Designing Expressive Movements for Non-Anthropomorphic Hotel Restaurant Service Robots

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Contents

Acknowledgment

This project represents a journey in exploring the expressive movement of service robots in the hospitality industry, focusing on the nuanced field of Human-Robot Interaction (HRI) in hotel restaurant settings. It has been a culmination of dedicated research, creative exploration, and collaborative efforts, envisioning the role of the service robot and the implication of its movement in the scene of the robot restaurant experience. Even though it is a project with my name on it, I could not have finished it without the help of precious people.

I express my deepest gratitude to the supervisors, Nazli and Marco. We first met in the course 'Designing Human-Agent Collaboration' they coordinated, where they introduced me to this exciting field. Their support and motivation from the very beginning have been invaluable. They nurtured my initial fascination with the topic and allowed me to research the behavioral aspects in the hospitality context, shaping this fascination into a graduation project. Their insightful, critical, and constructive feedback guided a novice student design researcher to confidently explore the complexities of Human-Robot Interaction (HRI) in the hospitality context.

Special thanks are due to Mr. Klaas Koerten and Hotelschool the Hague. Mr. Koerten, as the third mentor, provided invaluable input and guidance from the hospitality industry perspective. The project benefited immensely from the support of Klaas and Hotelschool the Hague, which allowed for conducting ethnography and the XR experiment in an authentic context. This support was crucial in understanding the nuanced nature of guest service in the hospitality industry.

I am thankful to Dalco Robotics. The non-anthropomorphic robot Rober, a creation of Dalco Robotics, served as a foundational element for this project. Mr. Tom Dalhuisen's willingness to share his knowledge and insights on hotel restaurant service robots from a robotics perspective greatly enriched the project's scope and depth. I am also thankful to Mr. Kaji for allowing ethnographic research within his innovative restaurant and providing a unique perspective on the operational dynamics of robot restaurants. I also wish to thank XR-Zone, TU Delft, for their technical support in XR prototype development and experimentation. Their expertise was instrumental in effectively incorporating XR technology into the project.

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My heartfelt appreciation goes to my family in Korea. Their enduring support and encouragement have been a constant source of strength and motivation. Last but not least, gratitude must go to my lifelong partner, Isaac, who has been a CFO, participant, creative advisor, graphic designer, and, more importantly, a faithful companion through every step of this journey. I cannot imagine myself writing this final note without your support.

This project found a beautiful intersection where design bridges performative art, technology, and the hospitality industry, envisioning the future of HRI in hotel restaurants. I appreciate the transdisciplinary mindset shared among all contributors and look forward to seeing future research make this collaboration flourish further.

Summary

The hospitality industry, struggling with significant staff shortages, has increasingly turned to service robots as a solution. However, the prevalent service robot's design with anthropomorphic appearance is considered inharmonious with the fine-dining restaurant ambiance and may harm the guests' perception of the service. An alternative approach is exemplified by Rober, which adopts a design resembling a traditional cart. The non-anthropomorphic design offers flexibility, economic efficiency, and enhanced acceptability in hospitality settings. However, it also raises challenges in expressing intentions that are typically conveyed through human non-verbal cues. Consequently, the movement quality of service robots becomes a critical area of design to facilitate nuanced human-robot interaction (HRI) in hotel restaurant contexts.

The research focused on two main questions: how to design robot movement to facilitate essential interaction and collaboration qualities during dining experiences, and how to craft these movements using a dramaturgic performative approach. The project employed methodologies like speculative enactment and Extended Reality (XR) experiments to explore and evaluate robot movements. These methods allowed for creative ideation and assessments of the robot's movements in simulated dining scenarios.

The project's findings revealed that specific robot movements, including refined presence, prompted actions, and engaging addresses, significantly enhance the experience of guests, staff, and managers of the hotel restaurant. The robot's role was envisioned as an 'Ensemblist,' a term encapsulating its function as an integral yet unobtrusive participant in the fine dining scene. This role demands the robot be 'response-able,' adapting to the fine dining rhythm. Furthermore, the project's performative approach illuminated methods to design the robot's movement as expressively meaningful and contextually appropriate. Methodological reflections revealed the effectiveness of speculative enactment and XR experiments in capturing the complexities of human-robot interactions, though suggesting future improvements in prototype fidelity, participant diversity, and advanced data treatment.

