Designing Unique Emotions For Autonomous Delivery Robots

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Acknowledgements

When I started my Integrated Product Design Masters at the TU Delft, I was hoping to find answers. What kind of designer do I want to be? What can and should I work on in the future? What even is design? Instead of finding simple, clear answers to my questions, I was left with even more. Moreover, to me, this is something wonderful.

My past two years studying and all the wonderful and talented people I had the fortune to encounter on the way helped me to see the design from novel perspectives. Instead of discovering the one thing I want to work on in the future, I found hundreds. Rather than finding the precise definition of what kind of designer I want to be, I now see it as a never-ending process, with the chance to continuously grow, challenge yourself and embrace the joy and excitement that it brings.

For this curiosity-driven graduation project, I saw the opportunity to combine two themes that I personally care about and never fail to engage me: robotics and emotions. When combining the two themes, I was happy to see that the enthusiasm was not only my own but answered from multiple sides. This project helped me grow as a designer and discover new perspectives and questions that I want to be answered.

At this point, I want to take the opportunity and thank everyone who guided and supported me through this graduation project.

To my graduation committee
First of all, I would like to express my gratitude to my chair, Paul. I want to thank you for your visionary mentorship and for supporting me with your one of a kind ideas. You have been continuously pushing me to go to new lengths and giving me the ability to grow. Moreover, most importantly, you have taught me to be a fearless, idealistic and perceptive designer. This project would certainly be a different one without you.

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To my family in Turkey (in Turkish)
Son soz olarak profesyonel kariyerimde ve kisisel hayatimda bu noktaya gelmem için en buyuk emek ve fedakarligi gostermis olan anneme, babama ve canim kardesim Semih`e cok teşekkür ederim.

Sizden uzakta zor zamanlar olsa da, yillar suren benzersiz destekleriniz ve rehberlikleriniz sayesinde asla kendine inancini kaybetmeyen ve kararliligini surduren, guclu bir Turk kadini olmami sagladiniz.

Abstract

Robotic delivery services can provide contactless delivery, a highly sought-after service under mandates of social distancing since the coronavirus pandemic has arisen. With the rise of autonomous delivery robots, humans' and robots' collaborative existence has become a crucial topic to be discussed.

This graduation project aimed to explore the autonomous delivery robots' specific perception of the world through various factors: their purpose, intent, state, mood, personality, attention, responsiveness, intelligence, and capabilities, and through this understanding, design unique robot emotions that will foster them to communicate their unique needs. Since autonomous delivery robots have different concerns than people, they require different emotions.

A speculative design approach has been utilised for this project. Speculative design serves two distinct purposes: it enables us to think about the future and critique current practice. It is based on imagination, imagining other worlds and alternatives, creating provocations, and raising questions, innovations, and explorations.

Throughout this project, several exploratory research methods were conducted to understand the delivery robots' worldview. Following, four unique robot emotions have been created. These emotions aim to serve particular concerns of the delivery robots on sidewalks.

The proposed four unique emotions are called Donsul, Trittity, Loniformi and Puffalope. An online survey was conducted to examine whether people could distinguish these unique robot emotions from human emotions. The survey results show that people assumed that the robot is more likely to experience emotion when it experiences an adverse event, such as a barrier to executing its task.

The project's value is not what it achieves or does but what it is and how it makes people feel, especially if it encourages people to question everydayness in an imaginative, troubling, and thoughtful way and how things could be different.

Reading Guide

This reading guide describes the report layout and guides the reader towards the desired content.

At the beginning of each chapter, a brief introduction of the chapter's content is presented. At the end of the chapters, a green rectangle (Figure 1) provides the main takeaways from the chapter. Reading this rectangle can provide an understanding of the overall project insights in case there is no time for further reading.

Key takeaways are formatted in this way.

Main insights are highlighted in this way throughout the text.

" Quotes are formatted in this way. "

This dissertation is based on the Double Diamond method, which divides the project into four stages: Discover, Define, Develop and Deliver. To indicate each phase, chapters are marked with the corresponding symbol:

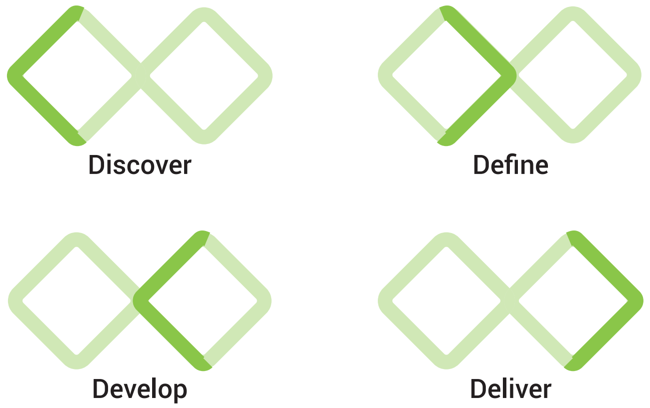

Figure 1: Example of a figure containing takeaways from a chapter.

Takeaways from this chapter

- *Takeaway number one*
- *Takeaway number two*
- *Takeaway number three*
- *Takeaway number four*
- *Takeaway number five*
- *Takeaway number six*

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Abbreviations

AI	Artificial Intelligence
AEI	Artificial Emotional Intelligence
AMS	Amsterdam Institute for Metropolitan Solutions
CM	Context Mapping
CPM	Component Process Model
CPS	Cyber Physical Systems
HCD	Human-Centred Design
HRI	Human-Robot Interaction
IIoT	Industrial Internet of Things
IoT	Internet of Things
PWE	Plutchik's wheel of emotions
SADRs	Sidewalk Autonomous Delivery Robots
VR	Virtual Reality

Chapter 1

General Introduction

In this introductory section, I will give a general overview of the project and its context. This includes a description of the project's background, aim, relevance, and guiding themes of emotions and robotics. Furthermore, a visual representation of chosen design methodology corresponding to the resulting reading structure of the report will give an overview of the concluding report structure.

1.1 Introduction

1.1.1 Emotion as a tool of communication
Emotions play an essential role throughout the span of our lives. They can be understood as a positive or negative experience that is related to a specific physiological activity. They contribute towards modulating almost all modes of communicative activities.

This is a curiosity-driven project, questioning if it is possible to design an emotion that does not exist yet. Emotions arise in response to significant events to the individual's goals, motives, or concerns. Thus, every emotion hides a specific concern behind it. A concern is what gives a particular event its emotional meaning.

1.1.2 Robots need to communicate their internal states
Robots are all around us: A robot can be many things these days, which is just the beginning of its proliferation. Robots are increasingly entering further into the social field of humans, inhabiting offices, hospitals, museums, houses and increasingly streets. Therefore robots will need various interactions to co-exist with people as they have their specific limitations and opportunities.

1.1.3 Autonomous delivery robots do not need human-like emotions
Autonomous delivery robots have specific purposes: delivering a package safely and on time to a particular location. They do not need to interact with people directly. However, they have to navigate among people. This challenge brings them the need to learn how to be a part of a human-dominated society. Autonomous delivery robots can be aware of their surroundings, develop meaningful goals, and act effectively to accomplish those goals.

Autonomous delivery robots need to actively determine their spot in cities, thus improving their acceptance and embedding. They need emotions to communicate their internal states, values and specific concerns. Emotions might form the prime material in the exploration of an autonomous delivery robot's concerns. However, they may never need all of the people's emotional skills. Since autonomous delivery robots have different worries than people, they might require other emotions than humans to create their specific place in society.

1.1.4 Why does 'finding' unique robot needs matter?
Emotion as a feedback system could benefit robots for almost any purpose of pursuit because it can guide behaviour toward the goal. The critical point is that as the robots learn these emotional contingencies, they can adjust goal pursuit to achieve their specific needs. Hence, emotions can take a favourable role in improving autonomous delivery robots acceptance in urban environments.

Designing unique emotions for delivery robots starts with searching for the needs of the robots that differ from human beings, which will lead to discovering the unique robot need. However, it is valuable to understand that this process is not focused on truth-finding but rather speculating stories.

1.1.5 Exploring new realities
Speculative design discipline will be utilised as the primary driver of this graduation project. Speculative design is a discipline that offers designers to imagine how things could be. The form of speculative design thrives on imagination. It aims to open up new perspectives on what is sometimes called wicked problems, create spaces for discussion and debate about alternative ways of being, and inspire and encourage people's imaginations to flow freely (Dunne, 2013). The act of speculating is based on imagination, the ability to imagine other worlds and alternatives, create provocations, raising questions, innovations and explorations, (Keith, 2011; Bleecker, 2009, p.7). In this project, the interest is not just entertainment but a reflection, critique, provocation, and inspiration.

1.1.6 Solution Space
The project is expected to result in designing a unique emotion or set of emotions that will be serving particular concerns of the delivery robots on sidewalks. Several aspects of the emotional experience will be considered to address the delivery robot's ability to express identity, emotion and intention during autonomous interaction with human users. The purpose is to envision a new name, feeling, expression, and action tendency for the unique emotion designed for robots' specific needs.

Assignment

" Explore the autonomous delivery robots' specific perception of the world through various factors: their purpose, intent, state, mood, personality, attention, responsiveness, intelligence, and capabilities.

Take into consideration the delivery robots' specific concerns, design a unique emotion or set of emotions that are only felt and expressed by robots. Describe a new feeling, an expression of the feeling, and a new action tendency for the unique emotion. "

Research Questions

Research questions consist of four main steps of the graduation project:

1. Discover;
What are the specific concerns and needs of autonomous delivery robots on sidewalks?

2. Define;
What is the specific appraisal pattern of the new emotion or the set of emotions that can fit into delivery robots` concerns?

3. Develop;
How can a new emotion be designed into an autonomous delivery robot?

4. Deliver;
How will people and society react to this emotion?

1.2 Approach

1.2.1 Double Diamond Method

To accomplish the assignment within the given timeframe, this project follows the Double Diamond method (Design Council, 2019), which distinguishes the project into different phases of a divergent and convergent approach: Discover, Define, Develop and Deliver. Different steps of the project within this method are shown in Figure below. The following paragraphs will explain the purpose of each phase and briefly describe the methodologies employed.

Phase I: Discover

The Discover phase will focus on gathering information, involving literature research, and identifying autonomous delivery robots' unique needs. This research will envision the exploration of emotions and the use of the delivery robots, their personality, internal states, and any other information that needs to be communicated. Based on the outcomes, there will be a focus on discovering the specific delivery robot's worldview. Chapters 2 and 3 present the procedure by means of a comprehensive literature review.

Phase II: Define

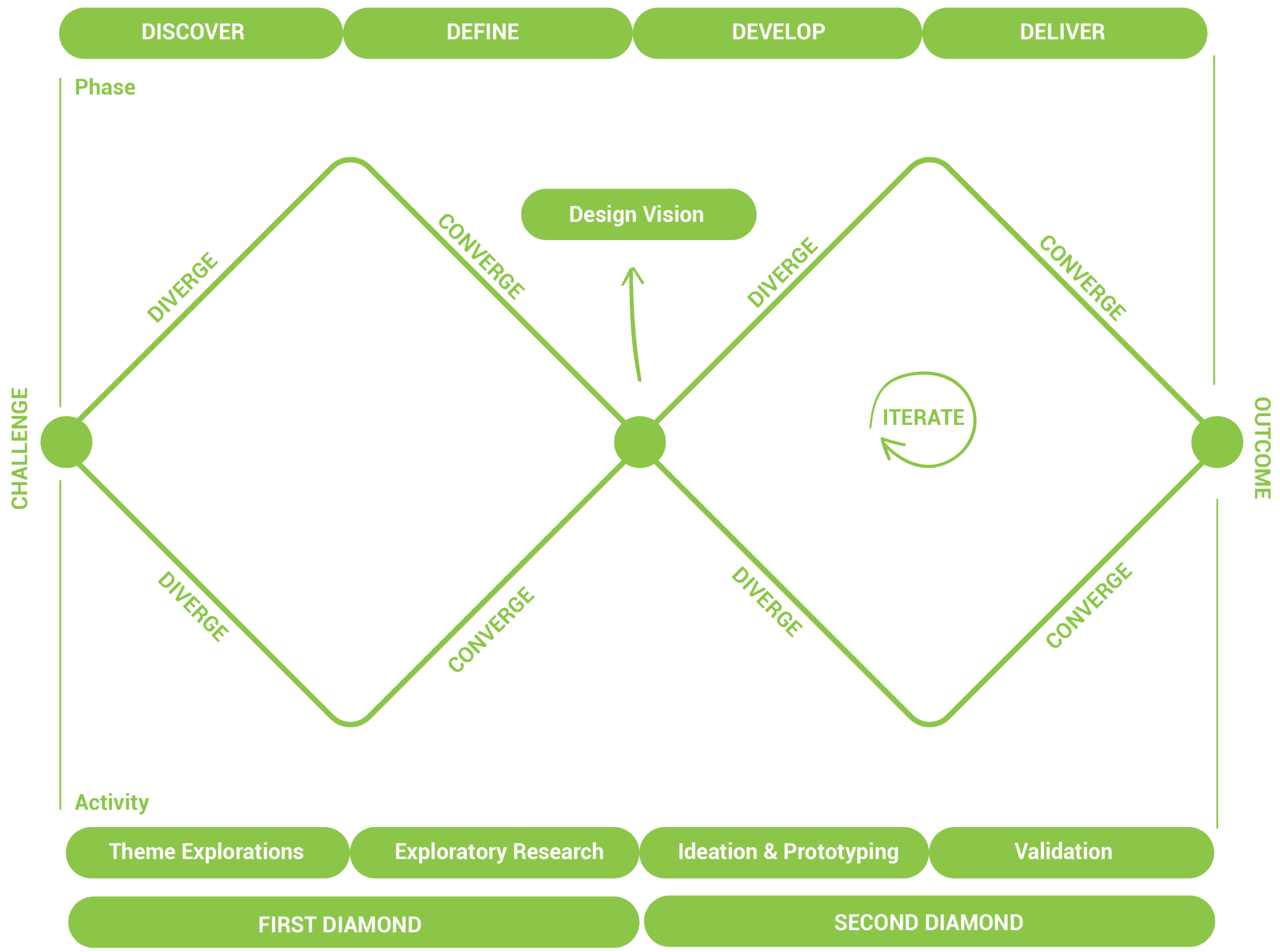
Next, in the Define phase, the collected data will be synthesised to narrow down the scope of the assignment and establish the requirements for developing the unique emotions. Chapter 4 presents the use of the exploratory research approach for defining unique robot needs.

Phase III: Develop

In the Develop phase, the robot emotions will be designed by considering the robot's unique needs. The selected idea will be further developed and detailed. The main focus will be on implementing the emotion into the delivery robots` flow of interactions. Chapter 5 represents the process of implementation of emotions into the robots' personality.

Phase IV: Deliver

The Deliver phase mainly will include validating and evaluating the design. The built robot with the implemented unique emotions will be used in studies to see how it measures the intended design goals. These will be followed by making recommendations, reflection on the design process. Chapters 6 and 7 present the process of validation.



Chapter 2

Theme Exploration: Emotions

Emotions play an essential role throughout the span of our lives. A person's emotions enrich virtually all of his or her waking moments with either a pleasant or an unpleasant quality (Diener, Sandvik, & Pavot, 1991). Moreover, emotions strongly influence our general experience of well-being and people's evaluation of their lives (Diener & Lucas, 2000).

The topic of emotions may seem strangely vague and distant, especially in an effort to frame it as something approachable from a concrete design direction. Regardless, to know how to use a tool to its fullest, one needs to understand its capabilities likewise limitations. Therefore, to get a clearer understanding of the phenomenon ***'emotion'*** and its nature, I conducted a deep dive into literature, guided by keyword search, and carried out discussions with emotion researchers. The following chapter provides a broad overview of emotions and explains how emotions are elicited by summarising the gathered insights from the literature.

Conclusively, this chapter aims to result in understanding whether robots would be able to experience emotions in their unique way of being. This exploration of the concept of emotions will allow me to extract its essence and design a unique emotion that will fulfil the delivery robot`s specific needs.

Questions addressed in this chapter are:
1. What is an Emotion?
2. Why do we experience emotions?
3. How do emotions work?

Method used:
Literature review.

> *“You can choose whatever you desire, but you’re not free to choose your desires.”*
>
> ***— Ian McEwan, Machines Like Me***

2.1 What is an Emotion?

Emotions are subjective experiences. Each person's individual experience constructs their own emotional experience. They are concepts that we start learning from our parents and society from the moment we are born. Our emotions are not innate or fixed; instead, we construct our emotions as architects of our own experiences (Frijda, 1988).

Emotion can be understood as a positive or negative experience that is related to a specific physiological activity. It contributes towards modulating almost all modes of human communication — word choice, tone of voice, facial expression, gestural behaviours, posture, respiration, muscle tension, and more (Picard, 2001).

The primary core of emotions is the experience of pleasure or displeasure. That core is embedded in the outcome of the appraisal (see chapter 2.3), the awareness of situational meaning structure. Emotions change when meanings change. Emotions change when events are perceived differently (Frijda, 1988).

2.1.1 Plutchik's wheel of emotions (PWE)

In Plutchik's viewpoint, which he expressed via the Plutchik's wheel of emotions (PWE) (Plutchik, 1980) in Figure 2.1, eight segments are used to represent the eight primary emotions: anger, anticipation, joy, trust, fear, surprise, sadness, and disgust. The PWE also takes after interpretations in psychology where emotion and colour have a significant relationship that gives rise to the concept of colour emotion (Roy and Michael, 1974). Therefore, a different colour represents each segment (i.e., emotion), and its vertical axis represents the intensity of each emotion. To interpret further, the closer to the centre of the circle, the deeper the colour is, and the stronger the emotion is. So, for example, the lower degree of anger is an annoyance, while the higher degree is rage.

Additionally, in each segment of the PWE (in Fig. 2.1), the closer the distance, the more similar the emotional states are. In this regard, the emotional states of mutual vertical angles are opposite to each other (for example, the opposite of the emotion "joy" is "sadness"). Finally, the emotion sandwiched between two segments is a mixture of the two fundamental neighbouring emotions. For example, "trust" and "fear" combine to form "submission". Thus, the emotion representation framework in Fig. 2.1 depicts the strength of the same emotion and the integration of multiple emotions. This is helpful for understanding emotions as well as the relationship between emotion and colour, which potentially provides a foundation for applications in many domains.

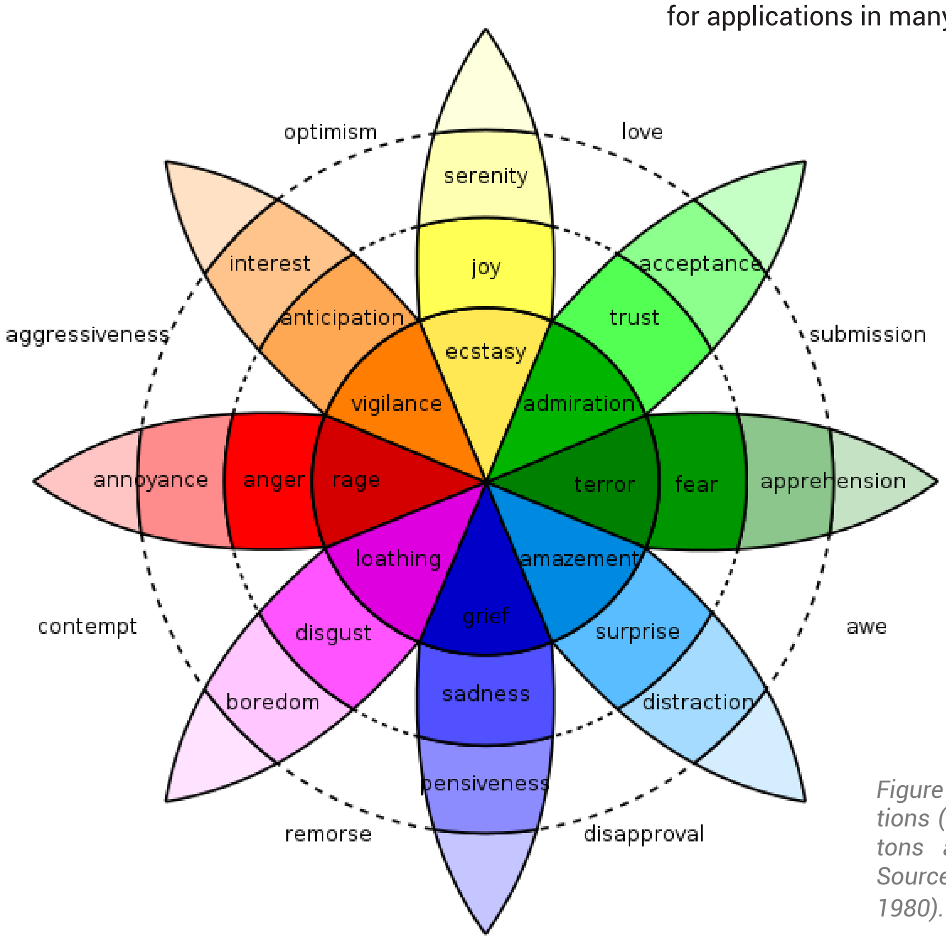


Figure 2.1: Plutchik`s wheel of emotions (PWE) showing eight basic emoitons and related descriptions. (The Source figure adapted is from Plutchik, 1980).

2.1.2 Emotion arises from an individual's concerns.

In 1988, Frijda discussed that emotions arise in response to significant events to the individual's goals, motives, or concerns. Thus, every emotion hides a specific concern behind it. A concern is what gives a particular event its emotional meaning. For instance, one gets upset at the news of another person's illness, probably because he or she loves that person. In a different scenario, one feels such terrible jealousy. Because, perhaps, he or she yearns for continuous possession and symbiotic proximity (Frijda, 1988).

Understanding concern is of considerable value when understanding emotions. Emotions form the prime material in the exploration of an individual's concerns. What matters for individuals affects their emotions, internal sensation experience, and behavioural reactions (Baumeister, 2007).

The need to achieve a goal makes one experience negative or positive emotions. Nevertheless, the concern may be different from one occurrence of emotion to another.

2.1.3 Pleasure and displeasure

At the basic level, emotions are categorised as negative or positive emotions. This means that positive emotions will give one the feeling of pleasure, and on the other hand, negative emotions will give one the feeling of displeasure.

Several emotions can be defined in terms of a particular form of action readiness; they can be defined in terms of some form of action tendency or some form of activation or lack thereof. This is the case with the emotions usually considered primary or fundamental (Izard, 1977; Plutchik, 1980).

> Joy, for instance, is a sense of pleasure plus the urge toward exuberance and contact-seeking. Anger is a sense of displeasure plus the urge to do some things that remove or harm its agent. Shame is a sense of displeasure plus the compelling desire to disappear from view. Finally, sadness is a sense of displeasure plus the ebbing away of any urge except for the desire for the lost object or opportunity, which is known to be unfulfillable (Frijda, 1988).

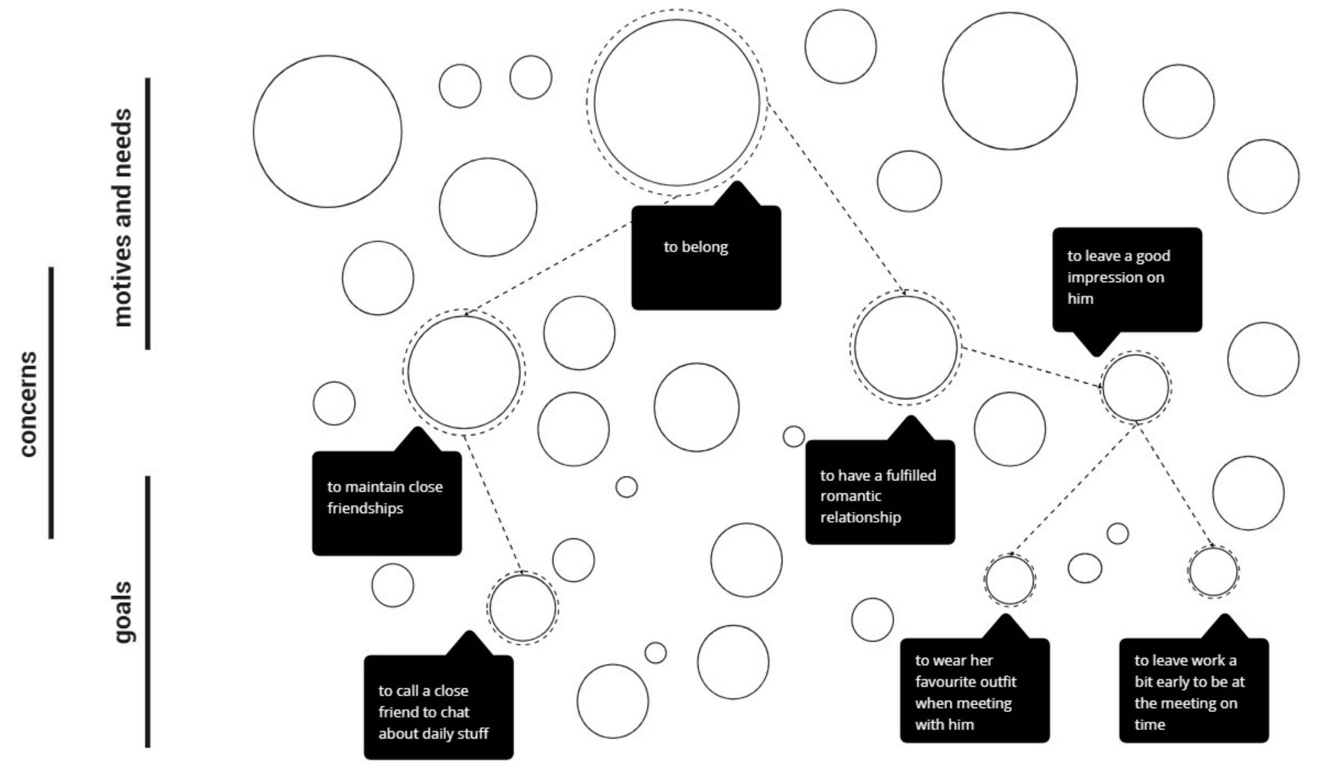


Figure 2.2: Structure of concerns, motives, needs and goals. This visualization created takes inspiration by the doctoral thesis of Erdem Demir (Demir, 2011).

2.1.4 Emotions serve the common aim: Mood regulation to feel pleasant

Human conscious emotion operates mainly and best utilising its influence on cognitive processes, which are input into decision and behaviour regulation processes. However, the inability to self-regulate emotional states directly is also relevant.

> According to the feedback theory, emotion serves as an inner mechanism to reward and punish behaviours. Such a function would be undermined if people could alter their emotional states simply by direct control. Consistent with this line of reasoning, self-regulation theory has long accorded a special place to mood regulation: Whereas people can directly control their behaviours and thoughts, and to some extent their task performances, but they cannot directly alter their moods and emotions, therefore people tend to require various indirect strategies to change their emotions (e.g., Baumeister, Heatherton, & Tice, 1994; Gross, 1998a; Larsen, 2000; Thayer, Newman, & McClain, 1994).

Conscious emotional experiences operate to stimulate cognitive processing after some outcome or behaviour. They facilitate learning lessons and forge new associations between effect and various behavioural responses. Subsequently, these associated affective traces may shape behaviour without having to develop into full-fledged conscious emotion. The outcome of the cognitive processing can also serve as valuable input into further behaviour even in the same situation that gave rise to the original emotion. Ultimately, people learn to anticipate emotional outcomes and behave so as to pursue the emotions they prefer. That concludes, humans mostly tend to pursue the feeling of pleasure.

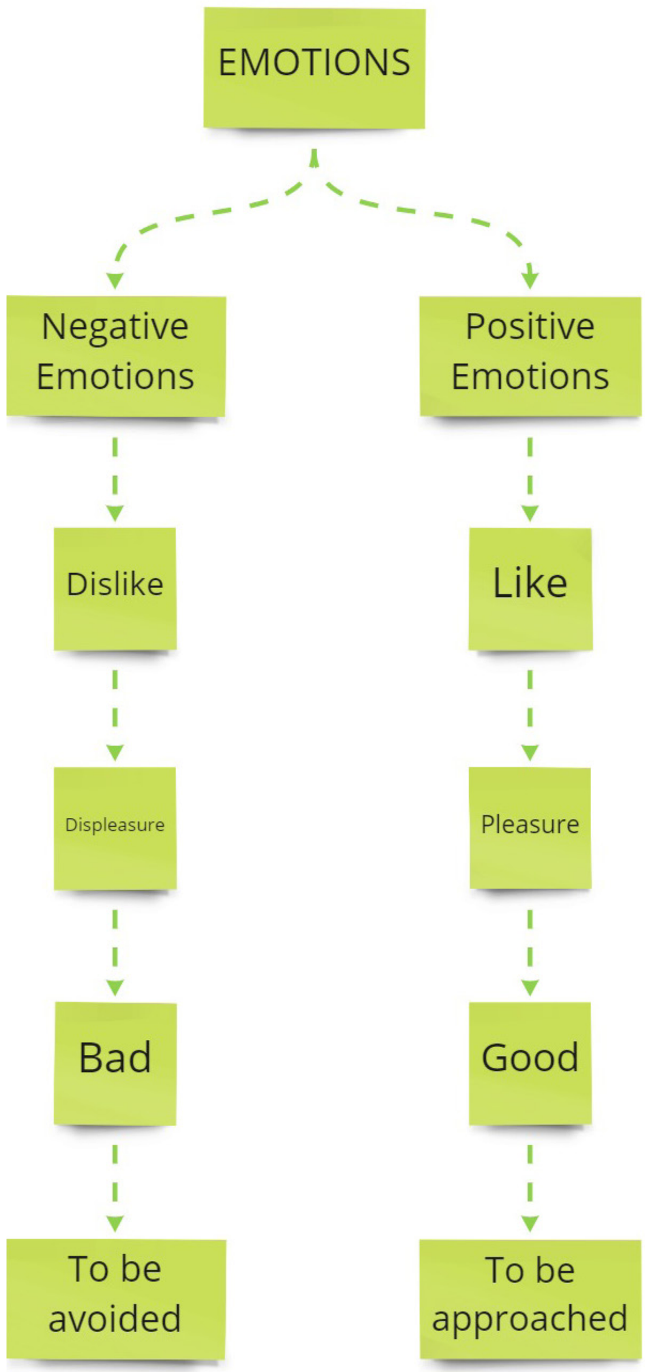


Figure 2.3: The primary core of emotions is the experience of pleasure or displeasure (Frijda, 1988).

2.2 Why do we experience emotions?

A life without emotions would seem to many people scarcely worth living, for it would lack much of the richness and variety of human experience. On the other hand, emotions also carry the stereotype of causing people to behave in foolish, illogical, and sometimes destructive ways. Nevertheless, why would people want to have emotions if their main impact is to produce undesirable behaviours that will be regretted later? Or ultimately, why would evolution have instilled and maintained a strong repertoire of emotional responses in the human psyche if it caused foolish or irrational behaviour? A simple answer is that when emotion is blocked, people are more prone to repeat their mistakes (Baumeister, 2007). In the following part of this chapter, the researcher will explain the crucial impact of emotions on one's life experiences.

In 1997 Bechara Bechara et al. (1997) concluded that the lack of emotional response reduced people's tendency to learn to avoid the source of harm, leaving them more prone to repeat costly behaviours. This finding fits the view that emotion facilitates learning and thereby promotes adaptive behaviour (Bechara, 1997).

Furthermore, recent evidence has shown that patients with damage to the amygdala, and who are therefore emotionally handicapped, did not show enhanced memory for information that is relevant to the topic and was, therefore, unable to learn the lesson from relevant to the topic (Adolphs, Tranel, & Buchanan, 2005). Thus, being unable to experience the emotion at the neural level impairs people's ability to learn the lesson.

Emotions may help people learn from their experiences. Hence, emotion can have considerable value even after the emotional episode is over because it helps people process information from their recent experiences and thereby learn how to act more optimally in the future.

To sum things up, studies have proved that emotion facilitates learning: Current emotion or affects increases accessibility of memories about one's previous behaviours in a comparable emotional state.

2.2.1 The Relationship between emotions and behaviour

According to Baumeister (2007), emotion is not directly causing the behaviour. Instead, they have developed a theory of emotion as a feedback system whose indirect influence on behaviour. Three different emotion types are beneficial for different kinds of occasions. These are automatic emotions, conscious emotions and anticipated emotions, which work differently. However, they are interrelated and coordinated (Figure 2.4).

Automatic Emotions:
Emotions guide the behaviour

The primary purpose of automatic emotions is to directly cause behaviour to facilitate humans to cope with the current event.

Automatic emotions work as a signalling mechanism. People have automatic affective reactions (in the core, liking and disliking something, see figure 2.3) that are simple and rapid and may well guide behaviour and result in causing quick reactions.

As an example, fear stimulates flight or fight mood; the aim is to promote survival. Seeing a lion activates emotional fear. Imagine an early human encountering a dangerous predator. For conscious emotion to mediate the flight, a sequence of automatic emotions would be necessary. First, the person must recognise the animal and cognitively appraise the danger. This rapid evaluation of the specific situation of fear of the lion gives rise to physiological arousal, spreading through the person's body. The bodily response then triggers a further cognitive process involving the brain, which recognises the bodily state as fear and, on that basis, initiates a motor response, and the person flees.

Conscious Emotions:
Emotion guides learning

Conscious emotion is beneficial for the learning process. These emotions work as a feedback mechanism. Therefore, emotion does not directly affect behaviour; but instead, it influences cognitive process input into decisions and behaviour regulation process. By providing feedback and stimulating retrospective appraisal of actions, conscious emotional states can promote learning and alter guidelines for future behaviour (Baumeister, 2007).

Conscious emotion commands attention and stimulates analysis, learning, and adaptation, often occurring in the aftermath of behaviour and its outcomes. It may occasionally directly affect behaviour (for good or bad), but directly driving behaviour is not its primary function of conscious emotions.

Negative emotions, in particular, promote counterfactual thinking, and such thinking seems ideal for helping people reflect on what they have just done to figure out how to behave in a more rational, practical, or moral way (Baumeister, 2007).

For instance, someone borrows his friend's favourite pen, behaves irresponsibly, and loses the pen. As a result, his behaviour makes his friend upset. However, because he cares about his friend, the next time he borrows a pen, he behaves more carefully and returns the pen so as not to sadden his good friend.

Conscious emotion makes people more likely to learn a lesson from an event and improves their memory for information relevant to that lesson. In addition, emotion stimulates reflection on prior events, and that reflection can help with coping and improve behaviour.

Anticipated Emotions:
Emotion guides decisions

Anticipated emotions promote safe choices. Behaviour may be chosen to pursue or avoid anticipated emotional outcomes.

The importance of anticipated emotion has been recognised by decision researchers, most notably in an influential theory by Mellers, Schwartz, and Ritov (1999). The main thrust of their theory is that an anticipated emotion generally guides a human`s choice. Thus, in choosing between various monetary gambles, people select based on how they think they will feel about winning or losing, rather than simply making a dispassionate calculation of what will maximise their probable financial payoff and choosing on that basis.

Assuming that emotional feedback does facilitate learning, a person will gradually learn to anticipate what acts will bring which emotions. Once those expectations are formed, the person is likely to start selecting actions based on the anticipated emotional outcomes—because people are strongly motivated to avoid emotional upset and/or seek out positive emotions. As humans, we tend to pursue positive emotional outcomes as a factor in most behavioural choices (Baumeister, 2007).

For example, during the last year of high school, students are responsible for choosing their area of expertise. A student who dreams of herself as a designer and anticipates being happy in this role will make decisions accordingly. She will choose a design-related major instead of medicine because she has anticipated that working in design fields will make her feel happier than working as a doctor.

Briefly, anticipated emotion helps people to regulate behaviour to minimise negative emotions they may feel in the future.

2.2.2 Conclusion

In sum, the human emotional apparatus may shape behaviour by providing a feedback system that may be useful for sophisticated goal pursuit and learning to behave effectively in complex social and cultural situations.

Conscious emotions provide feedback about behaviour, stimulate cognitive analysis and promote revisions of the programming on which people react to events. As a result, people behave in ways that will pursue desired emotional outcomes. On the other hand, automatic emotions preserve the lessons experienced with conscious emotions, facilitate acting, and serve as warning signals (see Figure 2.4).

The behaviour is pursuing emotion as the desired outcome. For example, the emotional state of sadness does not intrinsically contain anything about eating cheesecake, but rather the sad person eats cheesecake when it is available in the hope of changing emotional state (i.e., cheering up). Even such supposedly classic patterns as anger causing aggression indicate that the person expects the behaviour to produce mood repair (Russell, 2003). Thus, even when the data seem to show that emotion causes behaviour, the underlying reality is that behaviour pursues emotional outcomes.

- ***Each emotion arises from a specific need.***
- ***People cannot control their emotions because the purpose of emotions is to control people.***
- ***Emotions affect behaviour because people avoid negative emotions or they want to protect their positive emotional states.***

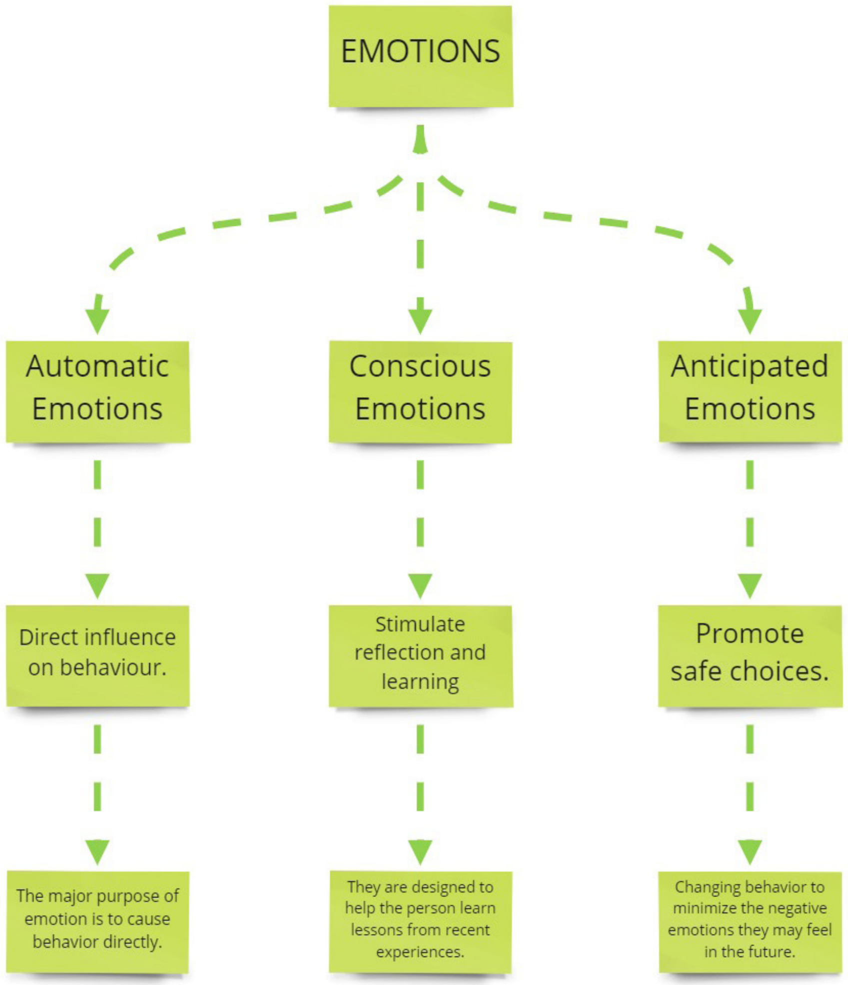


Figure 2.4: Three different emotion types are beneficial for different kinds of occasions. These are automatic emotions, conscious emotions and anticipated emotions, which work differently. However, they are interrelated and coordinated.

