DOCTORAL THESIS

Title	On the relationship between people, objects, & interactive technologies: Transforming digital & physical experiences through the process of Realizing Empathy
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DEDICATION

I want to dedicate this thesis book to my family, my husband Matthew Pellicane and my future son. You are my constant inspiration and motivation.

"Beauty lies in the details, in the appreciation of the small moments in between that make you smile, connect, remember, and how you see something come to life with you as a witness".

Extract from conversation with fellow Seamless Interaction friends

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This thesis might have begun in 2015, but its history started 10 years prior at Rhode Island School of Design. During my college years, I was the student that preferred to understand and research people and their needs to decide what type of product I could design for them rather than follow the traditional teaching guidelines. Design research became my passion. I thank my RISD mentors, Soojung Ham & Khipra Nichols, and my classmates, Seung Chan Lim (a related work author in this thesis), Stephanie Castilla, and Matthew Hall, who during this time fostered this curiosity within my Industrial Design degree. With the seed of this curiosity, I embarked on to Barcelona to pursue two master's degrees related to research for Design and Innovation with a focus on Interactive experiences first at Elisava and then at La Salle. In these environments the curiosity flourished into a career full of experiments, multidisciplinary collaborations, an entrepreneurial venture, and creative exhibitions. I thank the mentors and classmates during this time, in particular Jorge Rodriguez and Daniel Zentgraf from Design Thinkers Group Spain, Emiliano Labrador and David Miralles from GTM La Salle, where the result from these ventures led to pursue a Doctorate Thesis at La Salle- Ramon Llull University.

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ABSTRACT

How people engage with their surroundings, whether physical or digital, becomes increasingly complex and rapid, making the user's relationship with their objects and digital tools, at times, extreme and short-lived. Yet, there is still meaning in ownership of objects and interactive technological objects, they are tokens of reflection and representation to others and their role in society. The key to sustaining a relationship and sense of meaning with these objects lies in the design and intention of the interactive experience created. Inspired by disciplines of psychology, design, Human-computer interaction, and business modeling, this thesis explored, analyzed, created, and tested theoretical foundations on Empathy and the concept of initiating a long-term relationship between people and their interactive technologies.

To that end, the thesis book was managed in 4 main stages: (1) presenting a deeper dive into bibliographic references within HCI and the role of both design and psychology in the attempt to tackle questions like: "How can we build potential long-term relationships between people and their smart objects?" (2) Collect and adopt from related works that helped build the main contributions of the thesis book, (3) Create an interaction model between humans and their technology that lent itself for long-term engagement, and (4) a case study that implemented and instantiated the model designed.

After mapping the HCI bibliographical works in the first phase, a gap was revealed indicative of the main concerns expressed: a lack of connection between theory and design practice as well as a lack in the topic of Empathy. The result makes many of the models of interaction with empathetic and affective intention unsupported between each other. This has led us to the second phase of the thesis where we leveraged references across multiple disciplines to survey what empathy is, how it is implemented, perceived and evolved toward the goal of long-term relationship, as a focal point toward the main thesis contributions.

After an exhaustive gathering and analysis of the work around Empathy, we entered the third phase where we present the proposed theoretical model of interaction with the potential for long-term engagement named the Process of Realizing Empathy (RE). Rather than attempting to further define empathy, this proposal is about offering a different perspective to empathy that visualizes its scope as a process influenced by dialogue and collaborative models with the goal to reach meaning between the actors involved.

With a clear model in place and a strong theoretical foundation, the final phase of the thesis looked to test the proposed model with the goal of observing if the model can provoke its indicators of Affective Attachment and Trust between a person and their technological object. In the case of this thesis work, we had the opportunity to work with social robots as our "other actor" to design the tests for the model. This testbed meant to capture the indicators of early empathy realization between a human and a robot encompassing affective attachment, trust, expectation regulation, and reflecting on the other's perspective within a set of collaborative strategies. We hypothesized that an active collaboration strategy is conducive to a more meaningful and purposeful engagement of realizing empathy between a human and a robot compared to a passive one. The results are encouraging and clearly establish a path for further research on this model's design.

Keywords:

Human-Computer Interactions, Interaction Design, Human-Robot interaction, Social Robots, Empathy, Realizing Empathy process, Human-Technology Relationship, Human-Centered Computing, Mapping Theories, Interaction Design Theory, Human-Robotic collaboration, Human-Robot argumentative dialogue, Human-Computer Dialogue.

RESUMEN

La forma en que las personas se relacionan con su entorno, ya sea físico o digital, se vuelve cada vez más compleja y fugaz, haciendo que la relación del usuario con sus objetos y herramientas digitales, en ocasiones, sea extrema y de corta duración. Sin embargo, la propiedad de objetos y objetos tecnológicos interactivos no es vacía de significado, son muestras de reflexión y representación para los demás y de su papel en la sociedad. La clave para mantener una relación y significado con estos objetos radica en el diseño y la intención de la experiencia interactiva creada. Inspirados en las disciplinas de la psicología, el proceso de diseño, la interacción humano-ordenador y los modelos de negocio, esta tesis explora, analiza, crea y prueba los fundamentos teóricos sobre la empatía y el concepto de entablar una relación de larga duración entre las personas y las tecnologías interactivas.

Con este fin, esta tesis se divide en 4 fases: (1) estudio en profundidad de las referencias bibliográficas dentro del sector HCI, con especial atención al rol del diseño y la psicología con la intención de responder a preguntas como: "¿Cómo podemos construir relaciones potencialmente de larga duración entre personas y objetos inteligentes?"(2) Recopilar y adoptar definiciones, herramientas y terminología de trabajos relacionados que aporten a la construcción de la contribución principal de esta tesis, (3) Crear y presentar un modelo de interacción entre personas y tecnología que aporte a una interacción de larga duración, y (4) presentar un caso de estudio donde se implemente el modelo propuesto.

Tras el trabajo bibliográfico en el sector del HCI se ha identificado un vacío, fruto de las principales preocupaciones expresadas: la falta de conexión entre la teoría y la práctica del diseño, así como una falta en el tema de la Empatía. El resultado hace que muchos de los modelos de interacción con intención empática y afectiva no se sustenten entre sí. Esto nos ha llevado a la segunda fase de la tesis en la que aprovechamos las referencias de múltiples disciplinas para estudiar qué es la empatía, cómo se implementa, cómo se percibe y cómo evoluciona hacia el objetivo de una relación a largo plazo, como punto focal hacia las principales contribuciones de la tesis. .

Después de una reunir y analizar exhaustivamente las referencias en torno a la empatía, entramos en la tercera fase donde presentamos el modelo teórico de interacción con el potencial de entablar una interacción a largo plazo y denominado Proceso de realización de la empatía (RE). Más que intentar definir qué es la empatía, esta propuesta trata de ofrecer una perspectiva diferente a la empatía y visualiza su alcance como un proceso influenciado por modelos de diálogo y colaboración con el propósito de crear comprensión mutua y dar significado a ese intercambio.

Con un modelo claro y una sólida base teórica, la fase final de la tesis busca probar el modelo propuesto con el objetivo de observar si el modelo puede detectar indicadores de Apego Afectivo y Confianza entre una persona y su objeto tecnológico. En el caso de este trabajo, tuvimos la oportunidad de trabajar con robots sociales como nuestro "otro actor" para diseñar las pruebas del modelo. Estas pruebas pretendían capturar los indicadores de de empatía entre un humano y un robot que abarca: el apego afectivo, la confianza, la regulación de las expectativas y la reflexión sobre la perspectiva del otro dentro de un conjunto de estrategias de colaboración. Planteamos la hipótesis de que una estrategia de colaboración activa conduce a un compromiso más significativo de generar empatía entre un humano y un robot en comparación con una estrategia pasiva. Los resultados son alentadores y claramente establecen un camino para futuras investigaciones sobre el diseño de este modelo.

Palabras Claves:

Interacción Humano-Ordenador, Diseño Interactivo, Interacción Humano-Robot, Robots sociales, Empatía, proceso de realizar empatía, Relación Humano-tecnología, Computación centrado en el humano, Trazado de teorías, Teoría del Diseño, Colaboración Humano-Robot, Diálogo argumentativo Humano-Robot, Diálogo Humano-Ordenador.

RESUM

La manera com les persones es relacionen amb el seu entorn, ja sigui físic o digital, és cada cop més complexa i fugaç, fent que la relació de l'usuari amb els seus objectes i eines digitals, de vegades, sigui extrema i de curta durada. Tanmateix, la propietat d'objectes i objectes tecnològics interactius no és buida de significat, són mostres de reflexió i representació per als altres i del seu paper a la societat. La clau per mantenir una relació i el significat amb aquests objectes rau en el disseny i la intenció de l'experiència interactiva creada. Inspirats en les disciplines de la psicologia, el procés de disseny, la interacció humà-ordinador i els models de negoci, aquesta tesi explora, analitza, crea i prova els fonaments teòrics sobre l'empatia i el concepte d'entaular una relació de llarga durada entre les persones i les tecnologies interactives.

Amb aquesta finalitat, aquesta tesi es divideix en 4 fases: (1) l'estudi en profunditat de les referències bibliogràfiques dins del sector HCI, amb especial atenció al rol del disseny i la psicologia amb la intenció de respondre preguntes com: "Com podem construir relacions de llarga durada entre persones i objectes intel·ligents?" (2) Recopilar i adoptar definicions, eines i terminologia de treballs relacionats que aportin a la construcció de la contribució principal d'aquesta tesi, (3) Crear i presentar un model d'interacció entre persones i tecnologia que aporti a una interacció de llarga durada, i (4) presentar un cas d'estudi on s'implementi el model proposat.

Després del treball bibliogràfic, al sector de l'HCI, s'ha identificat un buit, fruit de les principals preocupacions expressades: la manca de connexió entre la teoria i la pràctica del disseny, així com una mancança en l'àmbit de l'Empatia. El resultat fa que molts dels models d'interacció amb intenció empàtica i afectiva no se sustentin entre si. Això ens ha portat a la segona fase de la tesi on aprofitem les referències de múltiples disciplines per estudiar què és l'empatia, com s'implementa, com es percep i com evoluciona cap a l'objectiu d'una relació a llarg termini, com a punt focal cap a les principals contribucions de la tesi. .

Després de reunir i analitzar exhaustivament les referències al voltant de l'empatia, entrem a la tercera fase on presentem el model teòric d'interacció amb el potencial d'establir una interacció a llarg termini i l'anomenat Procés de realització de l'empatia (RE). Més que intentar definir què és l'empatia, aquesta proposta intenta oferir una perspectiva diferent de l'empatia i visualitza el seu abast com un procés influenciat per models de diàleg i col·laboració amb el propòsit de crear comprensió mútua i donar significat a aquest intercanvi.

Amb un model clar i una sòlida base teòrica, la fase final de la tesi cerca provar el model proposat amb l'objectiu d'observar si es poden detectar indicadors d'afecció afectiva i confiança entre una persona i el seu objecte tecnològic. En aquest cas, vam tenir l'oportunitat de treballar amb robots socials com el nostre "altre actor" per dissenyar les proves del model. Aquestes proves pretenien capturar els indicadors d'empatia entre un humà i un robot que abraça: l'aferrament afectiu, la confiança, la regulació de les expectatives i la reflexió sobre la perspectiva de l'altre dins un conjunt d'estratègies de col·laboració. Plantegem la hipòtesi que una estratègia de col·laboració activa condueix a un compromís més significatiu de generar empatia entre un humà i un robot en comparació amb una estratègia passiva. Els resultats són encoratjadors i clarament estableixen un camí per a futures investigacions sobre el disseny d'aquest model.

Paraules Claus:

Interacció Humà-Ordinador, Disseny interactiu, Interacció Humà-Robot, Robots socials, Empatia, procés de realitzar empatia, Relació Humà-tecnologia, Computació centrat en l'humà, Traçat de teories, Teoria del Disseny, Col·laboració Humà-Robot, Diàleg argumentatiu Humà-Robot, Diàleg Humà-Ordinador.

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1 Introduction & Motivation

The bond humans form with their objects becomes an extension of themselves representing: a memory, responsibility, vision of their future, a loved one or as an expression of their own character. Essentially, a token of their past, present, and potential of their future. As time goes on, these objects and their functions grow deeper in meaning for their owners, to the point that they may become heirlooms to the future generation [Belk, R. W., 1988]. Through their scratches, broken pieces or general deterioration, these objects tell a story about the life, priorities, and attachments their owners had. Yet, now with objects that can speak through their digital interfaces or smart connectivity while learning from their user's behavior, how does this relationship look like?

As connected objects can identify their owner's patterns, overall behaviors, and emotional cues, while also expressing that data, the relationship people carry with their objects is shifting or, rather, becomes more intensified [Schweitzer, 2019]. Characteristics that helped carry the connection with analogue objects gain that much more relevance. For example: in [Schweitzer, 2019] users felt a better relationship with objects they perceived as their servants or when they exhibited relatable emotional cues, rather than an equal in intelligence or function giving a sense of trust. With analogue objects clearly, they are a support for the owner, but as soon as the object no longer worked as it might have in the past, they were often kept around as keepsakes or memorable trinkets. Now, these objects with smart technologies can talk back, and some even have human-like abilities like replying with a realistic tone, semantics, and jargon, or "remember" events with the owners. If these "talking" objects fail, they might not be treated with the same nostalgia as analogue objects once did [Parasuraman, 1997]. Many objects though, due to the emotional response and servant-like presentation have reached a level of integration in people's lives that seem to have caused a more intimate interaction with their owners. For example, many Alexa users already express love and deep connection with their device, indicating a possible empathetic interaction between them in the basic functions of the device (Schweitzer, F, 2019). Yet there is still much to understand in the complexities of day-to-day interactions within a variety of contexts and needs a person may have, while also responding to how can empathy provoke this type of situation that may seem rather extreme. HCI practitioners are searching for a way to maintain long-term engagement between a smart interactive object and their users, while users also desire to find longer-lasting devices that enhances their day-to-day activities, yet there still seems to be tendency of abuse and abandonment of these objects after a brief period [Leite, I., 2014; Epstein, D.A., 2016].

The connection with our surroundings, homes, and everyday objects embedded with smart interactive technologies, are becoming both more intense as well as delicate. It means that there is much to explore in that relationship and in how that relationship can be built and reinforced.

This thesis began in 2015 with an overly broad perspective in the pursuit of a single challenge: to study and exemplify a guide that renders a new or improved way of creating and sustaining an engaging relationship between people and their smart, interactive technological objects. At the time it was clear that whatever contribution this endeavor would offer it needed to be researched within four pillars: *design impact, psychology, human-computer interaction (HCI), and business modeling* [Meinel, C., 2010]. These pillars reflect the Design Thinking and innovation frameworks that have been popularized in both academia and commercial sectors: Desirability, Feasibility and Viability. Yet, in the context of a doctorate thesis that explores concrete scientific venues, it was pertinent to specify these pillars in a way that is most relevant to the work. Desirability is born from design and psychology principles, while feasibility means to focus on possible technological implementation, which in the case of this thesis lived within the HCI sector, and finally viability directs the attention in the business opportunities the innovative approach can produce. With this background and the objective of providing new contributions to the scientific community, these pillars served as a guide for the initial phase of the thesis work presented here. Because they are general on their own, literature within these pillars were explored within the topic of human-connected object long-term engagement.

The first pillars explored and surveyed were: first the role of *Design and its impact*, with an overview of the design process for connected objects, and the second being *HCI* with a more in-depth look at Human Computer Interaction bibliography. This literary exploration along with the understanding of the connected object's creative design process in HCI, revealed a gap that motivated the work for this thesis book. A significant number of resources initially collected within the role of design and HCI pillars, were driven by psychological and sociological theories, frameworks, and models, covering some of the research intended to be explored within the *psychology pillar* presented above. At the same time, while collecting this ample roster of bibliographical material, the gap found revealed a need for more clarity around the concepts related to long-term relationship building in human-computer interactions

and better communion between theory and practice in HCI. This gap will be further explained in the following sections and in Chapter 2. Among the concepts that required further study within this gap is empathy, as both a consolidated theoretical concept and in how it was to be implemented in practice, and design elements and principles as tools for the practice of HCI. At this point the literature was carefully analyzed to derive a path towards a clearer set of research questions and objectives.
The initial parallels found during the first phase of the thesis research, spoke to how humans engage with their connected objects, the meaning they ascribe to them, especially in long term interactions. This general concept catalyzed the motivation behind the rest of the thesis.

1.1 Motivation

Each pillar as it was being explored, catalyzed the motivation behind the direction of the thesis research and final book. Below the initial research and reflection is presented as it became the driven motivation evolved from the thoughts expressed at the beginning of the introduction.

1.1.1 Overview of Design Process

Aware of the impact objects has as an extension of a person's expression throughout time makes examining its design and crafting process fitting within the efforts of the pillars described above. Traditional design practices and studies beginning during the industrial revolution, encourage a mastery of craftmanship. This movement was led by the Bauhaus school. Their methodology became widely adopted after its international exhibition debut in 1923. The process in their methodology followed a mantra of "art and technology: a new unity" meant that craftsmen needed to use art principles as a significant aspect of creation and making, which in turn became essential to their understanding of a design process (Cadle, B. 2009). It was clear to them this intersection between design, craft, art, and technology was not only possible but essential to move forward in advances and product innovation. Johannes Itten, a professor at the Bauhaus institute developed an innovative program in 1919 that focused on the students learning about material characteristics, composition, and color through the perspective of artistic liberation. (Periton, D.,1996). Here is an excerpt of his teaching methodology:

> "Itten's process of freeing the student's natural abilities was seen to depend on rediscovering their psychological empathy with whatever it was he was being asked to communicate or represent. This might be a human figure, a material, texture or shape, an emotion-laden subject such as war or a storm, or a relationship of contrasts."

Students were trained to deeply understand the states, characteristics, limitations, and capabilities of the materials being used in the design process. Understanding the characteristics of how metals, woods, and other materials behave under certain circumstances as well as to learn how to harmonize them with color choice, composition, and other design elements. In this process they were building a language that communicates to the audiences, projecting the type of engagement they want their pieces to portray as a form of dialogue.

> "Both the artwork and its creator then become simply 'intermediaries in an act of transference . . . between the original subject or concept, and the viewer.' In Itten's own words, 'to experience a work of art is to re-create it. Because, intellectually speaking, there is no greater difference between a person who experiences a work of art and a person who outwardly represents an experienced form in a work.' Through empathy, the artist or the person experiencing the work of art is expected to make direct contact with the essence or idea of the form as the ultimate and genuine reality; the way in which it is embodied is only relevant as a vehicle to represent this reality."

As these notions became pervasive among product and industrial design studies, another layer to this process became equally important and relevant to its process: ergonomics and user-centric observations (Kolko, J.,2005) as a way to move beyond form and aesthetics. This aspect of the design process delineates the importance of understanding, studying, and observing user's needs, contexts, and the way they hold their objects and utilize them within those contexts and in resolving those needs. The conversation craftsmen and designers have in this path goes beyond their expression to an audience, but to also represents the perspective of the user in the work. Now, these layers among others like iterative prototyping, multidisciplinary team practices and design thinking processes continue to shift the way products are created and perceived.

In time, knowledge, experience, and constant practice develops intuition, that subconscious automatic information processing that leads people to act swiftly (Wan, X, 2012). For designers it is constant training in the language of materials and art elements along with the skills of user related studies. Therefore, the design process involves both rational aspects and non-conscious aspects, such as the roles of intuition, imagination, and personal insight (Hardman, T., 2009). The design created meant for a particular audience may be ephemeral or long-lasting, but the harmonic design choices are the result of observing the target audience, their needs, pain points, as well as the understanding of how they will perceive the composition of materials, forms, and colors. How all this process engaged in marrying materials and user study is embedded as part of the designer's intuition. By association, the prior dialogue and empathy described through artwork becomes a formalized conversation through the objects created in the design process.

This intimate relation between the designer, their materials, and user research practice can also be extended to all professionals and how they perceive, create, and use their tools. No matter the profession, what may seem mundane, the choices of those tools have an intention, the professional understands their importance and rates their trust in them with the resulting quality of work.

This insight of the design process behind objects sparks the interest related to how human-computer interaction activities translates this inherent practice when creating connected objects and smart interactions.

1.1.2 Exploring the HCI context

Moving towards this curiosity, we took a turn to explore HCI bibliography exploring the creation and development of connected objects as well as assessing how audiences are engaged with their objects. First it is important to set the tone of how we define HCI: "Human-Computer Interaction (HCI) is "a discipline concerned with the design, evaluation, and implementation of interactive computing systems for human use and with the study of the major phenomenon surrounding them" [Stuart, 2018]."

Many theories, books, articles, and case studies were collected on HCI concepts and projects, clarifying how vast and comprehensive the field of HCI can be. Particularly in recent years, as connected objects are being studied to become more involved as collaborative tools, the field continues to expand greatly [Wang, 2020]. As quickly as I realized the depth of HCI literature's impact, it was also becoming increasingly clear the divide and series of concerns among its authors [Bødker, S., 2015]. These concerns relate to three main aspects: an overabundance of theories and models, a lack of defined scope for human-machine relationships and a lack of connection between theory and practice converting results into tangible assets, material, and examples for applicability in HCI [Colusso, 2019].

Most theories and models are based on specific interactions, rather than analyzing the comprehensive breadth of its influence through time and contexts, as needed for a relationship. After all, humans do become attached to their objects, developing a relationship with them, attributing to them values that span generations, but now, this relationship transforms further as artifacts are given intelligence, autonomy, and agency [Odom, 2012]. This does not reflect how authors wanted to capture more aspects of a relationship, but due to their scopes and fragmentation of the HCI bibliographical ecosystem, it made the tracing of relevant materials difficult to incorporate [Heckler, E., 2013].

These concerns meant that much of the literature was fragmented and could easily become biased depending on the author that reads them. These are not fruitful to a better understanding of the HCI potential to view the interactions as a relationship between humans and their smart objects. The scope of what is needed for a long-term engagement like a relationship, is also highly debated. There is evidence coming to light of how action driven theories, like persuasive technology, rather pushes to users to become overdependent, misuse, or abandon technology ownership rather than maintain a relationship with them through time [Lazar, A., 2015]. There is a new direction focused on human-machine cooperation and empathy to improve long interactions, but it remains either too novel or in theoretical format for it to describe what can be a guided scope for an HCI relationship. To address the final concern, design is essential to transform theory into practice in HCI [Grimpe, 2014]. It brings together the perspective of usability, human perception as well as how the machine would express itself to the human agent. Despite its importance, there is a distance between the theory and practice within the discipline [Colusso, 2019]. This distance, has caused a divide in how HCI should be approached, practiced (see chapter 2, section: h. Translating HCI for Design application), and how HCI objects and interactions are presented to users. In chapter 3 we delve deeper into other process of design and how it impacts the way we can construct empathetic interactions with objects.

The sister discipline of HCI, Human-Robotics Interaction (HRI), also carries similar concerns and difficulties [Huang, 2016]. The context of creating a relationship with robots is more explicit than HCI. In HCI objects are meant to seamlessly integrate in people's habits and environment. Interactions with robots are meant to be felt in presence, as many are being designed to be social with its user. They consider, analyze, and express human-like attributes like emotions and reasoning depending on the context and purpose. At the same time, they are judged at an even higher standard of expectation than most HCI objects, and users, when there is not enough understanding around the robot's purpose, tend to be abused and abandoned rather than just misused and abandoned them [Bartneck, 2020]. Because there is a tangible need for an improved relationship between Humans and robots, and there are many relevant common draws between HRI and HCI disciplines, we decided this discipline also presented an opportunity to explore practical cases within this area and expand the impact beyond HCI.

1.1.3 Understanding HCI Relationship

According to several market statistical tools, users have been increasingly looking to maintain a longer lifecycle of their device ownership (Belk, 2018). The meaning they attribute their devices beyond practicality is the extended ownership it provides them in the digital realm, or the long-term accessibility users expect in that dimension [Kirk, 2018]. At the same time, often users expect a use, result or data that does not fully match their goals. Because many of these devices lie out of reach in their expectations, users abandon their technological objects after a brief use [Lazar, 2015]. Just as an example, in Lazar, et.al 2015, 65% of participants abandoned their purchased devices after 2 weeks of use and 80% of them after 2 months. This does not take away from the desire to obtain a long-term technological object, or a connected object that allows for long-term engagement in their digital accesses, rather it means that the design of the interaction has not properly addressed: (1) how to communicate its purpose, (2) not fully assessed user's needs and concerns, (3) used short-term interaction design tactics with the intention to produce long-term use [Epstein, 2016]. The discrepancy between intent and practice results is yet another example of the concern seen within HCI theory turning to practice and the lack of design theory as a tool for that practice. But it is also an indication that users do have a need to view these engagements as a relationship. Both HCI designers and users have this need, for longer-lasting objects that can be trusted and cared for [Rupp, 2018]. To take on the perspective of building a relationship means to design for long-term engagement with smart, connected objects.

Inherently, the concept of relationship means that there is a long-term set of interactions that is maintained or grows through time. Humans constantly build relationships, whether it is with other people, their environment, their objects, or experiences. These shape people's journeys, as well as hint who they become in the decisions taken every day, small or big. A part of that relationship is the objects surrounding them in representation of those experiences, environments, and people. They are the tools for their profession, daily tasks, as well as tools of nostalgia, emotional connections, and personal identity [Russell,1988]. When these objects become enhanced with smart, learning technology, the relationship with them becomes more complex and nuanced. As societies evolve, innovate, and their technologies become intrinsic to people’s activities and decisions, it becomes even more relevant to examine these types of engagements. Although people do not engage in a relationship with objects with the same clarity of investment as with other people, when they become tokens of affection and remembrance, people do care for them and have a meaningful, conscientious interaction with them, depending on the overall context of use [Russell, 2013]. Here the approach to defining the relationship is by using two key elements: what is the value the object possesses and what is the kind of relationship being established in the context of an HCI frame.

First, after much evidence on the role of objects in social ecosystems, it is pertinent to echo the belief that the object's value goes beyond monetary and practical values but is held by the meaning people attribute them. They become a link to events, activities, surroundings, other people, memories, self-expression, etc., impacting them in everyday decisions [Aaron, 2005]. In summary, it is argued that objects are part of a social system of communication that allows them to reflect in their overall context but also as part of their own sense of self. This sense of self includes what people perceive of their own skills and potential, as well as a form of expressiveness to others. Therefore, when adding smart technological elements, the meaning transforms past the intended analog use of the object, but with an added layer of emotionality and demand for trust [de Graff, 2017]. It is no longer about interactions only, but also about how the objects acquire deeper and even transversal meanings to their users [Novak, 2019].

Secondly, Bickmore and Picard's proposal of understanding what a relationship between people and relational agents (computers) should be, seems the most appropriate in this setting [Bickmore, 2005]. They define a relationship with several complimentary models including the Dyadic Model. With this model two bodies have interdependent behaviors, where the relationship does not reside in one or the other but in the constant build-up of exchanges between each other. It becomes a pattern or a

> "Persistent construct that is incrementally built and maintained over a series of interactions that can potentially span a lifetime. This focus is on maintaining engagement, enjoyment, trust, motivation, and productivity over a long period of time" [Bickmore, 2005].

This concept is not alien to either a relationship between people or between people and their objects. Rather, it implies that a relationship is bidirectional and cyclical, in consideration of those involved, and what they can provide for each other, as if engaging in a dialogue [Bohm, 2013].

As part of this attempt, we have decided to study the role of empathy for long-term engagement in HCI relationships. Not only is it becoming more visible among HCI works and cases in recent years, but it is a concept present in other disciplines from design, to psychology, and neuroscience, that also impact how Human-technology interactions are being created. Though, as briefly mentioned previously, the study of empathy in HCI also has its pitfalls that add to the potential set of opportunities for this thesis book. We will explain this further in the following chapters. Throughout its history and applications, empathy as a process of interaction is meant to sustain a bidirectional attention and engagement emotionally, cognitively, and at times, physically [Darwall, 1998]. Because empathy must have at least 2 agents in engagement and demands mutual understanding, it is often a tool or a characteristic for constructing a relationship. Without a tool for mutual understanding and meaning, a relationship becomes fractured and eventually abandoned.

1.1.4 Direction of the Thesis

Ultimately, as we explored the concerns within the HCI community, it sparked the motivation for the thesis book: how overabundance, fragmentation and lack of cohesion in HCI literature of theories, models and frameworks have provoked a further rift between the theories and it's practices: the design process is not leveraged in HCI, there is a lack of support to design for relationship building between people and technological objects, these concerns is also reflected in HRI, and the current theories used do not reflect or foster the intention of trusting and affective engagements long-term. Empathy is present in all these areas of relevant concern and yet it does not seem to be well understood or have a clear guided application. Discovering these insights have driven the motivation of this thesis book, rising a series of questions and a general objective to begin the research approach.

Some questions and objectives

Though we will showcase a deeper discussion on these questions and objectives in Chapter 4 with added context, it is relevant to point out that taking on this direction raised a series of questions from the perspectives of: HCI, HRI, Empathy and Design. For example: Is there a way we can organize the overabundance and fragmentation of theories and models within HCI that can be visually intuitive from the perspective of a relationship? How can Design theory and design research practices add value to the HCI interactions and the Empathetic engagements? How can we use design in the Empathy modeling to bring its practice closer to HCI/HRI practical implementations? Can we leverage Empathy to indicate potential long-term engagement or relationship building between people and technology impacting the creation of HCI interactions? What does the structure of empathy look like? How can we empower collaboration and trust between people and social robots while supporting the user's self-determination (S-D) through an empathetic designed interaction? Will the proposed empathy model's intentions and goal translate well to HRI scenario cases? Can an empathy model provide some potential indication to reduce abandonment and abuse of both with social robots and connected smart objects/devices?

The objective of answering these questions will lead to begin building a type of guide for future designs and implementations of interactive projects relating human and smart, technological objects based on Empathy. The intention would be to start: (1) clarifying the connections between HCI bibliographical work and how they relate within a human-computer relationship, (2) bridge theory with design practice tools, (3) explore a path to model empathy for interaction design applications. We hypothesize that can achieve this by framing the HCI ecosystem and gap discovered, designing an approach to model for empathetic interaction design, with tangible steps and examples, along with case studies that focuses on different aspects of the model.

1.2 Book Structure

The previous sections describe the motivation as we engaged in acquiring the that has set the stage for the thesis. The following chapters described below are the book's structure, which delve deeper into the actions taken. The order of the chapters carries the reader through the process in which the authors naturally evolved the research divided in 6 main chapters as follows:

Chapter 1: Introduction: In this chapter we introduce the thesis by addressing its the motivation and a summary of the thesis research questions and contributions.

Chapter 2: Theoretical Framework: this chapter follows content from the introduction material with a framed map that displays the breadth of literature gathered, defines the identified gap, and a deeper study of empathy.

Chapter 3: Related Works and refined research questions: In this chapter we focus on the works that shaped the main contributions focused on empathy's role within Design, HCI, and HRI fields. This is followed by how we address the direction of the thesis with the research questions assessing concerns related to empathy within the HCI and HRI fields as well as defining the key differentiator of this thesis approach.
Chapter 4: Proposed theoretical model of realizing empathy: In this chapter we present the theoretical model of realizing empathy a novel model for a designed interaction. We also present a study that begins exemplifying the process within a practical scenario, specifically using design elements and principles for creating a new measurement language for provoking self-reflection within the proposed model's process.
Chapter 5: A chapter dedicated to the main case study in Human-robotics Interactions divided in 2 phases, instantiating the previous chapters model.
Chapter 6: This chapter is directed to conclusions of the thesis work, the final contributions, response to the research questions, as well as the limitations found and future lines of the research.

1.3 Summary of contributions

Throughout the research process the objective of the thesis has transformed to become more precise, with a series of research questions and hypotheses of potential contributions. The core of the thesis contributions stands, with four main elemental contributions:
(1) A proposed visual mapping of HCI bibliography focusing on the most impactful theories, frameworks, and models within the discipline up until 2020 in building a relationship between humans and machines from the design perspective of a dialogue as a tool to organize the overabundance and division within the discipline; (2) A proposed novel theoretical model based on the process of realizing empathy; (3) offered examples of design elements and practices that tangibly impact the delivery of the model proposed; (4) a case study of human-robotic interaction experiments that argues that along with the existing computational models, a context of active exchange modeled after the proposed realizing empathy model in this thesis (while using design element examples for the delivery) is essential to effectively create empathetic experiences and thus achieve longer engagements in human-robot interaction.

The results in these contributions are encouraging signs of how a new perspective on empathy can be adopted to design interactions between people and robots with the potential for a deeper emotional connection or for potentially have longer lasting engagement between them. The results presented also signify that this model, as designed for the case studies can be considered for HCI field case studies, and other interactive design efforts.

In this thesis I will present how the theoretical foundation was compiled, analyzed, and framed within an organized mapping of the literary references used, taking into consideration the broadness of the initial objectives, explicitly highlighting the identified gaps that led to both a more defined set of research questions and objectives with focused research activity in related works that shaped the thesis contributions.

2 Theoretical Framework

In this chapter we take the first step by addressing the first concern that motivated the thesis work by understanding the scope and breadth of the HCI bibliographical ecosystem and how these works can be reflected within a relationship exchange between people and their technology. Survey authors within HCI also exemplify how the bibliography can be organized and mapped in different ways, to understand a line of context, but they continue to lack the perspective of a relationship or the bidirectional approach of the HCI interaction.

2.1 Mapping HCI

The direction of the thesis work began with a wide scope, using the design and HCI pillars to begin exploring the creation and development of connected objects as well as assessing how audiences are engaged with the objects helped clarify the potential for scientific contribution.

In this process and considering the definition of HCI described in Chapter 1, section 1.1.2, many theories, books, articles, and case studies were collected on HCI concepts and projects, clarifying how vast and comprehensive the field HCI can be. Particularly in recent years, as connected objects are being studied to become more involved collaborative tools, the field continues to expand greatly. As quickly as I realized the depth of HCI literature's impact, it was also becoming increasingly clear the divide and series of concerns among its authors [Susanne Bødker. 2015].

The divide can be tracked by the history of HCI. HCI is a field that began with the vision of computers having the potential to be tools of collaboration and enhancing human capabilities in the late 1960's [Roussell, 2014]. Though the first articles and efforts that gave the field a title as it focused on user interaction of technologies and computers into "Human-computer interaction" were published between 1979 and 1980. [Savage, 2005]. The rapid growth of computers and interactive technologies led this field to be highly multidisciplinary touching many industries simultaneously, which also led to a divide in its perspectives and applications. This divide is often seen as a gap between research works between the disciplines, lack of clear consensus of terminologies that exist within them, and the continuity between research, application, and design translations [Colusso, 2019].

The growth in HCI exponential as technologies advance in imitating human abilities more closely. This includes an abundance of new tools that expand knowledge on translating human behavior into computer codes, improving the connection and capability of collaboration with them [Oh, 2018]. Yet, concerns among scholars remain [Seeber, 2018]. First, there is a difficulty in tracking the overabundance of theories, models, and frameworks that model these new tools, secondly there is a lack of a defined scope on what are the interactions needed to sum the relationship between humans and their objects or machines [Hekler, 2013], and thirdly, there is a lack of communication or approach to convert results into tangible assets, material, and examples that can be translated to applicability in HCI practices (Colusso, 2019). Most theories and models are based on specific interactions, rather than analyzing the comprehensive breadth of its influence through time and contexts, as needed for a relationship. After all, humans do become attached to their objects, developing a relationship with them, attributing to them values that span generations, but now, this relationship transforms further as artifacts are given intelligence, autonomy, and agency [Odom, 2012]. These concerns meant that much of the literature was fragmented and could easily become biased depending on the author that reads them. These are not fruitful to a better understanding of the HCI potential to view the interactions as a relationship between humans and their smart objects. To properly assess the relevant literature for the thesis work, an opportunity was found to develop a tool that examines the scope of a Human-Computer Relationship in the form of a map that visually organizes the layers and context of that long-term engagement as seen by current and relevant work in the field. The framing of the map is inspired by the process of a dialogue as a tool to develop that potential relationship.

The purpose of this map is to visually organize HCI literature within the context of a relationship between people and machines, as a stepping-stone for a clearer surveying of literary works that best add value to the thesis development and bridge the understanding of references across other disciplines.

It is important to underline, that this map does not focus on instances of interactions between people and connected, smart technologies, but utilizes the concept of a relationship [Novak, 2019] in HCI as the context of analysis and development. With this mindset, there are two main concerns addressed: one is the overabundance and diversity of frameworks, models, and theories that impact HCI projects across academia and commercial use [Hekler, 2013; Colusso, 2019], and two is the lack of defined scope of the interactions that occur when humans relate with their objects or machines [Long, 2022]. Though there are existing examples that reference a map-like networks of frameworks and theories within HCI, along with illustrating their impact in the interactions between people and smart objects, most focus on other aspects in which HCI literature is impactful. For example, the influential work of John Carroll, organizes theories based on the potential parallels between machine behavior, and Human activity [Carroll, 2003]. While Yves Rogers diagrams the complex network of theories based on both the perspective of a "time periods" and trending approaches [Rogers, 2012]. Though they help navigate the growing knowledge in HCI, a clearly defined comprehensiveness of the relationship between the people and objects in interaction continues to be vague. The intention here is to complement, or add comprehensiveness to the existing analyses, helping to map and visually navigate HCI literature. In chapter 1, section 1.1.3, we described the importance and relevance to begin studying the context of HCI bibliography within the perspective of a relationship as more demand for it takes root, from a commercial, design, and HRI perspectives.

2.1.1 Other maps

The HCI compilation of works is rich and diverse because of the growing multidisciplinary nature of the field. Yet, Y. Rogers et al. (2012) has pointed out, this diversity has created many branches that diverge the field in many directions at a high pace. This phenomenon scatters material across the field making it harder for colleagues to collaborate more closely. Despite growing interest in relational research, much of HCI works are focused on moments of interactions, or specific use of tools rather than consistently creating bridges among them [Rogers, 2012]. To better understand this mix of frameworks, theories, and models, we have focused on a survey of articles that primarily concentrates on organizational aspects of the HCI literature. There are authors that have a: categorization point of view, chronological, and trend driven, while others have taken a more specific perspective through which the theories can be interpreted. Here we will present some of the most impactful references found.

a. *Chronological Paradigm*

To understand the scope of HCI literature, there are a few authors that focus on the changing trends, paradigms, or waves in HCI. As these paradigms are identified so are topics and mindsets that classify the overall view of the different literary contributions through time. In Harrison et al. (2007), the overview of changing paradigms throughout the years has been explored as a set timeline of three waves [Harrison, 2007]. For example, the first wave in HCI, "Human Factors," spanning a couple decades mid 20th century, was about a pragmatist approach to interactions by “fitting” the machine to human convenience in terms of functionality and ergonomics. This gave rise to the following change in paradigm “Classic Cognitivism” exploring how the human information processing or psychology theories play into the interactions with those machines. Yet this jump from one paradigm to the other marginalized other aspects of the human experience like context, which became present during the third recognized paradigm, named “phenomenologically situated.” This paradigm tends to reveal theories and concepts positioned from the nuanced lens of human experiences in interaction with objects and computers as well as within their context and environments [Harrison, 2007]. This focus has trended onto experiences and meaning-making [Meckler, 2010]. As this framework considers a flow from one paradigm to the next, there are still a few gaps that have not been explored in this body of work. For example, as the second wave cemented, a growing concern over unreliable results from testing is driving scientists towards a shift in mindset in HCI. The consequence of this situation brewed motivation among other authors to work from a unique perspective, from the mind to studying the direct interaction between a person and their object through a contextual and cultural lens [Bodker, 2006]. Yet in [Kuutti, 2014], this new paradigm continues to evolve where the human-machine interaction is viewed as one factor throughout a timeline, not as static moments of individual interactions. This turn to practice is based on observations and constant activity from a systemic point of view making it flexible and comprehensive in how people engage with their technology and their context. Despite its positive elements, it does not delve deeper into the psychology or the intricate variables that motivate people intrinsically towards those activities, like affective states or internal reflection [Kuutti, 2014]. This set of frameworks mentioned in the different references set the contextual stage of HCI history, and a viewpoint to understanding the author's choices and alignments. Yet for the purpose and deeper understanding of the relationship between people and smart objects at a: physical, affective, active, and psychological implication, this mapping remains quite broad.

b. Methodological Approaches

Other authors interpret the large array of works as paradigms based on a categorization of overall methodology approaches, rather than explicitly reflecting a timeline [Rogers, 2012]. Rogers’ dividing the works within the categories of Classical, Modern, and Contemporary theories (Figure 1) fits as a comprehensive framework for visualizing theories in a temporal characterization, while exemplifying how these theories fit within the related methodological styles without being exclusively written one after the other as if in a timeline. For example, Rogers, Y [Rogers, 2012] writes within the "Turn to Social" modality in HCI, about CSCW Theories that "frames concern primarily with how computer technologies could be designed to support collaborative working practices" a theory coined by 1984. The following example talks about Activity Theory, first explored for HCI in 1978 [Kuttii, 1996]. As a mindset for HCI, they are both similar in how people interact and collaborate with artifacts and their community for their own experiences. This correlation between the examples shows how the chapters somehow relate to each other's work but were not necessarily influenced by each other based on the time they were written. Even though, the work presented in [Rogers, 2012] is very thorough and inspiring in mapping how these theories can be implemented and relate to each other, it remains a complex network of relations between them, and it only gives clues as to finding a helpful unifying perspective based on human-artifact relationship.

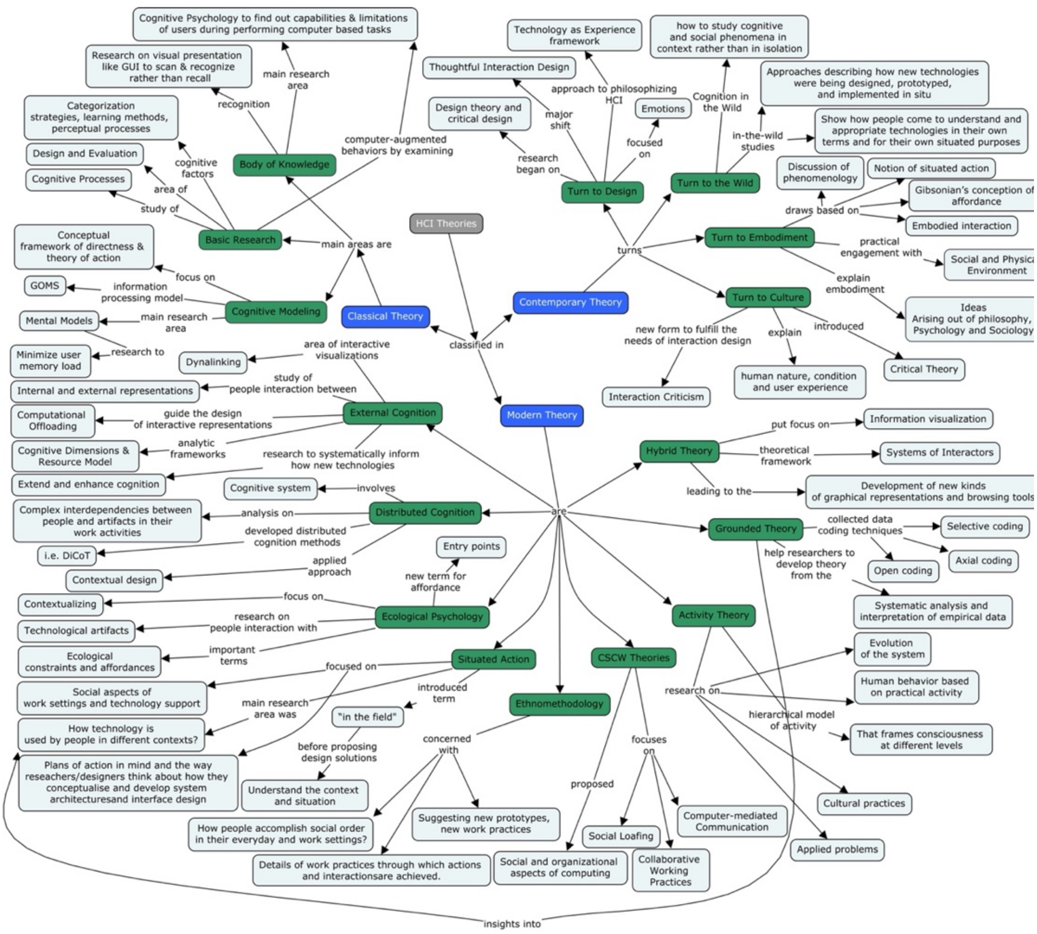


Figure 1: Visualization of Rogers, Y. 2012 book on HCI Theory waves through the classic, modern and contemporary times. (Rogers, 2012)

c. Topics on simulation between humans and machines

Another body of work that leads in this direction is found in Carroll, J.M. (2003) [Carroll 2003]. In this case, the interpretation of all the literature is within exploring categories that draw parallels between human behavior and functions with machine processing theories and models. The concepts of multidiscipline and diversity in the field are imperative in this work, as he continues bringing approximations between humans and machine interactions. This contribution has set up building blocks for interpreting human perception and information processing towards simulating them in machine behavior. Yet, as it tries to bring closer mechanical aspects of humans for machine development, it does not reflect how they can build a relationship, as well as other important concepts of a human-artifact relationship like emotionality, contextual influences, etc.

d. Activity Theory

As the previous surveys or maps focused on an overview of the interaction between humans and machines either through timeline, trends, set of behaviors, or mindsets, there are other frameworks that look to incorporate a sum of theories and models within a specific framework perspective. This means that theories, frameworks, and models would pass through a sort of filter used to understand how they can fit within a specific topic. Kuutti, K. has built a framework with a compelling perspective with the proposal of identifying HCI experiences through Activity Theory [Kuttii, 1996]. Although this theory has been explored and studied abundantly in the past, it has grown and gained popularity across behavioral sciences in recent decades [Chung, 2019]. The process of Activity Theory can be both: highly interactive by experimenting on the construct of a system, and passive by observing people's actions within a system (Figure 2). This allows the framework to be flexible from different perspectives when studying a set of interactions. Its ease of use, effectiveness, and adaptability across fields and case studies, is in part due to its intent to deconstruct reasoning of actions. In their practice, it is believed that only through observed human behaviors within a determined context, and considering their role within a system, can reasoning constructs be accurately concluded [Nardi, 1995]. Because of its attributes, some authors have nominated it as a framework that can encompass and help organize HCI literature within a system of interactions: including context, artifacts, community, culture, etc., [Carroll, 2003]. Activity Theory has grown and expanded becoming one of the most influential frameworks for HCI, yet the structure itself mostly sets up a broadened network for activities and interactions not just in relation to artifacts, but also with their environment, role, and community. With a systematic analysis there is little room for deeper review on mental states and individual transformation within those moments in between activities and exchanges with others [Clemmensen, 2016]. Some authors, like Simeonova, have begun to explore the integration of more ontological perspectives within the Activity Theory's systemic framework [Simeonova, 2017].

