WASH-E 2.0

Research and design of social machines and their impact on humans

Master's thesis in Interaction Design and Technologies

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CHALMERS UNIVERSITY OF TECHNOLOGY
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MASTER'S THESIS 2019

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ABSTRACT

Social interaction is something that comes naturally for humans, we are used to recognize and interpret faces, emotions, and behaviors. However, the use of social machines, as a way of improving the usage experience, is not a topic that has been commonly applied to daily life products. This thesis explores the idea of having a social washing machine with emotions and personality, inspired by a concept developed during the Designathon17, with the purpose of encouraging positive environmental behavior when doing laundry.

The thesis consists of two parts; first it focuses on a literature research, as a way to explore the topic and understand the implications of this type of products; and second on the concept design of a social laundry machine.

The literature research is divided in three main topics: Human Factors, Social Machines and Similar Cases. The main findings are based on two theories, first the idea that when a machine is perceived as having beliefs, desires and intentions it can contribute for a better product bonding; and that bonding can be used as a persuasive tool to encourage sustainable behavior. Within the most relevant findings were the social characteristics a machine should have (Fogg 2002), in order for these theories to be achieved, those characteristics are: physical, psychological, language, social dynamics and social roles.

For the second part of the thesis a new concept was developed based on key findings of the literature research. The process of this development involved two design iterations, including an expression test, a digital prototype, and a physical mock-up. The final design is a futuristic concept of a washing machine that includes the physical shape of the machine, the interface design with the basic function controls, the design of expressions through eyes and eyebrows, and the use of a smile as a level consumption indicator.

This thesis was carried out as an exploratory project within this topic of social machines. It is only a first step into this new way of interaction, and a lot of research and innovative design needs to be done to create a successful product. But it will hopefully be used as an inspiration for future projects of this type.

ACKNOWLEDGMENTS

This thesis was part of a two theses project, done in collaboration with Electrolux Professional, and would not have been possible without the help of several people that guided and supported me throughout the project.

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Thank you all.

Alejandra Torres Vazquez

CONTENTS

1 INTRODUCTION

We live in a time in which technological devices are present in many aspects of our lives, and with the use of new technologies, our interaction with them is continuously increasing. When designing a new product there are two main actors that need to be taken into consideration, the user and the product, but more importantly the interaction between them. Designers need to pay special attention to this interaction mainly because it has a psychological impact on people and it can negatively affect our ability to think, remember, pay attention, and regulate emotion (Wilmer et al. 2017), therefore this can cause a significant impact that can change the future of our society.

Interaction design is a crucial aspect of a product's design because it can influence both, the emotional state of the user and the way the product is operated. Good interaction design does not only anticipate user behavior, but also shapes it (Cao 2015). If designed correctly, this interaction can be used as a tool to positively influence behavior and provide a better experience for the user.

At the same time we are also facing a serious environmental problem in the planet. Some companies like Electrolux Professional are taking care of this issue by designing more sustainable products e.g. the greenhouse effect of Electrolux machines was reduced 31% from 2005 - 2017 (Dahlman 2018) by improving the performance of the machines. But by designing better interactions and giving the user better tools, it is also possible to influence the user's behavior to make more sustainable decisions.

It is known that human beings respond to things that seem alive in some way (Reeves and Nass 1996), so when computer products are perceived as social actors they can be a social influence to motivate and persuade the users, with this idea in mind, some research and development has been done around social machines and how they can have a more emotional impact on users. This can be achieved by applying social cues to make people infer social presence in a computing product; these cues can be physical, psychological, language, social dynamics, and social roles (Fogg 2002).

The purpose of this thesis is to research, explore and ideate about social machines and the behavioral influence they can have on people, all this in order to enhance the experience by making it more fun and enjoyable for the user, but also to contribute to the environmental sustainability of the planet.

The project is done in collaboration with Electrolux Professional, as a continuation of a concept developed during the Designathon17, carried out in Gothenburg, Sweden.

1.1 Research Question

Knowing that humans tend to be more emotionally attached to machines that somehow seem alive, and taking into consideration that this alive aspect in a machine can be achieved by the use of different characteristics from visual to more behavioral features, the following hypothesis has been made: *A social machine with personality can add to a more emotional attachment and therefore to influence people's behavior.*

With this in mind a research question has been stated:

"What characteristics a machine should have, in order to both provide a better user experience and to emotionally influence the user to make more sustainable decisions?"

1.2 Delimitations

Within the design field there are mixed opinions about different design terms, however in order to delimitate this thesis the following descriptions will be considered. Interaction design is a discipline that focuses on the interaction between a user and a product (Siang 2018), within interaction design there are other disciplines such as Human Computer Interaction, Human Factors, Industrial Design, User Interface Design, among others (Saffer 2009). And all of them are part of a larger discipline called UX Design (User Experience Design), which involves a wider scope including the interaction with the company, its services, and its products (Norman and Nielsen 2018).

An important part of the project is to understand the user from different perspectives and contexts, designing interactive products requires considering who is going to use them, how they are going to be used, and where they are going to be used (Preece 2011). The first part of this thesis consists on a literature research about the interaction between social machines and users, and the different aspects around it.

The literature research focuses on three main topics. First on *Human Factors* (emotions, behaviorism, psychology, cognition, etc.) to understand how the user thinks and makes choices. Secondly, on *Social Machines* to see the different characteristics a machine can have, in order to affect the user's behavior, and how they can be applied into a new machine. And third, on *Similar Cases* of interaction with social or non-social machines, considering robots, household machines, apps, etc.

The second part is about developing a concrete concept with all the acquired knowledge. The development considers different disciplines such as Industrial Design, User Interface Design and HCI. It focuses on designing key characteristics that make the machine be perceived as a social actor, those can include physical or digital features, personality, language, etc., always having in mind that social machines can enhance the user experience and contribute to sustainability.

Two main final results are defined. The first is a summary of key findings from the research around the interaction between social machines and users, describing briefly the theory behind and suggesting a way it can be implemented on physical machines for professional use. The second is a design concept of a social machine exemplified with illustrations, renderings, animations, etc., that describes the characteristics of the machine and that can be used as a starting point to make Electrolux Professional devices into social machines.

1.3 Stakeholders

It is important to identify the stakeholders involved in this thesis, to be aware of their needs and desires along the project. They can be divided into four main categories. The first category is related to the end users, since the thesis will be done with Electrolux Professional the users are mainly professional or semi-professional, that means they can be employees of hotels, restaurants, laundry service institutions, etc.; however it can also include household users that share machines for example in apartment buildings.

Another important stakeholder is Electrolux Professional, who has two main interests on the project, they want to provide great experiences with an added value to their customers, and they want to contribute to the environment. However, they are also a business that has different need and interests in terms of sales, marketing, future development, etc., aspects that also need to be taken into consideration.

Having in mind that Electrolux Professional does not sell to private users, a third group of stakeholders needs to be considered, which are companies that use the products within their businesses such as hotels, restaurants, tenants, laundry service institutions, etc.

Finally, another group of stakeholders is the people involved in this thesis project, from the academic side: the thesis author, the academic supervisor, the thesis manager and examiner. And from Electrolux Professional side: the supervisor, people involved in product development and the people that would wish to continue with this project in the future.

2

BACKGROUND

2.1 Research Area and Problem

The goal of this thesis project is to improve the interaction experience for professional users but also to influence the way a machine is operated in terms of technical and environmental functionalities. To achieve this, the hypothesis states that it is needed to first have a strong emotional bonding between the user and the machine and then to use that bonding to influence the user's behavior. This section deals with the different aspects of this interaction and explains the reasons of conducting this study.

User experience is defined as the overall experience of a person when using a product. It is important for companies such as Electrolux Professional to invest in improving these experiences because it not only benefits the customers but consequently delivers results for the company (Weisbach 2017). It also strengthens the loyalty towards the company which is translated into a more successful business.

Additionally, it is also necessary that users have conscious and responsible behaviors because their actions are directly related to the environment. Ham & Midden (2013) say, in their paper related to energy consumption of washing machines, it is always in the interactions with the user that CO2 is produced; this is why the behavior of users of technology is crucial in diminishing CO2 production effects. This means that a good interaction design not only benefits the user and the company's interests, but it is also crucial for reducing the environmental impact. For this, it is necessary to first educate the user about the potential consequences of their actions and then provide meaningful feedback along the interaction.

Creating an emotional bonding with the user is an important factor for having a better interaction. The interaction of humans with social artifacts that have aspects of personality and emotions is relevant when trust and sympathetic feelings are needed (Billard et al 2002). Social machines improve the interaction because they are perceived as social actors that understand and communicate in a humanlike way (Graaf et al 2014), so users can easily relate to them.

This emotional attachment obtained through making machines act as social actors, can be used as a tool to persuade the user to think and act in a more responsible way. Persuasion is a technique used in different fields, in the case of environmental behavior, the often used instruments are mass media campaigns, Ham & Midden (2013) explain that mass media campaigns may change attitudes related to energy consumption, but do not lead to significant behavior change and this is because they lack concrete information about the specific behavior that is to be changed. The purpose of including persuasion as part of this study is related to this last statement, it is not only about persuading behavior but also to provide the information and tools to achieve it.

2.2 Electrolux

Electrolux Professional develops, among other products, professional laundry systems. In the aim of lifting professional laundry to a next level, they organized the challenge Designathon17 where different teams came up with innovative ideas about the future of laundry. One of those ideas was to make Wash-E (see Figure 1), a washing machine that has personality and emotions. It measures energy and chemical consumption, and its emotions change depending on the environmental decisions the user makes.

Figure 1: Wash-E design and prototype, developed during the challenge Designathon17.

Electrolux Group purpose is to "create desirable solutions and great experiences that enrich people's daily lives and the health of our planet" (Electrolux Group 2018) this means they want to provide better experiences for the user but at the same time inspire people to make more sustainable choices. That is the main reason why the idea of making a social machine with personality was very appealing for Electrolux Professional, because it can be used as a tool to both influence users to a more sustainable behavior, and create a better experience of use.

With this in mind they decided to continue developing it further as two theses projects. One is this thesis that has a theoretical approach of the topic, concluding on listing the different findings and developing an initial concept of how they can be applied. And in parallel another thesis is performed where the initial idea is implemented and evaluated in a prototype. The two theses intend to contribute with each other and share relevant information between them along the process.

3

LITERATURE RESEARCH

As previously mentioned, the literature research is focused on three main topics: human factors, characteristics of socials machines and similar cases. This section describes each of the topics, together with related concepts and theories.

3.1 Human Factors

In this section the human factors around this topic are described, these factors are focused mainly on human cognition, which include decision-making process, the role of emotions and information processing; as well as different types of personality users can have.

The diagram in Figure 2 explains how a human-computer interaction works, where the machine displays some information that goes to the human through his senses, and then he processes that information and takes a decision that comes back to the machine through controls. The main goal of the project is to understand how to design the displays so they can create a stronger emotional connection between the user and the machine, and then turn that into persuasion to make the user take more sustainable decisions. For that reason, the understanding of how people think and make decisions is crucial for this study.

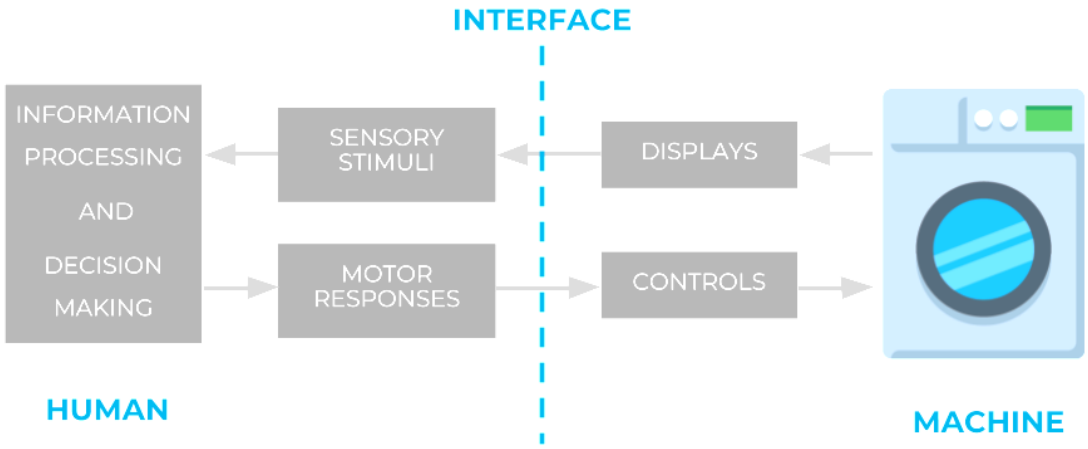

Figure 2: Human-machine interaction, based on MacKenzie (1995) diagram.

3.1.1 Human cognition

Cognitive psychology is the study of human mental processes, which includes the study of how people perceive, learn, remember, and think (Sternberg & Sternberg 2012). A big topic within cognitivism is cognitive neuroscience; it is a field that studies how people process information that ultimately leads to behavior, by analyzing the link between the brain and the nervous system.

The brain is the organ that controls thoughts, emotions and motivations (Sternberg & Sternberg 2012); but at the same time it gets influenced by the other organs of the body. In other words, the information that is perceived by different organs of the body shapes the way the brain works (information processing) but at the same time it controls what organs do the other way around (decision-making).

The study of cognitive psychology is crucial because it studies cognitive processes such as information processing and decision-making, which are the core processes of the interaction between the user and the machine. In order to design a product that truly connects emotionally with the user, it is important to be aware of how the human brain works, how it perceives and process information, how it takes decisions that turn into behavior and how emotions influence these processes. This study is the base for defining what information to present and how to present it to the users, so their behavior can be influenced.

3.1.1.1 Information processing

In order to understand how information processing works it is necessary to first describe perception. Perception is a process where the brain takes stimuli from the environment interpreting and giving meaning to it. In their book Sternberg & Sternberg (2012) describe this process, according to James Gibson framework, defining that it has four main elements: the distal object (object in the external world), an informational medium (information the object emits), proximal stimulation (information perceived by senses), and the perceptual object (perception of the object in the brain).