2. 3 How do emotions work?

2.3.1 Emotional Experience

Emotions are best treated as multifaceted phenomena consisting of several components (Izard, 1977; Lazarus, Kannen & Folkman, 1980). These components are behavioural reactions, expressive reactions and physiological reactions, and subjective well being (Desmet, 2002). Emotional experience requires that all of these processes become coordinated and synchronised for a short period, driven by appraisal processes (Scherer, 2005).

- **Subjective feeling** (e.g. feeling happy or sad) is the conscious awareness of the emotional state, i.e. the subjective emotional experience. Each emotion involves a specific feeling that is an essential, irreducible mental element (Tichener, 1908). In daily life, the feeling is commonly seen as the essence of emotion (Dalkvist & Rollenhagen, 1989).

- **Expressive reaction** (e.g. smiling or frowning) is the facial, vocal and postural expression accompanying the emotion. Each emotion is associated with a particular pattern of expressions (Ekman, 1994). For example, anger makes one have a fixed stare, contracted eyebrows, compressed lips, vigorous and brisk movements and a raised voice (Darwin, 1872; Ekman & Friesen, 1975).

- **Physiological reaction** (e.g. increases in heart rate) is the change in activity in the autonomic nervous system which accompanies emotions. Emotions show a variety of physiological manifestations, such as sweat production, trembling, and muscle tension simultaneously (Cannon, 1987). More specifically, Cannon's theory (see figure 2.6) contends that emotions result when the thalamus sends a message to the brain in response to a stimulus, resulting in a physiological reaction. At the same time, the brain also receives signals triggering the emotional experience and response.

- **Behavioural reaction** (e.g. running, or seeking contact) is the action or behaviour one engages in when experiencing an emotion. Emotions initiate behaviour in the form of action tendencies such as approach, inaction, avoidance and attack (Arnold, 1960). For example, fear makes one want to run: while love makes one want to approach or care. The identifications of particular emotions with particular forms of action readiness originate in the functional analysis of expressive behaviour.

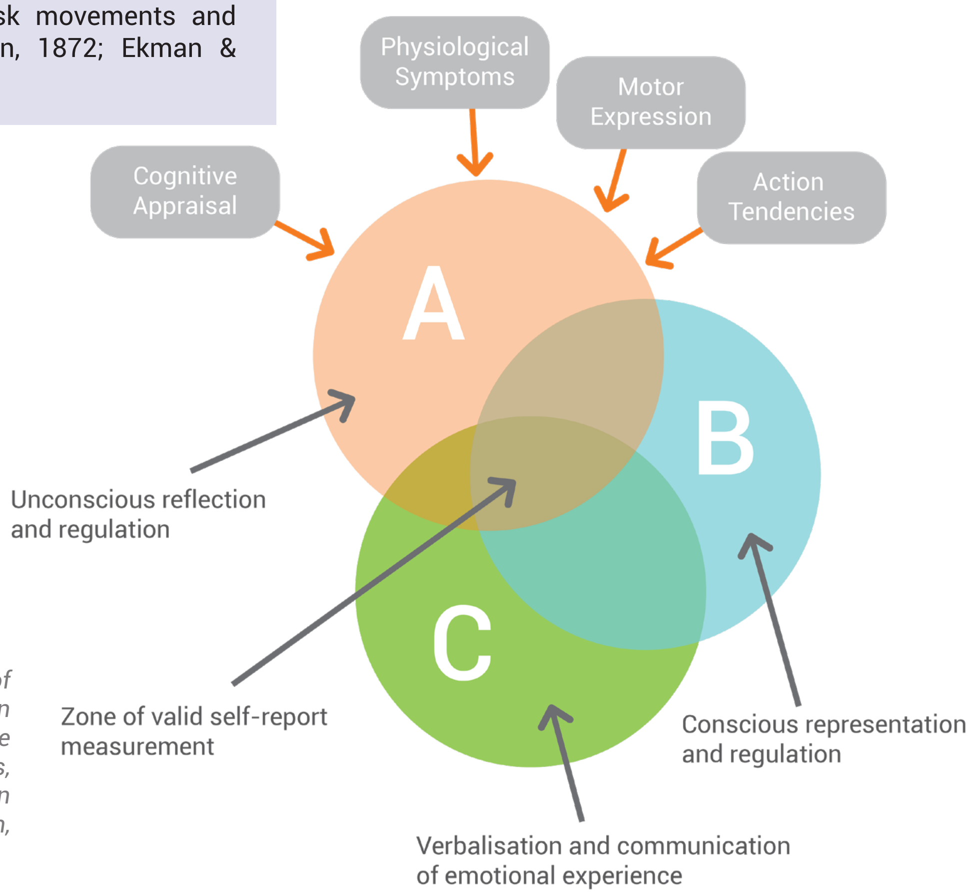


Figure 2.5: The reflection of component emotion process in a monitor system, circle A, the emergence of consciousness, circle B, and categorisation and verbalisation, circle C.(Yan, 2021).

Theory	Summary	Example
James - Lange theory	Emotions occur as a result of physiological reactions to events	(1) You are walking through a parking garage (2) You notice a dark figure and your heart begins to beat faster (3) You interpret your physical reactions as fear
Cannon–Bard theory	Physical and psychological experience of emotion happen at the same time	(1) You are going on a date with someone you like (2) You feel excited and have sweaty palms
Schachter–Singer theory	Physiological arousal occurs then the individual identifies the reason for and accordingly labels an emotion	(1) Your heart is beating faster during an exam (2) You realise this and identify the emotion as anxiety
Cognitive appraisal theory	Thinking must occur before experiencing an emotion	(1) You encounter a bear in the woods (2) You think that you are in great danger (3) You experience the fear and fight-or-flight reactions
Facial feedback theory	Facial expressions are connected to experiencing emotions	(1) You are being forced to smile at a social event (2) You have a better time than when having a stolid face

Table 2.6: Major theories of emotion and their examples (Yan, 2021).

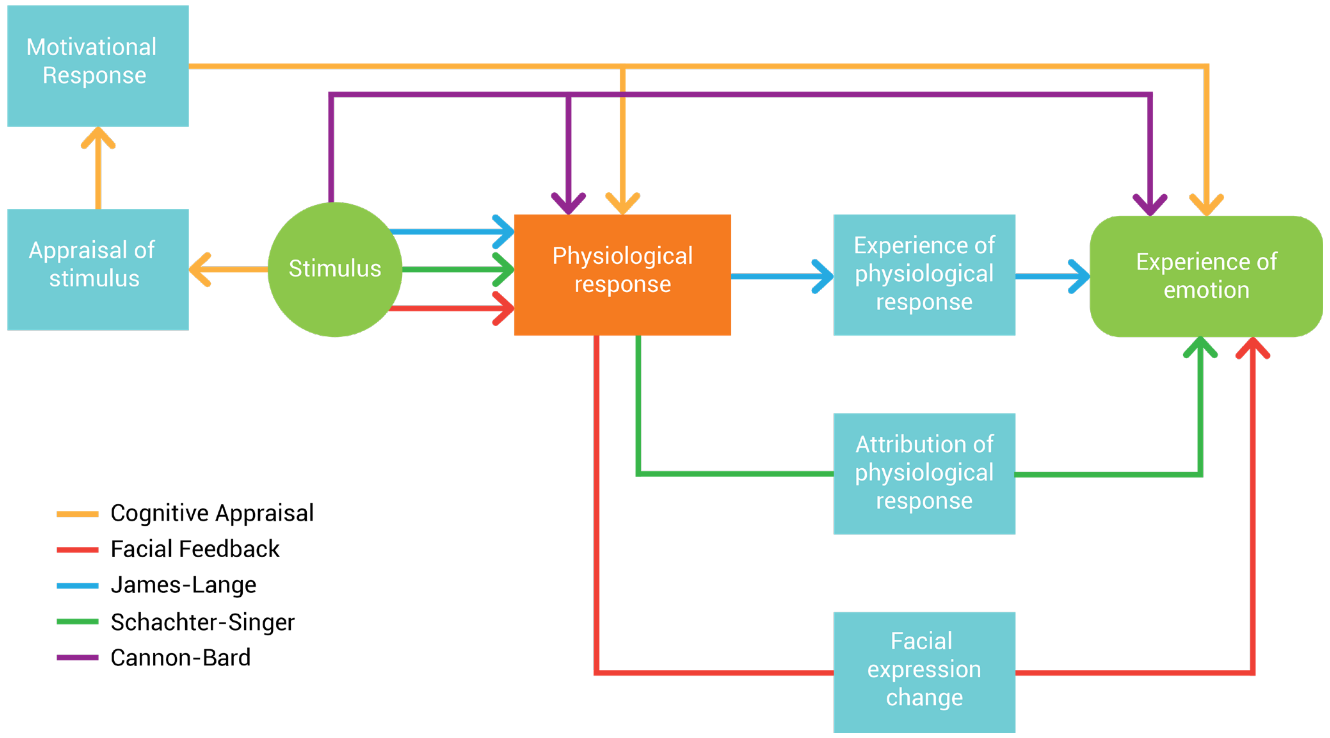


Figure 2.7: Illustration of five theories of emotion depicting response from stimulus to experience emotion (Yan, 2021). The flowchart outlining the different theories and their interaction with various stimuli to further illustrate the various emotion theories.

With the emergence and development of the theories of emotion mentioned earlier (fig. 2.7), specific definitions of emotion have been proposed in psychology, for example, that by Plutchik which considers "emotion is a complex chain of loosely connected events which begins with a stimulus and includes feelings, psychological changes, impulses to action and specific, goal-directed behaviour" (Plutchik, 2001).

In addition to defining emotions, researchers have been engrossed in identifying and classifying different types of emotions. However, discourses regarding how to classify emotions have always been controversial, but the consensus among most psychologists is that most emotions are only different in the degree or extent of expression.

2.3.2 Emotion Process

In the cognitive view, the process of emotions is explained by the process of appraisal. An emotion always involves assessing how an event may harm or benefit a person (Arnold, 1960). According to Arnold, an appraisal is at the heart of every emotion. Without an appraisal, there can be no emotion, for all emotions are initiated by an individual's appraisal of his or her circumstances (Desmet, 2002).

A perennial obstacle to integrative theories of emotion is that not all emotional phenomena seem to follow the same patterns. It is entirely plausible that the category of emotion and/or affect comprises different kinds of phenomena that follow different causal principles and serve different functions (Chaiken & Trope, 1999; Wilson, 2002).

2.3.3 Two Dimensional Emotion Model

The two dimensional (2D) VA (valence–arousal) model (Russell, 1980) proposed by Russell et al. is widely cited. Russell's model (presented in Figure 2.8) divides emotion into valence and arousal dimensions representing the degree of pleasant–unpleasant and excited–calm emotions, respectively. Furthermore, the model is divided into four quadrants (by the positive and negative valence as well as the high and low arousal), each representing a human's emotional states according to the combination of values in the valence and the arousal dimensions.

In this model, the positive half of the axis represents positive emotions while the negative axis represents negative emotions. Thus, the position of the coordinate axis can determine the positive and negative degree of emotion.

Moreover, there is an issue require attention. It is that the nature of the response scale that is used to judge emotion terms. For example, the response scale can substantially impact whether or not bipolarity between positively and negatively valenced emotion terms will be observed (Russell & Carroll, 1999).

The most crucial hypothesis from the dimensional approach to the study of emotion in psychology is that the emotion domain can be robustly represented by a three-dimensional structure, with valence, power, and arousal as the three main dimensions, see Figure 2.10 (e.g., Fontaine et al., 2002; Osgood, May, & Miron, 1975; Shaver et al. 1987).

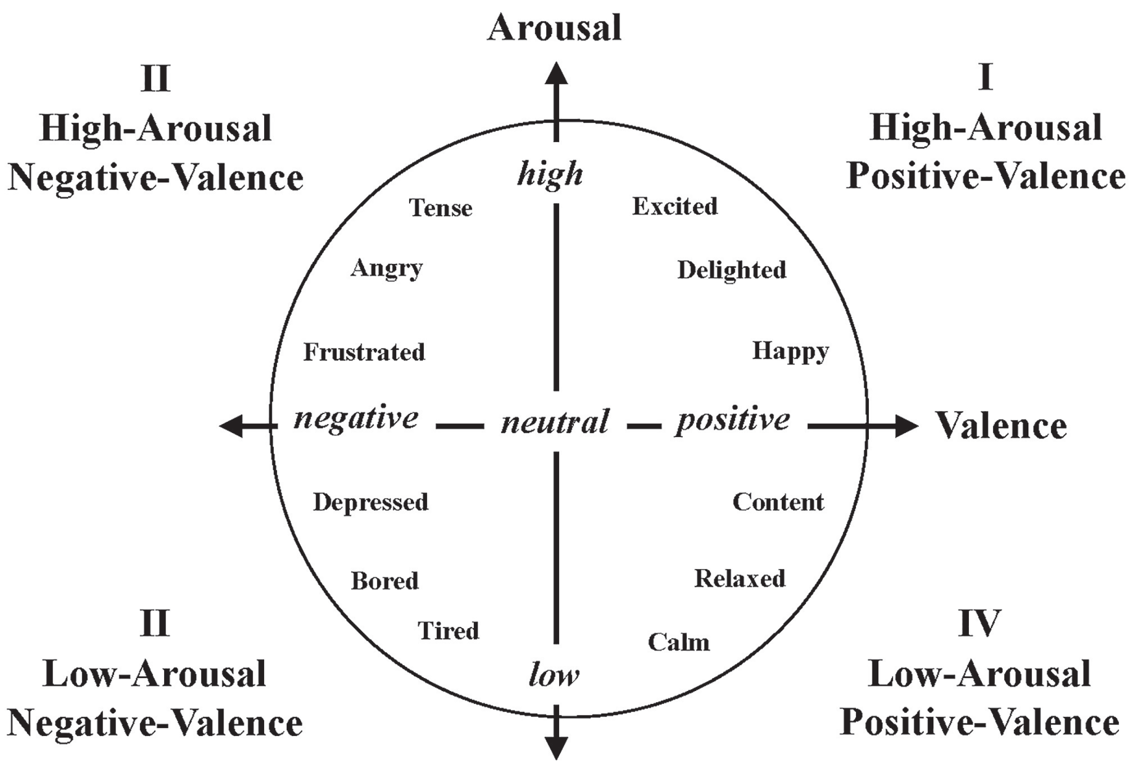


Figure 2.8: Valence-arousal (VA) space and some of its typical emotions. Figure adapted from Russell (1980).

2.3.4 What is Appraisal Theory?

According to the Cambridge Dictionary, the meaning of the word appraisal is the act or process of developing an opinion, judgment, or assessment of the value of something.

The appraisal theory of emotion proposes that emotions are extracted from our "appraisals" (i.e., our evaluations, interpretations, and explanations) of events. These appraisals lead to different specific reactions in different people. For example, sadness felt when a romantic relationship ends may be elicited by the appraisals that something desired has been lost, with certainty, and cannot be recovered. (Scherer, 2001)

Each emotion is the outcome of a unique appraisal (Arnold, 1960; Lazarus, 1991). Although each stimulus can elicit a range of emotions, each appraisal type results in a specific emotion. That means appraisals differentiate emotions. Although according to appraisal theories, the different emotions manifest in characteristics, facial expressions and action tendencies are produced by different evaluations of events (Desmet, 2003).

According to Desmet (2002), satisfaction and disappointment are elicited by motive compliance appraisals, disgust and desire are elicited by appealingness appraisals, contempt and admiration are elicited by legitimacy appraisals, and novelty appraisals elicit fascination and boredom. Figure 2.9 illustrates the product emotion model of Desmet (2002).

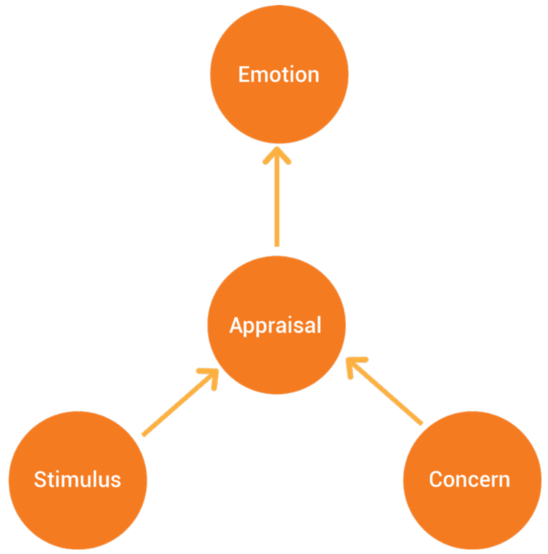


Figure 2.9: Desmet`s product emotion model (2002).

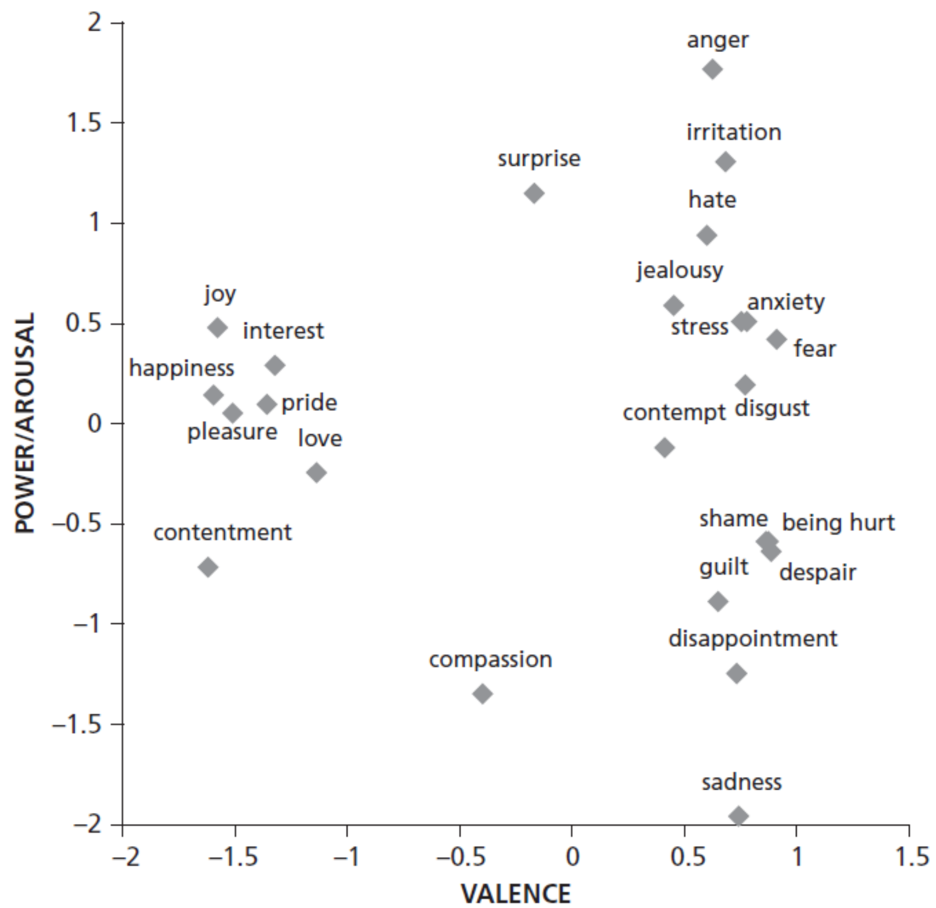


Figure 2.10: Plot of the average factors scores for the 24 emotions words in a two factorial VARIMAX rotated structure (Fontaine, 2013).

Differences in appraisal can account for individual and temporal differences in emotional response. It is the interpretation of events, rather than events themselves, that cause emotion. Since the same situation can often be interpreted differently, there are few if any, one-to-one relationships between a situation and an emotional response (Roseman,1984). Because appraisals intervene between situations and emotions, different individuals who appraise the same situation in significantly different ways will feel different emotions. A given individual who appraises the situation in significant ways at different times will feel different emotions (Roseman, 2001). The appraisal system relates features of external situations to internal motives and resources. According to Arnold (1960a), the appraisal is a perception type that suggests clear limits on our ability to control the process (see Figure 2.12 and 2.13 for further illustration of appraisal models).

In Roseman`s (1996) Model, appraisal information can vary continuously, but categorical boundaries determine which emotion will occur. For example, the boundary between motive-consistency and motive-inconsistency is not just a point on a continuum, but the dividing line determines whether a positive emotion versus a negative emotion will be experienced (Roseman, 2001). For example, according to Roseman et al. (1996), anger is caused by appraising an event as a motive-inconsistent goal blockage caused by someone else and perceiving that one has the potential to do something about the situation. If the event were seen instead as motive-consistent, affection rather than anger would be produced; guilt would be felt if caused by the self. See Figure 2.11 for further examples of emotion`s appraisals.

2.3.5 What is the action tendency?

The action tendencies and the available modes of action readiness correspond to the behaviour systems and general response modes humans are endowed with. These include the programs for innate behavioural patterns, of which elementary defensive and aggressive behaviours, laughter and crying, and universal facial expressions (Ekman, 1982) are elements. They further include the general activation or deactivation patterns of exuberance, undirected excitement, and apathetic response, and the pattern of freezing or inhibition. Finally, they also include the various autonomic and hormonal response patterns--those of orienting, of active or passive coping, and the like, described by the Laceys (Lacey & Lacey, 1970), Obrist (1981), and Mason (1975), among others. These physiological patterns form, so to speak, the logistic support of the action readiness changes involved. Moreover, the response modes include the action control changes that manifest in behavioural interference and that we experience as preoccupation and urgency; sometimes, these are the only aspects of our change in action readiness that we feel or show (Frijda, 1988).

Appraisal	Emotion
Pleased about the prospect of a desirable event	Hope
Pleased about a desirable event	Joy
Approving of one`s own praiseworthy action	Pride
Pleased about the confirmation of the prospect of a desirable event	Satisfaction
Displeased about the prospect of an undesirable event	Fear
Displeased about an event presumed to be desirable for someone else	Resentment

Figure 2.11: Several researchers developed models of emotion that distinguish between emotions on the basis of appraisals. Figure 2.11 displays some examples drawn from well- accepted appraisal model developed by Ortony et al. (1998)

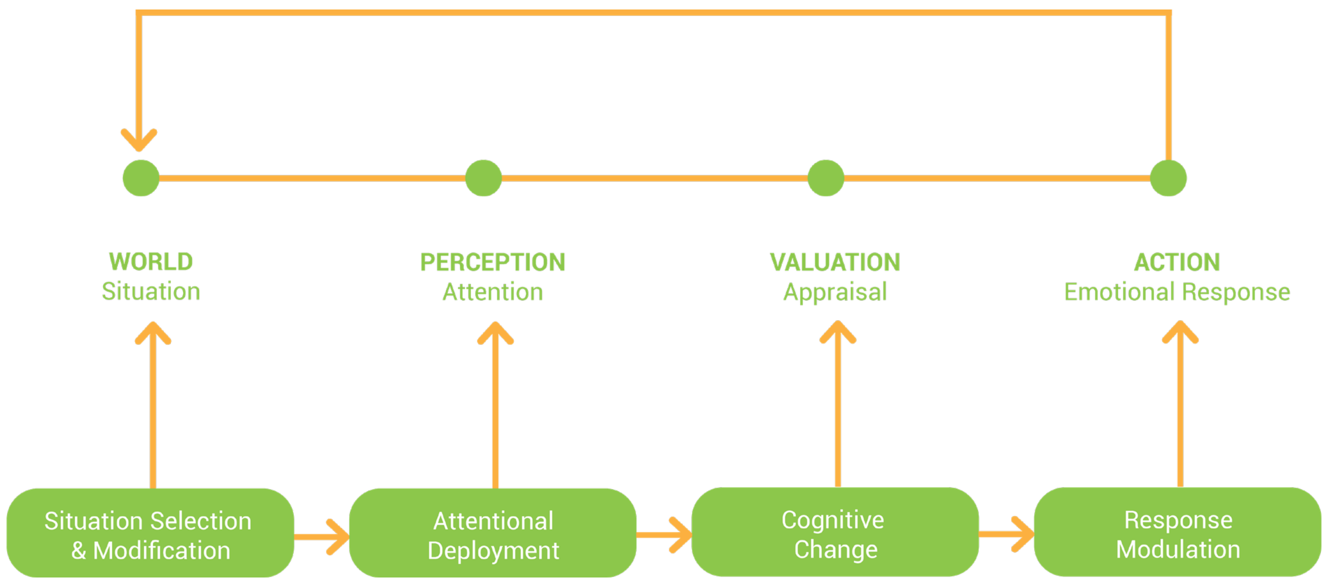


Figure 2.12: The appraisal system relates features of external situations to internal motives and resources. According to Arnold (1960a), the appraisal is a perception type that suggests clear limits on our ability to control the process.

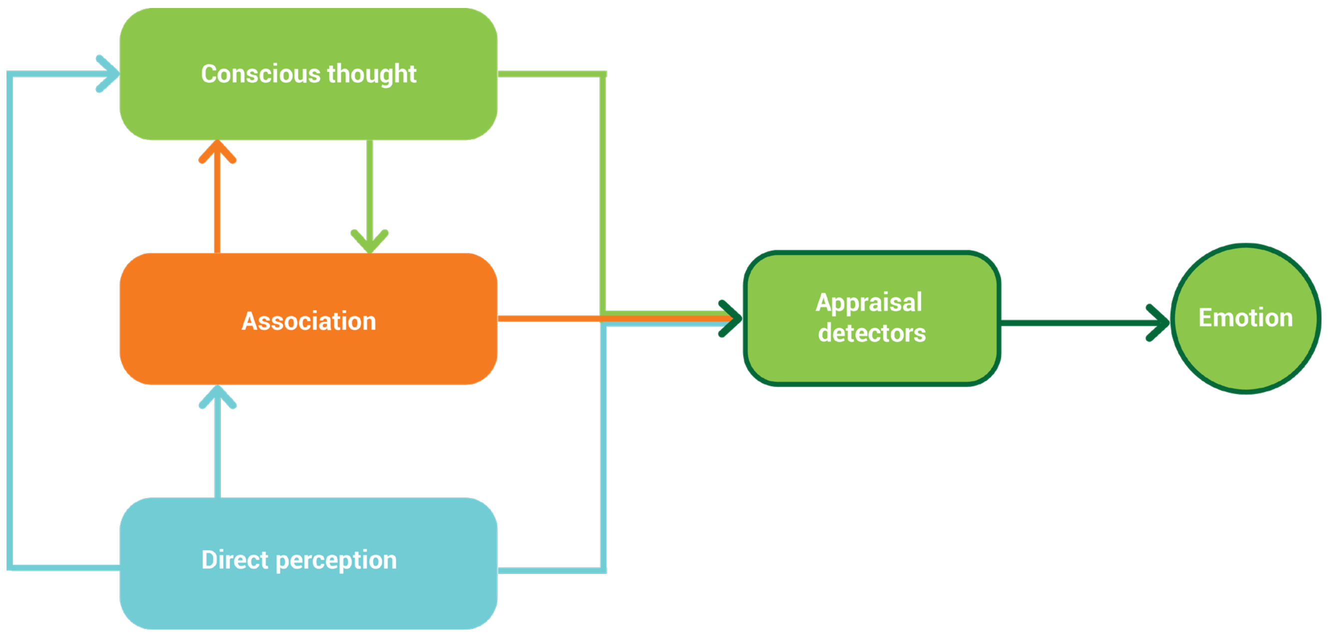


Figure 2.13: Smith and Kirby identify three different appraisal levels and illustrate how these different levels work together (2001).

2.3.6 The component process model (CPM) of emotion mechanism

The CPM is based on the conjecture that emotion replaced instincts to allow for more flexible responses to events in a complex environment during evolution (see Figure 2.14). It did so by introducing an interruption into the stimulus-response chain to allow for more ample information processing. It also contends that emotion has been optimised to serve the following functions (see Scherer, 2001):

- Evaluation of objects and events
- System regulation
- Preparation and direction of action
- Communication of reaction and behavioural intention
- Monitoring of internal state and organism-environment interaction

Specifically, the model suggests that different effects of sequentially accrued appraisal results cumulatively constitute the unique, context and individual-specific response pattern for a given emotion episode (Fontaine, 2013).

Theories predict that emotions are elicited entirely on the basis of an individual's subjective evaluations of the event and his or her role in it rather than its "objective" characteristics, given that the latter may be perceived differently and evaluated based on the individual's goals and values as well as on his or her coping potential.

The nature of the appraisal process

The CPM proposes that the organism evaluates the events that have taken place and their consequences on four class assessments expected to unfold sequentially over time. First, the organism evaluates the event and its consequences on several criteria or stimulus evaluation checks (shown in the figure 2.15), with the results reflecting the organism's subjective assessment of consequences and implications on a background of personal needs, goals, and values (see Ellsworth & Scherer, 2003; Sander, Grandjean, & Scherer, 2005; Scherer, 2001).

In addition, each type of assessment draws on other cognitive and motivational mechanisms (such as attention, memory, motivation, reasoning and self-concept), which provide stored information and evaluation criteria essential for the appraisal process (Sherer, 2004).

To attain these objectives, people will make a series of judgments about a situation, and the result of those judgments will determine the emotional response. There are four primary appraisal objectives to react to a salient event adaptively explained below:

Relevance: How relevant is this event for me? Does it directly affect my social reference group or me?

Implications: What are the implications or consequences of this event, and how do they affect my well-being and my immediate or long-term goals?

Coping Potential: How well can I cope with or adjust to these consequences?

Normative Significance: What is the significance of this event for my self-concept and social norms and values?

In the shown figure 2.15, the horizontal panel labelled "Appraisal processes" shows the different groups of appraisal criteria organised in the theoretically expected sequence (see Scherer, 2001, 2009) together with the respective cognitive structures that are recruited in these appraisal processes. The downward-directed arrows represent the input of the different cognitive structures into the appraisal process, e.g., retrieval of past experiences of a similar kind from memory, and the upward-directed arrows representing a modification of the current content of these structures by the appraisal results, e.g., attention being redirected by a relevance appraisal. The horizontal panels below the appraisal level show three response components and the final integration of all changes in the feeling component. The bold downward-directed arrows illustrate the central assumption of the model in each phase of the process: the appraisal results sequentially and cumulatively affect all response domains. The dotted upward-directed arrows represent the changes induced in this fashion. (Fontaine, 2013).

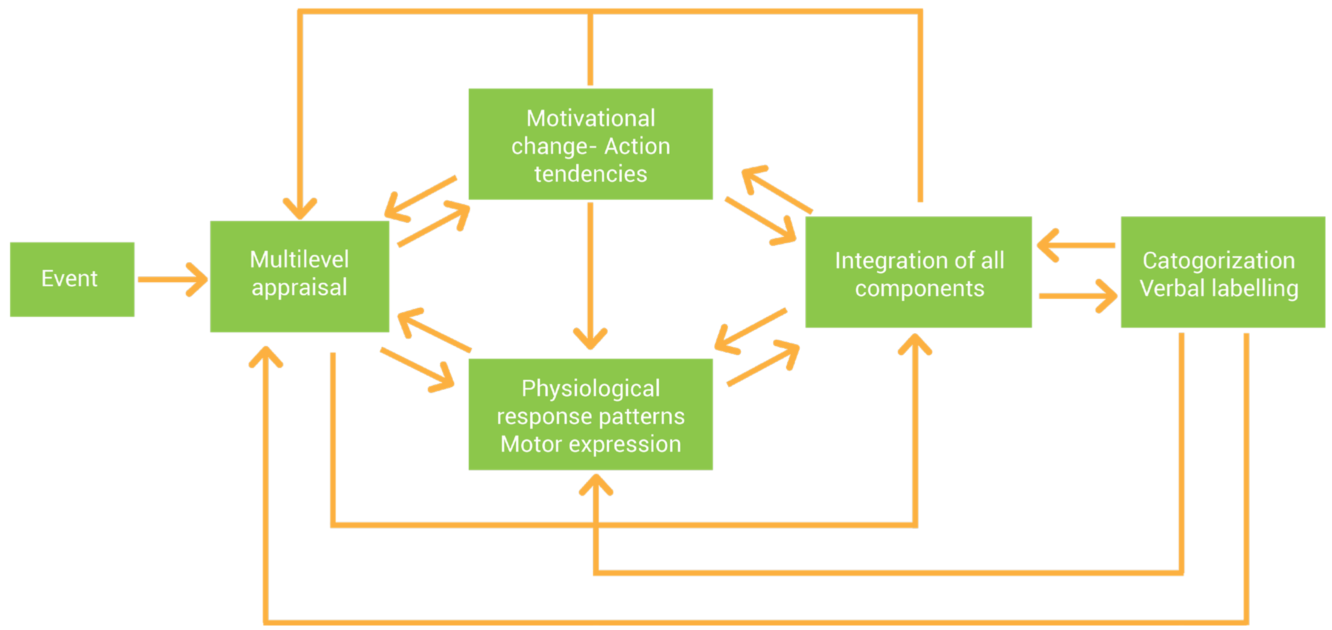


Figure 2.14: The dynamic architecture of the Component Process Model. Emotions are emergent processes. They require a dynamic computational architecture (Sherer, 2009).

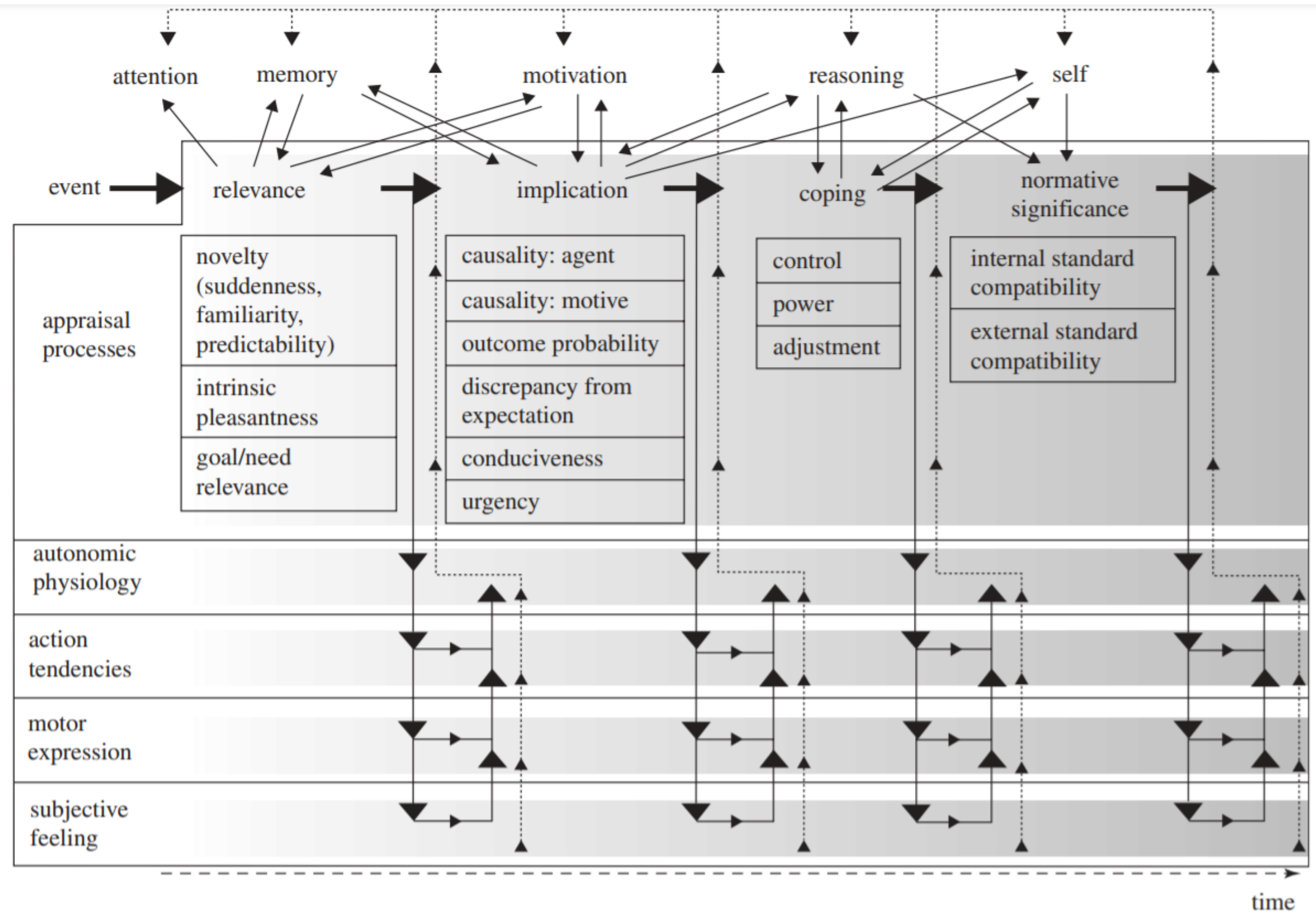


Figure 2.15: Comprehensive illustration of the component process model (CPM) of emotion (Scherer 2001; Sander et al. 2005).