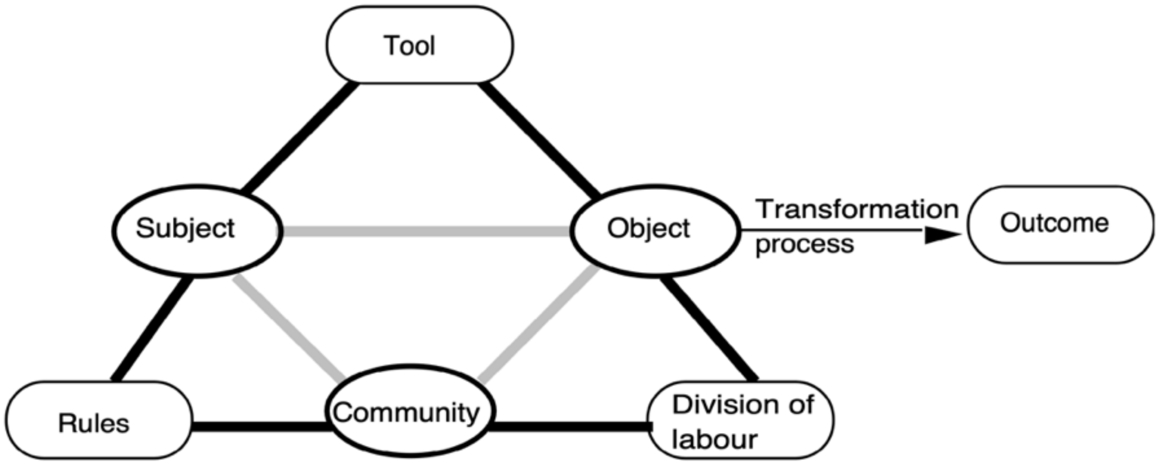


Figure 2: Activity Theory framework as described for HCI research (Kuutti, K. 1996)

e. Empowerment in HCI

On the other hand, there are authors like H. Schneider that focus on mapping HCI frameworks through the presence of empowerment throughout HCI literature and practice. Through this singular lens of analyzing the breadth of theories and models that speak about power or empowerment is relevant in how people engage, form bonds, and interact with others and themselves. Schneider used an alluvial graphic (Figure 3) example of where these articles lie within 5 clusters of research focus giving a clear example of where they stand in the concept of empowering humans with the support of tech in an array of fields connected to HCI [Schneider, 2018]. This focus sheds light on the importance of understanding the impact these technologies can have in people providing sense of control and freedom through "power to" and "power over", situations and others, whether good or bad. Yet, the precise notion of power and empowerment continues to resonate concern among authors that are unsure how to tackle consequences of an implementation that is not as well measured or tempered within a clear, easy to interpret definition of the terms. Though the author mentions suggestions of use and implementation, the graph remains a mapping of theories that limits the concept of a relationship within the perspective of power or empowerment.

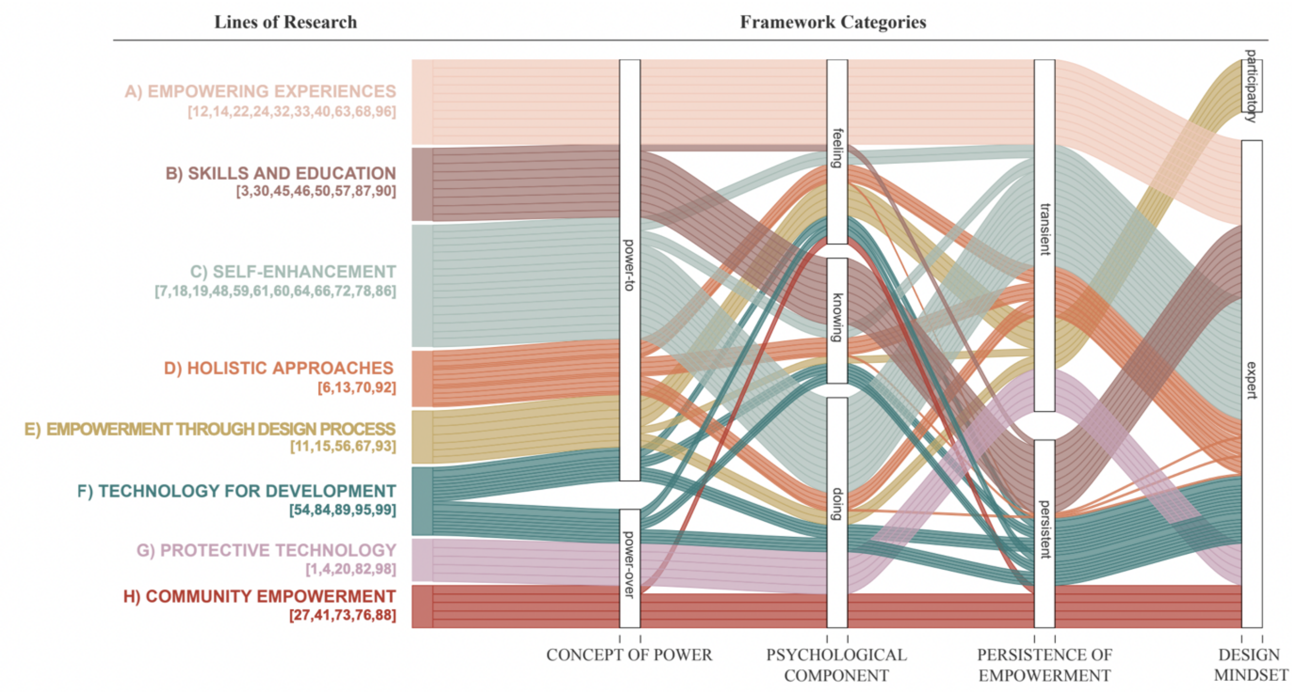


Figure 3: Map of HCI theories around Empowerment represented in Schneider's survey of frameworks. (Schneider, 2018)

f. *Responsible Design in HCI*

Schneider's work also alludes to a conversation around the topic of empowerment that has not been explicitly discussed in the HCI community, arguing a need to become more open to dialogue around the ethical concerns when implementing empowerment with technology. She calls for reflection to understand the maxims of ethical, responsible application. Yet these concerns have been in the minds of scientists for decades, one way or another envisioning how people perceive, use, and develop technology and latest information. Among them, B. Grimpe et al. (2014) maps out the complexities when achieving responsible design [Grimpe, 2014], with the objective of bringing closer the relation between Responsible Research and Innovation program (RRI) to HCI initiatives. Grimpe exemplifies some HCI theories or models within the RRI program, as the categorization explained within it directly influences how these works are judged. The four key concepts used to position the models within their responsible design framework are: Designing for Reflexivity, Responsibility and Responsiveness, Inclusion, and Anticipation. As Grimpe's work progresses and is used as an international pillar for responsible technological design, so does the focus on trying to define concepts that align with empathy and dialogue for interactive technologies, key for relationships. Yet, this framework also exhibits a limitation, as throughout time the field expands, user needs change, and perceptions of the context shifts [Carsten, 2016]. Grimpe's model might not be flexible enough to consider those changes. Understanding how those limitations work and impact people's context and relational priorities is important in the process of developing a relationship between people and smart objects.

g. *Relationship Journeys in HCI*

From the market-consumer point of view Novak & Hoffman [Novak, 2019] echo the current mindset among HCI researchers that look to understand the field beyond interactions and into the concept of a relationship. The impact smart objects or consumer technology has on their users through time effectively creates a new kind of engagement that changes, not only the way objects are designed, but also consumed. Using as a metaphor to study the consumer's reaction to their objects and brands, Novak et al. (2019) built a framework around the current human behaviors observed and artifact designs, particularly their attributed agency and autonomy of interaction. These authors built a framework theory around other works and models across disciplines that best describe these current behaviors and designs in an assemblage style diagram of interactions. In the process they collect varying types of relationships that exist now and how they can be visualized individually with a similar diagram. Despite the comprehensiveness and analysis that can be applied to HCI research, it touches on these theories, models and types of relationships based on current use of the objects without clearly stating where these models lie within the relationship diagram. Also, although helpful to understand the current types of relationships and the models that impact them across the fields, there is a lack of clarity and vision of their interdependent collaboration [Novak, 2019].

The work compiled in the initial research reviewed in Chapter1, that catalyzed the motivation behind the thesis, states both the process of design and the delving into the HCI literature. It was clear that there were inconsistencies that needed further reflection and clarity. As part of the thesis theoretical framework, we present an interactive Map that has helped clarify and reveal the gap in which the thesis dove into. Within this gap, in this chapter we also look at concepts, theories and works that bridge aspects of the human-computer relationship, role of design in HCI and the concept of empathy. The interactive map organizes and visualizes a series of impactful theories, frameworks and models within a relationship driven frame based on a dialogue exchange between humans and computers. Below we will describe the proposal, how the map was built, and the works situated within this mapping. The result of this mapping is an additional contribution within the theoretical framework scope of this thesis book.

h. Translating HCI for Design application

Colusso et. al have explored another perspective on mapping the potential gap within the HCI research, developing a framework that can be used and debated among professionals and researchers alike. This framework is meant to be a "continuum model" between research in HCI and its applicability and design practices within translational science of TS. "In the field of HCI, TS is about translating rich understandings of people and their interactions with technology with a goal of influencing the design of interactive systems." This framework looks at literature, interviews, and case practices related to HCI: user research, education, entrepreneurship, basic research, policy making, applied research, other design practices, healthcare, psychology, among others. They use 2 main strategies for their framework to bridge the connection between these practices: Trickle-down and bubble up models that attempt to find commonalities between research terms, tools, methodologies, and concepts and convert them into theories and vice versa. This process of mapping and attempting to construct a continuity of works, had revealed a root cause for the divide and overabundance of material: there is an inherent gap in the way the practices are both perceived and executed. The application of HCI is a design practice, yet researchers and practitioners have had difficulty collaborating and taking each other's work into account particularly in understanding each other's processes. Research work tends to be more flexible and broader, while design practices must apply protocols, requirements, and limitations within a restricted period of time that researchers do not apply. At the same time, though the definition of the language used is similar, the terminology used in academia tends to not translate well into the applied practices.

This framework is laying the groundwork for what we may find as the gap within our interactive map that hopes to engage the perspective of a relationship between humans and their smart objects. Acknowledging the significance of design, user experience, and translated works for developers and researchers already gives affirmation in the direction of the thesis and initial exploration of the research.

2.2 Mapping Proposal

With the previous background pieces setting up the landscape for the thesis, in this chapter we take a closer look at both the surveyed literature within HCI, and the tool designed to understand their impact. The map proposed here describes the relational perspective taken between humans and computers. First, the following sections describe the construction, design, and how the current HCI literature relates within this structure, followed by the discovery of a potential gap within this HCI relationship and therefore key references within the map shaping the direction of the thesis.

2.2.1 Construction of the Map

A human-smart machine relationship is the contextual perspective of this map's design. As it can be seen from related works and introduction presented in the previous chapter, an active dialogue process is the key to enable and sustain that relationship, along with the constant inherent processes related to emotions, cognition, and embodiment. It is the process of a dialogue that delineates the structure of the map along with its detailed layers and descriptors influencing the dialogue between humans and machines. These structured layers allow the theories and models to be aligned within the relational map.

The first (1) element to describe in the structure is the base that positions the actors involved in the relationship, at each end of the dialogue exchange: people and machine. The second (2) element represents the influential behaviors each side takes towards each other in the form of layers, to the point of describing what occurs in the moment of information exchange. Finally, because the exploration of theories, models, and frameworks is rich and nuanced, the third element considered is a set of descriptors within each layer to create a smoother transition between them with more accurate understanding of the instances within that dialogue.

Base Structure

With the concept of a dialogue process used to structure the map, there are two sides, each end representing an actor in the relationship. In the context of this map, each resides at an extremity: on one side the humans, on the other the machines. (Figure 4). Beyond the actors, in a dialogue, there is a process of exchange as they approach each other to a meeting point of information. Here, it is represented as a series of layers that exemplifies how each side is characterized in their process of approaching information exchange with the other, whether it is the person through psychological steps, or the machine through the object's design.

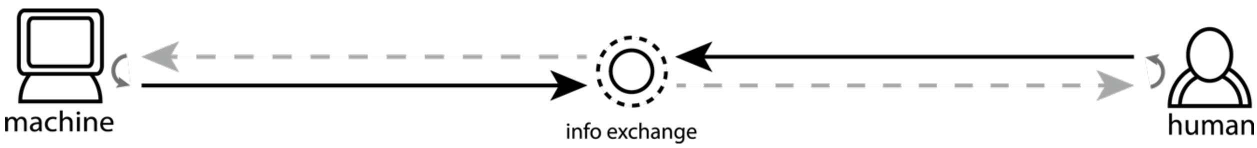


Figure 4: Base structure of relationship for HCI theories map.

Beyond the characteristics of the actors at each side, it is important to note that throughout the entirety of the relationship there are three inherent, ever-present processes that occur both in humans and in the machine's design to emulate human behavior: Emotion driven processes, Cognitive driven processes and Embodied driven processes. Each theory, model, and framework tackle them to some degree, either equally or focusing on one more than another. Because of its importance and overarching nature, it has been visualized on the map above the layers and the actors (Figure5).

Relationship Map Layers

Underneath each actor, the layers from each end are described from the deepest form of behavioral influence in each one, to the more expressive behaviors, as they reach the layer of information. Based on the analysis of the collected literature, this map proposes five layers that impact the human-machine relationship. From the human side, follows the layers from right to left: Unconscious influence on the Conscious influence. From the perspective of Machine behavior, going from left to right, the layers follow: The Internal structure to the Object design. Each side leads toward the final layer of: Transfer of information between the human and machine relationship. (Figure 5).

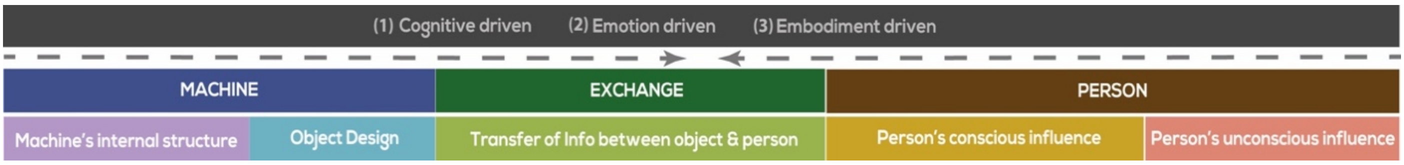


Figure 5: The layers representing the process from each side of the relationship

Defining the Descriptors

Although these layers begin to clearly delineate the positioning of theories and models, the nuanced number of works can benefit from further detailed organization. To best perceive and visualize the models, theories, and framework's impact within the layers of a dialogue driven relationship, it was imperative to re-read and analyze them through the lens of a dialogue as a primary social interaction exchange. This examination allowed us to approximately define descriptors within each layer, therefore situate each work more coherently on the map. (Figure 6).

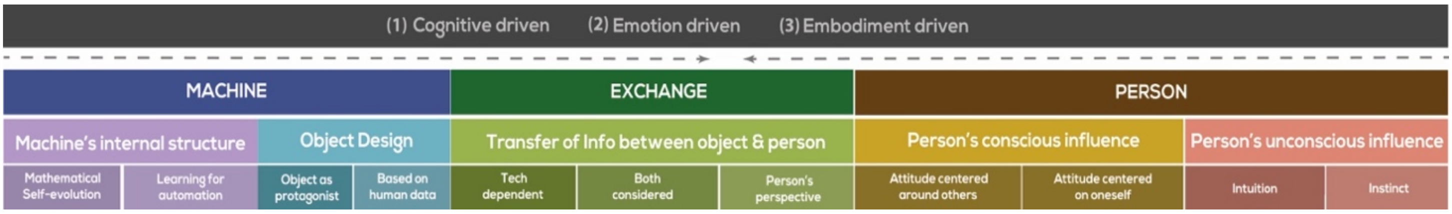


Figure 6: The descriptors exemplifying the scope at each layer.

Each theory, model, or framework in this collection emphasizes a specific or a series of attributes that impact how individuals and machines engage with each other. From theories that explain the genetic instinctive impact of people's behavior, embodied experiences, and reflective exercises, to how mathematical algorithms allow machines to self-learn. Below you will find further explanation of each layer and their descriptors with examples. After the discussion section a view of the whole map is available, along with all the literary works used to construct the map.

2.2.2 Layer Content analysis with descriptors

From the Human perspective

A person's unconscious influence is the deepest layer, that would gather works describing aspects that people have little control over, attributes and variables that may lie dormant in the dialogue process. Among them theories reflecting unconscious tendencies built by their biology, genetic evolution, and followed by environmental factors and past experiences. Therefore, the order of descriptors that details the Unconscious layer are instinct followed by intuition. For example, within the instinctual descriptor you can find, Heritability in Decision Making Theory. It talks about how some aspects of how we behave are based on unconscious heritable genetic motivation or instinct from our predecessor's decisions and survival driven actions [Lea, 2015]. Adding to people's instinct in decision making, is intuition. Mainly built into the unconscious by impactful connection between the reflection people have of their past experiences and behavioral impulse associated to that past, or repetitive actions [Strack, 12].

A person's Conscious influence is a more complex layer to describe. Throughout HCI and psychology literature that is present within the discipline, the three innate processes of embodiment, emotionality, and cognitive influences, constantly run in parallel within people, although they have been studied independently [Niedenthal, 2005]. At a conscious level, these innate processes' influence becomes clearer, particularly when you see people approach others. First people act on the attitude they have developed towards themselves, followed by their attitudes or perceptions towards others.

For example, a theory that speaks to people's perception of themselves focused from a cognitive process perspective, we find the Lay epistemic model. This model presents the way in which people perceive themselves, their depth of knowledge and abilities in a social context. Mainly geared to understanding scientific thought process, this knowledge is acquired by careful hypothesizing, while gathering evidence of their assumptions through confident trial and error, within the context of an accepted social environment. All this is driven by motivation or cognitive closure, giving them the information support that evidences their perceived level of knowledge and role in society [Kruglanski, 1990]. On the other hand, Embodied Cognition expresses the perception people have of themselves and surroundings based on their physical experiences [Marshall, 2013]. While from an Essentic Form and Sentic Cycles is part of a theory that explores the generalization of the emotions people have through dynamic stimuli as it can impact their perception and decision-making [Clynes, 1988]. For equal consideration of these processes, we can find theories like Self-Determination Theory that studies human motivation, self-development, and wellness as they consider their social context, emotionality, and acquired knowledge [Deci, 2008].

The following descriptor focuses on the reflection of people's perception and attitudes towards others, particularly in connection to objects. The models and theories you can find here are Theory of Mind, Attachment Theory, and Meaning of Possessions. These express from a cognitive point of view how people perceive their reality impacted by others [Anderson, 2004], while attachment implies an emotional connection with others [Salter, 1969], and possessions as a reflection of ourselves as we engage with our environments and others, going beyond one-self as a tool to engage with others, our context, and their goals [Russell, 1988].

From the Machine perspective

Before stepping into the middle ground of mutual information exchange, it is appropriate to draw the parallel from the other side, the machine's perspective literature.

Machine's Internal structure: is the machine's deepest layer presented here. It organizes theories and models that build the inherent behavior and intelligence capability of the machine, learning from itself, their context, other machines, and their users. Here the descriptors used to best exemplify this layer begin with Mathematical

Self-Evolution because of the growing examples around genetic algorithm models, that in a way, becomes the "instinctual" behavior of machines [Fowler, 2016]. While the following descriptor reflects how they Learn for Automation with working models like Natural Language Processing becoming the more intuitive, reflexive example of their designed behavior [Neustein, 2013].

Machine's Object Design: is the next layer that presents models that focus on more "expressive" aspects of the machine's behavior after considering the base code in them. The first (1) descriptor in this layer draws inspiration from models that design the expressive behavior with the Machine or Object itself as the protagonist of the interaction with the intention to influence the human's behavior. The following descriptor (2) describes how the machine's behavior design rather takes into consideration collected Human Data related to people's needs and habits. An example of a model and theory that utilizes technology as the protagonist of an interaction is Persuasive technology [Fogg, 2002]. Where, even though its behavior may be based on users, the intention and way the functionalities are implemented, considers it best to use technology to predict and nudge users to execute certain actions without further human reflection. An example of a model that takes a step further towards a dialogue with a person, considering their quantitative data, their overall context, and emotional impact is Affective Computing [Picard, 2000]. Although Affective Computing is concerned with understanding human emotions, it remains a study from the perspective of machines and their ability to interpret and emit those affective states [Picard, 2003].

Information exchange as the meeting point layer

After understanding both side's layers as they begin to consider the "other" in their behavior and attitudes, you may find the transfer of information exchange layer. It focuses on communicating information from both sides, humans to machines and vice versa. Here the descriptors allow for a unifying column that reflects models, theories, and frameworks that contain consideration for each other. For example, the Theory of Cooperation, Competition and Beyond, there is a measured role for both the human and the "other" as they cooperate and engage in competitive or collaborative scenarios [Deutsch, 2011]. This layer also points to descriptors about people conveying motivation or volition, as in the goal-action setting approach in the Theory of Action Phases. As a goal-setting theory based on decision-making influenced by external elements, each has reflected on their attitudes towards themselves and others, before acting on their motivations [Gollwitzer, 1990]. While on the other side of Information transfer, the map also shows the descriptor that focuses on the transfer of information from the machine. Here machines and objects are considering human data, while also trying to provide the space for reflection, exemplified in models around Personal Informatics [Li, 2010].

2.2.3 Positioning of content on map

The collection presented was carefully chosen after surveying papers, studies, articles, and books on social psychology, mental structure theories, theories described throughout the different waves and paradigms in HCI, models used for designing affective and empathetic computers, and books that describe the history and applications of HCI, among others. The estimated amount of the theories, models, methodologies, and frameworks that have appeared consistently throughout the literature are about 83 and growing. Each article was analyzed and distributed within the layers according to their main strategy and perspective intended to serve.
The way the theories, models, and frameworks are situated on the map does not relate to a certain timeline, categorization, or to paradigms of thought. Rather, the variety is presented according to this authors' interpretation of where they focus their research on within the relationship dialogue previously described. You can see how it was done in Figure 7.

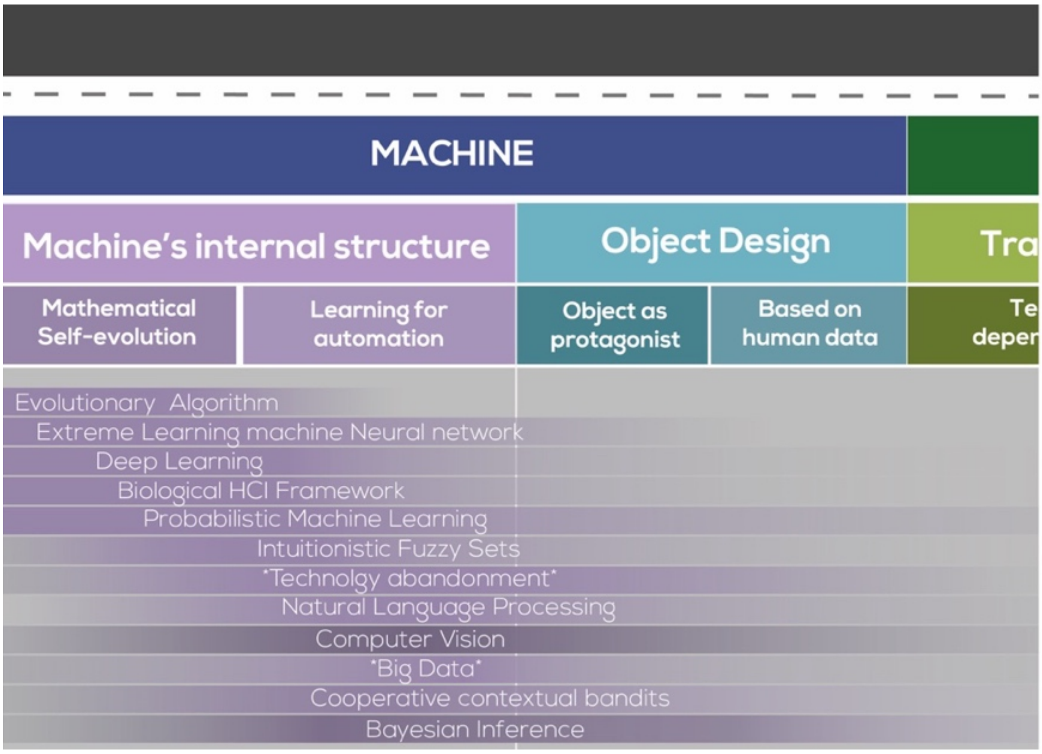


Figure 7: A zoomed-in view of the Machine's internal structure section in the map as an example.

Yet, determining the range of impact they have beyond their particular focus on the relationship spectrum was also analyzed. As seen above, most models and theories tend to focus on specific aspects of the relationship. But they also touch on other aspects of the relationship as well, though not with the same depth of concern or study. This opens the door for expansion and collaboration into other works that can be observed in parallel, even within the same map. To visualize the scope each model and theory has, visual elements of color, gradience and composition were used to describe the details. In this case each layer has an assigned color, the position is centralized within the degree of the descriptors, while the scope in the relationship is defined by the variation of the gradience reach in the color present in its row of the map. For example, Affective Computing is currently a field of work that began studying and observing an abundance of data and information on human emotions and their impact in their decision-making behavior. These observations were then used to best design machines that evaluate, interpret, and express those emotions. Although the main research focus remains from the machine's perspective, it has garnered a great impact in human emotion studies, therefore exemplified in the gradient shown on the map.

2.2.4 How to read the map

With the structure reflecting the process of a dialogue, describing the organized layers, descriptors, and breadth of impact on the relationship between humans and machines, this map is meant to be dynamic. Because of this dynamism, the map itself can be read in any way: from left, right, center, or from the top. The way it is suggested to be read is by choosing the theories wanted to explore, identifying its focal position in its gradience along the layers, and how far it extends to both sides of the relationship. For example, Activity Theory is a framework that focuses on constructing or observing systems based on specific actions within a context, roles taken on by people or entities, and external relationships. In these cases, the creation or gathering of information from those involved in the system are based on those actions, more than exploring human emotional and mental models [Kuttii, 1996]. In conclusion, the scope of the theory for implementation is broad but does not necessarily cover deeper into human consciousness of cognitive processes and emotions, nor fully speaks to their unconscious influence of their relationship with objects. Hence, this framework is seen focused in between Object Design and Transfer of Information, while showing a gradient as it explores part of Human Attitudes Towards Others.

To debrief the focus of where each theory stands is extensive and cumbersome to the nature of this portion of the thesis book. To further study each theory, here is a list of all the theories, frameworks, and models present in the map with their references toward the end of the book.

2.2.5 Discussion

All interactions HCI researchers, artists, and designers experiment with provoke a sincere and genuine conversation on how their results may impact users. From how people perceive their objects, to how those interactions affect their day-to-day habits, self-reflection, emotions, and actions towards others. Currently, it is of particular interest how these sets of interactions with machines and smart objects impact people's perception of their context, environments, social rules, and overall meaning in their relationships. After all, a relationship is a collection of interactions, built-up through time, strengthening or defining a level of attachment and trust [Bickmore, 2005]. Every interaction, big or small, provoked along the spectrum of that relationship, whether internal or externally expressed, impacts that construct of a relationship. The tool used to spark, maintain, or reignite that relationship is a dialogue [Bohm, 2013]. The tool of communication may be passive, or it may be based on actions. Having this insight in mind while surveying HCI literature, it was evident that, overall, HCI projects have the potential to be part of that dialogue, building a relationship with machines and through its technology. From this perspective, when evaluating the main concerns within the field, a way of organizing and visualizing seemed to be a good approach.

The visualization map positions work along that relationship revealing the breadth of each one, but also their gaps. By positioning author's works side by side, allows for examination on how they can relate, collaborate or improve to cover potential gaps. This map format has become a good exercise to find insights for both a more holistic perspective of what could be that dialogue-driven relationship, its layers and descriptors, as well as finding necessary nuances imperative to an improved relationship between machines and humans.

The placing of the listed theories, models and frameworks, is not absolute, rather it is expected that in time the map could grow and become more refined in its structure and perspectives. Seen through this visual lens it highlights gaps that otherwise may have been hard to identify throughout the years because of the fragmented nature of HCI history [Rogers, 2012].

It is relevant to clarify that it is understandable that there are many more theories, models, and strong concepts beyond the ones shown in this map. The authors are aware that there can be much more added and improved to this mapping, both in content and design that are just as relevant to the HCI relationship. In the case of the ones listed here, the main criteria considered for this map were models, theories and frameworks that have made a more prolific impact in their related fields in recent years, been mentioned consistently across fields as key references or are being used as part of commercial product design.

The full map

In Figure 8 you can view the full map of the researched theories, frameworks, and models along with the URL of the interactive map that can be viewed and used. In the Appendix of this thesis book, you will be able to view the full list of content material used in this map in their relevant categories.

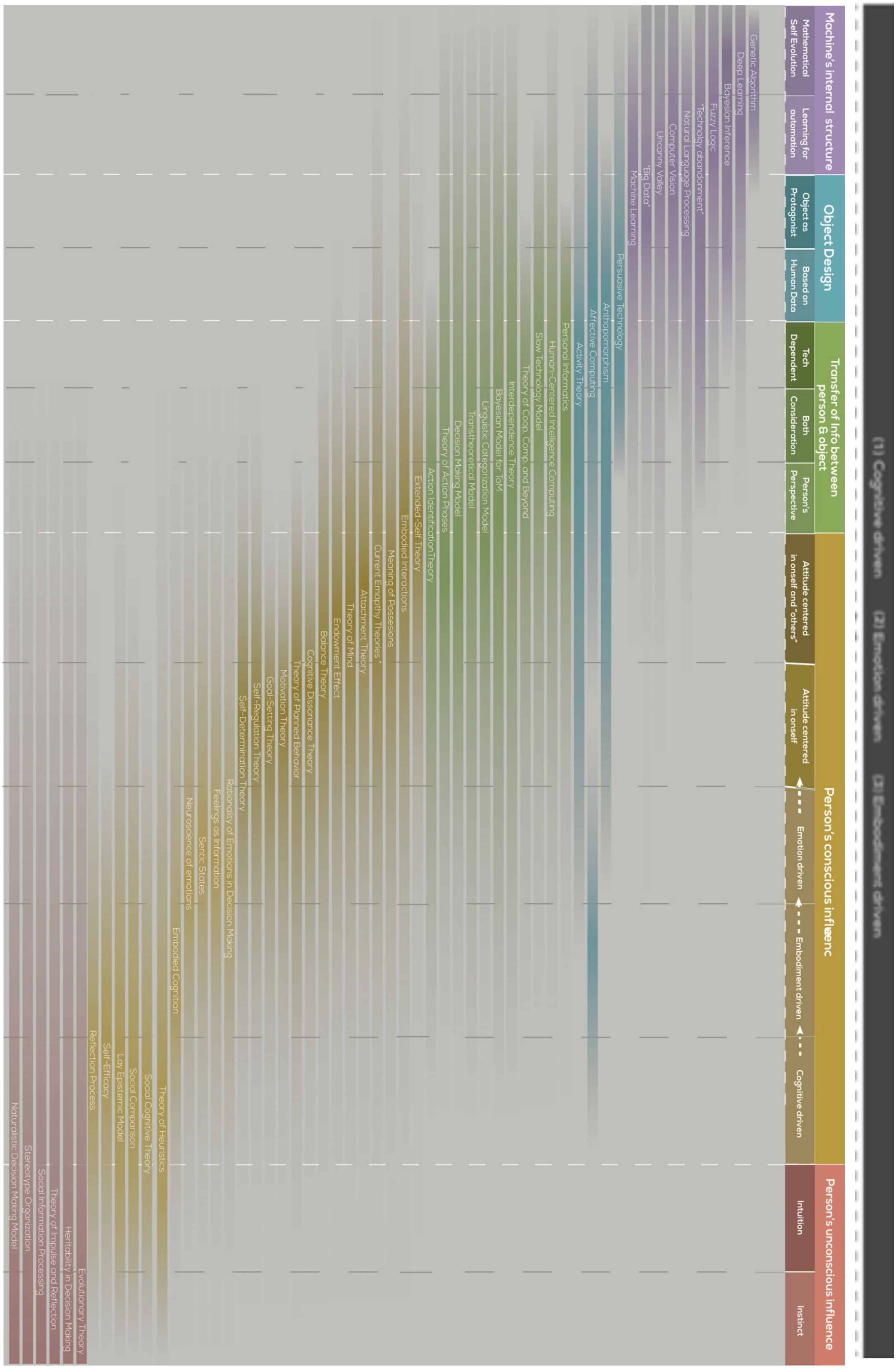


Figure 8: The full view of the map. An expanded version of this map can be seen both in Chapter 7: Annex and in the online interactive version online: http://graphicsii.epizy.com/?i=2

2.3 The gap

The resulting body of work for mapping the HCI bibliography environment helped gather a significant amount of work and perspectives. Along with an initial overview of the design process behind objects, these collections provided a comprehensive bird's eye view of the fields within it a gap. This gap is due to limited resources and references within the field and among its most impactful works: the use and translation of user-centered design practices in HCI, empathy and how it can be achieved between human and connected smart objects as part of a long-term relational interaction.

Aside from this assertion, and after careful examination of the collected works within the created map, it revealed an interesting gap within them, therefore a visual that can add value to designing for HCI relationships (Figure 9). Though there is a gap within the map, it is not to say that literature does not exist within this topic, it merely means that there is a lack of predominant impactful works at the same degree as other works seen in the map. The gap seems to lie within the moment of exchange between machines and humans where the "human perspective for information transfer" is not as present as the "machine's influence" in the exchange or where "both may be considered". The works that grade within this descriptor do mention, speak to and consider the perspective of the person when engaging in the exchange with a smart agent, yet it does not lie at the core of the work.

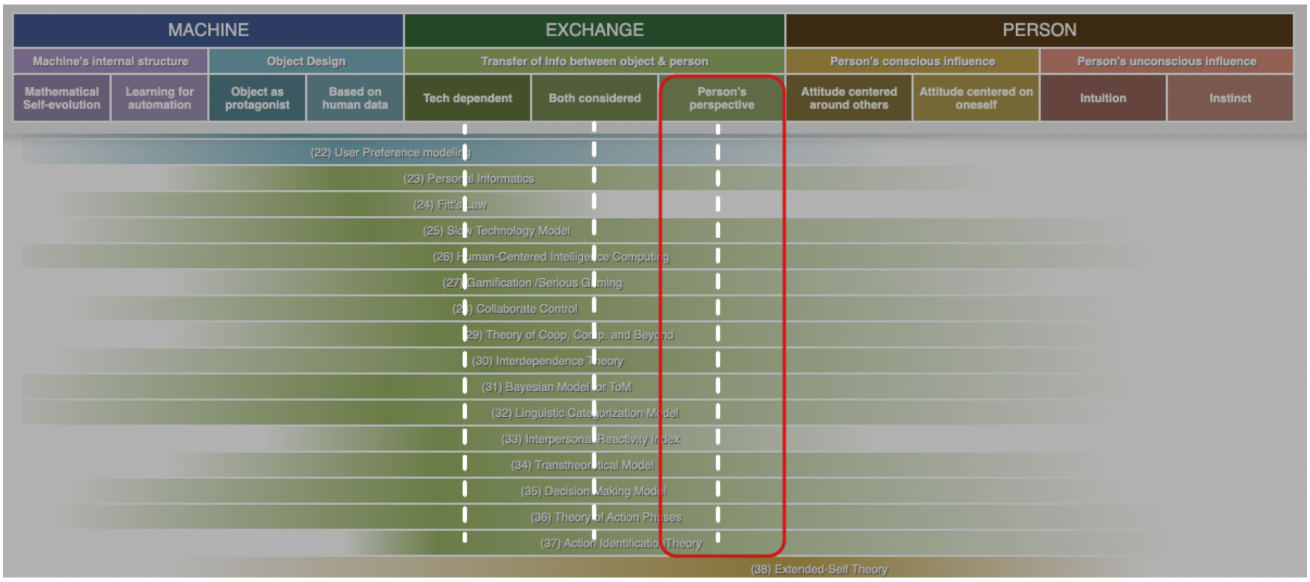


Figure 9: A visual representation of the gap that can be seen within the map of HCI relationship.

With this perspective we engaged in focusing on theories, articles, and works that spanned toward that descriptor of an exchange from all the different areas of the relationship. The moment of exchange in a relationship engagement speaks to methods and theories exemplifying applicable actions. This means that the gap visualized may coincide with Colusso's observations relating to the discontinuity or lack of collaboration between theory and practice in HCI [Colusso, 2019]. Much of the focus in the gaps seen by Colusso and other authors [Kuutti, K., 2014] relate to translating the theory to applicable design approaches or to design tools for the theories explored. This means that the role of design in HCI is a path relevant to study. In the initial overview of the design process, taking users and their experiences into consideration is key, therefore designers intuitively understand empathy as a key element to create and maintain long-term engagement with their creation's users [Wright, 2008]. This potential glimpse of how the design process develops empathetic engagements might continue shedding some light on how it can be incorporated in HCI application practices.

Yet, empathy remains elusive and broad as a within the HCI context. Within the bibliography shown, works like (Einfülung Theory, Perception-Action model for Empathy, and Social Neuroscience of Empathy) construct models or explore Empathy focusing on the theory within the person's internal influence as they form their attitudes towards others and themselves towards others. Despite their influence, their work remains unclear as to what could be actionable integration of their findings. The concept of Empathy continues to be a highly debated topic across disciplines and there is a difficulty of pinpointing how it can be applied as part of a designed interaction in HCI [Decety J.,2006]. Because it is highly debated and vague in practice, HCI authors that work on models, frameworks, and theories, have not been using Empathy as a focal point in their work but do use elements that allude to definitions that to the author seems credible and relevant to what is being studied. In view of how critical empathy can in the design process as well as an area of study impacting HCI and in how relationships are built, exploring the applicability of empathy is a central piece to be tackled within this thesis.

In the following sections we begin by exploring Empathy as an area of study with exemplary bibliography tracing a path to understanding how it can come about in a relationship with smart agents and how it can be translated as a guide for designing interactions.

2.4 Study of Empathy

Recent HCI literary works within the third HCI wave, affective computing, social robots, and person-AI cooperation, focus on topics related to fostering a relationship between people and their technology [Bickmore, 2005], creating tools to engage them in collaboration to empower their knowledge and act creativity [Oh, 2018], and the role of empathy in these scenarios [Wachowicz, 2016]. As empathy continues to play a central role in how people relate with each other and becomes the basis for how people perceive their objects, and contexts, the term itself has been a topic of constant discussion and debate across fields of study [Leite, 2013; Joireman, 2002; Decety, 2006; Darling, 2016; Cooper, 2001] . Beyond understanding the nature of empathy between people, their relationship with advanced technology and smart objects also become the subject of empathy related observations and scrutiny [Kou, 2019]. One of the main concerns among authors that approach empathy as a component of human-machine experiences and relationships is that the scope of the concept of empathy is unclear. They question if it is mostly about affective mirroring, or about cognitive and emotional appraisal, embodied and behavioral assimilation, all of them, or if there is more to how these processes occur [Nakao, 2009]. These questions reflect that beyond establishing what Empathy itself is, the search among authors is for the essence, nature, and process of Empathy. Their objective is to observe if they can design a more natural, considerate, and long-term engagement with users through their own distinct perspectives [Zaki, 2012]. Yet, when answering these questions, there is another concern that arises as current models of empathy being applied may not necessarily translate across projects, types of users, or for long-term relationship between a person and their technology [Bickmore, 2005]. To properly tackle these concerns, we surveyed works that speak to empathy and human-object relationship from across time and disciplines, as well as their role in a design process.

2.4.1 Theories on Empathy

Empathy as a term has had great evolution and transformation since its origin during the late 19th century and throughout many fields [Gernot, 2018]. Its ephemeral yet tangible nature has intrigued scientists across multiple disciplines, including disciplines like HCI and Social Robotics, that hope to enhance or develop a model for an empathetic relationship between people and their technologies [Singer, 2009].

Despite numerous and on-going efforts to understand empathy, there are several main points in which most authors generally agree on: (1) It is a term with a no-universal definition; (2) There are sets of elements and variables that need to be present for an empathetic interaction to occur; (3) Because of the variables and different elements, it is a phenomenon difficult to pin point as a behavior and where it occurs in the brain activity; (4) There is a general consensus that empathy can occur at different depths and manners, from instinctual to reflective, from active to passive, cognitive to affective [Wondra, 2015]; 5) Most agree that there is a clear pattern related to "imitation" or "mirroring" by the subjects of either specific embodied relatedness, cognitive reflection, or emotional circumstances [Carr, 2003]. This "mirroring" behavioral pattern has resulted in theorizing that predicting other's thoughts, actions, or emotions may play an important role in identifying whether empathy has occurred or not [Ashar, 2017]. To expand on this further, in the next sections you will find the evolution of its definition, the impact of neuroscience, its presence in the arts, philosophy, and other disciplines, while also speaking to the relevant psychological evaluations around Appraisal Theory, Vicarious emotions in Empathy, Perspective taking or role-taking theories of empathy, and others.

Beginnings of Empathy

Empathy was initially born out of the concept coined as Einfühlung, by German philosopher Rober Vischer in the late 19th century, meaning "feeling into", describing the emotional experience of a person observing a piece of artwork they relate to, later extending to the embodiment felt with other types of objects and environments [Gernot, 2018]. As a term, the origin is situated in the context of an expanding curiosity in psychological literature around sympathy, over how people perceive their feelings in nature, their contexts, and through objects as tools of expression.

Theodore Lipps shifted the concept of Einfhlung beyond the relation with objects and art to how we can understand the mind of other people, by observing the instinctiveness of how people imitate and reflect each other's sensations and emotional expressions, equating it to the sense of relatedness people have when attracted to expressive artwork or structures [Jahoda, 2005]. Despite this jump forward, he did not infer differences between Einfhlung and sympathy. Though soon enough the blurred concepts between sympathy and empathy were evaluated and heatedly debated [Jahoda, 2005].

Even to this day sympathy and empathy are often confused due to their natural similarity and evidenced activity in the brain [9]. Yet as Darwall, (1998) assesses, the concepts are distinct. Philosophers and psychologists alike challenged Lipps' work

hoping to clarify distinct processes in these terms, yet it was Edward Titchner in 1909 [Darwall, 1998] whom by translating the concept into the term Empathy argued its difference from sympathy [Galles, 2003]. In essence, the argument is that sympathy relates more to the observation and caring for oneself and others in a sense of compassion towards them from a third-point perspective, or what was termed fellow-feeling. While on the other hand, empathy has been described to be about embodying the emotions and the state of mind of the other as a tool for reflection and understanding, rather than just about caring about the other [Darwall, 1998].
This observation grew in acceptance among scholars that quickly questioned if Empathy could lead to acts related to sympathy, like compassion. Theorists, among them philosophers and psychologists, followed this topic by testing when people are most empathetic with others, and observing how they react in those circumstances. These experiments since the 1960's, ranged within the idea that, first people may be most empathetic in highly emotional situation stemming from pain and misfortune, called vicarious emotion conditioning [Berger, 1962], and second that people observing others under these circumstances are generally more compelled to show compassion or aid them [Lerner, 1966].
Correlated to the pain-sharing experimentations, some of these insights have led to theories that people are also able to cognitively identify the other's perspective, particularly exemplified in studies of perspective–taking in relation to Theory of Mind [Barnes, 2004]. This means that perspective-taking and Theory of Mind may provide clues to how empathy occurs as well. Though these concepts continue to be debated and inconsistently defined, the underlying differences are identifiable, stirring up the clear layering and complexity of the Empathetic experience [Asada, 2015].