After the information is perceived then it is processed in a cognitive level. This processing is based on three things: what we sense (the sensory data), what we know (knowledge stored in memory), and what we can infer (using high-level cognitive processes) (Sternberg & Sternberg, 2012). With this, the user can understand the situation, evaluate it and then come to a decision.

3.1.1.2 Decision-making process

The decision-making process can be understood as the process of choosing between different alternatives on the basis of given criteria or strategies (Wang & Ruhe 2007). The process is divided into two major topics, one concerned primarily with choice among competing actions and the other with modification of beliefs based on incoming evidence (National Research Council 1998). According to the "Subjective expected utility theory", when making a decision people try to maximize pleasure and minimize pain, it also suggests that this process is totally subjective, where people consider aspects of utility and probability to make decisions (Sternberg & Sternberg 2012).

It is difficult to consider all the alternatives when making a decision, so in order to make that process easier people make use of heuristics, which are mental shortcuts that ease the cognitive load of making a decision, they can also be seen as filters that reduce the number of options

based on different parameters. The most commonly used heuristics in decision making are: satisficing, eliminations by aspects, representativeness heuristics, availability heuristics and framing (Sternberg & Sternberg 2012).

People normally use the satisficing heuristic where they choose the first minimally acceptable option, but this is only useful for quick and not so important decisions. For more thoughtful decisions people use a process of elimination by aspects, where they eliminate alternatives by focusing on key aspects of each alternative, one at a time. Another heuristic is representativeness where people assume that a sample of something represents the whole thing. The availability heuristic is used when people make choices using information that is easily available in their memory. The anchoring and adjustment heuristic is related to availability and is used when people take an aspect as an anchor and adjust their thinking according to that. Finally, framing is when people choose a small but certain gain over a larger but uncertain one, unless the uncertain gain is much greater.

After the decision is made people often encounter different biases that affect the outcome, the three main biases are: illusory correlation, overconfidence, and hindsight bias (Sternberg & Sternberg 2012). Illusory correlation is about people considering two things to be correlated even if they are not. Another common, and maybe the most serious, bias is overconfidence where people overestimate their own skills, knowledge or judgement. And finally, hindsight bias is when people look at situation in retrospective and think they could have easily predicted the outcome of that situation.

The National Research Council (1998) talks about judgmental errors in decision making, which are another version of the biases previously described. However, it also mentions that the outcomes of a situation are often evaluated in comparison with others, so it considers regret and disappointment as other types of biases. Regret refers to the comparison of an outcome with what could have been received under another choice and disappointment is when comparing with a more fortunate outcome (National Research Council 1998).

3.1.2 Personality types

When making a decision, a very important factor is personality, because depending on the type of personality the decision-making process can differ in multiple ways, such as risk-averse versus risk-seeking attitudes, optimistic versus pessimistic opinions, passive versus aggressive inclinations, rational versus irrational thinking, impulsive versus compulsive tendencies, and expert versus novice abilities (National Research Council 1998). The different types of personalities can be explained by the five factor model of personality, also known as "The Big Five", developed by Goldberg (1993), which includes five two-edges span dimensions: neuroticism, extraversion, openness, agreeableness and conscientiousness (see Figure 3).

Figure 3: Big Five Personality Diagram (Tunikova 2019).

Rothmann & Coetzer (2003) describe these dimensions as following:

- *Neuroticism* is the tendency to experience negative emotions such as fear, sadness, embarrassment, anger, guilt and disgust; high neuroticism is a risk of a psychiatric problem, whereas low neuroticism is an indication of emotional stability.
- *Extraversion* includes characteristics such as sociability, assertiveness, activity and talkativeness; extraverts are known for being energetic and optimistic, while introverts are reserved, independent, and even-paced.
- *Openness* includes active imagination, aesthetic sensitivity, attentiveness to inner feelings, a preference for variety, intellectual curiosity and independence of judgement; people with low openness tend to be conventional and conservative, while people with high openness tend to be unconventional, willing to question authority and prepared to entertain new ethical, social and political ideas.
- An *agreeable* person is normally altruistic, sympathetic to others and eager to help them; in contrast a disagreeable person is egocentric, skeptical of others' intentions, and competitive rather than co-operative.

- *Conscientiousness* refers to self-control and the active process of planning, organizing and carrying out tasks; high conscientiousness may lead to annoying fastidiousness, compulsive neatness or workaholic behavior, while low scorers are less exacting in applying moral principles.

This model is used to define people's personalities and then adapt the information that is presented accordingly e.g. some companies use this to personalize information in social media to change people's behavior. For this project it is very important to understand this, because it deals with a more psychological interaction that each user will experience differently. So this model is good not only for analyzing user's personalities, but also for creating a machine's personality that is compatible with the users.

3.2 Social machines

This thesis is based on the hypothesis that social machines can have more influence over the user than common machines. To prove this, there are two main concepts that need to be considered; first the idea that a machine is perceived as social when the human believes the machine has beliefs, desires and intentions (Breazeal & Scassellati 1999), and therefore it can turn into social bonding. And the second that suggests this bonding can be used to influence the user to make better and more sustainable decisions.

These two concepts are related to each other in a consequential way. Persuasive technology is a topic that considers both of them because it states that social products persuade by giving a variety of social cues that elicit social responses from their human users (Fogg 2002). These social cues can be seen as the different characteristics a machine should have to create an emotional attachment with the user. The identification of these characteristics is the main focus of this research study.

3.2.1 Bonding

3.2.1.1 Human bonding

In order to understand how humans can have an emotional attachment with machines, it is important to first study how human bonding works. Humans are highly motivated by the need of belonging, it is considered to be a powerful, fundamental, and extremely pervasive motivation. Also it is known that the need to belong shapes emotion and cognition, because it intensifies the emotional responses of people towards others. Therefore it can be assumed that emotions regulate behavior in order to form and maintain social bonds (Baumeister & Leary 1995).

People tend to naturally bond with other people, it is considered to be not only something they want but a basic need, also it has been proven that humans have a strong desire to form and maintain enduring interpersonal attachments. People are so strongly inclined to form social relationships that there is not necessarily a motive behind them, they arise quite spontaneously and people spend a lot of time and effort on them (Baumeister & Leary 1995).

When designing a new product it is of high importance to be aware of the ethical consequences it might have. In this project in specific, which considers the use of emotions as a behavioral tool, it is crucial to know the impact of this bonding during the interaction as well as in case of terminated. Therefore, it is important to know that once this bonding is formed, people seek for frequent, positive and pleasant interactions that are free from conflict, and they want to make sure that bonding will continue in a long term. If that bonding is broken it will lead to ill effects but people will recover best if they form a new one (Baumeister & Leary 1995).

3.2.1.2 Human-machine bonding

Product attachment is about the emotional bond a consumer experiences with a product. In his paper, Page (2014) mentions that this attachment can be formed through three levels of involvement: the appearance or aesthetics of the product, the pleasure of effectiveness of the product when used, and the personal satisfaction when using the product. He also encourages designers to make use of seven determinants to create attachable products: enjoyment, self-identity, memories, life vision, utility, reliability and market value.

Although there are many determinants that can produce attachment with products, it is difficult for a designer to predict what will be effective. However, one of the first goals should be to achieve enjoyment and pleasure because they are the primary reason for attachment to newly purchased items and since the way of interaction is completely different, the first impressions of the product are crucial. If this is successfully achieved, over time it will be transformed into nostalgia and the users will feel a stronger and meaningful bonding with the product. Another way of creating emotional attachment, is when the machine stimulates social contact by allowing it to be used by multiple people, because it can create shared fond memories that will turn into associations of happiness (Page 2014)

People tend to react to machine systems in a similar way as with humans (Midden 2015), because when they perceive social presence, they naturally respond in a social way (Fogg 2002). This connection is achieved when the product meets user's desires of aesthetics and functionality; but it is only when a product is performing better than others that the attachment will occur (Page 2014). So if these characteristics are achieved, it is very probable that the user will create a strong emotional bonding with the machine.

3.2.1.3 Anthropomorphism

Anthropomorphism is a very relevant topic for this research because it talks about how nonhuman things can be perceived as social actors. It can be described as the "attribution of human characteristics or behavior to a god, animal or object" (Oxford Dictionary). Anthropomorphism goes beyond the perception of behaviors or actions of nonhuman agents, it represents their mental or physical characteristics using humanlike descriptions (Epley, Waytz & Cacioppo 2007) in other words it is not only about how humans perceive nonhuman things but what they attribute to those things in terms of physical, mental and emotional characteristics.

In an attempt to understand the reasons behind anthropomorphism and to predict when humans will treat nonhuman agents as humanlike or not, Epley et al (2007) proposed a framework that includes three psychological determinants: elicited agent knowledge, effectance motivation and sociality motivation (see Figure 4). Elicited agent Knowledge is about how much knowledge the person has access to and can apply to the nonhuman agent. Effectance motivation is used to understand and control other agents. And social motivation is the need of social contact and attachment.

Categories of independent variables	Key psychological determinants		
	Elicited agent knowledge	Effectance motivation	Sociality motivation
Dispositional	Need for cognition	Need for closure, desire for control	Chronic loneliness
Situational	Perceived similarity	Anticipated interaction, apparent predictability	Social disconnection
Developmental	Acquisition of alternative theories	Attaining competence	Attachment
Cultural	Experience, norms, and ideologies	Uncertainty avoidance	Individualism and collectivism

Figure 4: Key psychological determinants (Epley et al 2007).

For his research in particular, the most relevant determinant of this framework is the social motivation, since the goal is to make people have a social connection and attachment to the machine. Epley et al (2007) propose that anthropomorphism can increase the usefulness of technological agents by creating social bonds; they also explain that these bonds can be facilitated by the use of morphologically human features. However, it is also important to take into consideration the other two determinants when designing a social machine, because it affects the cognitive perception of the person using it.

Normally, anthropomorphism increases when people feel a lack of social connection and decrease when they feel a strong sense of social connection. Therefore, it is important to be aware of the ethical implications that this types of machines can have, because it is proved that people tend to judge nonhuman agents the same as they do with other humans. Also, people can feel more attracted to these types of machines than to other humans because they have control over them and they can get more satisfactory outcomes (Epley et al 2007).

3.2.1.4 Characteristics of social machines

It is important that the user responds to the machine in a loving and nurturing way, and build a relationship with it, rather than perceiving it as just something artificial, which are the two ways people normally react to social machines according to Graaf, Allouch & Klamer (2014). For this, there are different characteristics and social cues that a machine can have in order to be perceived as a social actor.

First of all, the machine should convey intentionality, meaning that it must make the user believe it has beliefs, desires and intentions. Also it must have ways of expressing its internal states and show consistency around them, with certain flexibility when dealing with unexpected events (Breazeal & Scassellati 1999). All of this to show the machine has an autonomous individuality displayed through its design and behavioral configuration (Graaf, Allouch & Klamer 2014)

Normally, humans convey intentionality through their gaze direction, posture, gestures, vocal prosody, and facial displays (Breazeal & Scassellati 1999). In this case, there are specific social cues that a machine can have to convey intentionality and social presence, Fogg (2002) proposes five of them (see Figure 5): physical, psychological, language, social dynamics, and social roles.

Cue	*Examples*
Physical	Face, eyes, body, movement
Psychological	Preferences, humor, personality, feelings, empathy, "I'm sorry"
Language	Interactive language use, spoken language, language recognition
Social dynamics	Turn taking, cooperation, praise for good work, answering questions, reciprocity
Social roles	Doctor, teammate, opponent, teacher, pet, guide

Figure 5: Types of social cues (Fogg 2002).

3.2.2 Persuasion

3.2.2.1 Roles of technology in human behavior

In order to understand how persuasive technology works, it is first necessary to know how technology shapes human behavior and decisions. For this, Midden (2015) describes four roles of technology regarding human behavior, where technology can be used to reduce the environmental impact. These roles are:

- *Intermediary role*, where the environmental effects depend on the type of technology applied e.g. an old washing machine versus a modern high-efficient one. In this case, the behavioral decision relies on when to change the washing machine for a new one, considering that the disposal of the old one also has an environmental impact.
- *Amplification role*, this is about how technology amplifies the effect and scope of human behavior, but at the same time this can cause more consumption.
- *Determinant role*, by which technology shapes human behavior without requiring awareness from the user e.g. sliding doors.
- *Promoter role*, by which technology helps to encourage sustainable behavior.

In this case Electrolux Professional has been doing a good work in the intermediary role, where they managed to reduce the greenhouse emissions from 2005 to 2017 by 31%, among other results stated in the Electrolux Sustainability Report 2017 (Electrolux Group 2018). And now their aim along with the purpose of this thesis is to develop a machine with the promoter role, so it can provide the necessary tools to the user, for making more sustainable decisions.

3.2.2.2 Persuasive technology

Persuasion is an inter-human activity used to convince other people of something specific, it makes use of argumentation, praise, reciprocity, norm activation, authority and trust as social mechanisms. When incorporating persuasion into machines or computer systems, Midden (2015) talks about two types of biases that can be used to persuade the user: de-biasing and counter-biasing. De-biasing is the one that triggers the rational system and make the user decide based on risk awareness. Counter-biasing, on the other hand, aims to trigger the impulsive system to make more quick decisions. For this project in particular, the focus should be on the de-biasing because it aims for a more conscious decision and awareness of the environmental impact; however, it should also consider the counter-biasing as a tool to make more impulsive and easier environmental choices.

Persuasive technology has been used and studied for a long time, and different techniques to promote behavior change have been found. Those techniques include feedback, reward, goal setting, prompting, and norm activation (Midden 2015). If those techniques of persuasive technology are applied to social machines the results are often more effective even compared to human persuasion. The integration of the social aspect can open the door for more social dynamics, the same way humans interact with each other; these dynamics include normative influence (peer pressure), social comparison, group polarization and social facilitation. Therefore, the user will tend to respond to the social machine as an entity with principles of motivation and influence (Fogg 2002).