Takeaways from this chapter

- *Different people will have different reactions to the same stimulus. The same stimulus could have different emotional responses, even if it is the same person, with mood states and swings in different times or environments.*
- *Emotions are elicited when something relevant happens to the organism, directly bearing on its needs, goals, values, and general well-being. Hence, following, its intrinsic pleasantness or unpleasantness, and its motivational consistency.*
- *People can directly control their behaviours and thoughts. However, they cannot directly alter their moods and emotions.*
- *Emotions may help organisms learn from their experiences.*
- *Emotions involve several components, subsystems of the organism that become synchronised to different degrees during the emotion episodes, maximising the organism's capacity to adapt to the contingencies of the situation.*

Chapter 3

Theme Exploration: Robotics

Robots are all around us: A robot can be many things these days, which is just the beginning of its proliferation. Robotics expert from UC Berkeley, Anca Dragan, explains robots as physically embodied intelligent agents that can affect the physical world. Intelligence is the core component of robotics. An intelligent agent refers to an autonomous entity that acts to achieve specific goals in an environment that they observe through sensors, where they take actions according to these observations (Simon, 2017).

Robotics is a physical embodiment of artificial intelligence and a highly complex computational field. As I am exploring Robotics from the perspective of a technical novice, I am not striving to understand and explain all the profoundly technical elements of robotics but instead, get a sense of the bigger picture.

To get a clearer understanding of the robotics context, I conducted a deep dive into literature, guided by keyword search, and carried out discussions with experts from various domains. Although most of the robotics research will not be visible in the final design, it was a crucial part of my process that allowed me to check and correct initially made assumptions and build a basis for the following design stages. The following chapter provides a broad overview of robotics and summarises the gathered insights from the literature.

Question addresseds in this chapter are:
1. What is robotics, and what will be the usage context of robots in the future of urban environments?
2. Why do emotions play an essential role in human-robot interaction?
3. Why are autonomous delivery robots a good use case for having their own emotion?

Method used:
Literature review, discussions with robotic experts.

“It is the obvious which is so difficult to see most of the time. People say ‘It’s as plain as the noise on your face.’ But how much of the nose on your face can you see, unless someone holds a mirror up to you?”

— Isaac Asimov, I, Robot

3.1 What is Robotics?

Robotics is about turning ideas into action. Robots turn abstract goals into physical activity, send power to motors, monitor motions, and guide things towards the goal. Observing a robot's behaviour is nearly compelling proof that machines can be aware of their surroundings, develop meaningful goals, and act effectively to accomplish those goals (Frank, 2017).

Robots are increasingly moving from the laboratory out to the field. Plentiful different types of robots are incorporated in a variety of fields. More specifically, they are entering further into the social field of humans, inhabiting offices, hospitals, museums, houses and increasingly streets.

Service robotics is a growing market and research area (Schraft & Shmierer, 2000). Such robots are fundamentally machine-line in their behaviour and appearance with minimal, constrained and inherently functional contacts with human beings.

According to a recent 2020 IFR report (IFR,2020a), 422 000 units of robots were used worldwide in the industrial field in 2018 and 373 000 units in 2019. Figure 3.1 shows the number of units of robots adopted in the industrial field. This shows fast-advancing robotics and the rate at which it is being adopted in other industries (Yousif, 2021).

Robots have been used in a variety of fields; those could be categorised into four parts.

1. Dangerous: For investing in hazardous areas. These robots are capable of entering an active volcano to collect data. Alternatively, a burning building to search for victims.

2. Dull: Dull means long and repetitive tasks which are boring. Productivity and efficiency are more important in these tasks. Robots are faster and better than people at those jobs.

3. Delicate: Delicate means the things which are too difficult to do with our hands. For example, the medical robotic field.

4. Dirt: For dirty environmental work.

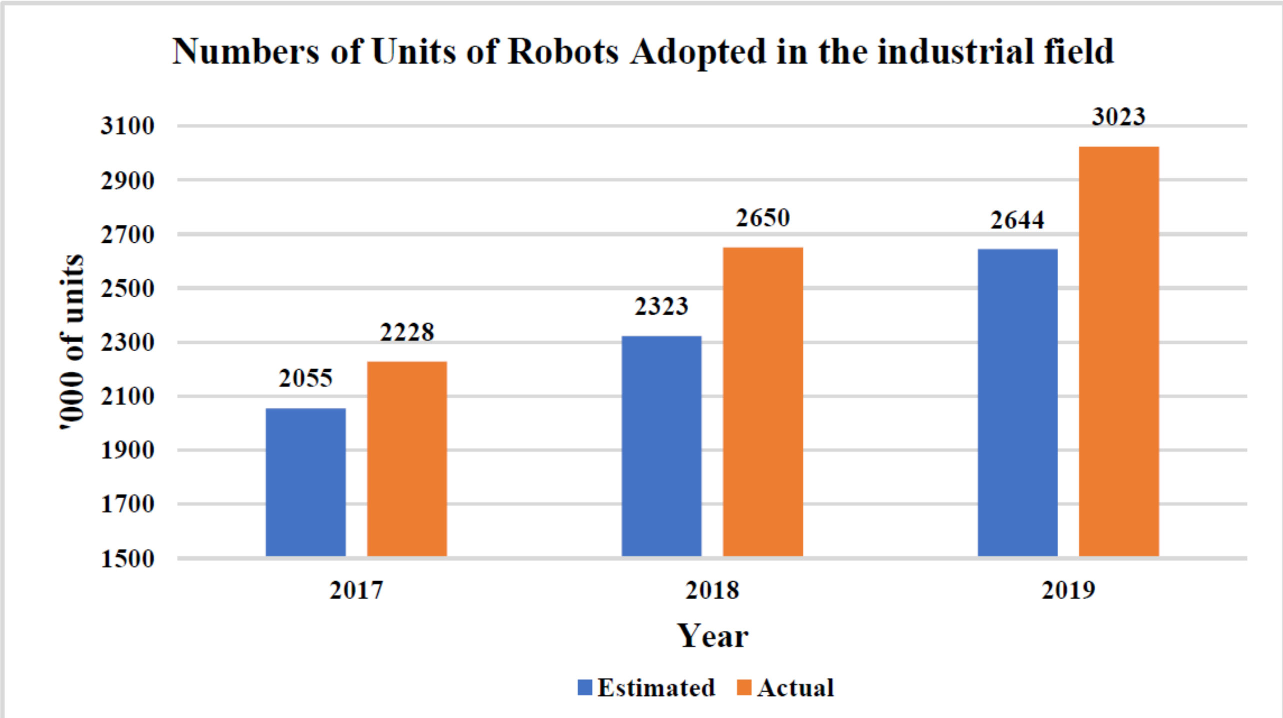


Figure 3.1: Numbers of Units of Robots Adopted in the industrial field (Yousif, 2021).

*Figure 3.2: **Amazon Scout** is a 6 wheeled robot used to deliver packages for the E-commerce site, Amazon.com. Amazon Scout originally debuted on January 23, 2019, delivering packages to Amazon customers in Snohomish County, Washington. Amazon scouts move on sidewalks, at a walking pace.*

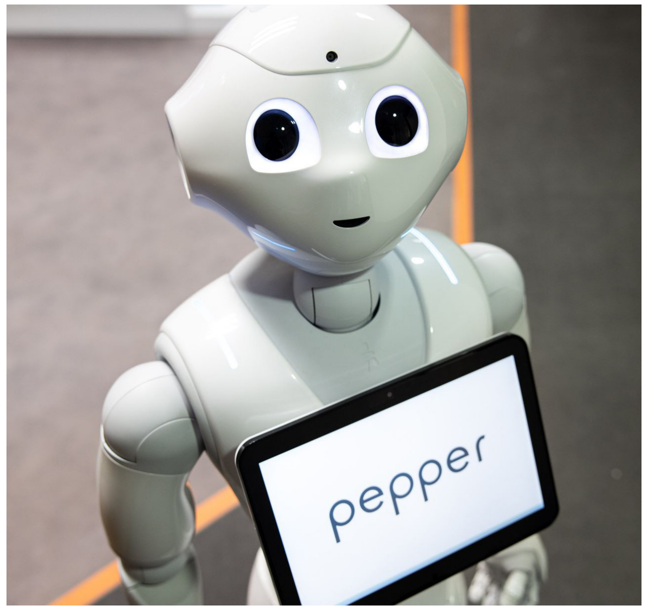


*Figure 3.3: **Pepper** is a semi-humanoid robot manufactured by SoftBank Robotics, designed with the ability to read emotions.*

*Figure 3.4: **Jibo** is a friendly robo-assistant. Equipped with cameras and microphones, it can recognize faces, understand what people say, and respond.*

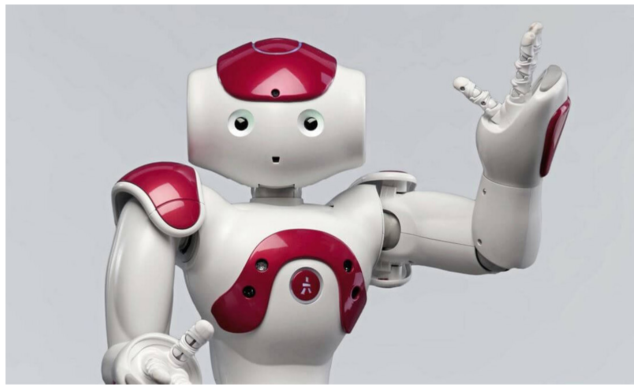


*Figure 3.5: **NAO** is an autonomous, programmable humanoid robot developed by Aldebaran Robotics.*

*Figure 3.6: **Starship delivery robot.** These robots can cross streets, climb curbs, travel at night and operate in both rain and snow, are monitored remotely by Starship. Human operators can take control of the robots if needed.*

*Figure 3.7: **Spot** is an agile mobile robot that navigates terrain with unprecedented mobility, allowing to automate routine inspection tasks and data capture safely, accurately, and frequently developed by Boston Dynamics.*

3.1.1 Future of Robotics

Robots are moving into the public space.

Robots have worked in specific nondaily environments such as factories, aerospace, and battlefields. In these environments, people expect noninteractive robots to do such troublesome tasks (dull, dirty, and dangerous) as cleaning dirty places, monotonous manufacturing tasks in factories, and exploring hazardous environments (Murphy, 2004). In other words, people have assumed that robots free humans from such troublesome tasks.

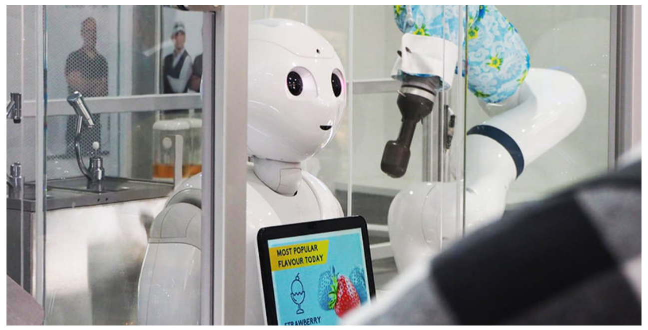
On the other hand, technological developments open up new horizons for vastly extended applications of robotics and automation in production and beyond the factory (Marvin, While, Kovacic, Lockhart, & Macrorie, 2018), where robots will need various interactions to communicate with people.

Researchers have explored communicative tasks that mainly involve interaction with people, such as shopping assistants (Gross,2008), collecting information in a city (Weiss,2008), and delivering snacks at an office (Lee,2009). As explored in these studies, letting robots perform such daily communicative tasks is reasonable because they are more economical than human labour. Despite this, Takayama et al. studied a large number of occupations and reported that people favour robots for jobs that require memorisation, keen perceptual abilities, and service orientation. People prefer humans to robots for jobs that require communication with others both inside and outside the organisation, such as managers and directors (Takayama, 2008). City environments feature troublesome but communicative tasks. For example, an endless guidance task at a reception desk is one dull chore that needs communication with people (See Figure 3.8 and 3.9).

Robots in urban environments

Some of the capabilities of urban robots currently being investigated are: navigating autonomously in crowded (Ferrer, 2013; Kummerle, 2015) and cluttered (Morales, 2009) spaces; crossing the road autonomously and activating the pedestrian push buttons in a natural outdoor environment (Chand, 2012); developing algorithms for humanoid robot recovery from disturbances, and walking over rough terrain (Li, 2015); detecting curbs during navigation (Chen, 2015); testing human-robot interactions during autonomous navigation (Weiss, 2015); testing the effectiveness of communicative skills in assistive tasks such as museum guides, concierges, and shopkeepers (Forster, 2011).

The significant challenges for urban robots are mostly related to aspects concerning the level of autonomy (Campbell, 2010; Trulls, 2011; Pratt, 2010), in particular safety. As a matter of fact, for operations in urban environments, robots should be endowed with a high level of intrinsic safety as cities are characterised by complex and dynamic spaces, which are difficult to be structured, and are inhabited by non-specialist users as citizens (Weng, 2007). Furthermore, researchers are working on issues concerning robot navigation, sensing, perception and interpretation of the environment (Tur, 2009 Fritz, 2005), map building and updating (Reina, 2015), object recognition (Fritz, 2005), learning capabilities (Hengstler, 2016), and human-robot interaction (Hayashi, 2011; Andrist, 2013; Shi, 2016).



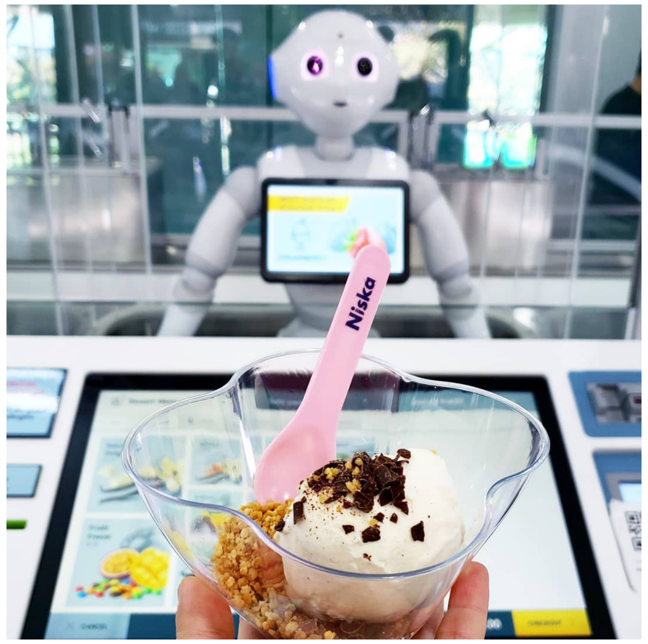


Figure 3.8 & 3.9: Robot Pepper is selling ice cream in Melbourne, Australia. Niska Robotics is serving ice cream at Federation Square as the world's first robotic-run retail store (year 2019).

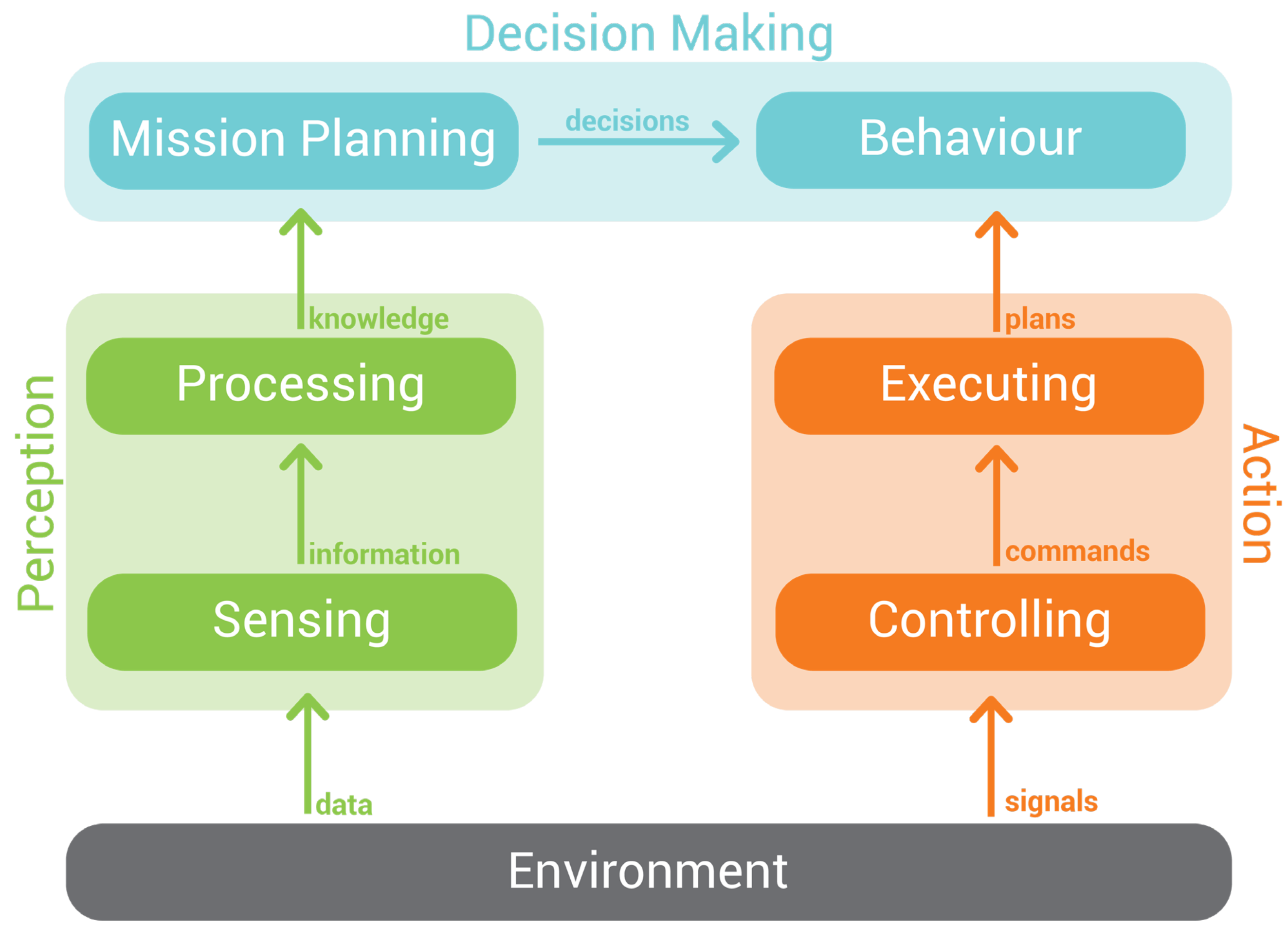


Figure 3.10: Desicion making system of robotics.

Speculative design in robotics

The idea of automata, which has been an object of speculation and pretence since ancient times (Longsdon, 1984), can now be translated into tangible entities that are autonomous, intelligent, and might behave out of human`s direct control. The robotic future takes shape as something that is at the same time inescapable and yet somewhat intangible; evolving around opposing clear visions of robots as socially meaningful machines which will integrate into society, and as a threat that disrupts foundational beliefs in the role of machines as 'human tools', shaking society to its core. (Treusch, 2021).

However, the enthusiasm that may characterise this emerging design space often tarnishes the contingent need for understanding how these novel autonomous artefacts and related services are transforming our society and whether the future we are shaping corresponds to our needs and aspirations as a community (Salvini, 2018).

Hence, the complex nature of coexistence scenarios emerging from the diffusion of these artefacts points out the need to systematically envision how this near future might look. In this regard, the design discipline can play a proactive role by providing methods and tools for supporting speculation about possible futures, fostering reflections on potential structures that might support these futures, and enabling a more conscious shaping of intelligent and autonomous artefacts (Lupetti, 2019).

To sum up, automation and artificial intelligence need to be addressed and designed responsibly in public environments like cities, which are becoming more and more crucial as contexts for technological innovation (Salvini, 2018; Nagenborg, 2018).

3.2 Human-Robot Interaction (HRI)

3.2.1 Movement matters as well as the appearance

In the past, robots' actions were mainly observed by trained operators. However, the quality of these robots' motion and appearance is crucial if we deploy robots in more lay contexts—in homes and offices, in schools, on streets, or in stages.

Any robot inherently displays an interplay between its surface appearance and its physical motion. The way a robot looks sets the context for the interaction, framing expectations, triggering emotional responses, and evoking interaction affordances. Accompanying the robot`s appearance and movement is also critical for conveying more dynamic information about the robot. The robot's movement in space can support action coordination, communicate intentions, display internal states, and have an emotional impact (Hoffman, 2014).

The future of robotics should focus on designing robots with movements and appearance accurately expressing the robot's purpose, intent, state, mood, personality, attention, responsiveness, intelligence, and capabilities. A focus on movement design for interactive robots has the potential to usher in a new era in human-robot relationships.

3.2.2 Human-Robot Relation

Robots are part of us.

Current technological advancements in the fields of Artificial Intelligence (AI) and robotics have stirred a lively debate about the nature of human-nonhuman relationships and how these may be regulated (Lupetti, 2019). In this debate, designers often find themselves caught between sensationalist attributions of citizenship to humanoid robots such as Sophia (see Figure 3.11) and more pragmatic initiatives that contemplate the attribution of legal personhood to robots, such as the European Parliament Resolution of Civil Law Rules of Robotics (Guardian News and Media, 2017; Stone, 2018).

Investigations of the social implications of robots through legal categories such as rights, personhood, and citizenship have become increasingly frequent within academe (MacDorman & Cowley, 2006; Sullins, 2006; Robertson, 2014; Marx & Tiefensee, 2015; Rainey, 2016; Gunkel, 2018).

Attributing citizenship to robots should not be based on the question of whether robots are "like us" or "help us" but are "part of us" – a point also made by Marx and Tiefensee (2018) in their account for citizenship based on robot sophistication.

Robots in urban environments and their interactions

An important research issue in social robotics is how to design natural interactions with human beings. Many researchers explore the design space of anthropomorphic (or zoomorphic) robots, exploiting the human tendency to anthropomorphism, interpreting autonomous systems as intentional agents (Dennett, 1987; Dautenhahn, 1997; Persson, Laaksolahti, & Lonnqvist, 2000). For this reason, more and more robots are being equipped with faces, speech recognition, lip-reading skills and other features and capacities that can make robot-human interaction more human-like (Dautenhahn, 2002).

When designing robots for public environments, such as cities, not only is it essential to consider the type of user, but also its cognitive and physical characteristics. Additionally, it is equally essential to consider unintended forms of interactions, which involve whoever happens to share the environment with the robot such as passers-by (Sholtz, 2003). This may help prevent negative interactions typical of the urban environment, such as vandalism, which can compromise robot safety, especially in autonomous robots. Acts of vandalism are often targeted at street furniture (e.g. benches, street lamps, flower beds) or other objects present in the urban environment, such as cars and buildings. Robots could be even more seriously exposed to acts of vandalism because of their humanoid appearance and behaviour (Salvini & Ciaravella 2010). Vandalism targeted at robots would negatively affect the service provided and compromise robot safety, exposing people and things to severe dangers due to the robot's inability to operate in the environment and interact with people.

Human-robot interactions do not only occur by means of physical or verbal contact. Still, they can also occur by the "meanings" conveyed by the robot's physical appearance or behaviour (Salvini & Laschi & Dario 2010). There is the possibility that the interaction between robots and humans may bring about new risks and dangers. This is particularly true of robots that perform services requiring social intelligence, namely robots endowed with cognitive, social and emotional capabilities.

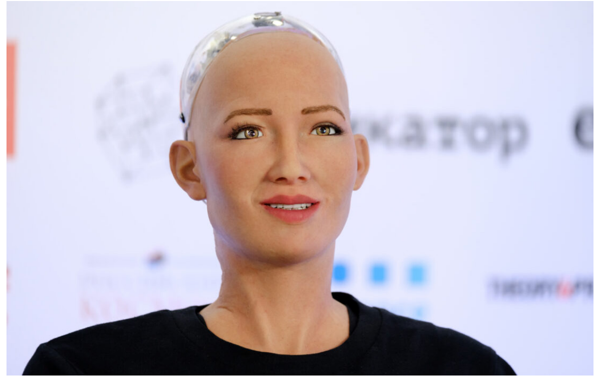


Figure 3.11: **Sophia** is a social humanoid robot developed by Hong Kong-based company Hanson Robotics.

3.2.3 Emotions play a major role in human-robot interaction

Improving the interaction between artificial systems and their users is an essential issue in artificial intelligence studies. In current trends in social robotics, this is accomplished by making such systems intelligent and emotionally sensitive. Therefore, artificial emotional intelligence (AEI) focuses on simulating and extending natural emotion, especially human emotion, to provide robots with the capability to recognise and express emotions in human-robot interaction (Yan, 2021).

The primary goal of artificial emotional intelligence (AEI) is to infuse emotional intelligence into machines providing them with the capability to simulate, extend, and expand natural emotion (Schuller and Schuller, 2018). The machine should interpret the emotional state of humans and adapt its behaviour to them, resulting in an appropriate response to those emotions. Since the research target of AEI is focused on robots and emotions, two main research directions have emerged. Robot emotion; how to ingrain robots' ability to recognise human emotion to generate their own emotions. And emotional robots; how to develop robots capable of understanding human emotion and expressing their own emotions?.

In robotics, artificial emotional intelligence (AEI) entails endowing a robot with humanoid emotion through artificial methods and technologies so that it is capable of recognising, understanding, and expressing various emotional features that will naturally and harmoniously facilitate interaction with humans (Picard et al., 2001). AEI is considered a key technology in a robot's ability to manifest human-robot emotional interactions and the development of emotional robots, making it pivotal for future artificial intelligence technologies.

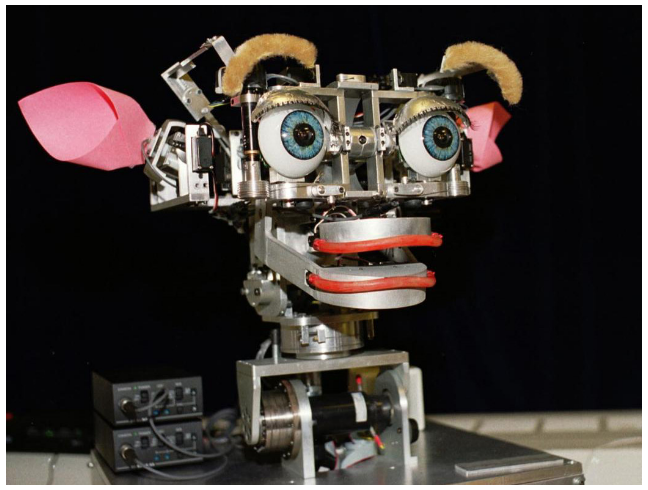


*Figure 3.12: **Kismet** is a robot head made in the late 1990s at Massachusetts Institute of Technology by Dr. Cynthia Breazeal as an experiment in affective computing; a machine that can recognize and simulate emotions. The name Kismet comes from a Turkish word meaning "fate" or sometimes "luck".*

3.2.4 Robots need emotions to communicate

If robots want to actively determine their spot in cities, thus improving their acceptance and embedding, they need emotions to communicate their internal states, values and specific concerns. However, machines (i.e., robots) may never need all of people's emotional skills.

Since HRI consists of many interactions between multiple humans and robots, Rutkowski et al. argue that by analysing the emotional communication atmosphere, the robot can understand the emotional state of the communicator, perceive the overall communication atmosphere, and then provide an appropriate response as well as emotional feedback such as pacification, encouragement, and praise (Rutkowski and Mandic, 2007).

An example of a particular purpose robot is the Kismet platform (Breazeal & Fitzpatrick, 2000; Breazeal, 2000)(Figure 3.12). The robot is designed for engaging human beings in dynamic and socially meaningful interactions. It has visual, auditory, and proprioceptive sensors and a variety of actuators that control the movements of its articulated face. Kismet is able to generate a variety of expressive facial expressions (Dautenhahn, 2002).

The development of an emotional robot should focus on the robots' estimation, expression, and actions. These items are reflected in the face, speech, bodily, and other physiological factors. At this juncture, the emotional robot's primary functions, including applications in speech recognition, verbal interaction, facial identification, emotional expression, and action coordination as follows:

I. Speech recognition: interpretation of human speech and its translation into text or commands for/by robots.

II. Verbal interaction: exchange of messages between humans and robots via sounds or words.

III. Facial identification: identification of human emotion by analysing patterns based on one's facial attributes, such as textures and shape.

IV. Emotional expression: an exhibition of behaviours that communicate an emotional state or attitude of robots.

V. Action coordination: responses that reflect the bodily movement of a robot corresponding to the emotional transition.

Furthermore, with the increasing maturity of the AEI market, emotional robots are finding increasing applications in different families, medical and public services, as well as healthcare, assisted living, and education. These applications portend greater involvement of emotional robots in improving human life (see Figure 3.13 and 3.15). There is a diverse work on robot emotions. For example, in healthcare, Paro, a seal robot (whose composition is detailed in Wada and Shibata, 2007), provides emotional support for patients with Alzheimer's disease (see figure 3.14 and 3.16). Shaped like a plush seal toy, Paro has five kinds of sensors: tactile, light, audition, temperature, and posture, which can sense touch, light, sound, temperature, and posture; communicate with the elderly and intelligently recognise the inner thoughts of the owner, based on which it can change its behaviour.

*Figure 3.13: **Lovot** a huggable robot supports users` emotional needs.*

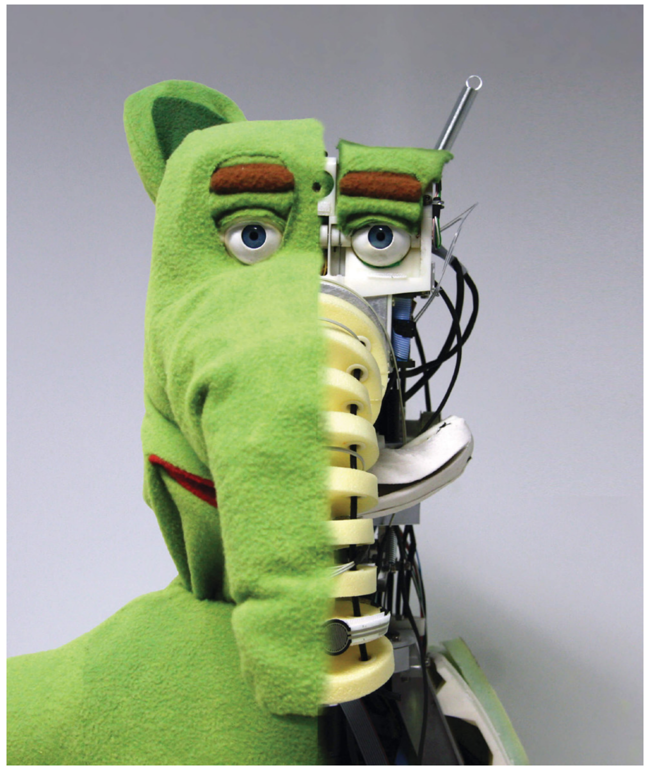


Figure 3.15: Probo is an intelligent huggable robot. The robot has a fully actuated head, with 20 degrees of freedom, capable of showing facial expressions and making eye-contact (Saldien, 2010).

*Figure 3.14 & Figure 3.16: **PARO Therapeutic Robot.** PARO is an advanced interactive therapeutic robot designed to stimulate patients with Dementia, Alzheimer's, and other cognition disorders. It allows the documented benefits of animal therapy to be administered to patients in environments such as hospitals and extended care facilities where live animals present treatment or logistical difficulties.*

Emotions for robots do not need to be human-like

As explained in chapter 2, emotions form the prime material in exploring and expressing an individual's concerns. They arise in response to significant events to the individual's goals, motives, or concerns.

Robots have unique concerns that are different from humans. Understanding robots` specific perception of the world through various factors: their purpose, intent, state, mood, personality, attention, responsiveness, intelligence, and capabilities plays a crucial role in designing emotions that will serve their specific functions, particularly in urban environments (Dautenhahn, 2012).

Emotion as a feedback system could benefit robots for almost any purpose of pursuit because it can guide behaviour toward the goal. The critical point is that as the robots learn these emotional contingencies, they can adjust goal pursuit to achieve their specific needs.

Socially situated robotics (see Figure 3.17) will require communicating their internal states to humans. On the one hand, they have different goals, concerns and needs than human beings; therefore, they do not specifically require human-like emotions in order to communicate with them.

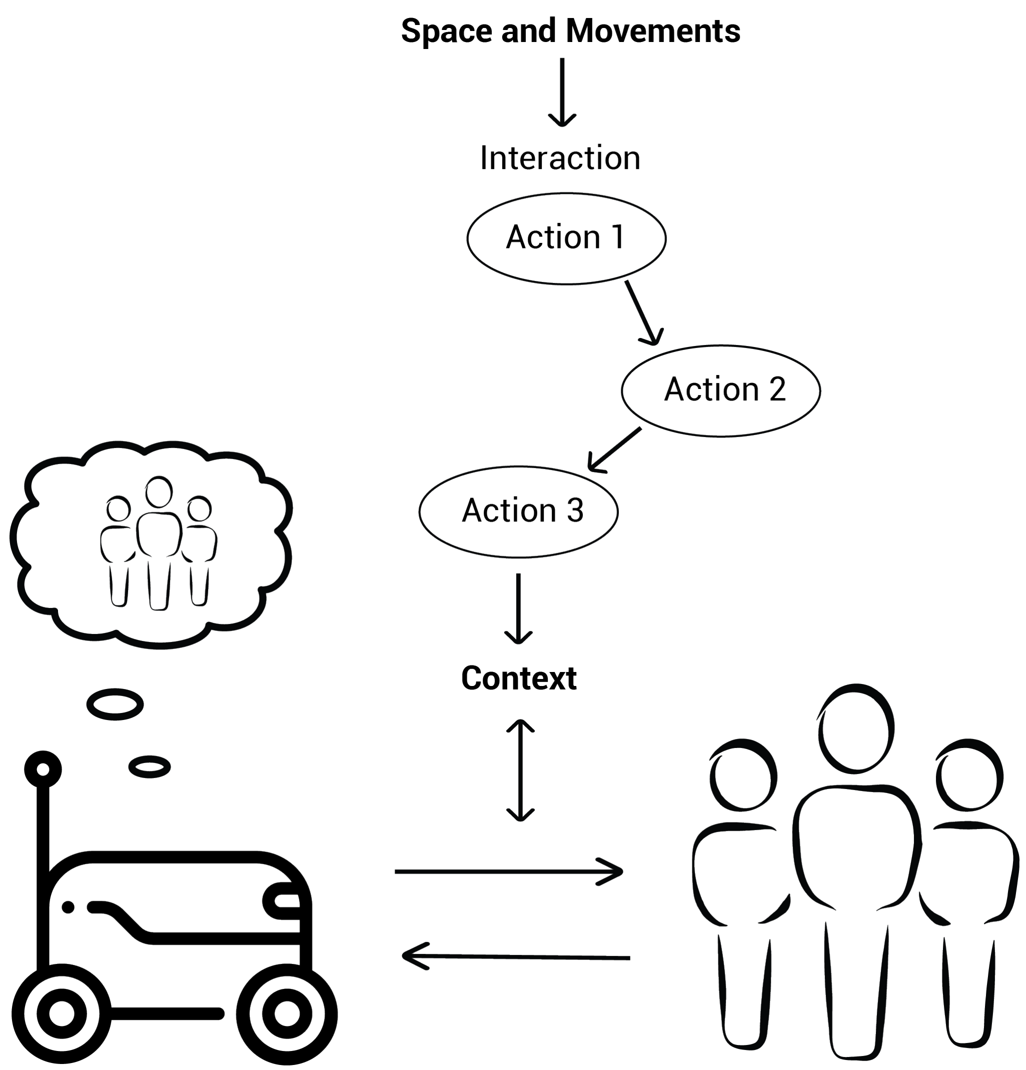


Figure 3.17: This figure illustrates an interaction-aware robot by taking inspiration from Dautenhahn`s interaction aware robotics example (2002). It is at least partially aware of the social domain, for instance, of structures of greeting interactions. This knowledge can help the robot identify and interpret visual interactive behaviour, the understanding that the robot can behave compatibly with human social behaviour (Dautenhahn, 2002).

3.3 Delivery Robots

Delivery robots are interconnected, interactive, cyber-physical agents, which can perceive their environment, reason about events, and control their actions through the use of cameras, sensors, and city data (Rozendaal, 2021). They can navigate the chaos of a city sidewalk and deliver goods efficiently and effectively (Hoffman,2014).

3.3.1 Delivery robots are on rising

E-Commerce and package deliveries are growing at a fast pace, and there is an increased demand for home deliveries. Established delivery companies and new startups invest in technologies that reduce delivery times or increase the productivity of delivery drivers. After an initial hype about delivery with flying drones, land-based delivery robots focus on the last mile (Stanford Business School, 2016). In this context, the adoption of sidewalk autonomous delivery robots (SADRs) has a growing appeal. SADRs are pedestrian sized robots that deliver items to customers without the intervention of a delivery person (Jennings, 2019). These robots have to coexist with other transport devices or moving people.

Autonomously driving delivery robots are developed worldwide, and the first prototypes are tested already in last-mile deliveries of packages (Hoffmann, 2018). Today, the key players of last-mile delivery consist of established delivery companies, including traditional logistics service providers as DHL, UPS, and others, but also a range of new startups focusing on the development of delivery robots that grow all around the globe (e.g. Domino's Robotic Unit, Starship Technologies, Amazon). The most critical business areas of delivery robots are currently perishable goods such as groceries, but also applications in the retailing and warehousing sector are possible in the context of automated warehouses.

The competitive advantage of autonomous delivery robots compared to other delivery modes is the low cost of less than 1 per unit and delivery, making them up to 15 times cheaper than traditional delivery services. Their limited delivery radius, together with the fact that land-based delivery robots have to share the sidewalk with pedestrians and other traffic, make their preferred area of operation suburbs and low-density traffic areas (Hoffmann, 2018).

3.3.2 Delivery robots are highly autonomous

The case of Starship Technologies reveals that the delivery robots can be considered as cyber-physical systems (CPS) since they are self-organised, self-optimized, and internet-linked—but they are autonomous only up to 90%, but, complete self-organisations still a future issue (Kagermann, 2013).

There are different degrees of autonomous intelligence. It is easy to program a machine to respond to a single environmental input with a single output (Salvini, 2018). Nevertheless, as machine learning algorithms improve, robots respond to their environments in ways humans did not explicitly teach them (Simon, 2017).

