reset with a push button with "START" printed on it. This visualisation uses a simple LCD display that requires minimum energy. That's why the manufacturer decided to not offer charging or replacing the battery. When the indicator is empty the indicator has to be replaced fully.

Figure 15: Wall clock.

Wall clock

Most wall clocks use an electromechanical clockwork that moves the indicators. The time is set by turning a wheel on the back of the watch. This function could be translated to this thesis by letting the elderly set a one-time setting, like their age, weight and height, on the back or bottom of the product.

2.5.4. Setting adjustments

Figure 16: Oven knobs.

Oven knobs

The knobs on an oven are used to set the mode of heating and the temperature of the oven. While heating up, a light is indicating that the set temperature is not yet reached. When the light turns off, usually accompanied by a "click" sound or paired with an acoustic "peep" signal, the set temperature is reached. While heating up, the current temperature can be determined by turning down the temperature knob until the light turns off. The knobs use symbols, numbers and scales to communicate functions. Some of the symbols are not intuitively understood by users which is indicated by the source article figure 16 is derived from. In this article oven icons commonly used are explained.

Figure 17: Floor heating thermostat.

Floor heating thermostat

Heating systems with floor heating usually have a wall-mounted thermostat. This is using a similar approach to the radiator thermostat by showing numbers from 2 to 6 and a dot to represent the ideal room temperature according to recommendations. A snowflake symbol represents the lowest possible heating setting which prevents the freezing of water pipes.

Figure 18: Fridge Interfaces

Fridge interfaces

The left image depicts a conventional temperature knob of a fridge. It consists of a turning knob with numbers printed on it. The higher the set number the higher the cooling power and the lower the temperature. This interaction is confusing to users as the temperature range of a refrigerator is close to the numbers printed on the knob which can lead to confusion.

The right image shows a more user-friendly fridge interface. The user can push a button to scroll through five LED lights paired with written temperatures. The button shows an icon of an expansion thermometer. A sixth LED light which is separated from the others is specially paired with a second push button that depicts a snowflake to turn the cooling to the highest setting.

Figure 19: Radiator thermostat.

Radiator thermostat
A common mean of heating in Germany are radiators. Most radiators have individual thermostats to set a temperature. The numbers on the thermostat represent specific room temperatures. A thermoelastic element in the knob opens or closes the radiator valve to set the room temperature. The number 3 is printed in bold and stands for the optimal room temperature according to recommendations. As the numbers represent specific temperatures the scale can be confusing. It would be more user-friendly to directly write the room temperatures that the numbers stand for.

2.5.5. Conclusion

The analysis of household interactions, particularly those products frequently used by the elderly, provides insights into the design and functionality preferences of this target group. Several key takeaways are:

Clarity and simplicity
Devices like the water filter change indicator and the digital clinical thermometer emphasise the importance of clear, straightforward interfaces. Any hydration product for the elderly should prioritise intuitive design.

Feedback mechanisms
The acoustic signals in the clinical thermometer and visual cues in the oven knobs highlight the significance of immediate feedback. This can be crucial in ensuring the elderly user is confident in their interactions with the product.

Consistent and understandable symbols
The confusion caused by the oven and the fridge interfaces emphasises the need for universally understood symbols and labels. This is especially important for the elderly, who may not be as familiar with newer or less intuitive icons as younger generations.

Incorporating these insights into the development of a hydration product for the elderly will contribute that the end product is not only functional but also user-friendly, reducing barriers and ensuring consistent use.

3. Definition

3.1. Personas

Two user personas were developed depicting typical elderly personalities. The personas are based on extensive interviews with eight elderly people which were performed in the form of individual context mapping sessions. Emma is noticing her age and started to be less active, while Gerda is still very active. Both are not very concerned about their water intake and tend to drink by intuition.

Emma, 84

"I feel like I might drink enough, but I'm not sure about it. I guess it could be more?"

Background
Emma lives alone in the house she shared with her late partner. She doesn't have any major health conditions but notices her age. Emma used to enjoy gardening, but in recent years she has experienced a decline in energy. She leads a structured life with fixed routines and schedules her day accordingly. After lunch, Emma takes a long nap to rest and recharge. Although her family members live in a different city, they regularly check in on her. She enjoys staying connected with her neighbourhood through local events and social gatherings. In the evenings, she enjoys watching television or sitting on her terrace.

Hydration habits
Emma relies on her intuition and body signals to manage her water intake and maintain hydration levels.
Emma sometimes struggles to remember to drink enough water throughout the day.

Expectations
Emma values her independence but requires some help in managing her daily tasks on her own.
She is open to using technology but prefers simple and user-friendly devices.

Drinking vessels

Gerda, 86

"I don’t really think a lot about drinking - I just do it."

Background
Gerda leads an active lifestyle and enjoys going for long walks every day. She is currently grieving the recent loss of her husband, which adds to her emotional state and challenges her daily routines.

Hydration habits
On her walks, she doesn't carry beverages with her.

She has a glass of water strategically placed in her dining room, which serves as a reminder for her to take regular sips each time she walks by. However, she doesn't prioritise hydration and often forgets to drink enough water.

Expectations
Gerda values simplicity and would benefit from gentle reminders or cues to help her stay hydrated throughout the day, especially during this difficult time. She is open to exploring solutions that make hydration easier and more convenient for her.

Drinking vessels

3.2. Problem Definition

Most elderly people are inadequately hydrated, which leads to negative health consequences, impacting their quality of life.

Elderly individuals are usually aware of fluid intake recommendations but are unsure if they meet the required amounts.

Some elderly people with very low fluid intake are aware of the discrepancies with recommendations but aren't aware of the benefits of changing their fluid consumption habits.

Currently, most elderly are drinking intuitively, leaving them with insecurities about their hydration.

3.3. Design goal

- Create awareness and engagement with personal fluid intake.
- Enable users to set daily hydration goals.
- Provide a tracking mechanism to motivate users towards achieving their daily hydration goals.
- Ensure certainty for the elderly by enabling intuitive drinking while offering precise feedback on consumption.

3.4. Requirements

Physical product
The solution should be a physical product, rather than a digital one like an app. This is because some elderly individuals aren't comfortable using digital technology. Most of them prefer a product that they can touch and interact with in a more tangible way. Additionally, a physical product is more visible and serves as a constant reminder for users to stay hydrated, unlike a digital app that can be easily forgotten or ignored.

Quiet
The product shouldn't claim attention beyond the users' preferences. It should serve as a friendly companion rather than an intrusive observer. Here, quiet is meant figuratively to describe a discreet appearance, enjoyable acoustics and pleasant aesthetics.

Encouraging
The product should respect the elderly's independence and autonomy, avoiding design features that feel condescending or infantilizing to the users. Instead, the product should empower the user to take control of

their hydration and health by providing them with the necessary tools and support.

Honest and caring
The product should convey an honest and caring message to the user, emphasising the importance of hydration in a friendly and empathetic manner. The product should communicate the benefits of proper hydration for elderly individuals without being overly pushy or aggressive in promoting a certain behaviour.

Easy to use
The product should be easy to use and intuitive, with clear instructions and minimal setup required. It should not consist of too many components. Product functions should be indicated clearly with design elements rather than including hidden features.

Environmentally conscious
The product should have a minimal carbon footprint with a design that minimises its environmental impact. Moreover, elderly individuals are particularly conscious of their consumption and a product that aligns with their values in this regard could be more appealing to them. This may include using recyclable materials, incorporating energy-efficient features and most importantly creating a product that lasts a long time without losing functionality or becoming outdated.

Health considerations
The product should promote healthy hydration habits and empower the user to make informed decisions about their health and hydration needs in consultation with their healthcare provider. This means the product should not provide a false sense of security or encourage risky behaviours related to hydration. Furthermore, it must be communicated clearly that the resulting product is not a medical device and their healthcare provider should always be consulted if any questions regarding their fluid intake needs arise.

Aesthetics
The design should be simple, clean and easy to use, with a colour scheme and materials that are visually appealing and calming. An aesthetically pleasing design can increase the appeal of the product and make it more likely to be used consistently.

4. Product Development

4.1. Formgiving

4.1.1. Product design

The product design is influenced by conventional beverage coasters, adapted to meet the technological and aesthetic requirements of this product.

Inspiration and design language
The design is minimal with a combination of a round organic drop-like shape that is interrupted by the two edges, giving it geometric definition. The two edges point towards the display area, giving the product a clear direction by visually guiding the user towards the display area.

Ergonomics
The relatively large shadow gap allows picking up the product easily. The wide ring around the coster surface prevents accidentally touching the sensor when moving the product around. The display is angled at 36° to ensure a comfortable viewing angle when sitting and standing.

Functionality in aesthetics
While the design prioritises functionality, determined by the technical package and ergonomic considerations, the introduction of clear edges adds a modern aesthetic without compromising the usability of the product.

Size and proportions
The dimensions of the circular felt surface are based on standard coasters. The outer ring's size balances the need to house technical components and not make it appear bulky.

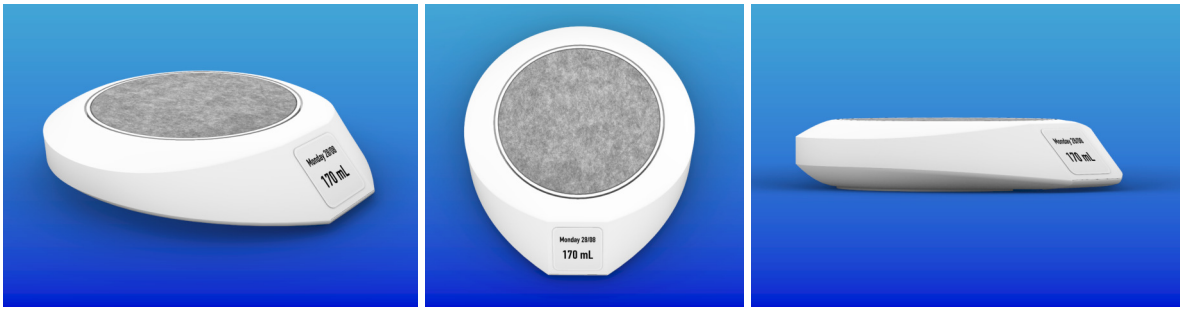


Figure 20: Final product design.

4.1.2. CMF selection

Colour: light beige
The choice of a light beige colour is due to its neutral and subtle shade that can seamlessly blend into the interiors of most elderly homes. This ensures that the product doesn't stand out but rather complements the existing decor.

Figure 21: Color Moodboard.

Material: semi-stiff silicone and felt inlays

Silicone is known for its durability and flexibility. This makes it an ideal material for products that require frequent handling. Its inherent non-slip property ensures a good grip, making the product easy to pick up and move around, especially for elderly users who might have reduced hand strength. Additionally, silicone can be moulded to have fine features as needed for the physical buttons.

The addition of interchangeable coloured felt coasters adds a layer of customisation and individualisation to the product. Not only do these coasters provide an aesthetic appeal, but they also serve functional purposes:

- Ensures hygiene as they can be changed and cleaned regularly.
- The felt material absorbs condensation water and accidental spills, ensuring that the surface remains dry and clean.
- The coasters act as a barrier, preventing the beverage containers from adhering to the surface, especially when wet.

Together, the combination of light beige silicone for the case and coloured felt coasters for customization ensures a blend of functionality, aesthetics, and user experience

Finish: translucent to LED lights

The silicon material has the benefit that a matte translucent finish can be directly moulded without the need of further processing. This material has been chosen specifically to allow LED lights to shine through. This not only adds a visual appeal to the product but also serves the functional purpose of progress tracking.

Figure 22: Material and finish Moodboard - Case.

Figure 23: Material and finish Moodboard - Coaster Inlay.

In conclusion, the CMF selection has been made keeping in mind the target group – the elderly. Every aspect, from colour to material and finish, has been chosen to ensure ease of use, durability and a design that resonates with the elderly while providing them with a product that is both functional and aesthetically pleasing.

4.1.3. User interface

Data input

For the product to function the user is asked to input a personal water intake goal. Together with the product the user is provided with an instruction manual explaining the use. This manual contains table 3 giving a reference to how much one should drink based on age and weight. This manual also mentiones factors like hot weather or physical activities. However, it is also mentioned that the user is free in their choice to what they set their personal goal to. They can actively decide to set it to less than the recommendation if the recommendation seems unrealistic to them. Based on the recommendation of elderly homes not consuming less than 700 mL per day (J. Gaßebner, personal communication, 15.04.2023) this is the lowest possible value to set.

As seen in figure 24 the goal setting takes place on the bottom of the device using a dial with a written scale. The decision to hide the input function was based on the infrequent necessity to change this individual goal. The goal is set before starting to use the device for any given day and then stays the same. Having the dial present at all times would be an unnecessary distraction from the product's main functionality, giving feedback on the fluid amount consumed and the progress on the goal.

Figure 24: Individual goal dial on the bottom of the product.

		age		
		40-50	50-60	60+
weight (kg)	40-50	0,9 - 1,2 L	0,9 - 1,2 L	0,9 - 1,1 L
	50-60	1 - 1,5 L	1 - 1,5 L	1,1 - 1,3 L
	60-70	1,5 - 1,7 L	1,3 - 1,7 L	1,2 - 1,5 L
	70-80	1,7 - 1,9 L	1,5 - 1,9 L	1,5 - 1,7 L
	80-90	1,9 - 2,2 L	1,7 - 2,2 L	1,7 - 1,9 L
	90-100	2,2 - 2,5 L	1,9 - 2,5 L	1,9 - 2,1 L
	100-120	2,5 - 3 L	2,1 - 3 L	2,1 - 2,5 L

Table 3: Fluid intake Base requirement (Date derived from Herold (2021))

Data output

Total consumed fluids:

By using the smart coaster the fluid intake is monitored. Each morning the device resets the e-paper display, welcoming the user and waiting for the them to start drinking. The display accumulates the total amount drank throughout the day in millilitres (Figure 25). With the arrow buttons on the left of the display (Figure 26) the user can go back one day each to view the total consumption of the previous days (Figure 27).

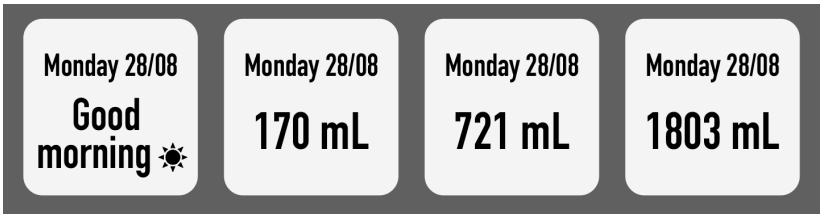


Figure 25: Total consumed fluid display throughout the day.

Figure 26: Physical arrow buttons next to the display.

Figure 27: Viewing previous days on the total consumed fluid display.

Progress towards personal goal:
A circular LED bar is used to visualise the progress towards the daily goal. To make it clear to the user what the full bar looks like, all LEDs light up on startup. The LEDs gradually fill in the colour white throughout the day in correlation to the total amount drank. When the daily goal is reached 100% of the LEDs are on. In the example shown in figure 28 the personal fluid goal was set to 1500 mL. To encourage the user of drinking more than the personal goal, the progress bar starts to fill up again in the colour green to indicate overachievement of the goal while continuing to monitor the fluid intake (Figure 29).

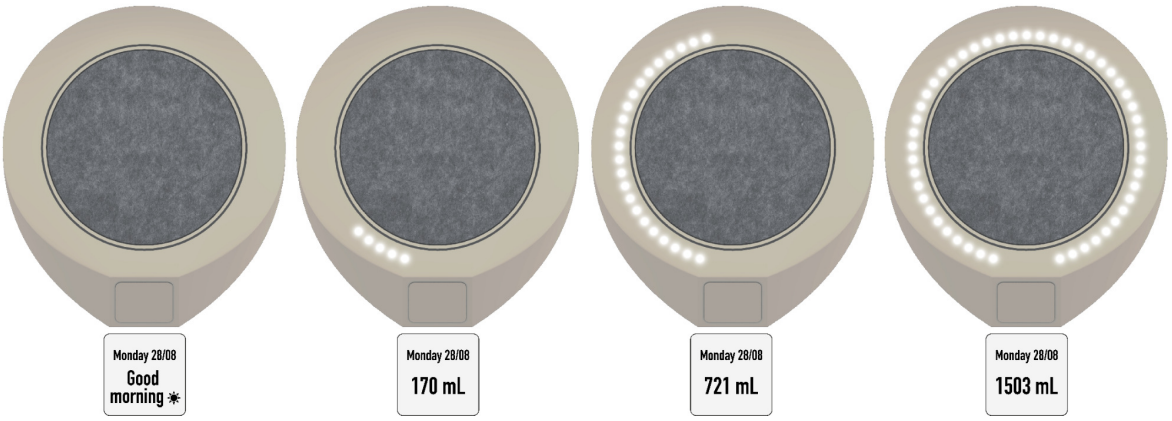


Figure 28: Progress visualisation throughout the day combined with the corresponding screen content.

Figure 29: Progress visualisation when overachieving the personal goal combined with the corresponding screen content.

Goal achievement animation:
When the personal goal is reached, the LED ring is displaying a colourful animation for 10 seconds. This indicates the achievement of the personal goal and adds a layer of gamification.

Figure 30: Goal achievement animation.

Busy indicator:
Two blue lights above the display indicate that the product is busy. This indicates to the user that they have to wait for the product. The waiting time is required because the load cell sensor, that is registering the weight of the beverages put on top of the coaster, needs around two seconds to reach equilibrium and output a stable value. In terms of usability this wait time has little disturbance, because two seconds is less than the time needed to lift up the glass, drink and put the glass back on the smart coaster. After the light turns off and a decrease in weight is detected, the new values are visualised immediately.

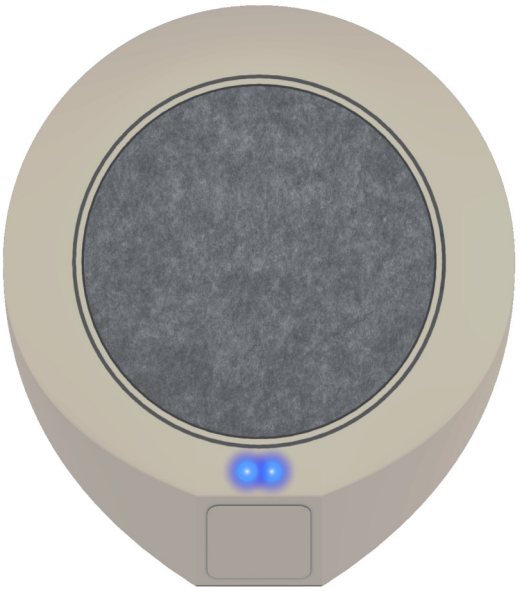


Figure 31: Busy indicator.

4.2. Product Specifications

4.2.1. Product components

This chapter lists the required components of the product that are needed to provide the desired product functions.

Figure 32: Load cell.

Load Cell
A load cell is used to measure the weight that is added to the coaster. The chosen load cell can measure up to 1 kg of weight and provides a precision of 1 gram. The load cell requires an amplifier that will be integrated in the custom PCB.

Figure 33: E-paper screen.

E-paper screen
For displaying information to the user an e-paper screen is selected. Although an e-paper screen is much more expensive than an OLED or LCD screen, its advantages outweigh the price. An e-paper screen consumes very little energy. In fact, it only consumes energy when the content of the screen is changed. This makes it very suitable for the desired use case in which information is only renewed several times per day. Another major reason for choosing an e-paper display is the user experience related to the appearance. E-paper screens are similar to analogue methods of conveying information as shown in Figure 34. It is expected that this similarity increases the acceptance of the product in the home environment of elderly people. Contrary, if the screen would be a bright LCD screen, it could be perceived as a form of intrusive technology that does not fit in the product's surroundings.