One of the main techniques of persuasion in social machines is the use of feedback; it can be used as positive or negative. However, negative feedback leads to more conservation actions

when it comes to sustainable behavior, because it normally draws more attention and is processed more intensely by the user. Also it has been found that negative feedback from social machine is less threatening and leads to more constructive decisions than using positive feedback only (Midden 2015).

Specifically talking about sustainability e.g. energy consumption, sometimes the feedback is too complex for the user to process it in an intuitive way and that can cause the user to ignore the presented feedback. Therefore, it is necessary to provide the user with feedback that requires less cognitive effort and attention. To achieve this Midden (2015) also suggests the use of ambient feedback such as changes in form, movement, sound, color, smell or light can provide a more subtle influence.

The idea of using social machines as persuasive actors can be a very good solution to reduce the environmental impact of household appliances, because it can offer the user advice and feedback in real time, with the precision and consistency that a human agent would not be able to. However, trustworthiness of the machine as a being and avoiding annoying behaviors (Midden 2015), are the key factors for a successful product of this type.

3.2.2.3 Social characteristics used for persuasion

By nature, human beings tend to respond to social cues especially from things that seem alive. As mentioned before, there are specific social cues that make a machine be perceived as a social being, these characteristics can trigger automatic responses in the user, which can provoke feelings of empathy or anger, or can make the user engage with social dynamics, and that can be used for persuading the user into certain behavior. The five social cues proposed by Fogg (2002) physical, psychological, language, social dynamics, and social roles, are explained in this section from a persuasive point of view.

Physical: It has been proved that a humanoid face and body can enhance persuasiveness of technology and it can create more trust with the machine (Midden 2015). If these features are physically attractive they can be more effective in social influence (Fogg 2002), this is because of a psychological effect where people tend to assume physically attractive people have better qualities (Fogg 2002). But of course, attractiveness varies between people, culture or generation, so this is something that has to be evaluated when designing the physical features of the social machine.

In spite of the attractiveness, these characteristics do not have to be extremely human-like to have an influence over the user. In his study, Midden (2015) also found that social machines that unobtrusively mimicked the user's movements tended to be more trusted than non-mimicking agents.

Psychological: When computers are perceived to have a psychology they can motivate through conveying emotions, they can apply a form of social pressure or they can negotiate with people and reach agreements. The use of psychological cues are effective for persuasion when the user perceives the machine has a personality, emotions and other attributes that are similar to theirs. This is based on the idea that people that are similar to us can motivate and persuade us more easily than people who are not (Fogg 2002).

In his study Fogg (2002) and his team designed types of computer "personalities", one dominant and the other submissive, based on "The Big Five" (Goldberg 1993), personality dimensions. When testing both computers it was found that the dominant computer was perceived as more confident than the submissive one; however, participants preferred working with a computer they perceived to be similar to themselves in personality style.

This type of psychological cues can be very effective but they have to be designed carefully. If the machine shows behavior that is incompatible with human behavior, the persuasive effect can be compromised (Midden 2015).

Language: Language in a social machine can be a very effective tool for persuasion, but if its personality does not fit the users or if the machine has an inadequate behavior it will affect its acceptance. One of the best ways to use language as a persuasive tool is by using praise. A study showed that people responded significantly more positively after being praised by the computer via texts when making a contribution to the computer's database (Fogg 2002).

Social dynamics: Applying social dynamics to social machines can contribute to a more effective persuasion because, for instance, they can apply peer pressure to the user, or they can make use of reciprocity i.e. the social rule of paying back in some way after receiving a favor (Fogg 2002).

Social roles: When a machine has a social role it can influence the user in different ways, for example by playing a role of authority, a computer can become more influential (Fogg 2002) but also having a machine similar in authority can lead to more acceptance. To make a machine play a social role is something that needs to be chosen carefully because not every person is different, and a role that can work for some people might not be that effective for others.

3.3 Similar cases

3.3.1 iCat robot

In the paper "A persuasive robot to simulate energy conservation" (Ham & Midden 2013) an experiment is described where a social robot was used, this robot is called iCat and was manufactured by Philips Corporation. The robot has the shape of the head of a cat, and can move its eyebrows, eyelashes, eyes, and lips, and play speech files and thereby show social expressions, see Figure 6. Its main purpose is to provide positive and negative feedback about energy consumption of a washing machine, through the use of these facial expressions. The paper concludes that people are more sensitive with this type of social feedback and are more likely to diminish energy consumption. However is also suggests that negative feedback might have a more persuasive impact over positive feedback, because in some cases the results showed that positive feedback might even encourage users to decrease their energy saving and start using more electricity.

Figure 6: Design of the iCat Robot (Ham & Midden 2013).

3.3.2 Save the day application

An example of how persuasive technology can influence behavior by providing useful tools is the concept application "Save the Day" (Røsok 2014). It is described as a collaborative competition to

save energy, where the user can join a group to collaborate with. The purpose of the competition is to save as much money and energy as the group can. The system provides a visualization of the energy consumption in a household (see Figure 7) that is also compared with the energy usage locally, this visualization is intended to help the consumer take control over the usage and reduce it when needed.

The study resulted in the conclusion that the majority of participants think this type of application would help motivate them to reduce their energy consumption. However, even when the visualization made them more aware of their consumption, they would only change their behavior if this meant making small adjustments to their usage. It also says that in order to prove if the application would lead to behavioral change in people's energy consumption, long term testing on a working prototype would be needed.

Figure 7: Visualization design of the Save the Day Application (Røsok 2014).

3.3.3 DooBoo: Pet-like interactive electric vehicle dashboard

This concept was born from the need of a more emotional user experience between a driver and a vehicle. The concept consists of an interactive dashboard for an electrical car that has the personality of a pet. DooBoo has a mobile display and a white, round-shaped tentacle; the display is used for showing basic vehicle information and the facial expressions of DooBoo, whereas the tail-like tentacle expresses the emotions in a physical way (see Figure 8). As part of the design exploration, the concept was focused on four characteristics that helped to apply key interaction features of a pet-human relationship, those characteristics are: providing emotional rapport, personalized attachment to the owner, delightfulness from active behaviors, and serving utilitarian purposes (Row et al 2016).

After testing the prototype, DooBoo was proved to be perceived as a "pet-like soul embedded in the vehicle" and "felt similar to actual passenger sitting next", it also contributed to have a more emotional attachment. However, there are still aspects to consider before implementing a concept like this, firstly the safety issues that it might bring because it can attract too much the driver's attention, but also the psychological effect that such digital pet can bring.

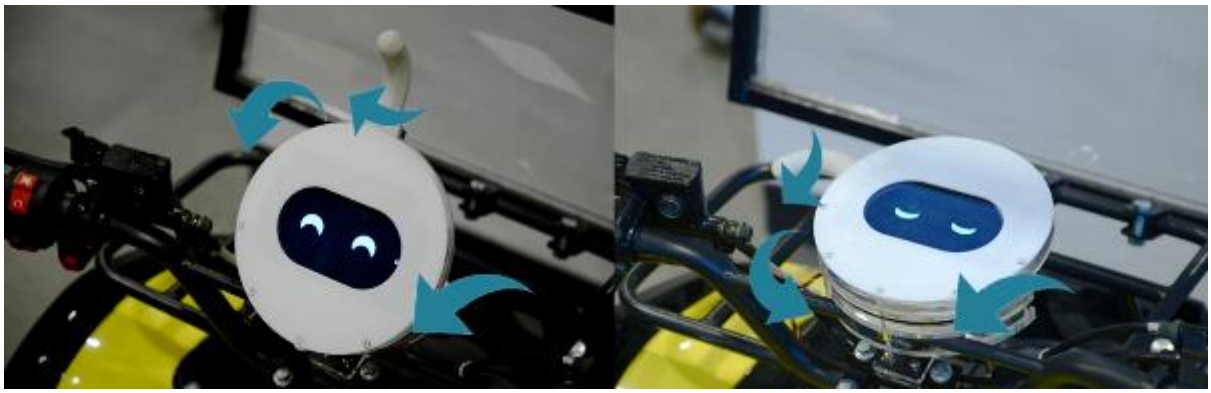

Figure 8: DooBoo prototype (Row et al 2016).

4

METHODOLOGY

Conducting research through design is not the same as typical scientific research because design is used to generate ideas rather than used to compare or refute theories (Gaver 2012). This thesis has a strong focus on researching and collecting relevant theories, however the overall purpose is to explore and design a good concept that can inspire or be applied to Electrolux Professional products.

As mentioned before, the project is divided in a research phase and a design phase. In between the phases, a summary of findings from the research phase was developed as suggested by Wadsworth (2011), along with constant meetings to define and inform about the progress of the project. In order to develop this thesis project, different methods and frameworks were used, which are described in this section.

4.1 General framework

This project is focused mainly on research and an initial ideation, therefore the general framework used was the Double Diamond Model, represented in Figure 9, which was developed by the British Design Council. This model follows the creative process of divergent and convergent thinking that is represented by a diamond shape; but in this case it proposes that it happens twice, where the first diamond helps to define the problem and the second one to create the solution (Design Council 2015). In other words the first diamond is to know if we are "designing the right thing" and the second to "design things right" (Nessler 2016).

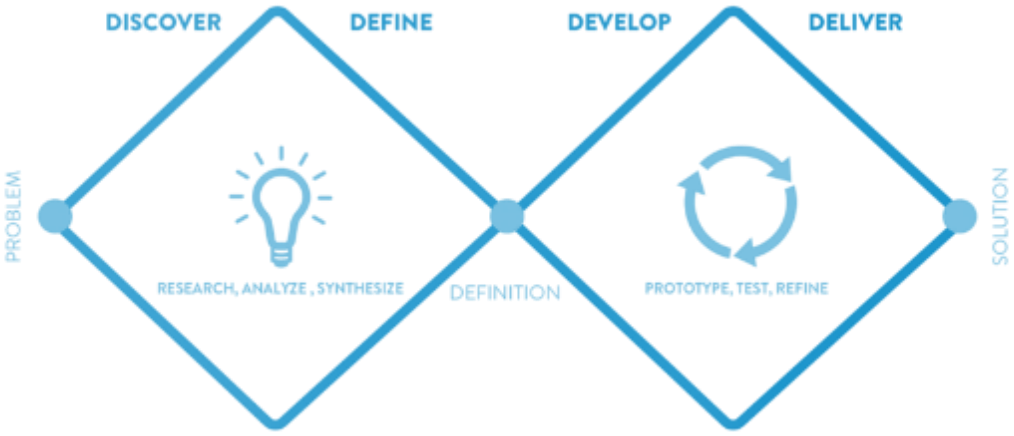

Figure 9: Double Diamond Model developed by the British Design Council (2015)

The model consists of four main phases of the design process: discover, define, develop and deliver. Considering the duration of the thesis and the strong focus on research, the project involves only the first three phases of the model. Starting with an initial idea of what could be done, going into the first diamond researching and exploring the topic, then defining the

problem and proposing "how might we" (Nessler 2016) proceed to create the solution, here the list of findings is defined. Finally, concluding with an early ideation within the development phase.

The Double Diamond Model (Design Council 2015) previously defined is the overall framework process of the thesis project and within each stage different methods are applied, which are followed defined.

4.2 Literature research methodology

In the research phase of the thesis, the overall used method is called the Seven-Step Model (Onwuegbuzie & Frels 2016) and it includes:

1. Exploring beliefs and topics
2. Initiating the search
3. Storing and organizing information
4. Selecting/deselecting information
5. Expanding the search to include one or more MODES (Media, observation(s), documents, expert(s), secondary data)
6. Analyze and synthesize information
7. Present the CLR (Comprehensive Literature Review) report.

With this method the literature review is not only considered as one step of the many steps in the design process, but rather viewed as an embedded study by itself (Onwuegbuzie & Frels 2016), included in the first diamond of the Double Diamond Model (Design Council 2015).

4.3 Summary of findings

In order to have a good summary of findings that can be understood by the different stakeholders, Wadsworth (2011) suggests a way for approaching this process that consists on the following steps:

1. What we want to achieve
2. Who we want to tell
3. Why we want to tell them, and
4. How to convey our findings.

This method is a good way to clarify the story that will be told about the project findings. It is not only relevant between the two phases of the thesis but also at the end, as a way to summarize the thesis results.

4.4 Concept development methodology

For the second stage of concept development different methods were applied.

4.4.1 Design thinking process

The methodology of design thinking is used to solve complex design problems "by understanding the human needs involved, by re-framing the problem in human-centric ways, by creating many ideas in brainstorming sessions, and by adopting a hands-on approach in prototyping and testing" (Dam & Siang 2018). It consists of five stages: empathize, define, ideate, prototype, and test (see Figure 10). This process was used in the concept development phase of the project to come up with a solid idea with a human-center approach; however, the prototyping and test stages were only initially developed, as planned from the beginning.

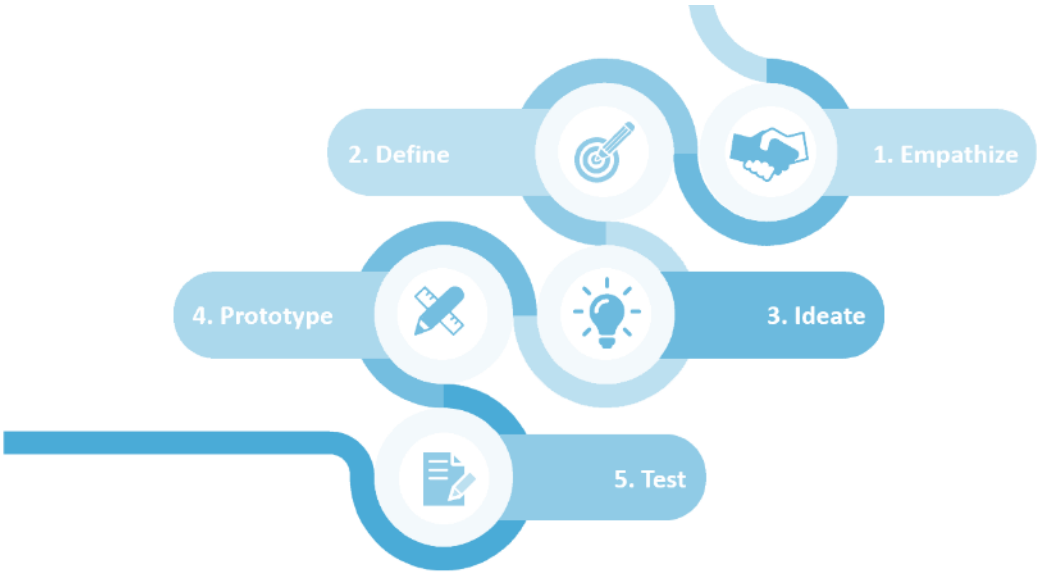

Figure 10: Design thinking process (Everest Group 2017)

4.4.2 Problem definition

As part of the define stage in the design thinking process, the problem was defined by using several statements taken from the collected insights. Based on that, different *design requirements* were established to be used as a guide in the ideate stage. And finally the *target user* and *context of use* were defined to have a clearer idea of how the product would be used.