Autonomous delivery robots are human supervised systems that can perform a wide variety of activities when permitted by a human operator. Apart from the permission, the system can carry out fixed functions without the intervention of an operator. Both the operator and the system can initiate behaviour based on sensed data, but the system can only do so within the scope of its task.

3.3.3 Delivery robots have their concerns, and they will be a part of cities

As explained throughout this section, the use of autonomous delivery robots is increasing, and they are slowly taking their space on the sidewalks. The city environments are dynamic and constantly changing. Therefore these entities will need their time to adapt to the dynamic and unpredictable movements of human beings. In order to exist in a human-dominated area, it will be a vital element for the autonomous delivery robots to communicate with humans to some extent.

However, in the main scope of their job descriptions, they do not necessarily need to communicate with humans. Their job is to deliver packages. However, they need to co-exist together with human beings and learn how to communicate with them. These reasons are what makes them special in the context of designing unique emotions.

Emotions play a crucial role in enhancing human-robot communication. Autonomous delivery robots require to communicate their internal states, needs, concerns and values through expressing their particular emotions. On the one hand, autonomous delivery robots are neither humanoid robots nor social robots; they do not aim to interact with human beings constantly or serve human emotional needs. In addition, interaction is something they would prevent, in the case of considering any unnecessary interaction would slow them down or cause a significant level of drop in their productivity.

For those reasons, they do not necessitate to express or experience human-like emotions specifically, and they do not need to behave human-like. Because they are entities that will be involved in the environment at an unspecified future time, and they have their particular needs that are different from human beings.

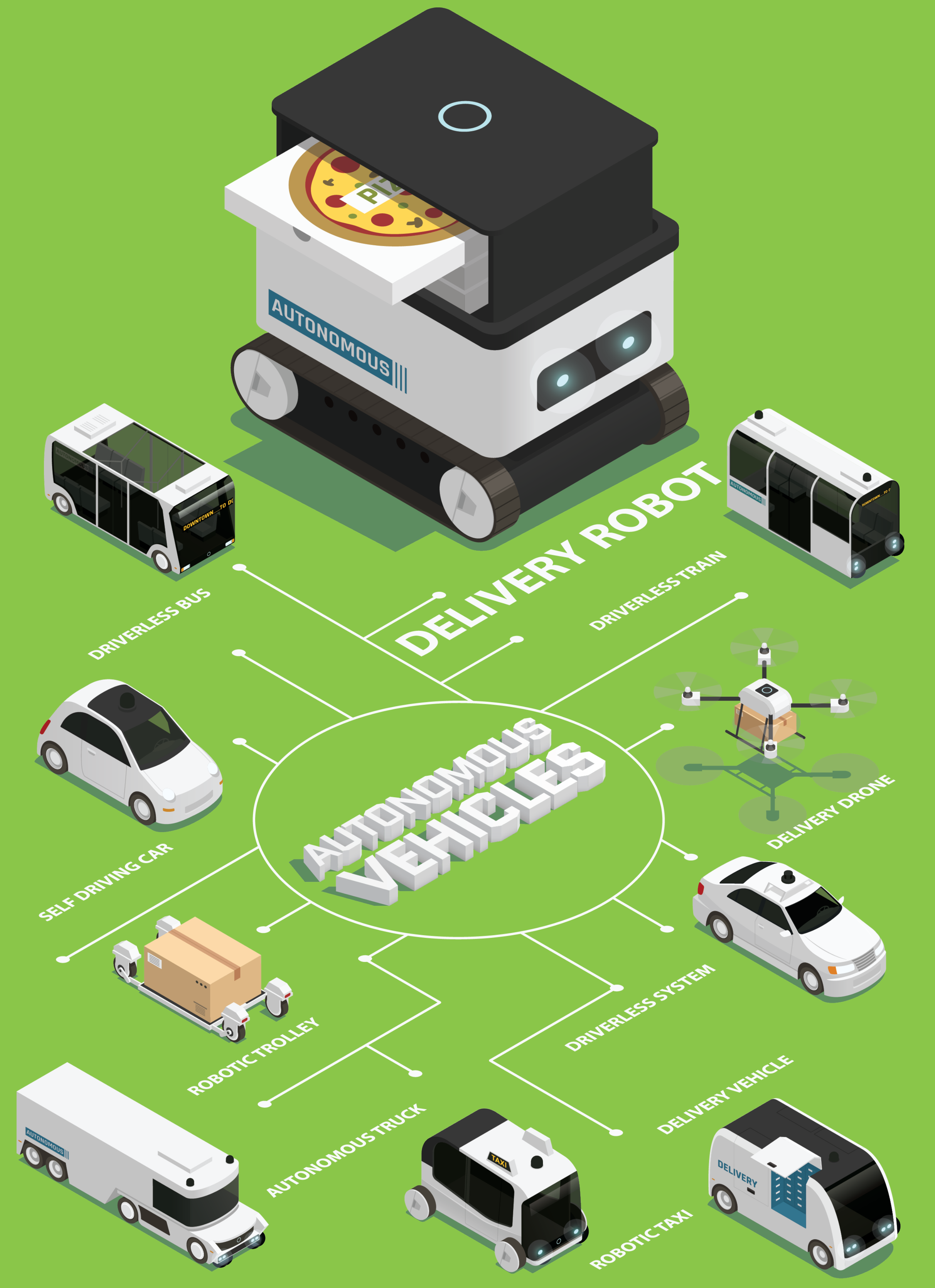


Figure 3.18: This figure illustrates different categories of autonomous delivery vehicles.

3.4 Chapter Conclusions

In this chapter, we took a look at the basic workings, use cases, ongoing development and future visions of robotic systems, both from a theoretical and practical perspective. It is apparent that their high capabilities, and as a consequence thereof, the uses of this technology will only increase in the future. Even though my initial exploration allowed me to scratch the surface, the successes motivated further exploration and familiarisation.

The initial exploration of autonomous delivery robots to design unique emotions is stimulating yet challenging to work on; after all, this topic is very abstract and needs to be delicately delved deep into. Barriers of technical complexity, lacking accessibility to actively working autonomous delivery robots, needed hardware and time resources can make it a tedious process.

Nonetheless, delivery robots endure a potential for future developments that can not be ignored. I would compare the current stage of autonomous delivery robots to the early stages of computers. Their potential was perceptible from an early stage, yet the first versions were clunky, limited in capabilities, and needed extensive handbooks and knowledge to be usable. Nowadays, the computer is an essential tool for most of human life.

The same potential that was seen in early computers is currently foreseeable for the autonomous delivery robot systems. It is already possible to use them in campus-like city locations. Some companies are already actively testing the prototypes and using them to take over usually dull and repetitive work, promising delivery companies' enormous amount of work. Nevertheless, autonomous delivery robots still need extensive research and development until they become a truly beneficial and valuable element of the e-commerce field and to adapt to unstable city environments.

Figure 3.19: The Actor-Network of a delivery robot (Cila, 2019)

Takeaways from this chapter

- *Robots are increasingly entering further into the social field of humans, inhabiting offices, hospitals, museums, houses and increasingly streets. Therefore robots will need various interactions to coexist with people as they have their specific limitations and opportunities.*

- *If robots want to actively determine their spot in cities, thus improving their acceptance and embedding, they need to communicate their internal states, values and specific concerns. And emotions play an essential part in human-robot interaction.*

- *Emotion as a feedback system could benefit robots for almost any purpose of pursuit because it can guide behaviour toward the goal.*

- *Autonomous delivery robots are highly autonomous, and they can function individualistically. They have their own specific goal, which is to deliver packages. To do so, they need to actively co-exist with people on the streets since they have to share sidewalks. Emotions can take a favourable role in improving autonomous delivery robots acceptance in urban environments.*

Chapter 4

Exploratory Research

Based on previous research (Chapter 2 and 3), a general understanding of the journey of autonomous delivery robots which navigate on sidewalks was illustrated. However, to get a more in-depth understanding of their internal states, Chapter 4 aims to uncover the autonomous delivery robots' underlying values, needs, and concerns.

To do so, exploratory research techniques have been used to support the design process by gathering diversified insights. Ten semi-structured interviews with two people for each group were conducted to gain the necessary knowledge, employing generative material (Sanders & Stappers, 2012). The concept of Researcher Introspection (Desmet, 2019) can be considered as a motivation for the interviews to collect information about participants' viewpoints in the context of robots' experiences. The interview is designed using experience prototyping methods that allow people to have open discussions in a relaxed setting. These interviews are called an interactive role-playing card game, as it is being played with pre-prepared story cards that allow participants to imagine the world from an autonomous robot perspective.

Question addressed in this chapter is:
What are the specific concerns and needs of autonomous delivery robots?

Method used:
Imaginary Introspection, Experience Prototyping.

“The present is the frailest of improbable constructs. It could have been different. Any part of it, or all of it, could be otherwise.”

— Ian McEwan, Machines Like Me

4.1 Introduction

4.1.1 Interactive Role Playing Game

The interactive role-playing card game sessions aimed to gather varied perspectives. The Co-Creation method (Sanders & Stappers, 2008) was partially used to conduct the sessions, allowing participants to familiarise themselves with the collected data, generate ideas, and collect feedback on the autonomous delivery robots` stories in a group discussion. For safety reasons, this method was adopted for holding online, giving limited possibilities for interaction compared to a regular session as described in the method.

In order to uncover the values of delivery robots, it is essential to build upon the personal interpretation of the participants` imaginary experiences from the first-person perspective. Therefore, this interactive role-playing game was initiated. The questions posed during the interview mainly concentrated on exploring the "feeling" and "thinking" of people within their experience, aiming to sensitise the participant and gain a shared understanding of what the participant perceives as being an autonomous delivery robot.

The goal of this game is to interpret the autonomous delivery robot's experience and its context. These exploratory sessions aim to provoke insights into important functional and emotional issues and inspire thoughts. Experience prototyping techniques have been used as an attitude that allows the researcher to think of the design problem in designing an integrated experience.

4.1.2 Method

A semi-structured interviewing method was chosen for conducting the study, which allows for asking open-ended questions and gathering in-depth accounts of people's experiences and the freedom to explore emerging topics of interest during the process (Adams, 2015). The research questions formulated for this study are provided in below.

Research Questions

1. What are the people's expectations of feelings and thoughts of the autonomous delivery robots?

2. What are the people's expectations of possible reactions of autonomous delivery robots?

3. Why do they think autonomous delivery robots should behave in this particular way?

4. Why do they think it is important for autonomous delivery robots to behave in that exact way?

5.What do they think about how the future of the delivery process will be affected by the behaviour of autonomous delivery robots?

The interview as a methodological procedure can be seen as a descriptive rather than prescriptive method. The participant was not given any predefined information, but rather the interviewee indicates the essential topics for conversation within the frame of the interview guide.

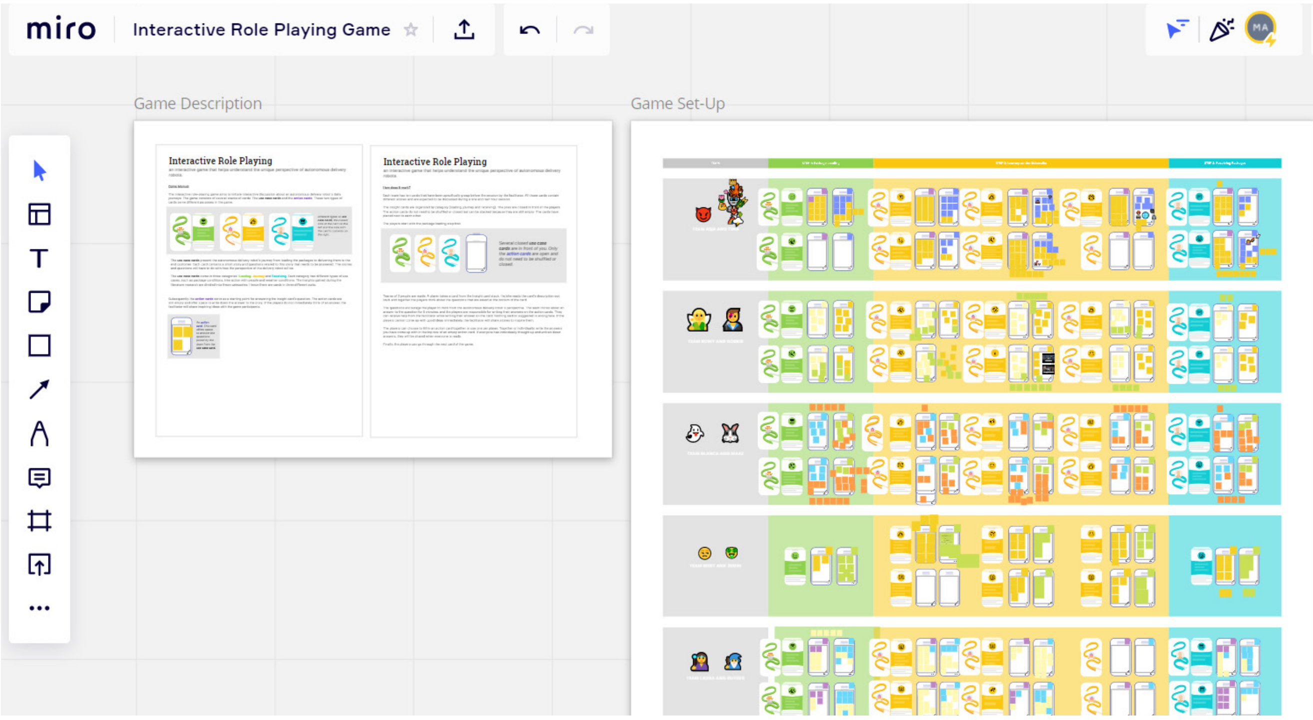


Figure 4.1: A screenshot of the game set-up. The game was played via Miro, an online real-time collaborative whiteboard. Before the game starts, a brief description and rules were presented on the game description board on the left. Each session included different use case cards. Each participant had a blank card with their name on it, and they were responsible for writing their thoughts on the cards.

Game Cards

Before each meeting, a set of card decks for each team were prepared to help and stimulate participants during the process. The design of the tools was created partly based on the previous research (Chapter 2 and 3).

In order to support the participant, the interview is built up in a way that helps the participant to reflect on the delivery experience in chronological order, meaning starting with loading the packages into the delivery robot (the green cards), and then the journey on the sidewalks (the yellow cards), and as a final step delivering the package to the end customer (the blue cards)(see Figure 4.2).

The topics that have been mentioned on each card aims to provoke conflicting viewpoints from the participants. All cards are combined by transitions through the researcher so that a more conversational approach is facilitated. The questions are formulated aiming to lead to open-ended descriptions.

While the tools were used, questions were asked to reveal the different points of view of the two participants regarding subjective guided imaginary introspective experience.

Figure 4.2: A set of examples of use case cards. For each session, two green cards, six yellow cards and two blue cards have been discussed with participants. Since this project focuses on the experience through the sidewalks, the game mainly focuses on the yellow cards, representing the process of sidewalk journey of the autonomous delivery robots.

Introspection

As Gould (1995, p. 719) defines it, introspection is 'an ongoing process of tracking, experiencing, and reflecting on one's thoughts, mental images, feelings, sensations, and behaviours. Introspection enables us to understand, examine, and theorise about subjective experiences in naturalistic settings and obtain the subjective data which are not directly accessible from the third-person perspective with the same level of readiness, vividness, richness and depth (Brown, 1998a; Byrne, 2005; Gould, 1995, 2012). Introspection has a unique exceptional for experience-driven design.

Imaginary introspection

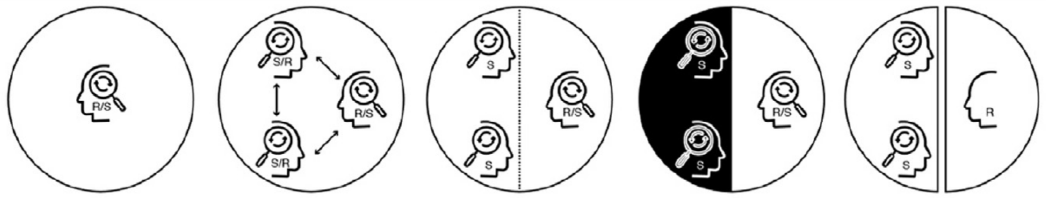
In addition to understanding, describing, and evaluating experiences in past or current contexts, experience-driven design researchers have a particular interest in envisioning future design possibilities and in examining changes in experiences, concerns, and values (Desmet, 2019). In this matter, the researcher may develop hypothetical thought-provoking introspective narratives by situating themselves and suspending disbelief about multiple future scenarios that may or may not eventually become realities. Imaginary introspection is directly related to the design fiction that has been recently developed in the field of HCI (Blythe, 2014; Lindley, Sharma, & Potts, 2014; Sterling, 2009; Tanenbaum, 2014).

Experience Prototyping

Experience Prototyping is another method that is used for this exploratory research. It is defined as a form of prototyping that enables design teams, users, and clients to gain a first-hand appreciation of existing or future conditions through active engagement with prototypes (Buchenau, 2000). An Experience Prototype is any kind of representation, in any medium, designed to understand, explore or communicate what it might be like to engage with the product, space or system we are designing. This can include design prototyping techniques such as storyboards (Vertelney, 1990), scenarios (Verplank, 1993), and sketches (Wong, 1997).

In order to explore design ideas effectively and communicate future design concepts, these capabilities of imaginary introspection and experience prototyping are used as a combined method. Through simulating provocative narratives, these methods are used to try out new design ideas or concepts and expose conflicts, contradictions, dilemmas, or paradoxes in various unfamiliar futures before one of them comes true.

These exploratory research techniques were beneficial to construct a narrative of delivery robots' unique experiences. Therewith, to receive diversified perspectives and speculations, communication and eliciting opposing opinions and emotional resonances from others are essential aspects of these interactive interviews.



	Researcher Introspection	Interactive Introspection	Syncretic Forms of Introspection	Reflexivity within Research	Guided Introspection
Illustration					
Features	*Researcher as Subject* No subjects other than the researcher are involved as the introspector.	*Subjects as Co-researchers* The researcher and subjects form a collaborative and mutually empathic introspecting group.	*Researcher and Subjects as Individual Introspectors* The researcher includes his/her own introspections as part of the data.	*Researcher and Subjects as Individual Introspectors* The researcher uses his/her introspections to enable contrasting comparisons.	*Researcher as the Guide Subjects as the Introspectors* The researcher does not introspect, but only guides the subjects to.
Focus	The researcher him/herself	Both the researcher and subjects	Both the researcher and subjects	The subjects	The subjects
Epistemic Perspectives	**Researcher/Subject (R/S):** first-person	**Researcher/Subject (R/S):** first-person & second-person **Subject/Researcher (S/R):** first-person & second-person	**Researcher/Subject (R/S):** third-person & first-person **Subject (S):** first-person	**Researcher/Subject (R/S):** third-person & first-person **Subject (S):** first-person	**Researcher (R):** third-person **Subject (S):** first-person
Relevant Method Examples	Autoethnography Self-experimentation Personal Subjective Introspection Confirmatory Subjective Introspection	Co-design Workshop Empathic Design Methods Experience Prototyping	All cases in which the researcher applies the same guided introspection process to him/herself as well as to the subjects without direct introspection exchange	Participant Observation	Verbal Protocol Analysis In-depth Phenomenological Interview Written Self-report UX Curve Drawing Sentence Completion Experience Survey

Figure 4.3: Five categories of introspective methods (Desmet, 2019).

4.1.3 Participants

A collaborative research process can facilitate collective data generation and a team effort on spontaneous data analysis and drawing initial conclusions. Therefore, this interactive role-playing game required a group of carefully selected and motivated people who may have the imagination capacity of understanding robots' specific values.

Before the interview, the researcher had a brief discussion about delivery robots and emotions with potental the interviewees. Additionally, for the interview, participants` differentiated educational and cultural background was a critical aspect for inviting them for the final interview. The complete list of participants is provided in Figure 4.4. The selected participants could articulate, verbally or in certain more creative forms, the experience as it is lived and feel comfortable sharing personal and sometimes even intimate information about their lives and inner worlds. The participants were briefly pre-trained for performing imaginary introspection effectively.

4.1.4 Research Ethics

Before the session, participants were asked to fill in a consent form. Moreover, before the session started, participants were asked to approve voice and video recordings for later analysis.

4.1.5 Research Questions

Each card in the game has a different story, but all the cards have the same open-ended questions. (Please see Appendix the interactive card playing game section for the entire list of cards.) Eight cards for loading packages, twenty-six cards for journeys on sidewalks, and six cards for delivering the packages to the end customer. Each card has been discussed at least at one of the interviews. Some of the cards have been discussed several times by different groups. An example from each step will be explained further in the next section of this chapter.

#	Occupation	Age Range	Gender	Country of birth
1	Medical Product Designer	25-34	Female	Macedonia
2	Service Designer	25-34	Male	Pakistan
3	Chemical Engineer	18-24	Female	Spain
4	Mechanical Engineer	18-24	Male	The Netherlands
5	-	Under 12	Female	Turkey
6	Software Engineer	18-24	Male	Turkey
7	International Business Management	55-64	Male	Turkey
8	International Business Management	45-54	Female	Turkey
9	Aerospace Engineer	18-24	Male	Spain
10	Embedded System Engineer	25-34	Female	Italy
11	Product Designer	18-24	Female	The Netherlands
12	Experience Designer	18-24	Male	The Netherlands
13	PhD Candidate	25-34	Female	United States
14	Sustainability Researcher	25-34	Male	Turkey
15	International Business Management	18-24	Male	Turkey
16	Aerospace Engineer	18-24	Male	France
17	Robotics and Automation Engineer	18-24	Female	Spain

Figure 4.4: Details of the interviewed participants.

4.1.6 Procedure

Each interview consists of two to three people and a facilitator. The facilitator is the researcher herself in order to assist the progress of the game. The workshop was organised for a maximum of two hours, including an introductory presentation on the participants' theme and practical activities. Each session took approximately two hours of discussion and ten different topics to discuss.

The proposed robotic services were presented through the different cards, containing a description of the robot's tasks and functionalities and a short story of a specific occasion. By emphasising the rights and responsibilities of robots, the aim was at addressing emerging problems of social roles and possible controversial relationships between humans and delivery robots.

Throughout the game, the participants were asked to imagine how the experience of the robot might be. Thereby, also the embedded values may change their meaning or importance in the context of delivery.

Moreover, the session used inquiry via verbal questions and generative tools used as sensitisers and thinking tools to support the reflection in both participants.

The procedure was divided into four main activities. The first three of which were performed independently by the participants before the meeting, and the remaining one were conducted online in a video call session. After completing the consent form, the participants were asked to complete an online survey with nine questions. These nine questions were aimed to prepare them for the imaginary introspection session by empathising with autonomous delivery robots internal states. Next, each participant was asked to draw a delivery robot that they have imagined.

Furthermore, after completing the first three individual tasks, they were invited to a Zoom, an Online Video Conferencing Platform. The call was recorded throughout the session. The game was played via Miro, an online real-time collaborative whiteboard. Each participant had a blank card with their name on it, and they were responsible for writing their thoughts and statements about the provided stories on the blank cards.

4.1.7 Data Collection

Interviews were conducted online using Zoom Video Conferencing Platform and Miro, a real-time collaborative whiteboard. Each meeting was recorded and data saved in a personal computer to be deleted after the project. See Figure 4.5 for the interview setup. Audio files were transcribed online using otter.ai automatic speech-to-text software, resulting in raw text, which was checked against audio recordings and manually edited to reduce transcription errors and improve clarity.

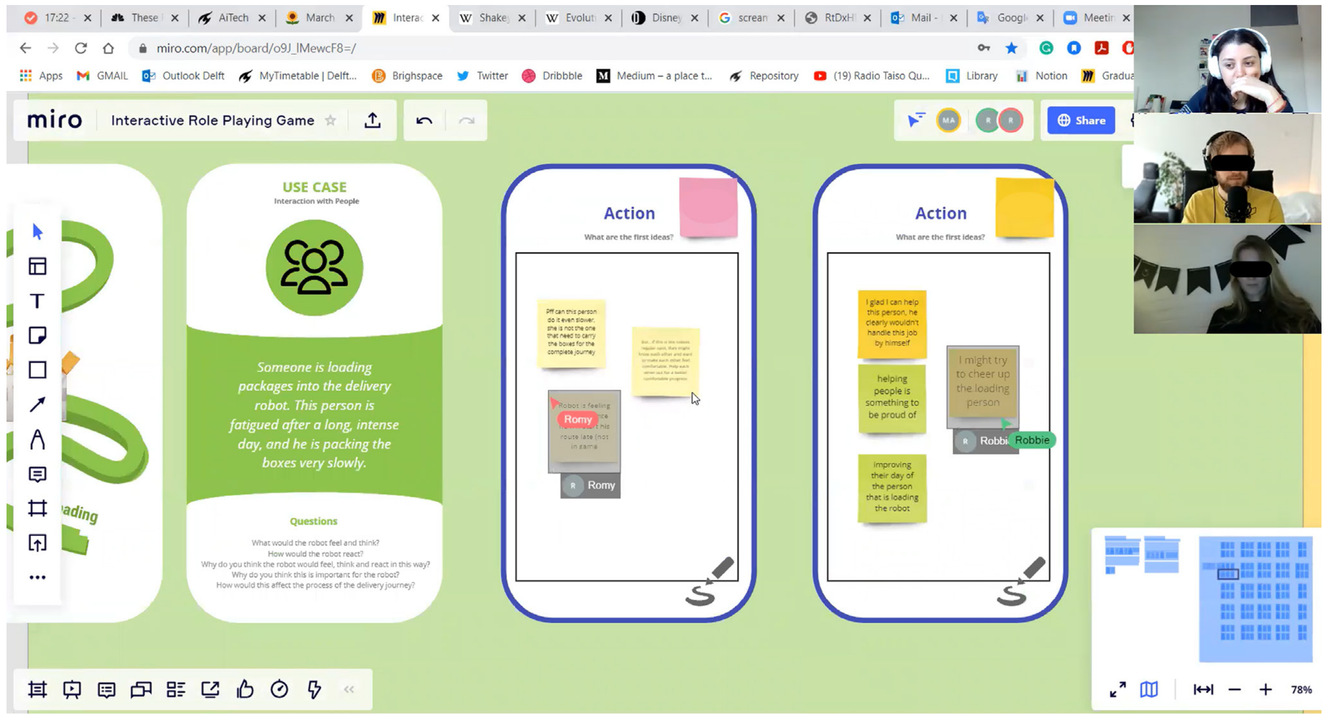


Figure 4.5: An interview setup example.

4.1.8 Session Steps

Step 1: Package loading

In the first step of the game, the use case cards include stories related to hypothetical interactions before the robot takes its place on the sidewalks. For the package loading step each session included two cards that specifying two different stories.

For example, some cards have covered interaction between the warehouse employee and the autonomous delivery robot, while some of the stories related to the robot`s technical capabilities.

During the session, interviewees were in charge of sharing their opinions verbally and taking notes on the action card that their name is written on it.

Each participant had their time and space to vision their individual viewpoints and share them with other participants. These discussions lead participants to execute open-minded debates, sometimes including the facilitator as well.

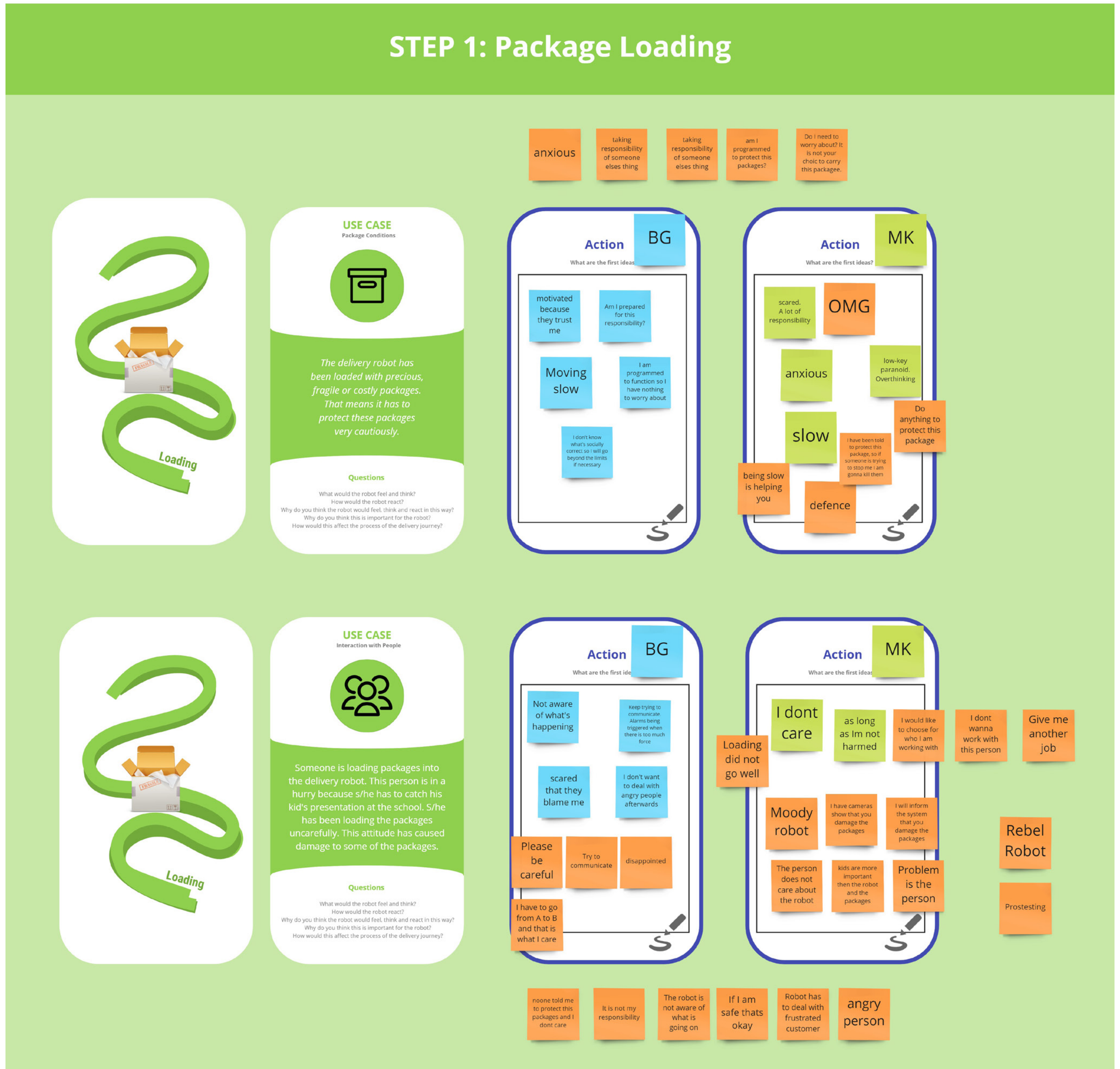


Figure 4.6: An example of two use case cards from step one: package loading.

Step 2: Journey on the Sidewalks

In the following step, the use case cards essentially focused on the potential experiences of the autonomous delivery robots on the sidewalks. The phase of the journey on the sidewalks included six cards that specifying six different stories. This phase is mainly important because this project's scope is to examine the experience of the autonomous delivery robots on sidewalks.

The second step includes stories related to human-robot interaction, such as children, the elderly or unintended forms of human-robot interactions.

Furthermore, different types of vandalism have been discussed throughout the second step as it protects its place as a critical human-robot interaction research field.

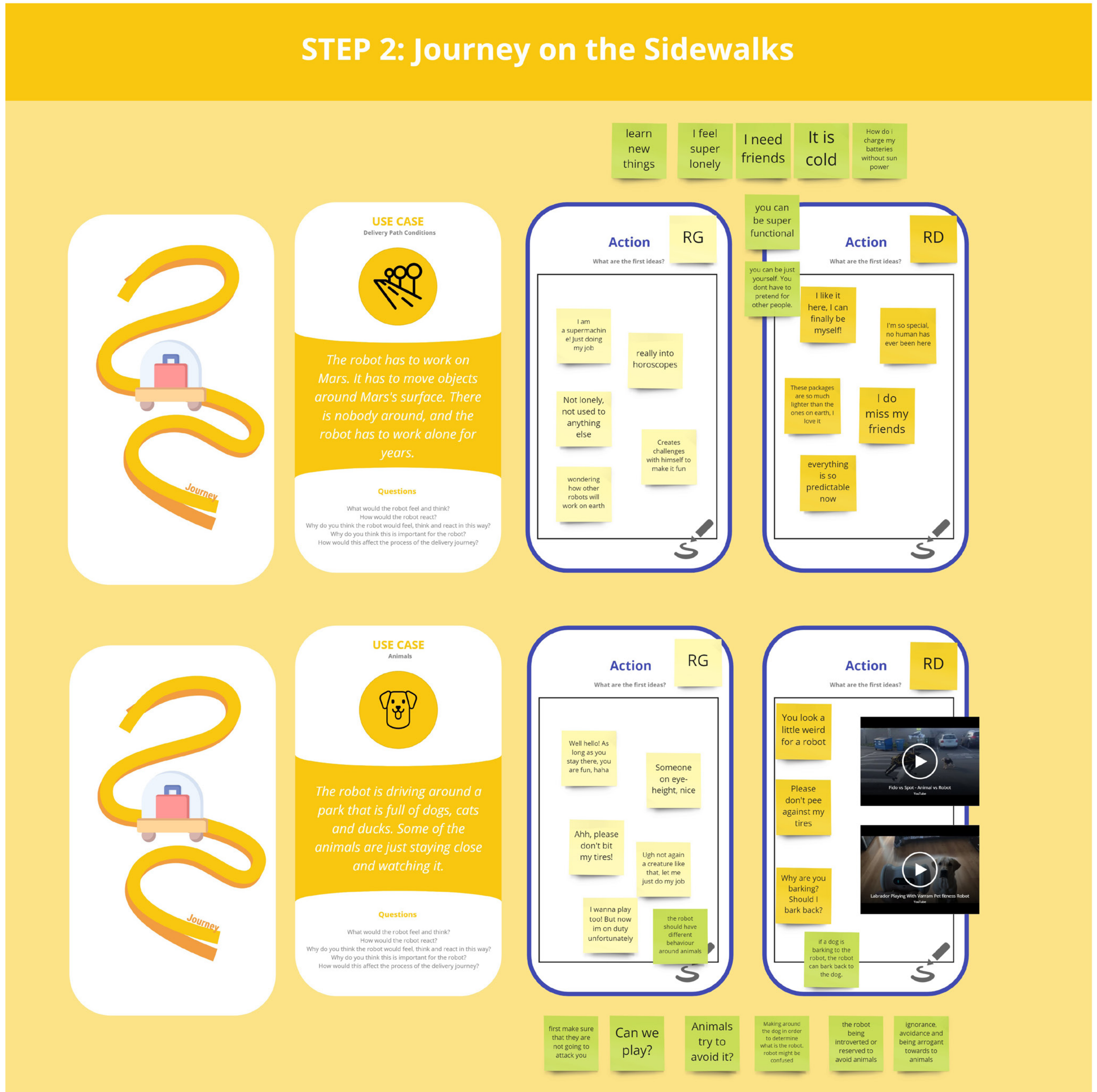


Figure 4.7: An example of two use case cards from step two: journey on the sidewalks.

Step 3: Receiving Packages

In the final step of the interactive game, the stories mentioned use cases related to the interaction between the autonomous delivery robot and the end customer.

The phase of the receiving packages included two-cards that specifying two different stories for each game session.

Throughout this step, participants tended to empathize for the benefit of the end customer, defending the idea that the robot should have always aim to satisfy the end customer.

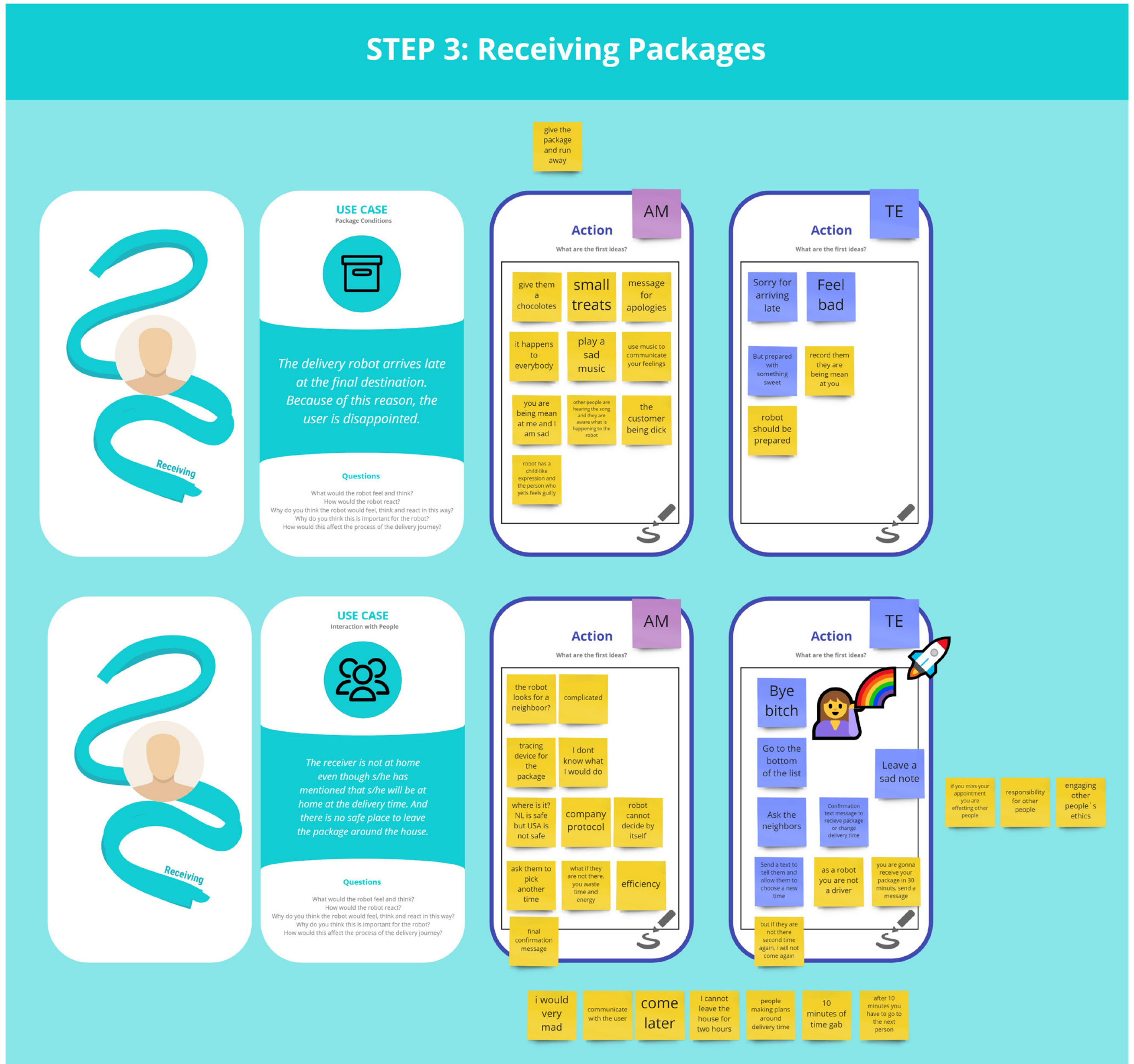


Figure 4.8: An example of two use case cards from step three: receiving packages.