Vicarious Emotions in Empathy and Appraisal Theory

Emotions and how they are perceived have played a big role in how Empathy is evaluated and defined. According to Wondra J.D., to "feel what others feel" is a way of sharing affective states and experiences based on people's own memories or how they imagine would be their own experiences of what they perceive is another person's situation. These vicarious emotions can be achieved through different means whether it is mimicking, direct observation, assimilation, role taking, or memory recollection [Wondra, 2015]. These tools facilitate the experience of these emotions, some more direct than others and while vicarious emotions are real, felt emotions by an observer, it is considered the imitation of the felt emotion the other is having. It is important to acknowledge that the observer also carries their own emotionality in the

process. This will allow them to feel what the other is feeling, become a tool to act in compassion, or pivot away from the other [Mehrabian, 1972].
But observing emotions or situations alone is not enough. Sensory, embodying inputs also add to this experiential revival as people identify with the other's experience. This can vary throughout the emotional spectrum, from physical pain to general consequences of actions. This led to the observation that when people expressed their emotions or sensory experiences through their facial and body expressions, the observer also mimicked or vividly imagined that embodied feeling [Lamm, 2007]. Therefore, when the observed person sees the observer mimicking their expression, as if they have also felt it, it is often assumed the other person is able to share those experiences. This does not mean that the people involved are experiencing the exact same emotion or perception of the circumstances. After all, everyone lives under unique conditions, genes, and personal perspectives. A concept that takes this into consideration is the Theory of Appraisal in Empathy.
It is believed that in the process of observation and imitation, the person appraises what they are observing rather than perceive it. To appraise, the person interprets the situation and emotions gaging what it means to them and how they believe they would experience it [Roseman, 2001]. This inherently means that there is a cognitive, reflective layer to empathy that can be instinctive, as well as be a more profound thought and belief. This supports the fact that psychological theorists have been arguing, for a better part of the recent decades, that empathy more than relying solely on vicarious and personal emotionality, embodied mirroring, and visceral response, it can also be a process that requires a level of cognitive reflection, appraising people's situation [Roseman, 2001].
This theory assumes that if a person appraises a situation, interpreting very closely to how the other is feeling and thinking, then Empathy would have occurred. To this end, the theory emphasizes two important factors: that the observer has all information necessary given properly to correctly interpret the other with communicated emotions. If what is given is not enough, there might be confusion or misinformation causing the process of empathy to fail [Wondra, 2015]. The second key element is that all emotions come with a goal, in most cases a goal for well-being and understanding. This sense of having a goal is important, as it helps move the process of Empathy for those involved [Roseman, 2001]. Whether the observer might be affected by the other's goal or not, it is a shared experience they can relate to. This entails that Appraisal theory helps to view Empathy more than just interpreting and deeply understanding the sentiment, embodiment, and knowledge of the other, but that is goes hand in hand with an emotional response, whether about care, show of

compassion, expression of shared circumstance, or absolute rejection [Batson, 1997]. In any case, it continues to be a theory that assumes those involved are intrinsically motivated to understand each other. Yet, to elicit that vicarious response there must be an innate sense of identity the actors identify with in the other [Preston, 2007]. This relatedness facilitates the imagining of the other's situation and appear empathetic, just because it is assumed they know who the other is. At this point there is a level of expectation in how the experience will be felt and perceived.

With a goal and function, empathy becomes a complex tool that can clearly be instinctive but can also provoke more discerning reactions. It all depends on the goal for good state of well-being for oneself and the other. During this moment of reflection, interpreting the other's situation and their own role, people weigh the risks, their morality, and the level of relatedness with the other.

Yet, empathy does not only occur when the people involved already identify with the other person. Empathy can also be evoked when people listen, read, and learn of other people [Bohm, 2005] or despite the understanding, not have the willingness to have an empathetic reaction towards them. There are several ways Empathy can turn into an act of rejection or a push away from the observed. For example, if the other is too different than themselves, it becomes harder to understand and identify with them [Fiske, 2011]. They can also reject the other if the defined concepts of morality, social rules and structures are affected and not within their taught definitions [Lerner, 1966]. One other form of rejection can simply be that the observer, despite understanding and empathetic to the situation, deems any possible action too risky to their own well-being and personal goals [Gerdes, 2009]. As these forms of rejection do exist in empathy, there are potential set of variables and elements that may facilitate a positive empathetic reaction, starting with simulating elements from the Attachment Model. Some social psychology theories and practices believe that when provided flexible communication tools, a space that feels safe and inclusive, time for self-understanding and transform their intrinsic motivation and allowed freedom to choose their role in the exchange, empathy can be practiced and guided [Lenzi, 2013]. An Attachment Model integrated into the guided practice is crucial to construct a caregiving system representative of Empathy [Lenzi, 2013]. One such practice is Perspective Taking Theory. Independently of the reactions that may occur, when the subjects exercise observation and consider what the other is feeling, thinking, or acting, they are making a conscious effort to role-play the situation of the other, even if in their own minds [Decety, 2004]. Though a more effortful process, previous studies have shown that with this guided practice to appraise the other's situation when the other is not someone the observer might initially relate to or to their situation, has provoked an increased compassion and reduction of bias [Batson, 1997]. This means that there can be an active process of gathering information, listening, and reflecting on how to best interpret the other's point of view, independently of their differences and potential of rejection.

In general, the current theories focus on how Empathy is a phenomenon related to emotion sharing, with the help of reflexive, embodied understanding coming to three main values of caring for others, understanding others, or validating other's emotions. Yet there is a lack of detail in most theories about the process itself of how the appraisal or perception identifies that empathy was created for the purpose of further engagement and in building a relationship [Wondra, 2015]. In the search for clearer objectivity in this process in relation to creating a relationship between people and their technology, it might be worth to begin exploring how people make impressions of other people and objects.

Neuroscientific evidence shows that people are sensitive to social-cognitive demands when forming impressions on meaningful social objects, examining other's mental state and other traits [Mitchell, 2005]. This means that impression formation is not general but a selective process to further engage and have interest in the other. In contrast to inanimate objects, the impression formation in the brain does not activate in the same intensity as when forming impressions on other people, but it can be stronger when linked to a meaningful connection to them or as part of a story they can relate to [Fletcher, 1995]. To engage the impression, meaningful objects must carry relatable humanistic attributes or a strong assimilation to a person's values [Ahuvia, 2005]. Understandably this impression formation can lead to further engagement and interaction with the object. This can be in any type of activity, but it might give further clues of how empathy can be provoked if part of the focus studied is on what are the tools to create engagement facilitating perspective taking. As seen throughout the previous theories, communicating information and emotions are important to convey. A format that has been used in scenarios of transforming conflict into moments of empathy and trust, is dialogue [Head, 2012]. This is also explored and used to have people get closer or interact with artificial agents, robots, and computers [Bickmore, 2005]. Dialogue is used as a way of connecting the engagement and naturally speaks to a process of desired understanding of the other emotionally and cognitively in order to drive trust and empathy, with a goal of developing meaningful set of interactions through time [Head, 2012].

Self-Determination Theory (SDT), Motivation, Close Relationships, and Empathy

In the last two sections we observed empathy as a way of engaging in observation of the other and form a dialogue that can drive consistent exchanges through time. Yet, there is an aspect that is inherent in the exchange with others that appraisal theory and perspective taking theory begin to touch on: Motivation. The motivation to engage with other with the intent to generate meaning is essential to that dialogue. Both intrinsic motivation and extrinsic motivation (that is regulated internally) can drive an exchange, interactions with others and nourish relationships (Figure 10) [Ryan, 2000]. Though the motivation to act and engage with a situation and others is highly relevant, this only occurs when the three needs in self-determination (SDT) are considered within that exchange: relatedness, autonomy, and competence. When these needs are supported within a social context with others and artifacts, motivation continues to flow with the intent to continue engaging in the activities and relations people are having [La Guardia, 2008] In appraisal theory we already began alluding to the concept of relatedness as a key factor that facilitates connectedness with another satisfying the need to belong. Although this particular need is supported by extrinsic motivations, the care a person might have of the other, however slight, can help integrate and regulate that extrinsic motivation to be internalized. This means that relatedness can provoke an activity to be self-motivated [Ryan,2000; Thorne, 2021]. Even if relatedness is present at a minimum, in a social context, when the person's autonomy is respected, basically the freedom to willingly participate, have, or give control over a decision or situation is paramount to initiate and maintain engagement with the other. In a similar fashion, when the person is provided the positive reinforcement that they have the capability, tools and knowledge to complete an activity on their own with mastery, also affords the intrinsic motivation to participate and engage with others.

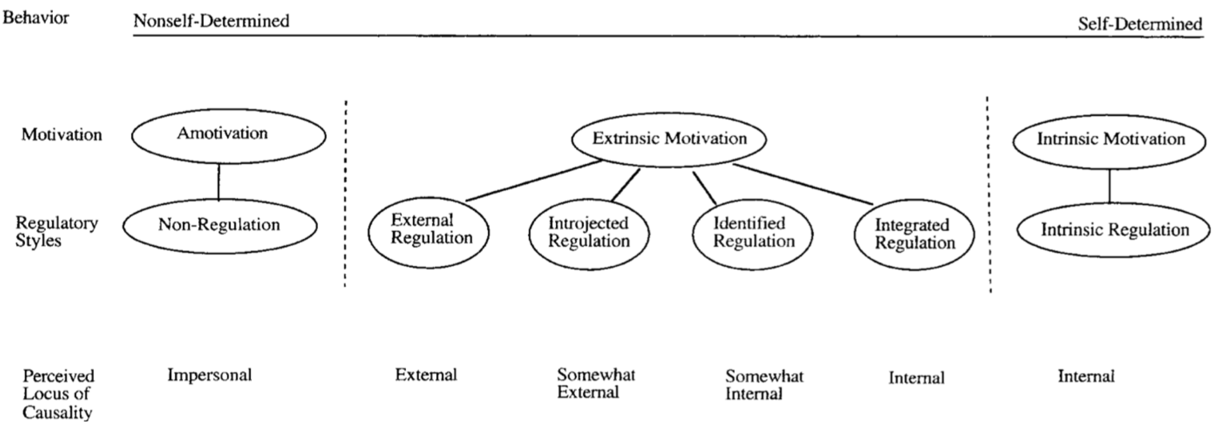


Figure 10: Self-Determination Continuum showing types of motivation with their regulatory styles. Ryan, R. M., & Deci, E. L. (2000). Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. American psychologist, 55(1), 68.

As essential as these are in engaging in activities with intrinsic motivation, they play a significant role in building relationships as well. Relations are bidirectional by nature, both sides need these pillars of self-determination to be present and respected for those involved to have the motivation to continue engaging and growing that relationship, no matter its nature [La Guardi, 2008]. When supported, and openly assessed, the participants become willing to relate with the other and become open to learn and expand their capabilities. People begin to trust, willingly take on other's perspectives which in turn encourages care, and the desire to better understand the other's needs and affective states [Thorne, 2021]. In a motivation study, Thorne (2021), focused on understanding the relation between self-determination theory and empathy in youth. They used a descriptive-correlation survey design with a series of peer-reviewed accepted surveys that measure the three self-determination individual needs and for empathy. The theories of empathy used were focused on were (1) perspective taking theory "the tendency to spontaneously adopt the psychological point of view of others" and (2) empathetic concerns "assesses 'other-oriented' feelings of empathy and concern for unfortunate others". It was deliberate to assess empathy from both the affective and cognitive aspects of empathy. The sample size of the study was close to 6,000 participants, from several countries, as they engaged in social activities within their communities. After contrasting the results, the questions considered within the Empathy index, had 100% positive correlation to the individual dependent variables of autonomy, relatedness, and competence as well as its relation to being intrinsically motivated to participate in their activities.

Affective Attachment, Embodiment, and Empathy

As we have observed in the previous sections, emotions are key to understanding empathy from its beginnings and continues to be considered the key for defining empathy. These emotions or affective states are not only felt but expressed physically whether in the intent of mirroring the other's potential emotions in a situation, or as a result of what the observer interprets can be the feeling the other is having in that moment. By both eliciting emotional and cognitive interpretation of an observed situation along with a physical response, the empathetic experience becomes embodied [Cooper, 2001]. Yet these emotions and embodied reaction become more impactful when the observed is an actor the observer has some form of affective attachment. Affective attachment occurs when a person fulfills the need for emotional closeness, safety, and security [Bowlby, 1980]. Affective attachment is present and develops continuously from birth all throughout people's lives. These affective attachments develop in 3 styles: secure, avoidant, and ambivalent as they represent the nuances of how the person believes they are worthy of love, and how others are worthy of their trust. As people grow there is evidence that secure affective attachments form when the primary caregivers have: accepted the child as they are and were sensitive to the child's needs. Throughout their lives, it has been observed that people growing with this attachment style exhibit greater empathy that children with other styles of affective attachment [Erlanger, 1996]. This transpires to other relationships people have throughout their lives, how they create and manage friends, coworkers, clients, loved ones, and their objects. Adults with a secure style of attachment are more willing to interact with others, engage in activities, reporting greater satisfaction in interpersonal relations, and more open to relating to others [Joireman, 2002].

Embodiment of empathy requires a relatedness that is only natural to humans as somatic beings [Cooper, 2001]. Not only do we relate to other people, but we also related to animals and objects. As we become more open to engaging with these other actors, and willingly care for them, their physical movements can provoke in the observer an embodied understanding of them [Darling, 2016], the same way a designer was able to understand the limitations of their materials, described in the previous sections. A study that reflects on this type of embodied empathy reaction is one where a person reacted physically and felt sorry for a Roomba vacuum cleaner stuck in underneath a sofa (Figure 11) [Sung, 2007]. These same somatic, embodied reactions can occur for positive feelings when robots or objects elicit positive affective cues [Paiva, 2017].

Figure 11: Roomba used in the study: Sung, J. Y., Guo, L., Grinter, R. E., & Christensen, H. I. (2007, September). "My Roomba is Rambo": intimate home appliances. In International conference on ubiquitous computing (pp. 145-162). Springer, Berlin, Heidelberg.

Neuro-scientific Presence of Empathy in the Brain

The vicarious emotions in empathy, appraisal theory, affective attachment and embodied empathy have been a big part of how scientists understand empathy in recent decades, mainly because the arguments are observed and detected in the human brain with the presence of mirror neuron and mentalizing system activity [Braten, 2007]. In order to detect the presence and trajectory of mirror neurons, which are considered a direct biological manifestation of empathy, and other activities related to feeling-sharing in the brain, fMRI is used as a main tool of reference.

fMRI studies reveal that Empathy lives in several related behavioral regions of the brain. On one part you have the somatosensory, insula, and limbic regions of the brain where mirror neurons have been initially detected and where the activity related to perception, imitation, and embodied recollection occur; or how they imagine they would act and feel after observing another person's situation [Morelli, 2014]. This region also exemplifies how people might instinctively physically react to an other's physical reaction imagining how they may be feeling or sensing physically. For example, Ashahr, Y.K., states that this region was also related to the concept of empathy distress as people observed others under duress. Yet, besides these regions of the brain, the desire for care almost automatically followed after observing distress. In this situation, the septal region of brain activated, mostly related to pro-social behaviors, partner support, and trust [Ashar, 2017]. Another fMRI study goes further than care, in a study that looked at indications of predicting prosocial behavior (Figure 12). This study found that beyond the instinctual process of understanding the other's pain through observation and indicating motivation to care, there are types of distress that require context. When people looked to the context of others, there was a layer of cognitive appraisal that helped interpret the other's situation driven by the mentalizing system. A manner of perspective taking, through their environment in order to observe and engage with more profoundness and care for that other [Lamm, 2007]. The mentalizing system in the brain is composed by dorsomedial and medial prefrontal cortex, temporoparietal junction, posterior superior temporal sulcus and temporal poles [Morelli, 2014]. For an additional layer to this, in studies related to the neuroscience of attachment, fMRI experiments have shown that secure styles of attachment can reduce distress-related activities and support people with better control in emotional regulation than people raised in insecure attachment styles [Vrtička, 2017].

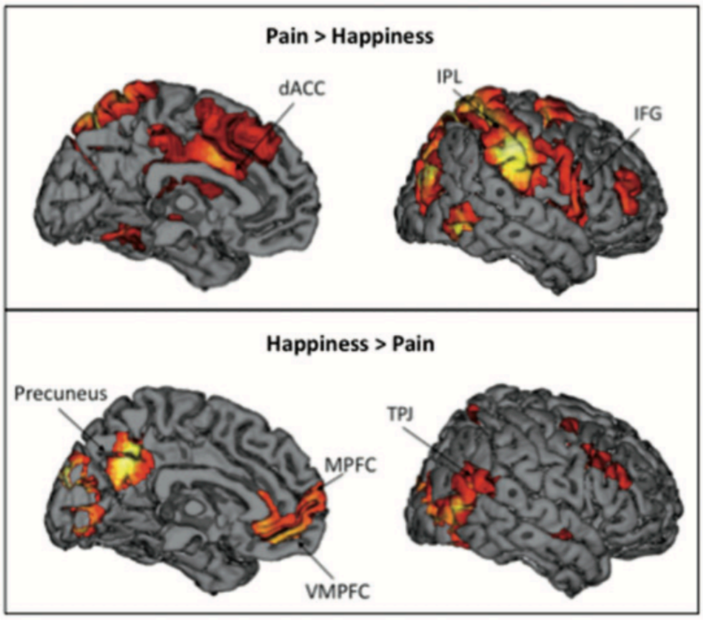


Figure 12: example of Morelli's fMRI depicting empathetic pain reaction to other's situation in pro-social behaivors. The neural components of empathy: predicting daily prosocial behavior. Social cognitive and affective neuroscience

These studies evidence three key points around empathy and its process: one that empathy may be induced by simply observing the other's emotional experience, but at times requires to actively learn about their context, meaning the environment they are in and what happened previously, taking their perspective to connect and understand them. This shows a direct correlation between mentalizing, mirroring, and empathetic altruism [Nakao, 2009]. Second, this also demonstrates that empathy is physical, sensorial, and embodied. Taking perspective and instinctively mirroring the other's emotions and feelings, moves the person to enact pro-social behavior, thus being part of the empathetic process [Morelli, 2014]. Third, these studies reveal that empathy appears in the brain at different times and places to create a correct affective interpretation. It remains unclear the path through the different areas of the brain the empathetic process takes to support the changes that happen. This also means that an empathetic process is flexible and malleable depending on other factors like context, the level of relatedness the subjects have with each other, or the perspective adopted during the observation [Singer, 2009].

These and many more studies related to mirror neuron activity and empathy have helped better understand key aspects of its process, providing tangibility to the array of definitions. But, as scientists continue to dig deeper, the understanding of the empathetic process becomes more complex and nuanced, therefore the exact mapping of where empathy happens becomes vague to pinpoint [Morelli, 2014]. Though it is a natural phenomenon, the evidence shown points to the idea that empathy is not always an automatic response but can also be learned or be a practiced activity through time [Strickfaden, 2009].

A Philosophical tool for Empathy

Philosophy takes a unique perspective that allows to see Empathy and other relational subjects and concepts from an analytical introspective point of view. The general observation around empathy has led philosophers to argue how it happens either purely by how people perceive someone else's emotions in a situation, or by how people perceive the other's situation overall. These arguments became a reference during a time when emotions and cognitive processes were studied individually and continue to be part of a larger debate as neuro-scientific evidence supports aspects of both arguments [Wondra, 2015]. Yet, part of the new evidence suggests that cognitive processes and emotionality occur simultaneously in the brain, analysis and emotional mimicry. This has led authors to evaluate what takes part in that cognitive analysis and emotional adoption, things like risk assessment, conversation, negotiation, and dialogue in order to maintain empathetic interaction [Strickfaden, 2009]. David Bohm, a respected physicist and philosopher, introduced dialogue as a process tool for sustained social interaction, ideal to exchange thought, and expression.

Dialogue as a process is "aimed at the understanding of thought as well as exploring the problematic nature of a day-to-day relationship and communication with the goal of making a shared meaning" [Bohm, 2013]. Dialogue is meant to be an open process where the people involved willingly express, share, and absorb mutual thought without the push of trying to win or make any one point of view prevail. As previously observed from perspective-taking empathy theory, the meaning each person forms in their own minds in reflection and consideration of the other may be similar but never exactly the same. Yet identifying those differences is precisely the key to creating something new in collaboration [Bohm, 2013]. This kind of communication can only exist if people freely listen to the other without judgement and the desire to want to know them as who they are without intent of influencing the other. The actors involved must have an open mindset interested in truth and coherence. Otherwise, without this premise, communication will fail. Because the purpose is not to convert someone else's perspective to their own, but interpret meaning beyond their own assumption, it is suggested that people come into the dialogue willing to challenge those assumptions to then actively cooperate towards something new.

Beside the structure of openness while listening to the other without judgement or reserve, the space each person is given to interject and express themselves is also

important in this process. This space should be perceived as safe and open enough for each person to have the sense of freedom to contribute their thought in the dialogue. This space may be physical and time based [Boukricha, 2011].
As the space is provided for the people in the collective, the tool of communication, the language used in the dialogue, is also a collective variable to be considered [Head, 2012]. Language is in great part a societal construct that is used to build individual assumptions, how society works, etc. Therefore, it is so important to pay attention to how things are communicated as individuals and as a collective. The type of language used depends on the collective context it is being used in, whether it's spoken, signed or other forms of communication.
As all these elements and structures unfold it becomes clearer that the process of a dialogue is cyclical with the potential for growth if the elements are taken with seriousness and care. As dialogues can shift and be dynamic in content and with how it is done, the consistency of practice can solidify the structure more and more having the actors involved feel more freedom and openness to delve deeper into how they make meaning [Bohm, 2013]. This means that with time, people will be more willing to share content that is more personal and intimate.
From the very beginning, as people look for truth and comprehension there should be a level of trust in the goal of a dialogue. This will translate to trusting each other as they continue to get to know each other in the process. With that time as people are more willing to freely share their personal and intimate perspectives, trust grows.
In parallel as trust grows, and consideration of being listened to is present, so is love, according to Bohm,D. What begins as a fellowship an initial care for collaboration, to active participation, and then friendship, means deep care or attachment can also grow out of a constant practice of dialogue [Head, 2012]. Most importantly, this parallel growth is a sign that coherence is met consistently, motivating people to continue the cyclical process [Bohm, 2013].
This kind of dialogue is present in all our day-to-day relationships, including that with inanimate objects [Lim, 2013]. There is a similar way of communication with our objects as with others, an artist has a relationship with his tools and materials. Though artists might have a clear picture in their minds, the material speaks to their potential, resulting in something similar to the expected. An artist should listen to this material and what was created and continue to evolve the work until it becomes a common result between the artist and their understanding of the material they used [Freedberg, 2007].
In summary, dialogue is a structured process with elements that need to be present in order to function: space, language and clarity of openness for truth and coherence.

Then these elements live within the premise of a constant conscious understanding of challenging personal assumptions and the willingness to cooperate with others. Once these elements and context are considered, only then can the steps of openly listening without judgement and reflective search for similarities and differences can be done in a constant cycle that makes constant meaning together. If this cycle continues and is practiced with time, openness and freedom become a growth of trust and care.
As the process of a dialogue is present in all or most relationships as a tool for communication and interaction, it is only natural, based on case study works, that it may be an inspiring tool for creating empathy and trust [Head, 2012]. As Empathy is not always an automatic response, the cyclical process of listening to the other in the search to match the other's perspective or assumptions, as a form of dialogue, may provide the necessary information needed to create Empathy. In consequence the practice of dialogue can elicit affective responses needed to best emulate an empathetic interaction. As an example, during an initial exchange as you are welcomed into knowing one another, the actors pursue truth and comprehension in a dialogue. People are open to taking the perspective of the other, searching to match the appraisal on what they feel, think and embody. So, when a person emits an emotional expression say a laugh, the other may reciprocate or mirror a response appraised to the situation. This initial indication allows for dialogue to open, and for empathy to take place.
One of the literary works that has inspired this philosophical stance, is the work by Seung Chan Lim, where he does a deeply reflexive study of his own personal experience and collected observations form other professionals that influenced his work in coming to realize empathy. His work, though not scientific in nature, has a comprehensive structure and terminology that resonates with current empathy work from the HCI third wave literature, the role of empathy in design, the structure of a dialogue within the HCI community, and the current applications of empathetic interaction with objects and technology [Lim, 2013].

3 Related works & Research Questions

Applied perspectives of Empathy within related fields

From economics and game dynamics discipline to anthropology and medical practices, empathy is present, and models have been constructed to best serve these fields, each with interesting focuses from motivation, curiosity, to trust and drive [Charon, 2001]. To discuss in detail how these disciplines focus on these concepts is pertinent and relevant to the work, yet it goes beyond the immediate scope of this thesis book. The literature used is considered within the pillars of the thesis, specifically how it is involved within human behavior, interaction with objects and technology, and the design process.

After having a general understanding of Empathy as seen by the academic community in psychology and neuroscience within the previous chapter, the following sections discuss and focus on the topic of empathy within the fields of art and design, HCI and subfield of Human Robotics Interactions (HRI). We are specifically looking at related works that also review and apply empathy or relationship driven cases. This exploration has helped identify that beyond theory, there are practical empathy models of interaction with the potential of being applied within scenarios like the ones we will discuss under the HRI sections.

3.1 Empathy in Art and Design

3.1.1 Meaning of Making

Despite the complexity and broadness of empathy definitions, there is something to explore when artists and designers continue to move and entrance people into sustained engagement through expressed tools of visual elements, music, literature, or dance. There is a long history of how "empathic processes are essential to the aesthetic experiences of visual and other forms of art" [Gernot, 2018]. These works create a story that the audience relates to as their own, mirroring their own perception and values. Their process to develop those stories may also provide clues as to how they are able to create empathy with an audience at a distance merely through the tool of expression [Koopman 2015]. Most artists talk about having a dialogue with their materials while also reflecting deeply on their own vision. And with that reflection, they embody their intention with the material they have at hand [Cadle, B. 2009]. Once created there are clear traces of motion, gesture, and intensity of emotion, where the observer can also interpret and embody themselves [Freedberg, 2007]. Brands also dig into understanding their audience, bringing them into the fold as part of their product and service development, so the perception of the brand continues to be relevant and intimate for each follower [Forlizzi, 2006].

An influential literary work by Lim (2013), recounts years of reflective experience around the process of making and how that relates to empathy. In his work, though not academic in nature, does echo much of what decades of study throughout a diverse communion of sectors have experienced in both observation and empirical evidence. The singularity of his observations is the clear and relatable metaphors and use of terminology to better understand beyond empathy itself, into what it means as a process. In principle, he is constantly reflecting from the point of view of an artist and designer as if an intimate look both of his own process and of other artists and professionals.

With all the literature around art, aesthetics, design, innovation processes, and its deep roots in empathetic relationship between artist-work-audience, here is a brief description of why it is important to consider this perspective of empathy. To decode visual language is to decode a tool of communication or dialogue [Strickfaden, 2009]. To clarify, this language does have grammar, syntax, and a series of formats that enable the optimal way of communicating with it. From the space it is viewed, the canvas it is drawn on, to the lines and use of color within its content, all have a role to play and a significance in its development [Horn, 1998]. And like any other art form, it requires time and practice, a constant iteration and conversation between the artist, materials, and audience until they capture meaning between them, a significance that moves both the artist and the audience [Mekler, 2019]. In that dialogue, what the audience can see is the artist exploring all the diverse ways his tools allow him to wield it, like a carpenter knowing how to cut, bend, and join the wood to make it stronger. Through the iteration and practice, the artist learns to measure their expectation of the material, listen, and care for his tools of expression the same as any professional that cares for their tools of work. It is logical to these professionals, that the moment a tool is forced to act in ways it is not supposed to, the tool reacts in a negative way, as if it speaks to its owner on what it can and cannot do [Lim, 2013].

In this close observation of craftsmen, artists, and designers going through the intimate process of making, it becomes clear that with the right environment, context and intention, a meaningful empathetic relationship may occur for the general public as well with their objects. Even more so if they represent or serve a profound purpose in their lives. Here is where in this book it begins to become clear that it is only natural to assume that empathy and its process can occur with objects, and with more potential when they are technological smart objects.

3.1.2 Art as a tool of self-reflection both in the artist and audiences toward Empathy

In art and design, there are at least two more steps in the process of expression and presence of empathy. The first one is at the other end of the author-canvas spectrum. Beyond developing empathy with tools and materials, the dialogue also exists in how the message or expression develops for the author. This dialogue within the artist as they use their materials is a constant process of self-reflection, keeping an open mind, and being critical with their work until the message they want to express to an audience is fully formed [Hardman, 2009]. This reflection is what they hope to instill in the audience as a metaphor [Robert & Kelly, 2010]. As artists and designers there is a constant process of shaping and iterating that is natural and needed for the author to conclude their work to have provoked enough meaning for them, and potentially for their audience as well [Schuh, K. 2003].

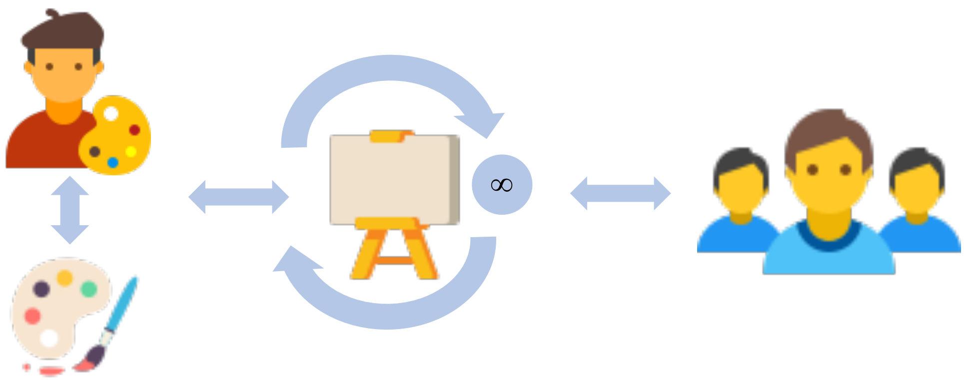


Figure 13: A visual representation of the interactions between artist, their tool, canvas, and audience.

The second step is within the exchange of canvas-viewer using the canvas or artistic result as the tool for communication from the author. At this point, the audience member visualizes or reads the message and can both empathize with the content narrative while also being provoked to reflect on that content [Koopman, 2015]. This dialogue between the artist and the audience through the canvas (Figure 13) can be an instance or become profound, long-lasting depending on the content, space, style of communication, and the expectation of the audience member [Hardman, 2009]. Interacting with work that proves profound can drive the audience to relate to the characters or the author, then to self-reflect, and even act on that reflection. We just need to reference literary works that have inspired movements and debate shaping our history [Koopman, 2015]. Now if we consider interactive works, that immerse the audience, often with technological applications, it brings the potential of empathetic interaction to embody the author's intentions, heightening the sense of connectedness between the viewer and the performer and their work (Figure 14). The intentionality of creatively embedding the audience within the author's expressed thought converging the narrative, space, communication tools, while challenging their expectations becomes a direct invitation to reflect, engage, listen, and connect with the narrative [Da Silva, 2018]. An interesting take-away from exploring empathy within the artistic process is the significance of self-reflection to both provoke and be provoked by the author.

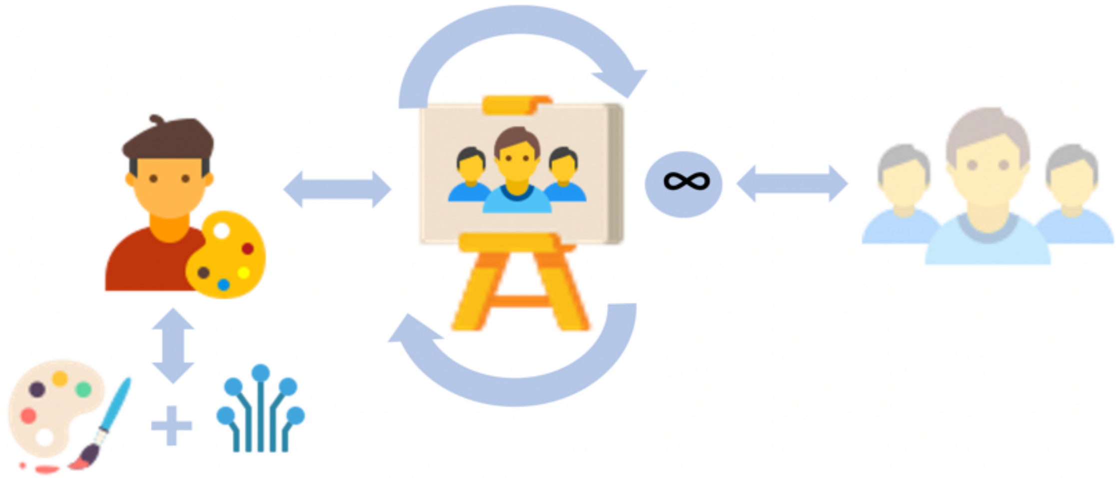


Figure 14: The interaction between the artist, their tool with the added element of technology and the shift of the Audience's role being immersed within the canvas the artist is using.

3.1.3 Empathy in UX and Innovation driven methodologies

On the other hand, for designers and design researchers, the perspective of the audience is precisely the main source of inspiration as they use the artist's tools to portray a closeness to that audience's perspective [Plattner, 2012]. User Experience (UX) practices converge between the understanding of the user's needs, the technological environment, and the use of visual communication tools. Yet the designs are driven by the users, their needs, their perception and reaction to what is being designed for the very beginning of their process. UX practice is a constant type of collaborative exchange with the end user within the specific context of the technological product or service being created [Wrigth, 2008]. Empathy, reflection, and dialogue through the design process is key to achieving the goal of the practice,

resolving users' needs, or facilitating the experiential use of technologies [Wright, 2008].
In the design process there are an array of tools and methodologies to approach the audience or users. Tools from co-creation activities to "in-the field" research of interviews, user stories, ethnographic techniques to the development of "personas," empathy maps, and user testing methods [Makki, 2020]. These tools and practices seen within Design Thinking Methodology and User-Centered Approaches, are considered to promote innovation and a new way of thinking. Though there are several frameworks with stages related to these practices, they all coincide in "Empathy" as the first step of the process (Figure 15) within these methodologies as a way to discover or understand the audience, their context, and needs [Kouprie, 2009]. This stage consists of observing, gathering, and interpreting the user in their environment, day to day needs, frustrations but also their goals and ambitions. It is about understanding anything and everything surrounding the target audience. Yet, the concept of embodying and relating to the audience is not limited to this stage of the process, but rather, like in UX design practices, it is very present throughout with workshops and collaborative sessions that encourage co-creation, prototyping, and testing [Planttner, 2010].

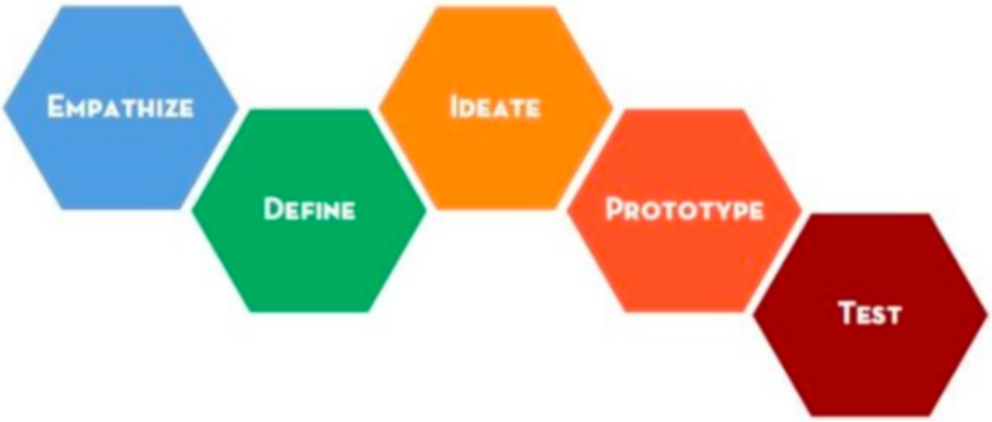


Figure 15: Design Thinking Process as designed by Stanford School Design Thinking Program, (Meinel, 2010)

The process itself, in practice, is a constant movement back and forth with iterative interactions with the end user, where designers intentionally come into conversations with users with an open mind, testing their own perceptions and listening, in the hopes to find insights that have inspired them to create and refine. This process continues until there is enough evidence that the results from the exercises resolve the user's needs and generate meaning for them [Planttner, 2010].
Visualizing Empathy within these practices, seems to take the form of a process due to its level of implication in both the practitioners and their targets. While a key

difference between these design practices in comparison to the artistic process, the author of the solution is in direct and constant dialogue with its audience (Figure 16) with an open mind, without pre-conceived ideas to what should be the user's experience but rather allows results from the dialogue to inform that designed experience [Makki, 2020]. Yet, one thing that remains in common, is how these processes prove results and meaning that lasting through time. Art pieces that become "classics" while the design practices push innovative solutions forward [Jones, 2018].

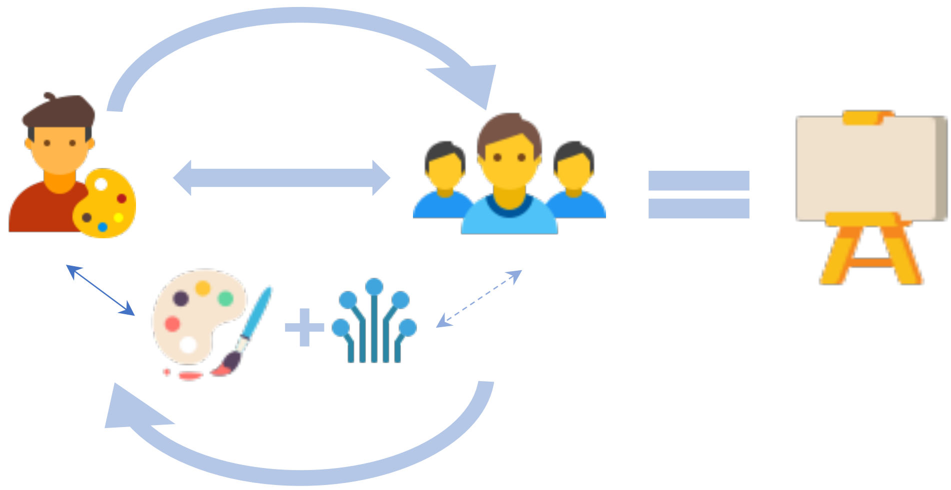


Figure 16: The interaction between the artist and the user within a collaborative scenario as both make meaning together within a shared canvas.

3.2 Examples of Empathetic-related indicators in HCI

3.2.1 The role of User-Centered and Service Design approaches in HCI

In HCI, UX and Innovation driven design practices are acknowledged as an important practice for delivering practical cases in the field. Although, the disconnect of the practices makes it difficult to transfer the full breadth of each other's knowledge there are some efforts that hope to bridge that gap [Colusso, 2019; Yoo D.,2019]. Below are some models and examples that are relevant to empathy and relational experience within HCI.

As it was discussed in the first chapter, there have been attempts to understand the gap between design practice and theory within the HCI field. Within those attempts groups of scientists and designers showed a growing interest in experience design in

HCI accompanied by a rich interdisciplinary discourse that included topics such as the aesthetics of interaction, affective computing, ludic engagement, and others [Bohner, 2007; Forlizzi, 2006, Gaver, 2004]. These efforts have driven areas within HCI that broadens theory and framework scopes and impacts [Blyth, 2006]. Among them we find the series of Works by Wright P. along with other authors, has explored the concepts of User-Centered, and user experience design methodologies to as a tool to improve HCI theories and methodologies. There is a significant challenge they perceive in the process "to know the user" and to understand their experiences within HCI. They have been able to bring together a number of qualitative measures to support that process as well as to define what that process may look like: for example, they used tools like scenarios, role playing, and personas, among other tools. They identified 3 potential approaches: the measuring approach that focuses on aspects of the experience that can be measured, the empathetic approach that hopes to find meaningful emotional encounters through techniques that allow designers to understand the user, and the pragmatist approach that sees experiences as the basis for all interactions. In the above approaches they realized that there was a slight common thread of affective and empathetic disposition. But they were inconsistent between each other when reviewing the response of the other and observing the full breadth of the experiences and how they can be applied within HCI cases.
On another related work, Yoo D. 2020, argues that service design perspectives, could provide significant contributions to design oriented HCI research due to its ability to map and understand complex sociotechnical systems. Its process and detail node-oriented approach can provide further layers to bridging the practice and theory of HCI. Yet, the perspective taken in her work is limited within the narrowed perspective of the relation between people and the services that they use, rather than taking into consideration the parent practices that Service Design lives within for example, other Design thinking methodologies. By viewing the practice through the narrowed perspective, it creates a focus on commercial implications and relationships that does not translate to other aspects of the HCI discipline.

3.2.2 Extended-Self Theory and the meaning of objects

Extended-Self theory began with the meaning objects had to people for various reasons as they represented aspects of themselves that felt intimate and profound, in essence a part of themselves. Objects help support or express parts of a person's identity within a certain context, time frame, or aspect of their lives. Which in turn, they develop a caring relationship with their objects, both ensuring their longevity, as needed, and mourning for their loss as well [Belk, 1988]. Since 1988 this theory continues to ring true and with even more relevance as people have gained digital, virtual, and smart possessions that deconstruct and are attributed a whole different set of needs from physical analogue objects [Belk, 2013]. As objects can identify their owner's patterns, overall behaviors and emotional cues, while also expressing on that data, the relationship people carry with their objects shift or rather becomes more intensified [Schweitzer, 19]. A whole set of relational variables that were present before, gain much more importance like trust and freedom of control. For example: in [Schweitzer,19]. users felt a better relationship with objects they perceived as their servants rather than an equal or when they exhibited relatable emotional cues. With analogue objects these existed, but as soon as the object no longer worked as it had, it may have often been kept around as keepsake or memorable trinket. Now these objects can learn, remember, respond, and even add value to a collaborative setting with a human-like voice and colloquialisms. If these talking objects fail, they might not be treated with the same nostalgia as physical objects once did [Parasuraman, 1997]. Many objects have reached a level of integration in people's lives that seem to have caused an empathetic interaction with their owners or a sense of "deeper connection", we just have reference once more the percentage of users who professed love to and desire to marry Alexa, as well as the novels dedicated to Siri and their user's love for their AI digital Assistants [Newman, 2017]. Yet there is still much to understand in the complexities of day-to-day interactions within a variety of contexts and needs a person may have.

As a person builds their sense of self, technology has the tendency to enhance, the perceived capabilities and human sensory systems [Heersmink, 2020]. This perceived enhancement as it impacts their relationship with others and their contexts can produce extreme behaviors toward the objects, particularly that of complete abandonment or over dependency, coming down to the owner's sense of control over the device [De Santis, 2019]. Beyond how people perceive themselves using their technological objects, the form they take also shift the way owners see themselves and the tangibility of their ownership, therefore how they relate and connect to it. Other factors come into play to impact on how a person perceives them as part of themselves: control, effort to gain and maintain, the fleeting nature of the product itself [Kuzminykh, 2020].

3.2.3 Affective Computing

In the previous areas of study in HCI, there is an aspect that present and even De Santis claims its importance for maintaining a relation between an owner and their technological object as a partner: Affectiveness. If a person believes their objects can correspond with their emotional states, they will maintain their relationship with their object, while the opposite is also true, if the object is not able to sustain the emotional connection with its owner, the user will abandon the object completely [De Santis, 2019]. This type of emotional connection is becoming more and more present as a key factor in the technological objects we create for users, except it takes a different form than from analogue objects. In HCI, Affective Computing has taken root as the ultimate reference to create machines that can perceive and express affect [Picard, 2000]. It is becoming more accurate and helpful in catering to people's emotions in decision making [Boukricha, 2011], yet the programmed devices and people's emotions remain separate and distinct [Belk, 2013]. For the device to be supportive of human emotion and compatible within a process that helps establish long-term relationship, the device must mirror people's own emotional and cognitive states clearly, otherwise, profound Self-Reflection will be inconsistent [Bohm, 2013]. Taking emotions into consideration with the goal of establishing a long-term relation between people and their objects is vital, as we see repeatedly throughout the theoretical framework of this thesis, therefore affective computing influences are vital to this process as well. This piece if the puzzle must work in sync with other variables for the relationship to withstand time and evolution like managing expectations and using the correct type of language for the affective interaction [Bickmore, 2005].

3.2.4 Managing Expectations in HCI

The relationship people have as owners of their objects can be profound and fickle depending on their sense of control or mastery, context of use, if the object is physical or intangible, among other variables, emotionality being highly relevant. But the play of the object's functionality with the emotionality they carry can dramatically shift in matching the expectation users have of their own objects [Trapp, 2018]. For a correct maintenance of the person-smart object relationship, it is important to consider how the user's expectations are formed, managed, and regulated throughout their experiences, therefore it must always be clear, despite endearing characteristics, what the object is for and what it can do for the user consistently [Bickmore, 2005]. Users will have clear initial expectations of their objects when obtained, but as time and practice happens, they may adjust their expectations without positive or negative affiliation. Soon enough, after some use and taking into consideration other characteristics of the object, the user can become disillusioned with the object, or it exceed expectations, these results can be an initial predictor for trust in the technology [Lankton, 2014]. Though it is difficult to force a person to form an expectation or opinion of the object to be used, there are tools that help instruct the user to help regulate their expectations [Bickmore, 2005]. This shaping of how a user can perceive an "other", in this case, a technological object, is also present within Empathy studies. The perception people have of others through mentalizing and affect sharing, while observing the situation's context, helps establish a baseline of what is expected. But, as the actors become involved and converse, the expectation may not match exactly or rather the expectation shifts based on their mutual understanding. [Trapp, 2018]. What is important in the role of expectation within empathy is that the actors who interact with each other step into it with an open mind, open to let their expectations regulate as they dialogue with each other to create meaning [Bohm, 2013; Strickfaden, 2009].