Figure 34: Analogue methods of conveying information.

Figure 35: WS2812B LED strip.

LED strip
To visualise the daily progress, a LED strip is used, specifically, a WS2812B LED strip. In this type of LED strip, each LED has its own microcontroller which allows one to change each individual LED compared to all at once in a conventional LED strip. The individually addressable LEDs are required for the desired product functionality. The chosen LED strip has 144 LEDs/metre allowing for a high

resolution in displaying the daily progress. For the product around 30cm of LED strips are needed which equals around 50 LEDs.

Figure 36: Photoresistor.

Photoresistor

A photoresistor makes sure the product's interface is contrasting with the light environment enough so it is visible, but not as much to a point at which the product would be perceived as disturbing. This is especially important for dimmed light conditions, for example when the user is watching TV in a dark room, the interface should be dimmed to the minimum brightness. On the other hand, when the sun is shining through the window, the interface should still be visible and thus be set to the maximum brightness.

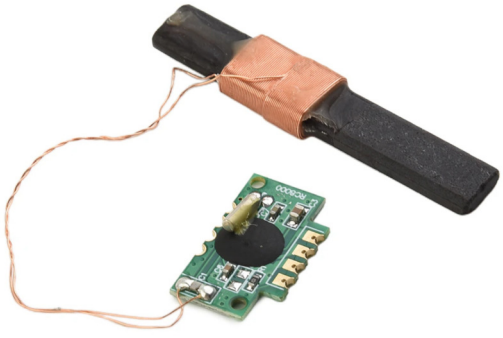


Figure 37: Radio time receiver

Radio time receiver

A DCF77 radio time receiver is used to supply the products system with the current time and date. This is needed to display the current date, map the water consumption data to a time and automatically reset the consumption tracker when a new day starts. Using a radio time receiver makes a tedious manual time-setting process redundant. This specific receiver is only capable of receiving the central European time, restricting the product's market to the countries in this time zone.

Figure 38: Push button.

Push buttons

To switch between days to display the previous daily total consumption, two physical buttons are incorporated in the product. They are embodied in the form of push buttons underneath the silicon case. Physical push buttons have the advantage of giving both haptic and acoustic feedback when pressing them, allowing for intuitive user interaction.

Figure 39: Battery

Battery

A rechargeable LiPoly battery is used to power the smart coaster. This battery is chosen because of its long lifetime and small dimensions. A detailed calculation of the product's energy consumption and charge cycle time is provided in the chapter “Energy consumption”.

Figure 40: Wireless charging coil.

Wireless charging coil

For a reduced product interaction complexity, wireless charging technology is used to recharge the internal battery of the product. A further benefit of wireless charging is that it allows to reduce the risk of short-circuits due to exposed charging contact. This is especially important because open water containers are intended to be placed on the product.

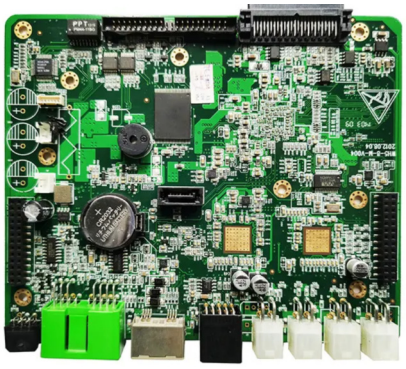


Figure 41: Example image custom PCB

Custom PCB

A custom PCB (printed circuit board) controls all system components. The PCB consists of a microprocessor that handles all the data received by the sensors (radio time receiver, load cell, photoresistor) and controls the LED strip and the e-paper screen. The PCB also contains the potentiometer that is connected to the dial for setting the individual fluid intake goal. Using a custom circuit board is only profitable if the product quantity is high. For small preseries off-the-shelf PCBs can be used to support the individual desired product functionalities (microcontroller, display module, load cell amplifier).

Figure 42: Felt inlays.

Felt inlays

The circular felt inlays provide three main functions: Sound reduction, prevention of glass adhesion and product personalisation. When placing a glass on the rigid coaster surface the felt provides a slight shock absorption and sound reduction. If water is on the outside of the glass or cup due to spills or condensation, this water is absorbed by the felt. Without the felt layer there is a risk that the glass is sticking to the coaster through adhesion, lifting the coaster together with the glass. The last function of the felt inlays is product personalisation. The user is provided with several different coloured inlays to choose from. To ensure high hygiene the inlays can be washed. They can choose their favourite colour and change the colours to their liking. If more than one person in a household owns the product the felt inlays can help to distinguish the products.

Figure 43: Power Adapter.

Power adapter
A standard AC/DC 5V 20W micro USB power adapter is used to supply the wireless charging station with energy. Using an off-the-shelf product reduces manufacturing costs significantly. A disadvantage of this approach is that the form giving of the power adapter does not match precisely with the product.

Wireless charging station
To reduce production costs initially the charging station is as well off-the-shelf. Although there is no control over the precise product design, a charging station that roughly matches the product's aesthetic qualities is chosen.

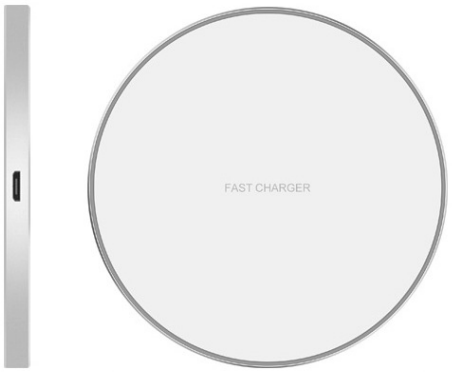


Figure 44: Wireless charging station.

4.2.2. Technical package

The required components (Figure 45) were arranged with spatial constraints in mind. Given the product's form factor and intended use, the space allocated for the technical package is a circular area with a diameter of 100mm and a height of 30mm. All the necessary components fit within this defined space (Figure 46).

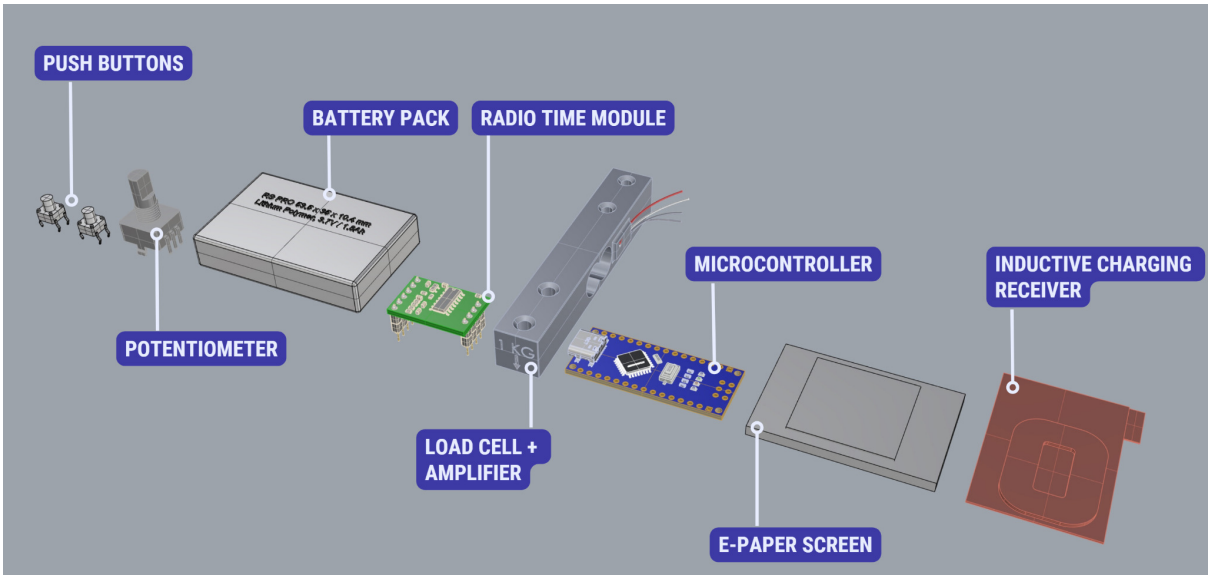


Figure 45: Size comparison of product components.

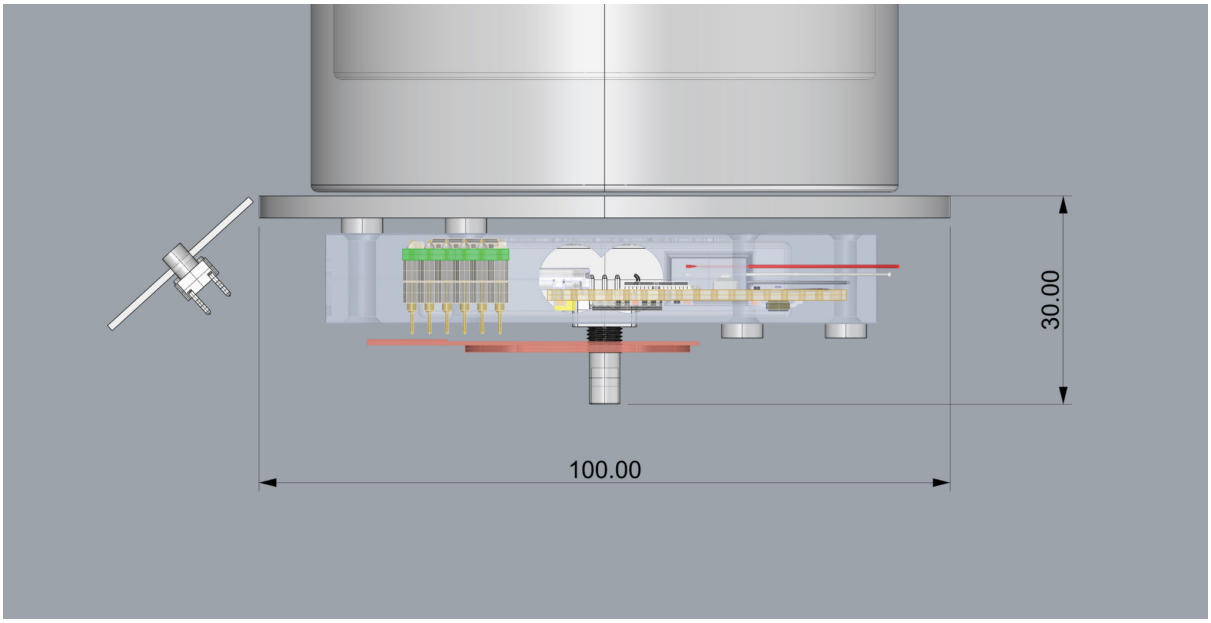
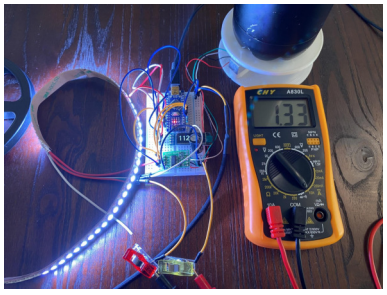
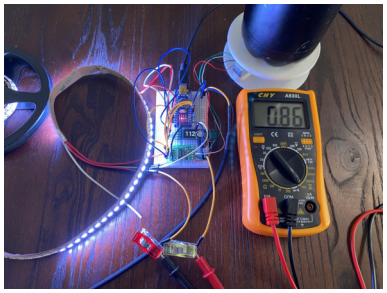


Figure 46: Technical package dimensions.

4.2.3. Energy consumption

The LED strip is consuming the most energy in the system. Because of this, a test was performed to evaluate the energy consumption of the LED strip in different configurations. The variables tested were brightness and LED colour.

Influence of LED brightness on power consumption.

Image of experimental setup	Brightness	Energy consumption [mA]
	100%	1330
	50%	860

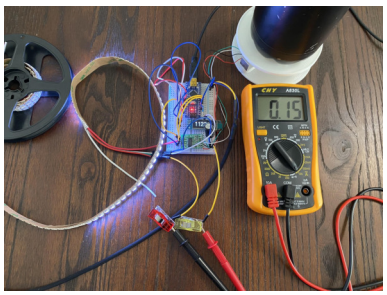
	4%	150

Table 4: Influence of LED brightness on power consumption.

Influence of LED colour on power consumption.

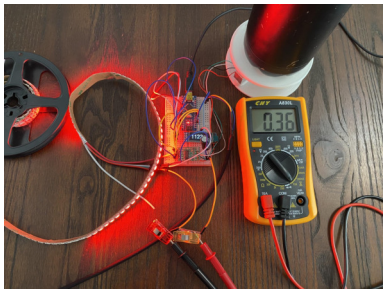
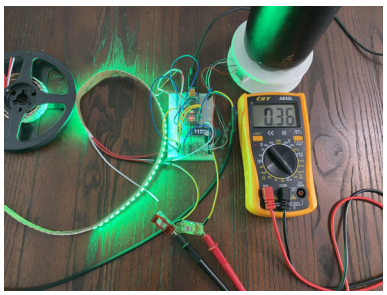
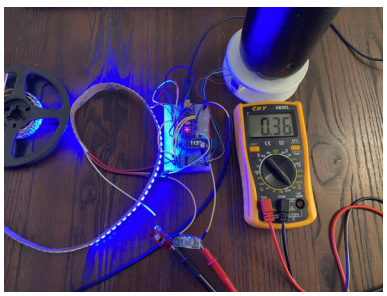
Image of experimental setup	Colour	Energy consumption [mA]
	Red	360
	Green	360
	Blue	360

Table 5: Influence of LED colour on power consumption.

Results and consequences

As evaluated in the second test setup, the colour of the LEDs has no influence on the energy consumption of the LED strip. As expected, the brightness has a large influence on the energy consumption. The lowest setting of 4% brightness still showed sufficient

visibility in indoor light conditions while only using a maximum of 150mA when all 50 LEDs are active. Because of this, energy consumption is being assessed with the assumption of 4% brightness with the LEDs set to the colour white (RGB active equally).

Total energy consumption

The following table provides an estimate of the energy consumed by the product. This enables to calculate how long the product lasts before it needs to be recharged. However, because prototyping equipment is used to assess these values, a large difference to a product with high production quantities can occur. Higher production quantities allow for customised PCBs that are optimised for energy consumption.

Product component	Specifications	Energy consumption
Arduino Nano	Resistor must be removed to decrease consumption	8,8 mA
WS2812B LED strip	50 LEDS; Brightness: 4%; colour: white; active for an average of 2 min per hour	5 mA
E-paper screen	Standby	0,005 mA
	Refresh	2mA for 2s = neglectable
DCF77 time receiver	-	0,07 mA
Load cell with controller	-	<1.7mA
	Total energy consumption	**15,57mA**
	Runtime with 1800mA battery	**~ 5 days**

Table 6: Total energy consumption

4.2.4. Product costs estimation

Manufacturing costs

The following table gives an overview of all components needed for manufacturing the product in series. The costs are estimates provided by the suppliers and can change significantly when initiating a detailed manufacturer inquiry. All prices given assume a production quantity of 5000 pieces. Producing lower quantities will lead to an immense increase in cost per piece.

Item	Specification	Quantity per product	Total quantity	Supplier	Cost/product [€]	Cost for 5000 products [€]
Load cell	1 kg	1 piece	5000 pieces	Shenzhen Sensor And Control Company Limited	1,39	6950

E-Paper Display	1,54 inch; 200 x 200 pixels	1 piece	5000 pieces	Shenzhen Saef Technology Ltd.	2,17	10850
LED strip	WS2812B, 144 LED/m	35 cm	1750 m	Shenzhen Coxo Technology Co., Limited	0,4	2000
Radio time receiver module	DCF77	1 piece	5000 pieces	Shenzhen Jingyuan Technology Copres. Ltd	1,08	5400
Push button	TS66HCJ-X	2 pieces	10000 pieces	Shenzhen Shouhan Technology Co., Ltd.	0,0186	93
Potentiometer	PT15	1 piece	5000 pieces	Dongguan Tianqian Electronics Co., Ltd	0,0222	111
Photoresistor	-	1 piece	5000 pieces	Zhongshan Wenming Electronics Co., Ltd.	0,0093	46,5
Custom PCB	-	1 piece	5000 pieces	Shenzhen FS Technology Co., Ltd.	0,37	1843,05
Battery	3,7 V 1800 mAh	1 piece	5000 pieces	Shenzhen Topway New Energy Co., Ltd.	1,34	6.700
Wireless charging module	Receiver	1 piece	5000 pieces	Kingstar Electronics Technology Co., Ltd	0,2304	1152
Wireless charging station				Shenzhen Usky Technology Co., Ltd.	2,57	12.850
Power adapter	5V 20W Micro USB	1 piece	5000 pieces	Shenzhen Silver Deer Industry Co., Ltd.	1,28	6400
Plastic injection moulding and assembly	Housing top/ bottom shell, Dial, Coaster surface	4 pieces	30000 pieces	Zetar Industry Co., Limited	3,85	19266
Felt fabric	98mm diameter	5 pieces	25000 pieces	Hainan Weicheng Trading Co., Ltd.	0,0575	287,5
				Total costs	**14,79 €**	**73949,05 €**

Table 7: Cost estimation.

Consumer price

The total cost of the components and product assembly results is 14,79 €. Additional costs for marketing, packaging and shipping can be estimated to be an additional 4€ per unit. If a profit of 25% is assumed, the consumer price can be set to 24,99 €, making the product affordable to most elderly living in central Europe. If the product is evaluated in a clinical study setup to be beneficial to the users' health behaviour, reimbursement of costs by health insurance companies is plausible.

4.3. Functional prototype I - proof of concept

To initially test the rough user interaction and technology used, a functional prototype was developed. The main component of this prototype was an Arduino Nano, an LCD display and a load cell sensor. The Arduino was programmed to display the weight of whatever is placed on the coaster. The setup basically resembles a scale but is close to the desired dimensions of the intended smart coaster. For the case, FDM-3D printing was used.

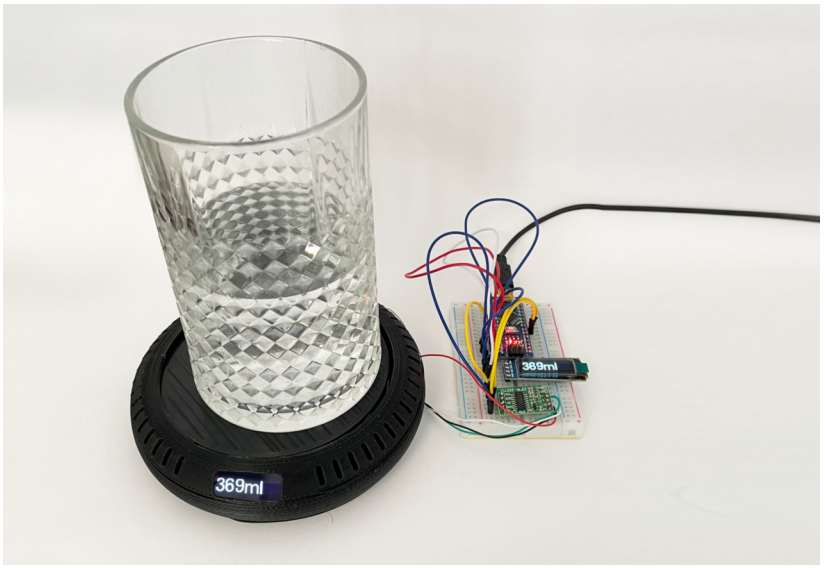


Figure 47: Functional prototype I.

4.3.1. Fluid consumption calculations

In this initial test the weight of the beverage was written down manually after each sip (Figure 48). At the end of the day, the values of each drink were grouped by hand resulting in the total fluid consumption of that day (Figure 49).