4.4.3 UX over time

For designing the whole experience, the method "UX over time" (Karapanos et al 2009) illustrated in Figure 11 was used. The method suggests three phases guided by three main forces: an increasing familiarity (Orientation), functional dependency (Incorporation) and emotional attachment (Identification); which alters the way individuals experience a product over time. This method is particularly relevant because an important factor to make the user have emotional attachment with the machine is to build a relationship between the two of them through a considerable period of time.

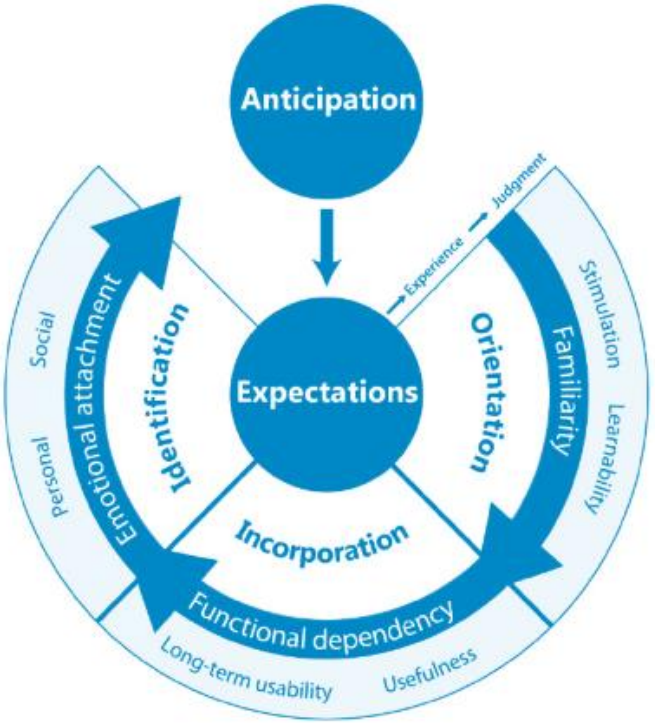

Figure 11: User Experience over time model (Karapanos et al 2009).

4.4.4 Interviews

In this project interviews were conducted twice, first in the research phase to get insights from the Electrolux managers, and secondly one-on-one interviews after the expression tests to let the participants explain their answers and make some more following questions or comments. None of the interviews were structured but they were planned regarding the topics that should be covered.

4.4.5 Literature findings to concepts

In order to make sense of the information and insights founded during the research phase, and to translate them into concepts, a self-made method was used. The method consists of writing several questions about thoughts that research findings raised, and then try to answer those questions with innovative ideas about specific aspects of the project.

4.4.6 Brainstorming

The method of brainstorming is used to generate novel ideas by stimulating the brain into thinking about issues in a new way, while encouraging originality and imagination (Arivananthan 2015). It is normally done in a group where the participants express their ideas in a spontaneous way. In the case, as it is an individual project, a similar session of ideation was conducted but in a more introspective way and taking into consideration the questions of the previous method. From there, three specific concepts were generated.

4.4.7 Journey map

A user journey map is a visualization of the experiences people have when interacting with a product or service, so that each moment can be individually evaluated and improved (Martin & Hanington 2012). Initially this method was used to visualize and analyze the whole washing/drying process, and later in the ideation phase it was used to determine the expression and reactions of the machine in every step of the usage process.

4.4.8 Concept sketching

Sketching is used for creating fast freehanded drawings of numerous ideas (MediaLAB Amsterdam). In this project it was used to ideate different physical shapes of the washing machine, based on the concepts developed in the brainstorming section, as well as the graphical design of the expressions and displays. It was used several times in the ideation stage.

4.4.9 3D Modelling & Rendering

In design, 3D modelling is used to explore and iterate design ideas (Autodesk Design Academy); it is a good transition between a sketch and a more realistic view of the physical design. For this project, it was used together with renders, not only to exemplify the idea in a visual way, but also to define the dimensions of the machine and its displays, to know how to place and define the expressions and controls.

4.4.10 Expressions test & Confusion matrix

Once the expressions of the machine were defined, it was important to test if they expressed what was intended. For this, the expressions were made as GIFs and tested with different

participants in an individual way. The participants were presented with a confusion matrix, inspired by the work of Kevin Byrne (1990) were they had to compare the expressions GIFs with different adjectives and rate them accordingly.

4.4.11 Mock-up

Normally a mock-up is an early prototype made of cardboard or low-fidelity materials, and it is used to get feedback of users about functionality/usability/understanding of the basic design idea/etc., by imagining that it works and testing it (Papantoniou). In this project, it was used to test the ergonomics, the placements of the displays, the size of the controls, the dimensions, etc.

4.4.12 Digital scenario

Prototyping is the tangible creation of artifacts at various levels of resolution, for development and testing of ideas within design teams and with clients and users (Martin & Hanington 2012). However, the prototype developed in this project was not a functional prototype but rather a digital scenario showing the different display steps in the washing process. It was used to exemplify the final concept in a more tangible way.

4.5 Innovation Model

From a more holistic perspective, this project intends to be the base of a meaningful innovation within the Electrolux Professional business. In order to create innovation it is necessary to integrate the needs of people, the possibilities of technology, and the requirements for business success (Brown 2009). Considering IDEO's innovation model, see Figure 12, the research of this work contributes directly to the human context and at the same time adding value to the business. Using this as the base for further development, where technology and a business strategy will be needed, Electrolux Professional can be nudged to integrate a new business idea into the company that can place them in a blue ocean market with a competitive advantage.

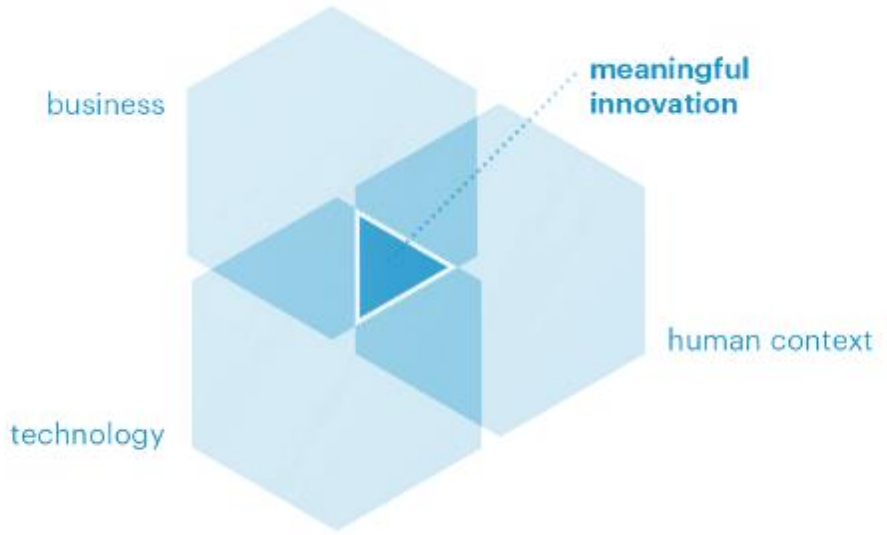

Figure 12: Innovation Model developed by IDEO

5

PLANNING

The initial plan of this thesis is exemplified in Table 1: Time Plan, where approximately half of the time was intended for literature research and the second half for concept development.

Week	Date	Activity	Additional description
5	Jan 29 - 2	Thesis proposal & Start-up meetings	
6	Feb 5 - 9	Planning report & Start-up meetings	
7	Feb 12 -16	Planning report	
8	Feb 19 - 23	Planning report & Electrolux visit	
9	Feb 26 - 2	Analysis of Electrolux business model & initial research on human factors	
10	Mar 5 -9	Research on human factors	
11	Mar 12 - 16	Research social machines	
12	Mar 19 - 23	Research on similar cases	
13	Mar 26 - 30	Research on technology & society	
14	Apr 2 - 6	List of key findings and half-time presentation (Electrolux)	Half-time presentation April 3rd
15	Apr 9 -13	Problem definition and personas	Types of personas, user scenarios, etc.
16	Apr 16 - 20	Development of initial concepts	Ideation
17	Apr 23 - 27	Iteration and evaluation of initial concepts	Development of material for evaluation
18	Apr 30 - 4	Iteration and evaluation of initial concepts	Evaluation of different solutions
19	May 7 - 11	Development of the final concept	Refine concept with evaluation findings
20	May 14 - 18	Visualizations	Illustrations and visuals for final presentation
21	May 21 - 25	Report writing	
22	May 28 - 1	Report writing	
23	Jun 4 - 8	Report writing	
24	Jun 11 -15	Presentation	

Table 1: Time Plan

6

CONCEPT DEVELOPMENT

Following the design thinking process mentioned in the methodology section, a conceptual washing machine was developed. This section will describe the steps used to develop that new concept, as well as a description of how the key findings of the literature research are translated into design ideas. Two main iterations are described in this section, which lead to the final design explained in the Results section.

6.1 Problem definition

6.1.1 Problem statement

The description of the design thinking process developed by Andrews (2017) of the Drawbackwards, says the "Define" step is used to "define the primary problem or pain point the user is experiencing and what needs to be fixed". In order to have a clear vision of what has to be done, this step of the design process was used to explore and identify different problems that users are experiencing with both, the current Electrolux Professional machines and multi-housing washing machines in general. Based on insights from Electrolux managers and people involved in developing new products in the company, and on personal experience, the problem was defined with the following statements:

- Users don't always know how to optimally operate the products.
- Users don't know how the machine works.
- Users don't get enough feedback of their actions.
- Electrolux washing machines are not being used in the best sustainable way.
- Users do not have fun when using washing machines.

6.1.2 Requirements

After analyzing the problem and taking into consideration the scope of the thesis of creating emotional attachment and persuade the user, general requirements were defined, which served as a guidance for the whole project. These requirements are the following:

- Create a machine that teaches the user the best way to operate the machine
- Create a machine that encourages the user to make sustainable choices
- Create a machine that emotionally connects with the user to improve the experience.

6.1.3 Target user and context of use

Since the project was developed together with Electrolux Professional the machines considered are professional washing machines; however the context of use was determined to be in multi-housing laundry rooms, which implies the machines are operated only by non-professional users.

This type of users and context was defined based on the idea that they are one the ones that are more likely to make a non-optimal use of the machine and that can have more variety of garments.

6.1.4 UX over time

The method UX over time (Karapanos et al 2009) is used to analyze a product through a long period of time and takes into consideration 4 different phases that the user experiences when using a product, those phases are: Anticipation-Expectations, Orientation, Incorporation and Identification. This method is particularly relevant because a product like this affects the user in a more psychological way, which is important to analyze and plan for a long usage period. The following Table 2 explains and compares the different stages of the current washing machine and the expected new machine.

	Current washing machine	New washing machine
Anticipation > Expectations	Must be easy to use since everyone does it	- The usage would be more fun, easier and intuitive - It depends on how they advertise the product and if the user knows what is a social machine
Orientation (excitement or frustration)	- Frustration for not knowing what to choose - Frustration of not knowing how much clothes to put - Frustration of not knowing how much detergent and softener to put -Excitement when figuring out how to use it and start the machine	- Excitement about interacting with a social machine - Excitement about learning new things of the washing process - Excitement about knowing exactly what to choose and what to put - Excitement about contributing to the environment -Excitement about being able to connect with other people
Incorporation	- Becomes meaningful and useful because the user can trust their clothes would be clean - The user knows how to use it, at least in an acceptable way	- Becomes meaningful because the user is emotionally attached to the machine - Becomes meaningful because the user feels is contributing to the environment

		- Becomes meaningful because of its easy usage and complete understanding of how the machine works
Identification	- Normally it doesn't participate in social interactions - It doesn't help to communicate self-identity - It doesn't help to differentiate from others or connect to others - It doesn't create a sense of community	- It participates in our social interactions - It helps to communicate self-identity through personal achievements - It helps to connect with other people - It creates a sense of community

Table 2: UX over time ideation.

6.2 Ideation

This section will talk about how the literature findings were translated into concept ideas, as well as two main iterations, described in detail.

6.2.1 Translating literature findings and requirements

In order to translate the information gathered in the literature research and the stated requirements into conceptual ideas, specific questions were formulated. These questions were used to encourage more thoughtful ideas about the machine's personality, its functionality and how it will impact the user, they are also relevant if this project were to be continued or redesigned.

Social machine

- What social role should the machine play?
- What type of personality should it have? The user will be allowed to change it?
- What kind of bonding?
- What physical characteristics should it have?
- What beliefs, desires and intentions?
- What emotions should it convey?
- Should it apply social pressure or disapproval? At what degree?
- Positive or negative feedback?
- Should it propitiate social interaction between people?

Functionality

- What type of knowledge it should "teach"?
- What parameters the user should be able to manipulate?
- What specific decisions it should encourage?

User

- What type of people it will be intended for (based on personality, culture, lifestyle, age, likes, etc)?
- What emotions the user should experience?
- How does the user should perceive the machine (as a social agent)?
- What does the user gain?
- In which context it can be more relevant?