3.2.5 Quantified Self and empathetic objects

An area of knowledge that takes to heart the management of their own expectations in their experiences and the tools they used is Quantified Self. This practice revolves around the premise of people being able to track their own habits, body statistics in order to improve their health and make their day-to-day habits more efficient [Swan, 2013]. This discipline has the objective to give people deep and varied knowledge of themselves so they can reflect and act in their own best interest. With a fast and rising following, its process and delivery is attractive as people engage in a conversation with their own bodies through data and the technological tools that provide that data. Embodiment continues to be a clear variable in how people perceive and feel other's experiences physically and emotionally, but there are times when people do not understand their own bodies or their habits impact creating dissonance between what they perceive, feel or should be feeling or embodying [Choe, 2014]. Quantified Self allows people to examine, learn, and above all, understand themselves and their situations. Though it is about self-knowledge, there is a sense of relationship building of their own bodies through their technologies that is highly emotional and reflexive as people hone their intuition around their habits and what they really need. The technological tools they use for these practices become essential to them, deepening their meaning and function beyond their core use as an extension of their emotional

and physical support. Many practitioners delve deep into researching and understanding their tools for quantifying the habits and aspects of themselves that needs tracking, telling of the type of connection they seek of these smart objects [Choe, 2017].
The process in which quantified-self practitioners go through is very specific and particular in order to achieve self-knowledge with set markers, that if not met, can cascade into a derailed understanding of themselves. Their technological tools are not immune to this process and can confuse or skew the person using the device while tracking their activity. Yet the concepts derived from [Li, 2010] do give an insight into the importance of listening and reflecting on information both quantitative and qualitative of themselves, and how the tool captures them. Mainly because even though the device "listens" or captures data, the person also acquires a version of that knowledge with qualitative information: how they felt at each turn, the emotions they had, and their context that the device itself might not be able to contain. This duality means that the person must be flexible in understanding that the device might not be as complex as they need it to be while also reflecting on the importance raw data can have, better interpreting their situation and shift their perspective about themselves [Rivera, 2012]. In essence this practice of constant listening to oneself and their surroundings while also having to reflect and analyze with that data, is a way of empathizing with themselves and their tools, or at the very least a way in which they can begin an empathetic conversation with others in the same practice.

3.2.6 Persuasive technology

Many tools, particularly used for quantified-self situations, tend to use an interaction intended to nudge or persuade a user towards a particular action [Ijsselsteijn, 2006]. This is part of the more general practice of persuasive technologies meant to serve as a way of supporting users in having more efficient processes and habits [Fogg, 2003]. In this sector the technology "listens" to the user, learns from their behaviors and sets goals with them. By using persuasive techniques of interaction like game mechanics, it intends to steer the user in the direction they had set out for themselves. There is significant evidence that persuasive, game-like designs and highly effective to initiate engagement and motivate people to change people's behavior that can become intrinsically motivational [Orji, 2017]. Yet mounting evidence, suggests that this active engagement with the user has caused a series of effects on the user's long-term interaction with the smart object's behavior from over dependency to complete abandonment [Parasuraman, 97]. When this approach is used literally to design interactions for long-term use, it will generate an unsustainable effect of human-technology relationship [Lee, 2017]. Despite the extreme effects this type of interaction design can provoke, when adhered to other relational processes, at some level it can add value to the experience of the user, but it must have the intention to allow space for the user to self-reflect, learn, and respond accordingly [Baumer, 15].

3.2.7 Empathy and Prediction

Practices like persuasion and nudging towards a set of actions implies that the technology can consistently predict the user's needs without a motion to consider if the interpretation is correct or not [Fogg, 2003]. Even though, one of the ten usability heuristic rules, the object interface should provide tools for control and freedom of use [Schön, 2017], the reaction of the technologies being used to promote improved well-being tend to suggest actions or outcomes to the user as if giving assurance to the user implying that they have done a good job of understanding the situation, at times more so than the users themselves would have been able to [Parasuraman, 97]. This creates a sense of doubt that when verified, it can create a breach of trust in the technological object [Rovira, 2010]. And yet despite knowing that the technology is infallible, users continue to use them, starting an unhealthy relationship with their objects. Therefore, it making smart objects "predict" users' needs does not necessarily equate to the objects empathizing with their users, but just that, they are trying to predict the user's needs. In the last decade there has been significant advances in predictability capabilities for technologies, becoming more precise and ubiquitous, but the result of these predictions used in consumerism, for example, has provoked a debated response among audiences that at times perceive the practice as intrusive [Gironda, 2019]. Many of these predictions that occur without direct contact or dialogue with users tend to inadvertedly misjudge the user actions proving to frustrate the audience [Slavny, 2018].

3.2.8 Human-Centered Technology

As we continue to observe the impact and value of creating a deep empathetic relation between people and their technological objects, it is even more so when they become active participants in our work and creative processes. Human Centered Technology is an umbrella term that engulfs many research lines that want to ensure people and their complexities are well integrated and considered within the design of technologies [Jaimes, 2006]. Another discipline beneath this term can be Human-

Computer Collaborations. Collaborating with technology is evolving as the complexities of human needs and reaction to their technological objects is revealed as well as the smart objects become smarter [Seeber, 2018)]. From the human perspective in its application, the interaction that they engage with the AI object varies with specific sets of behaviors that relate to the relevance of control and willingness to collaborate with the AI object [Gudzial, 2019]. What is evident across experimentation and studies is that AI objects and technologies will acquire enough knowledge to evaluate and decide on their own, but in the center of the collaboration is a dialogue of argumentation, whether between them or in the reflection the user makes on their own when implementing the technologies assessment [Azhar, 2012]. To include the human needs within this collaboration means to consider their need for control and sense of freedom of choice, if that element is respected within the collaborative scenario with a smart object, they might perceive it as a peer, marrying the initial concept of how they relate to their objects as an extended form of the self. To acknowledge the vastness and limitations of each actor is to acknowledge they can complement each other's knowledge and abilities. As much as technology can advance in relation to patterns and endless generation of possibilities, in everyday circumstances, there are unforeseen variables that may occur, and the machine will need the vision of the user to adjust their analysis. At the same, because of the efficiency, speed, and data analysis the machines can do, the user may have the option to be willing and open to the machine's point of view. At this point they should have an open platform where they can argue each other's points for true collaboration [Fong, 2003]. Through this back and forth, there can be control, consensus, and knowledge realization for both the user and the machine.

3.2.9 Collaboration Models between human-technology in HCI

In HCI, smart objects, digital assistants and tools are becoming an extension of our sense of self, an extension of how we interact with others and our role within a community. They can represent an emotional state, as well as persuade us to take other cognitive actions. To some, these objects are our servants, to others they are becoming our equal [Schweitzer, 2019]. Independently of how we perceive these objects, they are taking on an active role in our day-to-day habits and decisions as we hear their suggestions and consider the value of their input. Effectively they become our collaborators or at least participants in those habits and decisions. So, it comes to no surprise that collaboration and cooperation models for HCI are having a surge in recent years [Wang, 2020]. Though not a new concept, in "Man- Machine Symbiosis,"

J. C. R. Licklider (1960) originated the concept of symbiotic computing [Licklinder, 1960] the evidence of its impact and implications has made this notion more significant to explore as collaborators, and partners, for example AI-powered Clinical Decision Support systems (AI-CDSS), customer service chatbots [Yi-Chia, 2012], and automated machine learning (AutoAI) [Dakuo, 2019], among other potential applications. These systems are designed with great promise to work together with doctors [Mies, 2017], customer services, and data scientists respectively [Zhang, 2020].
The consensus among works is that "Collaboration is a process in which two or more parties work together to achieve shared goals. For collaboration to be effective, there must be: agreement of the goals to be achieved; allocation and coordination of tasks to be performed; shared context keeping track of what has been done and what remains); and communication to exchange information and solutions" [Fong, 2001].
The main approach engineers took, particularly at the start of this trend, to facilitate this collaboration is by emulating Human Interactions of collaboration and natural characteristics. This means developing machines that emulate language, behaviors, other human-like abilities, while making the computer a more intelligent partner [Fong, 2001, Rich 2001].
Yet as Dakuo (2020), Changhoon (2018), among other contemporaries, have practiced a sense of collaboration and cooperation between humans and AI- based agents by simulating a common context, a common language that was both easy for the machine to interpret and for the human to interact with (not requiring the machine to emulate human-likeness), a shared goal between them, a dialogue format of discourse among the actors, while using tools that motivated human curiosity to interact in the scenarios.
A result from the collaborative approaches and understanding of the types of perceptions people have of their objects in these scenarios is how trust in AI-agents and robots is being enabled, forming a clearer structure for researchers [Dakuo, 2020]. This trust, as is attachment to objects (previously mentioned under the Extended self-theory) can be fickle in nature, as well as influence each other. It can grow and be sustained if there is a balance in the sense of control, transparency, and expected results [Dakuo, 2020, Schweitzer, 2019, Lankton, 2014].
Although there is significant advancement in this field, there is one aspect of the collaborative engagement that seems to have eluded all the previous works mentioned: the motivation to initiate and maintain the collaborative engagement in the first place. Persuasive technological approaches can be part of the answer, but because it cannot be sustained, it is unreliable for a long-term relational engagement or empathy. What has been revealed from ludic activities is that they remain activities

designed to motivate by curiosity exploration rather than having external pressures or defined tasks, allowing for a sense of freedom and expression that otherwise can be hard to achieve [Gaver, 2004]. To sustain motivation in collaborative scenarios also means sustaining an empathetic relationship between actors. There are clear parallels between them as described in chapter 2. Looking at trust and collaboration models in goal-oriented studies, the most effective strategy to engage in successful long-term collaboration is to strike the right balance between intrinsic motivation and outside incentive [Bond 2018]. Each actor has their own perspective, objectives, emotionality, and traits. When a created scenario targets some of these traits that feed intrinsic reward, the human actor is more willing to participate and engage in collaboration. Extrinsic incentives can feed to the scenario therefore to the sense of reward the actors can perceive toward the goal [Mekler, 2016]. This sense of direction done together in collaboration as it feeds their intrinsic motivation with external incentives, only enhances the goal, beyond function and gives it purpose and meaning [Mekler, 19].

3.3 Empathy in artificial agents

Given the strong role empathy plays in shaping communication and social relationships, it has been identified as a major element in human-machine interaction [Bickmore and Picard, 2005]. There is evidence that people can feel, care for, or distress over their peers as well as game characters and even robots [Ashar et al., 2017]. Paiva et al. (2017)'s survey comprehensively addresses different case studies and agent-empathy models describing how robots and artificial agents can induce empathy with their users (Figure 17). The authors distinguish between two perspectives for defining the nature of such empathic situations: (i) empathy is evoked in users because of the observed states, i.e., the agent's features and contextual situation the agent is immersed in (e.g., Hayes et al. (2014); Rosenthal-von der Pütten et al. (2013); Riek et al. (2009)); and (ii) the agent displays an empathic response towards the observed user's emotional state. In this case, mirroring the user's emotional state (emotional mimicry) is typically proposed to adopt an empathic response of the robot [Leite et al., 2013] such as in Gonsior et al. (2012) and Hegel et al. (2006). More comprehensive models for emulating empathy beyond mimicry have been also proposed. For instance, Leite et al. (2013) propose a perspective-taking-based empathy model. The robot infers the user's affective state by analyzing the game the user is playing from his/her perspective and reacts accordingly through facial expressions and verbal responses. Obaid et al. (2018) present a rule-based system to trigger appropriate empathic responses of a tutoring system for children.

More recently, Bagheri et al. (2020) propose a reinforcement learning model based on facial emotional recognition to learn empathic responses (verbal utterances) according to different states.

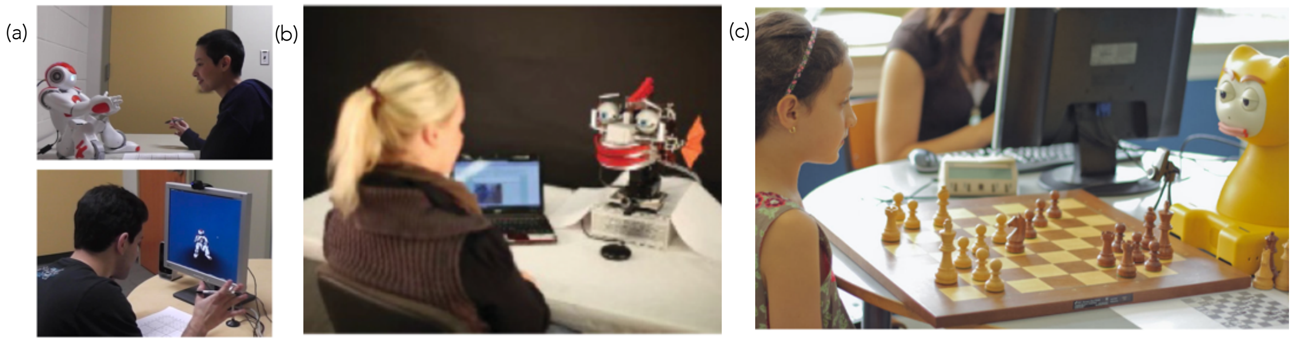


Figure 17: (From left to right) (a) Poor Thing! Would You Feel Sorry for a Simulated Robot, studying the difference in compassion between a physyical and simulated robot. (Seo, 2015); (b) Gonsior, 2014 , robot "Eddie" conversing with participant. (c) A child playing chess with iCat (Leite, 2014)

Besides understanding the features of the agents to induce an empathetic response from the user, we believe that it is equally important to provide a process by which the involved agents can be led to the realization of empathy. Dialogue has been often used to create such spaces of exchange and understanding to promote the development of empathy. For instance, Aylett et al. [2005] introduce FearNot!, where through dialogue users interact and engage in empathic responses towards bullied virtual agents. Rosis et al. (2005) present an embodied conversational agent that acts as a therapist. The goal is to achieve involvement between the agent and the user to support eating habits change.
More recently, Morris et al. [2018] proposes a conversational agent that could express empathetic support to enhance digital mental health interventions. Alves- Oliveira et al. [2019] show that an empathetic robot endowed with empathetic competencies fosters meaningful discussions among a group of children. Cunha et al. [2020] sets up a shared space between a user and a social robot that ex- pressed affective states as they collaborate deciding together in resolving a physical construct of pipes. In these recent studies, we can observe a shift in the robot's role from being a mere companion that shares the emotional state of the user (e.g., Leite et al. (2013)), towards an agent that "shares understanding, offering new perspectives" [Morris et al., 2018] and that such agent is a "means to open up discussions and raise awareness of others" [Alves-Oliveira et al., 2019] among the participants. Moreover, Cunha et al. [2020]'s study revealed that for "fluent inter- action and building trust, the robot needed to actively contribute to the work and continuously communicate its reasoning and decisions to its human co-workers". It is thus suggested that a shared immersive physical space

and opportunity for the robot to argue as they made decisions, augmented a positive collaborative experience for the participants. These concepts are reinforced by other studies that support the significance of having a physical shared space with a robot while playing a collaborative game [Seo et al., 2015] on the one hand. And on the other hand, the use of an argumentation-based dialogue framework between user and robot results in the user being more satisfied in their collaboration and feeling more trust for and from the robot [Azhar, 2015].

3.4 Empathy in Robotics

Given the strong role empathy plays in shaping communication and social relationships beyond others but also with themselves and their objects, it's only fitting that empathy is also a major element in human-machine interaction [Bickmore, 2005]. There is evidence that people can feel, care for, or distress for their peers as well as game characters and even robots [Ashar, 2017]. Paiva's survey work comprehensively addressed different case studies and agent-empathy models to best describe how robots and artificial agents can evoke empathy with their users. Despite the diverse definitions explored, the most comprehensive and used for agent or robot related empathy with users is De Waal's definition on empathy: the capacity to be affected by and share emotional states of another, assess the reason for another's state, and identify with the other, adopting his or her perspective." [DeWaal, 2002]. This definition has allowed to contextualize the study of empathy with robots to be considered as a process in which that artificial agent or person have or express feelings congruent to the other's situation than with their own [Paiva, 2017].

Although currently many artificial agents use the OCC (Cognitive Appraisal theory of Emotions, Ortony, Clore and Collins) model of emotions to be perceived as empathetic [Ochs, 2008], Paiva, can complement their work with other studies and authors that also consider reflexive and dialogue driven models toward empathy. This also means that more and more these models result in designed interactions of empathetic driven and provoked by vicarious emotions, a focus on care and distress empathy, dialogue driven interaction, and others [Paiva, 2017].

To best achieve this behavior, Paiva (2017) considers that there are three main considerations: the mechanisms in which empathy arises, the modulation of emotions and intensity of empathy, and the empathetic response by which it is expressed and communicated for actions to be taken [Paiva, 2017].

Part of the mechanism that has been widely evidenced is the instance of mimicry [Wachowicz, 2016]. This imitation of another's expression means an openness to engage with the other, or that there is a level of relatedness. When a person sees an agent or object mimic or have human-like attributes and behaviors similar to their own expression, people will react to a mimicking that is similar or relates to that which was expressed by the agent [Wachowicz, 2016]. Another, related aspect of mimicry is the anthropomorphic characteristics agents can be designed as a factor that may enhance social effects and emotions in humans. This is the initial impression people will have of these objects. With humanistic elements in both their aesthetic and behavior the observer will relate to them more and provoke meaning to them than when they are neutral [Epley, 2007].

Modulation factors considered are features related to observed emotions, social relationships, and the context of the situation, as depending on the intensity, it may impact more or less the perceived level of empathy. This means that behavioral transparency and consistency is important for the observer to be willing to further engage in empathy and rate the intensity of the empathetic interaction, this means elements of communication like language, expressiveness, movement, etc. This behavioral transparency must be seen as congruent with the information communicated to the person and the emotions linked to the content itself [Strickfaden, 2009]. The existing relationship and known intention, that the agents might have with the target either when they know each other or through time may also impact the perceived intensity of empathy. It is not that same a familiar person or agent, then a new object. Finally, the context of the situation and its proximity also affect the level of intensity of empathy. When the actors engaged in empathetic interaction are in proximity rather than absent or far, the empathetic experience will be felt more intense [Boukricha, 2011].

The last consideration of empathetic response, as De Vignemont & Singer argues, that empathy only exists of the observer is in an affective state and open to correctly appraise the other's situation without judgement. Therefore, the result of the empathetic process is a felt emotion by the observer which can trigger specific behavior. The response can be expressed or communicated through facial expression, body expression, physiological response, action tendencies or spoken [De Vignemont, 2006]. In the case of case studies that evidence how artificial agents and robots can evoke empathetic interaction here are three.

One example was developed by Rosis et al. (2005) who created an Embodied Conversational Agent that acted as a therapist driven by a model of dialogue. The goal was to achieve involvement between the agent and the user to help change eating habits. The results correlated positively to the behavior change and the agent's involvement opening the analysis of its impact in evoking empathy [De Rosis, 2005]. In a similar case study called FearNot! The dialogue and emotion expression are used to motivate users in the interaction and response of engaging in empathic process. Other elements that played a significant role was the context and clear goal of the agents and participants [Aylett, 2005]. A case study more clearly exemplified with robots is Gonsior et al. (2012) who created a system where a robot called EDDIE was able to perceive facial expressions and engage in small-talk dialogue through identifying key words. In the use of this robot the experiment conducted had a control neutral expression while the experiment led the robot to be able to respond and shift its internal "emotional" state according to the situation and hat it perceived [Gonsior, 2012]. The result of this experiment showed that people felt more empathy towards the robot when it expressed emotions & mirrored the user's expression in contrast to neutral response. The use of small spoken dialogues with affective expressions made the user want to help the robot in the exercise and exhibit empathetic behavior.

In all these case studies the three factors that needed to be considered were present, some at a higher level than others, but when present provoked the empathetic response needed to achieve meaning between the actors.

Though there is still much more room for growth, already there are clear indications that introducing: clear signs of affective states mirrored from the observer's emotional state, use of dialogue (whether pre-determined or not) to provide information exchange as well as a tool to process consideration of the other, and finally the manner of response to that consideration are relevant in approaching an empathetic behavior with Robots.

3.5 Objective of Empathy and Summary of common elements

Taking into consideration the evolution, transformation, and degree of difference in the perception of Empathy across disciplines and their applications, the objective of Empathy also becomes spread out according to the needs and perspectives each take. Because the definition of Empathy is varied, to distinctly and ultimately define what is Empathy is beyond the scope of this thesis. Rather, this body of work accepts that Empathy can occur in multitude of scenarios with different kinds of subjects and levels of interaction. Taking into consideration the different perspectives across disciplines, rather than emphasizing on the instinctual or automated revelation of Empathy, this book focuses on analyzing how these different perspectives identify the process to reach Empathy with other people or with technological objects. We believe there are parallels that can be drawn among them, proposing a process with steps, elements, and variables that need to co-exist for the result in an empathetic interaction to occur. We take into consideration both the congruence of terminologies that help define those variables, elements, and steps, as well as their interconnectedness and structures. Based on the general acceptance of Empathy we will adopt the following definition of Empathy and its objective: Empathy is "the capacity to be affected by and share emotional states of another, assess the reason for another's state, and identify with the other, adopting his or her perspective." [DeWaal, 2002]. This definition has allowed contextualizing the study of empathy to be considered as a process in which an agent or person have or express feelings and cognitive notions congruent to the other's situation than with their own [Paiva, 2017]. In Chapter 4, the considerations for the theoretical construct of a process to realize empathy is explained in more detail.

3.6 Research Questions and Objectives

It is only fitting that after the compiled survey of references, maps, and related works, the path of the thesis becomes refined and the questions that align within that path become clearer. In this chapter we will state the main gaps, problems and opportunities that were found after collecting the theoretical framework of the thesis book. From that analysis we expose research questions related to the key elements that shape the thesis project: the role of design in HCI relationships, Empathy and HCI related questions, and Empathy in HRI engagements. Though we initially researched and intended to work on HCI case studies, we decided to focus on the branch off HRI. Cases related to Artificial agents and robotics within the bibliography collected made it clear it was a discipline that directly engaged in the discourse and opens the opportunity to facilitate implementation of this thesis book's proposed practices.

3.6.1 Problems, gaps, and opportunities

Based on the gaps found in Chapter 2 and studying the works in the earlier sections of Chapter 3, in this section we reflect the problems, gaps and opportunities within 3 main areas pertinent to this thesis book. First, (1) the problems and gaps found on the role of design in empathetic relationships within HCI; second, (2) the role and implementation of Empathy within HCI discipline; and third, (3) more specifically the role of empathy within Human-Robotic Interaction (HRI) engagements. Particularly the first two englobe the gap found within the map of HCI theories, while the third is an applicable discipline, that according to the related works, the role of design and applied empathetic theory is still in being developed.

The role of Design in Empathetic relationships and HCI

PROBLEMS and GAPS

1. Lack of connection between design practices and HCI implementations both academically and commercially, while engineering and scientific-led results tend to be adopted more easily in those environments (Figure 18) .
2. It is not clear what are the best methodologies, strategies and tools that can be taken from design efforts and implement within the HCI development process.
3. Engaging in artistic or creative processes as a driver in HCI research are both new and relatively marginalized, seen as interesting experimentations with difficulty of translating to practical cases.
4. There is a general perception that the use and measure of creative tools in scientific research is susceptible to subjectivity, making efforts to measure their applications non-reliable at times.
5. Unless there is an active designer or UX specialist as part of the research team in HCI experiments that intend to use creative tools, most often, researchers are unclear or unaware as to what are the best visual or physical elements to use in their cases relying on simple tools that may not be the most conducive to the practice of their questions.

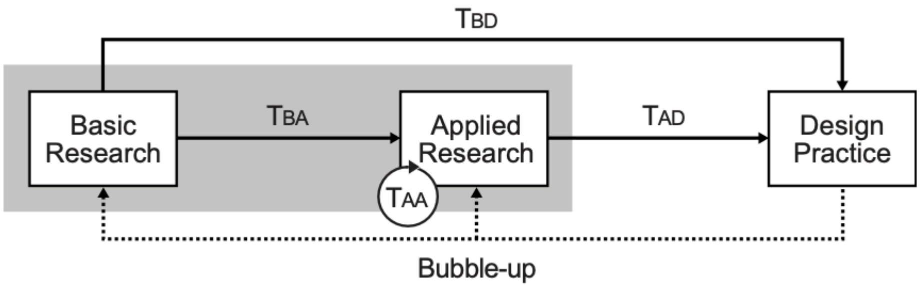


Figure 18: The HCI Translational Science Model consisting of 3 main steps suggesting a gap within Applied research. Colusso, L., Jones, R., Munson, S. A., & Hsieh, G. (2019, May). A translational science model for HCI. In Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems (pp. 1-13).

OPPORTUNITY:

Based on the problems and gaps seen above we have identified the following opportunities focused on how Design can intervene to improve the connection between practices in HCI theoretical implementation:

1. Though others have tried, as seen in the previous chapters, there continues to be an opportunity to converge some aspects from each world into one model that designers, researchers, engineers, and other HCI stakeholders can use.
2. There is an opportunity to clearly state how visual and physical elements from a design perspective are very much objective and measurable, for example, Datta's (2016) observations on material design, depending on the scenario and objectives of the experience being designed. For example: design elements and creative resources can provoke and express emotional message vs. informative content clearly and objectively.
3. By stating a model with design elements and clear examples of tangible references as tools to engage the interaction, this might render yet another opportunity of translating creative processes for more practical scenarios.

Empathy and HCI

PROBLEMS and GAPS

1. There is an overabundance and fragmentation of theories, term definitions, and models within HCI bibliography that includes the topic of relationship in HCI, empathy, and use of qualitative measures as reliable.
2. Consequences of using predominantly nudging smart objects have provoked extreme behavioral reaction toward the objects, mainly due to misunderstanding, and the lack of intuitive engagement tools, dialogue, and context for interaction.
3. Most of HCI references do not speak to long-term engagements, but about the construction and impact of specific instances of an interaction.
4. Though empathy is clearly an important factor to consider for HCI, there continues to be a disconnect between its theory and practice in HCI, since there is lack of consensus and direction.
5. Dialogue and collaboration are two topics getting traction in HCI, drawing parallels to how humans can build trust and affective engagements, but, again, there seems to be a difficulty of engaging empathy as a topic in these examples.
6. The existing empathy models being used within HCI tend to be structured and measured either overly technical based on strict lines of questioning that

can be applied to human emulated computer designs, needed to be evidenced by neuroscientific tools as its being implemented, or (in the other extreme) measured only through self-reporting from users.
7. There is a drive among researchers from a wide range of disciplines to search for the essence of empathy and pinpoint its process.

OPPORTUNITIES:
Based on the problems and gaps seen above we have identified the following opportunities focused on how a model can be built to clearly define key elements and practices that can bridge the HCI gap and the role of empathy in HCI:

1. The use of the Relationship-designed map of HCI works and theories has opened the opportunity to view more plainly the relation and overlap of theories in HCI. Though within their references it might not have coincided, many still relate to each other in practice and thought, further giving a stronger theoretical foundation to the research presented in this book despite the overabundance and fragmented view of the field.
2. These problems raise an opportunity to offer a potential model that brings together the common elements found within the bibliography used within the theoretical framework and related works that speak to empathy and human-computer long-term relationship building.
3. An opportunity to divulge specific steps towards empathy without having to be discipline specific.
4. Provide examples of what these steps look like and how they can be measured within different scenarios and disciplines.
5. Use the parallels of Dialogue and collaboration in direct use of an empathetic relationship.
6. Add insight to what can be a process towards empathy.

Empathy in HRI engagement

PROBLEMS and GAPS:

1. Robot abuse and abandonment after some curious driven interaction with it [de Graaf, 2017].
2. Empathy is mostly regarded as affective interaction in HRI.

3. Dialogue driven activities with robots seem to improve interaction but can become limited in certain scenarios (Figure 19).
4. There is a general mistrust of robots due to uncanny valley and lack of transparency.
5. There are high expectations on how robots should behave and the level of intelligence they should portray.

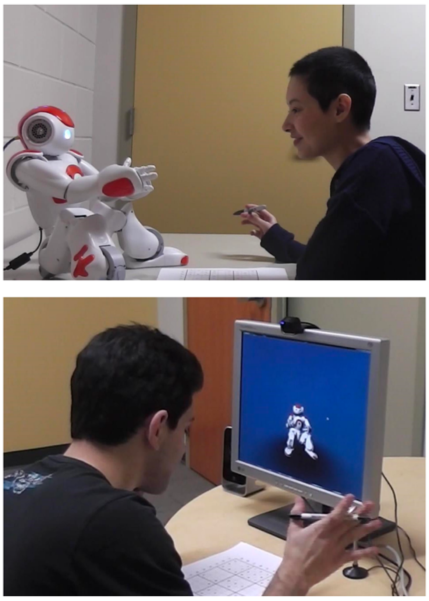


Figure 19: Example of a participant interacting with a robot physically and with a digitally simulated robot in the study: Seo, S. H., Geiskkovitch, D., Nakane, M., King, C., & Young, J. E. (2015, March). Poor thing! Would you feel sorry for a simulated robot? A comparison of empathy toward a physical and a simulated robot. In 2015 10th ACM/IEEE International Conference on Human-Robot Interaction (HRI) (pp. 125-132). IEEE.

OPPORTUNITIES:

Based on the problems and gaps seen above we have identified the following opportunities focused on how a designed interaction focused on empathy may improve HRI interactions:

1. Provide clear and tangible examples of what can be used to empathize in an interaction between humans and robots, with step-by-step interaction design references.
2. Add another layer to the engagement beyond affective states to what can be an empathetic interaction in HRI.
3. This is an opportunity to examine how to regulate the audience's expectations and relation with robots.
4. With the design of a novel approach to a model be able to add value to the discussion of trust in robots and potentially reduce abuse and abandonment of robots.

3.6.2 Research Questions

Here are a series of Research questions and sub-elements in which the practical areas of this thesis study focus on with the goal of shedding light on how to help confront some of the problems and opportunities found above. In a similar fashion we have guided the questions under the themes of: the role of design in empathy, the development of an empathetic model, and the role of this model within HRI.

Design for Empathy

1. How can Design theory and design research practices add value to the HCI interactions and the Empathetic engagement taking into consideration other principles described in the references of previous chapters?
2. How can we use design in the Empathy modeling to bring its practice closer to HCI/HRI practical implementations?

Empathy for HCI

3. How can we leverage Empathy and its elements to produce long-term engagement or relationship between people and technology impacting the creation of HCI interactions?
    a. If we are not defining Empathy itself, what does its structure look like to achieve Empathy and meaning between actors?
    b. What could be examples of how to enable common elements found for empathy in the bibliography like: affective states, trust, self-reflection, and base expectation through design practices?

Empathy in HRI

4. In an application to HRI setting, how can we utilize the answers to the previous questions to empower collaboration and trust between people and social robots while supporting the user's self-determination?
    a. Will the proposed empathy model's intentions and goal translate well to HRI scenario cases?

3.6.3 Direction and Objectives

The path traced in the bibliography collected and the observed gaps, problems, and opportunities highlight a clear direction toward establishing an instructional model to provoke Empathy. Rather, if we take into consideration the elements of Self-reflection, intrinsic motivation, and the independence of how the actors perceive the other with the goal to create meaning between them, instead of provoking empathy, it is more relevant to define the model as a way to come to the realization of empathy [Kyrychuk, 2019]. Therefore, the model would reflect a theoretical driven path to realizing empathy. The goal of which is meant to produce potential long-term relationships akin to characteristics related to long-term collaborations, dialogue, and meaning making. In the context of this research and body of work we are adopting Bickmore and Picard's [2005] understanding of testing relational engagement between a person and a technological actor long-term interaction as a period of 8 weeks and on. This clarification allows us to better frame the potential for the proposed model in the following chapter and the impact of the case studies.

The thesis objective is to begin building a guideline in the form of a theoretical model for future designs and implementations of the relationship between human and smart, technological objects based on the process of Realizing Empathy. To achieve this within the pillars mentioned in chapter 1, there were three main activities that we needed to cover within this thesis: (1) establish a strong theoretical foundation for the process of realizing empathy within the HCI ecosystem that can also be applied in other sectors, (2) provide clear examples of tangible tools or representations of the elements within the process of realizing empathy model proposed that can be applied across disciplines, and (3) offer case studies as applied examples with results that support the proposed model of realizing empathy.

3.6.4 Differentiator - objectives and impact

Most of the current Empathy theories and long-term relationship models within HCI either begin from scientific theory of Empathy or directly from a practice perspective. In this case we consider that starting from a wide perspective that spans industries and several disciplines, will allow us to visualize the path of the thesis from unique angles. Then, when focused on a discipline's path, we will be able to hone into specific practices of the field without losing sight of how those other disciplines can also provide insight in the process, especially when it comes to design, user-centered experiences, psychology, anthropology and even business and project management.

This perspective may help ground the practicality of the elements used as well as the overall design of the model for Empathy.
Due to the cross disciplinary nature of the research, we consider that another key differentiator in this thesis book is the use of the design processes as both a tool to visualize the theoretical fragmentation and as a tool to reflect on the construct of Empathetic interactions to provide a unique perspective within an engineering dominion. While at the same time, breaking down Empathy through scientific means and terms provides concrete support to an otherwise ephemeral way of describing empathy in the design and psychology research fields.
Finally, we understand that it will be important to reflect the model in a way that can be applied and understood across these disciplines. Therefore, the model would come with examples of instantiations of the model and its aspects within potential scenario applications. As many models of engagement are defined by directly expressing its process as algorithmic steps or with discipline-specific terms, in our perspective we will implement as best we can a perspective that is more accessible to other researchers.

4 A Novel Approach to Realizing Empathy

This chapter presents a theoretical approach for a novel model to Realizing Empathy along with an example of a study that begins to evaluate potential exemplification within a practical HCI scenario by using design elements and principles as a tool to make key aspects of the process tangible and accessible across disciplines. The process shown reflects the bringing together the common elements present throughout all the surveyed theoretical material from chapters 1 and 2 as well as taking into consideration the direct applications within related works of chapter 3. In the following chapter, you will read an exemplified case study within a ludic scenario of human and social robotics interactions done in 2 phases of the proposed model as well. In each case, the study revealed encouraging results that culminated in a grant acceptance, the Llavor program sponsored by the Generalitat de Catalunya, the ministry of Knowledge and Industry, to develop the concept in a state of testing, into an entrepreneurial case project. This opportunity is further described within the Annex of this thesis book. On the other hand, the 2 phases of the case study in the next chapter also provided good insights and results that pushed the concept of the model forward to be a contribution for the scientific community.

Based on the collected literature, we envision our empathy model as a living, moving, multilayered process, where without the variables involved to nurture it, the process would not survive. It is a phenomenon that needs: the right consistent conditions, variables to help sustain it through time, a set of stable elements that anchors the experience, and a series of stages of interactions, for the realization to occur. We have studied the terminology of authors from across several of the works presented in Chapter 1,2 & 3 to best exemplify the accessibility of the model intended. Among them: Lim (2013), Bohm (2010), Ryan (2000), Lancton (2014), Bickmore & Picard (2005), Paiva (2017), and others. Lim (2013), Ryan (200), and Bohm (2010) in particular, have given great insight into the construct of the process' structure identifying similarly as with other authors the potential elements, variables, and stages.

By viewing empathy not as a singular phenomenon, but as an active body of constant exchanges, can shed light on key attributes, contributes to a sustained person engagement and experience with others, whether in building a relationship or as part of a collaborative scenario with technology. The result being to generate meaning and

understanding between them. This falls within the objectives of the most recent HCI wave and trend as seen in Chapter 2.
To remind us of previous works around Empathy shown in chapter 1 and 2, most theories refer to empathy as a "relatedness", a mirroring of each other's experience, feelings, and thoughts. This mirroring refers to have in some way led on person recall their own experiences similar situation the other is in. Yet, it is pivotal to understand that although people may relate to another person's situation, the mental self-reflection, feelings, and sensations are individual and unique to each person. A person will most likely never have the exact same feeling or knowledge that the other is feeling or knowing at any given time [Rivera, 2012].
This sense of relatedness varies at different levels: perceived shared cognitive understanding, recognizing emotional states, and embodied reactions from physical situations [Preston, 2007]. As it can also vary in depth and comprehension. The profoundness of thought and emotional connection to a situation or another, as well as how complete or thorough the shared relatedness is.
How these levels, depths, and comprehensiveness are assimilated, but can be sensed immediate or more progressive. Immediate like the instinct of riding a bike or getting burnt, and progressive, like two foreigners getting to know common interests while travelling in the same group. In this case other factors, such as their current context, bring these actors together other than the sentiment of a past shared experience. In this exchange, empathy may be realized if the actors are encouraged and intrinsically motivated through the support of the self-determination theory variable needs [Thorne, 2021; Ryan, 2000]. When autonomy, relatedness and competence are supported and respected in a process of exchange, it feeds into the motivation to willingly have an open attitude to continuously engage in finding common understandings between them, similar to the process of a dialogue [Bohm, 2013]. In this sense, to realize empathy does not always mean to feel, know, or experience exactly what the other has. Rather, it can also be about finding common ground with another, finding a way to make their expectations of the other flexible, acknowledging the others needs independently of them agreeing on the same understanding over a topic [Phillips, 2016]. As we have seen in chapter 3, this way of building a connection that resonates between actors in interactions is explained as meaning (Mekler, 2019).
The model has a specific structure and layers that must work together for it to produce the key indicators if empathy has been realized and generated meaning.

4.1 Base and Indicators of RE: Attachment and Trust

This recognized relatedness at all levels is an instinctive action of attachment to the other, i.e., a link that each actor decides how profound or secure it might be [Lenzi, 2013]. Showing a willingness to explore that likeness between the actors and enter into a potentially collaborative setting is a result of trust with each other [Phillips, 2018]. The addition of trust and attachment are the base structure of empathy (Figure 1). They are the roots that anchor those involved. Without both present, the content and variables that drive the process to realize empathy disintegrates the same way the dialogue process does [Bohm, 2013]. The more the actors interact in empathy, the wider and more rooted trust and attachment develops between them (Figure 20) [Charon, 2001], hence becoming the indicators of Empathy Realization.

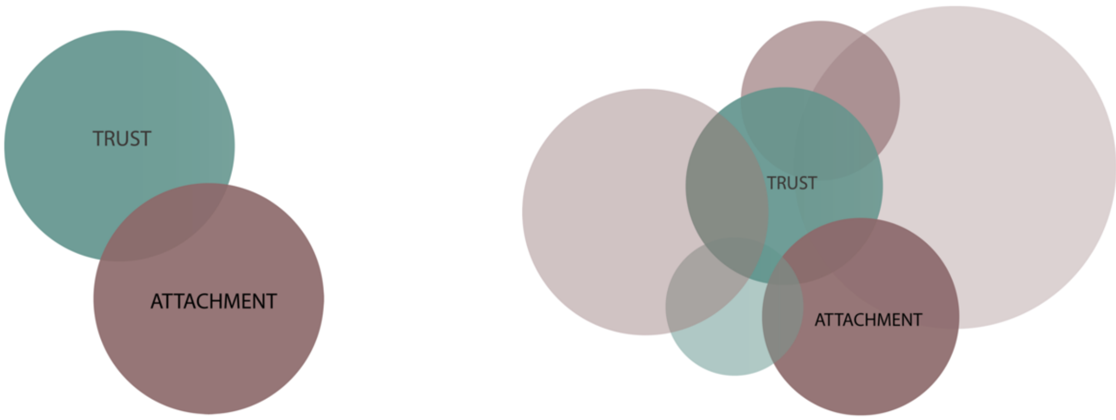


Figure 20: An abstract representation of the concepts of Trust and Affective Attachment (left), and the representation of their growth or expansion (right).

This marriage of trust and attachment exist intrinsically within those involved in the empathetic process. Even though in the works referenced in previous chapters, affective attachment and trust are equally important to Empathy, but have mostly been considered separately. Yet, in this case we see that attachment and trust alone are not enough to move actors into Realizing Empathy for long-term interaction. When people engage in collaborative, or dialogue-like scenarios, there is an existing level of trust and affective attachment, even if very minimal. Affective attachment in the sense that whomever you are starting to interact with minimally fulfills a sense of care, security, and relatedness to you: they are from the same gender, same country, same language, same troubles, etc, it fulfills a need of belonging [Ryan, 2000]. On the other hand, the minimal sense of trust comes from both the willingness to participate in the dialogue as well as the fact each actor has a baseline of expectation of the other, however minimal, that help shape and grow a sense of trust in the other. When both affective attachment and trust grow simultaneously, they influence each other creating a relationship between them or at the very least meaningful interactions [Mekler, 2019].

4.2 Variables in movement

These indicators, for them to grow, they must be driven within a setting that moves, initiating and maintaining that engagement. In the case of this model, to engage willingly the interaction must fulfill motivation (Figure 21) [Duan, 2000]. This motivation, within the multifaceted approach on motivation, can be interpreted as a constant cycle or wheel between intrinsic motivation and extrinsic incentives that is regulated internally becoming integrated. They feed each other to ultimately reach an understanding [Reiss, 2017] (Figure 22). It is a sort of journey between the internal reflection where the actor intrinsically forms their desires, to achieve their sense of purpose, to then have the willingness to reach out to the other to then fulfill that reward, mainly because that purpose they are searching for has value

Figure 22: A representation of the cyclical movement between intrinsic motivation and extrinsic incentive

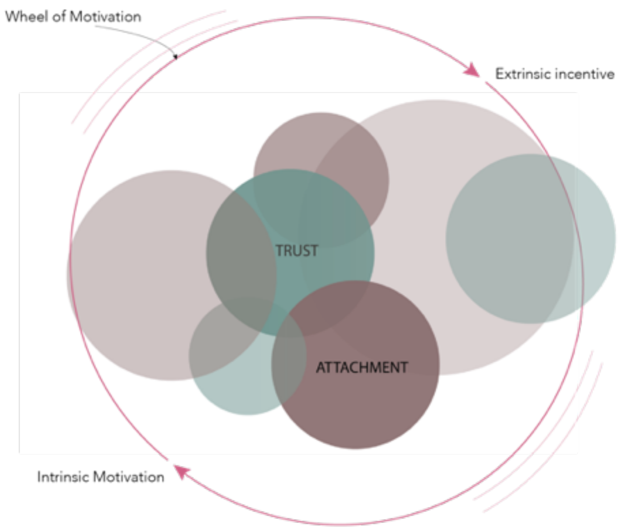


Figure 21: The view of how the movement of the wheel can lead to the growth of Trust and Attachment.

to them both [Duan, 2000]. These two sides influence each other as part of a dialogue process turning at each interaction.

In this process, those involved put aside their pre-conceived notions of each other and are willing to delve and learn from a different perspective to achieve that purpose of meaning [Phillips, 2016]. Not all actors are the same in their intention and their willingness to be influenced by the other, nor the motivations be completely of dual nature [Reiss, 2012]. As we have seen from Self-determination theory, there is no perfect balance between the intrinsic and extrinsic incentives, rather it tends to be fragile as it fluctuates and varies as the actors involved enter a rhythm of interactions that consider the needs of autonomy, competence, and relatedness. If and how these needs are supported in the process of Realizing Empathy as other elements come into play, the level of attachment and trust grows or diminishes. To help the wheel turn and nourish its exchange with some consistency, we define a set of stabilizing elements within this wheel.

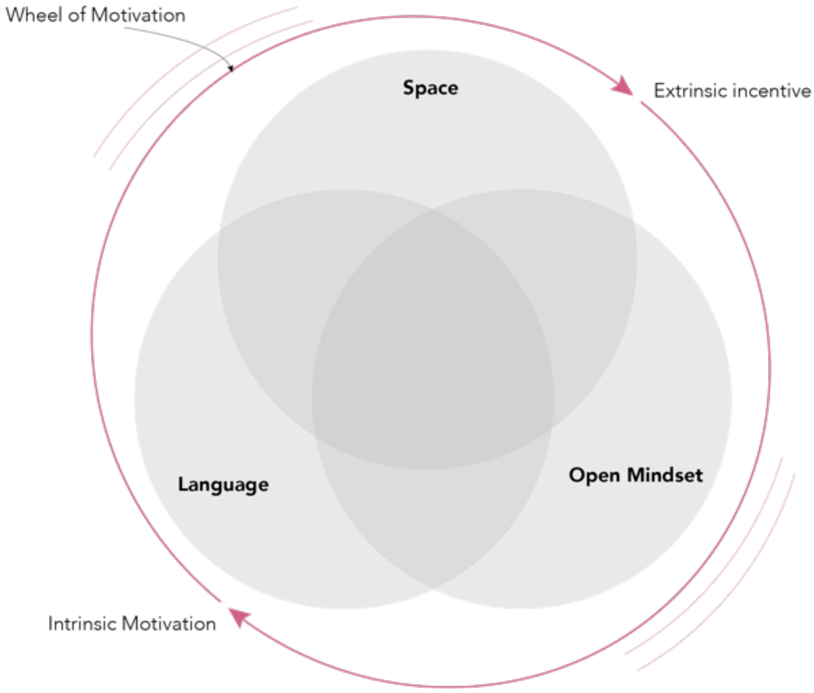
4.3 Stable elements

In order to make the process to Realize Empathy actionable, and allow for the motivation to turn, it needs a set of elements that stabilize the exchange and flow of the interactions (Figure 23). These are components that need to be agreed on and become consistent in the exchange:

Environment

In Dialogue designed interactions with robots and artificial agents, space and a common context was very important and could be detrimental to the interaction if not taken care of it properly under the context and circumstances of the interaction [Paiva, 2017]. This reiterates the design practice of choosing the canvas or stage in which pieces were to be communicated in to be taken as one more variable or part of the art piece itself [Strickfaden, 2009]. In consonance with works reviewed, the space or environment is a key element to consider for the Realizing Empathy model. The space chosen depends on the context of the interactions and the actors involved. The space must open enough to provide a sense of freedom and dynamism, as well be intimate enough proportionate to the situation and the number of actors involved as the information travels directly between those involved. If the space between the actors is too wide, the message may get lost or muddled, while if the space in between them is too small in relation to the context, the personal boundaries of those involved might feel violated, restricting the motivation to participate. This environment can be physical, digital, immersive, or through devices. In the end, it should be an agreed context or at least one where it is known the actors would be comfortable in.

Figure 23: Ven Diagram of the 3 stable elements within the "wheel of motivation".



Communication

Another key element to be determined is a common tool of communication between the involved, agreed upon to get the message across, whether it is a spoken language, written word, metaphors, body movement, art, music, or stimulating elements. In dialogue it is essential as much as the space of the exchange.

In the works related to collaboration in HCI, researchers believed in the fundamental aspect of making the experience for the user seem like their technology adopted human-like qualities in order to both express and capture what the user was saying [Fong 2001]. In other co-creation related works between humans and AI, the space was a large interface and the language were creative materials within the digital tool [Changhoon Oh, 2018]. If those involved are not willing to adapt, accept, or agree on a common language the communication will fail or be misinterpreted.