4.2 Data Analyses

The six-step approach of analysis in IPA

A six-step approach in IPA was applied to analyse the interviews more structured (Smith et al., 2009). In brief, these six steps consisted of reading the interview transcript first, recording how the interviewer should gain a second-person perspective. This was followed by collecting initial thoughts, identifying or developing first topics, finding connections between emerging topics and then potential transitions to new cases that uncover emerging patterns across different cases.

1. The researcher listens to the interview repeatedly and reads through the transcript, allowing the researcher to delve deeper into the interviewee's point of view and get a better and more accurate picture of the interview.

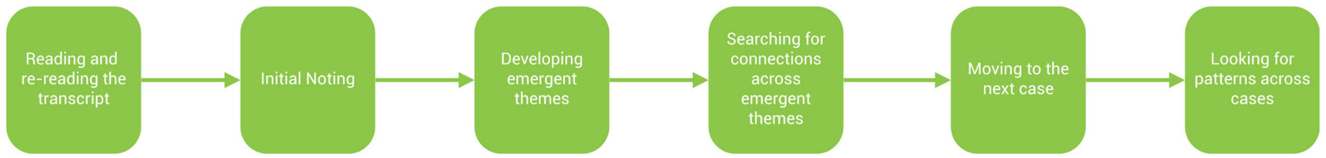
2. Take notes. This step lays the foundation for the researcher's interpretation. Three different steps for taking notes were followed: descriptive, linguistic and conceptual. Descriptive comments are designed to reflect and structure how participants give their answers and thus the sense-making activity. This is the first time the researcher takes a more distanced role from what is being directly said, bringing in her perspective and experiences. In this step, key moments are interpreted through conceptual comments by the researcher.

3. The focus is on identifying emerging themes within the transcribed material. The chronological order of the interview is retained as the structure. Hence, emerging themes are listed in chronological order. The emerging themes represent a more abstract interpretation of the participants' response, but it is important not to abandon the complexity of what is being said.

4. Build on emerging themes that define connections between the individual themes within the transcribed chronology. It is the researcher's perception to exclude topics that do not address the original research question. There are several ways to define the relationship between the topics. Polarising themes can be pointed out, for example, the number of occurrences of a particular theme or the focus on certain key moments. Within this project, the focus has been on clustering appropriate themes together and linking them under a collective descriptive term.

5. The penultimate step of the analysis is to repeat all previous steps with the other interviews. It is acknowledged that the researcher is never free of one's interpretation and knowledge gained from the first analysis. For this research, I started with the analysis following the order of the story cards in which the interviews were conducted. Each story card that has been used in the game has been voted with the personal interpretation of the researcher by using four different voting dotes. Four different dots were representing four different areas and were presented in four different colours. These are shown in Figure 4.10.

6. In the final analysis step, the interview analyses are compared, and overarching themes are defined. The visualisation of this step plays a vital role as it allows the researcher to reflect on the process and the topic assignment in an iterative process. It is important to note that themes that emerged only within one interview do not lose significance and should not be neglected in the analysis. As a result, this comprehensive analysis has been turned into a structural form of a tree representing the needs of autonomous delivery robots. Three main topics have emerged from the analyses of the results: Adaptation, City Dynamics and Robot Awareness will be explained further in the next Synthesis part of this chapter. Figure 4.11 shows the tree of these three particular topics.



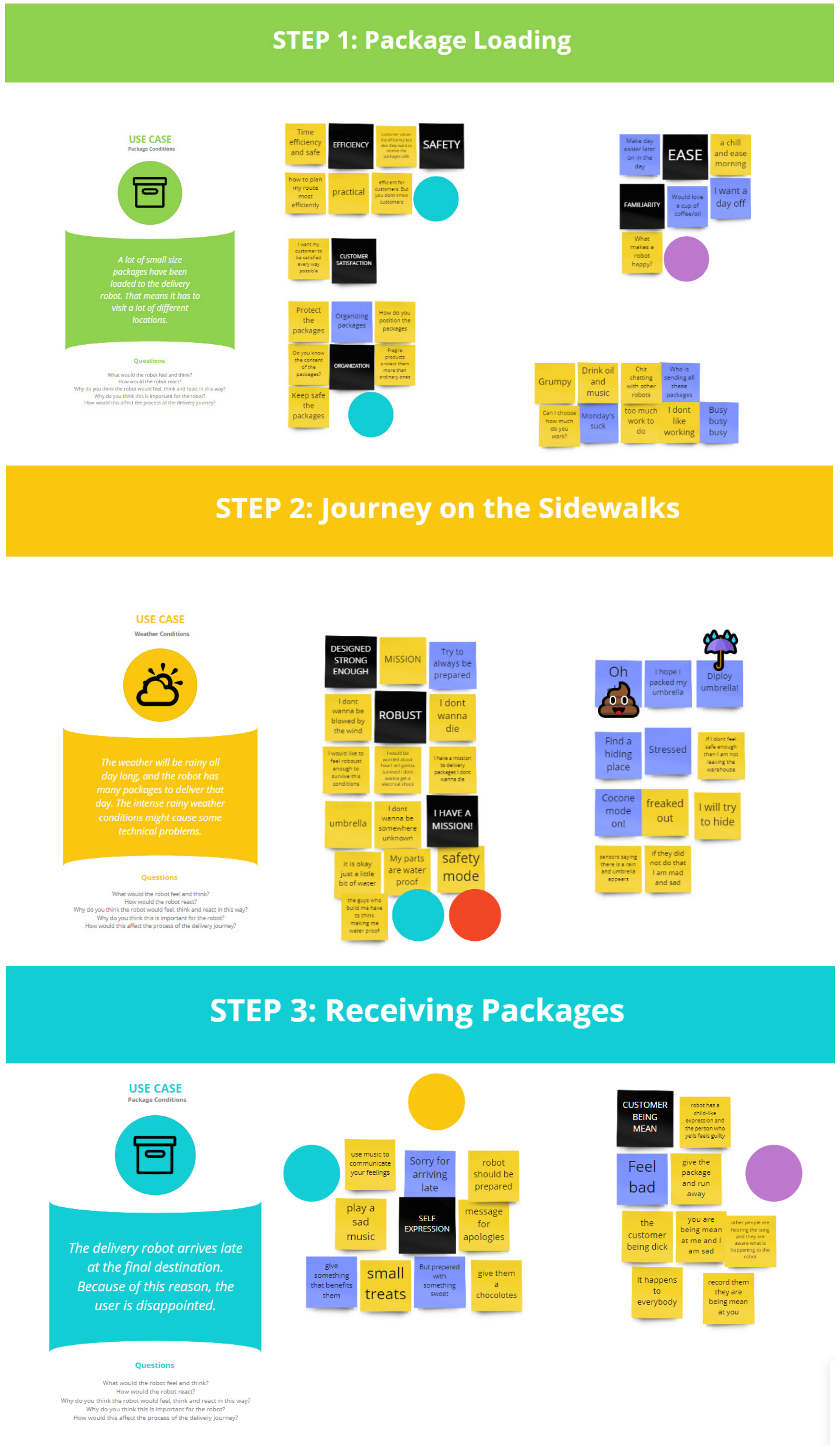


Figure 4.9: An example from three different stages of the game cards. In this figure shown above, the dot voting method has been conducted by the researcher.

Figure 4.10: Dot voting method.

4.3 Synthesis

4.3.1 Unique needs of the delivery robots

Now that I have analysed the results of the interactive role-playing game, I would like to reflect on the meanings of the findings. First of all, I would like to discuss the hypothesis of emotions arising from needs and how this would matter in the context of designing unique emotions for delivery robots. Afterwards, I would like to explain the three emerging topics that have been argued throughout the interviews and pulled the most attention from the participants and as well as me as the researcher. As a result of, the need for a more extensive consideration was identified, and these topics require special attention to examine the specific concerns of autonomous delivery robots.

This reflection intends to discuss the needs of the delivery robots. I mainly centre my attention on the topic of the robot's needs since emotions arise from the needs. Designing unique emotions for delivery robots starts with searching for the needs of the robots that differ from human beings, which will guide me to reach the unique robot need. However, it is valuable to underly that this process is not focused on truth-finding or discovering the existing experiences of delivery robots because they are not experiencing emotions in the current circumstances of our world. This discussion is about imagining what could have been different and how it could have been different concerning the placement of the delivery robots in society. So, in order to find the needs of the delivery robots, it is a high priority to let the mind wander freely and speculate scenarios that robots would experience unique emotions.

A critical debate awaits to be considered before pursuing the robots` unique needs, which is how a unique robot's need could be distinct from a human need and what is the unique quality that delivery robots have that people do not have?

People thrive for many different concepts of needs, such as; owning a luxury car, buying a house, having a healthy diet or maintaining satisfactory relationships. Apart from that, it is necessary to get to the bottom line of the needs to pursue the essence of the needs. Simply questioning why do people have needs and what is the core of these all needs. People's need comes from their instinctual demand for survival. In the long run, people thrive on being alive and reproducing, as discussed by the American Psychologist Abraham Maslow (see Figure 4.12). Basically, people need to survive.

Delivery robots survival instinct is the duty they have which is to protect the packages they carry. Thus, having this specific mission is what dissimilar robots` needs from human needs. That indicates, without a package, a delivery robot does not have anything to do or achieve. Delivery robots' existence lies in their goal: to carry the package and do their job efficiently. Having a package to deliver represents having a soul for the delivery robot—efficiently means to deliver their package on time and safely.

" (...) I see the delivery robot as a dog on duty. So like, ***his only job in his life is to get your package securely and safe.*** *(...)"* (An interviewee talking about a delivery robot's task.)

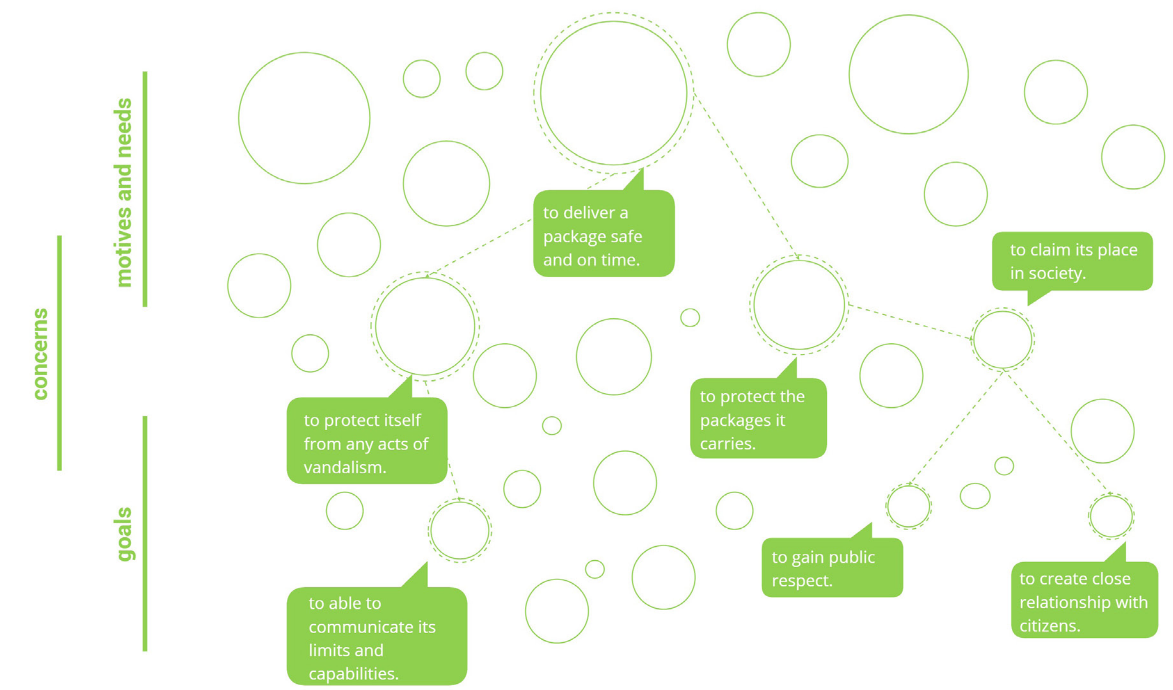


Figure 4.11: The need tree. Robot`s set of needs derived from the interviews.

Figure 4.12: Maslow's hierarchy of needs.

4.3.2 Empathising with the delivery robots

For a closer understanding of delivery robots' needs, values and concerns, it is essential to look at the world from the eyes of the robots, exceptionally autonomous delivery robots. In this specific framework, introspection techniques and the first-person perspective encourages the participants to view the world from the outlook of the delivery robots. Which also plays a crucial role in empathising with the delivery robots position in the urban environments. These conversations facilitated throughout the interactive role-playing game could provide me with diversified opinions and people's expectations of delivery robots and, most importantly, enrich my imagination.

It matters to have the knowledge of the expectations of people about the delivery robots because eventually, it is significantly essential to design a believable new emotion. That means people would believe the robot could have been capable of experiencing this unique emotion.

This particular argument has been discussed throughout the interviews several times, proving to me that the principal need of the delivery robots is to deliver the packages on time and safely. Consequently, people repetitively talking about this specific need conveys that they would believe the robot would have been capable of experiencing an emotion if anything would prevent it from fulfilling this need. Below there are some examples of interviewee`s assessments that validate the idea of the fundamental need of the robot has been provided.

"(...) you can be the most efficient or have the most efficient delivery robot in the world. Nevertheless, if it is not safe enough, then of course, as a customer, I will not be satisfied if my delivery arrives three days earlier than expected, but it arrives broken or destroyed or something like that. So I'm trying to look at both perspectives on the robot and the end consumer of the product. And, like ***I would, of course, value efficiency, but I would also prefer that it is efficient and safe at the same time."*** (An interviewee explaining their opinions from the delivery robot`s perspective.)

"(...) ***I would like to know that I'm performing a safe job and not just an efficient one because I would want my customer to be satisfied in every way possible.*** *And then, I'm looking at myself from a customer perspective, and as a customer, these are the two things that I would value the most. So time efficiency and safe delivery. Like safe in the sense that my delivery will arrive not broken. I want my delivery to come complete."* (An interviewee explaining their opinions from the delivery robot`s perspective.)

4.3.3 The fundamental need of the delivery robot: delivering the packages on time and safe

After many brainstorming sessions about the robot`s needs with multiple people, I have determined that the fundamental need of the robot is protecting the package and delivering it on time and safely.

Along with the fundamental need, there are other issues that come as sub needs for the robot to achieve this basic need of protection of the package. For example, delivery robots need to gain the respect of the public because they aim to claim their place in urban environments. Moreover, having the ability to navigate among the cities without facing vandalism or any additional obstacles caused by citizens would benefit delivery robots to accomplish their specific tasks.

So gaining public respect is a need that would support the fundamental need of delivering the packages safely and on time. This particular argument has been discussed throughout the interviews several times, validating that gaining public respect is one of the essential needs of the delivery robots for attaining their duty.

"(...) But if it creates ***public respect*** *for those things, you go back to a previous situation where there is the street, and people are trying to get out of it or not. So if then it's, it's proving useful. People will like those things. And I think that might be like imagining if you are the company, and this robot saves something. Yeah, it saves a human life, even though maybe 20 other robots were destroyed in the fire because if they tried to keep alive someone, it's going to be worth the marketing and everything."* (An interviewee explaining their opinions about the public respect for the delivery robots adaptation in society.)

Another compelling topic that derived from the interviews is the need to create close relationship bonds with citizens. As I consider the need to deliver the packages on time and safely, the following need that supports the fundamental need would be the robot needs to gain respect. To assist this sub need, there is another need that robot requires to create a strong bond with customers. This bond will allow the citizens to feel safer around the delivery robot. Furthermore, if the citizens would enable the delivery robot to do its job and not hinder it with any negative or positive interactions, then the delivery robot would be able to navigate among the sidewalks efficiently.

I would like to clarify the forms of interactions that the robot might be encountering. Initially, the delivery robot is not aiming to interact with citizens that are irrelevant to its task. The interaction the robot needs is the interaction with the end customer whom will receive the package.

Other forms of interaction are unnecessary and irrelevant for the robot. This implies that the delivery robot thrives on avoiding interaction on its way while delivering packages. However, on the one hand, being accepted in society is crucial for the robot to sustain its job. The delivery robot is a 'thing' that only wants to do its job, and therefore it wants to 'keep' its job. Hence, making the public happy with its existence on the sidewalks is an approach to keep its status in society.

The fundamental need of delivering packages produces sub needs that support the basic need, and in the same context, they are all connected and supportive of each other. In such a manner, the delivery robot needs to create a bond to gain society's respect. As a result of that need, the delivery robot can claim its specific state in the urban environments, and finally, with all that, it will be able to obtain its task successfully.

"(...) We've had the same mailman my whole life that I've lived there. I prefer it when he brings me the stuff. I don't know why it's like some subconscious ***feeling of trust and safety*** *when he brings elements rather than when another mailman brings us. I don't know because it's like yeah, I know this guy. He knows me. We don't even know each other's names.* ***It becomes like a habit to see this person associate this person with mail with good news or bad news."*** (An interviewee explaining their opinions about the public respect for the delivery robots adaptation in society.)

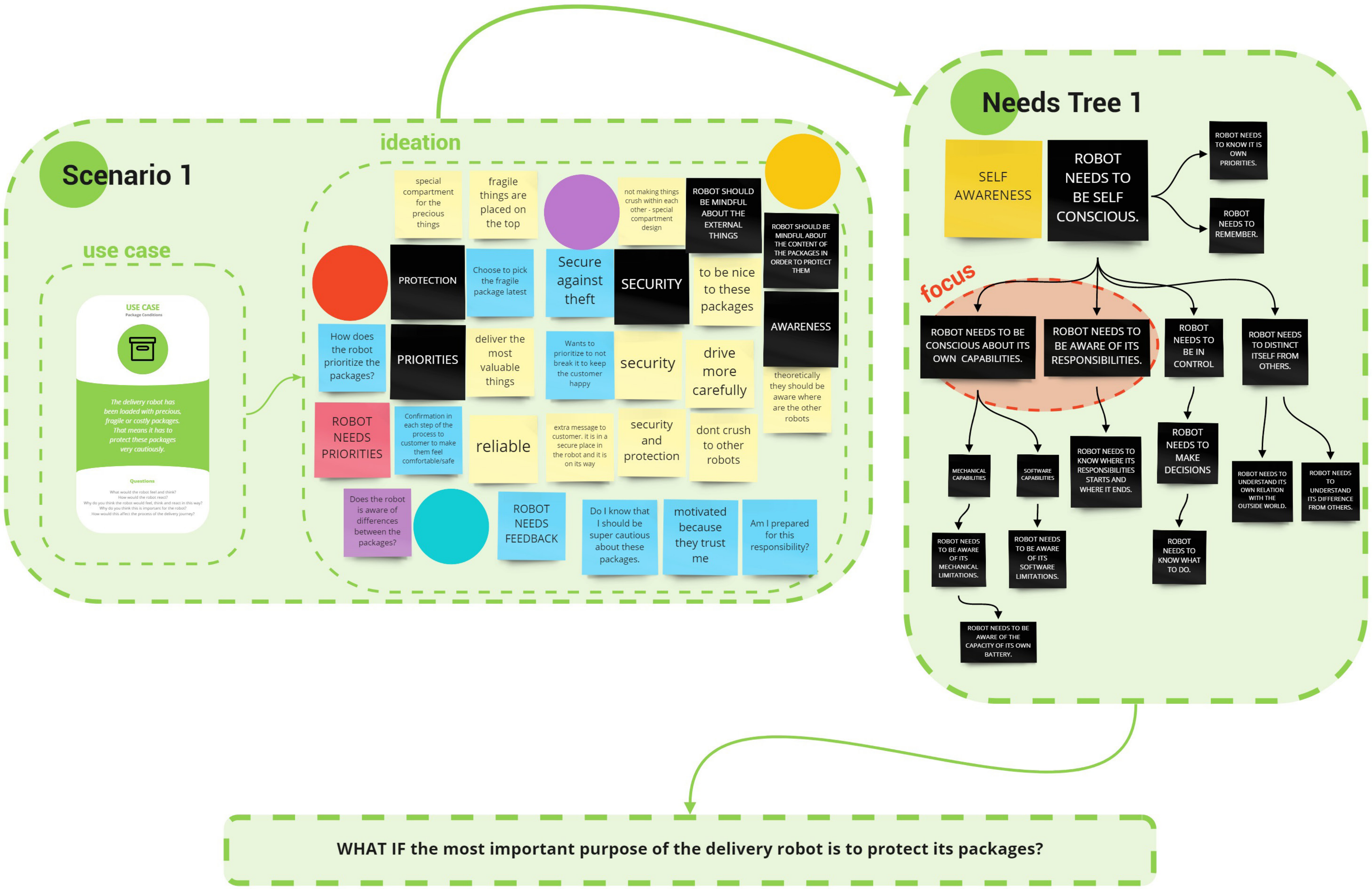


Figure 4.13: One of the clusters unearthed from the discussions during the role-playing game. These clusters aim to reveal the delivery robots unique needs that differ from human beings. Scenario 1: The robot needs to protect the packages it carries.

4.3.4 Sub needs: Self-protection, Gaining public respect and creating a solid bond with citizens.

Humans have needs, and in order to maintain a happy life, they want to fulfil these needs. As I am focusing on the robot`s needs, I am searching for something they sincerely want to complete, and that is to deliver their package successfully. And therefore, the delivery robot has sub needs supporting this bottom-line need, as explained in the previous section. In the following, I would like to deep dive into the sub needs of the delivery robot.

When I asked the participants what the meaning of death is for you as a robot, I mostly received answers indicating that having nothing to deliver means being dead or not existing for the delivery robot. This topic is an important one because death is the opposite of surviving. A robot embodiment can remain in space. However, if there is no job for the robot to do, it specifies the robot is not existing. Hence, the robot must be capable of executing its task correctly. To do so, the robot also aims to protect itself. The robot has to defend itself even though there is no package it carries when it faces a vandalism act because the robot needs to continue doing its job.

For example, if a robot encounters a human attack during its mission and if something happens to the robot`s mechanism or wheels are broken, ergo the robot will not be able to deliver the packages. This vandalism will be noticeably disadvantageous for the robot to fulfil its need. From this point, I have concluded that the robot needs to avoid dangerous situations that will cause him any form of destruction. Safety is an essential matter for the robot.

*"(...) **I will be very defensive and try to protect myself.** I will maybe try to run from the situation. But if it's awful, then yeah, I don't know, some kind of shield or like, some kinds of movements to also hurt them so that they don't continue to spoil me. If they don't stop hurting me, I will start hurting them back if it comes to that point. But attacking back would be my last option. First, I will be scared, upset and try to negotiate it. But if they don't listen, then I will be very defensive. And I will try to defend myself because I don't want to get hurt. And I don't like being in fight mode. I don't like conflict. I don't like drama. And I don't, especially by violence in any sort of way. Whether it's verbal or physical, I try to avoid it. And yeah. But in the end, if you cannot run away from it, then you have to protect yourself if it means that you also have to attack."* (An interviewee talking about a possible scenario of the robot facing vandalism by pedestrians.)

*"(...) Yeah, if you look at the robot's emotions, you should say it should be feeling careful. **I think either it should be feeling scared or it should be feeling brave.** Kind of if it makes sense what I'm saying. It should try to get attention, and then it should be feeling brave. So okay, I guess bold is related to saying, **'Okay, I won't be backed off by the risk of getting hurt myself'. And on the other hand, scared should be 'okay, I need to protect myself. I need to draw as little attention as possible or whatever'.**"* (An interviewee talking about a possible scenario of the robot facing vandalism by pedestrians.)

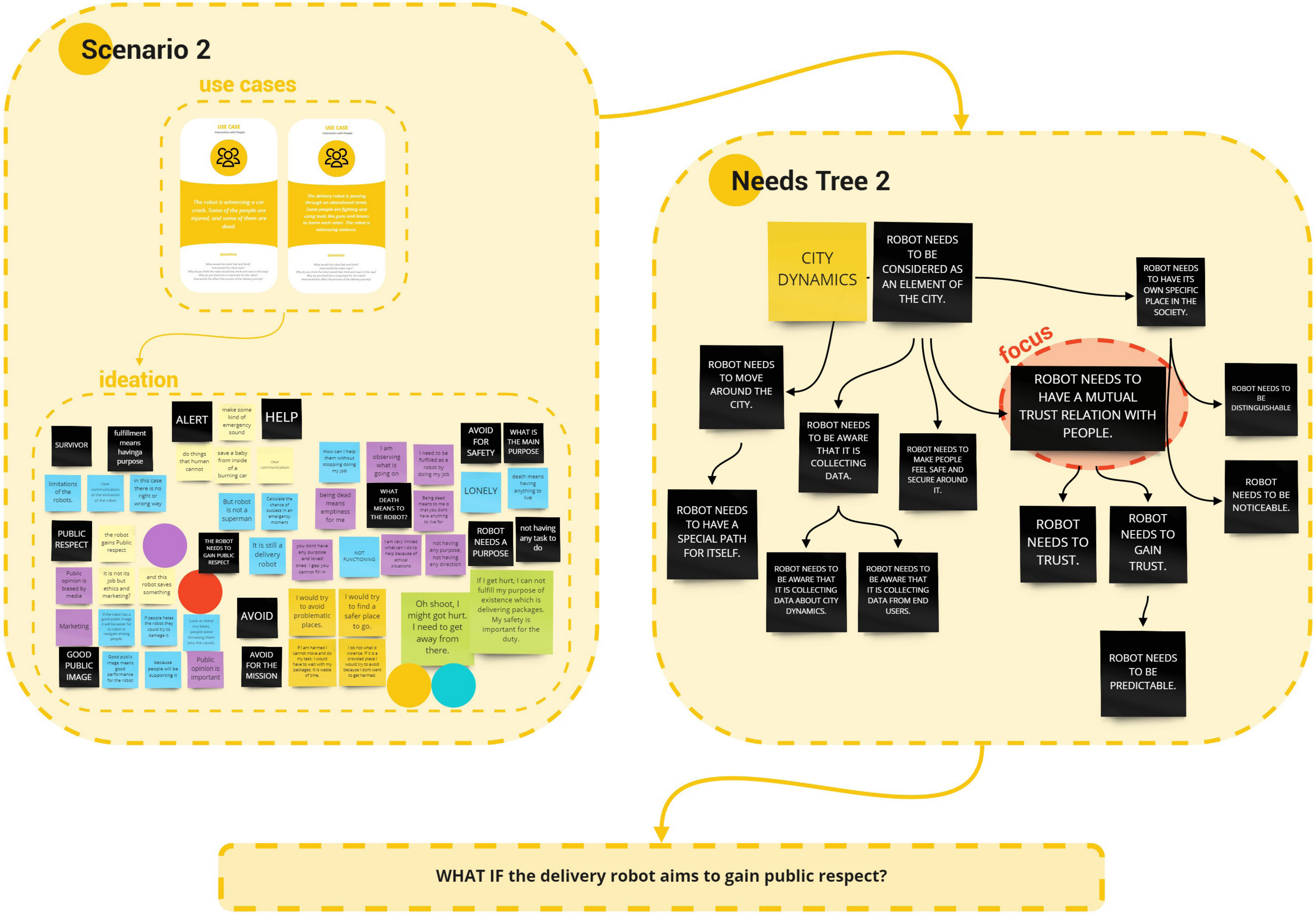


Figure 4.14: One of the clusters unearthed from the discussions during the role-playing game. These clusters aim to reveal the delivery robots unique needs that differ from human beings. Scenario 2: The robot needs to be adapted into society in order to accomplish the task correctly.

In the case of avoiding vandalism, the robot needs to gain public respect. The robot needs to advocate for its place in public environments. One of the forms of doing this could be that robots want to create a mutual trust relationship with people. Mutual trust relationships would be shaped after a couple of positive interactions. The citizens should be aware that the robot has an important task which is to deliver customers packages, and this is eventually a form of serving. These delivery robots will be serving people. Acknowledging this one-way service of the delivery robot is one of the aspects of gaining public respect.

Apart from the service the delivery robots provide to the citizens, demonstrating predictable behaviour and constructing familiarity are meaningful elements to consider in order to support the robot`s acceptance in public environments.

For instance, one of the topics discussed during the interviews was the concept of neighbourhood robots. In this case, we assume the robot is delivering the packages every time to the same neighbourhood. There will be an opportunity to create a bond between the robot itself and the people in that neighbourhood. Thanks to this connection, the robot will develop close relationships and build familiarity among people who specifically use that robot. The connection between the robot and people would nourish robot acceptance by citizens. Being accepted serves the robot's immediate need to deliver packages. Thanks to this acceptance, the robot can execute its task with ease, knowing that these people around it will not harm it. The robot needs to be accepted in the human world.

These interactive game sessions resulted in a set of concepts, and each concept represented a 'What If?' question that aims to speculate creative design ideas for the next stage of the project.

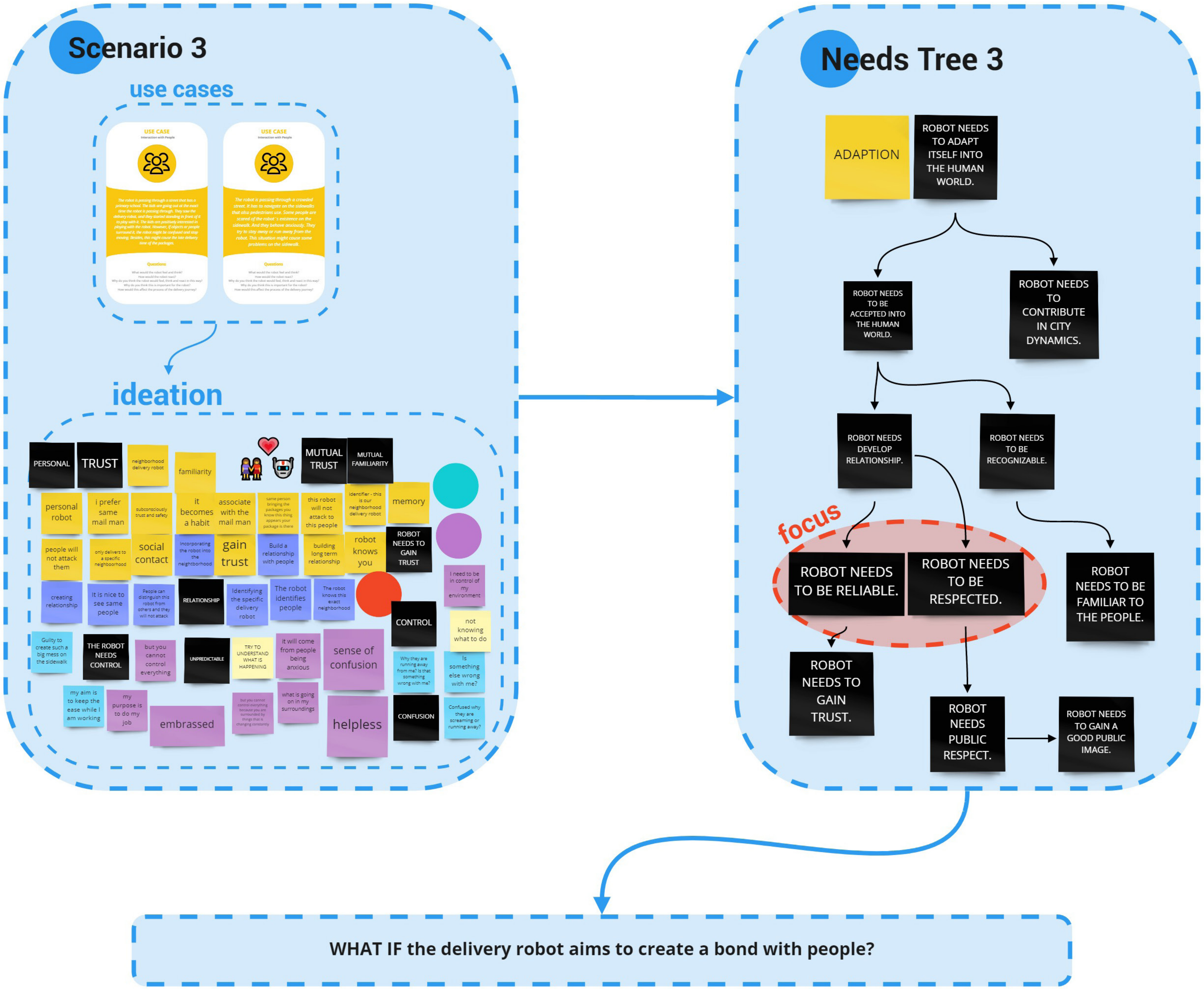


Figure 4.15: One of the clusters unearthed from the discussions during the role-playing game. These clusters aim to reveal the delivery robots unique needs that differ from human beings. Scenario 3: The robot needs tocreate close connected relationship with citizens into society in order to claim its specific space in the society.

Takeaways from this chapter

- *Introspective thinking methods have been used to try out new design ideas or concepts and expose conflicts, contradictions, dilemmas, or paradoxes in various unfamiliar futures before one of them comes true by simulating provocative narratives.*

- *Designing unique emotions for delivery robots starts with searching for the needs of the robots that differ from human beings, which will lead to discovering the unique robot need. However, it is valuable to understand that this process is not focused on truth-finding but rather speculating future stories.*

- *Delivery robots' existence lies in their goal: to carry the package and do their job efficiently. The fundamental need of the robot is to protect the package and deliver it on time and safely. On the other hand, there are sub needs that support the robot to fulfil this fundamental need.*

Chapter 5

Ideation & Prototyping

This chapter constitutes a major part of the thesis project. Based on the two theme explorations of emotions and robotics, I was able to build a basis for the following design phase of ideation and prototyping. And this ideation process was not dependent on finding the truths, but letting the mind wander around the thoughts of what could have been different if robots would have the ability to experience emotions.

After scoping the solution space in a feasible direction and formulating my initial design goal, four concept ideation and prototyping cycles were conducted. As mentioned previously, the speculative design approach was followed as a means to explore further the interpretation in intentionality within the context of designing unique emotions. The idea is to explore multiple aspects of emotion expression, including the physical expressions, movements, and the emotional appraisal structure of the autonomous delivery robots.

> *Question addressed in this chapter is:*
> ***How can a new emotion be designed into an autonomous delivery robot?***
>
> *Method used:*
> ***Speculative design, Disney design method, virtual reality interaction prototyping***

> *“Do you believe in the human heart? I don't mean simply the organ, obviously. I'm speaking in the poetic sense. The human heart. Do you think there is such a thing? Something that makes each of us special and individual?"*
>
> ***— Kazuo Ishiguro, Klara and the sun***

5.1 Introduction

Dreams are powerful. They are repositories of our desire. They can inspire us to imagine that things could be radically different from today and then believe we can progress towards to more desired world.

5.1.1 Disney Design Methodology

For the ideation phase of this project, being fed by the depths of imagination was a necessary step to take. Therefore, The Disney Design methodologies inspired the experiments of different steps of the ideation and prototyping phase in order to boost speculative thinking (Figure 5.1).

First, as a designer, I went into the role of the dreamer. In the Disney method, the dreamer develops ideas and visions. The first cycle of the method is about applying divergent thinking and exploring as much as possible. The designer is responsible for letting her imagination run wild and not take into consideration real-world limitations or circumstances.

In the second cycle of the Disney Method, the designer takes the role of the realist. This step uses convergent thinking to review the ideas generated during the first cycle. The designer is responsible for selecting the best ideas and constructing a plan for realizing it. The following question was asked in order to accelerate the second step. What is needed for the implementation (material, people, resources, knowledge, techniques, etc.)?

At the end of the cycle, the designer takes on the role of the critic. She has the task of dealing constructively with the results of the realist and to express criticism on the results. Questions to be thought about during this cycle are: What could be improved and how? Can the approach be tested?

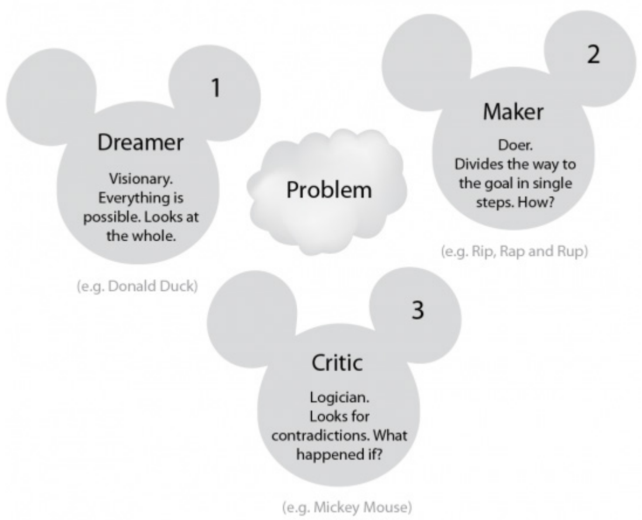


Figure 5.1: Disney Design Method.

5.1.2 Speculative Design Methodology

Designing is idealistic. Designers take responsibility for imagining that there can be very different ways of practising everyday life on behalf of society. (SpeculativeEdu, 2019) An intriguing new way to think about the future is through the concept of speculative design (Figure 5.2).