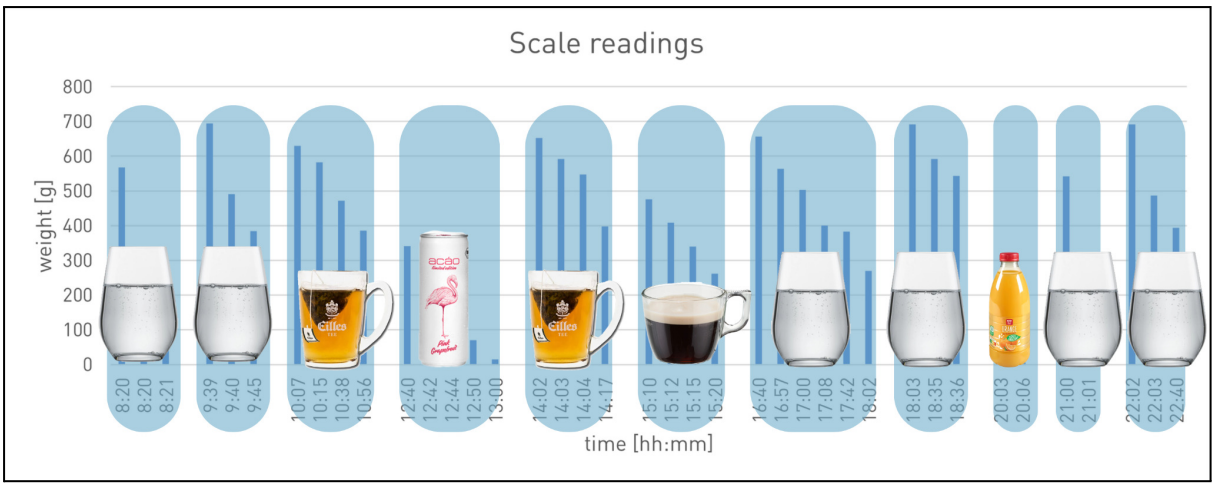


Figure 48: Example fluids grouping overview.

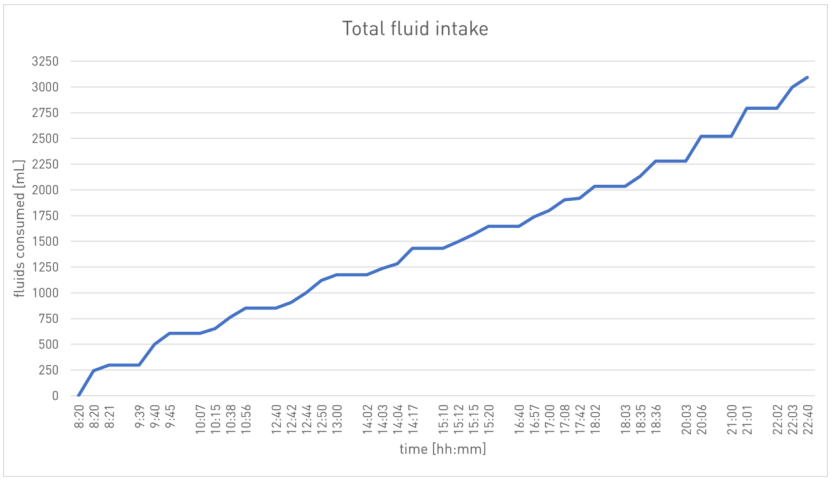


Figure 49: Example fluid consumption calculations.

4.3.2. Conclusions

Single beverage limitation
The product only allows for the monitoring of one beverage at a time. This limitation restricts users who might want to consume multiple drinks simultaneously, such as having a cup of coffee alongside a glass of water.

Sharing constraints
Sharing a beverage with another person leads to incorrect monitoring with the current design. If two individuals were to share a drink, the system would not be able to distinguish individual consumption.

Glass detection issues
The system operates on the assumption that a freshly filled glass will always weigh more than the previous empty one. This assumption can lead to inaccuracies, especially if a user places a lighter beverage container after consuming from a heavier one, like switching from a ceramic mug to a plastic cup.

Beverage adjustments post-placement
The current design doesn't account for changes made to the beverage after it's placed on the coaster. Common actions like removing a tea bag or a spoon can alter the weight, which will lead to unintentional sip detection.

Sensor stabilisation time
The load cell sensor, which is crucial for weight measurement, requires approximately 2 seconds to stabilise. This delay can lead to potential inaccuracies if the beverage is moved or consumed within that short window. It also means that users need to wait for a brief moment before getting an accurate reading, which might not be intuitive for all users.

4.4. Functional prototype II

The second functional prototype was built to closer resemble the desired functionality. While the first functional prototype already incorporated a rough shape similar in dimensions to the final design, the second functional prototype purely focuses on the technical proof of concept.

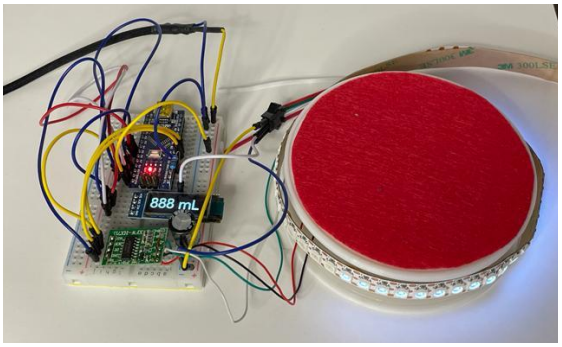


Figure 50: Functional Prototype II.

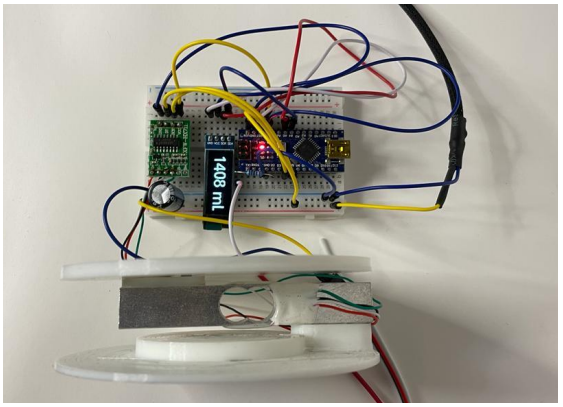


Figure 51: Functional Prototype II side view.

4.4.1. Functionality

Load-cell reading stability
The second prototype is visually representing the stability of the load-cell readings by turning the LEDs blue when the weight is not stable. This means that users can now see when the weight measurement has stabilised and a glass can be put on or removed from the smart coaster.

Calculation of total consumed amount
Beyond just measuring the weight of the beverage, the prototype is now able to calculate the total amount of fluid consumed over a period. This is based on the difference between the initial weight (when the beverage was full) and the current weight, translating it into volume displayed in mL.

Display of total consumed amount

To make the data accessible to the user, the prototype now displays the total consumed amount and not the weight.

Visualisation of progress towards individual goal

The second prototype offers a visual progress bar that displays the user's progress towards meeting their individual hydration target. This not only serves as a reminder but also acts as a motivator, encouraging users to meet or even exceed their daily hydration goals.

4.4.2. Programming

For the second functional prototype the desired functionality of the product was reduced. This is due to the limited possibility when prototyping with an Arduino Nano. Instead of an e-paper display an OLED display was used. E-paper screens require comparatively large processing power leaving no space for the other calculations needed for the system to track and visualise total water consumption. The functional prototype does not incorporate a potentiometer for individual goal setting. This function is directly programmed in the code. Furthermore, the radio time receiver and the date viewer are not incorporated in the functional prototype. When exceeding the daily goal the progress interface will not start filling up again in the colour green as intended, only the LCD display will show the increase in total consumption. The photoresistor is not implemented in the functional prototype. However, the brightness of the LED strip can be set manually in the code. Moreover, the functional prototype is not battery-powered but directly connected to a power source. Thus wireless charging is also not implemented in the functional prototype. These simplifications allow for increased resources in testing the main functionalities of the product.

4.4.2.1. Code breakdown

In the following the most relevant portions of the Arduino code will be explained. Note that some parts of the code were shortened to keep an overview. The full code is provided in the appendix.

```
#include <HX711_ADC.h>
#include <Adafruit_NeoPixel.h>

#if defined(ESP8266) || defined(ESP32) || defined(AVR)
#include <EEPROM.h>
#endif

#include <U8glib.h>    // include the library code
```

The script starts by importing several libraries:

HX711_ADC
This library is for the HX711 module, which is an amplifier for the load cell to measure weight.

Adafruit_NeoPixel
This library is for controlling the LED strip, which is used for the progress visualisation. With this library, every individual LED in the strip can be addressed and the colour and brightness can be changed individually.

EEPROM
The EEPROM library provides an interface to the internal memory of the Arduino Nano. The calibration value of the load cell is stored in this memory.

U8glib
This library is needed to control the monochrome OLED display used in the functional prototype.

```
bool calculationMade = false;

U8GLIB_SSD1306_128X32 u8g(U8G_I2C_OPT_NONE | U8G_I2C_OPT_DEV_0);
```

A global boolean variable “calculationMade” is declared and set to “false”. This variable is used later to determine if the consumed-amount-calculation has already been performed.

The U8glib line is used to specify which display is used: An SSD1306 128x32 OLED display.

```
//pins:
const int HX711_dout = 4;     // MCU > HX711 dout pin
const int HX711_sck = 5;     // MCU > HX711 sck pin
const int LED_PIN = 2;       // Digital pin connected to the LED strip
const int LED_COUNT = 50;    // Number of LEDs in the strip

// HX711 constructor:
HX711_ADC LoadCell(HX711_dout, HX711_sck);

Adafruit_NeoPixel strip(LED_COUNT, LED_PIN, NEO_GRB + NEO_KHZ800);
```

The next section defines a few pin constants and then creates instances of the "HX711_ADC" and "Adafruit_NeoPixel" classes.

The "LoadCell" object is used to communicate with the HX711 load cell module, while the "strip" object is used to control the LED strip.

```
const int calVal_eepromAdress = 0;
unsigned long t = 0;
float previousLoadCellValue = 0.0;
bool isStable = false;
unsigned long lastChangeTime = 0;
const unsigned long stabilityDuration = 500;  // Stability duration in
```

```
milliseconds
bool blinkOnce = false;
int brightness = 1;  // Default brightness (0-255)
```

This section declares some more global variables. They are used for various purposes throughout the script such as timing ("t", "lastChangeTime" and "stabilityDuration"), storing previous load cell values ("previousLoadCellValue"), determining whether the load cell readings are stable ("isStable") and controlling LED brightness ("brightness").

```
// Load Cell Value Table
struct LoadCellValue {
  int index;
  float value;
};
const int MAX_TABLE_SIZE = 100;
LoadCellValue loadCellTable[MAX_TABLE_SIZE];
int tableIndex = 0;

float glassWeight = 0.0;    // Weight of the glass
float sipWeight = 0.0;      // Weight of each sip
float totalConsumed = 0.0;  // Total amount consumed
```

This code declares a "struct" that represents a load cell value, a table (array) of these values with a maximum size, and a "tableIndex" that keeps track of the current end of the table. It also initialises variables for the weight of the glass ("glassWeight"), the weight of each sip ("sipWeight") and the total amount consumed ("totalConsumed"). This part of the code is needed to keep track of fluid consumption.

```
void printLoadCellTable()

bool isValueAroundZero(float value)

void blinkLEDsOnce()

void draw(float totalConsumed)

float calculateConsumedAmount()
```

The rest of the functions ("printLoadCellTable", "isValueAroundZero", "blinkLEDsOnce", "draw", "calculateConsumedAmount") are helper functions that do various tasks like printing the load cell table to the Serial monitor, checking if a value is around zero, making the LEDs blink once, drawing the total consumed to the OLED display and calculating the consumed amount based on the load cell table.

```
void setup() {
```

The "setup" function is a standard Arduino function that is run once at startup. It is used to initialise the LED strip, OLED display, Serial communication, and the load cell. It also retrieves the calibration value for the load cell from the EEPROM and performs a tare operation (setting the 'zero' weight).

```
void loop() {
```

The "loop" function is another standard Arduino function that is run repeatedly after "setup" completes. This function does most of the work in the script. It updates the load cell readings, checks for significant changes in the readings, blinks the LEDs once if the readings have been stable after adding or removing weight, adds the stable reading to the load cell table and calculates and displays the consumed amount. The number of LEDs to illuminate and the colour of the LEDs is determined based on the total amount consumed and whether the readings from the load cell are stable.

4.5. Functional Design prototype

The concept was embodied in a functional design prototype which serves the function of testing the product in its intended environment. The functional prototype is cable-bound and not battery-powered as intended. Moreover, it is not capable of storing values and thus does not allow for long-term tracking. The individual daily goal must be programmed via a wifi connection instead of selecting it on the dial. During initial testing, the E-Paper display broke and was replaced with a small white-on-black LCD screen. Other than that the functional prototype incorporates all desired functions including tracking the water intake, displaying the exact amount drank and visualising the progress on the daily goal.

Figure 52: Functional Design Prototype.

5. Concept Validation

To validate the concept, two different user tests were performed with the functional prototype. A usability test was performed to see the initial reaction of the target group to the product and a one-day test was performed to test the usability of the measuring period the device is intended to.

5.1. Usability test

5.1.1. Research aim and research questions

The primary aim of this usability test was to measure the initial response of elderly users to the smart coaster. The research questions are as follows:

Do users understand the purpose and functionality of the product?

Can users envision integrating the smart coaster into their daily routines?

5.1.2. Method

Participants
Three elderly individuals participated in this study. They were selected based on their willingness to participate and their relevance to the target demographic for the smart coaster. All participants were part of the initial context mapping interviews performed in this thesis and they expressed their willingness to be part of user testing regarding a potential prototype. The demographic details of the participants are as follows:

Gender: All participants were female.
Age: The ages of the participants were 74, 83, and 84.
Location: All participants were from South-West Germany.
Family status: Two participants were widowed and one was single.
Household size: Two participants lived alone and one lived with another person.
Housing type: Two participants lived in houses and one lived in an apartment.

Stimuli & equipment
The primary equipment used for this study was the smart coaster prototype. Additionally, an audio recorder was used to capture the participants' feedback. The participants were asked to provide three identical beverage glasses and a bottle of water for the product demonstration.

Procedure
The study was conducted in the participants' homes to ensure a comfortable and familiar environment.

1. Introduction and explanation

Participants were first introduced to the smart coaster. The goals of the product were

explained, emphasising its role in managing fluid intake, setting daily drinking goals and tracking progress. To explain the individual goal setting, a reference table was shown to participants, indicating the basic water requirement based on age and weight. While other factors like activity levels and temperature were mentioned, participants were informed that they had the freedom to decide on their drinking goals themselves.

2. Product demonstration

The product's functionality was demonstrated to the users. This included simulating a full day of drinking with a demonstration of achieving and overachieving the personal goal.

3. Initial interview

After the demonstration, a semi-structured interview with the following questions was performed:
What do you think this product is used for?
How would you use this product?
What do you like or dislike about this product at first glance?

4. Hands-on experience

Participants were then encouraged to try the prototype themselves. They poured water in a glass, placed it on the coaster, drank a bit, and then placed it back. They were then asked to interpret the feedback from the LED ring and the display.

5. Post-test interview

Following the hands-on experience, participants were asked the following questions:
What did you like about using the coaster?
What didn't you like or find difficult?
How well do you think the coaster fits into your daily routine?
How could the coaster be improved?

Data analysis

The data collected from the audio recordings were transcribed and analysed for common themes, feedback and suggestions related to the smart coaster's usability. Only information relevant to the project was transcribed.

5.1.3. Results

All participants appreciated the simplicity of the smart coaster and understood its functionalities without difficulty. Both the exact amount of display and the LED progress bar were considered valuable by the participants, despite their potential redundancy. Participants felt that the smart coaster could easily become a part of their daily routines. The mere presence of the smart coaster was seen as a potential reminder to drink. The complete transcript can be found in the appendix.

Initial Interview after explaining the product

Purpose of the product:
All three participants identified the smart coaster as a tool to monitor and encourage fluid intake, especially for the elderly. One participant specifically mentioned the device's potential to indicate whether they've reached their daily drinking objective.

Usage:
All participants expressed a proactive approach to using the smart coaster. One participant mentioned turning it on every morning and adjusting their drinking habits based on the previous results. Another participant saw it as a daily tool for measuring and controlling water intake, while the third viewed it as a reminder and information source about their drinking habits.

First impressions:
The simplicity and user-friendliness of the smart coaster with an emphasis on its suitability for the elderly was highlighted by one participant. Another participant appreciated its aesthetic appeal, describing it

as having a pleasant shape, being lightweight and portable. One participant mentioned its straightforward design.

Post-test interview

Positive feedback:
The ease of use was a recurring theme, with one participant highlighting its suitability for elderly users. Another participant was particularly intrigued by the exact amount being displayed, finding it both interesting and exciting. One participant valued the thought support the device offers.

Areas of improvement:
One participant suggested having a manual alongside the device for clarity on its usage. Another expressed concerns about the time it might take for older individuals to adapt and integrate the device into their routine. Sensitivity issues were raised by one participant, emphasising the need for the device to accommodate users with shaky hands.

Integration into their daily routine:
All participants believed that the smart coaster could seamlessly fit into their daily routines. One participant mentioned concerns about the device's functionalities when drinking while not at home. All participants could imagine carrying the device with them if they moved within the house.

Long-term tracking:
One participant compared the long-term tracking function to their blood pressure device, indicating a reluctance to use such features due to perceived complexity. However, all participants were interested in having a potential option for sharing their fluid intake record with a family member or their doctor.

Improvement suggestions:
Suggestions for improvement varied. One participant felt they would have more feedback after prolonged use. Another suggested reducing the device's size but raised concerns about frequent charging. One participant mentioned that the visibility of the LED lights might not be suitable for people with visual impairments due to a lack of contrast in colour and shape.

5.1.4. Discussion

The results from the usability test provide valuable insights into the potential of the smart coaster. The participants appreciated the simplicity and ease of use, which is crucial for the target demographic. The dual feedback mechanism was well-received, with both the exact amount displayed and the LED progress bar being considered valuable. However, there were concerns about the long-term tracking function's complexity and suggestions for improvements, such as reducing the size of the device.

5.1.5. Limitations

The study's primary limitation is the small sample size, which gives a first impression but does not capture the full spectrum of elderly users' opinions. Additionally, the study's short duration did not allow for a comprehensive assessment of the product's integration into daily routines.

5.1.6. Conclusions

The smart coaster shows potential as a tool to aid the elderly in monitoring and managing their fluid intake. While the initial response is positive, further studies with a larger sample size and longer duration are recommended to validate these findings and explore further potential improvements.

5.2. Extended Usability Test

After the initial usability test, the smart coaster prototype was left with the oldest and most critical participant for a one-day period to gather more in-depth insights into its daily use. The participant was instructed to use the coaster as she would in their daily routine and to note down any observations or issues she encountered. A follow-up interview was conducted afterwards to discuss her experiences.

5.2.1. Results

Post one-day-test interview
General experience:
The participant expressed that the smart coaster is ideal for individuals who are interested in information about their fluid intake. While she personally doesn't prioritise tracking their intake, the research made her more conscious of her drinking habits. She appreciated the feedback at the end of the day, which showed that her fluid intake was better than she had expected.

Challenges and difficulties:
The participant lives in a two-story home and felt that constantly moving the product between floors might be inconvenient. She experienced confusion regarding the placement of full and empty glasses on the coaster and struggled to understand the correlation between the coaster's readings and their actual fluid intake. The absence of a detailed written manual was felt, as she had forgotten the instructions provided during the initial test. The display values were hard to read without glasses, suggesting a need for larger font or display enhancements.