This project contributes to the field of HRI in hospitality, bridging theoretical concepts with practical applications. It lays the groundwork for future research in service robot design, emphasizing the need for nuanced interaction designs that resonate with human users in the hospitality sector.

1 Introduction

This chapter introduces the evolving landscape of service robots in hospitality and challenges, emphasizing the importance of expressive movement in non-anthropomorphic hotel restaurant service robots. It outlines the research objectives focused on enhancing interaction dynamics and incorporating a dramaturgic performative approach in robot movement design.

1.1 Background

"Due to a personnel shortfall, we are closing early."

Recently, while visiting a favorite restaurant in my neighborhood, I was stopped at the entrance by an unexpected announcement. Inside the restaurant, three staff members seemed busy cleaning the whole restaurant. Even though it was a visit in the middle of the week, I was surprised that the place, which was usually crowded with guests, had to encounter a hurdle due to the limited workforce. However, it is not just a peripheral issue of a local restaurant. The staff shortage is a challenge across the hospitality industry, which relies on human labor. The escalating integration of service robots within the hospitality sector emerges as a response to pressing industry demands. As highlighted by Choi et al. (2019), industries heavily reliant on human labor, including hotels, are progressively leveraging service robots with the expectation of augmenting productivity while upholding service standards. Tuomi et al. (2020) further underscore the pivotal role of service robots in addressing labor shortages and amplifying operational efficiency within the hospitality domain. These robots take on various roles, from welcoming guests to delivering items and performing cleaning tasks. This growth in the adoption of service robots is reflected in market trends, with the hospitality robots market size estimated to experience significant growth, reaching $3,083 million by 2030 (Allied Market Research, 2021). This growing trend toward deploying service robots signifies a concerted effort by the hospitality industry to navigate labor constraints and optimize operational workflows.

However, it is still not guaranteed that both human employees and guests can perceive robots as intelligent agents rather than gimmicks. The perception of service robots by humans often revolves around anthropomorphism, as explained by Choi et al. (2019), which indicates the extent to which robots possess human-like appearance, capabilities, and behaviors. In particular, the human-like appearance of robots has been considered appealing and relatable, possibly explaining the prevalence of humanoid service robots in the hospitality sector, exemplified by robots like Pepper Figure 1.1.1.. The use of a humanized appearance in robots, however, remains a subject of debate due to the Uncanny Valley phenomenon. As highlighted by Collins (2020), referencing Mori (2012), the Uncanny Valley theory suggests that robots closely resembling humans but failing to replicate human behavior can evoke eerie and repulsive feelings in observers Figure 1.1.2.. Appropriateness becomes more critical when integrating service robots in hotel restaurant settings, particularly in relation to the overall ambiance and interactions in the context. As Choi et al. (2019) bring up the participants' skeptical reaction to the hotel service robots, the mismatch between robots and the conditions of hotels could harm the guest's perceived hospitality and hinder the successful collaboration with human employees.

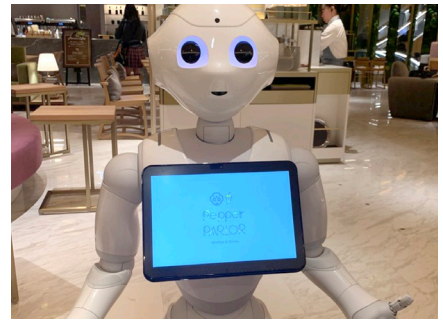


Figure 1.1.1. Humanoid robot 'Pepper' © ILO/K. Hongladarom.