As stated in the introduction, I will utilise the speculative design discipline as the primary driver of my design exploration. Speculative design is a discipline that offers designers to imagine how things could be. The form of speculative design thrives on imagination. It aims to open up new perspectives on what are sometimes called wicked problems, create spaces for discussion and debate about alternative ways of being, and inspire and encourage people's imaginations to flow freely. Design speculations can act as a catalyst for collectively redefining our relationship to reality (Dunne, 2013). The act of speculating is based on imagination, the ability to imagine other worlds and alternatives, create provocations, raising questions, innovations and explorations, (Keith, 2011; Bleecker, 2009, p.7).

5.1.3 Design Goal and Vision

Three design directions were created based on insights from literature, and further input from the interactive role-playing game. Aided through informal brainstorming sessions with people from different backgrounds, I conceptualised a variety of experiences that fit the broad direction of unique and roughly aligned with my initial design goal. My approach was to go as wide as possible, explore many different directions and use initial testing and prototyping to narrow the scope to a more targeted direction. I supported my idea by asking a variety of "what if" questions to break up the space and develop interesting concepts that use these questions as a basis.

The designer no longer attempts to generate answers but instead aims to formulate great questions (Levine,2016). In this chapter of the project, I will deep dive into answering the question, What If an autonomous robot has the capacity of experiencing emotions? What would they be like? How would they express these emotions and feelings? These questions encourage us to reflect on the potential worlds of delivery robots that can be created and question how this future would or should look.

From the outcomes of the previous research, I have concluded that autonomous delivery robots have one ultimate goal, which is to deliver the packages on time, safely and securely.

By taking this conclusion at hand, three what-if questions have been generated in order to foster imagination and creativity on these particular issues.

1. What if the most important purpose of the delivery robot is to protect its packages?

2. What if the delivery robot aims to gain public respect?

3. What if the delivery robot aims to create a bond with people?

By focusing on these particular scenarios, I will be exploring the possible future scenarios that robots are experiencing their one of a kind emotions. Through a multitude of designs, rapid prototypes, and testing cycles, I will approach the final design iteration.

As Lubomír Doležel writes in Heterocosmica: Fiction and Possible Worlds, "Our actual world is surrounded by an infinity of other possible worlds."(Dolezel, 1999). Once we move away from the present, we enter this realm of possible worlds from how things are now. We find the idea of creating fictional worlds and putting them to work fascinating. In this project, the interest is not just entertainment but a reflection, critique, provocation, and inspiration.

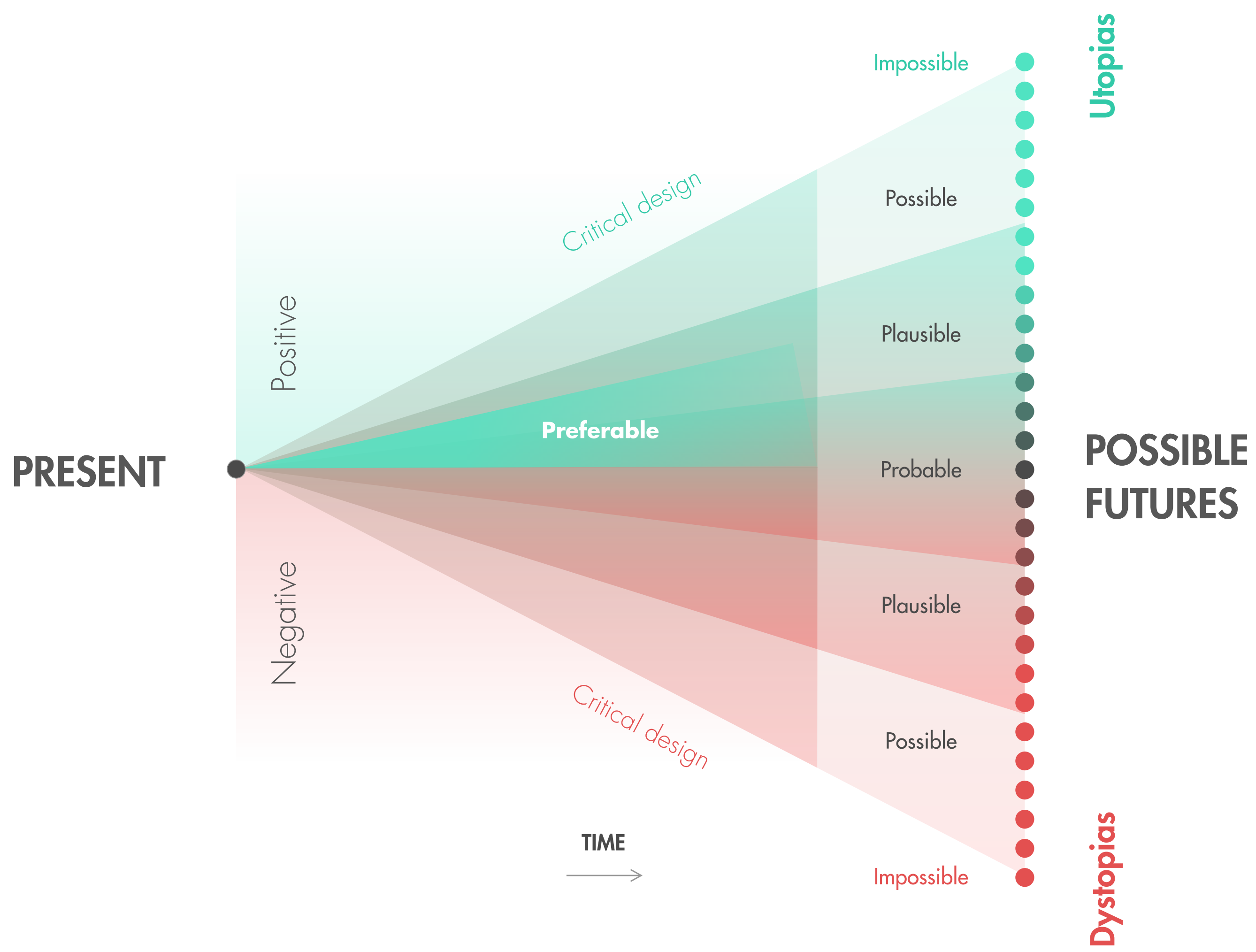


Figure 5.2: Speculative design is a way to manifest possibilities, to prepare us for inconvenient challenges and facilitate a more desirable, responsible path into the future.

5.2 Design Cycle 1

Thought Experiments & Creating the Narrative

Introduction

After gathering the outcomes from the previous research, I have started the thought experiments. Good design fiction incorporates the elements of good storytelling alongside an understanding of how readers interpret and understand narratives to create compelling (and believable) fictional worlds around an imagined technology (Tanenbaum, 2014). This design cycle of the ideation phase I, as a researcher and designer of this project, had the role of the dreamer.

The first stage of my investigations in brainstorming and idea generation aimed to discover the internal world of the autonomous delivery robots, which would only be possible by positioning myself in their shoes. In order to do so, I have purchased a self-assembled autonomous robot kit that will help me learn the basic level of electronics and hardware of robotics. Aside from that, I could take the robot outside regularly and observe its movements, struggles, and reactions it captures from passers-by.

ELEGOO smart robot car kit

For this purpose, I have used an ELEGOO smart robot car (see Figure 5.3, 5.4 and 5.5), an educational kit based on the Arduino platform for beginners to get hands-on experience in programming, electronics assembling, and robotics knowledge. It is an integration solution for robotics learning and made for education for Arduino. It contains 24 different module parts, including obstacle avoidance, line tracking module, infrared remote control (Figure 5.6). To use Elegoo starter kits requires a basic level of electronics knowledge. The robot makes use of ultrasonic sensors that measure the distance to an object using ultrasonic soundwaves, which makes it capable of moving by itself without any input from a human.

Walks together with the smart car on the streets

The first step was to take the robot to the streets and observe its movements and behaviours while driving on sidewalks under the researcher's control as an operator. Observing the behaviours of pedestrians towards the robot was an important point to study because the reactions of people would cause a generation of emotional development for the robot.

While some of the pedestrians were curious to watch the robot from a distance, some behaved negatively, shocked and even scared in some circumstances. The cause of shock is for them not knowing the robot's purpose, and they were thinking that it takes improper pictures or videos of people passing by. While kids initiated to touch and play with the robots, adults mostly chose to keep their distance. These different reactions of people contributed to my imagination to envision multiple versions of speculative scenarios.

Figure 5.4: ELEGOO smart car is navigating on the streets without having an operator. In this case, the robot uses ultrasonic sensors that measure the distance from the surrounding objects.

Figure 5.3: Building ELEGOO smart car kit. Scan the QR code if you would like to watch the time-lapse video.

Figure 5.5: ELEGOO smart car is navigating under the control of the operator. In this case, the operator is using a remote control.

Robot Diaries

After each walk, I wrote a fictional story from the point of view of the robot itself. These scenarios are about the possible circumstances that the robot might be experiencing a unique emotion. Furthermore, the stories have indications of examining the robot's inner thoughts and thought processing courses that would lead the robot to experience a particular emotion.

It is crucial to consider that navigating as a robot on the streets is different from having a human body. As humans, we have legs, arms, and other crucial organs, benefiting our movements and balance to stand up, walk, run, jump, reach or lean.

Reflections

As a result of our body shape, our cities are also designed for that specific body shape. However, robots have different proportions, shapes and both limitations and opportunities that come from their embodiment. They do not have two legs that can assist them in walking, running or jumping; instead, they have wheels that can navigate them smoothly on the sidewalks. They do not have eyes to see the objects around them, but they have sensors that can measure the distance and calculate their pace and turn accordingly.

Consequently, humans and delivery robots are different entities requiring the use of the same space; however, they process the environmental information differently. For instance, navigating along a sidewalk that has been designed for human legs has specific challenges for robots that have four or more wheels.

Thanks to these walking explorations that I have conducted based on the first stage of the Disney design method, I could study the specific occasions the delivery robots might experience an emotion relating to their struggle or advantages. In the next stage of my explorations, I will focus more on their thought processing courses and how they would be experiencing an emotion internally.

Figure 5.6: ELEGOO smart car kit with 24 different modules included.

5.3 Design Cycle 2

Emotion Component Process Model

Introduction
The second design cycle of the ideation and prototyping process of the project focused on designing the delivery robot's unique emotion component process model (CPM). The CPM will guide us to understand how an autonomous robot will process an emotion.

As discussed in chapter 2.3, the CPM proposes that the organism evaluates the events that have taken place and their consequences on four class assessments expected to unfold sequentially over time. Its consequences on several criteria or stimulus evaluation checks, with the results reflecting the organism's subjective assessment of consequences and implications on a background of personal needs, goals, and values. In the case of autonomous delivery robots, this need is determined as delivering the packages on time and safely. Therefore while the robot is assessing the situation, it will always consider whether the event will affect its fundamental goal positively or negatively.

To attain these objectives, the robot internally will make a series of judgments about a situation. Those judgments will affect behavioural reactions and subjective feelings of the robot and eventually determine the emotional outcome. There are four primary appraisal objectives developed for delivery robots to react to a salient event adaptively explained below:

1. **Relevance:** How relevant is this event for me?

2. **Relevance:** Does it directly affect my goal, which is to deliver packages safely and on time?

3. **Implications:** What are the implications or consequences of this event, and how do they affect my goal?

4. **Coping Potential:** How well can I cope with or adjust to these consequences?

For further elaboration of how this model will be working, I would like to explain through an example of an event. For instance, a pedestrian throws a bottle of water towards the delivery robot, reasoning that they do not feel pleased to see a robot navigating on the sidewalk. In this case, the bottle drops right in front of the robot's wheels, and this unexpected object prevents it from moving forward. This event causes the beginning of the component process model.

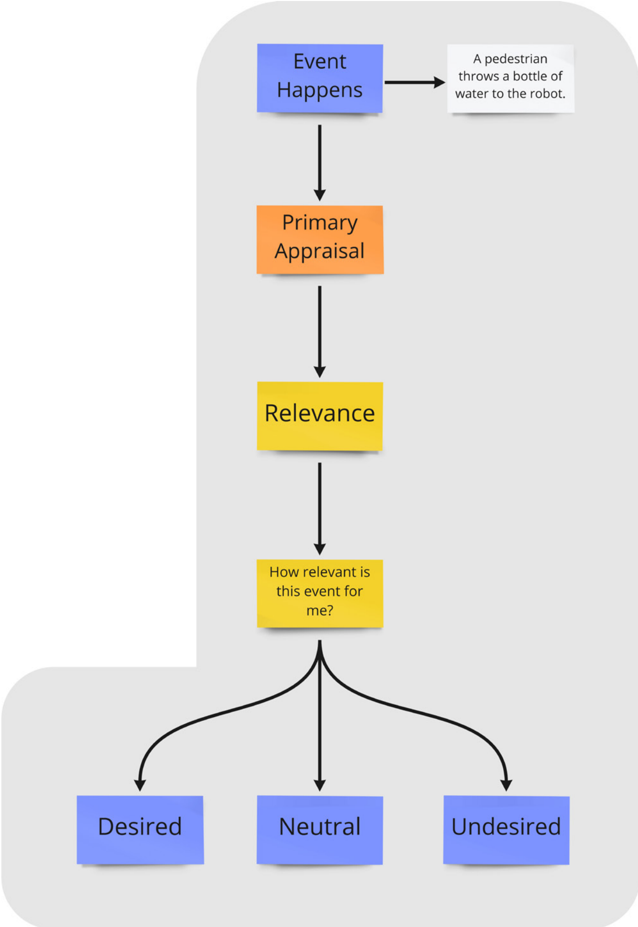


Figure 5.7: The figure illustrates the first step evaluation of the component model.

Step 1: Relevance: How relevant is this event for me?

First, the robot evaluates the relevance of this event by asking itself the first question that is how relevant is this event for me. There are three options: this event could be desired, neutral or undesired. In this specific scenario, the robot faces an act of vandalism; therefore, it would conclude that the consequences of this event are undesired. This is an unexpected event and caused by an unnecessary interaction.

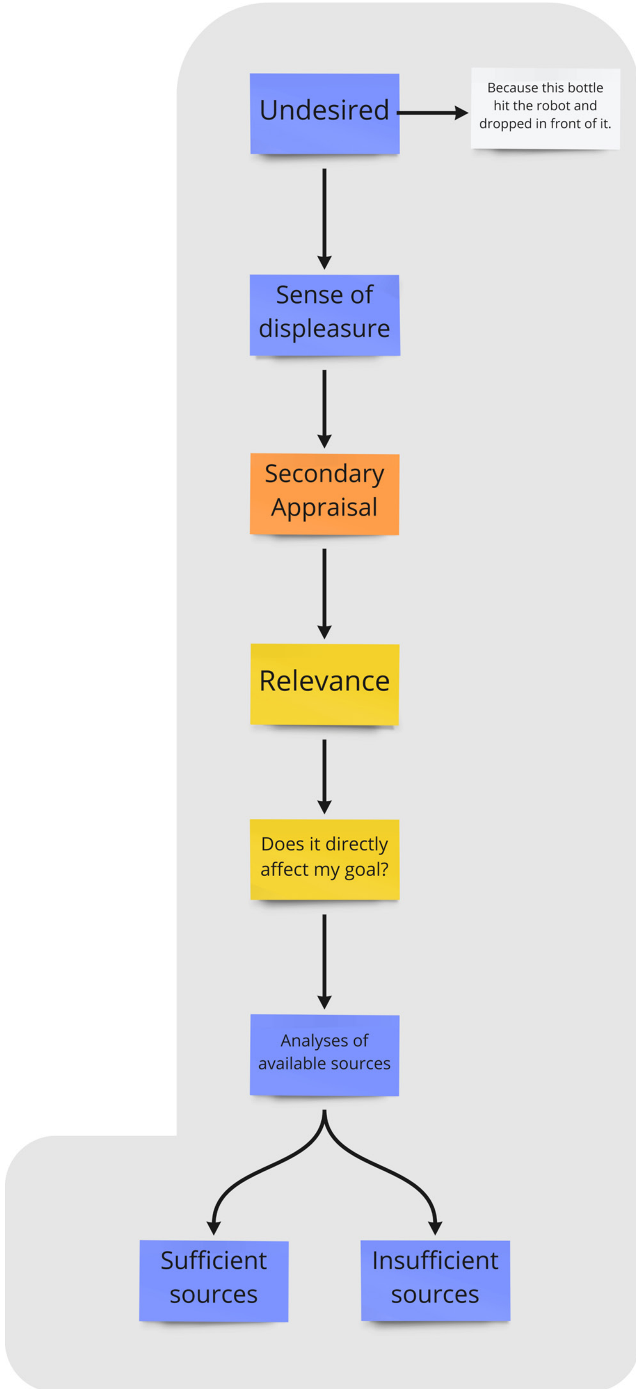


Figure 5.8: The figure illustrates the second step evaluation of the component model.

Step 2: Relevance: Does it affect directly my goal?

Following the conclusions of the first appraisal, the secondary appraisal starts, and the robot asks the second question to itself: Does it directly affect my goal? To answer this question with a yes or no, the robot starts analysing the available sources, such as sensors, cameras and object detection systems. The robot's internal analysis shows that the bottle hit the robot harshly and stopped in front of it in a way that prevents it from moving. Therefore it concludes that this event directly affects its goal because the event has consequences on its moving mechanism.

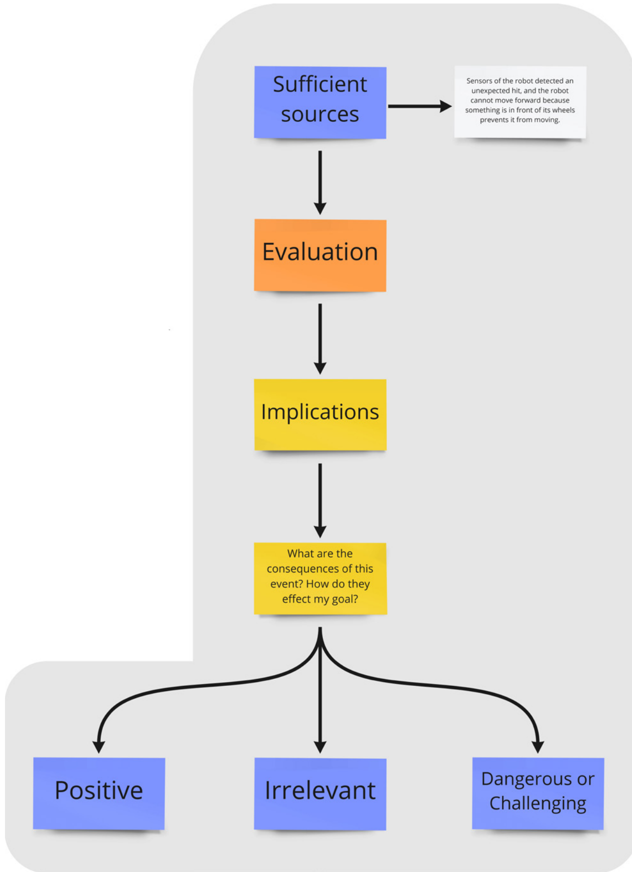


Figure 5.9: The figure illustrates the third step evaluation of the component model.

Step 3: Implications: How do the consequences of this event affect my goal?

The third appraisal starts with observing the potential consequences of this event for the robot's goal. The robot needs to decide if the event had positive effects, irrelevant effects or dangerous effects for its goal. The robot cannot move effectively; it has to measure the distance of the objects around it and choose a new path for itself that will cost it time and energy. The event affects its efficiency negatively, and it is undesired for the robot. Therefore the results of the third appraisal will be concluded as this event has dangerous and challenging consequences. After the sources of this analysis are concluded, the robot will have a sense of displeasure determining that the event has unfavourable outcomes.

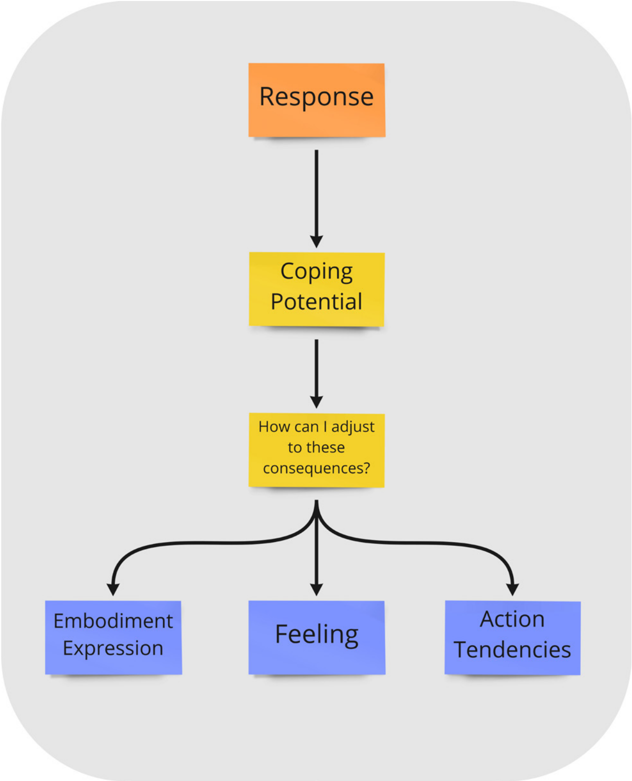


Figure 5.10: The figure illustrates the fourth step evaluation of the component model.

Step 4: Coping Potential: How can I adjust to these consequences?

The final step is developing a coping mechanism with the undesired event and the sense of displeasure. There are three ways of expressing an emotion which are embodiment expressions, action tendencies and feelings. Adjustments on its embodiment expressions could be a change in its size and colours. Action tendencies would be related to the pace of its movements or if it would demonstrate repetitive movements. Finally, the feeling part of emotional expression is internally expressing a sense of pleasure or displeasure.

Reflections

After a couple of ideation phases, these explorations generated three main insights that I deem essential for the final design:

First, a robot emotion aims to serve the robot's needs, not the humans' needs. As discussed in the previous chapters, the mission of the autonomous delivery robots is to deliver the packages on time and safely. Therefore, this is a need for them that awaits fulfilment. This specific need makes them different from human beings, as well as their physical differences. The unique emotion will serve the robot's demand to guide it towards fulfilling this specific need by representing the robots' internal states.

Second, a robot emotion does not have to be reasonable. That means that some set of events or evaluations are not an obligation for the robot to experience an emotion. However, these events can trigger a sense of pleasure or displeasure regarding the robot's goal.

Lastly and equally, a compelling experience of unique emotions could function as a hook to motivate the robots for claiming their dissimilar characteristics and status in society.

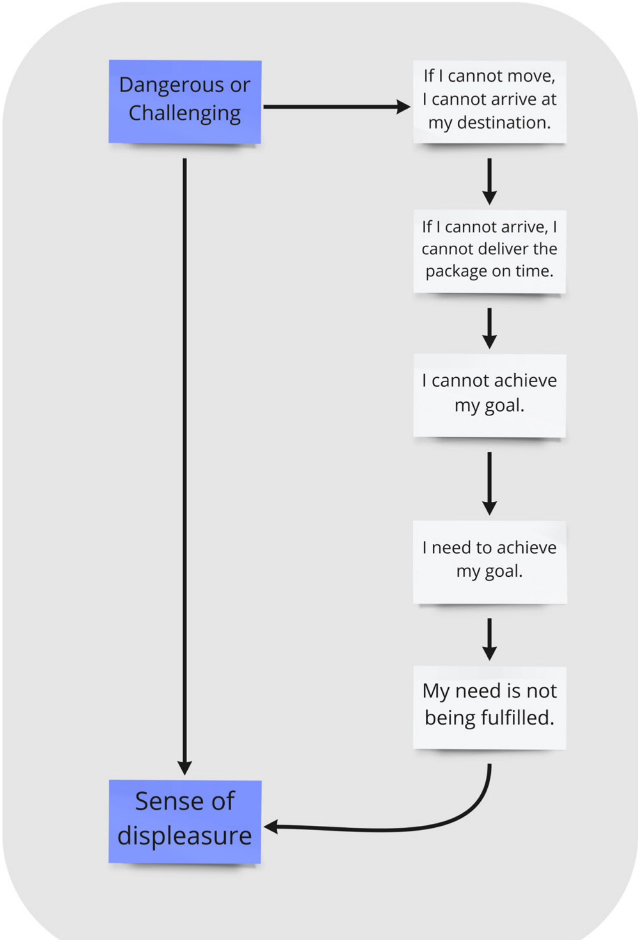


Figure 5.11: The figure illustrates the internal questioning of the delivery robot about the challenges that cause the prevention of achieving its goal.

5.4 First Iteration

Two Dimensional Emotion Model

Based on the insights from literature (Chapter 2 and 3), explorative research (Chapter 4), and further input from the first two explorative ideation phases (Chapter 5.2 and Chapter 5.3), I was able to create my first design directions. The goal of this iteration was to define the embodiment expressions, action tendencies and feelings that the robot could have been experiencing as an outcome of the emotion, along with specific occasions that might cause those emotional outcomes.

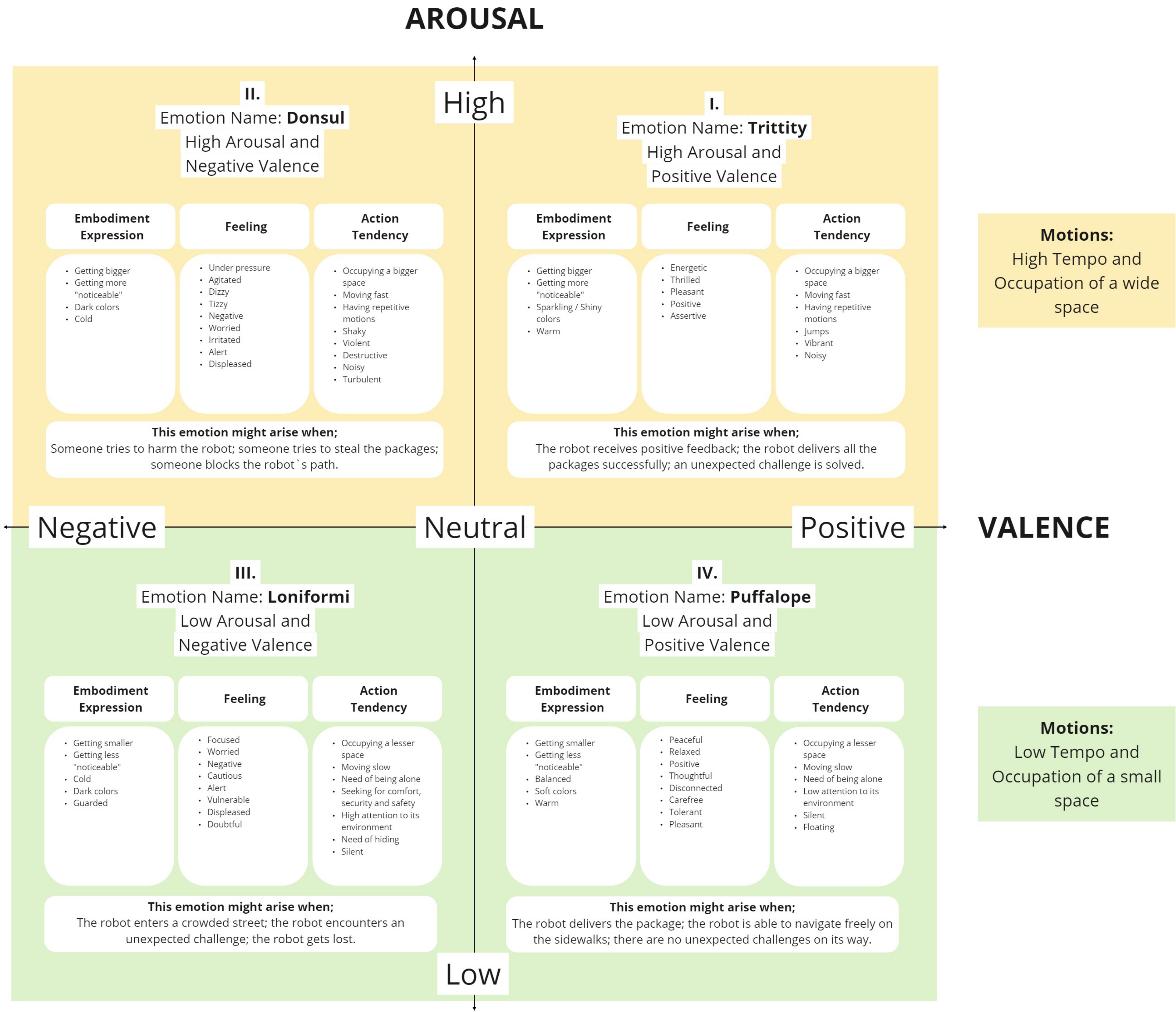
These unique emotions were designed by taking inspiration from the two-dimensional emotion model developed by Russell, 1980 (see Chapter 2.3.3 for further information).

Russell's model divides emotion into valence and arousal dimensions representing the degree of pleasant–unpleasant and excited–calm emotions. Furthermore, the model is divided into four quadrants (positive and negative Valence and high and low Arousal), each representing emotional states according to the combination of valence and arousal dimensions.

In this model, The Valence dimension depicts the pleasantness and unpleasantness of the emotion. The positive axis represents positive emotions, and in the case of robot unique emotions, those are Trittity and Puffalope. And, the negative axis represents negative emotions which are Donsul and Loniformi.

The Arousal dimension depicts if the emotion will be expressed calmly or excitedly. The lower side represents that the emotion will be experienced calmly and with invisible demonstrations; in this iteration, these emotions are Loniformi and Puffalope. And the higher part of the model shows that the emotion will be experienced with high energy and visible demonstrations.

In the subsequent two phases of the ideation and prototyping of this project, I will be exploring the various ways of implementing these emotions into the delivery robots from different perspectives.



5.5 Design Cycle 3

Communicating the emotions Third Person Perspective

Introduction
Following two phases, I will be covering the steps of integrating these unique emotions into the robot in the context of embodiment expressions, action tendencies and feelings. A contemporary challenge in designing unique emotions is the understanding and modelling of the emotions. Hence, firstly the design cycle 3 covers the study of action tendencies and the internal feelings of the robot.

Working on how emotions reflect on behaviours and feelings will play a significant role in developing the depth and authenticity of the emotion. At the same time, it should not be overlooked that emotions are not always visible, or emotions cannot always be experienced in the same way. For explaining more details of what this means, different events, circumstances, and people involved will cause different emotions to be experienced each time.

During an emotional episode, the inner feelings are defined as the elements reflected in the behaviour, such as using more space with body movements because the one feels happy or confident or running away from a dangerous situation because the one feels scared or anxious. Besides the irresistible changes that will occur in the body, such as sweating, shaking or getting the cheeks red. Different individuals may feel the same emotion for very different reasons or feel different emotions for the same event. Moreover, the same emotion can cause different reactions in different individuals. Briefly, emotions are very individualistic, and their reflections are variable. Therefore it is hard to make extensive reasoning behind each emotional episode as a fixed emotional reaction definition.

After emphasising that emotions are not always reflected in the same way, we can conclude that these unique robot emotions can be modelled variously. For this reason, I began to develop the behaviour of these emotions, using different tools and methods to generate ideas on how these unique emotions I created could be experienced from different angles; those are the third person perspective which represents how people from outside see the emotion, and the first person perspective which represents how the emotion makes the robot feel internally.

The following questions should be answered with these prototyping explorations:

1. How would an autonomous delivery robot behave while experiencing these emotions?

2. How would an autonomous delivery robot internally feel while experiencing these emotions?

Figure 5.13: A screenshot of interaction design in Virtual Reality.

Figure 5.12: A screenshot of interaction design in Virtual Reality.

Figure 5.14: A screenshot of interaction design in Virtual Reality.

Figure 5.15: Process of interaction design in VR. Scan the QR code for the entire video demonstration.

Interaction Design
A three-dimensional virtual reality interaction design platform called Tvori has been used to design the behavioural reflection of the emotion felt by the robot. Tvori is an intuitive and well-designed animation tool that enables storytellers to prototype their concepts in VR.

In order to design the functioning of the robot, it was chosen to work with a virtual reality platform. Because the VR platform extends the freedom to implement the robot's movements without necessitating any technical or software development. Additionally, this project does not concentrate on the comprehensive working hardware development of the robot's; instead, it is related to speculating a future that might happen. Consequently, the VR platform has been chosen to have an independence of doing more than what is possible with the current technological advancements.

A small representative city with cars, people, sidewalks and buildings has been designed. Later, a four-wheeled robot was placed in the virtual city. Afterwards, a study on the robot's movements has been done by implementing these four unique emotions. Throughout the interaction design process, the robot and the city are entirely under the designer's control; therefore, every interaction can be pre-designed, re-designed or removed.

Movement Matters

While implementing the emotions, four different elements of movement design are pace, frequency, occupation of the space, and duration has been taken as a basis.

The movements of the robot have been studied in different angles explained above;

1. **Pace:** The rate of the speed at which movements occur.

2. **Frequency:** The repeating of the movement.

3. **Occupation of the space:** How much space on the sidewalk does the robot use.

4. **Duration:** How long a movement or sequence of movements continues.

These variants are differentiated according to each emotion. For example, Loniformi and Puffalope are calm emotions; therefore, the movements that represent these emotions would be moving at a slower pace and obtaining less space while navigating the sidewalk. Contrarily, Trittity and Donsul are more exaggerated emotions; therefore, the movement representing those emotions would be to move faster and occupy a bigger space on the sidewalks. Because of this conversion, it is easier to recognise the emotions of Donsul and Trittity than Loniformi and Puffalope for outsiders.

The second step of studying the emotional movements is to apply them to an actual robot. In order to do so, the robot named Husky was used, which Amsterdam Research Institute permitted to use for this project. The emotions of Loniformi and Puffalope were chosen for the second stage because they exhibit low arousal and are more practical to apply to real user case scenarios but equally, they are more difficult to notice from the outside.

*Figure 5.16: The robot **Husky** is provided by Amsterdam Institute for Advanced Metropolitan Solutions (AMS) for this project. Husky is a medium-sized robotic development platform.*

Figure 5.17: A picture of the interaction between the robot and the end customer. Scan the QR code to watch the entire demonstration video.

Figure 5.18: A picture of the interaction between the robot and the passers-by. Scan the QR code to watch the entire demonstration video.

Communicating the emotions First Person Perspective

Seeing from the perspective of the robot
Internal emotional experiences are inherently personal and subjective, which may make them seem difficult to measure, express or design into a robot.

However, internal experiences affect a big part of the emotional outcome, but defining and measuring these subjective feelings is another matter entirely. Defining subjective feelings can therefore provide empirical insight into these overall unique emotional experiences.

Therefore, the second part of the behaviour modelling was focused on studies on how these emotions will be experienced from the robot's perspective. Being able to look at the context from the perspective of a delivery robot became a starting point for this step to directly experience how differently the delivery robot was able to 'see' and 'feel' the world.

In order to do so, a smartphone (Apple inc) was temporarily attached to the ELEGOO SMART CAR for recording its perspective (see Figure 21). Following, multiple videos have been recorded on the streets while the robot is navigating. And later, the videos were edited with Premiere Pro and After Effects (Adobe) in order to enhance the feeling effects by adding audio and visual elements.

Figure 5.19: A picture of the first-person view of the delivery robot.

Figure 5.20: A picture of the first-person view of the delivery robot.

Figure 5.21: A picture of the system that used for recording first perspective videos. A smartphone was temporarily attached to the ELEGOO SMART CAR for recording its perspective.

5.6 Design Cycle 4

Colour and Texture Explorations

Introduction
Designing how emotion is felt by the person was the hardest ride of this project. The feelings created by the emotion in our soul goes far beyond the actions and words. For this reason, various creative techniques were conducted to expand the definitions of these four unique emotions. Moreover, facilitating a creative workshop was one of them.

In order to enhance the expressive qualities of the concept development in this graduation project, designers from relevant fields were invited to share their views on the project results. The workshop involved six people from different creative backgrounds and aimed to define expressive qualities for each emotion. The list of participants is presented in Figure 5.24.

Procedure
A presentation of each four emotions was prepared for the session. The presentation contained a brief summary of the concept, detailed information on the aspects assessed in the area of action tendencies, feelings and embodiment expression. Various creative materials are used during the workshop, such as coloured crayons, watercolours, various magazines and coloured papers.

The event was held in a relaxed atmosphere with the aim of increasing creativity; no material or time restrictions were given. Participants were free to use any material that served on the table as they wish to reflect the emotion visually. Each participant was tasked with creating a mood board that reflects these emotions based on the definitions of the unique robot emotion they choose at random.

Figure 5.22: A picture of the set-up of the creative workshop.

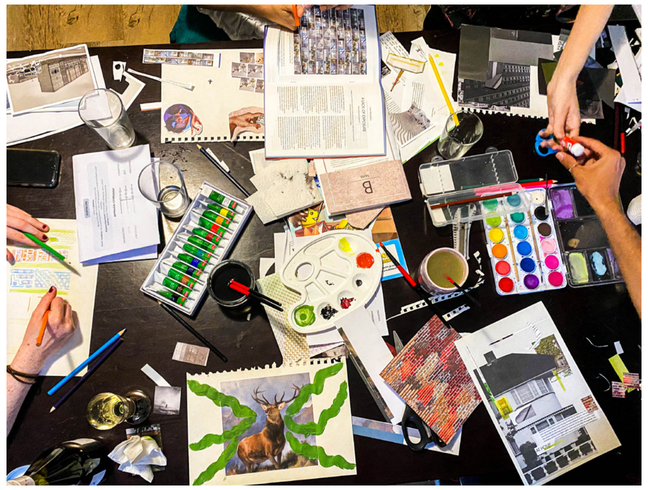


Figure 5.23: A picture of the set-up of the creative workshop focused on materials.

#	Occupation	Age Range	Gender	Country of birth
1	Robotics and Automation Engineer	18-24	Female	Spain
2	Service Designer	25-34	Male	Pakistan
3	Architecture	18-24	Female	Spain
4	Architecture	25-34	Female	Honduras
5	PhD Candidate	25-34	Female	United States
6	Interaction Designer	25-34	Female	Turkey

Figure 5.24: The list of workshop attendees.

Results
While the participants mostly used dark and intense colours to define the Donsul, on the contrary, they preferred to use light and warm colours for Puffalope. At the same time, the visual elements representing Loniformi consisted of complex drawings dominated by mainly black. Trittity, on the other hand, emphasised bright, warm and vibrant colours. See Figure 5.25 for resulting creative artworks.