Remarks and questions:
Concerns were raised about potential damage if water was spilt on the device, especially given the likelihood of elderly individuals spilling liquids. The participant noticed a bug attracted to the device during the night, possibly due to the heat emitted by the device.

Overall enjoyment:
The participant found the device challenging to use, primarily due to forgetting the initial instructions. Her primary motivation for continued use was to assist in the research study.

Figure 53: Product in different use scenarios (staged).

5.2.2. Discussion

The extended usability test provided insights into the real-world challenges and benefits of the smart coaster. While the participant recognized the benefits of the device, she also highlighted several areas of potential improvement. The most critical statement is the mention of not being willing to carry the product around while moving within the house. This should be addressed in further device versions for example by making transportability more easy by adding a handle.

5.2.3. Limitations

The extended test was conducted with only one participant, limiting the generalizability of the findings. The participant's self-admitted lack of interest in tracking fluid intake might have influenced her overall experience with the product.

5.2.4. Conclusions

The one-day usability test reinforced some of the findings from the initial tests while also uncovering new challenges. Future tests might benefit from a broader range of participants and environments to gather a more comprehensive understanding of the smart coaster's daily use.

6. Conclusion

6.1. Summary of findings

This master's thesis aimed to assist the elderly in maintaining optimal hydration levels to increase their quality of life. Although the elderly are at increased risk of insufficient water intake compared to the general population they are often overlooked in the development of hydration aid products.

The literature review underscored the significance of proper hydration, especially for the elderly population. Challenges faced by the elderly in maintaining adequate hydration, effective strategies and public recommendations were highlighted. Expert interviews further enriched the understanding of the problem.

Context mapping allowed understanding the daily routines and habits of the elderly, and an understanding of their fluid intake behaviours. Analysing the household interactions revealed that the design had to be intuitive, with a focus on clarity, simplicity and immediate feedback.

Usability tests provided valuable insights into the potential of the smart coaster. Participants appreciated its simplicity and ease of use, which aligns with the needs of the target demographic. The dual feedback mechanism, consisting of the exact amount displayed and the LED progress bar was well-received. Despite the positive feedback, concerns were raised about the long-term tracking function's complexity. Suggestions for improvements included reducing the device's size for better portability and ease of use. The extended usability test revealed real-world challenges and advantages. While the participant recognized the device's advantages, the need for better transportability for easier movement within the house was emphasised.

The primary limitation of the study was the small sample size, which provided a preliminary image but did not capture the full spectrum of elderly users' opinions. The short duration of the study also prevented a comprehensive assessment of the product's integration into daily routines.

In summary, the developed product “Daria” opens the door to further exploration, refinement, and innovation. Combining technology and geriatric care will be fundamental to avoid a healthcare system collapse.

6.2. Recommendations for future developments

Adapting to technological shifts
As the elderly demographic becomes more open to technology in the coming decades, a product like “Daria” can evolve into a connected product to provide more precise feedback based on variables like room temperature, climate, and activity level.

Beverage identification
Future versions could use machine learning algorithms to identify the type of drink based on drinking patterns, such as the size and frequency of sips. For instance, tea might be characterised by smaller sips and longer intervals between placing the drink on the coaster and starting to drink again. Such information could be used to provide the user with more detailed feedback on their fluid consumption.

Addressing design flaws
Integrating a pressure sensor matrix in the coaster could be used to distinguish between different cups, addressing the current design

flaw of cup detection based on weight difference.

The robustness of the coster must be tested to ensure it is strong enough to handle the force of a glass being placed violently on it without damaging internal components.

Currently, natural drinking impulses such as taking a sip directly from the tap are neglected by the system. Smart connected systems could track fluid intake with different methods such as AI-camera estimation and only use the coasters' visual feedback mechanisms.

With “Daria”, users have no possibility to undo accidental calculations. Incorporating a reset button to correct unexpected changes in value, especially when switching between beverage containers, would tackle this issue.

User Experience Improvements: Addressing the instinctive drinking impulse is crucial. Users should be able to refill their glass without having to place it back on the coaster immediately. Additionally, a reset button would be beneficial, especially if a mistake is made, like placing a full beverage container that's lighter than the previous empty one.

The functional prototype developed in this research is not optimised for spill protection. Future iterations should include design features that ensure that the product is waterproof.

Expert validation
Collaboration with geriatric care professionals can ensure that the product aligns with medical recommendations and addresses the primary health concerns related to dehydration.

Increase sample size
To identify yet unknown risks and potentials of “Daria” the usability tests should be performed with a larger and more diverse group of participants. Ideally, a representative study would be conducted in which the device is tested for the main objectives: Ensuring adequate hydration and increasing the quality of life.

Expand research
While this study focused on elderly individuals living outside care institutions, future research should explore if interventions like “Daria” could also help the hydration needs of those within such institutions.

6.3. Reflection

The motivation behind this thesis came from real-world observations and personal experiences, particularly those of my grandmother. The support from academic supervisors and participants was key in navigating challenges and refining the research direction.

The literature review highlighted the importance of hydration in the elderly and the complexity of the topic. While the literature offered a theoretical base, the data derived from interviews, iterative prototyping, and user testing provided critical insights into the practical aspects of the problem. These hands-on methodologies were essential in developing, validating and refining the product's design. With a larger focus on the practical aspects earlier in the research timeline, the product could have been developed to a more progressed state.

Interacting with my target group, understanding their daily struggles, and then translating those insights into a tangible product was a rewarding experience. It highlighted the importance of empathy-driven solutions that can make a tangible difference in people's lives.

With “Daria”, I developed a product that can support elderly people in their drinking habits. Although initial usability testing revealed the product's potential, more evidence is required to further test the impact of the design.


Daria
hydration by intuition

7. Resources

7.1. References

Allen, V. M., Methven, L., & Gosney, M. (2014). Impact of serving method on the consumption of nutritional supplement drinks: randomized trial in older adults with cognitive impairment. Journal of Advanced Nursing, 70(6), 1323–1333. https://doi.org/10.1111/jan.12293

Anjo, I., Amaral, T., Afonso, C. a. M., Borges, N., Santos, A., Moreira, P., & Padrão, P. (2020). Are hypohydrated older adults at increased risk of exhaustion? Journal of Human Nutrition and Dietetics. https://doi.org/10.1111/jhn.12702

Armstrong-Esther, C. A., Browne, K. D., Armstrong-Esther, D., & Sander, L. M. (1996). The institutionalized elderly: dry to the bone! International Journal of Nursing Studies, 33(6), 619–628. https://doi.org/10.1016/s0020-7489(96)00023-5

Bak, A., Wilson, J., Tsiami, A., & Loveday, H. (2018). Drinking vessel preferences in older nursing home residents: optimal design and potential for increasing fluid intake. British Journal of Nursing, 27(22), 1298–1304. https://doi.org/10.12968/bjon.2018.27.22.1298

Bennett, J. A., Thomas, V., & Riegel, B. (2004). UNRECOGNIZED Chronic Dehydration in Older Adults: Examining Prevalence Rate and Risk Factors. Journal of Gerontological Nursing, 30(11), 22–28. https://doi.org/10.3928/0098-9134-20041101-09

Bruno, C., Collier, A., Holyday, M., & Lambert, K. (2021). Interventions to Improve Hydration in Older Adults: A Systematic Review and Meta-Analysis. Nutrients, 13(10), 3640. https://doi.org/10.3390/nu13103640

DGE, ÖGE, & SGE. (2021). Referenzwerte für die Nährstoffzufuhr (2. Auflage, 7. aktualisierte Ausgabe). Deutsche Gesellschaft für Ernährung (DGE), Österreichische Gesellschaft für Ernährung (ÖGE), Schweizerische Gesellschaft für Ernährung (SGE).

Dunne, T. E., Neargarder, S., Cipolloni, P., & Cronin-Golomb, A. (2004). Visual contrast enhances food and liquid intake in advanced Alzheimer's disease. Clinical Nutrition, 23(4), 533–538. https://doi.org/10.1016/j.clnu.2003.09.015

EFSA. (2010). Scientific Opinion on Dietary Reference Values for water. EFSA Journal, 8(3). https://doi.org/10.2903/j.efsa.2010.1459

Ferry, M., Sidobre, B., Lambertin, A., & Barberger-Gateau, P. (2005). The SOLINUT study: analysis of the interaction between nutrition and loneliness in persons aged over 70 years. PubMed, 9(4), 261–268. https://pubmed.ncbi.nlm.nih.gov/15980927

Ferry, M. (2005). Strategies for Ensuring Good Hydration in the Elderly. Nutrition Reviews, 63, S22–S29. https://doi.org/10.1111/j.1753-4887.2005.tb00151.x

Frühwald, U. (2009). PflegeFakten: Entscheidungshilfen, Übersichten, Normwerte. Elsevier,Urban&FischerVerlag.

Grandjean, A. C., Reimers, K., & Buyckx, M. E. (2003). Hydration: Issues for the 21st Century. Nutrition Reviews, 61(8), 261–271. https://doi.org/10.1301/nr.2003.aug.261-271

Grünen, R. E., Günzkofer, F., & Bubb, H. (2015). Anatomische und anthropometrische Eigenschaften des Fahrers. In Springer eBooks (pp. 163–219). https://doi.org/10.1007/978-3-8348-2297-0_4

Guéguen, N. (2003). The Effect of Glass Colour on the Evaluation of a Beverage's Thirst-Quenching Quality. Current Psychology Letters, 11, Vol. 2, 2003. https://doi.org/10.4000/cpl.398

Guignard, A., & Hemlia, M. (n.d.). Connected Papers. Connected Papers – ETH Library | ETH Zurich. https://library.ethz.ch/en/locations-and-media/media-types/databases-standards-patents/connected-papers.html

Herold, G. (2021). Innere Medizin: eine vorlesungsorientierte Darstellung.

Herrmann, S. H. (2016). Die 10 liebsten Mineralwassermarken der Deutschen. W&V. https://www.wuv.de/Archiv/Die-10-liebsten-Mineralwassermarken-der-Deutschen

Hodgkinson, B., Evans, D. M., & Wood, J. K. (2003). Maintaining oral hydration in older adults: A systematic review. International Journal of Nursing Practice, 9(3), S19–S28. https://doi.org/10.1046/j.1440-172x.2003.00425.x

Holzapfel, S. K., Ramirez, R. F., Layton, M. S., Smith, I. W., Sagl-Massey, K., & DuBose, J. Z. (1996). FEEDER POSITION AND FOOD AND FLUID: Consumed by Nursing Home Residents. Journal of Gerontological Nursing, 22(4), 6–9. https://doi.org/10.3928/0098-9134-19960401-04

Hooper, L., Abdelhamid, A., Attreed, N. J., Campbell, W. W., Channell, A. M., Chassagne, P., Culp, K., Fletcher, S. P., Fortes, M. B., Fuller, N., Gaspar, P., Gilbert, D., Heathcote, A. J., Kafri, M. W., Kajii, F., Lindner, G., Mack, G. W., Mentes, J. C., Merlani, P., . . . Hunter, P. R. (2015). Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people. The Cochrane Library. https://doi.org/10.1002/14651858.cd009647.pub2

Hsu, L., Yang, J., Wen, X., Liang, X., Lin, L., Huang, Y., & Tsai, Y. (2022). Human thirst behavior requires transformation of sensory inputs by intrinsic brain networks. BMC Biology, 20(1). https://doi.org/10.1186/s12915-022-01446-5

Institute of Medicine. 2005. Dietary Reference Intakes for Water, Potassium, Sodium, Chloride, and Sulfate. Washington, DC: The National Academies Press. https://doi.org/10.17226/10925.

Jéquier, E., & Constant, F. (2010). Water as an essential nutrient: the physiological basis of hydration. European Journal of Clinical Nutrition. https://doi.org/10.1038/ejcn.2009.111

Kenefick, R. W. (2018). Drinking Strategies: Planned Drinking Versus Drinking to Thirst. Sports Medicine, 48(S1), 31–37. https://doi.org/10.1007/s40279-017-0844-6

Kenney, W. L., & Chiu, P. (2001). Influence of age on thirst and fluid intake. Medicine and Science in Sports and Exercise, 33(9), 1524–1532. https://doi.org/10.1097/00005768-200109000-00016

Kraal, J.J. (n.d.). TU Delft. https://www.tudelft.nl/io/over-io/personen/kraal-jj

Laube, S.-. S. (n.d.). Hausärzte in Giesing, Hausarzt in Giesing - Team. https://www.praxisteam-giesing.de/team

Leib, D. A., Zimmerman, C. M., & Knight, Z. A. (2016). Thirst. Current Biology, 26(24), R1260–R1265. https://doi.org/10.1016/j.cub.2016.11.019

Lin, S. (2013). A Pilot Study. Nursing Research, 62(1), 66–72. https://doi.org/10.1097/nnr.0b013e31826901d5

Löwik, M. R. H., Westenbrink, S., Hulshof, K., Kistemaker, C., & Hermus, R. (1989). Nutrition and aging: dietary intake of “apparently healthy” elderly (Dutch Nutrition Surveillance System). Journal of the American College of Nutrition, 8(4), 347–356. https://doi.org/10.1080/07315724.1989.10720310

Mack GW, Stachenfeld NS, Di Pietro L (1998). Altered osmotic volume control of thirst with aging. In: MJ Arnaud, ed. Hydration throughout Life. Paris: Libbey Eurotext, 127–136.

Maughan, R. J., & Griffin, J. D. (2003). Caffeine ingestion and fluid balance: a review. Journal of Human Nutrition and Dietetics, 16(6), 411–420. https://doi.org/10.1046/j.1365-277x.2003.00477.x

Mentes, J. C., & Culp, K. (2003). Reducing Hydration-Linked Events in Nursing Home Residents. Clinical Nursing Research, 12(3), 210–225. https://doi.org/10.1177/1054773803252996

Nela, L., Tang, J., Cao, Q., Tulevski, G. S., & Han, S. (2018). Large-Area High-Performance Flexible Pressure Sensor with Carbon Nanotube Active Matrix for Electronic Skin. Nano Letters, 18(3), 2054–2059. https://doi.org/10.1021/acs.nanolett.8b00063

Nordic Council Of Ministers. (2012). Nordic Nutrition Recommendations 2012 (Vol. 5). https://doi.org/10.6027/nord2014-002

Oppliger, R. A., Magnes, S. A., Popowski, L. A., & Gisolfi, C. V. (2005). Accuracy of Urine Specific Gravity and Osmolality as Indicators of Hydration Status. International Journal of Sport Nutrition and Exercise Metabolism, 15(3), 236–251. https://doi.org/10.1123/ijsnem.15.3.236

Pereira, P. (2014). Milk nutritional composition and its role in human health. Nutrition, 30(6), 619–627. https://doi.org/10.1016/j.nut.2013.10.011

Phillips, P. A., Rolls, B. J., Ledingham, J. A., Forsling, M. L., Morton, J. P., Crowe, M., & Wollner, L. (1984). Reduced Thirst after Water Deprivation in Healthy Elderly Men. The New England Journal of Medicine, 311(12), 753–759. https://doi.org/10.1056/nejm198409203111202

Pross, N., Demazières, A., Girard, N., Barnouin, R., Metzger, D., Klein, A., Perrier, E. T., & Guelinckx, I. (2014). Effects of Changes in Water Intake on Mood of High and Low Drinkers. PLOS ONE, 9(4), e94754. https://doi.org/10.1371/journal.pone.0094754

Ramsay, D. J., & Booth, D. (2012). Thirst: Physiological and Psychological Aspects. Springer Science & Business Media.

Roberts, K. J. (1963). Mechanism of dehydration following alcohol ingestion. Archives of Internal Medicine, 112(2), 154. https://doi.org/10.1001/archinte.1963.03860020052002

Robinson, S., & Rosher, R. B. (2002). Can a beverage cart help improve hydration? Geriatric Nursing, 23(4), 208–211. https://doi.org/10.1067/mgn.2002.126967

Sanders, E. B., & Stappers, P. J. (2013). Convivial Toolbox: Generative Research for the Front End of Design. https://openlibrary.org/books/OL28484092M/Convivial_Toolbox

Schmidt, R. (1980). Durst und Hunger: Allgemeinempfindungen. In Heidelberger Taschenbücher (pp. 285–304). Springer Science+Business Media. https://doi.org/10.1007/978-3-662-07609-5_9

Schnelle, J. F., Leung, F. W., Rao, S. S., Beuscher, L., Keeler, E. B., Clift, J., & Simmons, S. F. (2010). A Controlled Trial of an Intervention to Improve Urinary and Fecal Incontinence and Constipation. Journal of the American Geriatrics Society, 58(8), 1504–1511. https://doi.org/10.1111/j.1532-5415.2010.02978.x

Senay, L. C., & Kok, R. (1976). Body fluid responses of heat-tolerant and intolerant men to work in a hot wet environment. Journal of Applied Physiology, 40(1), 55–59. https://doi.org/10.1152/jappl.1976.40.1.55

Shimizu, M., Kinoshita, K., Hattori, K., Ota, Y., Kanai, T., Kobayashi, H., & Tokuda, Y. (2012). Physical Signs of Dehydration in the Elderly. Internal Medicine, 51(10), 1207–1210. https://doi.org/10.2169/internalmedicine.51.7056

Simmons, S. F., Alessi, C. A., & Schnelle, J. F. (2001). An Intervention to Increase Fluid Intake in Nursing Home Residents: Prompting and Preference Compliance. Journal of the American Geriatrics Society, 49(7), 926–933. https://doi.org/10.1046/j.1532-5415.2001.49183.x

Smith, M. A., Velasco, R., John, S., Kaufman, R. S., & Melzer, E. (2019). An Innovative Approach to Adequate Oral Hydration in an Inpatient Geriatric Psychiatry Unit. Journal of Psychosocial Nursing and Mental Health Services, 57(4), 15–20. https://doi.org/10.3928/02793695-20190124-03

Spangler, P. F., Risley, T. R., & Bilyew, D. D. (1984). The management of dehydration and incontinence in nonambulatory geriatric patients. Journal of Applied Behavior Analysis, 17(3), 397–401. https://doi.org/10.1901/jaba.1984.17-397

Statistisches Bundesamt (2021): https://bit.ly/3XOqnKN

Stookey, J. D., Pieper, C. F., & Cohen, H. J. (2005). Is the prevalence of dehydration among community-dwelling older adults really low? Informing current debate over the fluid recommendation for adults aged 70+years. Public Health Nutrition, 8(8), 1275–1285. https://doi.org/10.1079/phn2005829

Tanaka, Y., Nagata, K., Tanaka, T., Kuwano, K., Endo, H., Otani, T., Nakazawa, M., & Koyama, H. (2009). Can an individualized and comprehensive care strategy improve urinary incontinence (UI) among nursing home residents? Archives of Gerontology and Geriatrics, 49(2), 278–283. https://doi.org/10.1016/j.archger.2008.10.006

Thomas, D., Cote, T., Lawhorne, L. W., Levenson, S. A., Rubenstein, L. Z., Smith, D., Stefanacci, R. G., Tangalos, E. G., & Morley, J. E. (2008). Understanding Clinical Dehydration and Its Treatment. Journal of the American Medical Directors Association, 9(5), 292–301. https://doi.org/10.1016/j.jamda.2008.03.006

Thomas, D., Tariq, S. H., Makhdomm, S., Haddad, R. J., & Moinuddin, A. (2004). Physician Misdiagnosis of Dehydration in Older Adults. Journal of the American Medical Directors Association. https://doi.org/10.1016/s1525-8610(04)70088-2