6.2.2 Personality ideation

Based on the questions previously mentioned 3 main personality concepts where defined:

1. Puppy / Baby
    - Playful and with energy
    - Requires attention and caring
    - Through caring the user also learns what does it need
    - The user has to control and guide the machine

2. An extrovert friend
    - The soul of the party, it helps people meet and bond with each other
    - Likes to party but has good values
    - Is always there for the user
    - Gives the user advice of what to do and how to act
    - The user gets inspired by its personality

3. A trainer / psychologist / teacher
    - Has certain influence over the user, in terms of knowledge, expertise, etc.
    - Teaches about how the machine works and about sustainability.
    - Make the user improve through practice and repetition.
    - Fixes the user problems by teaching lessons and making him truly understand his decisions.

From these three personality concepts, the puppy/baby was chosen based on the idea that the users can relate more easily to this relationship of caring, as commonly done with babies or pets. However the other two concepts would also be interesting to develop and test, in future research.

6.2.3 First ideation concept

Based on the personality ideation, an initial physical shape ideation was developed with the use of handmade sketches (see Figure 13). The goal was to design the physical shape of a washing machine that would fit the personality concept. For this, different ideas were explored, from a machine with an added head to a machine where social characteristics were subtly merged with the whole body.

Figure 13: Sketching first ideation

6.2.3.1 Concept and design

The initial concrete idea consisted of an inverted squared cone shape (see Figure 14), which represents the body of the machine and in the top front, a display where the eyes were placed. This idea was further developed as a digital sketch where the display elements were integrated. For this initial idea the display was divided in two sections, one on the top where the eyes are displayed, and the second between the eyes and the drum, where the control display and the consumption levels are located. The control display includes icons that were designed to be more intuitive and understandable.

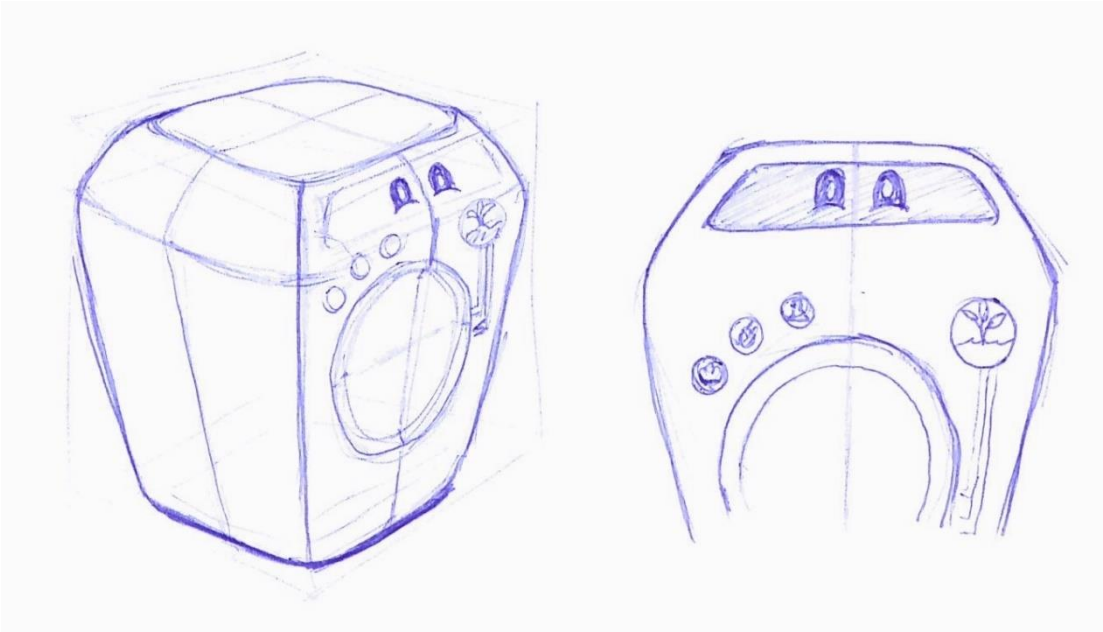

Figure 14: Sketches of the initial concept idea.

6.2.3.2 Consumption levels

The concept for the consumption levels in this initial iteration was based on the idea that the energy and the water are taken from the environment, and a way to represent that was with a plant where the user can more consciously perceive the consequences of their decisions. Different designs and placements for the plant and levels were explored; however the idea was discarded due to first, graphical issues of the levels not being clear, and more importantly because the plant makes the user focus too much on the sustainable aspect of the machine and that could affect the feeling of attachment that was intended.

6.2.3.3 Expressions

In this concept, the idea was to only have eyes (as social characteristics) that can emulate the different expressions of the machine. For this, different eye styles and expressions were analyzed and designed; however this defined style (see Figure 15) was discarded because of its difficulty to express a wide range of expressions and because it gives the impression of a more child-intended machine.

Figure 15: Digital illustration of the initial idea

6.2.4 Second ideation concept

6.2.4.1 Concept and design

Because the first concept idea was not as good as expected, a second iteration was conducted. In this concept the physical design changed completely and the main purpose was to include a smile that was used as a consumption level indicator. This new idea intended to keep the traditional cubic shape of current washing machines, so the user can relate more easily and hopefully, the social aspect would be better accepted.

Figure 16 shows that the shape, although traditional, has a more stylish and modern design with rounded edges. It has a surrounding layer that conceptually emulates the interface between the machine and the user. On the front top of the machine, the display is located with a certain inclination so it can be more ergonomic; there, the control display, the consumption levels and

the eyes are placed. And on the front edge of that display the mouth can be found, following the shape of the edge and merging with the design of the machine.

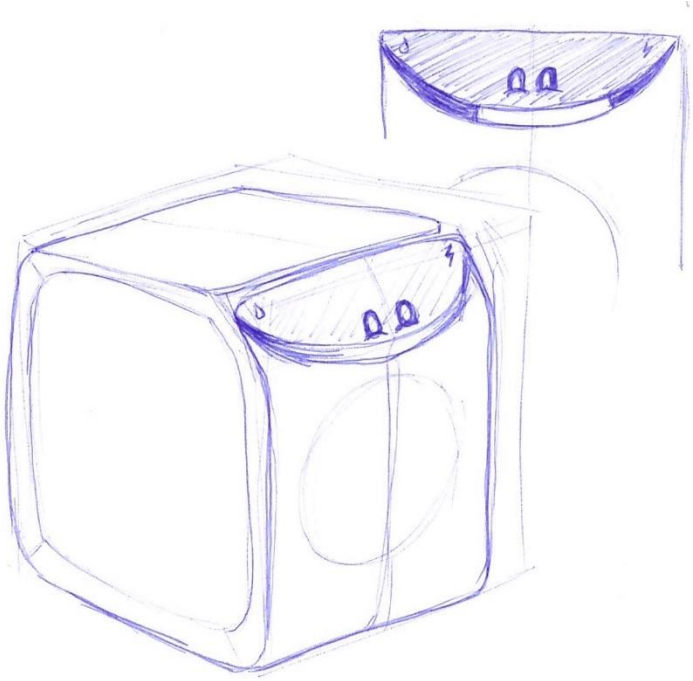

Figure 16: Sketches of the second concept idea

6.2.4.2 Consumption levels

As mentioned before this concept comes from the idea of using the smile as a consumption level indicator, which consists of the energy and water levels placed on both sides of the smile. These levels grow over the smile (the black parts on the sides) depending on how much is being consumed (see Figure 17), so the more consumption the sadder the machine will be, and the other way around, the less consumption the happier it will.

Figure 17: Digital illustration of the second idea.

6.2.4.3 Expressions

For this concept the expressions style was changed, the eyes, as shown in Figure 18, had a squared shape and eyebrows were added, which together with the smile give more freedom to express different emotions.

Figure 18: Illustrations of eyes styles and expressions.

6.3 Prototyping and testing

This last concept was considered to be a better solution, where the user could still perceive it as a washing machine but at the same time strategically integrate social elements that could improve the usage and the whole experience. In order to develop this idea further and test certain aspects of design, a digital prototype was developed along with a real size mock-up.

6.3.1 Journey map of the usage process

An important part for developing a more thorough solution was to clearly understand the washing process that both, the machine and the user have to follow. For this, a detailed journey map with each step of the process was developed (see Figure 19). Then, the personality concepts were narrowed down to specific emotions the machine would have in each step of the process, depending on the behavior of the user.

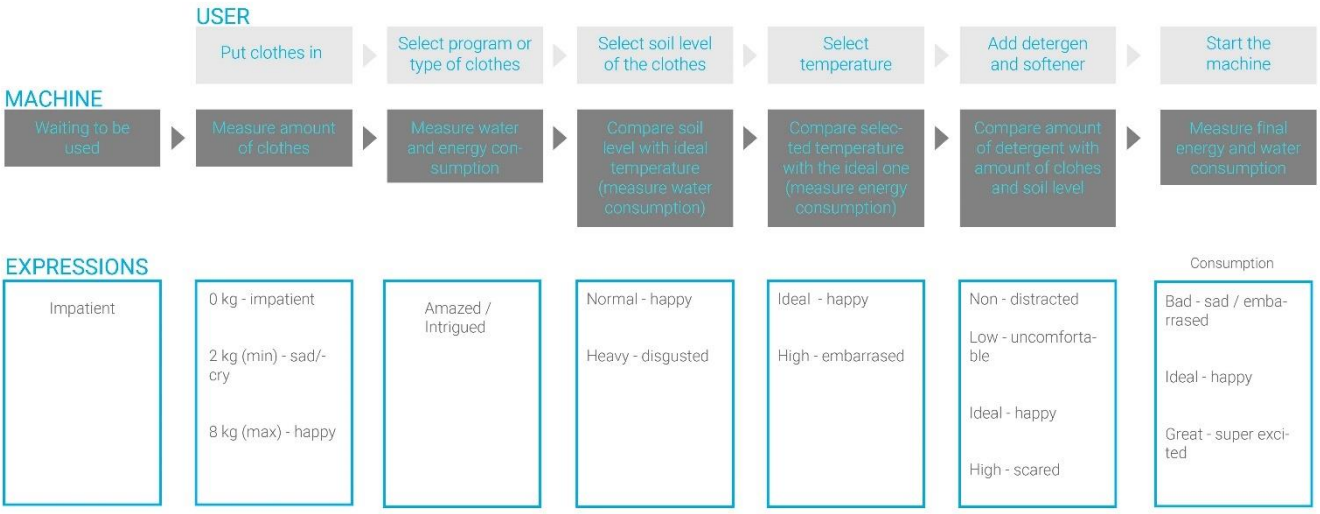

Figure 19: Journey map of washing process and the intended emotions.

6.3.2 3D modeling

To have a better idea of how the machine would look like, the physical shape of the machine was 3D modeled and rendered. The final measurements correspond to one of the smallest Electrolux Professional washing machine i.e. model W575H. Having a 3D modeled version of the design allowed to have a more realistic perception of where the digital elements could be placed and an overall feeling of the machine appearance.

6.3.3 Expressions iterations and testing

When designing expressions it is important to take into consideration what Krampen (1965) mentions in his article "Signs and Symbols in Graphic Communication", which says that when "illustrations are used to communicate specific ideas, they will be more effective if the number of objects and actions that must be perceived is kept to a minimum. All objects and actions should be depicted realistically and should not allow secondary (symbolic) interpretation."

With this in mind and based on the expressions defined on the journey map, different eye expressions were designed (see Figure 20). Nine of those expressions were tested (see Figure 21) with a sample number of users (3). To have a more accurate test, the expressions were tested using GIFs, which changed from a neutral expression to the intended tested one. The use of GIFs was found to be more effective than showing only static expressions because people are more used to perceive subtle differences and implied meaning when the expressions change.