Open Mindset

An open mindset requires for those involved to consciously position their mental state to practice an open behavior. This open behavior allows the other to interact with them accepting being the receiver of what they want to express. This does not mean that the person must agree or accept as their own the others viewpoint, it merely means that they are welcoming new information for them to consider. This is the one element that cannot be controlled or fully instilled in the other but is rather a personal choice to make for the purpose of the interaction. Bohm, Strickfaden, Fong, and others, agree that to come into a collaborative setting or a dialogue exchange the actors involved must see the process as flexible, where their expectations can change or evolve with an attitude that respects the state of the other as they are. This open behavior, when appropriately perceived by the other, can render support to the needs of autonomy and competence of each actor involved, as they are equally allowed and expected to have freedom, control, and participation.

4.4 The Process

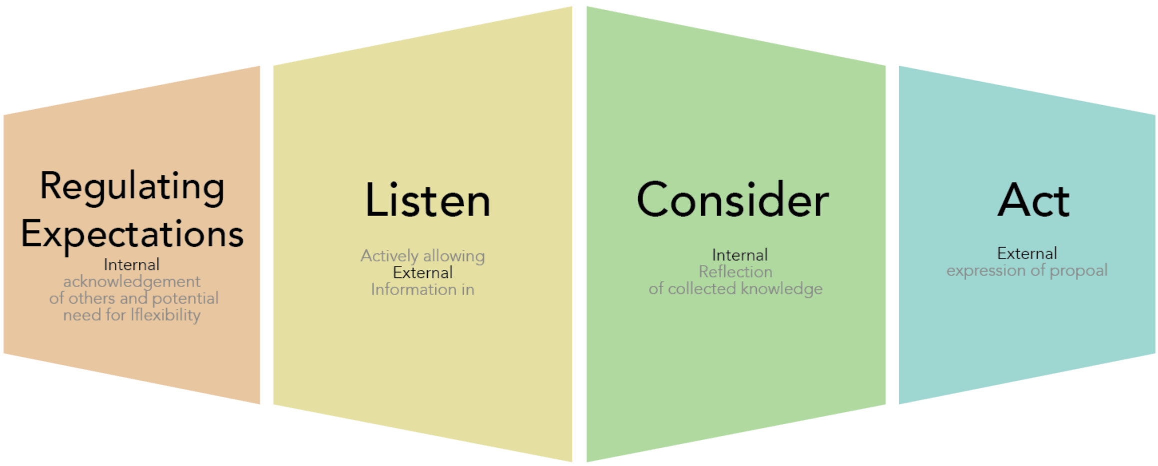


Figure 24: The process of Realizing Empathy (RE) in 4 steps. 2 Divergent steps: (1) Regulating Expectation as an internal process, (2) Listening which has an extrinsic component influencing internal processes; and 2 convergent steps: (3) Consider, a purely internal process of reflection or self-reflection, and (4) Act as an external expression of the reflection done in the previous step.

We have discussed the foundation and indicators of RE, the variables that vary and remain in movement, as well as the elements that stabilize the variables for the process of RE to occur. These layers are present in preparation for the stages within the process to happen and provoke meaning. The steps diverge and converge according to the nature of the activity in each step.

The following steps (Figure 24) enact the process to Realize Empathy:

REGULATING EXPECTATION

As the actors become involved and enter the space with an open mind, they set a base a line of expectations, a thought they reflect on internally before they engage with the other. This step is about having the opportunity to be instructed, reflect on who or what they are about to engage with. It is an opportunity to acknowledge that the other is as who they are, autonomous and capable, without judgment or wanting them to change. No matter the context, or what will be said, they must engage knowing that they will remain as who they are, independently of each other [Trapp, 2018]. By having a willingness to allow for their expectations to fluctuate as the interaction progresses this expectation regulates adjusting to match a sense of trust and care in the other. This step is often skipped or not referred to, yet in many instances it is reflected in the simple act of reflecting on provided clear instructions and context to a collaborative activity [Bohm, 2013]. This exercise helps set the bar for the expectations of what the activity is about, while giving the audience the opportunity to explore as the activity progresses. Therefore, this step is an internal process that diverges opening towards the other in the process.

LISTEN

Where Regulating expectations is often overlooked, to listen is probably the most used action in relation to Dialogue, collaboration and empathy that reflects a divergent part of the process. To listen is to actively and widely collect the information the other is willingly expressing externally. This means that the mind of the receiver must not hold pre-conceived notions, judgments, or comments at hand, since it is not the objective of realizing empathy to change another's mindset or have the actors match their own personal expectations [Bohm, 2013]. Neither is listening about silently waiting until the other is done expressing themselves; it means to actively take in the message as raw data for later comprehension and exchange. This is not an easy step; it takes conscientious practice, particularly when the meaning does not come as naturally as the actors would believe. Listening is being present with the other, attentively, and openly being a repository of their message [Strickfaden, 2009].

CONSIDER

To consider is to self-reflect internalizing, processing on the message and information collected both through the regulation expectation and listening phases. This internal act converges back as the cognitive, emotional and embodied trial and error occurring within the mind of each actor before they respond in exchange [Koopman, 2015]. It is the moment in which the actors choose the tools to examine if their interpretation resembles what the other is trying to express. It is the moment that they test if the information they reflect upon becomes knowledge or the potential for meaning [Mekler 2019]. This is another step that is often overlooked in empathetic processes in HCI and technological applications. When time is not provided to reflect and do a trial and error of the information going directly to the last step of the process, the result becomes actions based on assumptions and attempt to predict as empathy [Rovira, 2010]. As we can observe from the related works, this type of format in Empathetic interactions tend to provoke unsustainable relations between the actors.

ACT

Once the actors have the considered the information, reflecting on how they will exchange their understanding, the final step is to Act. In this step the actors converge in externalizing their interpretation of the considered information, in the hopes that the other accepts this as reminiscent of their own intended message. This act is done with the communication tools agreed on, within the space set, and with the mindset that the expectations set may shift. Though it is last step in this process, it is not the end of the process itself.

This process is continuous until the actors find mutual understanding and meaning. When the result of acting or responding to the other does not have the likeness expected, the results and the level of motivation, trust and care may still be enough for the wheel of motivation to turn and propel the actors to continue being involved in the engagement (Figure 25).

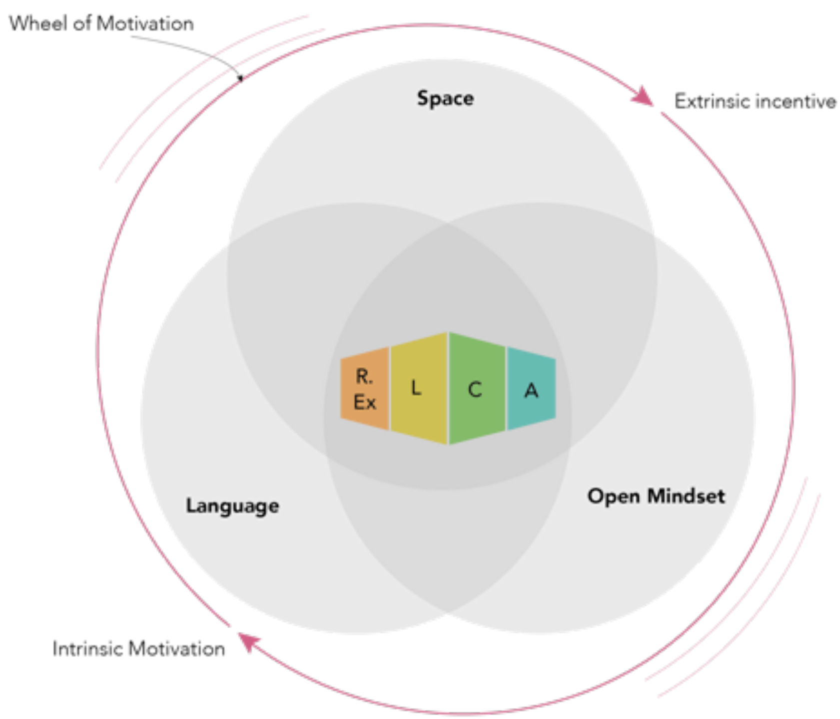


Figure 25: The model represented with all the layers: the process occurring within the triad of the stable elements, living within the movement of the "wheel of motivation".

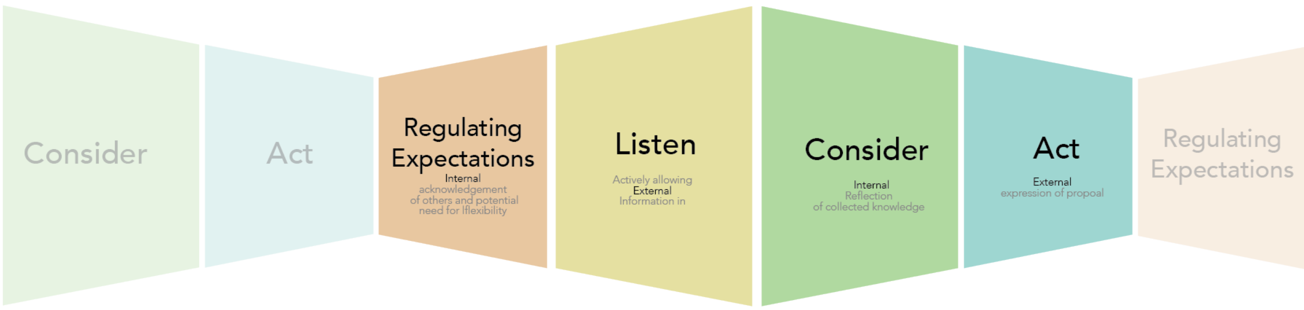


Figure 26: The process diverges in the Regulate Expectation and Listen steps, as they gather information, while through Consider and Act, the process converges to achieve meaning.

4.5 The Wave of Realizing Empathy

As represented in Figure 26, this process, even after meaning has been created, it can continue iterating by widening and focusing again and again, until a series of further meaningful insights string between the participants. This process with a series of activities that diverge and converge is like a wave, as each previous step informs and adds to the following wave moving information continuously. As we mentioned at the beginning of this chapter, we consider the process as "living", therefore having an organic type of format to it as it can grow, evolve, dwindle, or stop altogether. This goes for all the elements involved as well. The intrinsic motivation, extrinsic incentive, the environment, communication tools, and openness you engage with can transform into different types or become enhanced version of themselves depending on the direction the meaning is taking within the process. The key to these variables and elements is that their essence, in proportion to the context and need of the actors at the time, remains the same. All the layers and cycles feed each other, help each other grow and become more profound in meaning.

Empathy can appear and expand as well as it can partially disappear or dim. Acting like a wave, as it opens to the individuals interacting, and then closes as meaning is created between them, as so on. It is a wave that may shift in size and acuteness, and at times seem like it disappears. While if there is continuity in the process it may help knowledge, trust, and attachment expand, making the relationship grow.

In this respect, the waves and each step of the process may vary in size and breadth determined by the time and depth needed to execute them (Figure 27). There is no set amount of time or limit of range in each wave. This means that the steps may even interlace with each other as the actors make sense of the information and the other's needs, so long as the core attributes of each step, variable, and element are respected.

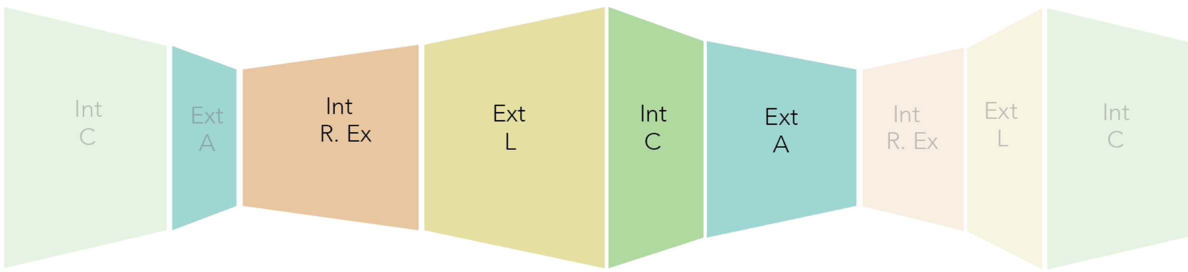


Figure 27: A representation of how each step in the wave can have different duration depending on the cycle it is going through.

4.6 Making Meaning

The objective of the process of realizing empathy is to generate meaning between the actors within the process. This meaning is ephemeral, living in the space between them in that moment and in each of them in their own interpretation that best assimilates to others, but never precisely the same (Figure 28). A similar phenomenon occurs to our perception of past events when stored in our memory as we build metaphors and elements that support our perception, which differs from other people's perception of those events even if both were present in that exact moment [Ashar, 2017]. Yet the reality of that event, though those involved may agree, the subtleties of what happened is perceived differently in each individual as they take on different perspectives. Therefore, the raw nature of meaning only exists in the time and space in which it occurred and within the internal value the actors afford it. It becomes the insight that transforms the actor's own personal beliefs, further actions, making experiences and others meaningful to them [Merkle, 2019]. Despite the fleeting nature of Meaning, its impact can also be long-lasting, rolling into new collaborative challenges and goals as the process of Realizing Empathy continues.

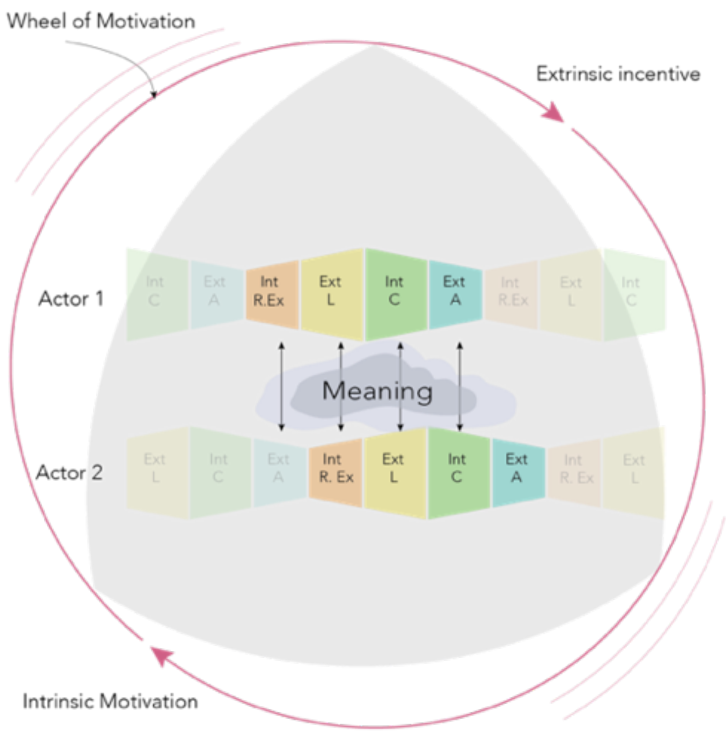


Figure 28: This representation of the model exemplifies the process with 2 actors as they interact and generate meaning.

RELATIONSHIP GROWTH

As the waves in the process of Realizing empathy continue to generate and add meanings and insights, the roots of attachment and trust grows and expands. The consequence of this growth is a relationship being built between the actors; making the process of Realizing Empathy the link between the multitude of interactions that becomes a relationship [Bickmore, 2005]. The longevity of that expansion is only relevant to the context of the relationship, the actors involved and the purpose of both (Figure 29).

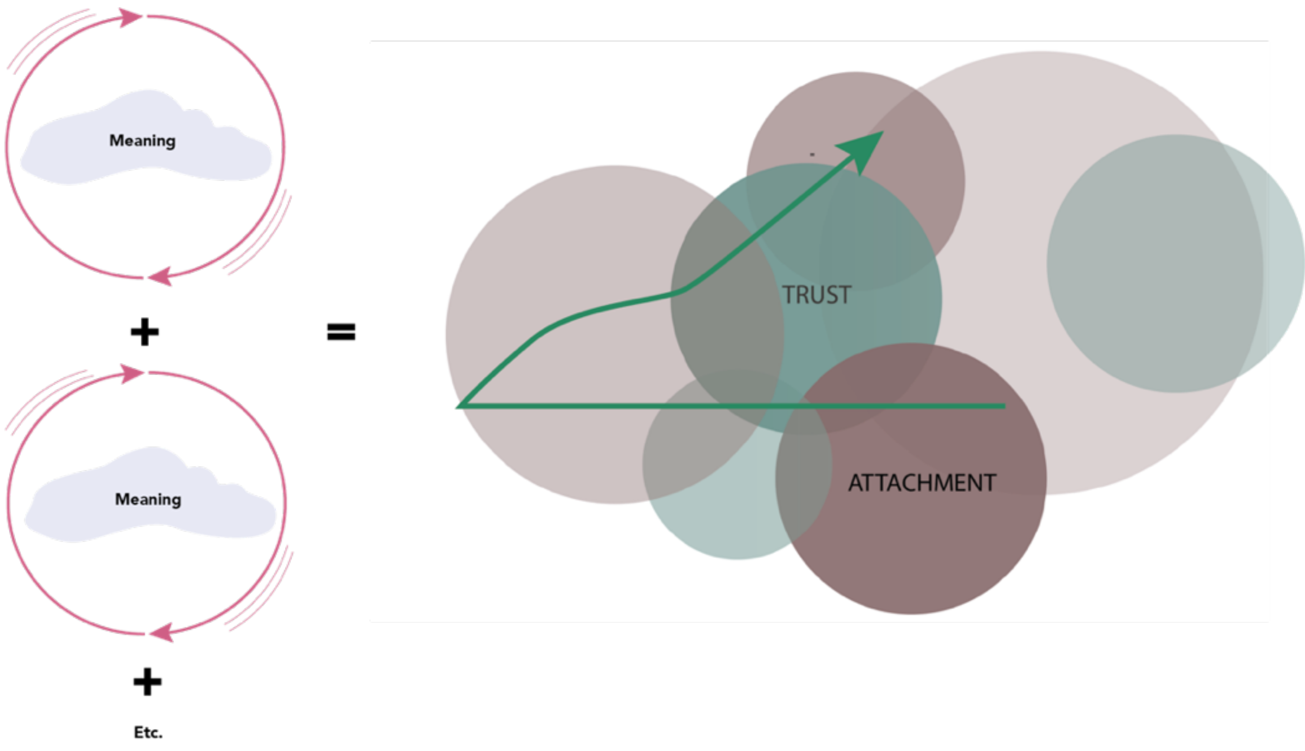


Figure 29: A figurative addition of what occurs as meaning is created through the process again and again with the result of growing trust and attachment.

4.7 A Study of Design elements in the process of RE model

This section looks to begin exemplifying how the variables, elements, and steps of the process of RE can be reflected within an HCI scenario. As the model proposed unifies concepts and models from various disciplines, this initial study is a helpful practice to make aspects of the model tangible for future tests and scenarios. The focus within this study has been to leverage on people's self-reflection (how they engage in the consideration step of the RE process) when interacting with a smart object or HCI application using specific communication tools to transform the insights from the interaction into Self-Knowledge (S-K).

4.7.1 Self-Knowledge in Personal-Informatics

To begin familiarizing the process of RE model within HCI practices, we decided to study how to incorporate the stable elements of the model into an existing HCI experience that innately incorporates some of the notions in the model, that exemplifies user focused technology, data, and objects as a support for decision-making. To this end, we decided to approach the *Personal-Informatics* or Quantified-Self discipline within HCI (Corretjer, 2017).

Personal-Informatics (P-I) is a growing sector meant as a tool to collect relevant information for the purpose of Self- Reflection (S-R) resulting in Self-Knowledge [Baumer, E., 2015] of its user related to habits, routines, or contexts they intend to track and monitor. To build a P-I system that supports S-R that guides people towards informed decision-making, the extensive literature and research on how emotions play a key and unwavering role in that process must be acknowledged [Dmello, S., 2005]. As we have seen in the chapter 3, emotions walk hand in hand with cognitive states, as they impact greatly how self-evaluation and self-knowledge is perceived and constructed towards a habit change. By accounting for emotions and understanding the process of Realizing Empathy (RE) this is an opportunity to explore how they can be reflected within a P-I scenario. In chapters 1, 2, and 3 we observe how RE can give clues as how to design and structure smart and intelligent systems to support humans [Zahavi, D., 2015] as its origins speak about how people have the ability to deeply reflect with and through inanimate objects, events, places, and situations [Kaki,J., 2012]. Although P-I, S-R, and the Process to RE are three different terms with specific definitions, we have observed that their objectives, steps, elements, and structures have parallels that can interweave as one whole experience. In this study we visualize how these terms that live within each other can help to engage people in how they perceive and gain self-knowledge more profoundly and sustainably within the process of RE. As we have stated earlier in this chapter, within the process of RE, one of the steps that is often overlooked in Empathy related literature is Consideration. Yet, we see that throughout all the different processes and related works: design processes, dialogue, Transtheoretical Model of decision making, affective computing, P-I and others, do value moments of self-reflection to better understand themselves and others. Throughout the related works and practical application in HCI, S-R and ways in which the actor introspect their consideration of the situation is vital to produce an action mirroring their care, trust, shared meaning with the other, or to match their own expectation of their personal journey [Odom, 2015; Lin, 2006; Prochaska, 1997]. Another component we have observed from these examples is the use of designed elements to produce communication tools to facilitate the S-R process. Though there are clear consistencies and parallels of using design tools and elements to create an environment, language, or tool for communication in S-R toward acquiring Self-Knowledge, there is only some initial evidence on the specific technical use of certain elements and their compositions to become conducive to an empathetic series of interactions promoting self-reflection [Datta, 2016; Özcan, 2016]. Therefore, this study focuses on exploring the element of communication tools to facilitate the step of consideration in the process of RE. We take advantage of P-I discipline to propose a new approach of self-monitoring using design elements composed of a light system with a new visual interface, as a language for the user to self-reflect, and interpret their own measurements implemented on a practical health scenario. This practical scenario is about designing a conceptual smart object that accompanies the user through a body regime change. The design of the object, its behavior, and interactive elements were carefully thought out taking into account the sections below. With this initial study related to the process of RE, in future studies and tests we can evaluate other aspects of the process as well.

4.7.2 Personal-Informatics, Self-Reflection, Realizing Empathy

This study gathers the nuanced collection of literature and related works related to Personal informatics or quantified self, Self-reflection, and empathy, and focuses on their summary in how they correlate and impact users within a diet health experience. Figure 25 shows these three experiences for better comprehension of their parallels.
The three main constant aspects throughout P-I, S-R, and RE, seen on the first three columns are: their objectives, influential elements, and format. On the fourth column, each experience defines their steps differently, but they all interconnect supporting each other's relevance. For example, in each of the S-R steps, the actions taken within P-I can be reflected, as well as the overall arch in each of the RE steps. All these stages together loop until there is a moment of realization and clarity that defines insight and self-knowledge [Lim, SC., 2013]. Despite the correlations, each experience has more aspects that influence the main overall objective, seen on the furthest left column [Baumer, E., 2015]. As previous studies have emphasized, it is relevant to design a system around creating constant opportunities for S-R [Ohlin, F., 2015], otherwise the step of consideration would be null, and the acquiring of knowledge would be limited. To do so, the study developed must support and engage as many of the aspects mentioned in Figure 30 as possible, while respecting the connected iterative steps. In study we present, the trial and its results support some of the key aspects, particularly ones approached by some fields contributing to P-I sector, mentioned in the next section.

S.-Reflection

Objective	Elements	Format	Steps	Levels
self-knowledge	context	continuos	breakdown	experiential cognition
transform	space	not always in order	inquiry	cogntiive reflection
	congitive	cyclical	transformation	transform reflection
	emotions	evolutionary		**Strategies**
	content/data			dialogue
				information
				expression

P.- Informatics

Objective	Elements	Format	Steps	Relationship
Self-knowledge	context	cyclical	prepare	ambient
better decisions	space/surroundings	evolutionary	collect	augmented
monitor	cognitive level	maintentance	integrate	cooperative
maintain	emotional state	specific order	reflect	
collect	data presentation		act	

R. Empathy

Objective	Elements	Format	Steps	Mentality
make meaning	space	continuos	respect	humilty
insight	language	not always in order	listen	courage
	attitude	cyclical	consider	curiosity
		evolutionary	act	love
		conversational		trust

Figure 30: correlations between the 3 processes of P-I, S-R, and R-E

In related fields, current literature in P-I finds that intentioned S-R for a deeper, transformative change is impacting throughout time, habit change, and self-knowledge [Baumer, E., 2015]. Going forward with designing for S-R, understanding how the different elements and processes are interpreted and managed in disciplines contributing P-I is evaluated. The main fields studied in this respect are: Affective Computing, Persuasive Technologies, Ubiquitous Computing, and HCI. They intend to improve people's relationships with technologies and behaviors by capturing, expressing, and influencing human emotions and cognitive decisions [Picard, R.1995, Picard, R., 2003].

4.7.3 Design Consideration

Understanding all the previous information the objective of the designed experience is to emulate aspects of the process of RE, creating constant opportunities for S-R, while respecting the steps within P-I towards self-knowledge. To do so, the concerned elements mentioned in the previous section are addressed: environment, communication tools, emotional state integration, and measuring qualitatively the overall process. First (1), the design should consider the environment to remain represented throughout the experience. Secondly (2), the language should be flexible in order to incorporate a variety of variables while remaining intuitive and simple. Third (3), the dialogue format of the design should integrate emotional reflection, as the person gestures with the object in hand and the device expresses the emotionality back, as well as provide the opportunity to inquiry and self-educate. To represent all these qualities, as well as enabling measurement of these processes, we use a set of elements from Art and Design disciplines that have specific meanings with measurable qualities [Sokolva, M., 2015]. Even though lone elements are inconsistent in meaning, combinations of these elements, for example: creating a series of compositions of specific colors, shapes, light, and intensity, can provide specific messages that result in informative, emotional data or both [Sokolova, M., 2015]. This becomes a flexible and intuitive communication tool that can go from basic to intricate, as well as used by the actors involved (the user and the object) [Machajdik, J., 2010]. If each combination of elements can be defined, they are measurable. Beside generating a language, these elements can also help define space, represent a sense of environment using design principles related to aesthetics, materials, textures, and scale. The next step would be to design how the system behaves in order to uphold the process of RE and S-R.

4.7.4 Methodology and implementation

To evaluate the concepts and the design considerations, the project went through a series of stages to develop a proposal to then implement with a test. The first (1) stage was to anchor the overall design considerations and concept in a health tracking, dietary and body regime industry smart product. The second (2) stage was to delve into the sector's literature, as well as directing a series of interviews, ethnographic research with experts, and a co-creation workshop session with a sample group of the target audience of the potential object. A number of consistent insights gathered made clear not only the kind of experience the audience had to have with the smart system but also, it's physical form and behavioral elements. Another aspect in which Design has influenced this work has been with Design research methodologies to gather relevant information for the potential creation of the object. From in-depth interviews with 8 professionals in the industry of nutrition and body regime, a co-creation workshop, personas, and journeys. At each stage of this research phase, we took the previous one in consideration. We approached the professionals with hypothesis and questions that related to the theoretical framework we were working with to detail as much as possible in the intricacies of their experiences as well as their patients. When we engaged a co-creation session, we were able to design the session with the analysis from the interviews and frame it within the process of RE.

Figure 31: Co-creation session framed within the (initial draft) process of RE considering communication tools, environment and the open mindedness elements as well as the processes within the model (Regulating Expectation, Listen, Consider and Act).

Among the key insights from the Design Research methodology activities (Figure31) were: (1) the measurement tool should be a version of a measuring tape instead of weight scale as it can be detrimental to motivation to interpret exact measures, (2) substitute the number interface feedback with a language that can provide data meaningful only to the person using it, (3) visually provide the goal of the user as well as information of the users progress, (4) that affective feedback based on their own emotional state motivates people to S-R, and (5) the physical design of the object must feel private, portable, ergonomic, and ideally to be held with one hand with as few buttons as possible and no digital screens capable of detecting the users response to the interactions.

Instantiating the process of RE in the study

The following stage was to conceptualize the design of the system with alternative, tangible interfaces. We conceptualized to use an LED light strip, pressure sensitive materials for the physical design, and a digital environment, (for example a specialized App), to safeguard and support inquiry in the process of use.

Because of the complexity and layering of the project, the proposal in this study concentrates on designing for the stable elements of the overarching concept through the experimental alternative tangible interface rather than all the elements to be developed for the model. Along with the stable elements of environment, communication tools, and an open-minded setting, we also took into consideration the communication of both cognitive and emotional data within the experience as part of a dialogue type interaction, as it supports the process of S-R and RE within the design. How these elements were hypothesized in the design will be further explained in the following items. You can observe the prototype of the device in Figure 33 and 32.

Figure 33: An eexample of the device's design fitting in a hand

Figure 32: An example of the LED measuring tape showing the progression for the user.

Stable Elements:

• *ENVIRONMENT:* The physical object must command space, while considering the contextual needs of the audience: a sense of privacy, inconspicuousness, ergonomic, comfortable, and attractive. To emit privacy yet attractiveness, the design remains compact, abstract, and simple. For comfort and ergonomics, the material chosen was platinum silicone for its softness and durability. Hidden in plain sight, turned off underneath the object, is a retractable strip of LED lights. When stretched out, the object manifests itself, demanding some space for the visual interaction [Gallese, V., 2003]. This device is meant to remain in a specific place chosen by the person at the level of their comfort.

• *COMMUNICATION TOOL:* Based on previous research [Sokolova, M., 2015], the language design was decided as an LED strip becoming an interactive interface displaying measurement without numbers. The concept concentrates on the attributes of color, intensity, light, and pattern behavior to compose a set of combinations. This makes it able to support a variety of variables and information, from goals to timelines. Beside quantitative information, lights, colors and behaviors also transmit specific emotional states. The combination of both shown throughout the experience allows for the person to S-R with all elements cohesively.

• *OPEN MINDEDNESS:* Is reflected in how the Conceptual design supports both the cognitive and emotional state of the person throughout the stages and variables present in P-I, S-R, and RE, a careful 5 step designed experience is in place. There is a constant opportunity for the user to share their states, explore the digital app environment, and the object is designed with an attitude of dialogue and mirroring of the user. The user has the freedom and control over their information and goals. The interaction steps are conversational, cyclical, and gives the person freedom to change or evolve their goals and intentions. Briefly, the steps include from stating goals and profiles, to the device offering professional guidance and tools on the digital space. Within the experience, the device would detect the handling and amount pressure of the person as asked about their feelings during that day. The object would give visual feedback on its interpretation of that emotional state as part of the conversation. Although the digital space is included in the system's concept, at the stage of the study's test it was a work-in-progress, as well as a more defined strategy for measuring RE process. The test and results will focus more on the effort of developing and evaluating the possible effectiveness of design elements towards a new interactive language, a sense of space, and Empathetic interaction. The experience, as a whole, is slower and more abstract than the normal measurement devices. These precise attributes of visual abstraction, behavior, and demand for space gives the person the continuous opportunity to S-R and self-motivate towards future actions.
Steps of RE:

• COGNITIVE *AND EMOTIONAL EXPRESSION:* The interactive design of the object's LED interaction is divided in stages that reflect the steps of RE model and its elements.

Regulating Expectations: The user would learn about the object through a digital space and what it can do, then they must find the right environment for the interaction and to read carefully its instruction. At this stage they have already established a base expectation, level of open mindedness with the object and the right environment. The user programs their goals, current measurements, emotional state, and other profile information through the digital environment, allowing for the object to analyze their current situation and set the base line of their interaction.

Listen: The user unrolls the LED lights from underneath the device, wrap the strip around the part of their body they would like to measure and use the tip of the device to detect the placement of the LED. The object will read the position of the measurement and once it has gathered the data it will announce to the user it has done this step correctly. The user can stretch out the strip in front of him to visualize the progress result. Both listen to each other as this data is exchanged. It is important to note that the position of the LED lights do not reflect that actual placement of any unit measure, rather it will only showcase a percentage in relation from where you are to the user's goal. Exact measurements would be provided through the digital space.

Consider: In parallel both the user and the object are analyzing and considering the information. The user has the time and space to reflect on the progress while the object detects the user's gestures and innate emotional responses.

Act: As the user gestures and responds to the result using the button and gyroscopic measures, the user is acting toward the object. The object would then respond by interpreting a mirrored emotional response to the user. The digital environment would support this chain of events in the interaction.

- *Progress design*: As seen in Figure 34, the are only 7 LED's being used to show the progress. The goal is always portrayed in blue while the starting point of the user's journey is represented with yellow. The progress is represented with 3 elements in these 7 LED's: (1) Color progression: red, orange, yellow, lime, green, turquoise to blue where orange and red means the user has moved farther from the goal versus colors from yellow to blue mean the user has moved positively toward the goal; (2) intensity where each color can pulse up to 3 intensities of the light showing if the user has stayed in the same percentage area as in the previous measurement; and (3) order of appearance, meaning that in each interaction the user will visualize the history of their progression as the colors and intensities of the LED's manifest.

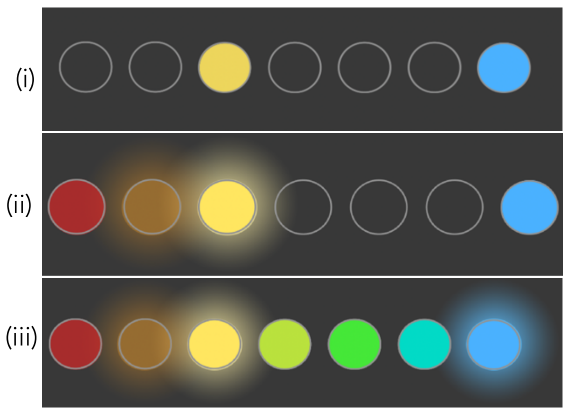


Figure 34: Example of the LED's design of the progression in the measurement experience. (i) showing the starting point and the end goal, (ii) showing the progress moving away from the goal with levels of intensity staying closer to the starting point, (iii) the full spectrum of the colors showing the user achieved their goal with its final intensity.

There are 58 potential variations of the progress reflected on the LED as seen in Table 1. For this study we created a series the variation of scenarios with the hypothesized emotional states based on the Ordinal nature of emotions [Yannakakis, 2018] and valence classifications [Wiem, 2017] as if the user were to measure themselves in 4 instances of interaction.

Video code	duration	description	nominal emotion	emotion rank
WEEK 1 - First Measure				
w1_m1	0.05sec	starting point	neutral	0
WEEK 2 - Second Measure				
w2_m2.1	01 sec	stay at starting pount	neutral /frustrated	-1
w2_m2.2	01 sec	got behind by 25%	neutral /frustrated	-2
w2_m2.3	01 sec	got behind by 50%	frustrated	-2
w2_m2.4	01 sec	got ahead by 25%	neutral /happy	1
w2_m2.5	01 sec	got ahead by 50%	happy	3
WEEK 3 - Third Measure				
w3_m3.01	03 sec	stay at starting pount	neutral/frustrated	-1
w3_m3.02	03 sec	got behind 25% & stayed	frustrated	-3
w3_m3.03	02 sec	got behind 25% & then 50%	frustrated	-3
w3_m3.04	02 sec	got ahead 25% & stay	neutral/happy	2
w3_m3.05	02 sec	got ahead 25% & then50%	happy	3
w3_m3.06	03sec	got behind 50% & stay	frustrated	-4
w3_m3.07	03 sec	got ahead 50% & stay	neutral/happy	1
w3_m3.08	03 sec	got ahead 50% & got back at start	neutral/frustrated	-2
w3_m3.09	03 sec	got behind50% & got back at start	neutral/happy	1
w3_m3.10	03 sec	got behind 25% & back to start	neutral/happy	1
w3_m3.11	03 sec	got ahead 25% & back to start	neutral	0
w3_m3.12	03 sec	got ahead 25% & back 25%	neutral/frustrated	-2
w3_m3.13	03 sec	got behind 25% & ahead 25%	neutral/happy	1
w3_m3.14	03 sec	stayed start & ahead 25%	neutral/happy	2
w3_m3.15	03 sec	stayed start & back 25%	neutral/frustrated	-2
w3_m3.16	03 sec	stayed start & ahead 50%	happy	3
w3_m3.17	03 sec	stayed start & behind50%	frustrated	-3
WEEK 4 - Fourth Measure				
w4_m4.01	04 sec	stayed at the starting point	neutral/frustrated	-1
w4_m4.02	03 sec	steady ahead - 25, 50, 75%	happy	4
w4_m4.03	03 sec	ahead 25%, 75% then back 50%	happy	3
w4_m4.04	03 sec	ahead 50%, 75% then back 25%	neutral/happy	2
w4_m4.05	04 sec	ahead 50%, back 25% then 75%	happy	4
w4_m4.06	03 sec	stayed then 25%, 50%	happy	3
w4_m4.07	04 sec	stayed then 50%, then back 25%	neutral/happy	2
w4_m4.08	04 sec	ahead 50%, then back 25% to the start	neutral/frustrated	-1
w4_m4.09	03 sec	ahead 25%, back to start, then ahead 50%	happy	3
w4_m4.10	03 sec	ahead 50%, back to start, then ahead 25%	neutral/happy	2
w4_m4.11	03 sec	behind 25%, then 50%, then back to start	happy	3
w4_m4.12	03 sec	behind 50%, then 25% then back to start	neutral/happy	2
w4_m4.13	03 sec	stay, then behind 25% then 50%	frustrated	-4
w4_m4.14	03 sec	stay, then behind 50% then 25%	frustrated	-3
w4_m4.15	03 sec	behind 25% then back to start, then back50%	frustrated	-4
w4_m4.16	03 sec	behind 50% then again to start, then back 25%	frustrated	-3
w4_m4.17	03 sec	behind 50% then back to start then forward 50%	happy	4
w4_m4.18	03 sec	ahead 50% then back to start then back 50%	frustrated	-4
w4_m4.19	03 sec	ahead 25% then back to start then back 50%	frustrated	-4
w4_m4.20	03 sec	behind 50%, then back to start, then ahead 25%	happy	3
w4_m4.21	03 sec	ahead 50% then back to start then behind 20%	frustrated	-3
w4_m4.22	03 sec	behind 25% then back to start then forward 50%	happy	4
w4_m4.23	03 sec	behind 25%, back to start, then ahead 25%	neutral/happy	2
w4_m4.24	03 sec	ahead 25%, back to start, then behind 25%	neutral/frustrated	-2
w4_m4.25	03 sec	stay at start, then behind 25%, then ahead 25%	neutral/happy	2
w4_m4.26	03 sec	stay at start, then ahead25%, then behind 25%	neutral/frustrated	-2
w4_m4.27	03 sec	ahead 25%, then back 25%, then back to the start	neutral/frustrated	-1
w4_m4.28	03 sec	behind 25% , then ahead 25%, then back to start	neutral/frustrated	-2
w4_m4.29	03 sec	stay at start, then 50% then 100%	happy	4
w4_m4.30	04 sec	ahead 25% then back at start then ahead 25% agn	neutral/happy	2
w4_m4.31	04 sec	behind 25% then back to start then behind 25% agn	frustrated	-3
w4_m4.32	04 sec	stay at start, then behind 25% then stay at 25%	frustrated	-3
w4_m4.33	03 sec	stay at start, then ahead 25% and stay there	neutral/happy	2
w4_m4.34	04 sec	behind 25% stay at 25% then back to start	neutral/happy	2
w4_m4.35	04 sec	ahead 25% then stay then back to start	neutral/happy	2

Table 1: Series of scenario variations of the potential progress with their respective emotional hypothesis based on the Ordinal nature of emotions within the Valence/arousal naming.

- *Emotional Design*: The progress showcasing through the design elements is methodical with a consistent pattern of intensity and timing to ensure the user can view the information and reflect. When the object reflects emotional instances depending on the valance of their emotions the colors shown with their intensity and pattern of showing will vary. For example, of the user felt relatively neutral to the situation the colors shown would remain between the yellow and its adjacent colors with little no intensity or repetition. While if the person was very satisfied and happy, all the colors would light in different interval of patterns with a higher rhythm to showcase upbeat attitude. While if the person was upset or angry the yellow to red colors would appear with a slower rhythm but with intervals of high intensity.

The result of these designs: the physical object, the steps of the interaction and the LED language, are meant to be self-explanatory and intuitive throughout the interaction so the user can interpret their own conclusions of their personal progress and evolution.

4.7.5 Test

The final stage of this study was to prepare a test that could assess the insights gathered and examine the direction and the concept's impact.
The test examined if: the use of design elements for creating a sense of environment with physical attributes, an interactive informative and emotive interface language using LED lights, and a step by step RE dialogue structure, creates the opportunity for S-R towards Self-Knowledge in 4 stages. The test was presented as a 40- minute, 4-part test with quantitative and qualitative evaluations. Quantitatively we examined their numeric answers from a survey, their timing in responses, and consistent behaviors such as the number of pressings on the main button. Qualitatively we observed their overall physical and verbal behavior throughout the test, while noting on their verbal responses. The sample group was of 23 subjects: 8 female, 15 male, between ages 14 to 60 with varied backgrounds. The first phase contextualized the subjects and the test itself on their current dieting and health monitoring experiences. The second part focused on the relevance of the 5-step RE conversation and the emotional integration to their goals by answering in a scale of 1-5. The third part sought to evaluate the effectiveness of design elements in providing the sense of space and attachment to the object. The fourth section sought to evaluate the designed language: its elements, their meanings individually, combined, and set in a variety of scenarios that reveal progress and emotional feedback.

4.7.6 Results

Though the first section of the test was taken into consideration for the evaluation of the test and is relevant to the context of the project, the focus will remain on the following 3 sections' results: Design of the physical object, the interaction of RE, and the LED language.

Physical Design

During the survey, the section of physical design perception, evaluated the attributes defined by the specific characteristics to be analyzed seen in Figure 35.

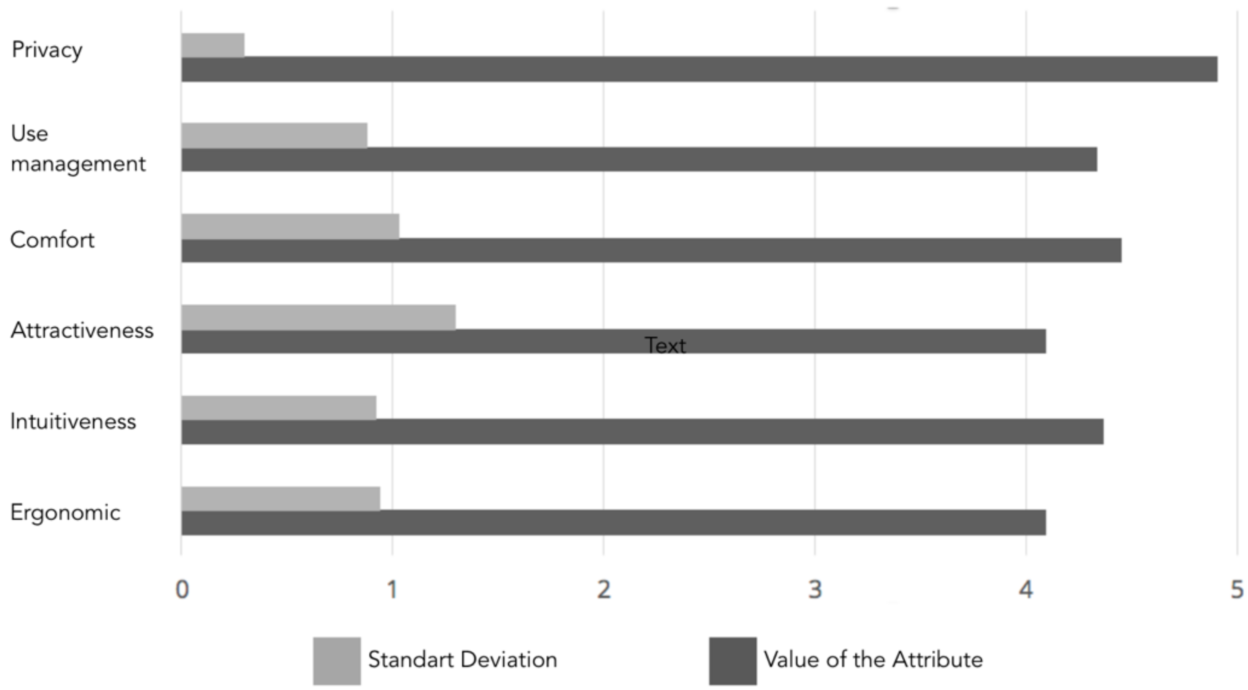


Figure 35: Physical design evaluation from 1 to 5 with the standard deviation.

The test evaluated how the physical design attributes provided a sense of privacy, space, and attractiveness between 1(not relevant) and 5 (very relevant). The overall result with a mean of the global attributes at 4.36 (SD 0.30). While the sense of comfort and privacy with the object resulted in 4,45 and 4.90 respectively. This reflected the comfort of the object in their hands and proactiveness to action the button at the top of the device. Me median of clicks per participant was 45 during the interaction. "The object's design and the materials give you a feeling that you can play with it without breaking".

RE interaction design steps

During this stage of the test the audience evaluated in a range valuation of 1 (being not relevant) to 5 (very relevant). With a mean of 4.68 (SD 0.27), the participants evaluated favorably the relevance of the RE structure and the steps in the interaction (Figure 36).