VuMA. (18. November, 2020). Beliebteste Mineralwasser- und Tafelwassermarken (Konsum in den letzten 4 Wochen) in Deutschland in den Jahren 2017 bis 2020 [Graph]. In Statista. Zugriff am 04. Juni 2023, von https://de-statista-com.tudelft.idm.oclc.org/statistik/daten/studie/171516/umfrage/konsum-mineralwassermarken-im-letzten-monat/

Wilson, J., Bak, A., Tingle, A., Greene, C., Tsiami, A., Canning, D., Myron, R., & Loveday, H. (2019). Improving hydration of care home residents by increasing choice and opportunity to drink: A quality improvement study. Clinical Nutrition, 38(4), 1820–1827. https://doi.org/10.1016/j.clnu.2018.07.020

Wotton, K., Crannitch, K., & Munt, R. (2008). Prevalence, risk factors and strategies to prevent dehydration in older adults. Contemporary Nurse, 31(1), 44–56. https://doi.org/10.5172/conu.673.31.1.44

7.2. Image directory

Seiler, Y. (2020, April 13). Adelholzener Alpenquellen mit neuer Kampagne. Seiler's Werbeblog. https://www.seilers-werbeblog.ch/adelholzener-alpenquellen-mit-neuer-kampagne/

Gerolsteiner Brunnen: Frische Marken-Identity. (2020, August 10). https://www.food-service.de/. https://www.food-service.de/industrie/industrie/gerolsteiner-brunnen-frischer-relaunch-der-marken-identity-45909

Volvic (2020). Adelholzener Alpenquellen mit neuer Kampagne. Seiler's Werbeblog. https://twitter.com/VolvicDE/status/1321425990829170692/photo/1

Kialka, D. K. (2022). Digital Branding für Ihre Website | MASSIVE ART. MASSIVE ART WebServices GmbH. https://www.massiveart.com/blog/branding-und-webdesign

Radio time receiver
https://ae04.alicdn.com/kf/S4417fca5d96841d9824da8ef04bfe7aee.jpeg

E-Paper Display
https://sc04.alicdn.com/kf/H396d101bc4324b87a5ef5674fc2f4825W/226438846/H396d101bc4324b87a5ef5674fc2f4825W.jpg

LED strip
https://sc04.alicdn.com/kf/H7132bfedef5844e2b022d6d8aea0ee28u/201565132/H7132bfedef5844e2b022d6d8aea0ee28u.jpg

Push button
https://sc02.alicdn.com/kf/HTB1hYOuXcTxK1Rjy0Fg761ovpXaa/231884820/HTB1hYOuXcTxK1Rjy0Fg761ovpXaa.png

Potentiometer
https://sc01.alicdn.com/kf/Ud72bd1afa1664c9dba2697d62611b071i.png

Photoresistor
https://www.alibaba.com/product-detail/Cheapest-price-photoresistor-switch-cds-Light_1600139584068.html?spm=a2700.galleryofferlist.normal_offer.3.18dc5b02RjlPMq&s=p

Custom PCB
https://www.alibaba.com/product-detail/China-Shenzhen-Popular-Custom-OEM-Electronic_1600341201901.html?spm=a2700.galleryofferlist.normal_offer.d_title.568dc8052XIxot

Load Cell
https://www.alibaba.com/product-detail/SC616C-electronic-scale-weight-sensor-load_60359336825.html?spm=a2700.galleryofferlist.normal_offer.d_title.424e30bbYeUofj

Wireless charging
https://www.alibaba.com/product-detail/KR29-5-0-5mm-RX-End_62482887108.html?spm=a2700.galleryofferlist.normal_offer.d_image.63ee67c1DSbOOA

Power adapter
https://www.alibaba.com/product-detail/Eu-Us-Plug-Usb-Type-C_1600435792989.html?spm=a2700.galleryofferlist.normal_offer.d_title.395431173S1Io4

Felt fabric

https://www.alibaba.com/product-detail/Customized-1mm-2mm-3mm-Felt-Fabric_1600349389939.html?spm=a2700.galleryofferlist.normal_offer.d_title.5bc6109duJl7X5

Battery
https://www.alibaba.com/product-detail/3-7v-103450-1800mah-Rechargeable-Lipo_1600193297842.html?spm=a2700.galleryofferlist.normal_offer.d_title.4fa16bcavhZTHz

Wireless charger
https://www.alibaba.com/product-detail/trending-2020-The-Best-Qi-Wireless_62524944451.html?spm=a2700.galleryofferlist.normal_offer.d_title.2eee1dc2PJ2INH

8. Appendices

8.1. Original Project Brief

DESIGN FOR our future

TU Delft

IDE Master Graduation

Project team, Procedural checks and personal Project brief

This document contains the agreements made between student and supervisory team about the student's IDE Master Graduation Project. This document can also include the involvement of an external organisation, however, it does not cover any legal employment relationship that the student and the client (might) agree upon. Next to that, this document facilitates the required procedural checks. In this document:

- The student defines the team, what he/she is going to do/deliver and how that will come about.
- SSC E&SA (Shared Service Center, Education & Student Affairs) reports on the student's registration and study progress.
- IDE's Board of Examiners confirms if the student is allowed to start the Graduation Project.

USE ADOBE ACROBAT READER TO OPEN, EDIT AND SAVE THIS DOCUMENT
Download again and reopen in case you tried other software, such as Preview (Mac) or a webbrowser.

STUDENT DATA & MASTER PROGRAMME

Save this form according the format "IDE Master Graduation Project Brief_familyname_firstname_studentnumber_dd-mm-yyyy".
Complete all blue parts of the form and include the approved Project Brief in your Graduation Report as Appendix 1 !

family name: Strobel
initials: TS given name: Tobias
student number: 5556961
street & no.:
zipcode & city:
country:
phone:
email:

Your master programme (only select the options that apply to you):

IDE master(s): ★ IPD ○ DfI ○ SPD
2nd non-IDE master:
individual programme: - - (give date of approval)
honours programme: ○ Honours Programme Master
specialisation / annotation: ★ Medisign
○ Tech. in Sustainable Design
○ Entrepeneurship

SUPERVISORY TEAM **

Fill in the required data for the supervisory team members. Please check the instructions on the right !

** chair: Dr. Ozcan Vieira dept. / section: HCD / DA
** mentor: Dr. ir. Sonneveld dept. / section: HCD / AED
2nd mentor:
organisation:
city: country:

comments (optional)

Chair should request the IDE Board of Examiners for approval of a non-IDE mentor, including a motivation letter and c.v..

Second mentor only applies in case the assignment is hosted by an external organisation.

Ensure a heterogeneous team. In case you wish to include two team members from the same section, please explain why.

APPROVAL PROJECT BRIEF

To be filled in by the chair of the supervisory team.

chair Dr. Ozcan Vieira date 27 - 02 - 2023 signature [redacted]

CHECK STUDY PROGRESS

To be filled in by the SSC E&SA (Shared Service Center, Education & Student Affairs), after approval of the project brief by the Chair.
The study progress will be checked for a 2nd time just before the green light meeting.

Master electives no. of EC accumulated in total: 30 EC

Of which, taking the conditional requirements into account, can be part of the exam programme 30 EC

List of electives obtained before the third semester without approval of the BoE

★ YES all 1st year master courses passed

NO missing 1st year master courses are:

name Robin den Braber date 28 - 02 - 2023 signature [redacted]

FORMAL APPROVAL GRADUATION PROJECT

To be filled in by the Board of Examiners of IDE TU Delft. Please check the supervisory team and study the parts of the brief marked **.
Next, please assess, (dis)approve and sign this Project Brief, by using the criteria below.

- Does the project fit within the (MSc)-programme of the student (taking into account, if described, the activities done next to the obligatory MSc specific courses)?
- Is the level of the project challenging enough for a MSc IDE graduating student?
- Is the project expected to be doable within 100 working days/20 weeks ?
- Does the composition of the supervisory team comply with the regulations and fit the assignment ?

Content: ★ APPROVED NOT APPROVED

Procedure: ★ APPROVED NOT APPROVED

- also approved for Medisign

comments

name Monique von Morgen date 06 - 03 - 2022 signature [redacted]

Initials & Name TS Strobel 6272 Student number 5556961

Title of Project Improving the quality of geriatric life by managing water intake.

Improving the quality of geriatric life by managing water intake. project title

Please state the title of your graduation project (above) and the start date and end date (below). Keep the title compact and simple. Do not use abbreviations. The remainder of this document allows you to define and clarify your graduation project.

start date 13 - 02 - 2023 14 - 07 - 2023 end date

INTRODUCTION **

Please describe, the context of your project, and address the main stakeholders (interests) within this context in a concise yet complete manner. Who are involved, what do they value and how do they currently operate within the given context? What are the main opportunities and limitations you are currently aware of (cultural- and social norms, resources (time, money,...), technology, ...).

Insufficient water intake can lead to medical discomfort and eventually to dehydration. Dehydration is a severe medical condition that more than doubles the risk of dying for elderly people while being hospitalized (Shimizu et al., 2012). Current statistics show an increasing gap between people needing care and the number of caregivers resulting in staff shortages that will further worsen in the coming decades (Statistisches Bundesamt, 2021). In the near future, the waiting time for care will increase excessively and healthcare worker burnout will become widespread. Therefore, solutions must be developed to counteract a severe healthcare system crisis. Specifically, interventions should be proposed which promote independent ageing to reduce the pressure on primary and secondary care. Previous research shows that water intake is decreasing with age as depicted in figure 1 (Institute of Medicine, 2005). While younger people have a wide range of drinking aids available, the elderly are not targeted by these products or don't have access to them. To give some examples there are smartphone apps to track and motivate water intake, innovative water bottles and IOT products to track hydration. These products are marketed within a healthy sporty lifestyle category aiming at high-paced generations.
The main stakeholder in this project will be elderly people. For this context, the definition of the elderly by Orimo et al. is used, which describes this group as people above 65 years old (2006). Specifically, the target group will consist of elderly people who do not live in a care institution - neither medical nor geriatric care. The demographic change will eventually lead to a lack of care personnel.
In the following an overview of the potential stakeholders will be listed:

Elderly: People aged 65 and older living on their own or with their family but without full-time care personnel. From initial literature research, it became noticeable that elderly people have currently little water intake awareness.

Informal caregivers: People that have close contact with elderly people with insufficient water intake might be aware of their situation. Therefore, they might be able to influence their behaviour and are thus considered in this graduation project.

Formal caregivers: An important stakeholder in this project could be doctors as they have the resources to diagnose insufficient water intake and may be able to introduce interventive measures to their geriatric patients.

Institutions of impact: Some institutions affect public knowledge and behaviour by releasing information and recommendations about drinking. Namely, the "German Nutrition Society" (DGE), health insurance companies and the World Health Organisation are providing recommendations. These recommendations are distributed by institutions such as the german "Consumer advice centre" (Verbraucherzentrale) or news institutions such as the german "Pharmacies review" (Apotheken Umschau).

1. Institute of Medicine (2005). Dietary Reference Intakes for Water, Potassium, Sodium, Chloride, and Sulfate. Amsterdam University Press. https://doi.org/10.17226/10925
2. Orimo, H., Ito, H., Suzuki, T., Araki, A., Hosoi, T. & Sawabe, M. (2006). Reviewing the definition of „elderly". Geriatrics and Gerontology International, 6(3), 149–158. https://doi.org/10.1111/j.1447-0594.2006.00341.x
3. Shimizu, M., Kinoshita, K., Hattori, K., Ota, Y., Kanai, T., Kobayashi, H. & Tokuda, Y. (2012). Physical Signs of Dehydration in the Elderly. Internal Medicine, 51(10), 1207–1210. https://doi.org/10.2169/internalmedicine.51.7056
4. Statistisches Bundesamt (2021): https://bit.ly/3XOqnKN

space available for images / figures on next page

Initials & Name TS Strobel 6272 Student number 5556961

Title of Project Improving the quality of geriatric life by managing water intake.

introduction (continued): space for images

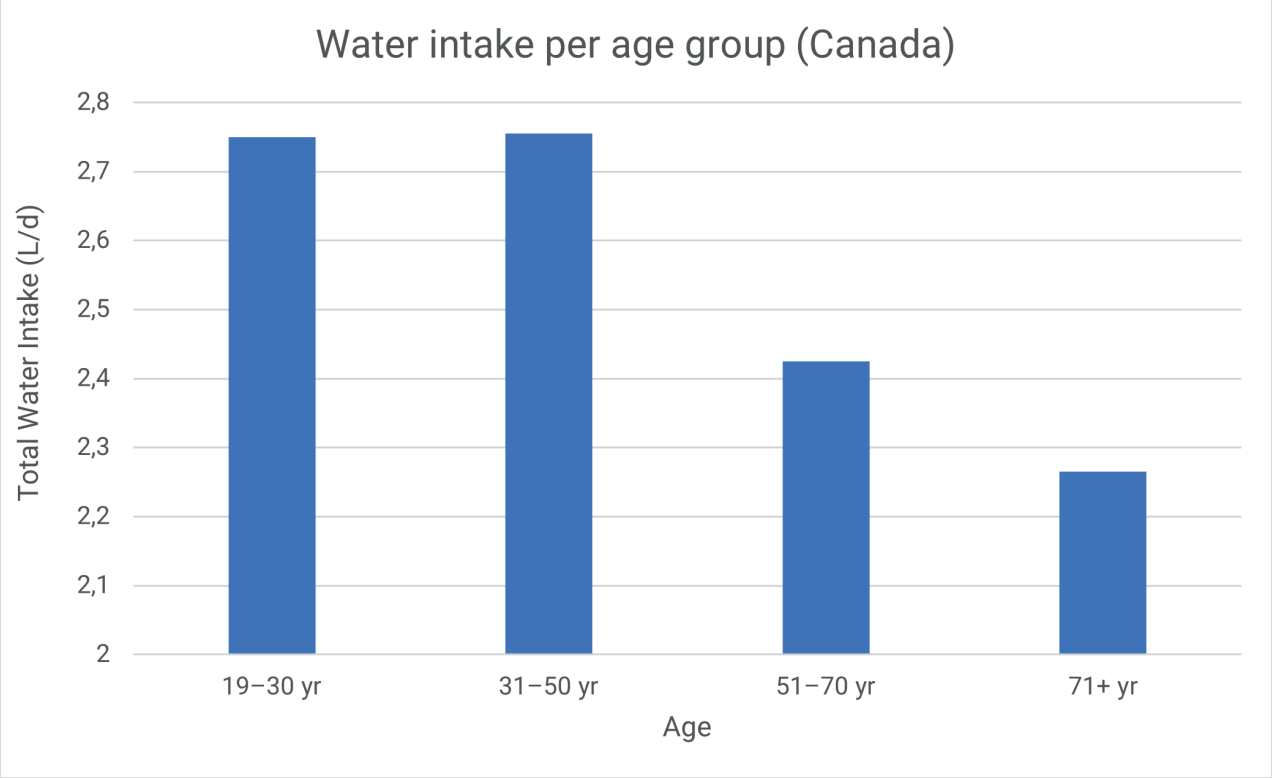


image / figure 1: Water intake in Canadians male and female combined. Data source: Institute of Medicine (2005)

TO PLACE YOUR IMAGE IN THIS AREA:

- **SAVE THIS DOCUMENT TO YOUR COMPUTER AND OPEN IT IN ADOBE READER**
- **CLICK AREA TO PLACE IMAGE / FIGURE**

PLEASE NOTE:

- **IMAGE WILL SCALE TO FIT AUTOMATICALLY**
- **NATIVE IMAGE RATIO IS 16:10**
- **IF YOU EXPERIENCE PROBLEMS IN UPLOADING, COVERT IMAGE TO PDF AND TRY AGAIN**

image / figure 2:

Initials & Name TS Strobel 6272 Student number 5556961

Title of Project Improving the quality of geriatric life by managing water intake.

PROBLEM DEFINITION **

Limit and define the scope and solution space of your project to one that is manageable within one Master Graduation Project of 30 EC (= 20 full time weeks or 100 working days) and clearly indicate what issue(s) should be addressed in this project.

Several main causes lead to dehydration in elderly people. Most of these are driven by a natural change in physiology during the ageing process. Other causes are acute medical issues that either directly lead to dehydration or require the patients to take dehydrating drugs. Disregarding the cause, increasing water intake can primarily counteract dehydration. Because of that the main issue being addressed in this work will be insufficient water intake. For this, methods of tracking water intake, monitoring hydration and changing behaviour will be explored.

As mentioned in the introduction current solutions are focusing on a young and active target group. These products create barriers towards the elderly by using trends and technology as their unique selling point.

While concentrating on improving the physical well-being of the target group mental well-being should not be neglected. Reduced water consumption can be subject to shaming by others such as family members. Both aspects will be included in the project scope.

What also will be investigated are recommendations regarding water consumption, by institutions but also cultural developments and perceived common knowledge about drinking. The cultural study will cover what role water bears in human life. To see the whole picture the history of drinking habits and drinking recommendations will be looked into as well such as how health beliefs regarding drinking have evolved.

Excluded from the project scope are actions that are not in the impact sphere of elderly people. This could be for example a solution that would require medical personnel to check on the users.

ASSIGNMENT **

State in 2 or 3 sentences what you are going to research, design, create and / or generate, that will solve (part of) the issue(s) pointed out in "problem definition". Then illustrate this assignment by indicating what kind of solution you expect and / or aim to deliver, for instance: a product, a product-service combination, a strategy illustrated through product or product-service combination ideas, ... In case of a Specialisation and/or Annotation, make sure the assignment reflects this/these.

Mapping the current context of elderly people and their drinking habits.
Identification of possible problem areas to tackle to induce behaviour change.

Developing a product-based intervention aimed at preventing insufficient water intake.

The expected outcome of this work is a product that supports elderly people in reaching their required water intake. Intentionally the outcome is left open as this will be determined by the synthesis of information that is yet to be gathered and researched.

A likely solution could be implementing an intervention that is interweaving behavioural theories to enhance drinking motivation. This could, for example, mean increasing self-efficacy by creating a social connection with relatives regarding drinking or introducing a non-intrusive uncomplicated method of self-monitoring to induce behaviour change.

The intervention aims at increasing the quality of life for geriatric persons by preventing health incidents and by promoting independent ageing.

Initials & Name TS Strobel 6272 Student number 5556961

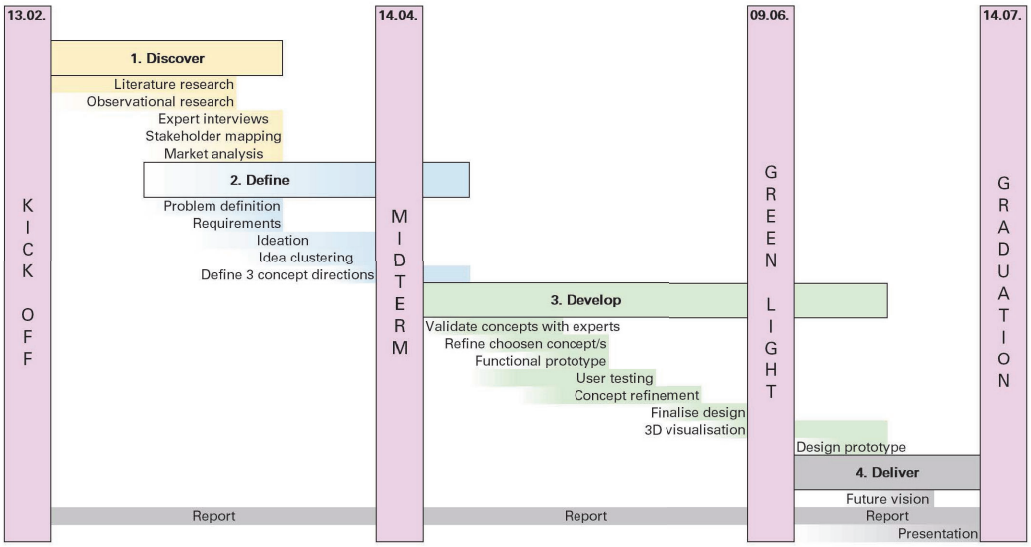
Title of Project Improving the quality of geriatric life by managing water intake.