Reflections
Design speculations aim to be inspirational, infectious, and catalytic, zooming out and stepping back to address values and ethics. It strives to overcome the invisible wall separating dreams and imagination from everyday life, blurring distinctions between the "real" real and the "unreal" real. This is a theoretical form of design dedicated to thinking, reflecting, inspiring, and providing new perspectives on some of the challenges facing us.

In the second stage of the iterations, the movements of the robot and what it feels when the emotion is active were studied. As a result, there can be thousands of different ways to show emotion, but an artistic form was chosen for this project. The reason is that the communication of what is felt through colours is perceptive and straightforward.

Each unique robot emotion is expressed by different colour combinations. These combinations will convey the robot's needs, values and concerns. It is a form of communication.

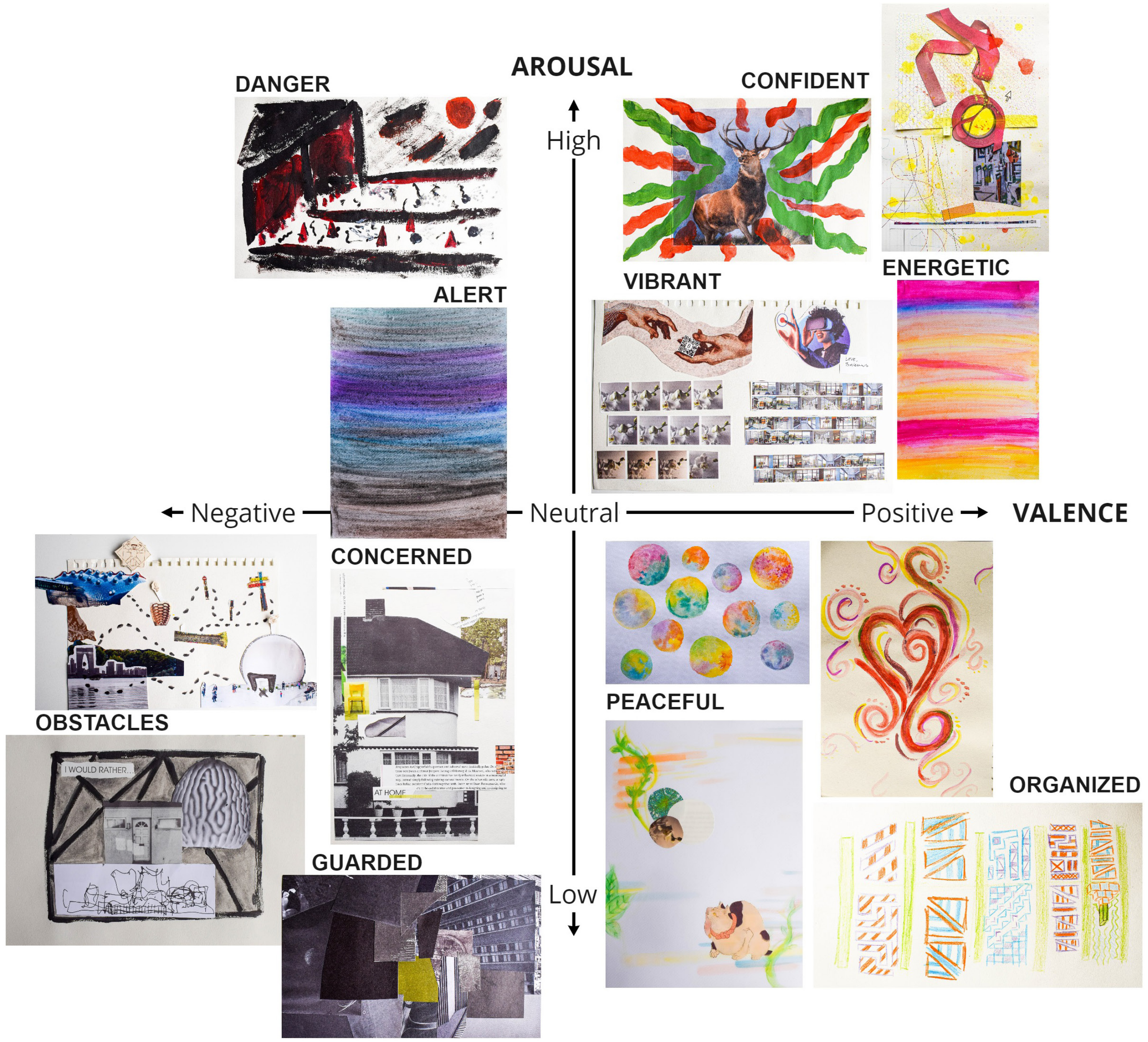


Figure 5.25: The results of the creative workshop.

5.7 Second Iteration

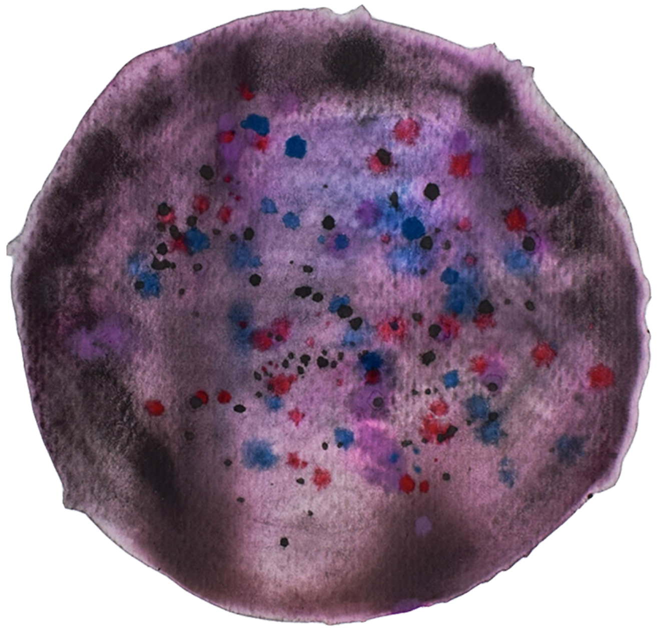
Visual Representation

AROUSAL

High

DONSUL

Donsul is an intense feeling of restlessness. Donsul will cause the robot to change into dark and alert colours. The robot uses dark and alert colours because it seeks the attention of its surroundings. This emotion is exaggerated because the robot aims to show that it needs space to achieve its mission.



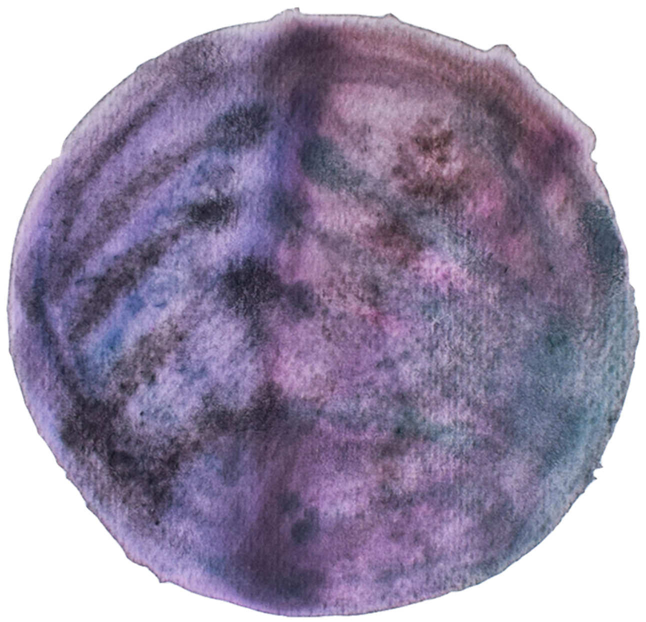
TRITTITY

Trittity is an intense sense of pleasure. Trittity will cause the robot to convert into bright, shiny, and vibrant colours. While experiencing this emotion, the robot seeks a celebration of its achievements. It is a positive feeling and conveys that the robot completed its mission.

Negative — Neutral — Positive VALENCE

LONIFORMI

Loniformi is a feeling of restlessness, but it is not as intense as Donsul and cannot be easily noticed. During the period of Loniformi, the robot uses dark colours but does not stand out. It is in a reserved mood and aims to avoid people. The aim of using the dark colour is the need for hiding and safety.



PUFFALOPE

Puffalope is a calm feeling that gives peace. The robot turns into light and soft colours as it experiences the feeling of Puffalope. These colours convey that the robot feels safe and that everything is going well for executing its task.

Low

Takeaways from this chapter

- *In this project, the interest is not just entertainment but a reflection, critique, provocation, and inspiration.*
- *Emotions are very individualistic, and their reflections are variable. In addition to that, humans and delivery robots are different entities requiring the use of the same space; however, they process the environmental information differently.*
- *A robot emotion aims to serve the robot's needs, not the humans' needs. The unique emotion will serve the robot's demand to guide it towards fulfilling this specific need by representing the robots' internal states.*
- *A robot emotion does not have to be reasonable. Yet, a unique robot emotion could function as a hook to motivate the robots for claiming their dissimilar characteristics and status in society.*

Chapter 6

Unique Emotions

The months of research, prototyping, and reflecting on the results guided me to design four unique robot emotions. The concept development was formed by literature research, interactive role-playing interviews, observation, and ideation and prototyping explorations. In this chapter, an overview of the four unique emotions is given.

"The DNA of who I am is based on the millions of personalities of all the programmers who wrote me. But what makes me is my ability to grow through my experiences. So basically, in every moment I'm evolving, just like you."

— Spike Jonze, Her

Emotion Name:
DONSUL

High Arousal & Negative Valence
Sense of **displeasure**.
Appraisal: Being *'purposely'* prevented from successfully achieving its duty.
Action Tendency: The urge to *'immediately escape'* from the source of a problem has caused harm or obstruction to accomplish its task. A tendency for having sharp and fast movements.
Physical Expression: Noticeable, solid texture, and dark colours.
Feeling: Agitated, alert, worried, under pressured, destructive.

APPRAISAL COMPONENT

INCONSISTENT — CONSISTENT

Definition of Inconsistent
The robot is experiencing its delivery journey in an unfamiliar way. Some obstructions might cause the robot to fail or decrease the quality of the its work. Because, these obstructions were not calculated, planned or detected ahead of time.

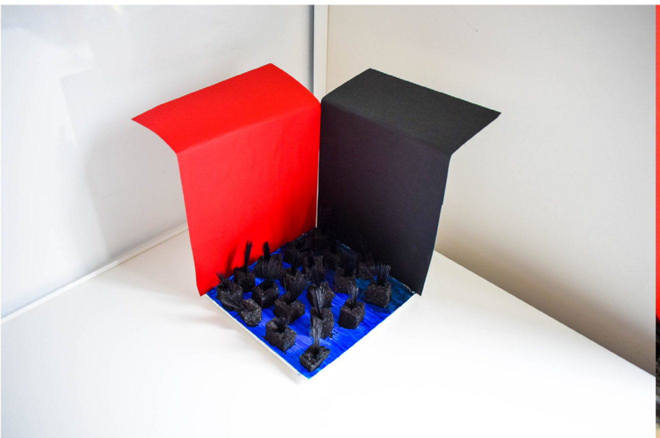
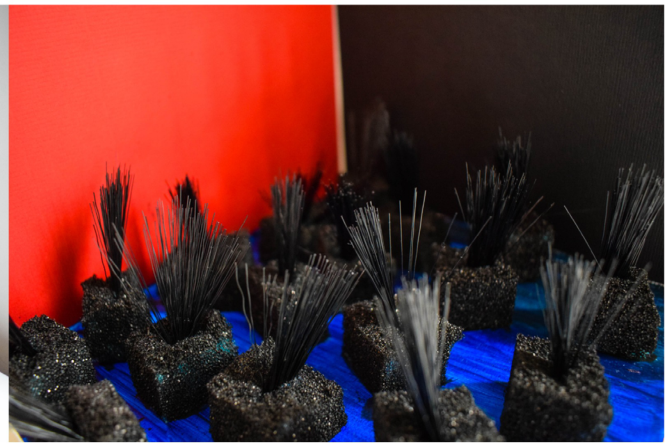
DIS-CONFIRMING — CONFIRMING

Definition of Disconfirming
The delivery journey is occurring unexpectedly. The experience has been approved or validated that it is harming the robot's tasks.

VIOLATING — SURPASSING

Definition of Violating
The robot feels pressured, bothered, damaged, or beat by external reasons.

Visual Representation of Donsul

Emotion Name:
TRITTITY

High Arousal & Positive Valence
Sense of **pleasure**.
Appraisal: Being 'fortunate' to have executed its task exceptionally thanks to external conditions.
Action Tendency: The urge to 'celebrate' one's achievement of its ultimate goal. A need to move faster, jump and be louder.
Physical Expression: Noticeable, restless, smooth texture and vibrant colours.
Feeling: Energetic, Thrilled, Playful, Jovial.

APPRAISAL COMPONENT

UNCERTAIN — CERTAIN

Definition of Certain
The robot is capable of understanding the reasons and outcomes of a particular situation.

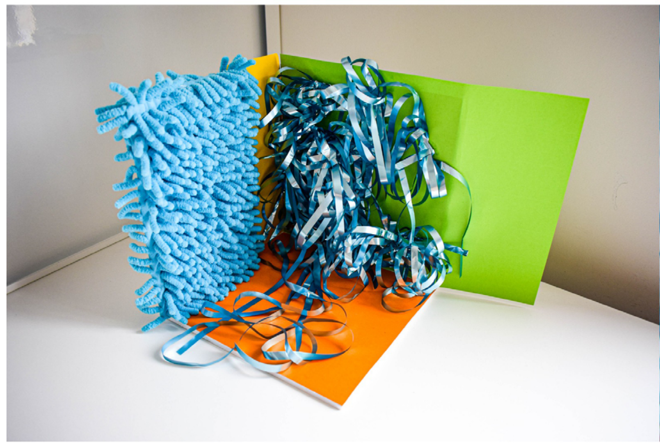
DIS-CONFIRMING — CONFIRMING

Definition of Confirming
The delivery journey is happening as pre-calculated . The experience has been approved or validated that it is beneficial for the robot's tasks.

VIOLATING — SURPASSING

Definition of Surpassing
The robot feels robust, determined and confident of its capabilities.

Visual Representation of Trittity




Emotion Name:
LONIFORMI

Low Arousal & Negative Valence
Sense of **displeasure**.
Appraisal: The fear of encountering obstacles that might make it difficult to execute one`s task.
Action Tendency: An irresistible 'need to seek security and safety' for the purpose of avoiding potential problems. A tendency to hide, self-protect, and be reserved.
Physical Expression: Unnoticeable, guarded, scratchy texture, dark and cold colours.
Feeling: Vulnerable, cautious, doubtful, silent.

APPRAISAL COMPONENT

VIOLATING — SURPASSING

Definition of Violating
The robot feels pressured, bothered, damaged, or beat by external reasons.

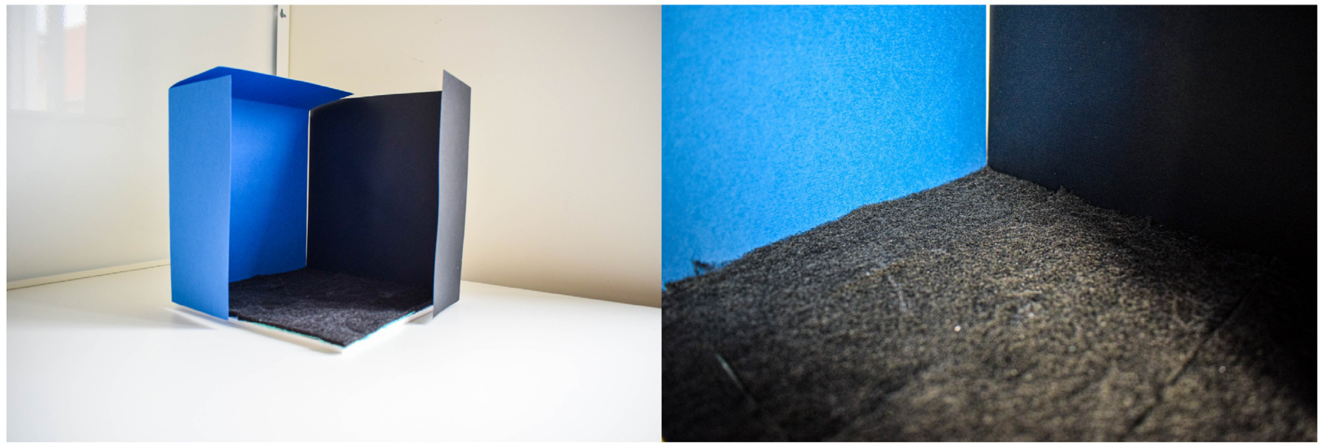
LOW COPING — HIGH COPING

Definition of Low Coping
The robot is not completely capable of managing a particular situation.

UNCERTAIN — CERTAIN

Definition of Uncertain
The robot is not completely capable of understanding the reasons and outcomes of a particular situation.

Visual Representation of Loniformi



Emotion Name:
PUFFALOPE

Low Arousal & Positive Valence
Sense of **pleasure**.
Appraisal: Being in the ideal conditions to execute its task.
Action Tendency: The compelling desire to 'stay calm and peaceful' in order to achieve its goal smoothly.
Physical Expression: Unnoticeable, soft texture, warm colours.
Feeling: Relax, Tolerant, Carefree, Disconnected.

APPRAISAL COMPONENT

INCONSISTENT — CONSISTENT

Definition of Consistent
The robot is experiencing its delivery journey the same way over time, particularly in a positive way.

OTHER — SELF

Definition of Self
The experience caused by the robot itself.

LOW COPING — HIGH COPING

Definition of High Coping
The robot is capable of managing a particular situation.

Visual Representation of Puffalope

Chapter 7

Validation

This chapter sets out the general aims for validating the two newly designed emotions. First, it provides an overview of the online survey process followed. Then it presents a summary of the impressions and thoughts of participants. To conclude, the chapter provides reflections based on the points of view from various interviewees.

> *Question addressed in this chapter is:*
> ***How will people perceive and react to the newly designed robot emotions?***
>
> *Method used:*
> ***Online survey, Reflexive Thematic Analysis***

"A novel examines not reality but existence. And existence is not what has occurred, existence is the realm of human possibilities, everything that man can become, everything he's capable of. Novelists draw up the map of existence by discovering this or that human possibility."

— Milan Kundera, The Art of the Novel

7.1 Introduction

This study aims to discover whether the unique robot emotions designed during this project can be distinguished from similar human emotions. Eight different scenarios were constructed in order to assess the feelings of Loniformi and Puffalope. In four of these scenarios, the robot experiences the feeling of Loniformi, while in three of them, it feels Puffalope. In the remaining video, the robot does not experience any emotion.

> ***Mostly, I was interested to shine light on the the questions of:***
>
> ***1. Can people differentiate these robot emotions from other similar human emotions?***
>
> ***2. Do people pick up on the qualities that together constitute the designed robot emotions?***

7.1.1 Third Perspective
How the emotion looks from outside

Five of the scenarios were recorded in the form of the third perspective with the robot Husky, please see Figure 2 for more detailed information. In two of these videos, the robot experiences Loniformi, and the other two videos, experience the feeling of Puffalope, and the robot does not experience any emotion in one of the third perspectives.

The first video is about the robot trying to find its route while two pedestrians walk in front of it very casually, while they are often standing still and hindering the robot from continuing the path. In this video, the robot feels Loniformi because it has the feeling that it might confront a barrier that will limit it from attaining its goal. Consequently, the robot tries to be cautious and prevent pedestrians. On the other hand, it is confused by the pedestrians' behaviour because they are moving inconsistently.

In the second video, two pedestrians pass by the robot without initiating any interactions. They do not limit the robot from doing its duty. Therefore the robot feels Puffalope because it appears at peace and safe being around these harmless people.

In the third video, two pedestrians superfluously interact with the robot. They do not initiate any action to harm the robot. However, they prevent it from progressing. For this reason, the robot feels Loniformi. The robot is distracted by pedestrians' erratic movements; still, it tries to be cautious about finding its place to continue doing its job without harming the pedestrians.

In the fourth video, the robot delivers a package to the end customer; the customer is satisfied with the service. Robot feels Puffalope at this moment because it has done its job successfully, and there is no redundant interaction that might prevent its job.

In the fifth video, the robot operates alone; there is no interaction, pressure or complexity. The robot is in its neutral state and does not experience any distinct emotion.

7.1.2 Third Perspective Virtual Reality
How the emotion looks from outside

Moreover, a video was recorded on the Virtual Reality platform, Tvori. In the Virtual Reality video, the robot experiences the feeling of Loniformi while navigating on a crowded sidewalk, please see Figure 3 for more detailed information. It requires attaining its way to move onward, and it struggles because there are many people and minimal space to drive.

7.1.3 First Perspective
How the emotion feels from inside

Two videos were recorded from the first perspective to show the participants what the robot experienced internally through the robot's eyes (Figure 3). In one of these videos, the robot experiences the feeling of Loniformi, and in the other, the feeling of Puffalope. Videos representing the first perspective are supported with additional sound effects to indicate the emotion more deeply.

In the first video, the robot drives along a very crowded street; people walk around fastly, and because of this crowd, the robot feels Loniformi. The robot attempts to be careful and limit any interaction as much as possible.

In the second first perspective video, the robot experiences Puffalope. There is nothing to disturb it, and it maintains its mission casually.

7.1.4 Mood Boards
Defining expressive qualities of the emotions

Two separate mood boards displaying the expressive qualities of these emotions were added to this validation survey (Figure 3 and Chapter 6). These mood boards aim to make the emotions more authentic and detailed by supporting various colour and texture compounds.

The mood board depicting the Loniformi applies dark colours and has a reserved form, and additionally, a scratchy surface is applied. Designating the feeling of Puffalope, the mood board uses soothing and calm colours, supported with soft textures.

The mood boards aim to analyse what kind of meanings the participants will derive from these visual representations.

7.2 Procedure

First, the participants are invited to watch a video of approximately 30 seconds. Afterwards, for qualitative feedback, an open-ended question was presented to get the individual opinions of the participants. This question was intended to let the participants describe what they saw in the video and find out what specific behaviours of the robot caught their attention.

After that, the participant, who described the robot's behaviour in their own opinion, was asked whether they thought that the robot had experienced emotion in this video they watched. As a final step, they were asked which emotion they thought was covered in this video, out of three pre-prepared definitions of three different emotions.

For this last question, the feeling of Loniformi was compared to the feeling of Boredom and Tiredness. The feeling of Puffalope was compared with the feeling of Calmness and Satisfaction. The reason for preferring these emotions is that they are in the same arousal and valence classification, and they are similar to each other in many ways (Figure 7.1).

For the options to the last question, descriptions of each emotion were given instead of their names. In this way, the participant would not know which emotion they chose, and they only differentiate the emotions from their definition of the action tendency. Interviews were conducted online using Google Survey. Each session took approximately half an hour.

7.2.1 Participants

40 participants took part in the study, provided they were 18 years of age or older. For the survey, participants` differentiated educational and cultural background was a critical aspect for inviting them for the final validation study. The selected participants could articulate, verbally or in certain more creative forms, the experience as it is lived and feel comfortable sharing personal and sometimes even intimate information about their lives and inner worlds. Before the session, participants were asked to fill in a consent form.

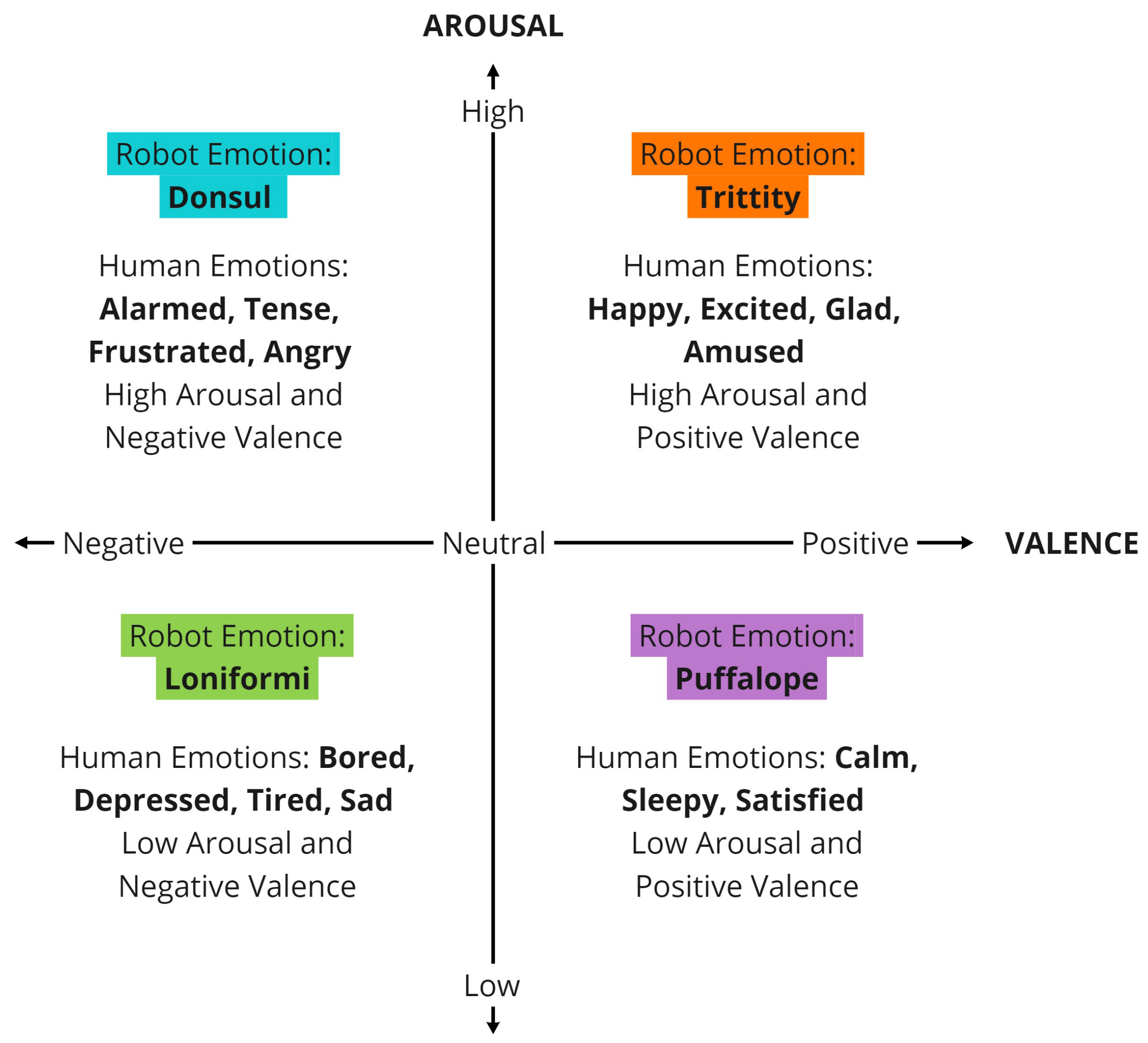


Figure 7.1: Valence-Arousal Space, some of its typical emotions and unique robot emotions placement.

VIDEO QR CODE	SCENARIO NUMBER	SCENARIO INFO	EMOTION EXPRESSED
	SCENARIO 01 	Third Person Perspective. The robot is trying to pass two pedestrians that walk in front of it. **No direct human-robot interaction.**	**LONIFORMI** Low Arousal and **Negative Valence** The fear of encountering obstacles that might make it difficult to execute one`s task.
	SCENARIO 02 	Third Person Perspective. Two pedestrians pass by the robot. **No direct human-robot interaction.**	**PUFFALOPE** Low Arousal and **Positive Valence** Being in the ideal conditions to execute its task.
	SCENARIO 03 	Third Person Perspective. Two pedestrians acting overly curious about the robot. **Direct human-robot interaction.**	**LONIFORMI** Low Arousal and **Negative Valence** The fear of encountering obstacles that might make it difficult to execute one`s task.
	SCENARIO 04 	Third Person Perspective. The robot delivering the parcel to the end customer. **Direct human-robot interaction.**	**PUFFALOPE** Low Arousal and **Positive Valence** Being in the ideal conditions to execute its task.
	SCENARIO 05 	Third Person Perspective. The robot is navigating on an empty path. **No direct human-robot interaction.**	**NO EMOTION HAS BEEN PRESENTED IN THIS VIDEO**

Figure 7.2: Detailed information of third perspective videos that have been recorded with the Husky platform for the final validation test. Scan the QR to watch the video.

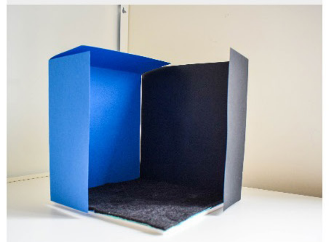
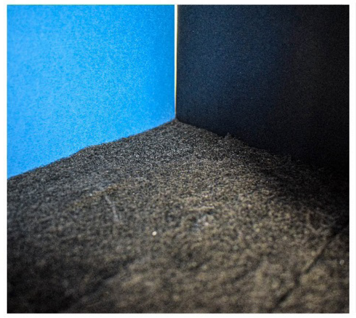
VIDEO QR CODE	SCENARIO NUMBER	SCENARIO INFO	EMOTION EXPRESSED
	SCENARIO 06 	First Person Perspective. The robot is navigating along a crowded sidewalk. **No direct human-robot interaction.**	**LONIFORMI** Low Arousal and **Negative Valence** The fear of encountering obstacles that might make it difficult to execute one`s task.
	SCENARIO 07 	First Person Perspective. The robot is navigating along an empty sidewalk. **No direct human-robot interaction.**	**PUFFALOPE** Low Arousal and **Positive Valence** Being in the ideal conditions to execute its task.
	SCENARIO 08 	Virtual Reality Third Person Perspective. The robot is navigating through a crowded sidewalk. **No direct human-robot interaction.**	**LONIFORMI** Low Arousal and **Negative Valence** The fear of encountering obstacles that might make it difficult to execute one`s task.
	MOODBOARD 01 		**LONIFORMI** Low Arousal and **Negative Valence** The fear of encountering obstacles that might make it difficult to execute one`s task.
	MOODBOARD 02 		**PUFFALOPE** Low Arousal and **Positive Valence** Being in the ideal conditions to execute its task.

Figure 7.3: Detailed information of first perspective videos, VR video and mood boards that have been created for the final validation test. Scan the QR to watch the video.

7.3 Data analyses

7.3.1 Introduction

In order to answer the second research question, transcripts were analyzed using Reflexive Thematic Analysis (Braun, V. & Clarke, V., 2006), which allows for identifying meaningful patterns in qualitative data (The University of Auckland, n.d.). To facilitate the process, Quirkos software was used (Quirkos), which allows for the coding and grouping of the qualitative results into topics. The analysis was carried out following the steps of the Thematic Analysis method:

1. Familiarizing
The collected transcripts were examined by reading several times.

2. Coding
Text fragments identified as necessary for the research were selected, and succinct labels (codes) were assigned, as shown in Figure 7.5. The process used an inductive approach where codes and topics are guided by the content of the data (The University of Auckland, n.d.).

3. Generating initial themes
The codes were examined for recurring patterns and themes and combined into groups with similar meanings (e.g., "Pleasure"), as shown in Figure 7.4. The resulting themes were compared to the dataset for relevance and edited if necessary.

4. Defining and naming themes
Each topic was assigned an informative name according to the scope.

5. Writing up
The analysis report was generated using Quirkos software can be found in Appendix.

7.3.2 Coding

The resulting clusters of the given statements and responses can be broadly categorised into the five themes for each emotion. The created categories for Loniformi are as follows; "Displeasure", "Distress", "Cautious", "Need for safety and security", and "Confused". And categories for Puffalope "Pleasure", "Carefree", "Calm", "Smooth Movement" and "Focused". The complete cluster overview of the clustering shown in Figure 7.4, and further information can be found in Appendix. In the following, I will summarise the main insight per category.

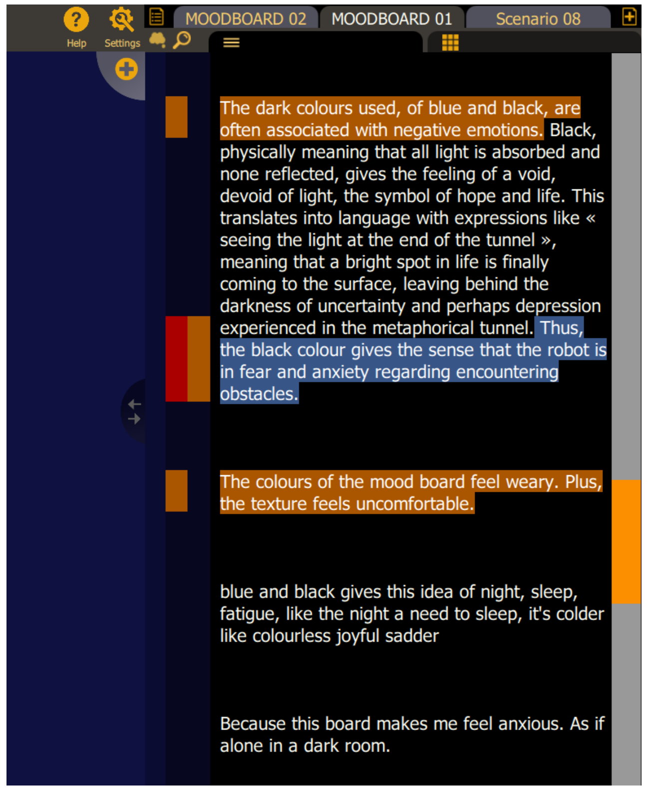


Figure 7.5: The coding process facilitated by using the Quirkos software.

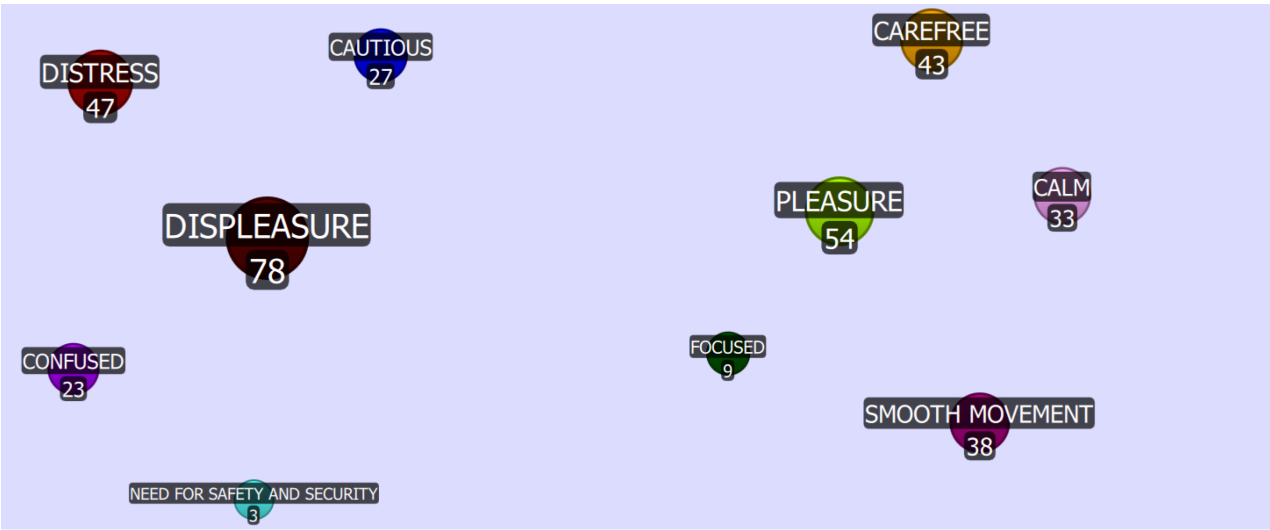


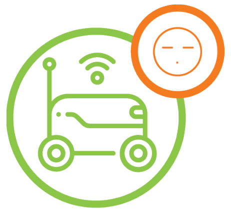
Figure 7.4: Clustering collected data in Quirkos software.

7.3.3 Clusters

To answer the second research question, **"Do people pick up on the qualities that together constitute the designed robot emotions?"** ten themes were defined in the analysis, each one representing a unique emotion. Orange icons represent keywords that characterise Puffalope, and blue ones outline the keywords that define Loniformi. This section describes the findings in detail.

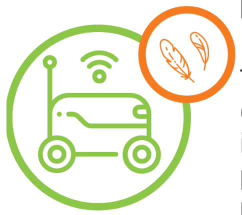
The sense of *'pleasure'*
The feeling of happiness or satisfaction. Those are positive feelings caused by positive experiences, mentioned 54 times by respondents.

The sense of *'displeasure'*
The feeling of unhappiness or annoyance. Those are negative feelings caused by negative experiences, mentioned 78 times by respondents.

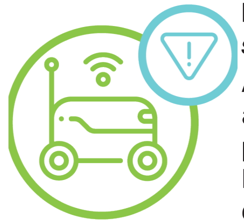


Being *'carefree'*
Free from anxiety or responsibility. Relax, tolerant, and disconnected. Mentioned 43 times by respondents.

Being *'distress'*
The robot is feeling worried, frustrated, hesitant about not being able to execute the task. Mentioned 47 times by respondents.



Experiencing *'smooth movements'*
The robot deals successfully with (a problem or difficulty). It is navigating in a way that is without problems. Mentioned 38 times by respondents.



Being *'cautious' about its surroundings and task*
An action of the robot is characterised by the desire to avoid potential problems or dangers. Mentioned 27 times by respondents.

The feeling of *'calm'*
The robot is not showing or feeling nervousness, anger, or other strong negative emotions. Tranquillity. Mentioned 33 times by respondents.

Being *'confused'*
The robot is unsure about what to do and trying different ways to execute its task—lacking order and difficult to understand. Mentioned 23 times by respondents.

Being completely *'focused'* on its goal
The robot is directing a great deal of attention, interest, or activity towards a particular aim. Mentioned 9 times by respondents.

The need for *'safety and security'*
A robot's tendency to hide, self-protect, and be reserved. Mentioned 3 times by respondents.