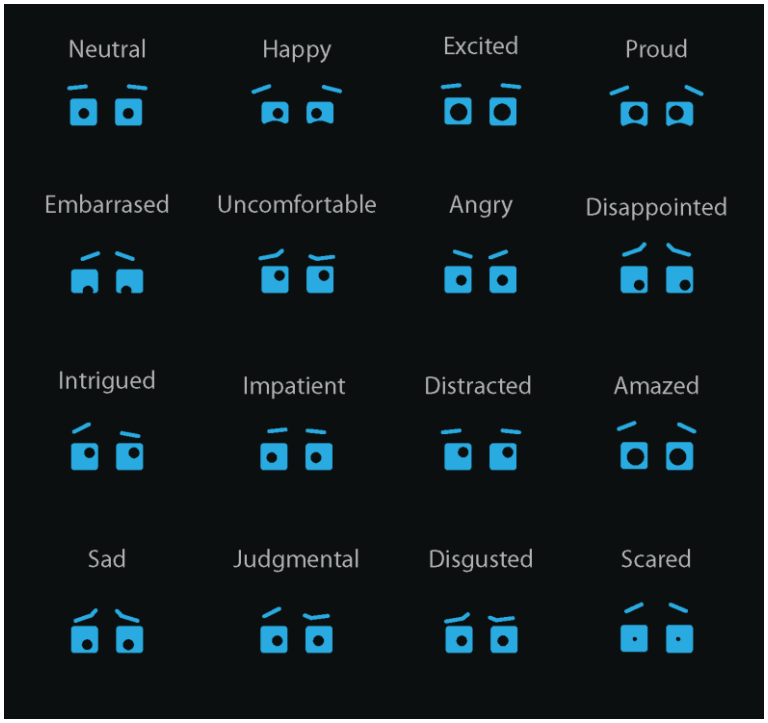

Figure 20: Designed expressions based on the journey map

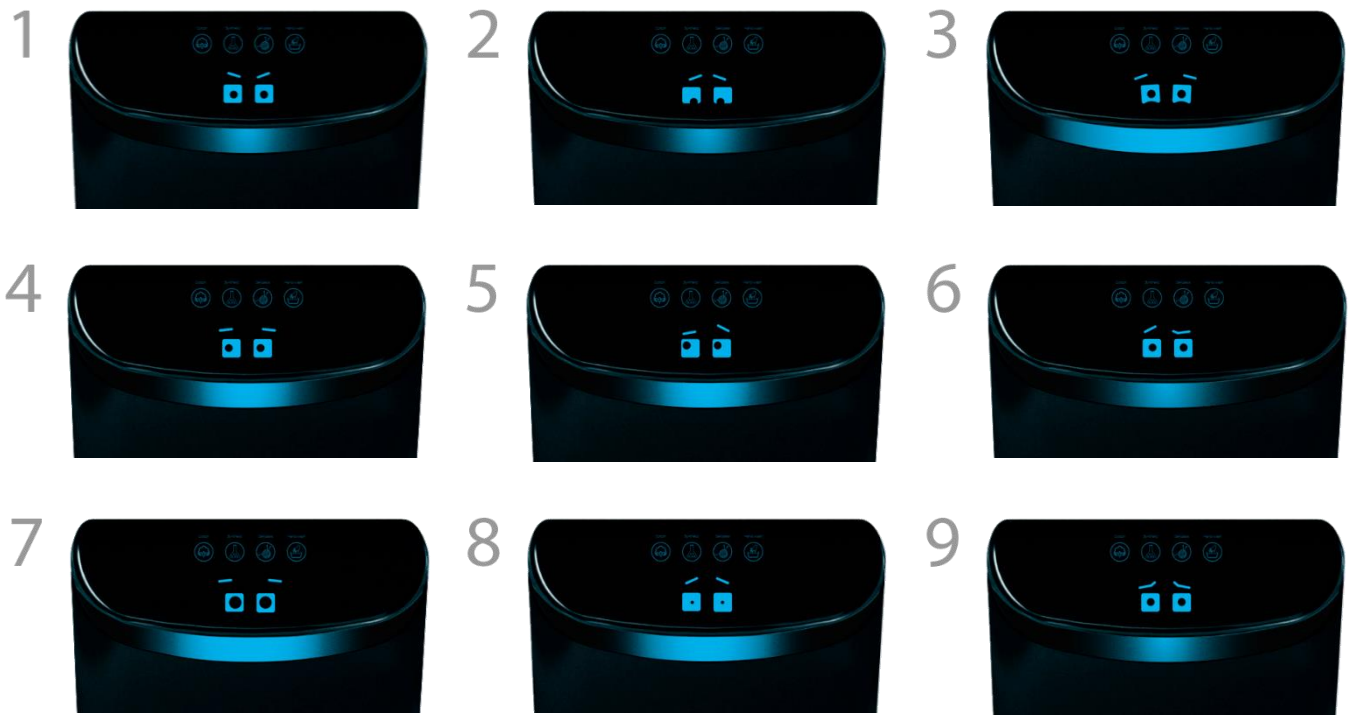

Figure 21: GIF expressions for testing:
1 Angry, 2 Embarrassed, 3 Happy, 4 Impatient, 5 Intrigued, 6 Judgmental, 7 Proud, 8 Scared, 9 Uncomfortable

During the test, a table was presented to the users (see Figure 22), this table was inspired by a confusion matrix designed by Kevin Byrne (1990) to analyze emotions and expressions. On the presented table a list of expressions was written and for each tested expression the testers had to rate from 1 (min) - 3 (max) depending on how well the words of the list described the expression. In that way, it could be proved if the expressions transmitted what was intended or if they expressed something unexpected.

Instructions: For each GIF (1 – 9) rate the adjectives that best describe them 1 (min) – 3 (max).

Leave them blank if they don't describe them at all

	1	2	3	4	5	6	7	8	9
Happy			3	confused					
Excited							3		
Proud			2						
Amazed							2		
Intrigued							1		
Impatient	1			2					
Distracted				3					
Embarrassed									
Uncomfortable		3			1	1		2	1
Angry	3								
Disappointed		2				3			2
Scared								3	
Sad		1							3
Judgmental					3	2			
Disgusted					2				
Other: Annoyed	2		worried but ok? 1					Surprised Lonely? in a bad way 1	

Confused 1

Figure 22: Sample test table

With the collected information, some changes were made. The major changes were made in the "happy" expression i.e. number 3 (see Figure 23), this was because the first expression transmitted a meaning of "worried but ok" (Mimmi 2018) rather than happiness. The rest of the expressions in general corresponded to the initial intention. However, this was only a sample test to have some sort of accuracy on the expressions, but a bigger study with more testers must be done for this expressions to be ready to use.

Figure 23: Comparison of "happy" expression First vs Final

6.3.4 Consumption levels iterations

In order to have a functional and intuitive design of the consumption levels, different iterations were made around it (see Figure 24). In the initial idea, as described before, the levels grew over the smile but this turned out to be not so clear. Another idea that was explored was to show the savings instead of the consumption, and place a level bar in the middle that grows with the smile, that way the more savings the bigger smile. However, that idea was discarded because the savings, in this case, are very subjective, since there is no general optimal usage, and it always depends on the chosen program, amount of garments, etc. Following this idea, it was also considered not to use the amount in numbers, and only an approximate level; but this was decided not to be helpful feedback for the user.

Figure 24: Different iterations of the consumption levels.

6.3.5 Animated demo

Unlike other digital interfaces, this concept of having social elements, as part of the interface, requires a livelier prototype for better understanding of the emotions and reactions the machine has. With this in mind, an animated demo was developed, and for this a graphical scenario was used (see Figure 25). In this scenario the different steps of the washing process are explained, along with the expressions that each selection causes.

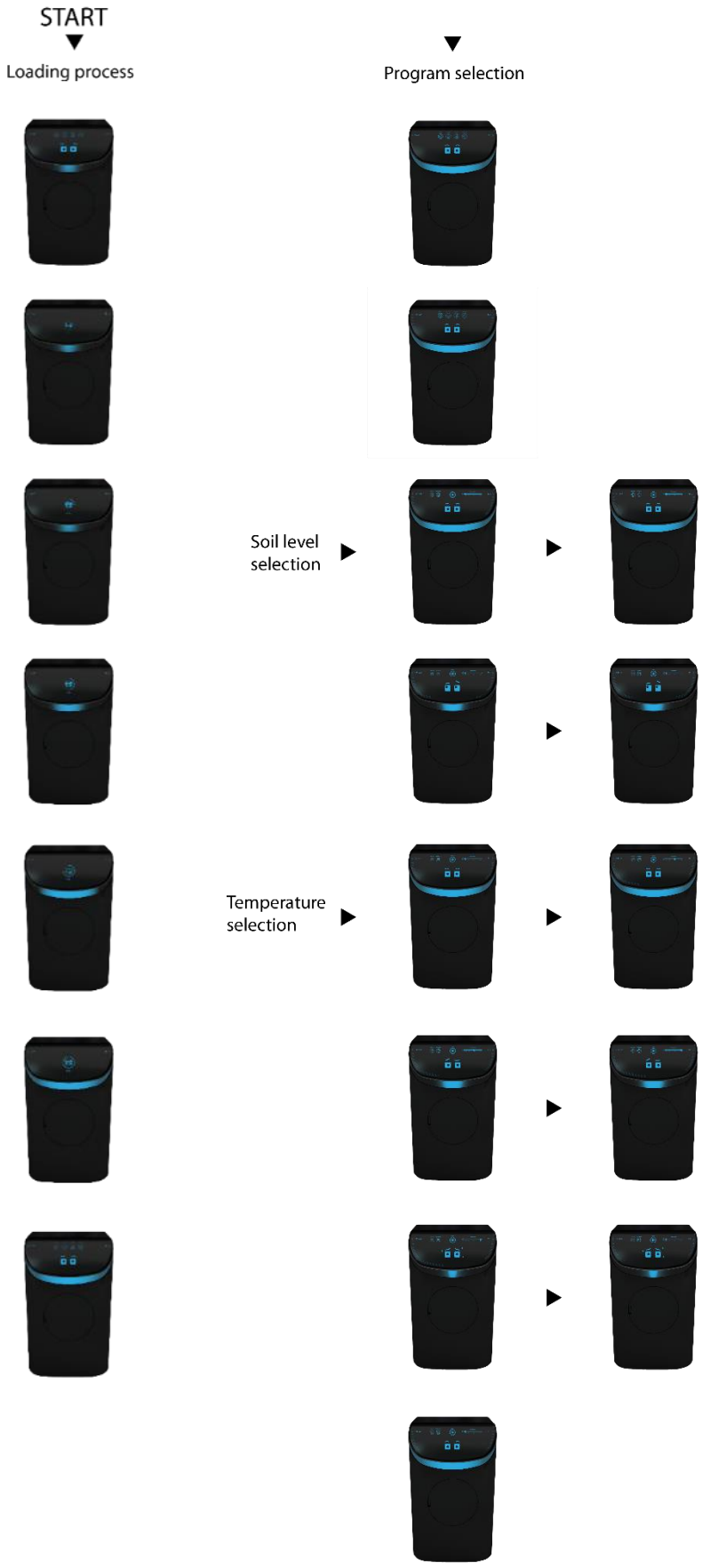

Figure 25: Sample screens of the graphical scenario

6.3.6 Mock-up

Once the shape and the graphical elements of the interface were defined, with the use of cardboard and printings, a real size mock-up was made (see Figure 26). This was made to check the real size proportions of the buttons, texts, eyes, etc., because normally with digital prototypes these aspects are hard to test. But also it was made to get a more realistic and ergonomic feeling of how the user would interact with the machine, and how they would perceive the expressions.

Since a mock-up was not part of the scope, no tests were performed with users. However, it was found that the eyes were slightly small so they were adjusted accordingly in the digital version. Also, the placement of the smile has a very straight angle that makes it difficult to be seen, especially if the user is too close to the machine. Related issues are discussed in the discussion section but no further improvements were made on the final design around this topic.

Figure 26: Real size mock-up

7

RESULTS

7.1 Key literature findings & interpretation

7.1.1 Human factors

7.1.1.1 Human cognition

The information that is perceived by different organs of the body shapes the way the brain works (information processing) but at the same time the brain controls what organs do the other way around (decision-making).

7.1.1.2 Information processing

Information processing is based on three things: what we sense (the sensory data), what we know (knowledge stored in memory), and what we can infer (using high-level cognitive processes) (Sternberg & Sternberg, 2012)

INTERPRETATION: Knowing how information processing works is useful for understanding how the user will take in the information that is presented. This can be used at the beginning of a project like this, to know what type of information to show, for example, taking into consideration other cultures and what do they "know", in order to understand how they could react to specific expressions. But it can also be used at the end of the project, as a final check to understand how the user will interpret the designed expressions, graphical elements, shape, etc.

7.1.1.3 Decision-making process

When making a decision people try to maximize pleasure and minimize pain, and this process is totally subjective, where people consider utility and probability to make decisions (Sternberg & Sternberg, 2012).

To decide between different alternatives people make use of heuristics (Sternberg & Sternberg 2012), which are mental shortcuts or filters that reduce the number of options. The most commonly used heuristics in decision making are:

- Satisficing: the first minimally acceptable option, only useful for quick and not so important decisions.
- Eliminations by aspects: focus on key aspects of each alternative one at a time, used for more thoughtful decisions.
- Representativeness: assumes that a sample of something represents the whole thing.
- Availability: use information that is easily available in the memory.

- Framing: choose a small but certain gain over a larger but uncertain one, unless the uncertain gain is much greater.

After the decision is made people often encounter different biases that affect the outcome, two of them are:

- Regret: the comparison of an outcome with what could have been received under another choice.
- Disappointment: when comparing with a more fortunate outcome.

INTERPRETATION: It is important to know the different types of decisions the user can make, because that will define the type of information that is presented. Since the idea behind this machine is to persuade the user into a more sustainable behavior, knowing how they can react is useful for having an idea of what information to present and when to present it.

For instance, knowing that the framing heuristics is about "choosing a small but certain gain over a larger but uncertain one", we can assume that presenting projected statistics of the savings for the week, as a way to show how much the user can save if he changes his choice, would not be more effective than the small gain the user could get by adding more temperature to have cleaner garments. Possibly, a better idea would be to use the disappointment bias, and have consumption levels that compare the user results with others that were saving more.

7.1.1.4 Personality types

The personality types can be explained by the five factor model of personality, also known as "the big five", developed by Goldberg (1993), which includes five dimensions with a two-edge span:

- Neuroticism: tendency to experience negative emotions.
- Extraversion: characteristics such as sociability, assertiveness, activity and talkativeness.
- Openness: includes active imagination, aesthetic sensitivity, attentiveness to inner feelings, preference for variety, intellectual curiosity, and independence of judgement.
- Agreeableness: altruistic, sympathetic to others and eager to help them.
- Conscientiousness: self-control and the active process of planning, organizing and carrying out tasks.

INTERPRETATION: This type of project makes use of a more psychological interaction, therefore the perception of each user will be different depending on their personality. This model is a good tool first for analyzing and understanding user's personalities, but also for defining a machine's personality that is compatible with the different types of users. It is good to consider the idea of allowing the user to change or configure the machine's personality, as a way to solve the personalities' compatibility. If this issue is not solved, there is a risk that certain users will get frustrated, bored or even upset with the machine.

7.1.2 **Social machines**

Persuasive technology states that social products persuade by giving a variety of social cues that elicit social responses from their human users (Fogg 2002).

7.1.2.1 Bonding

Human bonding
Humans are highly motivated by the need of belonging, which shapes emotion and cognition, because it intensifies the emotional responses. So it can be assumed that emotions regulate behavior in order to form and maintain social bonds (Baumeister & Leary 1995).

Once the bonding is formed, people seek for frequent, positive and pleasant interactions that are free from conflict, and they want to make sure that bonding will continue in a long term (Baumeister & Leary 1995). If that bonding is broken it will lead to ill effects, but people will recover best if they form a new one (Baumeister & Leary 1995).

INTERPRETATION: In order to design a machine that truly connects emotionally with the user, it is important to understand how human bonding works. And most importantly it is necessary to be aware of the ethical implications that this type of relationship might bring to the user. In this project in specific, which considers the use of emotions as a behavioral tool, it is crucial to know the impact of this bonding during the interaction as well as in case of terminated.

Human-machine bonding

When people perceive social presence, they naturally respond in a social way (Fogg, 2002), but the product needs to meet user's desires of aesthetics and functionality to create emotional bonding.