PLANNING AND APPROACH **

Include a Gantt Chart (replace the example below - more examples can be found in Manual 2) that shows the different phases of your project, deliverables you have in mind, meetings, and how you plan to spend your time. Please note that all activities should fit within the given net time of 30 EC = 20 full time weeks or 100 working days, and your planning should include a kick-off meeting, mid-term meeting, green light meeting and graduation ceremony. Illustrate your Gantt Chart by, for instance, explaining your approach, and please indicate periods of part-time activities and/or periods of not spending time on your graduation project, if any, for instance because of holidays or parallel activities.

start date 13 - 2 - 2023 14 - 7 - 2023 end date

Month	February		March					April				May				June					July	
Dates	13.-17.02.	20.-24.02.	27.02.-03.03.	06.-10.03.	13.-17.03.	20.-24.03.	27.-31.03.	03.-07.04.	10.-14.04.	17.-21.04.	24.-28.04.	01.-05.05.	08.-12.05.	15.-19.05.	22.-26.05.	29.05.-02.06	05.-09.06.	12.-16.06.	19.-23.06.	26.-30.06.	03.-07.07.	10.-14.07.
Working days (100 in total)	5	4	5	5	5	4	5	4	4	5	4	4	5	4	5	4	5	5	4	5	4	5
Public holidays								07.04.	10.04.		27.04.	05.05.		18.05.		29.05.						
Days off		24.02.				23.03.													23.06.		04.07.	
Project week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Calendar week	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28



During this graduation project, the topic of insufficient water intake in elderly people will be explored. Based on this research product-based interventions will be developed and tested with users and experts.

My project planning is using the framework of the double diamond. The concept design phase is represented by the "discover" and "define" segment. Besides a literature study and expert interviews, observational research within the living situation of elderly people will be performed. A market analysis will give insights into the current solution space. The insights gathered will lead to a precise problem definition and the formulation of requirements. This will enable the creation of three different concept directions.

The embodiment of the design is represented in the "develop" and "deliver" section. To be able to develop quick prototypes an interactive design process will be applied. For this, two main cycles of iterations will be performed. However, within these main cycles, an indefinite amount of sub-iterations in an experimental setting can occur. This enables continuous testing and a hands-on product development process. Concepts are tested and validated with users and experts, then refined and retested.

A design prototype and recommendations for future work and research will wrap up the project.

Initials & Name TS Strobel 6272 Student number 5556961

Title of Project Improving the quality of geriatric life by managing water intake.

MOTIVATION AND PERSONAL AMBITIONS

Explain why you set up this project, what competences you want to prove and learn. For example: acquired competences from your MSc programme, the elective semester, extra-curricular activities (etc.) and point out the competences you have yet developed. Optionally, describe which personal learning ambitions you explicitly want to address in this project, on top of the learning objectives of the Graduation Project, such as: in depth knowledge a on specific subject, broadening your competences or experimenting with a specific tool and/or methodology, ... Stick to no more than five ambitions.

Initially, the idea for this graduation project was inspired by conversations and experiences with my grandmother. For several reasons, her water intake is lacking. After long conversations with her, it became evident that the cause of not drinking enough is not easy to grasp. This made me excited to learn more about that subject and eventually led me to frame the topic as my graduation project.

In my thesis, I want to apply knowledge acquainted during my bachelor's and master's studies. My master's helped me especially to increase scientific argumentation of design decisions which was lacking in my bachelor's programme. This will help me base the project outcome on a solid foundation of research and prior literature knowledge and not on assumptions with the risk of them being false. For example, I want to apply behavioural theories from the medisign elective "Health psychology: Tools and methods" which coincidently appears to fit my chosen project very well.

Having a background in pharmaceutical research I have a natural interest in life sciences and I want to discover the physiological aspects of ageing related to thirst perception and dehydration and find ways to intervene with my acquired designer skills.

I am motivated to create a novel solution for the designated topic that puts an emphasis on my target group's needs and is based on accurate arguments. Moreover, I want to evaluate my solution to prove that my concept is valid and feasible.

In the course of this project, I will perform interviews with elderly people on a somewhat sensitive topic as some might frame dehydration as an individual fault or mistake. Having in mind to be careful not to irritate them I want to prepare these interviews very well to gain the finest insights possible.

To summarize, my overarching aim is to improve the quality of life of elderly people and enable independent ageing to hopefully contribute to the current and upcoming healthcare system challenges.

FINAL COMMENTS

In case your project brief needs final comments, please add any information you think is relevant.

As a preventative matter, this thesis aims to increase independent ageing by decreasing health issues related to dehydration or not drinking sufficiently. The graduation project will concentrate on elderly people in Germany. This focus will concern the involvement of stakeholders that operate country- or region-specific such as doctors or public institutions. Nevertheless, the outcome of this study might be translatable to elderly people from all around the world as the chosen problem field is not country-specific.

Initials & Name TS Strobel 6272 Student number 5556961

Title of Project Improving the quality of geriatric life by managing water intake.

8.2. Informed Consent Form Context Mapping

Informed consent form - Context Mapping

You were invited to participate in a research study with the title "Improving the quality of geriatric life by managing water intake.". This study is being conducted at the Delft University of Technology by Tobias Strobel and supervised by Dr Elif Özcan and Dr Marieke Sonneveld.

Aim

The aim of this research is to understand lifestyle habits in relation to water intake. These findings will form the basis for the development of a product that assists with water intake.

Procedure

The study is conducted at your home. You will be asked to provide information about your daily habits and routines regarding water intake. The total time required is approximately two hours and is divided into the following parts:

1. Questions on the topic of water intake
2. Task: Your daily routine (in relation to water intake)
3. Task: Free associations (related to water intake)
4. Questionnaire on your current knowledge about hydration

Privacy

By signing this consent form, you will be assigned a unique participant identification number. All information you provide during the study will be stored in anonymised form under this number to protect your privacy. The data collected will only be used for scientific purposes and will be published in a Master's thesis on integrated product design. At no time will information be shared outside of the research group by which you are personally identifiable.

The risk of a data breach is low but still possible. To the best of our knowledge and ability, your responses in this study will be kept confidential. By anonymising and storing your personal data separately from the study data, this risk will be minimised. After completion of the project, all materials containing personal data will be destroyed.

Participation

Your participation in this study is completely voluntary and you can withdraw at any time. You are free to omit any questions and you can request that your data be deleted at any time.

Contact

If at any time you have questions about the study or the process, please contact the study director Tobias Strobel (phone: xxxxxxxx; mail: xxxxxxxxxx@student.tudelft.nl, or the supervising researcher Dr Elif Özcan (phone: xxxxxxxxx (Netherlands); mail: xxxxxxxx@tudelft.nl).

Consent
Please indicate below whether you agree to participate in this study.
If you select "Yes, I agree to participate", this means that:

- you have read the above information or it has been read to you;
- you voluntarily agree to participate;
- you are at least 18 years of age.

If you do not wish to participate in this study, please decline by selecting "No, I do not agree to participate".

☐ Yes, I agree to participate

☐ *No, I do not agree to participate*

Items for explicit consent

Please tick the appropriate boxes	**Yes**	**No**
A: GENERAL CONSENT - RESEARCH OBJECTIVES, PARTICIPANTS' TASKS AND VOLUNTARY PARTICIPATION		
1. I have read and understood the study information or it was read to me. I had the opportunity to ask questions about the study and my questions were answered to my satisfaction.	☐	☐
2. I voluntarily agree to participate in this study and understand that I may refuse to answer any questions and may discontinue the study at any time without giving a reason.	☐	☐
3. I understand that participation in the study involves the following: ● Providing personal data (age, nationality, gender, place of residence). ● Answering a few questions about my water intake habits. ● The study director takes notes on the most important information. ● The interview is recorded in order to have access to the contents of the interview that were not written down during the interview.	☐	☐
4. I understand that the study will take about two hours.	☐	☐
B: POSSIBLE RISKS OF PARTICIPATION (INCLUDING DATA PROTECTION)		
5. I am aware that the following steps will be taken to minimise the risk of a data breach and to protect my identity in the event of such a breach: ● All information is stored locally. ● Voice recordings and written notes are destroyed at the end of the project.	☐	☐

6. I am aware that personal data collected about me that can identify me, such as name and telephone number, can only be viewed by the study director and will not be passed on.	☐	☐
7. I am aware that the personal data I have provided will be destroyed after the completion of the project.	☐	☐
C: PUBLICATION, DISTRIBUTION AND APPLICATION OF RESEARCH		
8. I am aware that the anonymised data I provide will be used for the following purpose after the research study: ● Decision-making processes during the product development process	☐	☐
9. I agree that my answers, views or other contributions may be quoted anonymously in the research results.	☐	☐

Signatures

_____	_____	_____
Participant	Signature	Date

Contact person of the study for further information:
Tobias Strobel
Phone: xxxxxxxxxxxx
Mail: xxxxxxxxxxx@student.tudelft.nl

I, as the study director, have read the information sheet carefully to the potential participant and have made sure, to the best of my knowledge, that the participant understands what he/she is voluntarily consenting to.

Tobias Strobel_____	_____	_____
Study director	Signature	Date

8.3. Context Mapping Interviews

Can you tell me one of your favourite drinks?
Participant 1: Medium carbonated mineral Water, Coffee,
Participant 2: Water from a Celtic spring, one small beer every evening as a ritual.
Participant 3: I enjoy a little glass of beer or wine.
Participant 4: Wine, I like the taste and it is good for me.
Participant 5: Coffee, My own homemade juice
Participant 6: weinschorle - I grew up in a wine region, we had our own wine and drinking wine feels like coming home; water, tea
Participant 7: I don't have a favourite, I have routines: morning, midday and evening I drink a cup of coffee. White wine
Participant 8: Black tea, I enjoy the ceremony. I learned that during an internship in England. It's a ritual for me.

Can you tell me one of your favourite dishes?
Participant 1: Kässpätzle, Maultaschen, Rindsrolladen, Linsen mit Spätzle (all traditional dishes from her city of origin)
Participant 2: Everything fresh, regional and high-quality
Participant 3: Across the garden: Vegetables, potatoas, Salas, pasta, meat
Participant 4: Kartoffel, Nudel, Reis, Gemüse, Salat
Participant 5: Braten, something I wouldn't do anymore because I'm on my own
Participant 6: I cook very mindful and only eat seasonal foods.
Participant 7: Simple and honest dishes. Seasonal foods
Participant 8: -

Do you know anyone who has ever had to be treated for lack of fluids?
Participant 1: My recently deceased husband did not drink enough because of his Parkinson disease.
Participant 2: No
Participant 3: Yes, I know someone that had to go to the hospital because of severe dehydration.
Participant 4: No
Participant 5: No
Participant 6: I cannot really walk anymore but I used to be in a walking group and every time there was someone that didn't drink enough and they had circulation issues and we had to call ambulances
Participant 7: No
Participant 8: Yes several times I experienced people getting dizzy not only elderly but also children.

What do you associate with the word thirst?
Participant 1: Going an a mountain hike and craving water (Was hiking until the age of ~76), Now she doesn't feel thirst.
Participant 2: Thirst is something wonderful. I love the feeling of extinguishing it.
Participant 3: Thirst comes after exercise. I used to play soccer until I was 70.
Participant 4: I don't have any sense of thirst.
Participant 5: It's a sensation that tells the body that it needs something. If I'm thirsty I drink, If I'm not thirsty I drink less.
Participant 6: One is thirsty when it's warm. I'm still thirsty.
Participant 7: It's a feeling that I have and if I have it I drink mineral water.
Participant 8: I enjoy being thirsty. I really like the sensation and quenching it with tap water. Usually, my sense of thirst is not strong.

Has your feeling of thirst changed compared to the past?
Participant 1: She has a little thirst and started drinking without feeling thirsty or craving a beverage because she has the recommended amount of 2L in mind. Doesn't measure her intake exactly but drinks at least a can of thin coffee and a bottle of mineral water a day.
Participant 2: No change
Participant 3: I'm not thirsty as often as I used to because I'm not doing that much exercise anymore.
Participant 4: I have no recollection at all that I ever had a sense of thirst.
Participant 5: Back In the days I also didn't drink that much. My sense of thirst is reduced and I have to think of drinking. I'm not feeling very thirsty but I try to consume my liquids.
Participant 6: When I was younger I didn't think much about my sense of thirst and it was easily forgotten. Now I'm more aware of my sense of thirst and that I should drink. Back in the days the recommendations of drinking 1,5 to 2 liters wasn't known and one would drink if necessary.
Participant 7: No
Participant 8: My sense of thirst did not change at all with age

What do you associate with the word water?
Participant 1: Water is the elixir of Life, it is the most important thing we have.
Participant 2: My garden needs water and I collect rainwater to water it.
Participant 3: Not only drinking, also water sports, swimming in the lake, water supply,
Participant 4: Valuable good. It's needed for everything.
Participant 5: It's not only for washing but also for drinking. It's also needed for nature. One should be mindful using water. Nowadays water is a rare resource and people use it to careless.
Participant 6: Water is vital. Everything needs water.
Participant 7: Water is the vessel of life. It's needed for all chemical reactions in the body and ist needed to get rid of the metabolic products. Water is the elixir of life.
Participant 8: -

What do you do when you are thirsty?
Participant 1: I would drink my mineral water.
Participant 2: I'm always carrying water.
Participant 3: During the day water. When I'm thirsty in the evening I'm sometimes craving a glass of wine.
Participant 4: I'm never thirsty and I never had the desire to chug down water.
Participant 5: When I'm thirsty I drink a glass of carbonated water with a sip of my homemade juice.
Participant 6: I drink carbonated water
Participant 7: I'm drinking tap water.
Participant 8: -

Do you feel you are drinking enough?
Participant 1: Yes
Participant 2: Yes
Participant 3: Yes
Participant 4: In my perception, yes.
Participant 5: I don't think I drink too little, but I think it's the bare minimum.
Participant 6: Yes
Participant 7: Yes, I would drink more if I would think I need more.
Participant 8: I'm taking a lot of effort to do so because my sense of thirst is not strong.

Has anyone ever told you to drink more?
Participant 1: I'm independent enough to not need anyone telling me how much I need to drink.
Participant 2: My husband tells me that I'm drinking too much which could flush out nutrients.
Participant 3: My doctor tells me to drink a lot. And my daughters tell me to drink 2 litres. Sometimes my wife reminds me to drink more.
Participant 4: Relatives. My doctor told me to drink when I'm thirsty - but I'm never thirsty.
Participant 5: No
Participant 6: My grandchild makes sure I'm always drinking.
Participant 7: Of course, in publications, I read a lot about it but I disagree. I don't take drinking too seriously and I don't keep track of my intake.
Participant 8: Yes, someone once told me that I should drink at least 3 litres a day but I don't think that's true for me.

Can you show me the vessels you usually use for drinking (e.g. your teapot or your favourite glass)?
Participant 1: I'm making 1 litre of thin coffee in the morning that I drink throughout the day. I drink water from my glass.
Participant 2: I distribute 10 litres of water throughout the week.

(Health-) Beliefs
Participant 1: Juice contains too much sugar and contains unnecessary calories,
The tap water in my region is of very high quality.
Elderly people have a reduced sense of thirst, that's why they don't drink sufficiently.
When drinking too little the skin gets wrinkly and a person dries out.

Participant 2: Pils Beer contains enough estrogen for me to be healthy,
I don't drink tap water, I get 10 litres of water from a Celtic spring.
I have a fine taste and can taste slight differences in water.
I'm rarely thirsty because I drink sufficiently. I always have a glass of water somewhere and each time I walk by I drink. It's part of my life, it's happening automatically.
I don't drink any wine or any juices.

Participant 3: For vacation, I'm only going to a specific spring water source to go swimming. This water immediately cures my back pain. The healing properties of this spring water are immense.
We don't need that much food. Because we don't move as much anymore we shouldn't eat that much - thats dangerous. I could eat more but I know I shouldn't
Every morning I do squats to strengthen my muscles.
Because I'm always moving enough I can sleep well.
Sometimes home remedies work better than medication.

Participant 4: The quality of our regional tap water is very good.
What should all this drinking be good for?
For my age, I'm satisfied with my health condition according to my age.

Participant 5: I know that compared to others I drink little. That's why I try to fill the gap and drink more.
I regularly hear about recommendations on how much water should be consumed but I could never drink 2 litres. I once calculated how much I drank in a day and if I drink 1 litre ist already much.

Participant 6: When my health started to decline at the age of 50 I started to take more care of my water intake.
I can not handle the acid in orange juice.

Participant 7: If I would drink according to public opinion - 2 litres - this would be bad for my health.
I drink a sip of ouzo if I feel unwell.
I can do exercise for hours without needing water.
I only drink tap water. To me all bottled water is dead water.
Because I'm very mindful of what I eat I don't consume many harmful substances and thus I need less water than others to flush those substances out of the body.
My doctor always tells me that I'm in very good health - that's why I don't see any problem in my water intake.

Participant 8: I try do drink 2 litres of water each day.
The mineralisation in water can benefit my health.
When I was young I did sports excessively - now that I'm older I notice the damage I have done.
I don't have a sense of thirst because I drink before it occurs. Instead, I have a desire to drink that occurs for example when I feel my mouth is dry.

Type of daily structure
Participant 1: Flexible, but with rough outlines
Participant 2: Strict daily routines, our lifes revolve arround meals
Participant 3: Flexible, but with rough outlines
Participant 4: very structured
Participant 5: Structured
Participant 6: Flexible, but with rough outlines
Participant 7: extremeley structured
Participant 8: Flexible, but with rough outlines

Daily Routine
Participant 1: 6: wake up, taking medication with water 30 min before breakfast
6:30 Müsli, with fruit, milk and oatmeal and joghurt
getting ready in the bathroom
8: sometimes going for a run (joggen), else reading, extensively reading newspaper, enjoing bread with jam, sometimes grocery shopping/ going to the doctors/ household/ appointments
11.30-12.30: having lunch, vegetables, potatos, ground meat,
Afternoon: Reading, watching TV, sometimes nap
Dinner: Fried egg, salad, vesper
Evening: watching TV, reading - drinking water, sometimes Drinking Tea (black tee, peppermint)
22: going to bed
night: sometimes insomnia - then reading 1 hour

Participant 2: 8: waking up, breakfast, getting ready, household chores, gardening
12:30 Lunch
13:00-15:00 Spending time on my own, reading
15:00 walking 7km
17:30 Drinking beer with husband

18:30 Dinner
Evening: Spending time on her own, watching TV

Participant 3: 6:30 wake up, going to toilet, taking medication with a full glass of water
taking a nap for one hour
8:30 Wake up, breakfast, reading newspaper, going grocery shopping, going for a walk, doing household chores
12:30 Lunch
15:00 Cup of coffee, sometimes cake
18:00 Dinner
taking medication with one or two glasses of water
23:00 going to bed, without water

Participant 4: Morning: Waking up, toilet, getting newspaper, preparing coffee, preparing breakfast, moving coffee cup to the side, reading newspaper, preparing medication, taking medication with half a cup of water, getting ready, household/ gardening chores, sometimes grocery shoppin
Lunch, without drink, cleaning up
Nap
Relaxing, watching TV, sometimes going for a walk
Dinner with Beer
Relaxing, watching TV, in summer sitting outside, drinking wine
In between: going to the toilet frequently.
At night: waking up once to go to the toilet

Participant 5: 6:30 Taking medication with tap water
7:00 Wake Up, toilet, breakfast, reading newspaper, household chores, grocery shopping,
11:00 cooking
12:00 lunch
13:00 Doing homework with grandchild or reading
14:30 Coffee
15:00 Gardening/ Household chores
18:00 Dinner, Bread with cheese and saftschorle
cleaning kitchen
19:00 Watching TV, Crossword puzzles, drinking saftschorle
22:00 going to bed
Night, going to toilet at least twice

Participant 6: 7:00 waking up, waiting until everyone left the house
8:00 standing up, bathroom, breakfast, reading newspaper, preparing yoghurt for later
09:30 household chores, grocery shopping
12:00 lunch
13:30 nap
14:00 knitting, relaxing
15:00 coffee
15:30 Gardening
18:00 Small dinner
19:30 watching Tv, reading, crossword coffee
23:00 going to bed
Because I'm drinking a lot I have to get up once or twice- but this is happening quite automatically and does not disturb me much.