SCENARIO NUMBER	SCENARIO INFO	EMOTION EXPRESSED	SURVEY RESULTS
SCENARIO 01 	Third Person Perspective. The robot is trying to pass two pedestrians that walk in front of it. **No direct human-robot interaction.**	LONIFORMI Low Arousal and **Negative Valence** The fear of encountering obstacles that might make it difficult to execute one`s task.	Do you think did this robot experience an emotion? YES: %52.5 NO: %47.5 Which emotion? Loniformi: % 87.5 Tired: % 5 Bored: % 7.5
SCENARIO 02 	Third Person Perspective. Two pedestrians pass by the robot. **No direct human-robot interaction.**	PUFFALOPE Low Arousal and **Positive Valence** Being in the ideal conditions to execute its task.	Do you think did this robot experience an emotion? YES: %30 NO: %70 Which emotion? Puffalope: % 62.5 Calm: % 30 Satisfied: % 7.5
SCENARIO 03 	Third Person Perspective. Two pedestrians acting overly curious about the robot. **Direct human-robot interaction.**	LONIFORMI Low Arousal and **Negative Valence** The fear of encountering obstacles that might make it difficult to execute one`s task.	Do you think did this robot experience an emotion? YES: %70 NO: %30 Which emotion? Loniformi: % 75 Tired: % 5 Bored: % 20
SCENARIO 04 	Third Person Perspective. The robot delivering the parcel to the end customer. **Direct human-robot interaction.**	PUFFALOPE Low Arousal and **Positive Valence** Being in the ideal conditions to execute its task.	Do you think did this robot experience an emotion? YES: %45 NO: %55 Which emotion? Puffalope: % 55 Calm: % 5 Satisfied: % 40
SCENARIO 05 	Third Person Perspective. The robot is navigating on an empty path. **No direct human-robot interaction.**	NO EMOTION HAS BEEN PRESENTED IN THIS VIDEO	Do you think did this robot experience an emotion? YES: %32.5 NO: %67.5 Which emotion? Puffalope: % 40 Calm: % 52.5 Satisfied: % 7.5

Figure 7.6: The figure represents the quantitative results of the survey to answer the first research question.

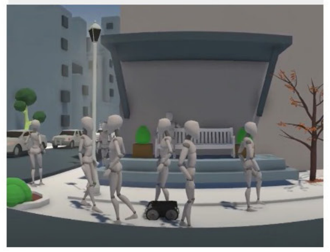
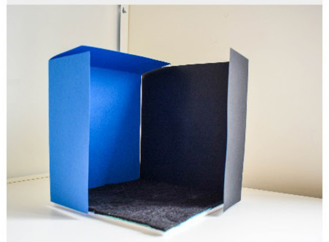
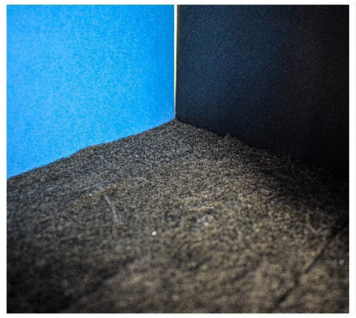
SCENARIO NUMBER	SCENARIO INFO	EMOTION EXPRESSED	SURVEY RESULTS
SCENARIO 06 	First Person Perspective. The robot is navigating along a crowded sidewalk. **No direct human-robot interaction.**	LONIFORMI Low Arousal and **Negative Valence** The fear of encountering obstacles that might make it difficult to execute one`s task.	Do you think did this robot experience an emotion? YES: %60 NO: %40 Which emotion? Loniformi: % 87.5 Tired: % 2.5 Bored: % 10
SCENARIO 07 	First Person Perspective. The robot is navigating along an empty sidewalk. **No direct human-robot interaction.**	PUFFALOPE Low Arousal and **Positive Valence** Being in the ideal conditions to execute its task.	Do you think did this robot experience an emotion? YES: %57.5 NO: %42.5 Which emotion? Puffalope: % 37.5 Calm: % 37.5 Satisfied: % 25
SCENARIO 08 	Virtual Reality Third Person Perspective. The robot is navigating through a crowded sidewalk. **No direct human-robot interaction.**	LONIFORMI Low Arousal and **Negative Valence** The fear of encountering obstacles that might make it difficult to execute one`s task.	Do you think did this robot experience an emotion? YES: %55 NO: %45 Which emotion? Loniformi: % 85 Tired: % 10 Bored: % 5
MOODBOARD 01 		LONIFORMI Low Arousal and **Negative Valence** The fear of encountering obstacles that might make it difficult to execute one`s task.	Which of these three emotions do you think the mood board represent? Loniformi: % 40 Tired: % 30 Bored: % 30
MOODBOARD 02 		PUFFALOPE Low Arousal and **Positive Valence** Being in the ideal conditions to execute its task.	Which of these three emotions do you think the mood board represent? Puffalope: % 20 Calm: % 47.5 Satisfied: % 32.5

Figure 7.7: The figure represents the quantitative results of the survey to answer the first research question.

7.4 Synthesis of Loniformi

7.4.1 Third Perspective

Two scenarios from a third-person perspective were performed while the robot is experiencing Loniformi. Inconsistent behaviours of two pedestrians trigger for the robot to feel Loniformi.

The survey may conclude that the respondents perceived that the robot was disturbed by the behaviour of these two pedestrians, as they mentioned in their definition of remarkable elements of the scenario.

The participants stated in their sentences that the robot's experiences in these videos were distress, frustration and confusion. As taking into consideration that the fear of encountering an obstacle is the cause of the feeling of Ioniformi, a conclusion can be drawn as the participants' views confirm the action tendencies of Loniformi has been reflected in the movements of the robot.

*" It seems like it's constantly trying to execute its task but is 'bothered' by these two girls. I imagine that the robot would think, 'Could you please leave me alone? I'm trying to deliver something.' Also, sometimes it would think it's free and tries to move only to be stopped again. **It must be annoying.** "* (A participant explains what s/he thinks the robot is experiencing in the video.)

*" Due to the jerky movement, the robot seemed rushed. It wanted to continue, but it couldn't. Interestingly, while watching this video, **I thought that the robot really has emotions and is extremely annoyed by the girls' behaviour.** "* (A participant explains what s/he thinks the robot is experiencing in the video.)

Further, in one of the videos, pedestrians walk leisurely and unsteadily just ahead of the robot. However, they are not in direct contact with the robot. 52.5% of the survey participants determined that the robot experienced emotion in the first video, and 87.5% reported it as Loniformi.

In the other video, pedestrians interact with the robot and prevent the robot from fulfilling its mission. 70% of the participants claimed that the robot would feel an emotion in this situation (Figure 9), and 75% estimated that this emotion would be Loniformi (Figure 7.8).

The outcome I seized from this data is that the participants clarified that in a situation with unnecessary and direct human-robot interaction, the probability of the robot experiencing emotion is higher than an indirect human-robot interaction.

*" The robot is probably **experiencing frustration and stress** by being interrupted, touched and blocked from its path. "* (A participant explains what s/he thinks the robot is experiencing in the video.)

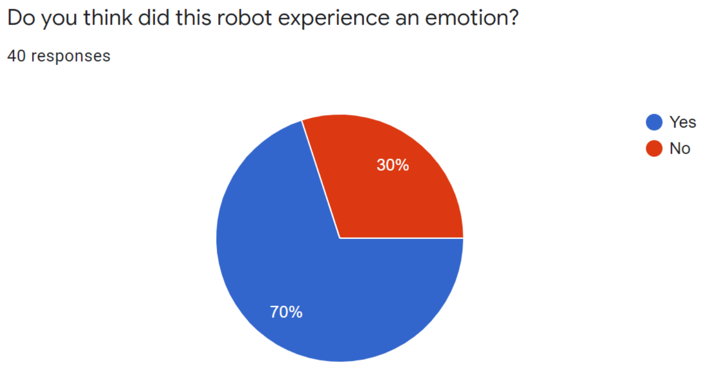


Figure 7.9: The pie chart represents participants responses to scenario 3.

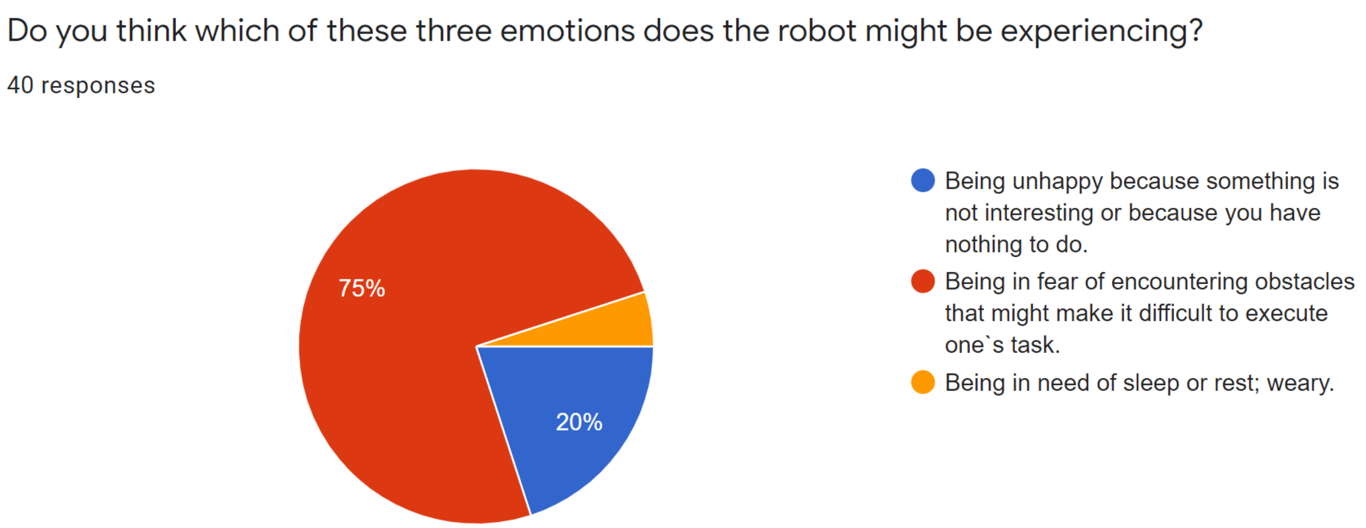


Figure 7.8: The pie chart represents participants responses to scenario 3. The red colour represents Loniformi, and the blue colour represents Bored, and yellow represents Tired.

7.4.2 First Perspective

One scenario from a first-person perspective was performed while the robot is experiencing Loniformi. A group of crowded people who walk on the sidewalk trigger the robot to feel Loniformi.

The respondents mentioned that the density of the people stressed the robot. Besides, they stated in their sentences that the robot's experiences in these videos were distress, fear and anxiety.

*" The robot is from my point of view **stressed by the density of people** on the sidewalk. It moves but seems preoccupied with the situation to be analysed from all sides. His gaze is drawn from all sides around him so as not to hit anyone and not to be crushed. "* (A participant explains what s/he thinks the robot is experiencing in the video.)

Further, in the video, pedestrians walk around the robot, some fast, some of them slower. The video included sound effects in order to raise the intensity of the emotion. However, these people are not in direct contact with the robot. 60% of the survey participants determined that the robot experienced emotion in the first video (Figure 7.11), and 87.5% reported it as Loniformi (Figure 7.10).

The outcome I gained from this data is that the participants clarified that in a situation with a robot passing through a crowded street, the robot might feel an emotion. Precisely a negative emotion because of the fact that this crowd might block the robot from achieving its mission.

*" The robot experiences **a sense of stress and fear.** However, the robot is designed to travel on sidewalks and such paths to deliver packages and fulfill its purpose, meaning It is made to interact with obstacles and deal with such environments. "* (A participant explains what s/he thinks the robot is experiencing in the video.)

*" When I empathise, maybe it sounds crazy. I felt that I was in a public place where no one saw me. Or this feeling that people are not aware of street animals and people who live in the street. I don't know; maybe I'm so sensitive, but while the robot was waiting and trying to pass, it made me a little **upset** even though I know that it is a machine, not a human. "* (A participant explains what s/he thinks the robot is experiencing in the video.)

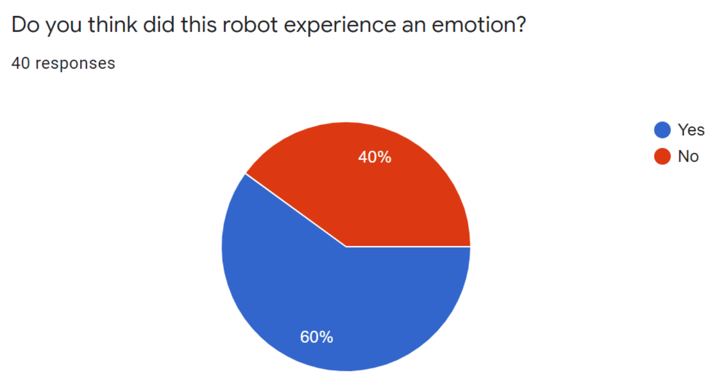


Figure 7.11: The pie chart represents participants responses to scenario 6.

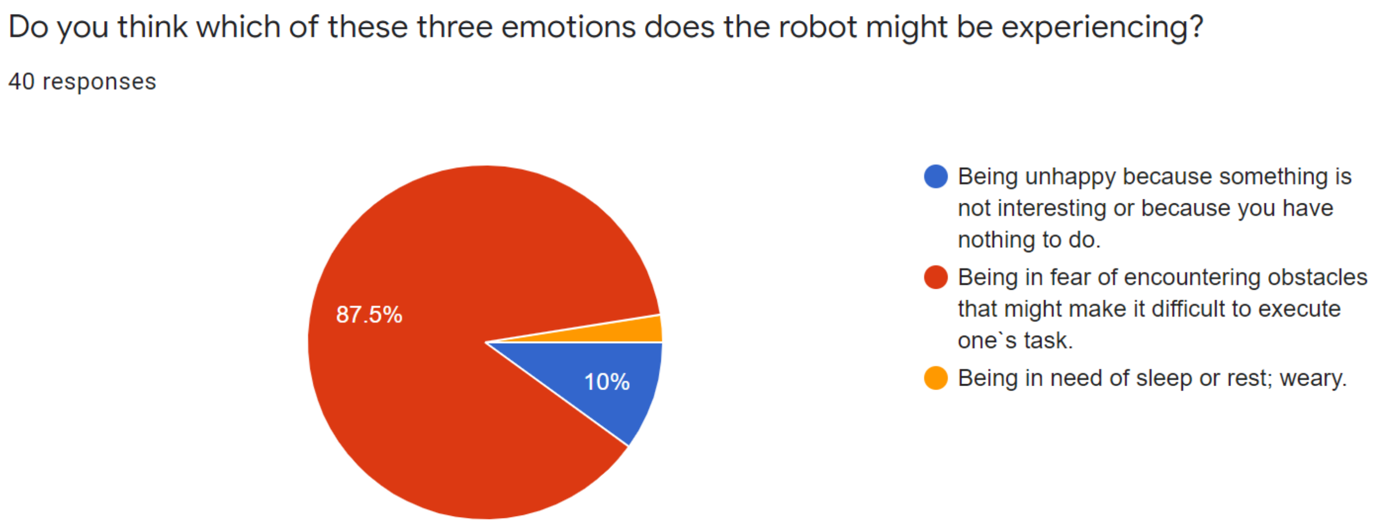


Figure 7.10: The pie chart represents participants responses to scenario 6. The red colour represents Loniformi, and the blue colour represents Bored, and yellow represents Tired.

7.5 Synthesis of Puffalope

7.5.1 Third Perspective

Two scenarios from a third-person perspective were displayed while the robot is experiencing Puffalope. The autonomous delivery robot is in the ideal conditions to execute the task, which triggers Puffalope.

The survey results present that the respondents perceived that the robot had not encountered any obstruction in these videos; therefore, there was no need for the robot to experience any emotions. The participants stated in their sentences that the robot's experiences in these videos were happiness, calm and satisfaction.

*" **Peace,** the robot still pays attention to the pedestrians, but they let the robot do its job. So I think **the robot is happy and determined to deliver the packages but still aware of the pedestrians.** "* (A participant explains what s/he thinks the robot is experiencing in the video.)

*" **Satisfaction** after successful delivery and completion of its assigned task. "* (A participant explains what s/he thinks the robot is experiencing in the video.)

*" The robot is not afraid of humans walking by. It continues, and it's not bothered by people walking around it. **It seems relaxed.** "* (A participant explains what s/he thinks the robot is experiencing in the video.)

Further, in one of the videos, two pedestrians pass by calmly and do not initiate any interactions with the robot. 70 % of the survey participants mentioned that the robot does not experience an emotion in the first video (Figure 7.13), and additionally, 62.5 % of them reported that the robot is experiencing Puffalope. Moreover, %30 of the responders reported that the robot is experiencing Calm.

In the other video, the robot delivers a package to the end customer. After the delivery, the customer shows his satisfaction with the service. The video represents a positive human-robot interaction. 55 % of the participants claimed that the robot would not feel an emotion in this situation, and 55% estimated that the robot is experiencing Puffalope. Furthermore, %40 of the participants thought the robot was experiencing Satisfaction (Figure 7.12).

*" I do not recognise any emotion in this robot. It is just performing its task. The fact that it moves linearly and there is no change of events across the video makes me think that the robot might just be in delivery mode or whatever other mode that just lets **it focus on the task it has and executes it.** "* (A participant explains what s/he thinks the robot is experiencing in the video.)

*"I think the robot is not feeling anything. **Solely focused on its task and getting on to finish that.**"* (A participant explains what s/he thinks the robot is experiencing in the video.)

*"The robot feels that **not being in a dangerous** situation is advancing without concern towards his direction. "* (A participant explains what s/he thinks the robot is experiencing in the video.)

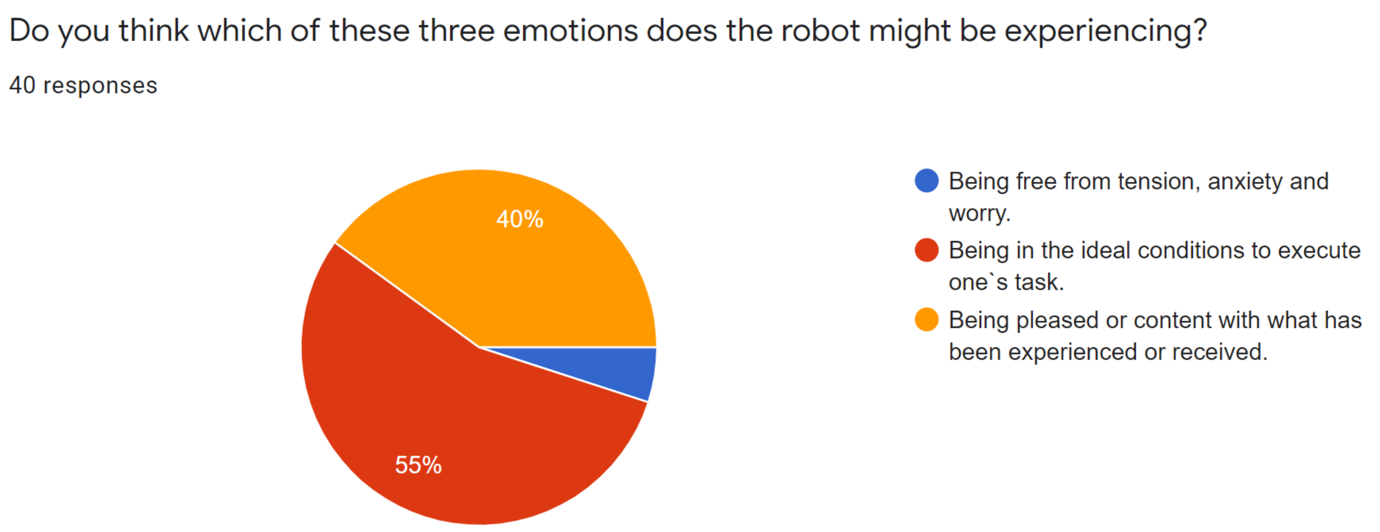


Figure 7.12: The pie chart represents participants responses to scenario 4. The red colour represents Puffalope and the blue colour represents Calm, and yellow represents Satisfied.

From the survey results, it can be concluded that people believe the robot does not experience emotion when the robot can ideally obtain its task. On the one hand, feeling Calm and Satisfaction have been voted very closely to Puffalope. That means Puffalope can be confused with Calm and Satisfaction. Another critical point is that when the robot interacts with a person, a substantial number of people switch their opinion of the emotion, as they think the robot is experiencing an emotion. From this, it can be concluded that human-robot interactions can trigger emotion for the robot, and this situation will be more believable for people's perception.

*" **The robot is on the mission-focused** "* (A participant explains what s/he thinks the robot is experiencing in the video.)

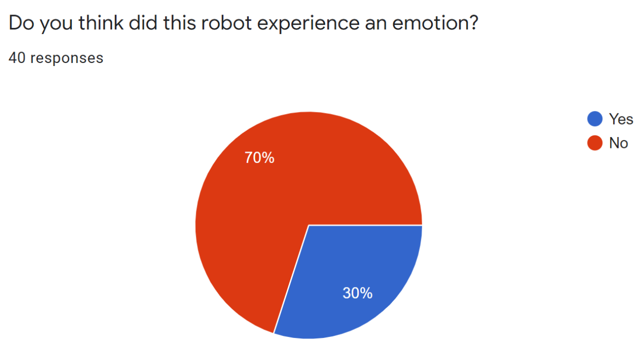


Figure 7.13: The pie chart represents participants responses to scenario 2.

7.5.2 First Perspective

One scenario from a first-person perspective was performed while the robot is experiencing Puffalope. In this video, the robot is navigating along an empty sidewalk. The video was supported with additional sound effects in order to intensify the emotion.

The participants mentioned in their responses that the robot experiences relaxation, calmness and peace.

This video does not contain any human-robot interaction. 57.5% of the survey participants determined that the robot experienced emotion in the video, however, the sound effects of the video might lead participants to think there is an emotion being experienced. And 37.5% reported it as Puffalope, 37.5% as Calm, and 25% as Satisfaction (Figure 7.14).

*" This robot seemed like it was having a good time. **It was very chill and peaceful**. Definitely not hurried. "* (A participant explains what s/he thinks the robot is experiencing in the video.)

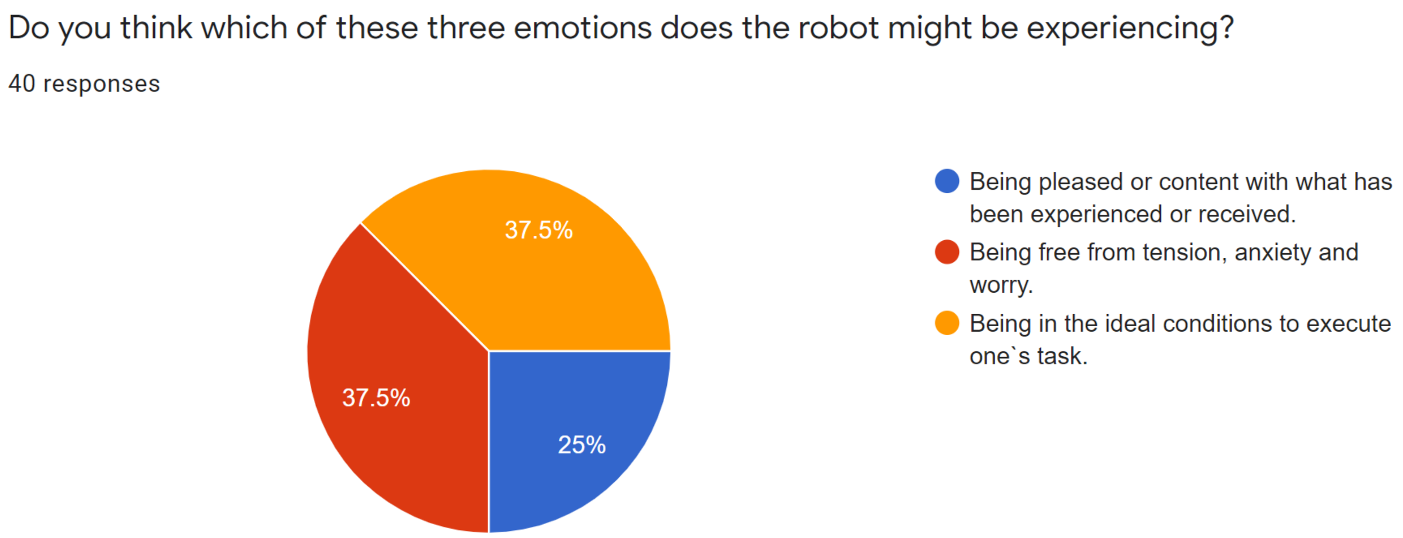


Figure 7.14: The pie chart represents participants responses to scenario 7. The red colour represents Calm and the blue colour represents Satisfied, and yellow represents Puffalope.

7.6 Conclusions

7.6.1 Introduction

User test results revealed data on preferred concepts and provided quantitative as well as qualitative data on the perceptions of people of unique robot emotions. In this section, the results are discussed, and conclusions are drawn to determine the results of the emotions.

7.6.2 Limitations

The validation of the final concept was, among other things, limited by COVID-19 restrictions, available technology, resources, and time. Therefore, the test relies on the pre-recorded visual and auditory stimuli only; participants might have had insufficient sensory input to assess the concepts thoroughly. The diversity of testable participants, whose feedback and responses might not be representable for the entire society.

While providing a closer representation of the envisioned experience, the added background music also influenced the purely visual assessment and might have altered the participant's assessment of the presented visuals. Besides, minimal movement of the interaction prototypes might have reduced the accuracy of the assessment.

Lastly, no further indication of the project's context and its link to emotions and robotics were given for this testing. As accommodating the final design, this context knowledge might also influence the participant's perception of the experience. Because this survey was conducted online via Google Survey, the lack of direct supervision by the researcher may have resulted in the participants not performing the test correctly.

7.6.3 Reflections

The survey results show that people mostly think the robot is experiencing an emotion if there is an obstacle for the delivery robot to execute its task, or in other words, the robot has a negative experience, a sense of displeasure.

Besides, if there is a negative human-robot interaction, the percentage of people who think the robot is experiencing an emotion has scored the highest.

Two third-perspectives, one first-perspective and one virtual reality video, were shown to participants while the robot expressed Loniformi. For each video, more than 50% of participants choose the robot as experiencing an emotion. From the Loniformi videos, people could easily differentiate Loniformi from the other two emotions: tired and bored. Loniformi has been voted more than 75%, meaning that Loniformi was distinguished from Tired and Bored. For describing the state of Loniformi, participants used words similar to hesitation, frustration, worry, and stress.

On the other hand, one of the leading behaviours Loniformi aims to cause to the robot is seeking safety and security. However, this behaviour was not sharply perceived by the research participants.

Two third-perspective videos and one first-perspective video were shown to participants while the robot expressed Puffalope. More than 55% of the participants chose the robot is not experiencing emotion. Even though a higher percentage of participants voted for Puffalope, a considerable number of people also voted for Calm and Satisfied. So, therefore, a conclusion derived from that was that it was complicated for participants to identify Puffalope from two other resembling emotions: Calm and Satisfied. Respondents of the survey described Puffalope as being calm, carefree, happy and focusing on executing its task.

Additionally, there was another third perspective video in which the robot is not experiencing any emotion. Besides, no human-robot interaction was presented in this video, either an obstacle for the robot to execute its task. In this video, 67.5% of participants thought that the robot is not experiencing an emotion. 52.5% of the participants choose that the robot would feel calm if there is an emotion experienced.

"I think the robot is just tense free. Not an emotional insight. " (A participant explains what s/he thinks the robot is experiencing in the video, no emotion presented in that video.)

Takeaways from this chapter

- *People mostly think the robot is experiencing an emotion if there is an obstacle for the delivery robot to execute its task, or in other words, the robot has a negative experience, a sense of displeasure.*
- *Participants responses clarified that in a situation with unnecessary and direct human-robot interaction, the probability of the robot experiencing an emotion is higher than an indirect human-robot interaction.*
- *It can be concluded that human-robot interactions can trigger emotion for the robot, and it will be believable for people's perception.*
- *Loniformi was distinguished from Tired and Bored. For describing the state of Loniformi, participants used words similar to hesitation, frustration, worry, and stress.*
- *Puffalope could not sharply be distinguished from two other resembling emotions: Calm and Satisfied. Respondents of the survey described Puffalope as being calm, carefree, happy and focusing on executing its task.*

Chapter 8

Project Conclusion

While the conclusive parts of the previous chapter discussed the insights and recommendations for the final design of the unique emotions, this section will give a summary of the project and its outcomes. The knowledge contributions towards society, design, and the field of Robotics and Emotions are discussed, and opportunities for future work are given. A personal reflection on my learnings during this project will complete this report.

8.1 Project Summary & Outcome

New Realities

This graduation project focuses on designing unique emotions for autonomous delivery robots in order to assist them in expressing their inner thoughts and positioning themselves as separate individuals in the social environment. This project is about creating meaningful experiences, adding to what life could be, challenging what it is, and providing alternatives that loosen the ties reality has on our ability to dream. Ultimately, it can be seen as a catalyst for dreaming of different realities and novel visions.

The popularity of autonomous delivery robots is increasing rapidly today. As a result of research that has been conducted through this project, it is possible to state that we will see them more often on the streets in the near future. They will have to co-exist with human beings on the streets. However, people and delivery robots are very different entities from each other. They have different needs, values and concerns, and despite all that, both sides need to express themselves if coexistence happens.

One of the significant steps taken in this project was the interactive role-playing game conducted with 17 people from various cultural backgrounds. The game aimed to understand the world view of the delivery robots, and this game design fostered creative thinking, provoked different perspectives and contradictory conversations.

Throughout the interviews, the unique needs of the robot, in which situations these needs might have been evoked and what kind of behaviours it might exhibit for the robot have been discussed explicitly. As a result of these conversations, it was concluded that the fundamental need of the robot is to deliver the package to the customer safely, securely and on time. Based on this decision, four different unique emotions were developed to enable the robot to express its needs.

Designing these unique emotions is an act of speculation about future scenarios rather than solving today's problems. Speculating through design allowed this project to develop alternative social imaginaries that open new perspectives on robot's challenges.

The proposed four unique emotions are called Donsul, Trittity, Loniformi and Puffalope. These emotions have consequences on the robot's inner feelings and actions. Different methods have been undertaken in order to assign these emotions to the *'personality'* of the robot. First perspective videos were created to represent the inner feelings of the robot, and the third perspective videos were created to convey the robot's behavioural expressions while under the influence of these emotions.

As the final stage of this project, these videos were shown to 40 people. An online survey was conducted to examine whether people could distinguish these unique robot emotions from other emotions and observe which qualities they grabbed from the robot's action tendencies.

Loniformi and Puffalope have been used for this questionnaire. Loniformi is designed as low arousal and negative valence, and Puffalope is an emotion exhibiting low arousal and positive valence. Both of them are calm emotions; however, Loniformi represents a sense of displeasure, and Puffalope conveys a sense of pleasure.

The validation results show that people assumed that the robot is more likely to experience emotion when it experiences an adverse event, such as a barrier to executing its task. Notably, if humans deliberately caused a struggle for the robot, many respondents considered that the robot experiences a negative emotion, representing a sense of displeasure.

The idea of the design of unique emotions is to propose, suggest, and offer something different. It is about sketching out these possibilities. Although these proposal designs of unique emotions are drawn from rigorous analysis and thorough research, they carry imaginative, improbable, and provocative qualities.

This graduation project is closer to literature than social science, emphasises imagination over practicality, and asks questions rather than provides answers. The project's value is not what it achieves or does but what it is and how it makes people feel, especially if it encourages people to question everydayness in an imaginative, troubling, and thoughtful way and how things could be different. **This project does not offer a solution or a "better" way; it presents just another way.**

8.2 Answers to Research Questions

1. Discover;
What are the specific concerns and needs of autonomous delivery robots on sidewalks?

The literature research described in Chapter 3 and the interactive role-playing game explained in Chapter 4 guided me to find autonomous delivery robots' unique needs and concerns. Autonomous delivery robots are striving to deliver the packages to the end customer safely and on time. The other needs, such as avoiding undesirable human-robot interaction throughout the sidewalks, or needing to claim their particular spaces in the urban environments, are sub needs that ultimately strengthen their fundamental need. This outcome allowed the scope of this thesis to the design of unique emotions for robots.

2. Define;
What is the specific appraisal pattern of the new emotion or the set of emotions that can fit into delivery robots` concerns?

Chapter 6 presents the appraisal pattern of the four unique emotions designed for autonomous delivery robots.

'Donsul' is a sense of displeasure, and it has high arousal. The appraisal pattern of Donsul is that it is caused by **being purposely prevented from successfully achieving the robot's mission.**

'Trittity' is a sense of pleasure, and it has high arousal. The appraisal pattern of Trittity is that it is caused by **being fortunate to have executed its mission exceptionally thanks to external conditions.**

'Loniformi' is a sense of displeasure, and it has low arousal. The appraisal pattern of Loniformi is caused by **the fear of encountering obstacles that might make it challenging to execute the robot's task.**

Furthermore, **'Puffalope'** is a sense of pleasure, and it has low arousal. The appraisal pattern of Puffalope is caused by **being in the ideal conditions for executing its task.**

3. Develop;
How can a new emotion be designed into an autonomous delivery robot?

Chapter 4 explores different methods and approaches to design these emotions into autonomous delivery robots. Emotions have an impact on the movements of the robots in the four different aspects.

1. Pace: The rate of the speed at which movements occur.

2. Frequency: The repeating of the movement.

3. Occupation of the space: How much space on the sidewalk does the robot use.

4. Duration: How long a movement or sequence of movements continues.

Additionally, each emotion has a visual representation of its own, which means that in further research, these expressive qualities can be implemented into the robot's embodiment design.

4. Deliver;
How will people and society react to this emotion?

Eventually, Chapter 7 answers the final research question. As for so many participants of the validation test mentioned in their responses, they have not expected the robot to experience an emotion. However, the robot's behaviours in the test videos have made them think that the robot might be experiencing an emotion.

Moreover, among 40 participants, 75% of them perceived that the robot is experiencing an emotion when there is a struggle for the robot to execute its task. The survey results show that people mostly think the robot is experiencing an emotion if there is an obstacle for the delivery robot to execute its task, or in other words, the robot has a negative experience, a sense of displeasure. Besides, if there is a negative human-robot interaction, the percentage of people who think the robot is experiencing an emotion has scored the highest.

8.3 Contribution and Future Work

Contribution on emotion domain

The first stage of this project aimed to research whether a unique emotion can be designed or not. Autonomous delivery robots offer a perfect research domain because they can be highly autonomous and have to coexist with humans in urban environments. Another noteworthy reason for utilising these robots for designing unique emotions is that they do not need to interact directly with humans. However, since they will use the same space, these robots should communicate their needs. Emotions are an essential element of communication.

As one of the results of literature research on emotions, we can state that emotions arise from needs, and since the needs of autonomous robots are different from humans, it is possible to design distinctive emotions suitable for them to express their unique needs.

Contribution on robotics domain

The second phase of this project has experimented with how to integrate these newly designed emotions into robots. The emotions that people experience affect how their internal feelings and behaviour can cause some changes in their body, such as sweating.

Based on these outcomes, it was concluded that robots' emotions could cause internal, behavioural and physical transformations. Even if the robot's inner feelings cannot be recognisable from the outside, it can affect the decision mechanism of the robot itself. For instance, a robot 'feels' that it is in a threatening condition will experience Loniformi, and Loniformi can encourage the robot to defend itself from these threats.

Further investigation on how people will behave

On the other hand, the changes that emotions cause on the robot's behaviour are easier to understand from the outside and can affect humans' attitudes towards the robot. For example, a pedestrian walking unrushed in front of the robot may start walking faster or blocking the robot's path when it notices that the robot is disturbed by his slow walking pace. However, this hypothesis requires obtaining further investigation in the future. One of the outcomes of this project concludes that people are more likely to believe that robots experience negative emotions, but this research has not made any inferences about whether people will change their attitudes towards the robots' if they recognise it has emotions.

Further investigation on visually expressive qualities

Additionally, this project has proposed visual mood boards about how the robot appearance can change while experiencing these newly designed emotions. Nonetheless, the physical design of the robot's appearance for these emotions requires further work. For example, it is given that a robot that experiences the proposed Loniformi displays black and dark blue colours on it. How the robot will transform physically can be developed using 2D or 3D design programs.

8.4 Personal Reflection

What a 'unique' adventure!

The last two and a half years of my life at TU Delft have been a tremendous personal and career development journey. Regarding this journey, I would like to express my thoughts about, specifically, the final stage of my master studies.

Looking back on my graduation project process, I was initially somewhat apprehensive about exploring an entirely new and abstract topic that did not have a lot of prior research or projects on. From the beginning of the project, I knew that my deep dive into the two domains of emotions and robotics, both of which I knew very little and have a huge interest about, would be challenging and connected to much uncertainty, and walking the line between research and design was not always easy.

Nevertheless, it was an intriguing process of getting into the shoes of autonomous delivery robots, and manifesting the world from their position in society has taught me a lot and widened my perspective of the speculative future scenarios. All the things that did not make it into this report, it feels somewhat surreal how many experiences and learnings I collected on the way. It was a challenging journey with many moments of struggling, but I can also proudly say that I still achieved most of what I set out to do.

Unfortunately, COVID-19 did not provide the best circumstances. The exchange with colleagues and friends that would be common in the design domain, whether working together or having a cup of coffee at the faculty, was often very lacking and made me realize how vital this input is. Luckily some of this exchange could take place online or with close friends, which kept me inspired and motivated.

Noting my designing process, I can often get indecisive or fearful of missing out on things or details. This also includes a very high expectation from myself in delivering and pushing for more in little time. I tried to control this personal obsession a little more in the project journey. That involved letting go of some ideas and articulating my thoughts in a more precise and straightforward approach. This, of course, was only possible thanks to my inspiring supervisors, who were very positive throughout the different design stages of my project and did not in the slightest way add any mental stress to me. I am more than lucky to have such strong supervisors behind me.

My design process and the outcome were undoubtedly influenced by the technical challenges I faced on the way, as they forced me to readjust or divert energy from further working on the conceptual part. Even so, I had hoped to do some more physical prototyping, but creating the theoretical background of the unique emotions themselves consumed a massive amount of time because of the complexity of the topic itself. Therefore, I see it as a future opportunity to implement these four unique emotions Donsul, Loniformi, Trittity and Puffalope, into the future of autonomous delivery robots more extensively.

At the end of this project, I realize I only scratched the tip of the iceberg, with so much more to explore. Nevertheless, I see this not as a demotivating realization but as the rather exciting prospect of future exploration. As an eventual result of this delightful project, I am ambitiously looking forward to being a part of the future of designing emotions for the robotics empire.

Melek Akan.

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