Product attachment can be formed through three levels of involvement: the appearance or aesthetics of the product, the pleasure of effectiveness of the product when is used, and the personal satisfaction when using the product. But it can also be formed through seven determinants: enjoyment, self-identity, memories, life vision, utility, reliability and market value (Page 2014).

To create attachment the first goal should be to achieve enjoyment and pleasure because they are the primary reason for attachment to newly purchased items. Another way is when the machine stimulates social contact by allowing it to be used by multiple people so they create shared fond memories (Page, 2014).

INTERPRETATION: Since this type of machine uses social interaction to create bonding, it is important to know what specific characteristics the machine should have to achieve this attachment. This project makes use of aesthetics as a way to create bonding, by having a futuristic and appealing design, but without being too far from common washing machines shapes so the user can easily relate to the machine. It also strives for having a joyful and pleasurable interaction by providing better feedback to the user's actions, but this aspect is something that still needs to be tested with a more realistic prototype. An interesting idea to explore is to allow the machine to be used by multiple people and see how the interaction between that people might look like.

Anthropomorphism

Anthropomorphism is the "attribution of human characteristics or behavior to a god, animal or object" (Oxford Dictionary). It is not only about how humans perceive nonhuman things but what they attribute to them in terms of physical, mental and emotional characteristics. It increases when people feel a lack of social connection and decreases when they feel a strong sense of social connection.

For this to be achieved, there are three psychological determinants: elicited agent knowledge (apply and access knowledge), effectance motivation (understand and control) and sociality motivation (need of social contact) (Epley, Waytz & Cacioppo 2007).

Social bonding with machines can increase by facilitating the use of morphologically human features. People can feel more attracted to these types of machines than to other humans because they have control over them and they can get more satisfactory outcomes (Epley, Waytz & Cacioppo 2007).

INTERPRETATION: To achieve this type of social interaction, it is useful to know how people can attribute social aspects to non-living things, and take advantage of the fact that people can feel more attached to this type of machines. A machine can create bonding with the user without being perceived as a social actor, however this project has the intention of creating a more social connection, therefore the most important determinant to use is social motivation. But the other two determinants are also good to consider because this interaction affects in a deep level the cognitive perception of the users.

Characteristics of social machines

There are different characteristics and social cues for a machine to be perceived as a social actor.

The characteristics of a social machine include:

- It should convey intentionality, meaning that it must make the user believe it has beliefs, desires and intentions (Breazeal & Scassellati 1999).
- It must have ways of expressing its internal states and show consistency around them, with certain flexibility when dealing with unexpected events (Breazeal & Scassellati 1999).
- Show that the machine has an autonomous individuality displayed through its design and behavioral configuration (Graaf, Allouch & Klamer 2014)

Fogg (2002) proposes five social cues to convey intentionality and social presence:

Physical	Face, eyes, body, movement
Psychological	Preferences, humor, personality, feelings, empathy, "I'm sorry"
Language	Interactive language use, spoken language, language recognition
Social dynamics	Turn taking, cooperation, praise for good work, answering questions, reciprocity
Social roles	Doctor, teammate, opponent, teacher, pet, guide

INTERPRETATION: This section of the findings is probably the most relevant for this project because it talks about practical characteristics that can be directly implemented on the machine. There are different things to consider when using each of these social cues:

Physical: A product can convey sociability through physical cues such as eyes, mouth, movement, body, etc., but these characteristics do not always have to be present for the machine to be perceived as a social being (Fogg 2002).

Psychological: The psychological cues can be present in different aspects of the machine, not only on the physical ones, for instance, they can be conveyed through texts or icons that portray emotions. For more complex cues that convey personality they require a longer time of interaction to become apparent; but if done it right, it can lead people to subconsciously be aware of the computer's psychology (Fogg 2002).

Language: The use of language is another effective way to convey personality and social presence; it can be written or spoken, and it is better when it goes both ways, which means the computer can also recognize what the user is trying to communicate (Fogg 2002)

Social dynamics: People in different cultures have set patterns for how to interact with each other e.g. how to meet people, form lines, take turns, etc. These types of dynamics can also be applied to machines if they need to be perceived as social beings, in order to have a more human interaction.

Social roles: Similar to social dynamics, people adopt different roles to be organized as a society, these roles can also be adopted by machines to be more immerse in the social interaction. There can be roles of authority such as teacher, referee, judge, counselor, etc., from whom people expect to lead them, make suggestions, and provide helpful information, because they assume they are intelligent and powerful. But there are also roles that do not necessarily have to leverage power or status (Fogg 2002) they can be someone in the same level as the user e.g. a friend, or someone the user has certain influence over e.g. a child or a pet.

7.1.2.2 Persuasion

Roles of technology in human behavior

Roles of technology concerning human behavior, where technology can be used to reduce the environmental impact:

- Intermediary role, where the environmental effects depend on the type of technology applied e.g. an old washing machine versus a modern high-efficient one.
- Amplification role, this is about how technology amplifies the effect and scope of human behavior, but at the same time this can cause more consumption.
- Determinant role, where technology shapes human behavior without requiring awareness from the user e.g. sliding doors.
- Promoter role, where technology helps to encourage sustainable behavior.

INTERPRETATION: In order to be effective in persuading the user, it is useful to understand how technology shapes human behavior and how that can be used as an enabler for more sustainable behavior. In this project the role the machine uses is the promoter role because its main purpose is to apply a new and innovative type of technology to encourage sustainable choices and enhance the usage experience. But it is also useful to understand the other types of roles in order to analyze and be aware of how current technologies are shaping the user's behaviors.

Persuasive technology

There are two types of biases that can be used to persuade the user:

- De-biasing: triggers the rational system and make the user decide based on risk awareness.
- Counter-biasing: Triggers the impulsive system to make more quick decisions.

Techniques to promote behavior change include: feedback, reward, goal setting, prompting, and norm activation (Midden 2015).

Social dynamics that can be implemented in a social machine include: normative influence (peer pressure), social comparison, group polarization and social facilitation (Fogg 2002).

One of the main techniques of persuasion in social machines is the use of feedback, it can be used as positive or negative.

Negative feedback draws more attention, is processed more intensely, is less threatening and leads to more constructive decisions than positive feedback only (Midden 2015).

To provide the user with feedback that requires less cognitive effort and attention, Midden (2015) suggests the use of ambient feedback such as changes in form, movement, sound, color, smell or light can provide a more subtle influence.

Trustworthiness of the machine and avoiding annoying behaviors are the key factors for a successful social machine (Midden 2015).

INTERPRETATION: There are different ways to use technology as a persuasive element, but one of the most crucial factors in this type of machines, and the one this project is more focused on, is feedback. In this type of appliances that are used in a regular basis, is very important to have a good balance of positive and negative feedback. Although negative feedback can lead to a more constructive decision, too much of it can cause frustration and anger from the user.

It is also important that he machine provides feedback in a more social and coherent way. For instance, if it is the first time the user selects a high temperature the machine should not provide very negative feedback right away, instead just acknowledge it, give some kind of hint that it might not be the best choice, and if this decision keeps repeating for several times then it can give more harsh feedback. The same as a human being would react in a non-desired situation that keeps occurring.

Another aspect of the feedback that was improved in this project was the display selection. Current washing machines are lacking feedback, for example, on the weight of the garments and the detergent amount, which in this case was added as part of the selection process. For this, change in form and movement of the graphics was very helpful, and possibly easier for the user to understand.

Additionally, another technique that was not used for this project but that can be interesting to explore is to apply social dynamics, such as peer pressure or social comparison, to encourage more sustainable behavior. But for this a broader scope will have to be considered because it will probably need some kind of platform where different users can have their own profile and then use their information.

Social characteristics used for persuasion

The five social cues proposed by Fogg (2002) from a persuasive point of view:

Physical:

- A humanoid face and body can enhance persuasiveness of technology and it can create more trust with the machine (Midden 2015).
- Physically attractive characteristics can be more effective in social influence (Fogg 2002)
- These characteristics do not have to be extremely human-like to have an influence over the user (Midden 2015).
- Social machines that unobtrusively mimic the user's movements tend to be more trusted than non-mimicking agents (Midden 2015).

Psychological:

- When computers are perceived to have a psychology, they can motivate through conveying emotions, they can apply a form of social pressure or they can negotiate with people and reach agreements (Fogg 2002).
- Psychological cues are effective when the user perceives the machine has similar attributes because people that are similar to us can motivate and persuade more easily (Fogg 2002).
- If the machine shows behavior that is incompatible with human behavior, the persuasive effect can be compromised (Midden 2015).

Language:

- A good way to use language as a persuasive tool is by using praise, people respond more positively after being praised by a computer (Fogg 2002).

Social dynamics:

- Social dynamics can contribute to a more effective persuasion because the machine can apply peer pressure to the user, or it can make use of reciprocity (Fogg 2002).

Social roles:

- By playing a role of authority, a computer can become more influential (Fogg 2002) but also having someone or something with similar authority can lead to more acceptance.

INTERPRETATION: For this project it was important not only to know the social cues proposed by Fogg (2002) but to understand how they can be applied as persuasive factors. The cues that were more used in this project were physical, psychological and the social role. However, it would also be interesting to explore other cues such as social dynamics, as previously mentioned, or language to have a more common social interaction; but is important to be aware that it will require more complexity because it must include different languages so many people around the world can use it.

7.2 Final design

7.2.1 Concept and design

The final design of the machine, illustrated in Figure 27, is based on the traditional shape of current washing machines but with a more futuristic style. It is surrounded by a black layer that conceptually emulates the interface that exists between the user and the machine, an interface that has social and functional elements that transmit, and let the user better understand, the internal state of the machine in a more intuitive way. On the top front a digital display is located, where the control display, the consumption levels and the eyes are placed. Below the display, following the curved shape of the machine, a smile can be found; this smile together with the consumption levels help the user understand the sustainable impact of their choices.

Figure 27: Final design of WASH-E 2.0

7.2.2 Machine's personality

The main purpose that drives the machine's ideology is to convince the user to make more sustainable decisions, while interacting with it. This ideology is transmitted through the machine's personality, which consists of a baby/puppy type, someone that requires attention and caring, who is very honest with its emotions but is also discovering them.

This concept was developed because it was thought that the user can more easily develop a sense of caring with the machine and find its reactions more fun, as people normally do with babies or pets. At the same time, it can be a learning process that the user and the machine experience together, since it is a very new and different way of interacting with a washing machine.

7.2.3 Emotions and expressions

The expressions design consists of squared shaped eyes and linear eyebrows that change inclination, position or curvature depending on the expressed emotion. The facial expressions are complemented with additional elements e.g. sweat drops or detergent stains, as shown in Figure 28, in order to have a more realistic and accurate meaning.

The concept behind the expressions is to give negative feedback when non-sustainable decisions are made, but also to give positive feedback when is the other way around. However, the intention is that the emotions reflect a more realistic personality e.g. if a high temperature is needed because of hygiene issues, the machine will not give a negative feedback the first time high temperature is used, but if this behavior is repeated several times then the machine will start getting mad or disappointed. This type of emotions make the machine be perceived more as a living being with a deeper personality, than a predictable machine that when a button is pressed is very easy to know what the reaction will be.

Figure 28: Sample expressions

7.2.4 Consumption levels

The final design of the consumption levels include both, the amount of consumption in numbers and graphical level bars for a better perception (see Figure 29) Consumption levels for water and energy are included, and are placed on each side of the display i.e. energy on the left and water on the right. The level bars are placed above the smile following the same curvature, this is in order to follow the idea that as the level bars grow the smile gets reduced, to subtly promote a sustainable behavior. However, for the expressions to be more accurate, the bars are not directly related to the growing of the smile. This means that both the smile and the level bars work independently, but because they are placed close to each other and they grow on the same direction, the user might imply they are related at some degree, where the idea is that more consumption relates to a sadder expression.

Figure 29: Consumption levels in numbers and level bar

7.2.6 Control display

The washing machine, in spite of all the personality elements i.e. eyes, smile and additional expression elements, is controlled in a similar way as the current washing machines but with a more intuitive interaction. The interaction process was inspired by Cirac (2017) who in her thesis, suggests two main steps for the machine's configuration. The first step in this case is for selecting the desired program, and the second step for adjusting the temperature and heavy soil, in this second step the start button is also located, in that way if there is nothing to adjust the user can go directly from the program selection to starting the machine. When loading the garments or detergent, the control display disappears and a loading circle bar is shown instead (see Figure 30). The circle bar corresponds to the optimal amount of garments or detergent, in order to give real-time feedback, which current washing machines are lacking.

Figure 30: Two selection steps (on the top). Garment and detergent loading (on the bottom)

8

DISCUSSION

The discussion chapter talks about different topics around this thesis project, and touches on themes such as challenges, issues, reflections or improvements that have to be taken into consideration if this idea were to be further developed.

8.1 Results discussion

This section discusses both, key findings from the literature research and the design concept of the social washing machine, and critically examines their results.

8.1.1 Literature findings discussion

This topic of social machines is not so common when it comes to everyday products; therefore the research phase of this project was helpful as a starting point as well as with other different aspects. First, and probably the most important aspect, was to prove that the hypothesis defined at the beginning was true. Most of the information was very useful for understanding how the user thinks, feels and make decisions around a social machine; which is a crucial thing to know in this type of project.

Secondly, there were some findings that are good as inspiration to come up with innovative ideas, some of them inspired the presented concept and some can be useful for future ones. However, there were not many findings of this type that could inspire truly disruptive ideas. Future research with a more futuristic approach can contribute more to this aspect.

And thirdly, these findings can be used in a more advanced phase of the project, where some design decisions need to be made or more specific aspects need to be defined e.g. when defining specific dimensions of the personality, the type of feedback or certain behavior.

In general the research phase brought good results, it proved the hypothesis and helped to answer the research question of the project. Possibly, future research can find more inspiring information or similar cases, but this research was a good start to get a grasp of the basics of the topic.

8.1.2 Design concept discussion

When it comes to designing a social machine there are several challenges that need to be addressed, mainly because it is a type of interaction that is not so commonly used, especially in appliances. Since this project is considered to be only the start and a small step on developing these types of machines, some of those challenges were tackled but some others correspond to improvements or future work that will be further discussed.