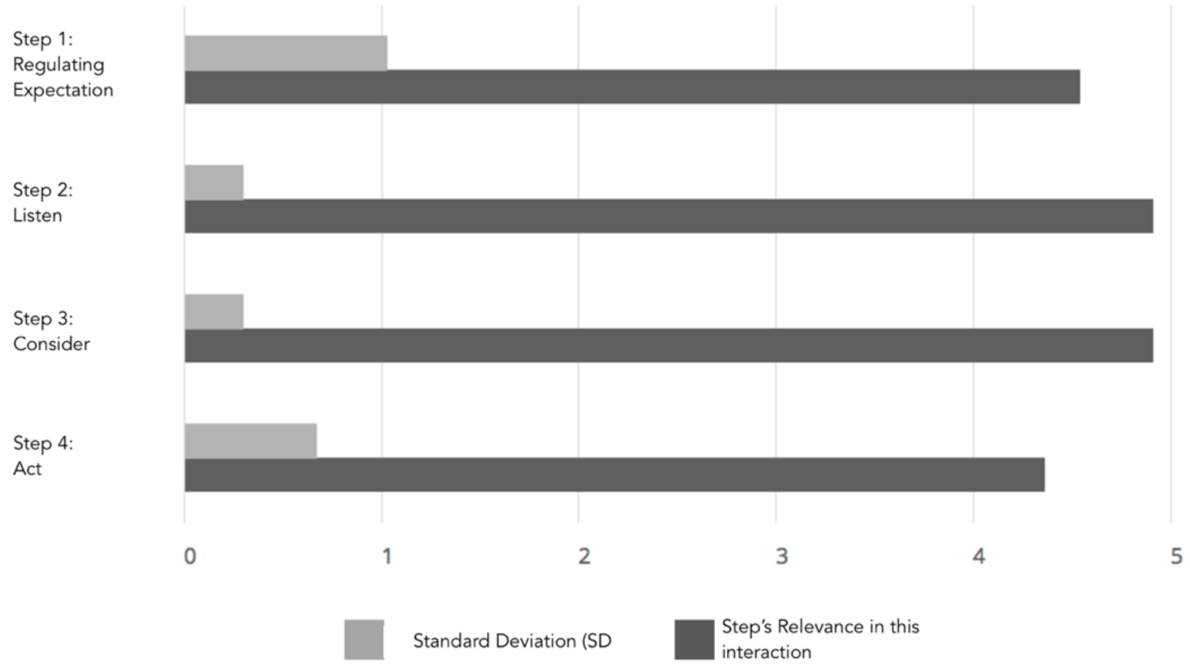


Figure 36: Graph that demonstrates the relevance of each step within the model of RE in the context of this study.

Although, there was a slight decline in how willing the participants were to share and visualize of their own emotions in the designed experience, towards their health goal and S-R. On the other hand, the steps of listen and consider were key to the participants for them to understand and the object to reflect their progress taking into account their opinion and evolution throughout their overall experience. Finally, when we asked if they were willing to continue the dialogue with the object in this format, the response was very positive with a mean of 4.72 (SD 0.46). A general qualitative response supports the decision to alternatively show the user their progress data rather than the actual measurement as a way of providing both data but also information that guides them toward a goal saying, "I want the object to work and tell me things that are useful, I don't want to know all my data, I want solutions".

Design of LED language

The final part of the test evaluated how the visual language with lights, colors, and pattern behavior on the LED strip was received and understood by the audience. People felt open and enthusiastic of using the LED light strip as a new tool of measurement with a 4.9 mean (SD 0.30). When evaluating the amount of time people took to understand and reflect on the new language, the average time was of 122 seconds (SD 91) with an efficacy of 86,9%. Compared to the average time of 10 second when people introspected the progress in relation to their goal (SD 2.5). Also, all the users understood effectively that the positive progress is when the lights evolve toward the blue led.

In Figures 37 and 38 we see the time taken for introspection or reflection vs the effectiveness and efficiency in which the user takes reflecting on 4 viewed experiences during the test. There is a slight increase in time for reflection during the 3 scenario experiences justifiably as the user interacts with more complex scenarios the user needs more time to understand the progress. Finally, the last experience shown obtained a 70% efficacy in a 20 second median time of reflection over this scenario. It is considered a positive result, since it is the only scenario that celebrated with an emotional expression of reaching the goal.

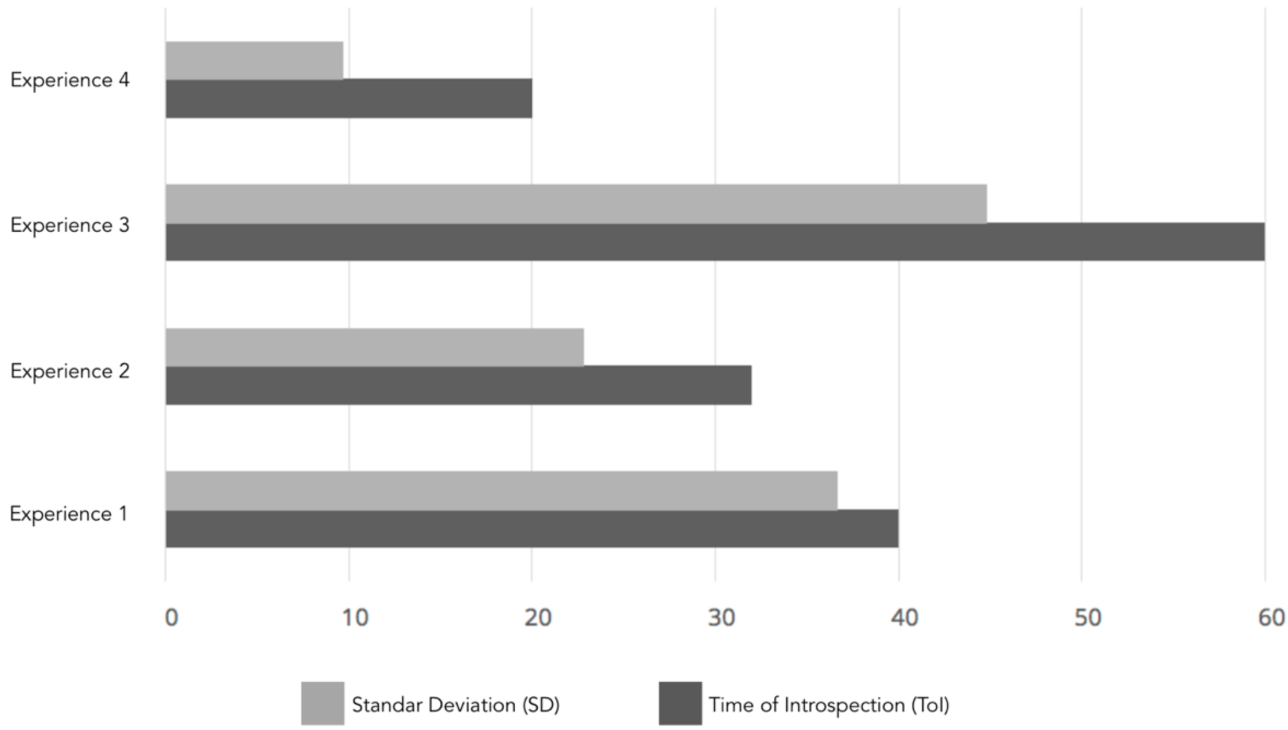


Figure 37:A demonstration of the time of reflection of each experience scenario shown.

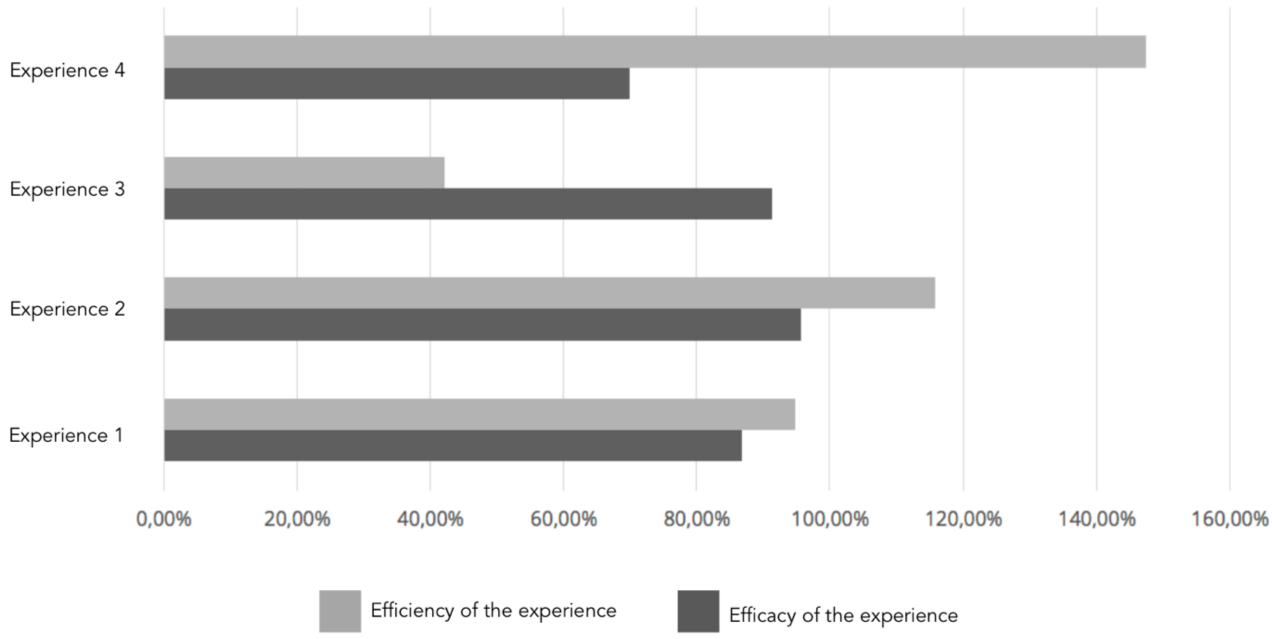


Figure 38: Demonstration of the efficacy and efficiency of each scenario experience.

4.7.7 Discussion and Conclusions

The results on the third part of the test reveal that the designed 5 RE steps experience, supporting both cognitive and emotional cues exchanged for S-R, had a consistent score with a small variance. Furthermore, the results on the second part of the test showed that the physical attributes did achieve a sense of privacy and comfort needed for the RE experience according to the subjects. Also, on the final part of the test, most subjects understood the designed language, taking their time to reflect and internalize the data with little explanation, and much interest. As an initial step towards a new method and tool of P-I measurement that provides moments for S-R, emulating the process of RE, the results here are encouraging. Although, there are supporting qualitative results as well, the ones mentioned already set a direction and sense of the impact this concept may have on leveraging S-R and RE for P-I devices.

This study sets up future studies that specifically test other aspects of the process of RE as well as to further this path of study towards more emotion recognition and its role within the model as well. In fact, this study was proposed for a European funds grant (Llavor & Producte), subsidized by the Generalitat de Catalunya's department of Industry and Knowledge as a seed project (Llavor) that had the potential to become an entrepreneurial project, transferring the scientific knowledge into the commercial industry. In 2020 we won the grant and went into a phase of development, prototyping, testing, and refining the smart object into an entrepreneurial case called

Melli. In the Annex we describe in further detail the: events, evolution of the product from a wellness object to one that we were testing to detect the user's emotions and unique gesture markers, its implementation within a series of practical RE scenarios, and the development of its business model.

5 Use Case:
Realizing Empathy with Social Robots

In this Chapter we present a case study that uses the process of Realizing Empathy as the base theory for Human-social robotics interaction. It is divided in 2 phases where the first was an introductory experiment taking some aspects of RE process into consideration with qualitative tools of collecting and measuring results. Initial indications did provide enough insight that this case study could go a step further. These results were published and presented at the 2020 29th IEEE International Conference on Robot and Human Interactive Communication (RO-MAN). In the second phase we were able to refine the elements within the RE process itself and the measurement tools to detect the indicators of Trust and Affective Attachment, particularly when observing how the participants regulated their expectations throughout the experience. The results from this second phase were also encouraging with future lines of improvement. The contributions were significant to publish the work in the Journal: User Modeling and User-Adapted Interaction, S.I. UMUAI, Personalization and Adaptation in Human-Robot Interactive Communication, 2022.
It is also relevant to emphasize how the study presented in Chapter 4 served as a preliminary trial to test some of the basic elements that brought this model to become more theoretically sound, signifying a step forward in the prospect of the model itself and tools that can be used to design this case study elements of communication tools and mode of consideration.

5.1 Social Robots case study: phase 1

This first phase presents a testbed within a human-robot interaction scenario, with the purpose of contributing a new perspective on how those involved in the interaction may realize empathy based on the model introduced in [Corretjer, 2020].
Empathy is central to the development of artificial intelligence and technologies that focus on improving human decision-making, supporting their intentions, and overall engagement [Asada, 2015; Bickmore and Picard, 2005; Paiva et al., 2017]. The interaction between people, objects, and the technology in their surrounding context is in constant experimentation on topics related to empathy, from affective computing

to collaborative strategies between human and machine [Picard, 2000; Schneiderman and Maes, 1997]. Current research on empathy suggests examining it as a set of stages with well-defined mechanisms [Asada, 2015]. This means going beyond viewing empathy as a singular phenomenon, but as an active body of constant exchanges shedding light on key attributes that may help best engage and sustain a person's experience with other agents/objects.

In this work, we are interested in studying the realization of empathy between humans and social robots in a collaborative scenario. This phase studied and analyzed the current approaches to empathy applicable to social robots to further contextualize the process of Realizing Empathy.

5.1.1 *Testbed for empathy evaluation*

In order to study the development of empathy between humans and robots according to the model presented above, we have designed a testbed where a user interacts with a robot through a ludic, game activity. We next describe the testbed and the reasoning behind the design decisions we considered throughout its conceptualization.

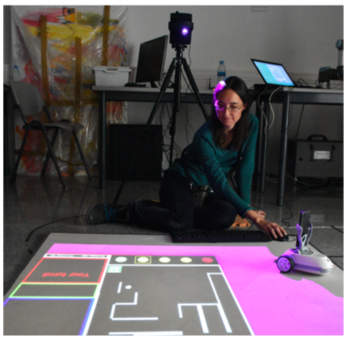


Figure 39: Maze testbed setting where a user is playing with the robot.

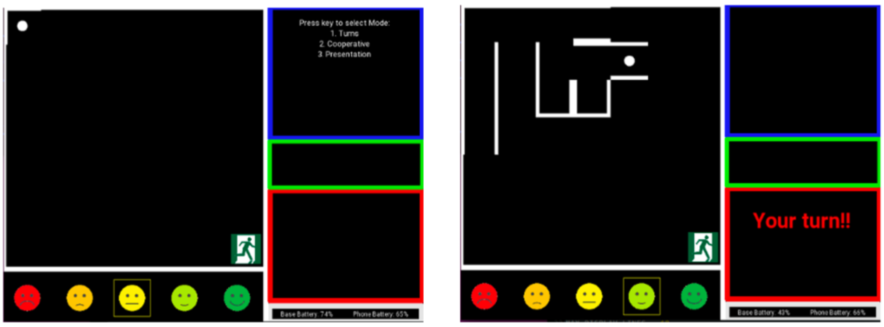


Figure 40: Maze GUI where the maze appears in the main area; icons on the bottom allow the user to state his/her affective state; and panels on the right provide feedback on the game state and written utterances of the robot's speech. The maze is discovered as the players move around it: initial state (left) and halfway (right).

The main requirements for the testbed were the following:

1) it had to involve an entertaining activity where no expertise was necessary to perform it in order to be inclusive with different users' backgrounds and educational levels.

2) it had to involve interaction with a robot, and it had to share a physical space (i.e., not to be fully digital).

3) the activity should foster collaboration between robot and user, rather than competitiveness, to encourage empathetic behavior [Paiva, 2015].

4) it should allow the instantiation of the empathy model variables and steps described in the previous sections.
5) it should allow easy configuration to compare the development of empathy around different settings.

The activity we opted for after brainstorming was solving a maze, where user and robot collaborate to reach the exit (requirements (1), (2), and (3). Requirements (4) and (5) are described in the following Sections). At each time-step, user and robot must agree on which movement to perform together, i.e., move forward, backward, left or right one step. This design intends to respect the need for the user to have a sense of freedom, control, and capability, as well as perceive that the robot also has that ability in the exchange [Ryan, 2000]. As shown in Figure 40 a token on the maze (white dot) represents their position in the maze and the game ends when the token reaches the exit sign. To make the game more challenging, the maze is only partially visible to both players, unveiling the walls as the players move together around the maze.
To facilitate the developing of the testbed and to avoid spending time on overcoming the robot potential limitations when performing the task, we opted for using a digital maze[1]. Hence, the user and the robot solve the game looking at a projection of the maze on the floor (Figure 39). We preferred the projection option in contrast to a laptop/monitor to reduce (or even eliminate) the feeling of playing with a computer instead of playing with a robot. In this sense, both players (human and robot) share the same physical environment with equivalent capabilities (i.e., no need to physically "walk" in the environment), and with equivalent information (both discover the maze as the game evolves).

5.1.2 Robobo, the robot, "Bobby"

The robot used in the testbed is Robobo[2]. It is composed of a small mobile base (17x20cm) and a smartphone attached on top (Figure 41) representing its "head". It has 8 infrared sensors and 4 motors (2 on the motor wheels and 2 in its head to allow pan and tilt). The base includes 7 color LEDs. The smartphone extends the robot sensors and actuators to cameras, microphone, gyroscope, accelerometer, magnetometer, tactile screen, light sensor, GPS, speaker, LCD screen and flashlight. The Android smartphone connects to the base via Bluetooth, and the overall system

[1] The goal of this work is not to develop a robotic system capable of moving through a maze to reach the exit, but to study the development of empathy between humans and robots.
[2] https://theroboboproject.com

is connected to a computer via Wi-Fi. The robot's mobile runs the Robobo free application which is used to configure the robot (e.g., IP) and to interact with the robot. Once the app is running, the screen shows a pictorial face which can represent up to 9 emotional faces (Figure 41). The robot can be programmed in Scratch, Python or ROS.

game state	face emotion	base motion	head motion	sound	LED
start	x	x		x	x
win	x	x		x	x
end-of-game	x		x	x	x
dead-end	x		x	x	x
backtrack	x			x	x
waiting			x	x	
persuading	x	x	x	x	x

Table 2: Summary of modalities used to communicate with the user

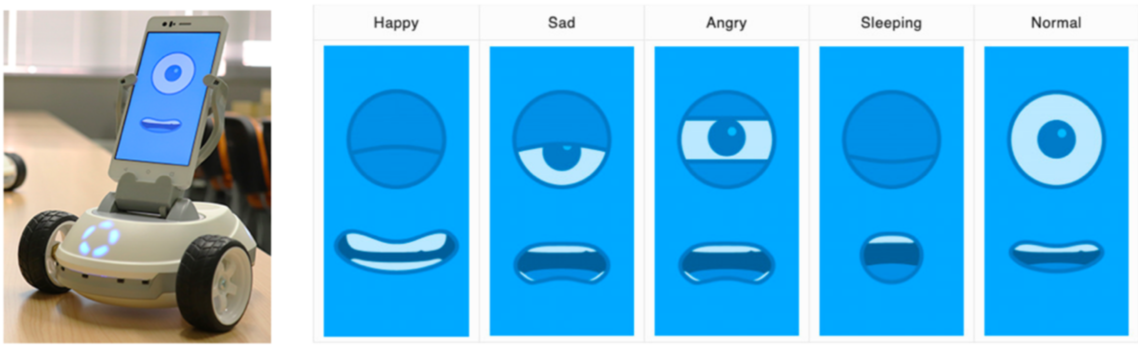


Figure 41 (Left) The Robobo robot. (Right) Some of the facial expressions Robobo can display.(Source: The Robobo Project).

To promote the development of empathy, we designed the robot behavior to be social and with attributes that can denote relatedness, using different modalities to communicate and to provide as much feedback as possible in the different game states. For instance, when the game starts, the robot smiles and turns its base 360 degrees while laughing. Then it says, "let's start". Each speech act includes at least three different utterances that are randomly chosen to avoid repetitiveness. A summary of the different modalities used in the different states of the game is summarized in Table 2 (speech is always used). Note that using the same modalities does not imply the same behavior, since each modality is instantiated in different ways.

We also provided the robot communicative behavior different stressing levels when it comes to suggesting a move in the maze to the user. In this case, the first time the robot suggests a move, it communicates its decision through a gentle motion, e.g., to indicate "left", it would only pan its head slightly while verbalizing it. However, if the user refuses the suggestion and the robot wants to continue persuading its peer, it will turn the base to the left to emphasize its position. The most stressing level includes repetitive base movements (e.g., turning left back-and-forth), the use of LEDs and displaying a disappointment face. This persuasion process does not take place systematically at every round, only as far as far as the robot opts for doing so.

5.1.3 Instantiating the empathy model

As described in the previous section, the empathy model is defined by three stable elements, which rule the context, and an iterative four-steps process. We instantiate them according to our test- bed context as follows:

Stable Elements:

- ENVIRONMENT: the user and the robot share a physical world, i.e., a space in a room where the user seats next to the robot; and a digital world, i.e., both observe a projection of the maze on the floor and their position inside the maze represented with a white dot (Figures 39 & 40).
- COMMUNICATION: the user communicates to the system through a keyboard and a mouse to indicate her actions (using the 4 arrows to move in the maze up, down, left or right), arguments (numbered justification for her decisions available in the top right panel de- scribed in next subsection) and emotional state (pointing at 5 iconic faces below the maze as shown in Figure 35). On the other hand, the robot communicates with the user through speech, movement (either head or base movements indicating the direction to take), sounds, LEDs, facial expressions and text within the projection.
- MINDSET: while the user's mindset is not controllable, i.e., we cannot force the user's mindset, we do control the robot mindset defining its behavior as receptive, i.e., open to listen to its peers and to consider their opinions during decision-making. We also attempt to nudge the user to an open mindset with a set of instructions and introduction to the robot before the start of the test.

Process:

- REGULATING EXPECTATION: the robot behavior is designed to be respectful with its human peer, i.e., being polite with the user and avoiding any harm to her. On the other hand, before the activity takes place, the user is clearly instructed about the robot's abilities, goals, means of interaction and asked not to damage the robot or sabotage the system in any way. The aim is to familiarize the user with the robot and establish a respectful mindset, a baseline for their expectation, and hence, setting early seeds of empathy.
- LISTEN: the available information for both players (human and robot) are the map of the maze (partially observable for both), the movements within the maze, the arguments justifying their decision-making and their emotional state. While the robot behavior is designed to take into consideration all these aspects in a systematic way to ensure the LISTEN step of the process, we cannot guarantee that its human partner will use such input in her decision process.
- CONSIDER: the information gathered in the LISTEN step is taken into account in the decision-making to determine what to do next (Algorithm 1). Given the current state, if both players suggest moving in the maze in the same direction (a^r), then the decision is clear, and no further consideration is necessary (line 1). Otherwise, if each player chooses a different action, then a joint decision must be made. The available options for both players are (i) to accept their peer's suggestion, i.e., make the suggested movement; (ii) to reject the peer's suggestion up to N times and provide an argument for such decision; or (iii) to toss a coin to decide whose suggestion is the one to be performed. While the strategy for the human player is uncontrolled, i.e., she can consider any option at her own will, we have designed a parametrized strategy for the robot decision making as follows.

```
Input: a^r_user, a^r_robot, r, emotion^r_user
Output: action
1  if a^r_user == a^r_robot or r < MIN_ROUNDS: then
2  |  action ← accept(a^r_user);
3  else
4  |  if emotion^r_user in {very sad, sad} then
5  |  |  action ← accept(a^r_user);
6  |  else
7  |  |  if available_arguments() and n_reject < N
      |  |   then
8  |  |  |  action ← get_argument();
9  |  |  else
10 |  |  |  action ←
   |  |  |   random(accept(a^r_user), coin_toss(a^r_user, a^r_robot));
11 |  |  end
12 |  end
13 end
```

Algorithm 1: Robot strategy in Consider step.

The robot accepts its peer's suggestion in the first m rounds (MIN ROUNDS) so the user gains confidence and to start populating the history of the game execution (line 1). From then on, the robot will take into consideration the game history as well as the user's emotional state when making decisions. If the user has reported a negative emotional state, then the robot yields to raise the user's internal state (lines 4

and 5). Otherwise, an argumentation process takes place, where the robot tries to convince the user about accepting its suggestion (line 7 and 8).
If no arguments are available or the maximum number of rejections has been reached, then the robot randomly chooses to either yield or toss a coin to decide where to move next. In the argumentation phase, the user is free to accept the robot's argument and then yield, or to counter-argue. The scope of this work is not to build an argumentation framework, but to provide an opportunity where the different actors' views (user and robot) are taken into consideration, which is essential in the developing of empathy. Hence, to simplify the argumentation phase, we have pre-defined a set of potential arguments from which both players select the most appropriate one given the current state and history of the game to counter-argue its peer's suggestions as follows:

a. *fairness*: frequency of actions for each player is unbalanced, where my own suggestions have been less accepted. This principle is represented by the argument "We're following your suggestions most of the time, it's my turn to choose".

b. *leadership*: frequency of actions for each player is unbalanced, where the other's suggestions have been less accepted. This principle is represented by the argument "I've decided most of the time, let me continue leading".

c. *failure rate*: frequency of actions that have led to dead-ends in the maze. This principle is represented by the argument "Your decisions have taken us to dead-ends, let me decide now".

- ACT: this step represents the execution of the action decided on the previous step, which can be: indicate the next movement to perform (the user through the keyboard and the robot through one of the modalities described in Section V-B); argue (the user through the keyboard and the robot through speech and written text); yield or toss a coin. Along with these actions, emotional expression can also be provided (the user through the mouse and the robot through its face, sounds and LEDs).

The testbed allows us to modify different parameters to observe different behaviors such as the maze size, number of rounds before yielding, probabilities for choices, deciding who proposes first a move, etc.

5.1.4 Initial Insights

A first set of exploratory trials have been run in order to gather initial insights on users' perception of the testbed. Ten participants were recruited within the university (4 females, 6 males, between 19-30-years-old (M = 22.33, SD = 3.39)) whose expertise varied from engineering, arts, and business management.

The aim was to observe if participants perceived the robot differently while it applied two different strategies during the CONSIDER step. The first strategy corresponds to an argument- based strategy (ARG). In this case, both players had the opportunity to justify (to some extent) their choices and to influence on the decision-making of their partner. Moreover, the robot also considers the reported emotional state of its peer during its reasoning. The second one is based on turns, where at each round of the game, the players alternate to decide which move to make next. The action is immediately executed, without space for discussion on the appropriateness of such move. And in contrast to the ARG strategy, the robot does not consider the emotional state of the user. We refer to this latter strategy as turn- based (TURN). We believe that the argument-based strategy promotes the development of empathy in the long-term, where the actors feel cared by each other because of a flourishing feeling of trust, matching expectations and attachment.

Each participant played twice with the robot, where the order in which each strategy was experienced (ARG or TURN) was randomly allocated. After each trial, we conducted a semi-structured qualitative interviews to participants to learn about their perceived experiences. The following initial insights were derived:

On attachment and care: At the beginning of each trial (regardless of the strategy), the robot provided a welcoming message (through sounds, body movement and facial expression) meant to elicit an affective state of happiness in the user. This instance of human-like behavior provoked a smile and slight giggle from most of the participants, suggesting an initial sense of fellowship, relatedness, and care for the robot [Paiva, 2017]. After the TURN trials, participants described the experience as: "I felt good", "it was nice" or "the robot was friendly". Interestingly, after the ARG trials, participants described the experience: "reflective", "more enjoyable", "more involved", "felt the robot wants to work as a team" and "there was understanding of each other". The use of more detailed language to differentiate the experiences gives us clues that the ARG strategy had provoked a change in how they perceive the robot's role in contrast to the TURN strategy.

On trust: 8 out of 10 of the participants would interact again with the robot. However, they did differentiate potential application settings based on the strategy the robot used. They were keen to interact again with the robot using the turn-based strategy in a fun activity. However, in a professional setting, they preferred the argument-based strategy. Based on these responses, we believe that participants trust the robot's capabilities using the ARG strategy when open discussions are necessary, providing the opportunity to reflect on the available options.

5.1.5 Conclusions and Future Work

In this first phase of the case study, we introduce a testbed to validate the proposed novel model for realizing empathy within a human-robot interaction setting. The testbed is designed around a collaborative activity, where the user and the robot play together to solve a maze. It allows easy configuration of strategies and parameters to evaluate the different aspects of the proposed model.

The promising first observations do point out that a reflective space might be suitable for developing empathy and hence, engagement and motivation in long-term human-robot interaction. These initial insights motivated a second phase of study that expand on the design of the testbed described above.

5.2 Social Robots case study: part 2

In previous section based on Corretjer et al., 2020, we explored through a qualitative approach initial insights of realizing empathy between a human and a robot. We observed that the shared space and opportunity to argue with each other led to a shift in perception of the experience highlighting trustworthiness and affective care. These insights, along with novel literary references, led us to expand our previous work and further examine the role of regulating expectation, trust, and affective attachment as key indicators to realize empathy.

We thus introduce a pilot study where the goal is to capture with further detail quantitative results of indicators of early realization of empathy between a human and a social robot. In the study, the actors: a human and a social robot, apply two different collaborative strategies to solve a maze: (1) based on turns, where one actor has no other choice than to accept the other's decision at each turn (passive collaboration); and (2), based on exchange of viewpoints to reach an agreement (active collaboration). We evaluate the participants' experience of regulating their expectations, trust, and affective attachment towards the robot as indicators of realizing empathy. We hypothesize that a strategy where space for argumentation is offered (active collaboration) will promote the realization of empathy more effectively compared to an individualized collaborative one (passive collaboration).

In the following section we provide the details that captured the goal of this case study's second phase at each of the sections from the previous description of the testbed, further amplifying on the implementation of the process of RE and the theoretical background.

5.2.1 Contributions

Early works on empathy in artificial agents mostly addressed a provocation of empathy through passive observation of a situation or studying the computational modeling of empathy in social agents (Paiva et al., 2017). Similarly to the latest works [Alves-Oliveira et al., 2019; Azhar, 2015; Cunha et al., 2020; Morris et al., 2018], we take Paiva's perspective of provoking empathy a step further, where the actors are meant to actively collaborate to resolve a task by deciding together at each step while exchanging their point of view. We propose the robot to have the role of a teammate with an active contribution in the task at hand, instead of a companion that shares emotional states mainly. In this sense, its decisions have an impact both on the development of the task and on its human partner's internal state (beliefs, intentions, and emotions). Moreover, we focus on studying the act of realizing empathy as an experience of developing trust and attachment between the involved through time. Thus, we argue that along with the existing computational models, a context of active exchange, where the involved agents have a chance to expose and reflect on the different views, feeling listened and understood, while in a shared space and with clear intentions, is essential to effectively create empathetic experiences and thus achieve longer engagements in human-robot interaction.

This phase studies whether providing an explicit space for exchange of views and reflection on the other's point of view, along with simple empathy mechanisms of affective expression, promotes the presence of indicators of empathetic interaction (attachment and trust) between subjects and robots.

5.2.2 A Testbed for Empathy Evaluation

In essence we conducted the same baseline design of the testbed explained in the first phase of this case study. Here we will describe at each section, the main differences that were applied in this second phase.

The Maze testbed

Though the main requirements remained from the first phase it is important to highlight the refined focus on following points:

a. There were 4 main reasons as to why we decided to design the activity between the user and social robot ludic or entertaining rather than practical. (a) In order to trigger initial trust, the sense of risk should be reduced, which in turn will increase the willingness to interact with the system [McKnight et al., 2002]. (b) The activity should foster collaboration between robot and user, rather than competitiveness, to encourage empathetic behavior [Paiva et al., 2017]; (c) To reduce bias based on demographic profiles, we needed to ensure that the activity did not require any specific expertise, to be inclusive with different users' backgrounds, and educational levels; (d) The design needed to de-focuses on external tasks or goals, while promoting curiosity and reflection [Gaver, 2004], to then allow us to focus on translating and evaluating the specific steps and elements in the RE process.

b. Based on the process of RE, dialogue models, case studies around empathy with robots, and other works, the shared environment between the user and robot needs to be well considered in the activity. As suggested by Seo et al. (2015) physical robots achieve higher empathetic responses from users than virtual ones), therefore, in our study we emphasized in creating a sense of space that was physical, not fully digital, that the user and the robot shared. This space was open, flexible, but intimate enough between the two using a projection on the floor. This means that both the user and the robot were at a "similar level" and both could move freely in the space. Preferring this option in contrast to a laptop/monitor to allow the experience to become immersive (reducing the feeling of observing through a display [Slater and Wilbur, 1997]), focusing the interaction and dialogue between the robot and the subject in a shared space (environment concept described in section 4.1).

Robobo, the robot, "Bobby"

After the first phase it was clear that we needed to ensure that the user got to "know" Bobby a bit more as part of the instruction phase of the activity. To do this we created a small video that displayed Bobby's full range of facial expression, body motion (head and base separately), sound, LEDs and verbal utterances that was going to communicate with through different modalities with the user. It is important, that "Bobby" was clearly behaving with some affective states as part of its feedback to the user, covering emotional communication necessary for a dialogue driven RE process.

Instantiating the empathy process

As described in Section 4.1, the process to Realize Empathy is defined by the cyclical movement of motivation, three stable elements, which rule the context for the process of RE; and four iterative steps. To grasp and attempt to study or provoke all aspects of RE would make the case too wide and difficult to measure. We decided to focus on certain aspects as a minimum viable model. By focusing on instantiating these particular aspects of the process, we can already start detecting the direction and viability of the model for further study and application. As we did not redesign from the initial intention, again, we rather emphasize on how they were focused during this phase:

a. Stable elements:

- *ENVIRONMENT*: the space the user and the robot share have a deliberate intimate, yet ample design where they interact in a physical world, i.e. a space in a room where the user seats on the floor, next to the robot; and a digital world, i.e. both observe a floor projection of the maze.
- *COMMUNICATION:* The communication elements remained the from the previous phase. It is important to note that the colloquialism and tone used was neutral for 3 main reasons. (1) The intention was to use the neutrality to identify potential perceptions of the user towards the robot, part of the qualitative data gathered. (2) The affective expression of the robot was carefully considered, and we intended to limit the

variability of this expression to sounds, color and movements (specific artistic elements). (3) With neutrality, the tone remains controlled as part of the intended base expectation for the robot's attitude and behavior towards the participant as described during the instruction phase.

- *OPEN MINDEDNESS*: There are two perspectives to consider within this element: the participant's mindset and "Bobby's" designed mindset. Though we cannot directly control the participant's mindset, we did provide 3 sets of instructions to set an initial level of expectation for the subject, as well as nudge the participant at a state of open mindedness and consideration for the robot, including an introductory video of the robot speaking to the participant and an in-person introductory phase of the robot presenting itself. On the other hand, we do control the robot mindset defining its behavior as receptive, i.e., open to listen to its peers and to consider their opinions and emotions during decision-making.

b. The process steps:

When instantiating the process, we noticed that we had to be more present in how we presented the baseline for what the participant could expect from "Bobby", that there was one more type of argument that needed to be considered by the robot, therefore one more way in which the robot could act accordingly. Below the details at these steps:

- *REGULATING EXPECTATION*: the robot behavior is designed to be respectful with its human peer, i.e. being polite with the user and avoiding any harm to them. At the beginning of the game, a familiarization phase takes place with a series of instructions to create set a base line of expectation of the experience with the robot [Gillath et al., 2021], and thus, adding to initial trust as early seeds of empathy. Throughout the game, the experience itself will naturally provoke the participant to evaluate and regulate their expectations from what they had previously set.
- *CONSIDER*: This is where the exchange becomes an active provocation in how the robot is no longer in a supportive role, but actively participates adding or shifting how the user perceives, trusts, and cares for "Bobby".

  In the argumentation phase, the user is free to accept the robot's argument and then yield, or to counter-argue. When we re-assessed the pre-defined potential arguments that both could use in the argumentative phase of the activity, we added a new potential argument:

invalid path: when the next step will only lead towards a dead end. This principle is represented by the argument "There is no way out"[3].

"Bobby" cannot see in the same way as the human counterpart can, and only navigates as the map is being revealed and becomes visible to it when it visits a cell. This means that there were movements that for the participant were very apparent on what to do next, but not for Bobby. This new argument to be considered, allows an acknowledgement of what maybe evident to either party.

- *ACT*: Because we added a new argument to consider, the actions reflect accordingly. If the "Invalid path" argument is raised, either the participant or the robot will automatically yield without further arguing.

5.2.3 Methodology

This section describes the pilot study design to evaluate whether initial steps of realizing empathy are triggered in people while using the testbed described above. We continued with the ARG and TURN-Based strategies in the design, but both the amount of participants and overall structure of the test has more nuance to detect more accurate qualitative and quantitative measures.

Experimental conditions

Two different collaborative strategies were designed for the players (human and robot) to follow when solving the maze. Though both strategies consider the self-determination (SDT) needs, they engage them differently. Each strategy corresponds to one experimental condition:

a. *ARG-BASED*: The first strategy, argumentative condition (an active collaborative strategy) corresponds to the one described in the Consider step. In this case, both players have the opportunity to justify (to some

[3] There are situations where dead ends become visible prior to visiting the cells in the maze. Contrary to the human, the robot is only aware of the maze cells once they are visited. Hence, this argument is only available for the human actor and if raised, the robot will immediately yield without further arguing.

extent) their choices and to influence on the decision-making of their partner. Moreover, the robot also considers the reported emotional state of its peer during its reasoning. When the user indicates feeling angry or sad, the robot would always yield when discrepancy occurs aiming at improving the participant's feeling of frustration. In this case self-determination needs are challenged but observes how these needs were supported and how the participant is also able to support the same needs in the robot.

b. *TURN-BASED*: the second one is based on turns (passive collaborative strategy), where at each round of the game, the players alternate to decide which move to make next. The action is immediately executed, without space for discussion on the appropriateness of such move. Thus, each player must accept the other's choice. Moreover, in contrast to the ARG-based condition, the robot does not consider the emotional state of the user in its decision-making at all. In this case self-determination needs are considered but not as challenged or support was as observed as in the previous strategy.

Participants

Gender		Background		Robot familiarity	
Female	6	Engineering	15	Very familiar	1
Male	11	Mathematics	1	Familiar	5
Rather not say	1	Architecture	1	Somewhat familiar	6
		Management	1	Not familiar at all	6
TOTAL	18		18		18

Table 3: Participants demographics and self-reported familiarity with robots

We recruited 18 participants (age range between 18-42, M = 27, SD = 7.1) from our university campus mainly from the Engineering Department. We asked participants about their previous experiences with robots through an initial survey. While some self-reported previous experiences with robots, most of the participants indicated not having or having very little experience with them. Table 3 describes our sample demographics. Due to the difficulties for recruiting participants during the COVID pandemic period, the study was designed as a within-subject experiment, where the order of the two experimental conditions were randomly assigned.

Procedure

The experiments were performed in a closed room at the university campus with only the test conductors and the participant. A projector displayed the game environment on a flat board on the floor with the lights dimmed to provide some sense of privacy between the participant and the robot. The participant sat on the floor during the experiment, and the robot was placed facing him/her to allow the user full view of the game and the robot itself.

Participants began the test as soon as they walked through the door. They were sat, provided a consent form to sign and approve for video recording, and read description of the study (avoiding specific references to empathy evaluation to prevent biasing their answers), with the added instruction to sign as a consent form signed a consent. Next, they went through a familiarization stage aiming at "nudging" an open mindset and to set the same baseline for both conditions, i.e., regulating their expectation (first step of the process). To this end, a set of instructions describing the game, the robot (named Bobby in the study), its limitations and how to interact with it were provided. Additionally, the participant also watched a video recording of the robot itself acting as if speaking directly to the subject.

Next, a demographic survey was filled in, as well as an empathy baseline questionnaire, the Toronto Empathy Questionnaire (TEQ) [Spreng et al., 2009]. As an example, here are some of the statements participants rated from the TEQ (5 of 16):

1. When someone else is feeling excited, I tend to get excited too
2. Other people's misfortunes do not disturb me a great deal
3. It upsets me to see someone being treated disrespectfully
4. I remain unaffected when someone close to me is happy
5. I enjoy making other people feel better

The aim was to assess the empathy level of the participant to evaluate any further correlation between their response to the experiment and their base empathy level.

The participant would then sit on the floor next to the robot to undergo the first trial in one of the conditions, either ARG-based condition or TURN-based condition. After the first trial was finished, the participant filled in a post-questionnaire. Next, the experimenter and the participant sat together to annotate the recorded trial based on the user descriptions (post-recall procedure). Then the second trial took place, applying the alternative condition. When the trial was over, the participant completed once again the post-questionnaire and the post-recall procedure. At this point the participant was debriefed. Overall, each experiment lasted around 50 to 60min per participant.

Measures

The objective of this pilot study is to evaluate the realization of empathy by observing (1) the participant's regulation of expectation, (2) the presence of attachment through affective emulation and (3) behaviors related to trust. If such indicators are present, then a form of empathy has been reached. Moreover, it is an added assurance if the expectation not only regulates throughout the experiment but is also perceived to match in understanding each other.

To this end, we have designed three types of data analysis: (1) subject perception of the experience through a set of questionnaires, (2) annotation of their perceptions and motivations behind their decision-making in the game through a cued-recall method, and (3) subject performance based on their actions and movements throughout the interaction based on logged information of the game. Moreover qualitative data was gathered as the subjects freely expressed their feelings, observations and natural reactions throughout the experiment, and an additional open-question at the end of the post-questionnaire.

a. *Self-reporting of the experience*

Inspired on existing questionnaires we decided to work with the following bodies of work: (1) the Networked Minds Measure of Social Presence (NMMSP)[4] [Biocca et al., 2001]; and (2) the Game Experience Questionnaire (GEQ)[5], specifically, Measure of Social Presence [IJsselsteijn et al., 2013]. Though these questionnaires do not use the specific language and modeling as we do in the theoretical process of realizing empathy, they tackle aspects of empathy, interrelation, and teamwork that do relate very closely to it. Therefore, we have designed our own set of questionnaires (Q1, Q2 and Q3) tailored to our context particularly focusing on the three indicators of our objective:

[4] The instrument specifically measures social presence defined as "a global, moment-by- moment sense of the other, an outcome of cognitive simulations (i.e., inferences) of the other's cognitive, emotional, and behavioral dispositions", where the other is either human, animate, or artificial being (a robot in our case). The authors define three levels of social presence, from which the two higher ones correspond to psychological involvement (including "responses to emotional states of the other") and behavioral engagement ("the degree to which the observer believes his/her actions are interdependent, connected to, or responsive to the other and the perceived responsiveness of the other to the observer's actions"). The definitions of these two layers match the principles of empathy described in related work, particularly that of Hoffman's definition of empathy and Strickfaden's active response.

[5] The GEQ measure evaluates game experience (the setting in our study), explicitly includ- ing a module on social presence focused on psychological and behavioral involvement of the player with other social entities (either virtual, mediated or co-located, directly linked with empathy theories).

-*Attachment*: Both NMMSP and GEQ questionnaires define empathy primarily as an emotional phenomenon that translate to our indicator of attachment. Items related to affective states in empathy were highly similar in both questionnaires. We thus chose the more comprehensive of the two questionnaires taking items 4, 8, 9, 10, 11 and 12 from the GEQ Social Presence module.

-*Trust:* We analyze trust in collaborative mindset as a concept interlinked to the notions of willingness to be with the other, observing their actions, teamwork, collaborating, and having affective trust [Ashar et al., 2017; Gillath et al., 2021; Rousseau et al., 1998]. We thus used items 2, 3, 5, 6, 13, 14 and 15 from the GEQ Social Presence module on the one hand, and all items from the Mutual Assistance NMMSP Behavioral Engagement module, on the other hand. Such items describe the perception of teamwork and assistance of each other.

-*Regulating expectation:* While expectation regulation is a dynamic process that takes place throughout the interaction, in this questionnaire we are interested in assessing the outcome of such process as a matched expectation, or mutual understanding. In this sense, we took all items in NMMSP Mutual Under- standing module, as well as items 3 and 4 from the Behavioral Interdependence module which relate to our concept of matched expectation.

Table 4 summarizes the items included in our questionnaire (Q1, Q2 and Q3), their sources and the Likert scale adopted for each.

Item	Questionnaire	Likert Scale
Q1 ATTACHMENT		
A1. I felt connected to Bobby.	GEQ-SP	1–5
A2. I found it enjoyable to be with Bobby.	GEQ-SP	1–5
A3. When I was happy, Bobby was happy.	GEQ-SP	1–5
A4. When Bobby was happy I was happy.	GEQ-SP	1–5
A5. I influenced Bobby's mood.	GEQ-SP	1–5
A6. Bobby's mood influenced me.	GEQ-SP	1–5
Q2 TRUST		
T1. My actions depended on Bobby's actions.	GEQ-SP	1–5
T2. Bobby's actions depended on my actions.	GEQ-SP	1–5
T3. Bobby paid close attention to me.	GEQ-SP	1–5
T4. I paid close attention to Bobby.	GEQ-SP	1–5
T5. I admire Bobby.	GEQ-SP	1–5
T6. What Bobby did affected what I did.	GEQ-SP	1–5
T7. What I did affected what Bobby did.	GEQ-SP	1–5
T8. Bobby did not help me very much.	NMMSP-BE-MA	1–7
T9. I did not help Bobby very much.	NMMSP-BE-MA	1–7
T10. Bobby worked with me to complete the task.	NMMSP-BE-MA	1–7
T11. I worked with Bobby to complete the task.	NMMSP-BE-MA	1–7
Q3 REGULATED EXPECTATION		
E1. My opinions were clear to Bobby.	NMMSP-PI-MU	1–7
E2. Bobby's opinion were clear to me.	NMMSP-PI-MU	1–7
E3. My thoughts were clear to Bobby.	NMMSP-PI-MU	1–7
E4. Bobby's thoughts were clear to me.	NMMSP-PI-MU	1–7
E5. Bobby understood what I meant.	NMMSP-PI-MU	1–7
E6. I understood what Bobby meant.	NMMSP-PI-MU	1–7
E7. Bobby's behavior was in direct response to my behavior.	NMMSP-BE-BI	1–7
E8. My behavior was in direct response to Bobby's behavior.	NMMSP-BE-BI	1–7

Table 4: Summary of the questionnaires developed to assess the three indicators of empathy realization. These were borrowed and reorganized according to our needs from different modules of the GEQ (Social Presence module, GEQ-SP) and the NMMSP (Mutual Assistance-Behavioral Engagement module, NMMSP-BE- MA; Mutual Understanding-Psychological Involvement module, NMMSP-PI-MU; Behavioral Interedenpence-Behavioral Engagement module, NMMSP-BE-BI). We have kept the original scales for each item to preserve scale consistency with the original questionnaires.