Participant 7: 6:00 waking up, feeling alive, thinking, planning
7:00 sleeping again
7:30 Preparing breakfast, PC reading news checking mail,
10:00 planning lunch, sometimes grocery shopping
12:00 Preparing lunch, Eating, after lunch: coffee break
13:00 Household chores, planning
18:00 ritual beer
19:00 Dinner
20:00 watching TV

Participant 8: 7:00 get up, waking up, drinking 2 glasses of lukewarm water
7:30 bathroom, making a can of tea, firing the oven, preparing breakfast
8:30 household chores, gardening, grocery shopping, sometimes going for a walk (3-5 times a week)
12:00 lunch
13:00 gardening, household chores
16:00 having a snack
in between reading, crossword puzzles
19:00 dinner
checking my mail

Hobbies
Participant 1: Used to do climbing, not possible anymore but still talks about it a lot, goes walking (fast) 2-3 hours regularly (doesn't take beverages with her), Gardening

Participant 2: Mountain biking. Walking 7km every day. Gardening

Participant 3: Skiing, Kniebeugen every morning, going to soccer games, going for walks, biking weekly with friends, gardening

Participant 4: Gardening, cooking, going for a walk, meeting friends, reading

Participant 5: Gardening, Reading, Crossword puzzles

Participant 6: gardening, knitting, reading, crossword puzzles

Participant 7: Cooking, Mountainbike

Participant 8: gardening, inviting guests over, walking tours with friends (5km every other day), talking to friends on the phone

Description of Images:
Lake
Participant 1: Nice lake, beautiful photo
Participant 2: See, Bäume, Haus
Participant 3: See mit Anlegestelle und Häuser im Hintergrund, blauer himmerl mit schönen Kumuluswolken

Participant 4: Water, reflections, peer
Participant 5: This is our regional lake with a peer. [it's not, it's a random image of a lake]
Participant 6: Nature
Participant 7: Beautiful still lake with a peer and around a lake.
Participant 8: A wonderful landscape that is still intact.

Water
Participant 1: A man is about to drink water
Participant 2: Bottle, Water, Shirt, Table, Table cloth
Participant 3: Eine Person steht vor einem Glas mit wasser wie ein soldat.
Participant 4: Glass, Water, Waterbottle with cork, The person is still in the nightgown drinking their water
Participant 5: Old person with an empty glass and full bottle thinking "I have to drink"
Participant 6: Water one should drink
Participant 7: Bottle and Glass on the table and a woman standing behind it.
Participant 8: Bottle as a reminder to drink

Plant
Participant 1: Every plant needs water. Nothing works without water.
Participant 2: Blumentopf, Untertopf, Kleine Schaufel, Erde, Wasser, Beine
Participant 3: Someone watering a flower while sitting down, watering can made of copper
Participant 4: watering while sitting
Participant 5: Someone repotted their flower
Participant 6: Watering flowers
Participant 7: Someone sitting and watering his plant. In the front is a burning candle.
Participant 8: someone watering a plant

Coffee
Participant 1:
Participant 2:
Participant 3:
Participant 4:
Participant 5:
Participant 6:
Participant 7:
Participant 8:

Reaction Images:
Participant 1: Kaffee und Kuchen, looks delicious
Participant 2: Espresso, Quarkkuchen, Teller, Kekse, Handy, Finger, Pullover
Participant 3: Kaffee, Gebäck, Kuchen, Teller
Participant 4: Typical modern times: Coffee, Cake and Smartphone
Participant 5: Kaffeetafel, most important: someones playing with phone which I cant because I don't have one. It's up to them to do so but I sometimes I think it's rude.
Participant 6: Midday coffee
Participant 7: The usual social structure: Coffee, Tea, Smartphone
Participant 8: The exemption, midday 13:00 coffee and a delicious piece of cake. But the phone: horrible, I hate it, i hate when people do this

Reaction to Images:

Lake
Participant 1: Reminds me of holiday
Participant 2: Very familiar, because I live close a lake and walk by the lake regularly
Participant 3: -
Participant 4: -
Participant 5: -
Participant 6: It reminds me of a nice lake close by with beautiful nature.
Participant 7: Calm mood - a beautiful image
Participant 8: I would love to sit there and relax and let go. It's a place of power.

Water
Participant 1: Maybe the person is asked to drink more, but doesn't want to drink more because she thinks "I'm not thirsty at all"
Participant 2: Very technical makes me think of technology.
Participant 3: Maybe thinking "should I drink, shouldn't I drink?"
Participant 4: -
Participant 5: I perceive it very sterile like a doctor is telling me to drink more.
Participant 6: -
Participant 7: -
Participant 8: A beautiful image. For me this image is art. It's full of details

Plant
Participant 1: I only have robust plants. My garden is natural and requires low maintenance.
Participant 2:-
Participant 3: Watering plants is a routine, my daughter lives close by and I'm taking care of the plants.
Participant 4: -
Participant 5: -
Participant 6: This morning I also watered my flowers.
Participant 7: A moment of peace.
Participant 8: It doesn't catch me emotionally

Coffee
Participant 1: Gemütlichkeit, Enjoying
Participant 2: Nice to have this rarely - but we never do this. Smartphones have no dimension in my life.
Participant 3: -
Participant 4: -
Participant 5: -
Participant 6: I only have cake on Sundays, usually that's too much for me. I wouldn't be hungry in the evening and I need to eat in the evening to have my medication. I hate it a lot when people use their phones.
Participant 7: This could be nice to drink and eat, but I'm not that much into eating unnecessarily.
Participant 8: -

Most liked Photo
Participant 1: Lake: Natural environment, Nice colours, reflection

Participant 2: Plant with watering can: This is my everyday life.
Participant 3: Coffe: It's a part of my daily life.
Participant 4: Nature: Because nature is just nature and it reminds me of my home.
Participant 5: Lake: This is still nature. Nature is of enormous importance for me. I grew up with nature - we had a farm. I'm in touch with nature and value my garden a lot.
Participant 6: Lake: It reminds me of nature.
Participant 7: Lake: It's real, It's nature. I like plants more in nature than in a pot.
Participant 8: Lake: It's a big gift being able to enjoy such a landscape. Water is important for everything. We have to be very careful and aware with nature. I grew up on a farm - thats what made me be in touch with nature.

Least liked Photo
Participant 1: Water: Face not visible,
Participant 2: Coffee: I'm not into cake and not into smartphones.
Participant 3: Water: Doesn't mean much.
Participant 4: Plant: Because the person is sitting, thats unusual and unnecessary. Water: I don't like it because it's so wet. I could be that person standing hesitantly behind that glass.
Participant 5: Coffee: The one with the smartphone - it's a very disruptive factor for me.
Participant 6: None, the rest is part of daily life.
Participant 7: -
Participant 8: Coffee: because the disruptive factor of the smartphone is in it.

Quotes
Participant 1: Went on a walk for 3 hours. I would have drunk something if I took something with me - but it wasn't that urgent. I drink when I'm at home.
We once went climbing and only took 1 litre of water per person on a hot summer day. It took the whole day from morning until 0:30 AM. Felt extremely thirsty then.
Once went on a hike with my son on the hottest day of the year, only took one litre and we had to interrupt our tour because we were too thirsty.
When going on a hike or climb we only take a litre of water and some nuts with us because of the weight. One could drink more but it's a matter of weight you have to carry around.
Some of my friends put a Jug of water on the table and force themself to drink up
Maybe after exercise apple juice with sparkling mineral water is better than water to refill electrolytes
Maybe I'm drinking too little, I honestly don't know.
I think doctors should be more empathic and better educated in working with people.

Participant 2: I'm not religious but the place where this spring is is holy to me.
We built our house together with our own hands.
Together with food we always serve water.
I would never leave the house without a bottle of my Celtic water.
I value the independence I have at my age. Nobody hustles me. I can decide whether to take a break (while biking) and to enjoy my water in the present moment. To sense what am I seeing, what am I smelling, what am I feeling.
I'm controlling my water intake with the two 5L jugs I fill every week.
I don't go to bed without a glass of water by my side.
My husband is cooking and he installed a bell in my garden that he rings when I forgot to come to have lunch on time - I value that.

I'm social and outgoing, my husband is not. We value our time we spend separately to then exchange our experiences.
Our retirement is paradise.
Before retirement, everything was driven by necessity. Now we can enjoy routines and rituals at our own pace.
Before retirement I was relying on a gardener and a professional cleaner - I'm happy that I can do everything by myself now so I can be sure it is done right.
I've always been sensitive. I cannot eat anything like others.
After lunch, I always eat one date. The sweetness and flavour filling my mouth is indicating the closure of the meal.
I would have never thought that I would enjoy retirement that much. For the first time in my life I feel free. I feel free of the pressure of earning money. Being driven stops, my desires are moderate, I have everything I need.
When I ride my mountain bike I get a lot of unnecessary comments like "Don't fall, it will permanently damage you" or "The bike makes you look younger"
I was born in war, I come from hunger and freezing and now I live like god in France. I could have never imagined that.
I live moderately in everything. I have no desires outside of what I can afford.
I enjoy the freedom of ageing. I have the possibility to do anything I want with what is available to me.
Only because I always worked hard and had a restricted life I can now enjoy the freedom of retirement.
I'm not a part of the throw-away society, I'm very aware with what I have and see the aesthetics in things.
Everything I own has a history and a meaning.
I'm thinking to myself: I'm so old and still healthy - my lifestyle choices couldn't have been that bad.

Participant 3: The quality of our regional tap water is very high.
Without carbonation, the taste of water is not good enough to drink it. I'm using a carbonator to make my own fizzy water.
Sometimes the eyes decide what to drink.
My doctor always tells me to drink a lot. Something around 1,5-2 litres, but that's not always doable if one doesn't keep it in mind.
Because my doctors and daughters tell me to drink more I try to do so.
I cannot manage to drink 2 litres of water. If I drink half a litre of beer I might be able to reach 2 litres.
In summer I prefer cold beverages over warm ones.
My wife and I drink by intuition, we don't keep track of our water consumption.
Sometimes we prepare a special snack that reminds us of our vacation and we still do repeatedly to the same destination.
When I'm gardening I sometimes notice that my whole mouth is dry, then I go drink something.
When I walk by the kitchen and see the water bottle, I drink.

Participant 4: When people tell me to drink more I think "I'm old enough I can decide for myself"
I don't have a precise overview of what I'm drinking.
I don't drink throughout the day.
I don't feel comfortable drinking large amounts of water.
Drinking never played a large role in my life. I have no recollection of drinking as a child or an adult.
I don't feel pressured by other people to drink more.
Back in the days, the field workers would drink thinned cider that they carried in special bottles called "Schlegel".
After the war there was no coffee, then we used to drink a plant-based coffee substitute.

Participant 5: If I'm thirsty I drink, If I'm not thirsty I drink less.
When we are active my son thinks of taking beverages with us. Myself I wouldn't bring any beverages with me.
I don't think I drink too little, but I think it's the bare minimum.
Covid changed people - they are less social and outgoing.

Participant 6: Many elderly people think they are not old. They don't want to accept that they are ageing.
I always have a cup of tea or water standing around and each time I go by I take a sip or two.
My son-in-law is taking care of that I always have enough bottled water in my house.
While I went to rehabilitation they gave me a bottle of water and told me to fill it three times a day.
Us elderly still learned that one should eat seasonal food.
When I'm out of the house the whole day I'll take as much water with me as I need.
For watering my plants I'm using a moon calendar that reminds me when to do what.

Participant 7: I do not submit to the compulsion that I must drink.
I'm not thinking about ageing I think about what I'm capable of.
When I go biking for 40 km I don't take water with me. I know, no one understands this. Sometimes I think I have a liquid reservoir like camels do.

Participant 8: For me drinking requires a sense of discipline. Usually, my sense of thirst is not strong so I have to drink without being thirsty.
Sometimes when I'm distracted I look at the watch and realize 3 hours have passed without me drinking.
When I see my cup of water it reminds me that I should drink.
Sometimes I'm doing a pinch test to see if I'm dehydrated.
I drink many different kinds of waters. I enjoy the variation.
When I'm going on a walk I only take water with me in summer.
The advantage of ageing is that you cannot work that long without interruptions. The body starts to ache and tells you exactly when it needs a break.
When I'm going out the whole day I reduce my water intake to not be forced to go on toilets outside my house. I don't like public toilets.
Back in the days, the adults would drink cider thinned with tap water. The children would drink homemade juice mixed with tap water. Carbonated and bottled water wasn't really available. Only beer and lemonade were available in bottles.

Ideas for Product
Participant 1: I can imagine a nice design of a Drinking Aid/Feeding Cup for people with severe diseases so that the appearance makes the product more attractive.
Participant 2: -
Participant 3: Something like a home remedy. Like curd wraps for removing swelling from legs.
Participant 4: I don't think it's possible to invent something new to improve the water intake behaviour of people. If something new is invented it would take a long time and be a difficult process.
Participant 5: I would like a simple and uncomplicated product.
The elderly don't want to go in elderly homes because this makes them feel abandoned. Instead, they could be integrated in a farm and do what they are still capable of and then have meals together - to fight loneliness.

Participant 6: I'd like to have something that gives me an overview of what I drank in one day. To get some confirmation if I'm doing it right or if I need to drink more.
Participant 7: From my experience with elderly people advice does not stick.
They should only consume good foods and not bad foods so that they need less water.
Participant 8: I would reject recommendations. I would accept advice that makes me feel like the author of the advice is honestly taking care of me and has valuable intentions.
I would hate aggressive reminders that I have to set myself.
The product shouldn't let the user tell that they drink too little. It should ask if they drink sufficiently and give reasons why it asks and gives reasons why one should drink.

Agreed to participate in potential prototype user testing
Participant 1: Yes
Participant 2: Yes
Participant 3: Yes
Participant 4: Yes
Participant 5: Yes
Participant 6: Yes
Participant 7: Yes
Participant 8: Yes

Uses Computer
Participant 1: No
Participant 2: Yes
Participant 3: Yes
Participant 4: No
Participant 5: No
Participant 6: No
Participant 7: Yes
Participant 8: Yes

Smartphone
Participant 1: No
Participant 2: No
Participant 3: No
Participant 4: No
Participant 5: No
Participant 6: No
Participant 7: Yes
Participant 8: No

Interview Duration (excluding preparation and informed consent)
Participant 1: 1h 16min
Participant 2: 1h 36 min
Participant 3: 1h 5min
Participant 4: 1h 11min

Participant 5: 1h 10min
Participant 6: 1 h 6 min
Participant 7: 2h 19 min
Participant 8: 1h 30min