8.1.2.1 Physical shape discussion

The final design of the washing machine works well with the idea of having a similar shape as current washing machines that users can relate to; however there are several things that can be improved. One of them was mentioned when the mock-up was described, and that is the placement of the smile that is not very visible when the user is standing too close to the machine, a solution for this issue can be to place it on the same display as the rest of the digital elements but that could also risk the interface of clutter.

If this design is seen from an ergonomic point of view, the outcome depends on the height of the user and the placement of the machine, which leads to another issue, the inclination of the display on the top of the machine. The presented solution works for the chosen size of the machine but for bigger ones, or if the machine is placed over some base, then the angle of the screen might not work as intended and will affect the ergonomic posture of the user. Another issue can arise when the machines are used in other contexts where the machines are stacked one over the other e.g. coin-operated laundry facilities, in that case the lower screen can be partially covered and the upper one can be unreachable due to the inclination.

Finally, if this machine were to be developed, many other technical issues would need to be solved, a mayor one is the door of the machine because current professional Electrolux machines have the drum and door separated from the rest of the machine, in order to avoid excessive vibration and movement, which would be a problem with the suggested design since the door is meant to be integrated with the body. Another issue is the placement of the box for the detergent that in this design is placed on one side of the machine, but that might not be the optimal solution when the space on the sides is reduced.

8.1.2.2 Machine's personality discussion

A very important part of this idea of a social washing machine is its personality, because it is what will help to create a more emotional attachment with the user, and if it is not compatible enough then it might cause more harm than enhancing the experience of usage. In this case, the baby or puppy personality was chosen thinking that the user can more easily develop a sense of caring; however, this personality needs to be tested to see if it really creates the effect that is thought. In the animated demo this personality can be appreciated to some extent, but a bigger study around this topic needs to be developed, to see exactly how the machine will react in different and specific situations. This will contribute to a deeper personality, and help the machine be perceived as a living being instead of a predictable machine, and hopefully to a more immersive experience.

An important part of the literature research was to analyze different types of personality that people have, that analysis can also be used to define the machine's personality and find one that can be compatible for many people as possible. That is why it is also important to test other types

of personalities, the ones mentioned on the ideation section can be good to start with, but a more thoughtful development needs to take place. All these personalities, including the one selected for this project, have to be tested with different users to see the compatibility between them e.g. for some people, a more calm personality can be very appealing, but others might find it boring and lose interest. Another solution to this compatibility could be to let the user choose the personality of the machine to fit their own likes e.g. they can choose to increase humor or more negative reactions that they might find fun.

8.1.2.3 Emotions and expressions discussion

The expressions, together with the personality, are very important aspects for the success of a product like this; they need to convey very specific emotions and at the same time be well accepted by the users. For this concept, the design of the expressions was a big challenge because there are many expressions that need to be design following the same style, the use of eyebrows was very helpful in that sense. In this case designing positive expressions was more difficult than the negative ones, this could be due to many reasons like the chosen style of eyes, cultural perception, or simply the designer's skills, but is a topic that needs to be further analyzed and developed. This type of expressions could be better designed by a character animator that has more knowledge about facial expression movements and emotions.

8.1.2.4 Consumption levels discussion

The idea of relating the smile of the machine with the consumption levels helps in many aspects, first to have more accurate expressions, but also to subtlety imply the machine's ideology. This is because by relating both of them, in a more unconscious way, the user can infer that the main purpose of the machine is to encourage sustainability, without making it too obvious. In this case, it was very helpful to have both the consumption amount in numbers and the level bars, for a more graphical and easier understanding. From that point of view it seems to be a good solution but testing will be necessary to prove if it really works and make adjustments if necessary.

8.1.2.5 Control display discussion

As mentioned in the results section, the way to control the machine is similar to current washing machines but with a more intuitive process. However, this aspect of the design was not the main focus of the project; therefore a better analysis and design will need to be performed in terms of the selection process, the graphical design and the placement of the elements. Whatever the design is, a very important aspect to consider is that the process needs to remain simple, intuitive and fast enough if the user decides to ignore the social part and just wants to get the laundry done.

8.2 Design process and methods discussion

8.2.1 Literature research discussion

For the literature research process it was very useful to have specific topics (Human factors, social machines and similar cases) from the beginning, because it helped for having a more structured and well planned research. Before starting the research, several questions were formulated about the different topics, questions that explored more specific aspects of the topic and from them key words were extracted. These keywords and the combination of them were the ones that guided the whole research and helped to stay focused.

One of the issues in the research phase was when the keywords did not help to get the information that was intended; in that case more time had to be spent than was planned. That was the case of the fourth topic Technology & Society, a topic that was considered in the planning of the project, but did not gathered enough relevant information due to lack of time, so it was decided not to be included.

8.2.2 Concept development discussion

The initial plan of the thesis was to first explore the theory and from there, based on the findings, decide what type of product and what characteristics it should have. Taking that into consideration, this thesis was successful on following the general framework and planned methods; however, more methods in the concept development were added. Such methods were common design ones, while some others were adapted for the intended purpose e.g. the questions used to translate the literature findings to concept ideas and the confusion matrix used to evaluate the different expressions. Normally is very useful to be inspired by defined design methods that make the designer think differently and consider things that he might not be thinking about; but sometimes this methods do not fit the purpose, so it is important that the designer is also capable of adapting or coming up with new methods.

For developing the concept, the design thinking process was followed, first of all the process only reached the prototype step and in a very early stage, without going to the test step; this was planned from the beginning due to time constraints. But an important part to discuss is the empathize step, which is intended for understanding what the user is doing, feeling and thinking, this part was not deeply researched, it was only based on Electrolux insights and personal experience, again because of time constraints, but also because the main focus was to show a concrete solution that might not be the optimal one, but that can inspire future work around this topic of social machines. If, specifically this concept, were to be developed a better research with

interviews, questionnaires, observations, etc., would need to be conducted to truly understand the user and prove that the design fulfils their needs.

An important variation from the initial plan is that the concept development took longer than was expected; it lasted approximately one more month. This extension was decided during the ideation phase because the time was very short for coming up with good concept ideas, so instead of rushing through the design of the physical shape and focus only the emotions, it was decided to extend the thesis time to come up with a more complete and developed idea.

8.3 Ethical issues

8.3.1 Emotional and psychological effects

One of the main ethical issues around this idea of social machines is the emotional impact the machine can have over the user. This can be in both, short term i.e. immediate emotions the user has because of the interaction and long term i.e. what type of relationship or attachment the user might develop.

This concept in particular, makes use of positive and negative feedback, being the negative the most important one because is the way to change the user's behavior. Although it was found in literature that negative feedback is less threatening and leads to more constructive processing (Midden, 2015), it is a sensitive topic with ethical implications, because it can make the user feel annoyed, uncomfortable, judged, etc., and that can affect not only the washing experience but the mood of their personal lives. These social interactions have to be treated with caution because it affects the user in a more psychological way, and what they might like at the beginning, can cause a negative effect in a long term.

8.3.2 Accessibility

A common problem with digital controlled machines, like the proposed one, is the accessibility aspect, firstly because it excludes people with sight impairments, something that physical knobs, with the use of sound and movement, can solve, as current Electrolux professional machines do. Another issue is when older people that are not used to this type of technology can feel confused or threaten, and decide not to use the machine. The proposed design did not consider these issues from the beginning, therefore it did not turn up successful in this aspect, but it is certainly a big issue that needs to be solved if a design like this were to be developed.

8.3.3 Privacy issues

Another important issue, that is also an emerging topic in AI, is the fact that in order to have some sort of social machine that can interact in a deeper level with the user e.g. remembering how many times the user have selected the unsustainable parameters or having a personal account, personal data needs to be collected, and the issue is how that information is going to be manipulated, how is going to be stored or who is going to have access to it.

8.4 Topics for future work

As stated from the beginning of the thesis, this project is only a first step on exploring a whole new way of interaction. Therefore, there are some important topics to consider for future work, that need to be better developed before it can be considered to be released on the market.

8.4.1 Personality

One of the topics that needs to be further developed is the personality of the machine, some of this was discussed previously, based on improvements of the suggested design; however, the personality can also be conceptually improved. An idea that came up during the ideation phase was to have a machine that could "grow" in personality over time. This idea can be worth exploring or at least inspire a similar kind of personality change through time that can add to a deeper relationship with the user and enhance the experience.

8.4.2 Functionality

If a more complex personality were developed, other types of functionalities can be useful for conveying such personality, but also for the user to better understand it. This project was focused on the characteristics that a social machine should have, so it did not explore in depth other functionalities that could improve the interaction. The parallel thesis developed by Wasamas & Kittipon (2018) explores this topic, where they suggest the use of extra information to help the user understand the emotions of the machine and to provide useful washing tips. That is one way functionality can be improved, but again, this is something that needs to be more researched and explored.

8.4.3 Context of use

A very important aspect that was not deeply explored in this thesis is the context of use, since Electrolux professional machines do not have private owners, the machines will most likely be shared. The issue of a shared machine is something that needs to be solved, especially because a social machine needs to remember some type of information about the user and that can

create functionality problems. Two solutions were thought during the project, one can be a personal usage where the user has to login somehow, and the other where every person can affect the mood of the machine; both options negative aspects because with the login it requires more effort from the user or a more sophisticated technology, and with every person affecting the mood it can cause problems between users e.g. if someone always chooses the sustainable parameters but other person does the opposite, then the first person might get frustrated.

This leads to another important topic within the context of use, one of the literature findings says that is better when the machine stimulates social contact and allows to be shared and used with others (Page, 2014), this is an interesting point because if the interaction with a machine has a more social aspect, then that can also be used as a platform to encourage interaction between people.

9

CONCLUSION

Doing laundry is a necessary task in our daily lives, but it is far from being a fun and enjoyable experience. One of the main causes of this is the interaction design of the washing machines, which normally lacks enough feedback for the user to understand the effects of their actions, and to know how the machine works. Also it is not designed to create an emotional attachment with the user, which normally helps to improve the user experience.

We, at the same time, are facing a serious environmental problem, and a way to contribute to solving it is by taking responsibility of what we do and be more conscious about our decisions. Some companies like Electrolux Professional are also taking care of this issue by designing more sustainable products e.g. the greenhouse emissions of Electrolux machines was reduced 31% from 2005 - 2017 (Electrolux Group 2018) by improving the machines' design. But it is also necessary to provide the tools to help the user to have a more sustainable behavior.

The purpose of this thesis was to contribute to these issues, based on the hypothesis that a social machine with personality can add to a more emotional attachment and therefore to influence people's sustainable behavior. In the literature study this hypothesis was proven to be correct but it needs to be carefully designed and tested because it deals with more psychological effects that might not turn out to be the desired ones. The answer of the hypothesis can be defined with this quote:

"... when you turn up the volume on the "social" element of a persuasive technology product, you increase your bet: you either win bigger or lose bigger, and the outcome often depends on the user. If you succeed, you make a more powerful positive impact. If you fail, you make users irritated or angry." (Fogg, 2002).

This is a completely new way of interaction that needs a lot of research and future work. A first step on this topic is to understand what makes a machine social and in what way it can create emotional attachment that will transform into persuasion. To answer this, the following research question was stated:

"What characteristics a machine should have, in order to both provide a better user experience and to emotionally influence the user to make more sustainable decisions?"

To answer this question a literature research was conducted, followed by the development of a new design concept, and it was found that there are five different social cues to make inferences about the characteristics a social machine should have. These cues will be followed described along with an explanation of how this was achieved in the design concept and how it can be implemented in the future.

Physical: Face, eyes, body, movement

This is probably the most obvious social cue, and is based on the idea that social bonding with machines can increase by facilitating the use of morphologically human features (Epley, Waytz & Cacioppo, 2007). The design concept makes use of eyes and a smile to convey emotions that are directly related with the sustainable behavior of the user. In this case the body is the whole machine that has the shape of traditional washing machines, this was thought to be useful in a first iteration of this type of machine so it can have a more smooth transition with the new way of interaction; however, in the future it can also use movement to better convey emotions e.g. the first design of Wash-E at the Designathon17 where it has a head that moves depending on the state of the machine.

Psychological: Preferences, humor, personality, feelings, empathy

The psychological cues are related to the idea that a social machine must convey intentionality, which means it must make the human believe that it has beliefs, desires, and intentions (Breazeal & Scassellati, 1999). The designed machine has the personality of a baby or a puppy, someone that needs caring and expresses very naive and honest emotions, which are intended for creating emotional attachment with the user, in a fun way.

Language: Interactive language use, spoken language, language recognition

Another way to make a machine be perceived as social is with the use of language. It can be written or through voice and it must be reciprocal, which means if, for instance, the machine can talk then it should also be able to recognize when the user speaks; all this in order to have a more realistic personality that will make the machine be perceived as a social being rather than just a computer. This type of cue was not used in the design concept but if implemented it can enhance the experience and contribute to a better understanding.

Social dynamics: Turn taking, cooperation, praise for good work, answering questions, reciprocity

The social dynamics are a more complex level of the machine's personality and it has something to do with Page's (2014) idea that it is better when the machine stimulates social contact and allows to be shared and used with others. This cue was not included in the design concept either, but it is a very important cue that can add to a more complex personality which will mentally stimulate the user and increase the sociability of the machine.

Social roles: Doctor, teammate, opponent, teacher, pet, guide

An important aspect of the machine's personality is the social role it will play, this is what can make a difference for the user in terms of interaction, mainly because it is how we interact in our society, and having a define role for the machine will help for a better psychological perception and acceptance. As mentioned before, the design concept includes a personality of a baby or puppy that require some degree of caring, but for future work it will be interesting to test this

and other types of personality to see which one works better for the intended purpose.

This thesis will hopefully be used as an inspiration for future related work because, as previously mentioned, this is only a first step into this new way of interaction, a lot of research and innovative design needs to be done to create a successful product. But if this is achieved it can also be implemented in other appliances, which can turn out into a competitive advantage for Electrolux Professional and at the same time change the way we experience household appliances for a better environmental future.

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