Moreover, we also wanted to assess how the participant felt the overall experience with the robot in terms of relational closeness [Branand et al., 2019]. We thus used the Inclusion of Other in the Self (IOS) (Figure 42) scale [Aron et al., 1992] (Q4 from now on). This scale measures how close the respondent feels with another person or group. The scale consists of a set of circles with different degrees of overlap representing the "self" and the "other". Participants should answer the question: "Which picture best describes your relationship with xxx", where xxx is replaced with Bobby in our setting. Figure 5 depicts the scale participants used to answer the question. Besides this scale, we also offered an opportunity for the subject to express in their own words how they perceived the robot's behavior and the experience overall through an open question at the end of each trial.

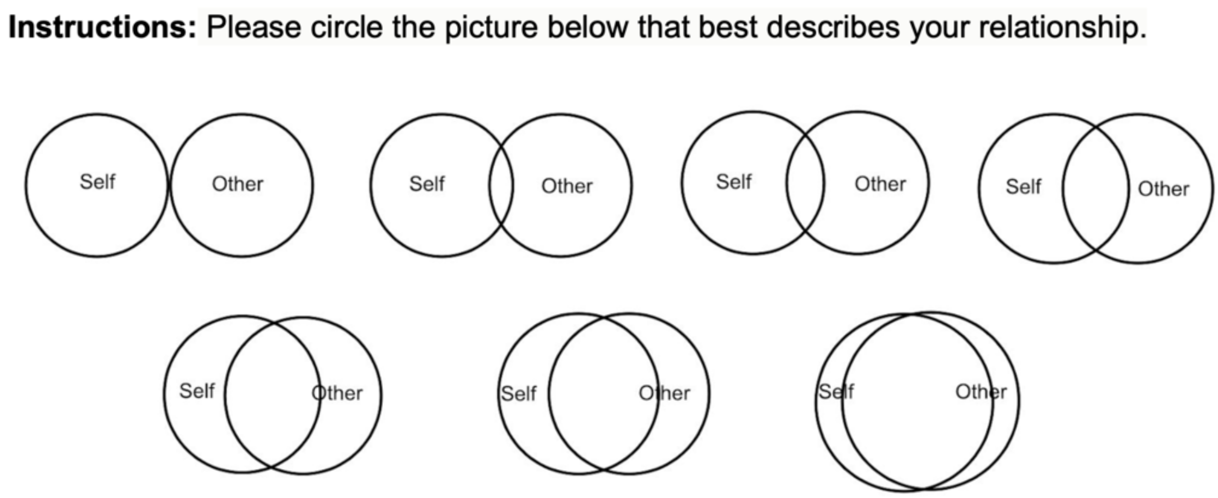


Figure 42: Inclusion of the Other in the Self (IOS) scale used to evaluate the level of closeness of the participant with the robot after the trial, where 1=no over- lap; 2=little overlap; 3=some overlap; 4=equal overlap; 5=strong overlap; 6=very strong overlap.

b. Cued recall debriefs

We were interested in gathering details of the participant's perception and motivations behind their decision-making throughout the experiment to best evaluate how these fell within the parameters of our realizing empathy process. We discarded questioning the participant during the game since we believed that such interruptions would have a negative impact on the natural interaction flow with the robot. Hence, we opted for using a cued-recall approach, a form of situated re- call[6], as a method to elicit information about the user during system use [Bentley et al., 2005]. We thus video recorded the participant while s/he was solving the maze with the robot. Once the trial was over, we asked the participant to watch the recorded video while answering a set of structured questions after each user action classified in three categories:

1. *Predictability*, to observe if the situation or behaviors where unexpected with respect to the robot or the game. We link these answers to the regulating expectation indicator of realizing empathy.
2. *Motivation*, to categorize why participants acted the way they did. Responses related to teamwork and testing are linked to empathy development. In the first case, taking into consideration our teammate's opinion and emotional state is a clear indicator of involvement with the other, and not driving our decision only based on a rational mindset. In this sense, we refer to "implicit yielding" as the act of agreeing or accepting the robot's choice without further discussion. Such decision indicates the participant trusts the robot's suggestion, hence, being a strong indicator of teamwork. In the second case, testing is usually driven by curiosity, a key element in the realization of empathy as the participant regulates his/her expectations in order to develop trust. We link this category to regulating expectation. Finally, random choices indicate that no clear stance has been adopted, neither trust in the self nor in the other. In any case, a lack of trust is evidenced. We thus link this category to the trust indicator of empathy.
3. *Joint affective expression*, to observe any shift on the way participants describe their emotional state. We specifically investigate the use of singular or plural subject pronouns in their speech, i.e. "I" vs "we". While the former relates to an egocentric point of view, the latter relates to working as a team. We thus link this category to the indicator of attachment.

We allowed the participants to freely answer each question to avoid biasing their responses. We then coded these as described in Table 5.

[6] Observing a recent past experience facilitates user recall of such situation and thus, evoking close cognitive and affective state.

Code	Description
PREDICTABILITY: Was there anything unexpected in this scene?	
Intelligence	Reasoning capabilities of the robot in terms of effectively solving the maze.
Behavior	Robot behavior in response to the participant's actions including both decision-making and affective state (e.g. yielding to user's choice, emotional response and social cues display)
Situational	Robot independent game situations (e.g. unexpected deadend)
MOTIVATION: Why did you do that action?	
Rational	Participant moves towards a given direction following a rational reasoning on the current state of the maze (e.g. best option, only option)
Teamwork	Participant's action takes into consideration the robot's choice (e.g. yielding to robot's choice, following robot's suggestion, emotional response to robot's state, etc.)
Testing	Participant performs an irrational action just to test the robot's response (e.g. going against the robot's choice, moving towards unreasonable situations, annoying the robot, etc.)
Random	Participant does not have clear positioning with respect what to do and acts randomly.
JOINT AFFECTIVE EXPRESSION: Why did you reported feeling that way?	
Self	Participant uses first person singular subject pronoun "I" to describe the situation (e.g. "I'm happy because I'm almost done")
Self/other	Participant uses first person plural subject pronoun "we" to describe the situation (e.g. "I'm happy because we're almost done")

Table 5: Questions asked to the participant in the cued-recall method after each subject's action took place.

Game performance

While the participant plays with the robot, all actions from both user and robot are stored in log files, along with general statistics on game duration, number of steps taken in the game, paths followed, success or failure solving the game, among other. In this work, we are only interested in observing in which situations the participant opted for either explicitly accepting (yielding) or denying the robot's choice in an argumentative process when using the ARG-based condition[7]. The aim is to provide objective additional evidence related to trust based on the participants motivations towards opting for an action or another when facing different stances on where to move next.

Table 6 summarizes the different tools and items used to measure indicators of empathy realization.

[7] Since the TURN-based condition does not provide space for argumentation, this measure will be only evaluated in the ARG-based condition.

Indicator	Questionnaire	Cued-recall	Game performance
Attachment	Q1	Joint affective expression	
Trust	Q2	Motivation - rational Motivation - teamwork Motivation - random	X
Regulating expectation	Q3	Predictability Motivation - testing	
Overall	IOS		

Table *6*: Summary of tools and items used to measure indicators of empathy realization.

Statistical analyses

We used the Wilcoxon matched pairs test to compare the different responses (both individual and overall scores) obtained from the follow-up questionnaires and cued-recall annotations for the two strategies. Furthermore, we assessed the influence of the degree of empathy of the participants on their responses using Spearman correlation analyses. Finally, we performed additional tests and analyses, namely the Wilcoxon rank sum test to explore the degree of influence of the first strategy used and gender of the participants on their responses, and Spearman correlation analysis to explore the influence of the age of the participants on their responses. We set the significance level to 0.05. All statistical analyses were performed using MATLAB R2018b Update 7 (9.5.0.1298439).

5.2.4 Hypotheses

The pilot study aims at verifying whether early indicators of empathy realization are present after interacting with the robot in the maze game when applying different collaborative strategies. Thus, we seek to validate the following hypotheses:

H1: An active collaborative strategy between human and robot will elicit affective response from the subject, developing a perceived and observed sense of attachment. We expect to observe higher scores in Q1, and more frequent occurrences of the "self/other" and less frequent of the "self" items in the cued-recall joint affective expression category when applying the ARG-based condition (collaborative strategy) compared to the TURN-based condition (passive collaborative strategy).

H2: An active collaborative strategy between human and robot will promote teamwork attitudes where the human is open to the robot's suggestions. We expect to observe higher scores in Q2, more frequent occurrences of the "team- work" item and less frequent occurrences of the "random" and "rational" items in the cued-recall motivation category when applying the ARG-based condition (collaborative strategy) compared to the TURN-based condition (passive collaborative strategy) reflecting on a basis of trust.

H3: An active collaborative strategy between human and robot will increase the perception of matched expectation from the subject towards the robot com- pared to a passive collaborative one. We expect to observe higher scores in Q3 when applying the ARG-based condition (collaborative strategy) compared to the TURN-based condition (passive collaborative strategy).

H4: An active collaborative strategy between human and robot will promote a discovery process driven by curiosity to regulate the expectation of the subject towards the robot. We expect to observe in the cued-recall predictability category more frequent occurrences of the "intelligence" and "behavior" items and less frequent of the "situational" one, and more frequent occurrences in the "testing" item in the cued-recall motivation category when applying the ARG-based condition (collaborative strategy) compared to the TURN-based condition (passive collaborative strategy).

H5: An active collaborative strategy between human and robot will promote higher levels of closeness perception compared to a passive collaborative one. We expect to observe higher scores in Q4 when applying the ARG-based condition (collaborative strategy) compared to the TURN-based condition (passive collaborative strategy) unveiling a general indicator of empathy realization.

5.2.5 Results

We next describe the quantitative data gathered in this pilot study.

Influence of gender, age, empathy baseline and order of strategies

First, we wanted to know whether there was any difference on the results obtained throughout the study with regards to gender, age, empathy base level and order of strategies applied in the within-subject experiment. The aim was to evaluate whether there was any bias in the data that should be taken into consideration when analyzing the participants' scores. We run the following statistical analyses considering the difference between the two strategies as outcome variable:

a. We performed a Spearman correlation analysis to assess the influence of the degree of empathy base level of the participants on their responses. We found a statistically significant association between the degree of empathy and the differences in items T8 in Q2 (p − value = 0.0402) and E2 in Q3 (p − value = 0.0120), respectively.

b. We used a Wilcoxon rank sum test to assess the degree of influence on the participants' responses of the first strategy used with respect to the second one. In other words, whether the first trial had any impact on the responses of the second one (regardless of the strategy used). In this case, we found a statistically significant association between the first strategy used and the difference in item E1 in Q3 (p − value = 0.0334).

c. We performed a Spearman correlation analysis to assess the influence of age of the participants on their responses. Age was statistically associated with the difference in item T1 (p − value = 0.0194) and T6 (p − value = 0.0164) in Q2, respectively.

d. A Wilcoxon rank sum test was used to assess the influence of gender on the participants responses. The difference in item T3 was statistically different across gender groups (p − value = 0.0043) in Q2.

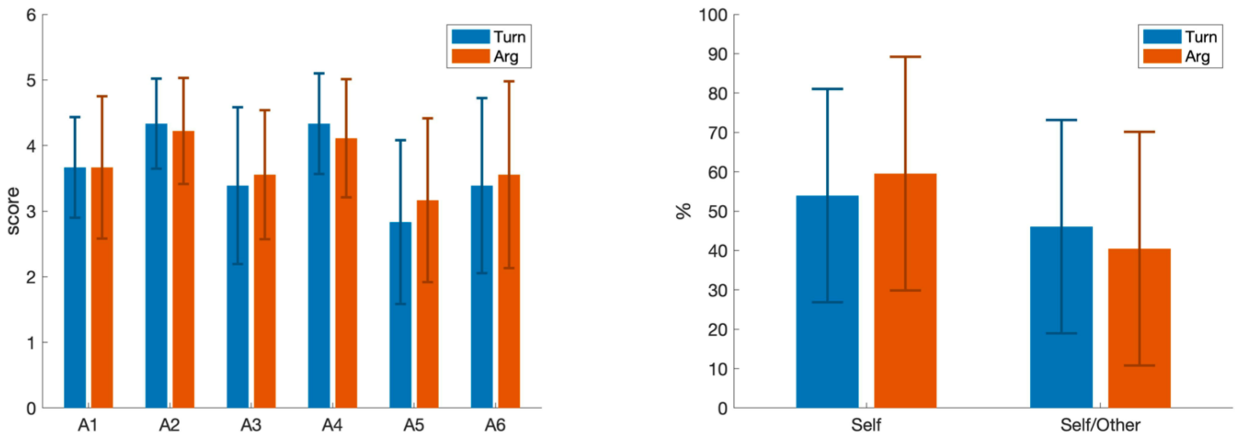


Figure 43: (Left) Average responses per item with Likert scale 1–5 in Q1 for each condition. (Right) Average ratio for joint affective expression items in the cued- recall method for each condition.

Despite obtaining some significant differences between few items, the items involved in the previous associations did not show statistical associations with the scores (see next Sections). Therefore, we can compare the different results in both conditions independently of gender, age, empathy level and first strategy used.

Attachment

The following analysis of attachment is based on questionnaire Q1 and the joint affective expression category from the cued-recall method.

a. *Questionnaire Q1*

No significant differences could be observed in any of the items of Q1. As observed in Figure 43 (left), both strategies scored very similar in all items. We thus cannot reach any conclusion from this seldom evaluation.

b. *Joint affective expression*

As shown in Figure 43 (right), we have computed the average ratio of annotations related to "self" and to "self/other", i.e., percentage of occurrences where the participant described his/her affective state using singular vs. plural pronouns. Contrary to our expectations, the TURN-based condition achieved higher scores for the "self/other" item compared to the ARG-based one, which means, that more often participants in the TURN-based condition made joint references.

Overall, we cannot confirm **H1**. However, we did observe differences on the language used when participants naturally described specific situations while solving the maze, or even on the way they directly addressed the robot. As we will show in the Discussion session below, such differences might provide insights on the development of attachment which could not be observed in the quantitative data presented here. In any case, no significant differences were found between the two conditions.

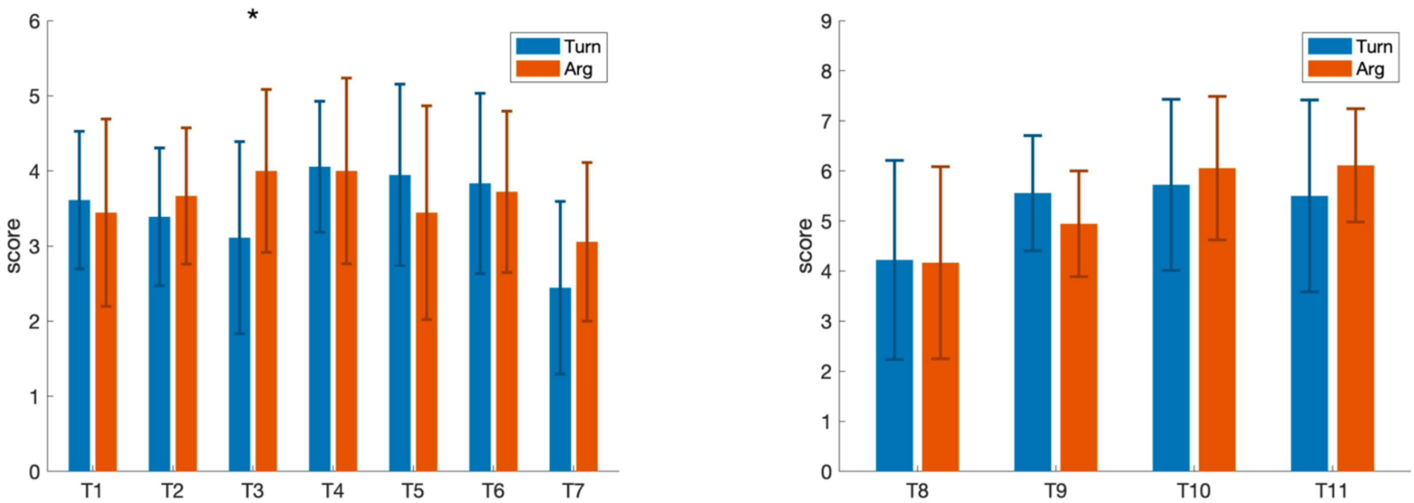


Figure 44: (Left) Average responses per item with Likert scale 1-5 in Q2 per condition (*denotes significant difference). (Right) Average responses per item with Likert scale 1-7 in Q2 per condition.

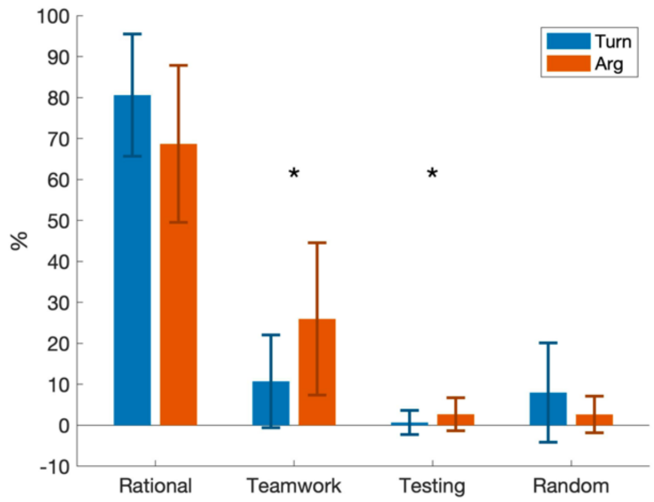


Figure 45: Average ratio of motivation items per condition in the cued-recall method (*denotes significant difference.)

Trust

The following analysis of trust is based on questionnaire Q2, the motivation category from the cued-recall method and the game performance log.

a. *Questionnaire Q2*

Figure 44 depicts the average outcomes for each item in Q2. Significant differences (p − value = 0.0107) between the two conditions was found on item T3 ("Bobby paid close attention to me"). No significant differences were found in the remaining items. Moreover, no clear indications towards higher values for the ARG-based condition can be observed either. Hence, we cannot confirm H2 based on Q2.

b. *Motivation*

As earlier described, we are interested in understanding the motivation behind the actions taken by the participant, i.e., why did they opt for one action or another. We thus compute the average ratio of annotations coded as rational, teamwork, testing and random. Significant differences were found between the two conditions with respect to teamwork (p−value = 0.0074) and testing (p−value = 0.0313) (Figure 45). In both cases, we can thus confirm that the ARG-based strategy promoted teamwork behaviors (i.e., accepting the robot's suggestions and taking into consideration its emotional state). The testing item is related to a process of expectation regulation discussed later.

With respect to the other two items, we can observe higher average rational responses for the ARG-based strategy compared to the TURN-based, but not significant. On the contrary, higher random choices were made during the TURN- based strategy, which suggests that more often participants relied on luck instead of trusting the robot's opinions. Nevertheless, no significant difference was found either. Based on these results, we can state that **H2** is partially supported.

c. Game performance

We were interested in observing the game state and argumentation outcome when the participant's choice did not match the robot's suggestion, i.e., when disagreement on the direction to follow next took place[8]. The only possible outcomes were: user explicitly yields, robot explicitly yields, user forces the robot to yield and coin toss[9] .

Figure 46 depicts a set of heatmaps representing the frequency of argumentation outcomes throughout all trials where the ARG-based strategy was used (the TURN-based strategy is not included in this analysis since it does not allow space for discussion on the next move to perform). We can observe that:

- As described in the previous sections, the robot always yields when the first two dis- agreements raise. We can see in Figure 46b that most occurrences (26 out of 36) took place at the first part of the maze (Figure 46a), where most uncertainty is present. Not only because when started solving the maze very few walls are visible (the walls only appear as the players walk through the maze), but also because it is the area where most crossroads are placed. Hence, opposed views easily raise, and it is an opportunity for the robot to yield to build a first sense of involvement and trust between the players.
- The next two critical situations where unclear direction towards where to move are within the middle-right area of the maze. At this point, it is the user's chance to demonstrate trust on the robot and accept its suggestion. As we can observe in Figure 46c, 5 out of 7 yielding towards the robot's suggestion occurrences took place at any one of these junctions (cells (4,4), (5,4) and (6,3)).

[8] Note that in this measure we are not considering implicit yielding, i.e. when the user adopted the same action as the robot in the first place. Such internal decision is only clarified through the cued-recall process. Thus, implicit yielding is only captured in the Motivation category.

[9] Either player, robot or user, can trigger a coin toss. However, in none of the trials carried out in the study the robot opted for a coin toss. Hence, in this work, we only refer to coin toss to when the participant opts for this choice.

- There are two obvious circumstances where a dead-end will be reached if the players follow that path: cells (6,1) and (4,4) or (4,3) (depending on how the maze has been explored and thus, unveiling different walls). However, the robot is not aware of such situation until it is too late, i.e., when the dead-end is reached[10]. Thus, only the user can foresee non-visited visible dead-ends. Figure 9d shows that participants forced the robot to yield to their choice in 8 occasions, but mainly when a dead-end was on the way (7 out of 8 times).

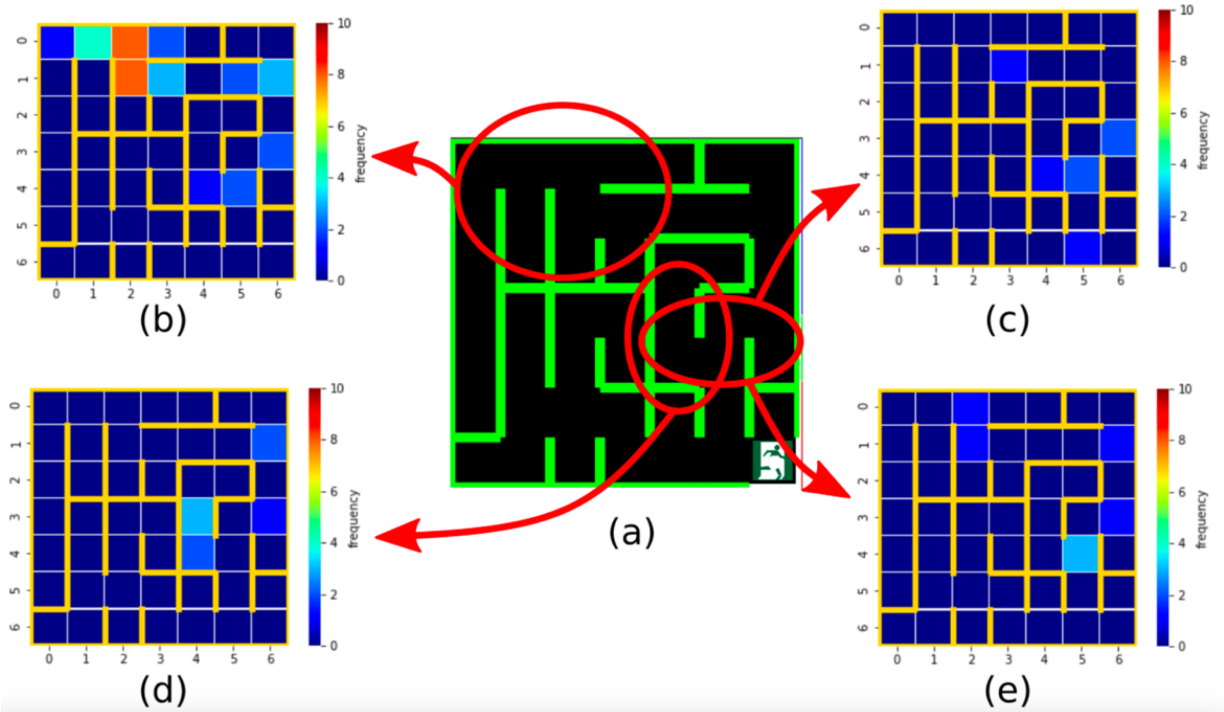


Figure 46: (a) Maze used in the study surrounded by heatmaps representing the frequency of argumentation outcomes categorized by: (b) robot yields, (c) human yields, (d) human denies, and (e) coin toss. Each heatmap also depicts the maze walls in yellow, and the X, Y axes to refer to the cells coordinates (x,y).

- Finally, coin tossing is also an option when uncertainty is present. As shown in Figure 46e, 4 single occurrences of this choice are scattered around the first and second areas of the maze, while the highest frequency (3 occurrences) takes place at the final crossroad before reaching the goal.

[10] As described in Section 4.3, the robot can only perceive the maze walls as it walks through them, i.e. when the cells are visited.

Overall, when an argumentative process started in situations where no clear path was foreseeable, participants equally balanced the option of yielding to the robot's suggestion or tossing the coin. However, except for one occasion, participants only used their option to force the robot to yield when strictly necessary, i.e., when dead-ends were present.

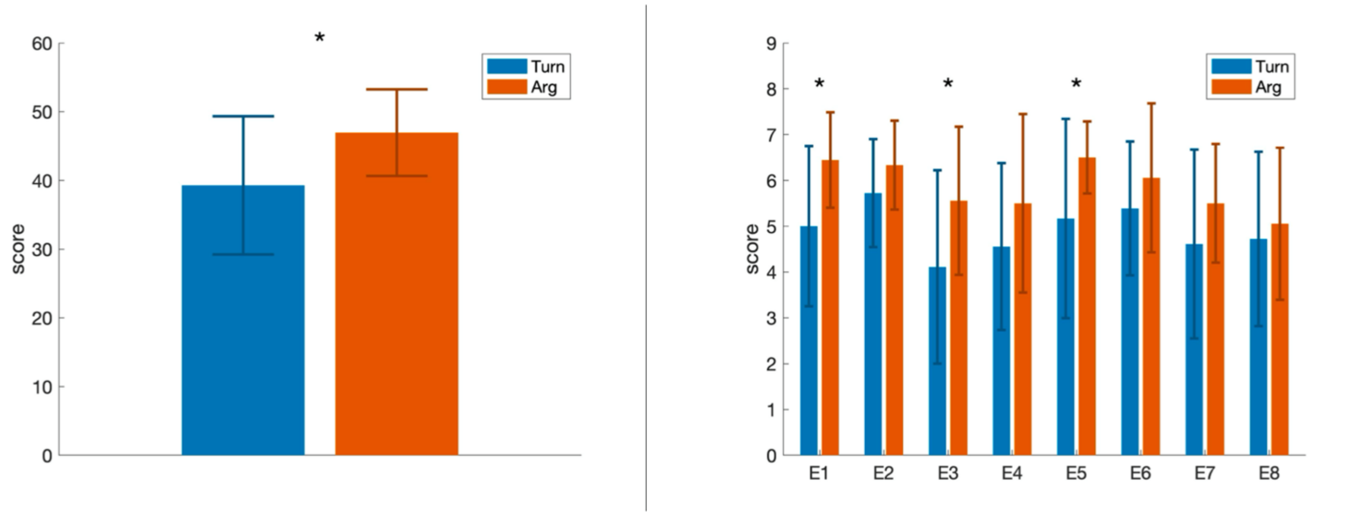


Figure 47: (Left) Average regulated expectation per condition. (Right) Average responses per item with Likert Scale 1-7 in Q3 per condition. (*denotes significant difference)

Regulating expectation

The following analysis of regulating expectation is based on questionnaire Q3, the predictability category and the testing item of the motivation category from the cued-recall method.

a. Questionnaire Q3

Significant difference (p−value = 0.0012) between the two conditions was found in the overall measure of regulating expectation (summed scores of Q3 items) as shown in Figure 42 (left). Moreover, individual significant differences were obtained in items E1 (p−value = 0.0071), E3 (p−value = 0.0166) and E5 (p−value = 0.0313). (Figure 47 right). We can thus confirm **H3**, where a perception of matched expectation from the subject towards the robot develops when using an argumentative- based strategy.

b. Predictability

We finally investigated understanding the reasons why certain situations in the game could result unexpected to the participants. No significant differences were found between the two conditions in any of the categories. The average ratio of unexpected situations is very similar in both conditions: M = 17.20% (SM = 10.91%) for the ARG-based, and M = 16.89% (ST = 15.80%) for the TURN-based. Interestingly, the distribution of unanticipated situations varies considerably for each condition (Figure 48). While situational elements are the most frequent source of surprise in the TURN-based condition, the robot features (both intelligence and behavior) are the most noticed in then ARG-based one. Such results suggest that participants in the TURN-base condition were more focused or aware of the game features (mainly unexpected deadens encountered along the path) than on the interaction with the robot. Despite observing a trend where the participants were more interested in the robot, no clear evidence could be obtained through this measure.

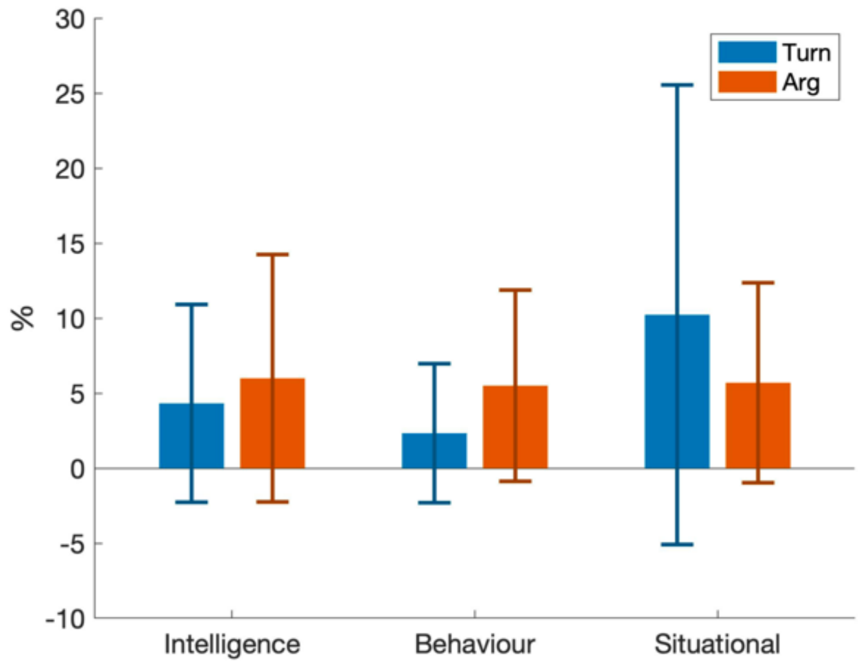


Figure 48: Average ratio of predictability items per condition in the cued-recall method.

c. Motivation

We did find significant difference in the "testing" item of the motivation category (Figure 48). Such category describes "messing with the robot" behaviors, related to an attempt to satisfy participants' curiosity towards the robot behavior and capabilities.

Based on the two measures described above, we can thus partially confirm hypothesis **H4**, where a collaborative strategy promoted a discovery process driven by curiosity to regulate the expectation of the subject towards the robot.

Overall empathic response

The analysis of the responses to Q4 indicated a significant difference ($p - value = 0.0045$) on the level of perceived closeness between the robot and the participant across conditions. As shown in Figure 44 (left) the ARG-based condition achieves higher average score (M = 5.11,SD = 1.13) compared to the TURN-based one (M = 3.83, SD = 1.79). A closer look at the frequency of participants' answers for each condition (Figure 44 right) shows that:

a. *ARG-BASED*: Most scores fall between "equal overlap" and "very strong overlap" (17 out of 18), showing clear indication that closeness was positively perceived at least equally and to even higher extent by almost all participants.
b. *TURN-BASED*: The most rated statement was "some overlap" (6 participants), followed by" little overlap" (3 participants). The remaining participants' responses are distributed along the different scores, thus evidencing little consistency across the perception of closeness with the robot.

With these results, we can thus confirm hypothesis **H5**, i.e., an ARG- based strategy does have an impact on the perception of the closeness with the other, which in turn, reveals potential growth of empathy.

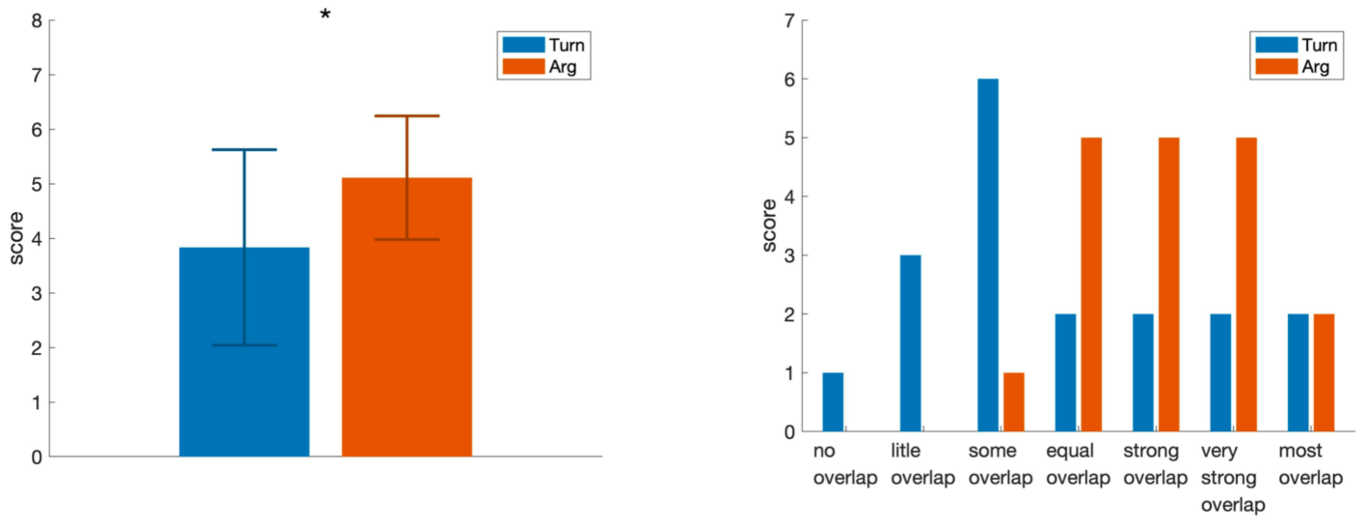


Figure 49: (Left) Average score in a 1-7 scale on Q4 with respect to ARG-based vs. TURN-based conditions (*denotes significant different). (Right) Participants' frequency responses for Q4 in both conditions.

5.2.6 Discussion

We next discuss the results obtained in this study, both from a quantitative and a qualitative perspective. Since we focus on the process of realizing empathy and not on empathy as a singular phenomenon, we measure indicators of such process through observing the development of affective attachment, trust and regulating expectations.

On Attachment

Based on the Q1 results presented, we observe that attachment indicators are equally present throughout the experiment in both conditions (achieving scores above 3 in average). Moreover, contrary to our expectations, joint affective ex- pressions showed a trend to be more frequent in a passive collaborative strategy compared to an active one.

Nevertheless, qualitative data does suggest a shift in affective attachment between the two conditions. Such data was collected at two stages: (1) during the trials, where participants' natural reactions while interacting with the robot or when describing situations in the cued-recall process were annotated; and (2) through participants' written feedback in an open question at the end of each trial. In the first case, participants in the ARG-based condition reacted naturally to the experience when: (1) they would "speak" to the robot saying things like "We are done", "we are happy", "we have done it!", or (2) they would comment things about the experience such as "It's fun. Should have last longer", or "in the experience you get into the character, it feels natural". In the latter case, multiple participants wrote they felt the "experience was better", "more involved", "more fun", that the robot was "nice to me" or that "this time around I felt the robot's emotions more".

In contrast, participants in the TURN-based condition greatly varied in the use of affective expressions throughout the trials. Some were more self-indicative, such as "I completed the maze", while others focused on how they viewed Bobby's feelings: "I feel bad for Bobby", "Sorry Bobby!", "Bobby is sad", "it doesn't feel right to be happy [when Bobby is sad]". With regards to the open question, the most frequently used phrase in reference to attachment was that they felt the robot acted "not emotionally connected".

It is also worth mentioning that in both conditions participants had an embodied instinctive reaction to the robot's affective cues, i.e. by laughing, pouting or smiling. Overall, there is no clear evidence, nor trend, that an active collaborative strategy between human and robot as designed in this experiment promotes the development of attachment more than a passive one. These results are merely indications that the design of the experiment and the robot's abilities achieved to fulfill the need of relatedness and affective response, but not necessarily indicative of empathetic formation or impact. We thus believe that either the measures used in this study or the experience itself were not appropriate to reflect on the indicator of attachment. In future assessments we recommend enhancing tools that allow for the participant to share their affective states more seamlessly as well as more thorough quantitative measures of the enhanced experience. Though we understand the limitations we had in our experiment in this regard, we continue to see signs of the potential impact the role of affective attachment has through the qualitative speech we gathered. Hence, there is much room for improvement in both aspects that merit further research.

On Trust

The results obtained in the quantitative analysis partially support the hypothesis that an active collaborative strategy will promote teamwork attitudes, where the human is open to the robot's suggestions. Yet, it also suggests that there is more to it than just agreeing with the robot, i.e., the willingness to act as a teammate.

Participants indicated that their motivations driving their decisions lies in their desire to follow the robot's suggestion and not wanting to contradict or oppose the robot, believing that the robot might be right or that "its suggestions make more sense". This idea is supported by qualitative statements of their experience. Quite a few participants specifically used the term "cooperative" when describing the ARG-based condition, while others defined to robot having "leadership" qualities. In natural response statements we have recorded participants saying things such as "we both agree" or "we made mistakes together", "we are in-tuned", "I trust Bobby" or "he was excited about going that way. I respect his wishes; it is all the same to me". In contrast, most participants in the TURN-based condition lacked a sense of teamwork, and when in doubt of where to go, they rather made decisions based on luck. The open question at the end of the trial reflected that most participants viewed the robot as being "more individual and independent" and the experience "not being about teamwork".

In deeper inspection based on the game performance analysis and the cued- recall process, we realized that trust in the robot was not present at the same levels throughout the movements of the maze. Instead, it depended on their position on the map. When the trial started, trust was initiated through the robot concessions. As the they progressed, we can observe that the subject was shifting from trusting the robot often explicitly and implicitly yielding to him/herself and back. These observations are supported by the qualitative comments of the participants.

We thus believe that trust itself evolves as a process. From the measures used in this study, the cued-recall method was capable of evidencing such progress, while the questionnaire items in Q2 did not. These results also reflect, that the design of the experiment within the argumentative strategy, the participant had the freedom to control and give control to the robot, while also believing in their own capabilities, despite some randomness fulfilling those needs within Self-determination. Thus, alternative measures to assess the development of trust and to capture what happens when human and robot balance leadership in an active collaborative scenario and its impact on trust is required. It is important to note that this study addressed a ludic and neutral experience useful to gather initial insights. However, a context that carries higher risk/consequences may heighten the value and contrast of trust and sense connection in relation to the process of realizing empathy, such as a professional setting.

On Regulating Expectation

Contrary to trust and attachment, we clearly observed through the designed measures that when it came to regulating expectation users were both adapting that expectation and ultimately, self-reporting if it was matched.

As our hypothesis states, a collaborative strategy between human and robot will promote a discovery process to regulate the expectation of the subject towards the robot. Results show that the ARG-based condition opened the door for participants to discover and test the robot driven by such curiosity. Participants wanted to see what it was ultimately capable of, which led to more subjects reporting un- predictable events in relation to the robot's behavior, focused on their play with their partner. Again these observations are also supported by qualitative data remarks that users made along the experimentation sharing things like: "don't use that argument! neither of us could have known", "it's not a bad idea to try something different", "[after arguing with the robot to play with it and eventually yielding] I was good to Bobby, it was just a joke, so Bobby could laugh a little bit", "I feel synchronized with Bobby", or "I can see that he respects that I went to the right, so I will do the same". In stark contrast, results evidence that in the TURN-based condition participants reported that unpredictable events were mostly associated to the maze itself, i.e. the environment rather than about the robot, as their frustrations stemmed from finding walls along the way.

After the trials, it was pivotal to gather data of how they self-report their expectations and if they were matched. We believe that matching occurs when the subject reports a mutual understanding, clear intentions and knowledge of the other. Results in Q3 did clearly showcase significant impact as participants did feel more understood and believe there was clearer knowledge of the robot's intentions in the ARG-based condition. We can also support this finding with the qualitative responses highlighting how several participants used the terms "clear behavior" to describe the robot's intentions. A clear difference can be also observed compared to the participants' responses in the TURN-based condition, where the data becomes rather neutral with no significant pattern, highlighting the lack of connectivity, understanding and teamwork. We can see with these results that ARG-based condition, as SDT needs were challenged, participants overall were more engaged and willing to participate and experiment, fulfilling the SDT needs described. In the case of regulating expectation, both the design of the study and measures served well for the purpose of this experiment, but there is still unlocked potential in understanding these shifts and their relation to affective attachment and trust processes.

Overall

Taking into consideration all these results, we also had one more element to draw a cohesive conclusion: a general indicator of how the participants overall felt their experience with the robot in terms of how the subject self-reported his/her relational closeness to the robot (as a result of affective presence, trust behavior and matched expectation). Q4 helps us visualize this generalization, and the results do show a very significant difference in that the ARG-based condition did induce participants to feel closer to the robot, despite moments of frustration, unexpectedness and experienced waves of trust. In contrast, the TURN-based condition revealed what many participants had already spoken and written: they felt the experience was more individual and not as close.

5.2.7 Limitations

We next summarize main limitations in the current pilot study that should be considered when evaluating the results obtained:

a. Gender bias: our sample includes more male than female participants (2/3 male, 1/3 female). Despite not finding statistical associations between gender and the outcomes in our study, there is some evidence that women tend to exhibit more empathetic responses than men [Rueckert et al., 2011], which should be considered in future studies.
b. Background bias: most of our participants were technology-based. While such background could have had some influence on the evaluation, because of the within-subject study design, such association does not have an effect. However, understanding how people from different backgrounds and past

experiences empathize with robot is essential, and should be included in the future.

c. Number of participants: the small sample size of this study did not allow us to find a larger number of statistically significant differences in certain items where the mean values appeared to be different depending on the strategy used (e.g., expectation item E7). However, we aim to leverage the information gathered through this pilot study to design a more powered study. In this regard, a sample calculation using a t-test with a two-sided 0.05 significance level revealed that 49 samples have 80% statistical power to detect statistically significant differences in E7 scores (mean of difference = 0,89; standard deviation of difference = 2,1; effect size = 0,42).
d. Experiment duration: this experiment allowed us to capture a good amount of data that does reflect on our current objectives on observing indicators of early empathy realization. The next step is thus to evaluate if the realization of empathy is sustained through time, in which case, longer and recurrent trials will be necessary.
e. Tools: collecting and measurement tools need a revision according to the nature of the elements being studied. For example, if trust is a process and is not meant to carry a constant weight on one side or the other, the measuring tool must reflect such ability. We thus question ourselves to which extent questionnaires shall be used to capture processes or on the contrary, to focus only on outcomes.
f. Further SDT focus: As self-determination needs and indicators play a significant role in the process to RE and in motivating participants to engage, in this experiment they are considered and reflected but are not central to the work and results. By adding a focus on these needs, using elements of a SDT framework it can enhance some of the aspects of the experiment that needs further study.

5.2.8 Take-away message

Despite the limitations and areas that need further refinement, the results shown do correlate with the hypotheses exposed and we have taken a step further where we do see clear indications that empathy was being realized. The analyzed data signals that a collaborative strategy, which allows for reflection as well as argumentation, has become a powerful tool in how participants see their relationship with the robot. It means that both parties get to have a say, a sense of freedom and control, even

though the participants always had all the tools needed to make all the decisions themselves. In other words, participants decided that they wanted to play and collaborate with the robot, instead of ignoring or playing against it. This is evidenced by the fact that participants associated the ARG-based condition to a "cooperative experience" with the robot as a "team member", while also feeling connected and automatically referring to the experience as "more fun" or "feeling more emotionally connected to the robot". As we analyzed the quantitative data in this new study, we realized that the measures did capture individual instances of the empathetic interaction indica- tors. However, it was also revealed that we need to capture with quantitative measures the rich detail in the nuances throughout the participant's experience, and the cause/effect between the appraised situations and their rational/emotional response, as observed in the qualitative data.
Therefore, we believe that we need to develop measures that can truly capture the internal processes that the participant experiences as s/he engages with the robot. We envision a set of mapped trends for each of the variables under a study (affective attachment, trust, and regulating expectation) where specific events happening at one layer may impact the other layers, thus, allowing us to clearly observe correlations between them which may reflect the divergent and convergent effect of the process of realizing empathy.

5.2.9 Conclusions

Our aim here was not to evaluate empathy as a singular event, but to measure indicators of such process through observing the development of affective attachment, trust and regulating expectations with more detail and nuance than the previous exercise of this case study. Through this process, the involved actors engage in mutual understanding of intent, listening, reflecting and acting, all within a conducive environment, open mindset and tools for communication.
We focused on quantitatively studying indicators of early empathy realization between a human and a robot in a maze challenge scenario. To this end, we have designed a pilot study where we specifically investigate attachment, trust and expectation regulation as indicators to validate our hypotheses. Two collaborative strategies were used by the human and robot to solve the maze: an active one (ARG-based condition) and a passive one (TURN-based condition). The main difference between them lies in the fact that an active one opens space for discussion between the involved, where consideration of additional factors (such as emotional state, justification of different on viewpoints, etc.) play a key role in the process of understanding and supporting

the other. The results obtained did confirm that a general sense of closeness with the robot was perceived within the ARG-based condition, both from quantitative and qualitative data. Focusing on the individual indicators of empathy realization, we could not confirm strong differences between the two conditions with respect to the development of attachment. However, we did partially confirm the development of trust based on the motivations behind the decisions taken by the participants. Here, participants clearly displayed teamwork attitudes when accepting the robot's suggestions in front of uncertainty, evidencing a sense of trust. Unfortunately, the questionnaires did not confirm differences between the two conditions, hence, not fully validating such hypothesis. Finally, we did confirm that an active strategy does influence the process of expectation regulation.