8.4. Arduino Code

```
#include <HX711_ADC.h>
#include <Adafruit_NeoPixel.h>

#if defined(ESP8266) || defined(ESP32) || defined(AVR)
#include <EEPROM.h>
#endif

#include <U8glib.h>    // include the library code
bool calculationMade = false;

U8GLIB_SSD1306_128X32 u8g(U8G_I2C_OPT_NONE | U8G_I2C_OPT_DEV_0);

//pins:
const int HX711_dout = 4;     // MCU > HX711 dout pin
const int HX711_sck = 5;     // MCU > HX711 sck pin
const int LED_PIN = 2;       // Digital pin connected to the LED strip
const int LED_COUNT = 50;    // Number of LEDs in the strip

// HX711 constructor:
HX711_ADC LoadCell(HX711_dout, HX711_sck);

Adafruit_NeoPixel strip(LED_COUNT, LED_PIN, NEO_GRB + NEO_KHZ800);

const int calVal_eepromAdress = 0;
unsigned long t = 0;
float previousLoadCellValue = 0.0;
bool isStable = false;
unsigned long lastChangeTime = 0;
const unsigned long stabilityDuration = 500;  // Stability duration in
milliseconds
bool blinkOnce = false;
int brightness = 1;  // Default brightness (0-255)

// Load Cell Value Table
struct LoadCellValue {
  int index;
  float value;
};
const int MAX_TABLE_SIZE = 100;
LoadCellValue loadCellTable[MAX_TABLE_SIZE];
int tableIndex = 0;

float glassWeight = 0.0;    // Weight of the glass
float sipWeight = 0.0;      // Weight of each sip
float totalConsumed = 0.0;  // Total amount consumed

void setLEDStripBrightness(int brightness) {
  strip.setBrightness(brightness);
  strip.show();
```

```
}

void printLoadCellTable() {
  Serial.println("Load Cell Value Table:");

  Serial.print("Index\tLoad Cell Value");
  for (int i = 0; i < tableIndex; i++) {
    if (isValueAroundZero(loadCellTable[i].value)) {
      continue;  // Exclude values around 0
    }
    Serial.print(loadCellTable[i].index);
    Serial.print("\t");
    Serial.println(loadCellTable[i].value);
  }

  Serial.println("----------------------------");
}

bool isValueAroundZero(float value) {
  const float tolerance = 2.0;  // Value tolerance around 0
  return (value >= -tolerance && value <= tolerance);
}

void blinkLEDsOnce() {
  const int blinkDuration = 500;  // Blink duration in milliseconds

  for (int i = 0; i < LED_COUNT; i++) {
    strip.setPixelColor(i, strip.Color(255, 255, 255));  // White color (R=255,
G=255, B=255)
  }

  strip.show();    // Turn on all LEDs

  delay(blinkDuration);

  strip.clear();   // Turn off all LEDs
  strip.show();
}

void draw(float totalConsumed) {
  u8g.firstPage();
  do {
    u8g.setFont(u8g_font_fur25);
    u8g.setPrintPos(0, 32);
    u8g.print(String(int(totalConsumed)) + " mL");
  } while(u8g.nextPage());
}

float calculateConsumedAmount() {
  const float sipThreshold = 5.0;  // Threshold to detect a sip (20g)
  const float mLPerGram = 1.0;      // Conversion factor from grams to
```

```
milliliters

  float lastSipConsumed = 0.0;  // Amount consumed in the last sip
  float totalConsumed = 0.0;    // Total amount consumed
  bool glassOnScale = false;
  float prevGlassWeight = 0.0;        // Store the previous glass weight

  for (int i = 0; i < tableIndex; i++) {
    float value = loadCellTable[i].value;

    if (value >= sipThreshold) {
      if (!glassOnScale || value > prevGlassWeight) {
        // New glass detected or larger glass weight
        if (glassOnScale) {
          // Start a new glass, add the last sip consumed to the total
          totalConsumed += lastSipConsumed;
          lastSipConsumed = 0.0;
        }
        glassOnScale = true;
        glassWeight = value;
      } else {
        // Existing glass with sip detected
        lastSipConsumed += prevGlassWeight - value;
      }
    } else if (value == 0 && glassOnScale) {
      // Glass removed from the scale
      totalConsumed += lastSipConsumed;
      glassOnScale = false;
    }

    prevGlassWeight = value; // Store the current glass weight for the next
iteration
  }

  totalConsumed += lastSipConsumed; // Add the last sip consumed to the total
immediately

  float mLConsumed = lastSipConsumed * mLPerGram;  // Convert amount consumed to
milliliters
  float totalMLConsumed = totalConsumed * mLPerGram;  // Convert total consumed
amount to milliliters

  // Clamp the value to the maximum goal of 3600mL
  totalMLConsumed = min(totalMLConsumed, 3600.0);

  Serial.print("Amount Consumed: ");
  Serial.print(mLConsumed);
  Serial.println(" mL");
  Serial.print("Total Consumed: ");
  Serial.print(totalMLConsumed);
  Serial.println(" mL");
```

```
  Serial.println("---------------------------");

  return totalMLConsumed;
}

void setup() {
  strip.begin();
  strip.show();    // Initialize all LEDs to off

  u8g.setFont(u8g_font_unifont);
  u8g.setColorIndex(1);   // Display draws with pixel on
  Serial.begin(57600);
  delay(10);
  Serial.println();
  Serial.println("Starting...");

  LoadCell.begin();

  float calibrationValue;
#if defined(ESP8266) || defined(ESP32)
  EEPROM.begin(512);
#endif
  EEPROM.get(calVal_eepromAdress, calibrationValue);

  unsigned long stabilizingtime = 2000;
  boolean _tare = true;
  LoadCell.start(stabilizingtime, _tare);
  if (LoadCell.getTareTimeoutFlag()) {
    Serial.println("Timeout, check MCU>HX711 wiring and pin designations");
    while (1);
  }
  else {
    LoadCell.setCalFactor(calibrationValue);
    Serial.println("Startup is complete");
  }

  // Set initial brightness
  setLEDStripBrightness(brightness);
}

void loop() {
  static boolean newDataReady = 0;
  const int serialPrintInterval = 0;
  const float changeThreshold = 5.0;  // Change threshold to detect activity
(20g per LED)


    if (LoadCell.update()) newDataReady = true;

    if (newDataReady) {
        if (millis() > t + serialPrintInterval) {
```

```
            float loadCellValue = LoadCell.getData();

            // Check for LED strip activity
            if (abs(loadCellValue - previousLoadCellValue) >= changeThreshold) {
                previousLoadCellValue = loadCellValue;
                lastChangeTime = millis();
                isStable = false;
                blinkOnce = false;
                calculationMade = false;  // Reset the flag when a significant
change is detected
            }
            else {
                if (!isStable && !blinkOnce && millis() - lastChangeTime >=
stabilityDuration) {
                    isStable = true;
                    blinkOnce = true;

                    // Add load cell value to the table (exclude values around
0)
                    if (tableIndex < MAX_TABLE_SIZE &&
!isValueAroundZero(loadCellValue)) {
                        loadCellTable[tableIndex].index = tableIndex;
                        loadCellTable[tableIndex].value = loadCellValue;
                        tableIndex++;
                    }
                }
            }

            // Blink once if LED strip activity stops
            if (blinkOnce) {
                blinkOnce = false;
                blinkLEDsOnce();
                // Print load cell value table
                printLoadCellTable();
                // Calculate consumed amount
                if (!calculationMade) {  // Only perform calculations and update
display if not already done
                    totalConsumed = calculateConsumedAmount();
                    calculationMade = true;  // Set the flag to true after
calculations are made
                }
            }

            // Calculate the number of LEDs to illuminate
            int numLeds;
            // Set the default LED color to white (RGB: 255,255,255)
            int ledColor[3] = {255, 255, 255};

            // Determine the color and number of LEDs based on the total
consumed
            if (isStable) {
```

```
                if (totalConsumed <= 1800) {
                    numLeds = map(totalConsumed, 0, 1800, 0, LED_COUNT);
                } else {
                    numLeds = map(totalConsumed, 1801, 3600, 0, LED_COUNT);
                    // Change the LED color to green (RGB: 0,255,0)
                    ledColor[0] = 0;
                    ledColor[1] = 255;
                    ledColor[2] = 0;
                }
            } else {
                numLeds = map(abs(loadCellValue), 0, 1000, 0, LED_COUNT);
                // Change the LED color to blue (RGB: 0,0,255)
                ledColor[0] = 0;
                ledColor[1] = 0;
                ledColor[2] = 255;
            }

            // Turn on LEDs up to the mapped value
            for (int i = 0; i < numLeds; i++) {
                strip.setPixelColor(i, strip.Color(ledColor[0], ledColor[1],
ledColor[2]));
            }

            // Turn off LEDs beyond the mapped value
            for (int i = numLeds; i < LED_COUNT; i++) {
                strip.setPixelColor(i, strip.Color(0, 0, 0));    // Turn off
LEDs
            }

            strip.show();    // Update the LED strip with the new colors and
brightness

            // Draw total consumed on the LCD
            draw(totalConsumed);

            newDataReady = false;  // Reset the flag
            t = millis();
        }
    }
}
```

8.5. Informed Consent Form Usability Study

Informed consent form - Usability Study

You were invited to participate in a research study with the title "Improving the quality of geriatric life by managing water intake.". This study is being conducted at the Delft University of Technology by Tobias Strobel and supervised by Dr Elif Özcan and Dr Marieke Sonneveld.

Aim

The aim of this research is to understand the usability of a product that assists with water intake monitoring.

Procedure

The study is conducted at your home. You will be asked to test a prototype and provide information about your experience. The total time required is approximately one hour and is divided into the following parts:

1. Demonstration of the prototype
2. Testing the prototpye
3. Semi-Structured interview about your expieriences with the prototype

Privacy

By signing this consent form, you will be assigned a unique participant identification number. All information you provide during the study will be stored in anonymised form under this number to protect your privacy. The data collected will only be used for scientific purposes and will be published in a Master's thesis on integrated product design. At no time will information be shared outside of the research group by which you are personally identifiable.

The risk of a data breach is low but still possible. To the best of our knowledge and ability, your responses in this study will be kept confidential. By anonymising and storing your personal data separately from the study data, this risk will be minimised. After completion of the project, all materials containing personal data will be destroyed.

Participation

Your participation in this study is completely voluntary and you can withdraw at any time. You are free to omit any questions and you can request that your data be deleted at any time.

Contact

If at any time you have questions about the study or the process, please contact the study director Tobias Strobel (phone: xxxxxxxxx; mail: xxxxxx@student.tudelft.nl, or the supervising researcher Dr Elif Özcan (phone: xxxxxxxxx(Netherlands); mail: xxxxxxx@tudelft.nl).

Consent

Please indicate below whether you agree to participate in this study.
If you select "Yes, I agree to participate", this means that:

- you have read the above information or it has been read to you;
- you voluntarily agree to participate;
- you are at least 18 years of age.

If you do not wish to participate in this study, please decline by selecting "No, I do not agree to participate".

☐ Yes, I agree to participate

☐ *No, I do not agree to participate*

Items for explicit consent

Please tick the appropriate boxes	**Yes**	**No**
A: GENERAL CONSENT - RESEARCH OBJECTIVES, PARTICIPANTS' TASKS AND VOLUNTARY PARTICIPATION		
1. I have read and understood the study information or it was read to me. I had the opportunity to ask questions about the study and my questions were answered to my satisfaction.	☐	☐
2. I voluntarily agree to participate in this study and understand that I may refuse to answer any questions and may discontinue the study at any time without giving a reason.	☐	☐
3. I understand that participation in the study involves the following: ● Providing personal data (age, nationality, gender, place of residence). ● Testing a protoype and providing feedback. ● The study director takes notes on the most important information. ● The interview is recorded in order to have access to the contents of the interview that were not written down during the interview.	☐	☐
4. I understand that the study will take about one hour.	☐	☐
B: POSSIBLE RISKS OF PARTICIPATION (INCLUDING DATA PROTECTION)		
5. I am aware that the following steps will be taken to minimise the risk of a data breach and to protect my identity in the event of such a breach: ● All information is stored locally. ● Voice recordings and written notes are destroyed at the end of the project.	☐	☐

6. I am aware that personal data collected about me that can identify me, such as name and telephone number, can only be viewed by the study director and will not be passed on.	☐	☐
7. I am aware that the personal data I have provided will be destroyed after the completion of the project.	☐	☐
C: PUBLICATION, DISTRIBUTION AND APPLICATION OF RESEARCH		
8. I am aware that the anonymised data I provide will be used for the following purpose after the research study: ● Decision-making processes during a product development process	☐	☐
9. I agree that my answers, views or other contributions may be quoted anonymously in the research results.	☐	☐

Signatures

_____	_____	_____
Participant	Signature	Date

Contact person of the study for further information:
Tobias Strobel
Phone: xxxxxxxxxxxxxxx
Mail: xxxxxxxxxx@student.tudelft.nl

I, as the study director, have read the information sheet carefully to the potential participant and have made sure, to the best of my knowledge, that the participant understands what he/she is voluntarily consenting to.

Tobias Strobel_____	_____	_____
Study director	Signature	Date

8.6. Usability study Interviews

8.6.1. Initial Interview after explaining the product

1. What do you think this product is used for?
Participant 1: When you are elderly you're supposed to drink a certain amount. This device lets you know if you did or didn't reach that amount.

Participant 2: I'm interested in how much I consume and I think the product is good for that. The product is an aid to reaching the fluid goal. It also acts as an incentive to drink more. It's an invitation and a reminder to drink. It reminds me of a watch but is more pleasurable. I think it's more practical. I'm curious about the product and I would have joy in trying it to see how it works and how I would handle it.

Participant 3: The product is an incentive to drink and shows how much one drinks

2. How would you use this product?
Participant 1: I would turn it on in the morning and then look in the morning at how much I drank. Then if I see "Oh I didn't drink very much" I can try drinking more the next day. Every day I can see If I reached my goal

Participant 2: I would use it as a daily means of measuring and controlling my water intake. I have a rough overview of my water intake but no control.

Participant 3: I would use it as a reminder to drink and to get information on how much I drink.

3. What do you like or dislike about this product at first glance?
Participant 1: I like that it's usable for elderly people as we don't know how to use electronic devices. This one is really easy to operate and to understand. I really dislike about electronics when nothing is written in German and I don't understand it.

Participant 2: The device has a pleasant shape. It's light, well to handle and I can carry it everywhere. I like that it's decent and doesn't claim attention

Participant 3: I like that it looks good and that it looks straightforward. I also like that It's not gigantic and if it does the calculations right it is a beautiful thing.

8.6.2. Post-test interview

What did you like about using the coaster?
Participant 1: I like that it's not complicated to use for elderly people. On other devices, I first have to set up for which I have to read the instruction manual several times. I think that this would be something that would be actually used after purchasing it.

Participant 2: The display of the exact amount I drank is very interesting and exciting. The light bar is useful in showing the progress I made - that's clear and concise. It is extremely easy to use. I don't have to think a lot and I can imagen that it's easy to transform into a routine because of that. I always have an exact measure of how much I consume - for me, that's the most exciting feature. It's pleasant that I don't have to think about how much should I pour in the glass, or how much must I pour in the glass - instead I'm free in my decision. I wouldn't like being required to pour a full glass of water - this would feel like being forced to drink. I really think it's a big advantage of the product that it works with little water. I like my water fresh, that's why I only pour a little.

Participant 3: It is interesting that there is such a thought support. That the device tells you how much you drink. I think this is a totally novel invention.

What did you not like or find difficult?
Participant 1: If I had this device I would write me note on how to use it and put it next to it. "Glass full: put it on the coaster; Glass empty: put it on the coaster again".

Participant 2: -
Participant 3: When one is older it takes a bit of time for information to reach the head. I think because of that it would take a while before it could become a routine.

How well do you think the coaster fits into your daily routine?
Participant 1: Yes, as long as I'm at home. When I'm going out of the house I'm always carrying a small bottle of water. When I'm watching TV I would put the coaster on my small side table.

Participant 2: I think that a routine would be established. I would wish that it would become a natural thing to do like using my phone. Drinking at high age is a challenge and it's important to me to take care of my body. This device would give me security which is something very valuable which would eventually tempt me to keep using it.

Participant 3: Yes I think it would fit my daily routine for me to know how much progress I made.

Would you use a long-term tracking function?
Participant 1: I have a similar function on my blood pressure device and I never use it. It's too complicated. I rather write down my values on a piece of paper to show it to my doctor.

Participant 2: I would show it to my doctor.

Participant 3: -

How could the coaster be improved?
Participant 1: I think that I only would have recommendations after using it for a while.

Participant 2: It would like it would be reduced in size. But if that meant I would have to charge the device every day I wouldn't like it. Every 2-3 days would be okay with me. In the beginning, I imagined that the lights would be green which might increase the visibility for people with impaired vision. I

would like to have more detailed feedback on how much I drink at what time of the day. For me it's easy to drink a lot in the morning and the rest of the day I have difficulties.

Participant 3: Some old people are shaky. So the device should not be too sensitive.

Where do you imagine having a touchpoint with such a product?
Participant 1: Maybe if I see the product at a friend's house or if my doctor recommends it to me. Sometimes stores do demonstration days - I could imagine seeing it there.

Participant 2: At my GP I would like my doctor to recommend it to me or at a pharmacy. I wouldn't buy this product in a supermarket because it's an unknown product to me.

Participant 3: -

How much do you think this coaster is worth?
Participant 1: 100€
Participant 2: 50€
Participant 3: -

How much money would you spend on the coaster?
Participant 1: 100€
Participant 2: 80 € (I wouldn't buy it for 30 € because I would think the quality must be low)
Participant 3: -

Do you have a recommendation for a product name?
Participant 1: Trinki (drinky) or schluckschluck (sipsip)

Participant 2: Tankstelle, Oase, Wasserstelle in der Wüste, Trinki, My lifesaver, wasser marsch, feuerwehr, sunny (because of the lights)

Participant 3: -

Other remarks
Participant 1: -

Participant 2: I think both visualizations are essential. I need both information and they are both equally important to me. I wouldn't want to miss out on one of them.

Participant 3: Does it only work for water or can I drink other beverages?

Unexpected Events
Participant 1: -
Participant 2: -
Participant 3: User touched the felt surface which the device incorrectly detected as weight.

Interview Duration

Participant 1: 48 min
Participant 2: 1 h 6 min
Participant 3: 41 min

8.7. Informed Consent Form Extended Usability Study

Informed consent form - Extended Usability Study

You were invited to participate in a research study with the title "Improving the quality of geriatric life by managing water intake.". This study is being conducted at the Delft University of Technology by Tobias Strobel and supervised by Dr Elif Özcan and Dr Marieke Sonneveld.

Aim

The aim of this research is to understand the usability of a product that assists with water intake monitoring.

Procedure

The study is conducted at your home. You will be asked to test a prototype and provide information about your experience. The total time required is approximately 3 days and is divided into the following parts:

Day 1: Demonstration of the prototype and instructions to use (60 min)
Day 2: Testing the prototype (without the researcher present) (From waking up until going to bed)
Day 3: Semi-Structured interview about your expieriences with the prototype (30 min)

Privacy

By signing this consent form, you will be assigned a unique participant identification number. All information you provide during the study will be stored in anonymised form under this number to protect your privacy. The data collected will only be used for scientific purposes and will be published in a Master's thesis on integrated product design. At no time will information be shared outside of the research group by which you are personally identifiable.

The risk of a data breach is low but still possible. To the best of our knowledge and ability, your responses in this study will be kept confidential. By anonymising and storing your personal data separately from the study data, this risk will be minimised. After completion of the project, all materials containing personal data will be destroyed.

Participation

Your participation in this study is completely voluntary and you can withdraw at any time. You are free to omit any questions and you can request that your data be deleted at any time.

Contact

If at any time you have questions about the study or the process, please contact the study director Tobias Strobel (phone: xxxxxxxxx; mail: xxxxxx@student.tudelft.nl, or the supervising researcher Dr Elif Özcan (phone: xxxxxxxxx(Netherlands); mail: xxxxxxx@tudelft.nl).

Consent
Please indicate below whether you agree to participate in this study.
If you select "Yes, I agree to participate", this means that:

- you have read the above information or it has been read to you;
- you voluntarily agree to participate;
- you are at least 18 years of age.

If you do not wish to participate in this study, please decline by selecting "No, I do not agree to participate".

☐ Yes, I agree to participate

☐ *No, I do not agree to participate*

Items for explicit consent

Please tick the appropriate boxes	**Yes**	**No**
A: GENERAL CONSENT - RESEARCH OBJECTIVES, PARTICIPANTS' TASKS AND VOLUNTARY PARTICIPATION		
1. I have read and understood the study information or it was read to me. I had the opportunity to ask questions about the study and my questions were answered to my satisfaction.	☐	☐
2. I voluntarily agree to participate in this study and understand that I may refuse to answer any questions and may discontinue the study at any time without giving a reason.	☐	☐
3. I understand that participation in the study involves the following: ● Providing personal data (age, nationality, gender, place of residence). ● Testing a protoype and providing feedback. ● The study director takes notes on the most important information. ● The interview is recorded in order to have access to the contents of the interview that were not written down during the interview.	☐	☐
4. I understand that the study will take place in the span of 3 days. Meetings with the researcher occure on day 1 (60 min) and Day 3 (30min)	☐	☐
B: POSSIBLE RISKS OF PARTICIPATION (INCLUDING DATA PROTECTION)		
5. I am aware that the following steps will be taken to minimise the risk of a data breach and to protect my identity in the event of such a breach: ● All information is stored locally. ● Voice recordings and written notes are destroyed at the end of the project.	☐	☐

6. I am aware that personal data collected about me that can identify me, such as name and telephone number, can only be viewed by the study director and will not be passed on.	☐	☐
7. I am aware that the personal data I have provided will be destroyed after the completion of the project.	☐	☐
C: PUBLICATION, DISTRIBUTION AND APPLICATION OF RESEARCH		
8. I am aware that the anonymised data I provide will be used for the following purpose after the research study: ● Decision-making processes during a product development process	☐	☐
9. I agree that my answers, views or other contributions may be quoted anonymously in the research results.	☐	☐

Signatures

_____	_____	_____
Participant	Signature	Date

Contact person of the study for further information:
Tobias Strobel
Phone: xxxxxxxxxxxxxxx
Mail: xxxxxxxxxx@student.tudelft.nl

I, as the study director, have read the information sheet carefully to the potential participant and have made sure, to the best of my knowledge, that the participant understands what he/she is voluntarily consenting to.

Tobias Strobel_____	_____	_____
Study director	Signature	Date

8.8. Extended Usability Study Interview

What was your general experience with the product?
For people that are interested in how much they drink this product is ideal. For me I'm a person that doesn't really want to get involved with that topic. If I feel like drinking I drink, and if I don't feel like it I don't. Because of your research, I started drinking more. Sometimes I'm curious about how much I actually drink. I like that in the end of the day I saw that my fluid intake is not as bad as I thought.

What did you not like or find difficult?
I live on two floors. I can imagine carrying the product around might be something I wouldn't do. I had some trouble using the product. I wasn't quite sure what I was to do with the full and empty glasses. I wasn't able to grasp the correlation between what I put on the scale and what it displays. I was missing a detailed written manual. After your explanation, I forgot how to use the coaster. I had difficulties seeing the values without my glasses - they should be larger.

What remarks or questions do you have after using it for a day?
What happens if I spill water over the device? Because when people are ageing they get shaky and likely to spill something. When I woke up in the middle of the night I saw a bug sitting on the device - it was probably attracted by the heat.

Did you enjoy using the device?
It was quite a challenge for me to use the device especially because I forgot how to use it. In the end, my main thought was that I'm trying to be helpful in this study.

Interview Duration
21 min

Daria

hydration by intuition