Thus, despite the limitations and areas that need further refinement, we can confidently conclude that an active collaborative strategy impacts favorably the process of realizing empathy compared to a passive one. The former strategy allows a mutual exchange in reflection and argumentation based on reason and affection, which became a powerful tool in how participants view their relationship with a social robot. To them, it means that both get to have a say, have freedom and control.

De Vignemont and Singer (2006) suggests that the social role of empathy "is to serve as the origin of the motivation for cooperative and pro-social behavior, as well as help for effective social communication". Based on our results and analysis we are emboldened to believe that we have taken a step closer towards this view, where we may be able to promote people's willingness to interact with social robots, reducing disillusionment and abandonment of the engagement by inducing an empathetic interaction with specific tools. Now we look forward to next steps that close some of the gaps and limitations this study has, particularly that of introducing a more seamless affective experience and measurement tools that best reflect the nature of trust and attachment. To do so we plan to endow the robot with more complex ability to express and observe the participant's affective states and behaviors, while continuing to refine the use of the realizing empathy process.

6 Conclusions

The culmination of the work collected, studied, theorized, and exemplified will be revised in this chapter with the final contributions and how they reflected in the work presented, the limitations during the process, and the intended future lines of this body of work.

6.1 Overall Conclusions

The theoretical collection of work in chapters 1, 2 and 3 is comprehensive as it captures the main lines of focus from the introduction to the research questions presented: the role of design in HCI and empathy, how empathy is perceived and implemented in HCI practices, and empathy in the discipline of HRI. The collection of related works and theoretical background provided a clear path of study to establish a novel theoretical approach to realizing empathetic interactions from a multilayered perspective to the proposed with variables, elements, steps, and indicators that influence each other to produce the goal of common meaning between actors in the exchange. These layers of interconnected variables and elements were studied within a human-social robot interaction context in 2 phases. Both phases provided encouraging results in the prospect of the model being proposed, yet it also highlighted the continued limitations both within the disciplines as well as the need for more in-depth approach to studying the individual elements and their interrelatedness. This reflection can be observed in the Future lines for this body of work. The work presented from the bibliographical analysis to the HRI testing ground has made us realize that there is a new open path for research and development that can apply across many scenarios and disciplines. First, it has opened the door to question, test, and explore the flexibility and versatility of current measurement methodologies within HCI and HRI. These include: Empathy; trust; affective attachment; design of language tools to communicate between participants and technologies; dialogue methodologies; fluctuations, and regulation of expectations; designing for reflection and empathetic collaboration taking into consideration the need for the person's sense of freedom, control, capability, relatedness, and expression toward their technology. As a path on its own is the need to further examine the role of affective attachment and how it can leverage their predictability capacity within the context of the RE model. We can also generally conclude how taking into consideration design, its principles, and processes can impact meaningfully the way HCI and HRI initiatives are approached, impacting its applications in and out of a controlled environment. In the cases shown in chapter 4 and 5, these elements added the value of exemplifying ways in which the elements and steps can be designed with the intended purpose. Though these are initial examples of making the different aspects of the proposed model more tangible, further study is required to form an array of scenarios and concrete examples in the form of a guideline. Finally, it is of interest to the HCI community and others to examine how this model and its potential for long-term engagement impacts or benefits other fields such as psychology, design, commercial applications, and business modeling. This book and the study within it are opening up a door of exploration moving away from researching or theorizing instances of interaction and attempting to bridge a more comprehensive overview of the HCI relationship. With this bird's eye view of studying HCI, the main actors, variables, and elements are considered constantly proving a platform to explore more specific aspects of the relationship, like the ones mentioned earlier. For now, we hope this is a path that we can take moving forward from the scope of this thesis book as well as for others to follow.

Next, we will clarify the responses to the research questions within the thesis book.

6.2 Responding to the Research Questions

6.2.1 Design for Empathy

1. How can Design theory and design research practices add value to the HCI interactions and the Empathetic engagement taking into consideration other principles described in the references of previous chapters?

2. How can we use design in the Empathy modeling to bring its practice closer to HCI/HRI practical implementations?

The foundational structure of the model considers the basis of dialogue and collaboration essential to design practices and research, from the concept of iterative design to dialogue driven practices [Azhar, 2015]. By viewing the method from a more detailed and layered approach, these steps that would be instinctively practiced in design, now can hold the potential for more technical instantiation. These instantiations can be both algorithmic and/ or with design tools. In the case of our case study, we were able to instantiate with both. The role of Design theory means not only the process of engagement but also understanding how to apply tools of design elements and principles with their socio-cultural meaning in context [Da Silva, 2018]. All design elements and principles carry a meaning as well as how they are used together the meaning can change, the same is true for words within a syntax of a sentence [Koopman 2015]. As a way of presenting, communicating, and exchanging interactions, the informed use of Design Theory within an HCI/HRI context can make the experiences refined and more accurate to the intention. These elements through the meaning they carry can help support: informative data versus more affective states, a suggestion of trusting and open behavior versus distant and closed behavior, among other mental models and structure of the context being used in the interaction.

In our social robot case of chapter 5, we decided to begin with simple combination of design elements and principles for the language used in communication as well as the materials used for establishing a baseline for the participant's expectation and design of the environment. The use of the design tools proved to be effective to provide a clear message to the participant in the instantiation of the model's elements used. Another example within this thesis book is the study example seen in Chapter 4 that primarily focused on design elements and principles to construct a new approach to communicate with smart objects in a practical scenario of a health progress that promotes Self-Reflection and meaning within the structure of the RE model. In both cases, there were no signs of misinterpretation throughout the tests. The use of Design elements and principles with the knowledge of what the elements mean together in a context can add immense value to developing refined experiences of empathy in HCI and HRI.

6.2.2 Empathy for HCI

3. How can we leverage Empathy and its elements to produce long-term engagement between people and technology?
    a. If we are not defining Empathy itself, what does its structure look like to achieve Empathy and meaning between actors?
    b. What could be examples of how to enable common elements found for empathy in the bibliography like: affective states, trust, self-reflection, and base expectation through design practices?

In Chapter 4 we present a novel approach to a theoretically based process of realizing empathy as a designed model of interaction between people and their technologies. This theoretical model, rather than trying to define empathy itself, takes on the details that authors across many disciplines to reach a design that structures the elements and variables most have spoken about in their own encounters with empathetic interactions. The result is a complex, organic, multilayered structure the influence each other to create the ideal conditions for empathy to be realized between a person and their technology. This structure uses the base of Affective attachment and trust to establish both a spark toward motivation between the actors as well as the indicator for empathy to occur, if these two components grow along the series of interactions. This foundation feeds the constant movement of motivation behind the willingness to interact and be interacted with by the actors. Yet, motivation is fickle, and needs stable elements that the actors have decided together or that each actor has agreed on their own: the environment, communication tool to be used, and the level of open mindedness in the interaction. With all these layers in place, the steps of regulating expectations, listening, considering, and acting between the actors can ensue. These steps loop until the actors agree there is mutual understanding or meaning is created between them. Often these elements and layers shift or evolved to best suit the circumstance, if the willingness to care and trust the other is present. All these elements are integral to dialogue and long-term engagement. This thesis and proposed model are meant to eventually be applied across disciplines, hence the terminology and abstraction of the graphical structures, yet the design itself was born out of the need for improved empathetic interaction between people and their technologies. In this chapter we also begin to introduce examples of how to make the elements, variables, and stages of the process more tangible using design tools and principles that can translate to other disciplines and practical scenarios. This example studied the minimum viability to communicate and consider the communication within a designed interaction following the RE model, as well as the overall acceptance to adopt the process. The results from this study helped refine the soundness of the theoretical model (as seen now in Chapter 4) and opening for more comprehensive experimentation on the model as a whole.

By studying and instantiating trust, affective care, and tools that help users regulate their expectations, as exemplified in Chapter 5, we are innately leveraging the empathetic process to a long-term engagement goal. Not only does this example: (1) showcase the potential for long-term engagement, (2) how the structure can be defined in a ludic scenario, but also (3) how using specific artistic/design elements and principles can portray affective states (sound, movement, color, imagery of facial expressions), a sense of trust with cognitive expressions (movement, voice, projected image) , a space for reflection (physical designed space and unlimited time provided as part of the design) and offered a tangible set of tools (the instructions, videos and projections) to deliver a base expectation as well as tools (argumentation texts and emotional expression to the robot) to help regulate the expectation through the interactions.

6.2.3 Empathy in HRI

4. In an application to HRI setting, how can we utilize the answers to the previous questions to empower collaboration and trust between people and social robots while supporting the user's self-determination?
    a. Will the proposed empathy model's intentions and goal translate well to HRI scenario cases?

In chapter 5, beyond being able to translate the proposed model into tangible examples for application within an HRI setting, the design based on RE had the goal to enhance empathetic collaboration between a person and a social robot while considering the needs of Self-determination theory. In the test we examined 2 ways in which these actors can collaborate: taking turns or by making a decision together through an argumentation method of dialogue. When utilizing the process of RE model, contrary to current empathy models based on persuasion and prediction, the participant in the argumentative phase was 100% owner of all the decisions, while also challenging the support of those decisions. Though most of the time, the participant decided to trust the robot's decision, this was done willingly. At a certain point the participant realized three things as well: that the robot was there to be a companion to the game showcasing affective relatedness, that they equally had the opportunity to succeed and fail, and that they could have all or most of the control of the game if they had chosen to. This means that the design of the interaction supported the participants need for autonomy, capability, and relatedness, enriching their motivation to engage in collaboration with the robot. As we can observe in the results from chapter 5, the argumentative mode or active strategy that enhanced the proposed model evoked a higher sense of trust between the person and the robot than the turn-based approach through a display of teamwork in the face of uncertainty. We confidently can say that this model and the manner we have begun approaching the tests for it, is a start to empower collaborative scenarios between people and social robots and therefore HRI has become a great discipline to test and evolve the model of RE and its exemplifications of practical use and implementations.

6.3 Contributions

The key contributions from this thesis book are as follows:

a. A Visual Map that organizes the HCI theories and models from the perspective of a relationship within a dialogue driven framework, as seen in Chapter 2.
b. A proposed novel theoretical model based on the process of Realizing Empathy presented in Chapter 4. This theoretical model is a potential approach for interaction between people and their smart technologies and social robots.
c. A new approach for a communication tool that fosters HCI relationships – as examples for tangible design resources to instantiate elements, variables, and the steps for the model of RE
d. Some examples of design elements and practices that tangibly impact the delivery of the model proposed within an HRI case study presented in Chapter 5. Within the design and considerations of the HRI interaction case study, design elements and practices were carefully adapted to instantiate the model's approach.
e. A case study of human-robotic interaction experiments that argues that along with the existing computational models, a context of active exchange modeled after the proposed realizing empathy model in this thesis, while using design element examples for the delivery is essential to effectively create empathetic experiences and thus achieve longer engagements in human-robot interaction. Also presented in Chapter 5 in 2 phases.

6.4 Limitations

The broadness and complexity of the work has come with a series of limitations that have helped further refine the potential future lines and next steps for this research path. Whether it is due to the nature of the work or other circumstances, these limitations reveal further challenges to explore. Below we describe some of the limitations we have found as we worked on the main contributions and objectives of the thesis book.

6.4.1 Complex and multifaceted

The model itself is complex and requires each element to be studied in-depth and their relation to each of the other elements. Though the case study began assessing those relations, and the results are encouraging for future work, there is much road to cover before the approach can become a stronger theoretical model for long-term engagement. Another aspect that adds to the complexity of this work is the influence of socio-cultural implications and how that is reflected, monitored, and considered by the actors both as part of their context, environment, and design. At this stage of the work, taking this into consideration to study is beyond the scope, but there is enough theoretical foundation to view it as a variable to consider for future lines of the work.

6.4.2 Long-term engagement tests and practical implementation

The scope of this thesis allowed for an initial set of evidence that begin establishing what can be a novel approach to long-term empathetic interactions. The intent for long-engagement requires further set of long-term studies with a larger number of participants for an estimated 2-6 months of work "in the filed" following Bickmore and Picard's lead on this effort (2005). Though it was the initial intention to cover this depth of experimentation, the novelty of the proposal within the disciplines we are working in, rendered the steps toward long-term interaction more detailed and with higher variability. It was more proactive toward this achievement to test the tools, the elements, and aspects of the proposed model more closely.

Another limitation here is that based on the concepts presented, the experimentation requires us to limit the bias of a controlled testing environment. The participant must engage with the object as if it was incorporated within their daily habits and routines for proper assessment of its design's impact long-term. This requires tests to be done "in the field" with a practical approach to the object.

6.4.3 Measures

There are 3 main paths of peer accepted measurement tools for Empathy within the fields of HCI and HRI. First, the work around empathy in Human-Computer and Human-Social robot relationship is mostly qualitative based on psychological metrics through survey or self-reporting. These measures can be helpful but have been deemed unreliable on their own to establish conclusive results.

A second path authors have taken to measure empathetic expression has been through a combination of either neuroscientific data recording, media material being viewed along with surveys to quantify affective states in the process. Yet these materials are limited to emotional measurements and mirror neuron activity. This reflects how Empathy, in HCI practice, has mostly been accepted as a series of affective state. This makes quantitative measurement approaches very limited and inflexible to potential multifaceted perspectives. Though affective state markers are very important to the process being proposed, it is one of several facets that we are exploring and testing.

Third there are a series of contrasted designed surveys with specific models of analysis that touch on: Empathy, perception of trust, engagement, collaboration, affective entanglement, and relation with the technology. Though the survey becomes specific to the areas we focus on within this thesis, the questions themselves continue to be broad and are not necessarily flexible when observing the interconnectedness of each element nor do they fully reflect the breadth of nuance the behavior it is studying can portray. They are flexible enough to contrast with other measure methodologies

To respect and best represent the integration of our proposed model within the HCI and HRI disciplines, in Chapter 5 we decided to use current peer reviewed survey measurement tools for empathy and empathetic engagement in the HCI, HRI disciplines combined with qualitative measures of cued- recall and self -reporting methodologies. This way we ensured to cover both qualitative and quantitative approaches to measurement.

6.5 Future Lines

The gap analyzed, challenges faced in the limitations, and the research path begun, only means there is much more to explore. It has opened an area of study in empathy and the design process as tools to implement and enrich the human-computer and human-robot interactions. Below are some of the areas in which this research path can continue to grow and refine to become a formal theoretical interaction model that promotes the process to realize empathy and long-term relationships between people and their technologies.

6.5.1 Further Model Research

Affective States

Opportunity to study Affective State prediction and its impact in RE process.

Measurement Tools

In-depth research on applied measurement tools for the individual elements within the process of Realizing Empathy, moving forward from theory and understanding how different models of measurement can be connected and applied.

a. Measure Trust-specific interaction as well as the role of affective attachment in how people trust their technologies.
b. Measure in more detail the nuances of how people regulate their expectations towards their technology in both ludic and practical scenarios from the moment they reflect on obtaining that technology. Also, how this fluctuation of their expectations impacts their trust and care for those technological objects.
c. Analyze the different emotional and affective attachment measurements, to then tailor a measurement tool to this type of study context. In correlation to the previous points, it is relevant to measure the perseverance of their attachment to their technological objects through time and how it has affected their self-sufficiency, trust, and expectation shifts.

Tests

Testing of more complex design theory patterns for developing more controlled and refined experiences in the RE model.

a. Refining the use of art and design elements and principles and their meaning to enrich the model and become more specific to the composition of elements and principles that work in relation to the intention of the interaction designed.
b. Create a short-term test designed for "in the field" testing with participants with a smart object that considers both the RE model and more complex design language and application.
c. Create a long-term test designed for "in the field" testing with participants with a smart object that considers both the RE model and more complex design language and application as a follow-up from the short-term testing results.
d. Create a short-term collaborative test with social robots within a practical scenario by further experimenting on the indicators of RE.
e. Create a collaborative long-term test with social robots in a practical scenario after the short-term test results. We have initially considered the application of architectural practices as a method for collaboration between them.

Other Fields

a. This research and methodology can be applied to other HCI disciplines like interaction with artificial agents, digital environments, smart objects, seamless interaction with environment. This direction can also provide clarity for commercial applications and cross disciplinary ventures.
b. An interesting path to explore is the impact this type of interaction model can have on Computer Vision, and automated projects. Current studies around automated help to people are limited to providing predictability of the audience and persuasive methodologies.
c. It would be of great interest to also explore how this model impacts Business models that rely on current models of interactions between people and their technologies.

Building a Guideline

The initial objective and goal for this thesis journey was to establish a guideline for Realizing Empathy as a model for HCI design and research. Though the work is promising and has opened a path toward this objective, the model remains quite novel and in need for further study of the individual variables and elements to be exemplified in a guideline format fully and clearly. The current thesis book does provide some examples using Design elements, principles, and research for the stable elements of environment, communication tools and instruction design and materials for an open mind and setting a foundation for the agent's base expectation. But this is not enough to provide a full scope of what could mean a guideline for design.

a. We find that this is a great objective for future work in this path, further making tangible the examples that can construct empathetic engagement in HCI and HRI relationships.
b. The potential for this guideline to be applied and translated to other disciplines is an added aspect to this future line of this research path.

7 Appendix

7.1 List of the map's content[11]

Here is a list of the map's content: theories, models and frameworks used for its construction. The order presented is from left to right using the map Above as a reference.

7.1.1 Machine's internal structure

Mathematical Self-Evolution

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7.1.2 Object Design

Object as Protagonist

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Based on Human Data

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From machine's perspective

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Both Considered

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From a person's perspective

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7.1.4 Person's conscious influence

Attitude centered around others

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Attitude centered on oneself

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7.1.5 Person's unconscious influence

Intuition

(70) Naturalistic Decision Making: Klein, G. (2008). Naturalistic decision making. Human factors, 50(3), 456-460.

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Instinct

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7.2 Published works and participations

7.2.1 Participation: Conference Proceedings New Friends 2016: 2nd international conference on social robots in therapy and education - SAR workshop description: Realizing Empathy: Designing for Social Robots (November 2016)

This workshop is about discussing how to create bridge between establishing an empathetic person-robot relationship and the design and engineering development of social robots. It is important to consider during this activity how people make decisions, the role of emotions, how they engage, trust, and sustain their relationships with others and objects. Even though these robots are able to express and recognize emotions [Picard, R., 1995], how are these affective behaviors conducive to a bidirectional relationship? How is the empathetic interaction between them reflected? Within the development of design processes for social robots, the concept of empathy is key. Empathy, in itself is the interpersonal capacity of people, or people and objects, that can comprehend intrinsically, deeply, and completely the cognitive and emotional experience of an other in a conversational format [Gallesse, V., 2003]. Though realizing empathy seems intuitive, it is quite a complex process with the objective that each party may find something in common behind the message and actions as if negotiating or conversing together [Chan Li,S. 2013]. This causes a sense of self-realization and reflection for the user. In the context of education and therapy, self-reflection is key [El Kaliouby, R., 2006]. Without this and the result of self-reflection with technology, the relationship can become strained, frustrating and cause distrust or detachment [Freedy, A., 2007]. Finally we will discuss in how this process of Realizing Empathy can be integrated and transformed into tangible elements within the process of development and use of social robots through design principles and technological tools. This means that robots would not only listen and react but actively suggest a mutual understanding with the user. In order for this to take place, how and when within the experience the design and technological tools are used, play an important role. This could help to answer open questions, like: how can algorithms and interactions be built, so that robots instead of expressing literal systematic approach, it is also able to let the user have a sense of control over their decisions? Rather than persuade, it could suggest or guide, while being open to learn from the user themselves?

7.2.2 Conference short paper: Towards a new measurement language for Self-Knowledge in Personal-Informatics (May 2017)

García-Corretjer, M. A., Navarro-Aubanell, S., & Miralles, D. (2017, May). Towards a new measurement language for self-knowledge in personal-informatics. In Proceedings of the 11th EAI International Conference on Pervasive Computing Technologies for Healthcare (pp. 382-385).

This paper proposes a new tool of measurement for Self- Knowledge and monitoring of health. The presented concept leverages on people’s self-reflection, empathetic interactions with smart objects, and HCI applications to reach transforma- tive insight and Self-Knowledge. The particular emphasis is on evaluating needed variables within the processes of Personal- Informatics, Self-Reflection, and Realizing Empathy found as gaps in fields contributing to Self-tracking and analysis. After those variables were translated into designed, interactive, smart behaviors, tests were done to verify their initial effec- tiveness a new method for visualizing and understanding one's own data measurement, encouraging the person to Self-Reflect. The concept is contextualized within a dieting or body regime experience.

7.2.3 Conference short paper: The maze of realizing empathy with social robots (September 2020)

Corretjer MG, Ros R, Martin F, Miralles D (2020) The maze of realizing empathy with social robots. In: 2020 29th IEEE International Conference on Robot and Human Interactive Communication (RO-MAN), pp 1334–1339, DOI 10.1109/RO-MAN47096.2020.9223466

Current trends envisage an evolution of collab- oration, engagement, and relationship between humans and devices, intelligent agents and robots in our everyday life. Some of the key elements under study are affective states, motivation, trust, care, and empathy. This paper introduces an empathy test-bed that serves as a case study for an existing empathy model. The model describes the steps that need to occur in the process to provoke meaning in empathy, as well as the variables and elements that contextualise those steps. Based on this approach we have developed a fun collaborative scenario where a user and a social robot work together to solve a maze. A set of exploratory trials are carried out to gather insights on how users perceive the proposed test-bed around attachment and trust, which are basic elements for the realisation of empathy.

7.2.4 Cornell University Arxiv Open Contribution Article: A Theoretical Approach for a Novel Model to Realizing Empathy (September 2020)

Corretjer, M. G., Miralles, D., & Ros, R. (2020). A Theoretical Approach for a Novel Model to Realizing Empathy. arXiv preprint arXiv:2009.01229.

The definition of Empathy and its nature is a constant topic of exploration and study across disciplines. Many of which impact and influence the HCI community and commercial production of "empathetic objects" as both engineers and researchers hope to promote an engaging relationship between people and their smart objects. Yet, it continues to elude most scientists and researchers without a clear direction of what is the essence of empathy, or rather it is a heavily debated discussion. What is becoming clear is that empathy is starting to be seen as a series of events that occur outside of affective states or emotions and promotes a sense of meaning for the user.

In this paper we present 2 main activities: First we provide an analysis of theories, models, frameworks and strong concepts across disciplines in relation to Empathy as they impact the HCI community from art and design to empathy in social robotics. Second, we present a proposed model of interaction with the potential for long-term engagement as the process of realizing empathy. The multilayered structure with elements and variables is derived from the related works and theoretical framing analyzed within the paper. Rather than attempting to further define empathy, this paper is about proposing a different perspective to empathy that visualizes a scope for it seen as a process influenced by dialogue and collaborative models with the goal of reach meaning between the actors involved.

7.2.5 – Published Journal Article: Empathy as an engaging strategy in social robotics: A pilot study. (April 2022)

Corretjer, M.G., Ros, R., Mallol, R., Miralles, D., (2022). Empathy as an engaging strategy in social robotics: A pilot study. Journal User Modeling and User-Adapted Interaction. DOI: 10.1007/s11257-022-09322-1

Empathy plays a fundamental role in building relationships. To foster close relationships and lasting engagements between humans and robots, empathy models can provide direct clues into how it can be done. In this study, we focus on capturing in a quantitative way indicators of early empathy realization between a human and a robot using a process that encompasses affective attach- ment, trust, expectations, and reflecting on the other's perspective within a set of collaborative strategies. We hypothesize that an active collaboration strategy is conducive to a more meaningful and purposeful engagement of realizing empathy between a human and a robot compared to a passive one. With a deliberate de- sign, the interaction with the robot was presented as a maze game where a human and a robot must collaborate in order to reach the goal using two strategies: one maintaining control individually taking turns (passive strategy), and the other one where both must agree on their next move based on reflection and argumentation. Quantitative and qualitative analysis of the pilot study confirmed that a general sense of closeness with the robot was perceived when applying the active strategy. Regarding the specific indicators of empathy realization: (1) affective attachment, affective emulation was equally present throughout the experiment in both conditions, and thus, no conclusion could be reached; (2) trust, quantitative analysis partially supported the hypothesis that an active collaborative strategy will pro- mote teamwork attitudes, where the human is open to the robot's suggestions and to act as a teammate; (3) regulating expectation, quantitative analysis con- firmed that a collaborative strategy promoted a discovery process that regulates the subject's expectation towards the robot.

Overall, we can conclude that an active collaborative strategy impacts favorably the process of realizing empathy compared to a passive one. The results are compelling to move the design of this experiment forward into more comprehensive studies, ultimately leading to a path where we can clearly study engagements that reduce abandonment and disillusionment with the process of realizing empathy as the core design for active collaborative strategies.

7.3 Melli: Empathetic System for Wellness Programs

Between 2018 and 2021 we worked on pushing the result from the HCI study of RE into a second phase of study. In the process we realized that it had the potential to become a commercial product with enough time, resources, and research behind it. In 2018 and 2019 we entered the Generalitat Llavor grant competition with the hope that we could propel the study forward. The proposal was a smart device that can help patients measure and monitor their body regime changes while being connected to both a community and medical experts. This proposal had the support from local companies that develop and design products for the pharmaceutical sector as well as the support from other research teams form within the academic environment who saw the potential of having some of their research results applied to it, for example the work by Serra G. (2019) where they were able to program objects that learned how people were handling the object, predict how and where they would lay the object after, and detect who was handling the object through gesture manipulation.
In the meantime, we worked on several prototypes and a digital environment to make the concept wirelessly work with all the different technological components needed, while contained in a physical design that fit in the palm of a hand comfortably. This became an engineering and design challenge as we faced some limitations that made the process of prototyping and testing long and unfocused. But by 2021 we had a working prototype used for testing.
In May of 2020 our project was accepted into the grant program for the Industry of Knowledge – Seed modality, with the hope to push the concept from a level of research work of initial prototyping and testing to a level of testing in the field within the related industry. This program recognizes several states of a projects with TRL (Technology Rediness Level), our proposal at the time of submission was at a TRL 2, were we have observed and developed the concept ready for long-term, autonomous testing in a lab setting. The goal after the program was to elevate the TRL to 3 or 4.
The objective of the program is to provide researchers with the tools, knowledge, entrepreneurial skills, and platform to venture their research products and inventions

into the commercial industries. If the project evolved favorably, the researchers had the opportunity to showcase their project to a panel of investors. As a selected few among the program participants within the 2 modalities of Seed and Product (LLavors and Producte), the investor's help meant the researchers would continue the project onto a second phase outside of the program. The different between the two modalities is that Llavor projects were younger, less matured as a project without too much exposure of testing and market study, while Producte were projects had a higher TRL, had some evolution throughout the years, implementation, and were ready to be brought into the market.

During the development phase and Business model evaluation we realized that though the technology can be implemented within the health and pharmaceutical industries, this effort was felt more as a strategy to enter the market rather than the foundational influence in the design and conceptualization of the product itself. Simply, it meant that instead of presenting a product that helped monitor and measure someone's body regime changes, we realized that the embedded technology had more business model opportunities as an object that was able to recognize its user's emotions through gestures and engage them in empathetic interactions according to the RE model presented throughout the thesis book. This highly simplified the product's development and in-the-lab to field testing as well as its potential TRL implementations after the program was over.

With this pivoting of the project, the development of the business proposal shaped into a proposal that was plausible, enticing, and with a lot of potential, based on program's jurors and mentors. The final product proposal in testing phase is a handheld device with a large pressure sensitive button over the top that learns from users' gestures: who they are, their intentions, and their emotional state.

Because of the design development, initial testing, and business modeling, Melli went through 2 rounds of internal assessments and was selected among the few to present to the panel of investors. At this point our strategy to enter the market was to continue developing the project with Sotavia as an engineering partner to develop and enhance the product for commercial application while leveraging their positioning within the health and pharmaceutical sector. We also had the support from WeLead a digital marketing and content creator experts that also have extensive experience in managing products within the wellness sector. We also realized that we could extend our strategy within the videogaming sector in relation to our internal research on the market and their current challenges within them.

Though the business modeling evolution of the project was not scientific in nature, it did exemplify how an instantiated product, designed after the RE model can provide a seemingly viable business model competitive for the market. In chapter 1 we spoke of 4 pillars in which we believed the research needed to be explored in, Business modeling was a pillar that throughout the scope of the thesis book did not necessarily impact the core scientific contributions. But in this context of transferring the knowledge into industry applications, the exploration within this pillar did bear fruit in practice. Though it is relevant to dive deeper into the Business modeling process, benchmarking, and market research for this portion of the exercise, it goes beyond the scope of this thesis annex. Below in the next section we present the pitch for the product that reflects the results of the effort within the Llavors program timeframe.

7.3.1 Melli: Business proposal pitch

Melli is a new technology that seamlessly embeds with surroundings and objects while bridging the emotion recognition gap for Internet of Things products and services with a more accurate and holistic profiling of users. Because Melli knows who you are and what you are feeling with just a touch. All while providing empathetic curated information through the channel you and customers feel most comfortable with. Melli is not based on large population trends or learns from online actions, but a technology that understands, learns from your natural gestures and unique physical and psychological footprint.

Melli goes beyond facial recognition, which requires a camera and distance to best detect emotions, or beyond speech and text analysis that needs the correct circumstances for it work, and it goes beyond biometrics that to accurately detect emotions it requires serval types of input, not just the ones on your wrist. Instead Melli, is in your hands, on your phone, game controllers, medical devices, or your cup of tea. That level of honesty, seamlessness, and simplicity, opens up a whole new dimension of what can be an improved sense of wellbeing through IoT products.

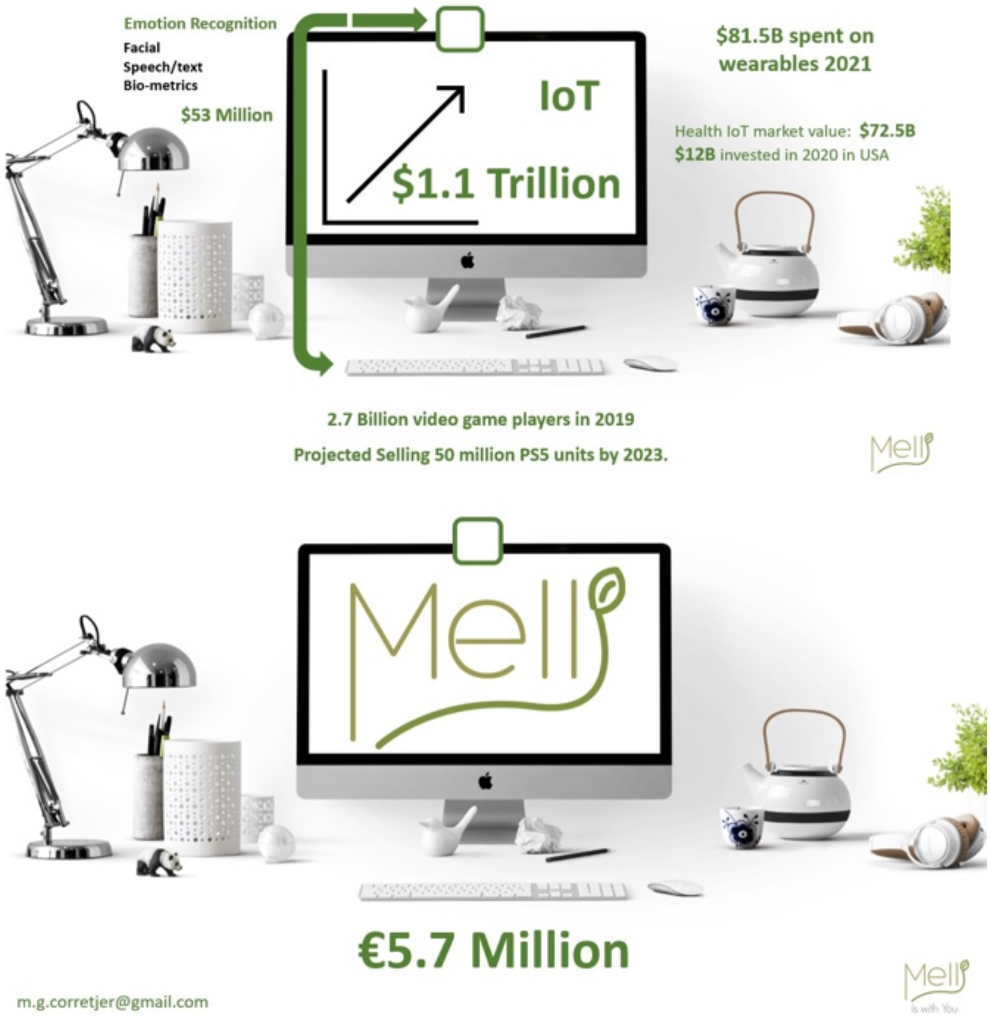

Figure 50: Melli initial valuation overview of the market and its value within it.

The niche sector of Emotion Recognition Softwares that focuses on facial recognition, speech/text analysis and bio metrics is currently valued at $53 Million. Here, Melli serves a refreshing new viewpoint that adds value to the current technology as it simplifies the resources needed for emotion recognition. Now, this sector lives within the umbrella of Internet of Things devices, imagine applying Melli to products and services that directly impacts customers like wearables, smart health technologies, gaming and digital devices, the possibilities are endless.

In particular we, are looking into Health IoT and Gaming segments because of the drastic growth in these sectors by the current customer trends, in the last year alone. First an exponential amount of people are willing and betting on emotionally connected experiences that both: help them monitor and improve their health and wellness as well as engage them in more meaningful gaming experiences. Now the Health IoT market is estimated at $72.5B with significant new investments in the last year. In the gaming industry, it has been very clear how 2020 has been an amazing year for them with ZERO signs of slowing down. Just look at how Playstation purchases of the new consoles have increased 36% since their PS4.

It is important to note that their customers are not too different from each other as they have a similar attitude toward new technology that improves an important aspect of their lives, not to mention that these segments, despite their differences, actually can work very well together.

We believe that Melli, based on our projections and the market entry strategy, the current value is estimated at 5.7M€.

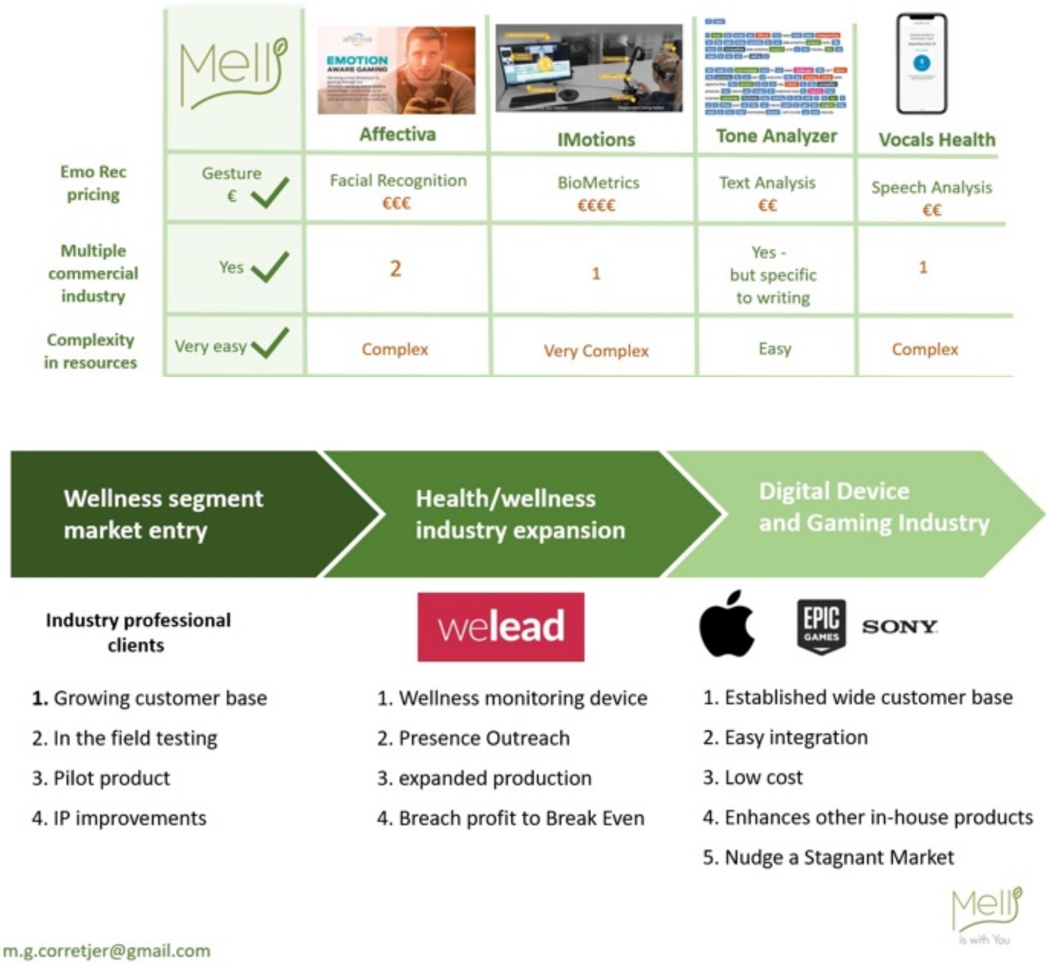

Figure 51: Benchmarking and entry to market overview strategy.

Some of our current competitors are: Affectiva, Imotions, Tone Analyzer, and Vocals Health. Despite their strides, first they focus on other ways to recognize emotions, mostly requiring unique circumstances for their software to properly engage and accurately detect emotions, Second, the resources needed limit how well embedded they can be in a more seamless way within direct consumer applications making devices more complex and expensive, And third: much of their commercial integrations and relationships is limited to academics, institutions, and specific contexts of use.

But before we compliment the industry we do have a roadmap that strategizes the next key steps to improve the product IP and generate the most impact for the end customers.

After our current stage of TRL4, we are envisioning 3 main stages for the next 4 years. First we will mature the project by implementing Melli into a practical IoT health monitoring device moving it from a lab setting into a context of use. After working on a phase of customer discovery we have gathered a list of Wellness industry professionals and experts that confirm intention to work with Melli in their practice at this stage. This will drastically improve the software abilities and hardware adaptations. Not only will we gain refined know how of emotional and psychological micro gestures but also be able to leverage the customer trends of wellness technology adoption. This kind of added value to the product can have major impact on other commercial industries later on, like in the gaming industry.

Second, Because we understand the growing demand among the general population to improve their wellbeing beyond counting steps to actually monitor their stress, anxiety, and body regime, we have confirmed interest from We Lead, a digital positioning strategy agency, to invest their time, money, and resources to expand Melli's growth attracting customers and potential partners.

Third: given a rollout working with these clients and partners our long term vision is to enter the video gaming and digital devices industries.

The Gaming industry is actively searching for accessible and innovative ways to improve game experiences and skyrocket in how they differentiate from competition, also their customer base is VERY open to new technologies, basically everything goes in order to improve their game play including being monitored and using their data. Melli will not only disrupt and expand the possibilities of game design experiences with live feed of the players emotions into the game, but it can easily integrate in their devices lowering cost production and enhancing other in-house products and services.

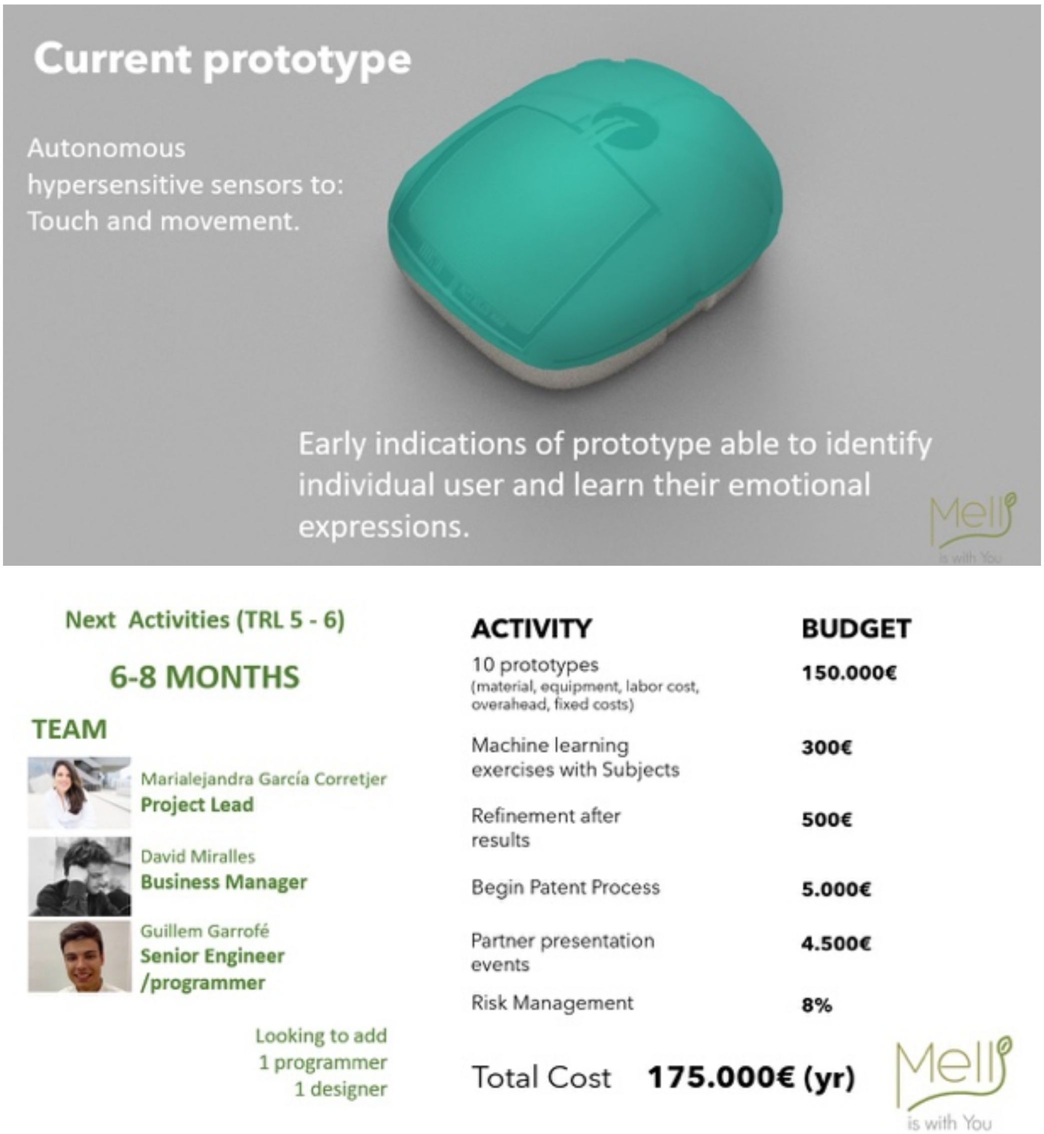

Figure 52: Prototype, team effort, and value.

Now, to get to this point: First, our current state is that we have a refined prototype, after having analyzed our results with clear indications that the initial prototype can identify users individually and learn from their unique gesture markers (Serra, G. 2019). We are ready to move into tests with users in context of use.

To reach that next step, as a team of 5 members, within the next 6-8 months we plan to:

-Make at least 10 prototypes

-Have subjects use the prototypes in their context as sessions "in the field"

-Refine the product according to those results

-Begin Patent process

-Once pending, we will do a show event inviting key potential partners and business clients to discuss the next steps.

Figure 53: Long-term vision and business revenue projections.

The long-term vision begins by ensuring the patents for the technology and have clear results from the initial pilot rollout of the health monitoring device.

With those results, we will engage in a campaign to produce a larger rollout and by the end start attracting bigger business clients and potential partners that can more easily carry emotion recognition technology.

We do aspire to grow with Melli, not only in one segment, but have Melli be available and applied across industries in the future.

This means that we firmly envision to maintain an active role in the relationship we build with our partners and clients. It is a key pillar of our work to continue developing improved experiences and technologies born from a keen understanding and empathy with their customer base.

Our business Model is based on licensing at an initial rate of 50€ per integration and varies according to volume needed by the client.

In the first year, including those 6-8 months, the cost will be of 175.000€ with one partner, industry support, a product in development, and a patent pending as our main asset.
By the second year we expect to have already entered the market and have good positioning with a small pilot rollout of Melli integrated in 500 to 2K health management devices.
In the third year we project to grow more reaching the break-even point.
While on the fourth year as we campaign to enter a second sector, we project to have acquired a new partner and expand the integration of Melli with a significantly larger rollout of 500K or more products.
Though in the first and second year we know that we will not render benefits, by the third year we project to break even or rendered up to 13% net benefit margins. At which point there will be an opportunity to make a new round of investment for Melli projecting a shift in its strategy.

Figure 54: Valuation of Melli based on the projections, business model, and strategy.

After working with Llavor in the last months, we are asking for an initial investment of 175k€ for the first year to cover: materials, equipment, labor, overhead, patent arrangement, and client exposure.
Now, between me, my family and friends, we will invest 33K€ in this total.
Having that initial investment of 175k€, a utility patent asset, and projecting this cash flow and strategy for the next 4 years, the current valuation is estimated at 5.7M€.

Though this project is in its initial stages, the potential for implementation, creates unique opportunities due to its flexibility and scalability across industries.

We are clear that the emotion recognition market within IoT is expanding both in technological applications and consumer demands. In no time at all it will becoming pervasive. What Melli offers makes the experiences and data gathering more accurate, and seamless while bridging the Emotion recognition gap for a wider, simpler commercial use.

The way we are developing the technology, will not only reduce manufacturing costs in time, but can also be embedded in almost any surface and device. The versatility means we need a higher initial investment upfront to refine the software and sensor adaptation with real time users. Needless to say, the opportunities that come from this product are only limited by the imagination.

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