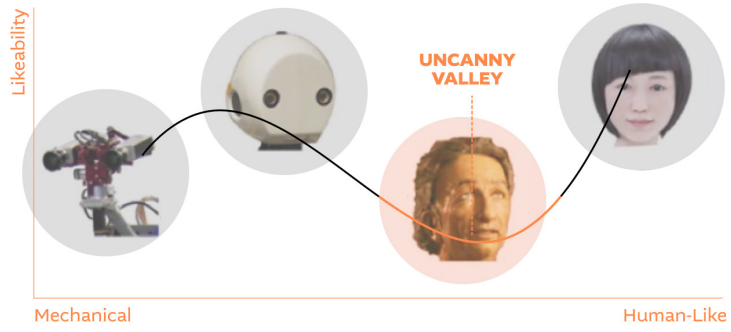
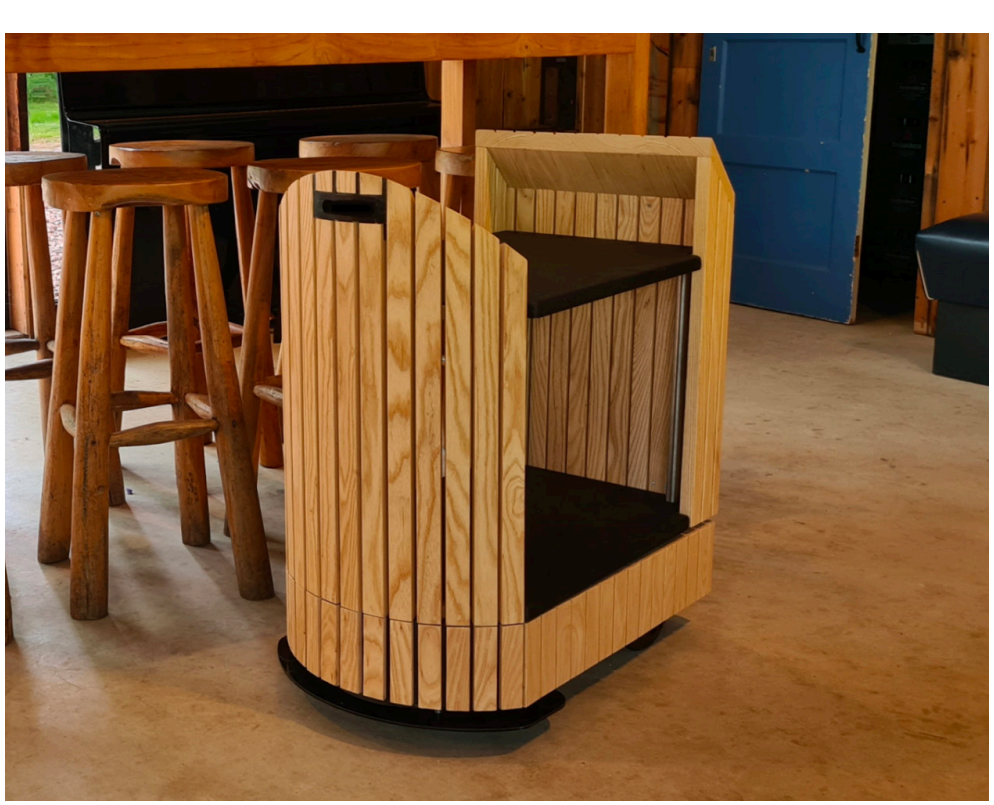


Figure 1.1.2. The Uncanny Valley illustrated by Mori(2012)

Accordingly, service robots are being developed to meet human needs and expectations. Rober, a service robot developed by Dalco Robotics Figure 1.1.3., stands out from prevalent robots. It adopts a non-anthropomorphic appearance, without any human-like components, more resembling the traditional cart with wooden materials. As Hoffman and Ju (2014) note in their paper, the non-anthropomorphic design has advantages, such as exploratory flexibility, economic feasibility, and the potential for greater acceptability. He also promotes its positive effects on interaction, such as lowering expectations based on anthropomorphic appearance or avoiding the uncanny valley. It is especially remarkable regarding the hotel context that the viewer can flexibly accept the less human-like appearance as attuned to a hospitable environment. While Rober's non-anthropomorphic design may be advantageous, it also raises concerns about the robot's ability to express its intentions, which humans often communicate implicitly through various non-verbal cues. Collins (2020) also suggests that the key to avoiding this uncanny valley is to build robots that exhibit human-like behavior without overly resembling humans. Consequently, focusing on the behavior of robots, which enhances communication and interaction with human users, would be a more productive avenue for designing service robots that are both relatable and effective in their roles.

Figure 1.1.3.
Rober from Dalco Robotics



Designing the robot's expressivity requires a creative approach to envision its movement relating to the situation and dynamic affordance. Hoffman and Ju (2014) highlight that finding the appropriate expression can be more of an art than a science, and people's engagement helps gain insights into how the robot should move. This creative endeavor involves not only technical precision but also a nuanced understanding of the context in which the robot operates. As Bleeker and Rozendaal (2021) introduce dramaturgy as a set of conceptual tools to design human-agent interaction, the principles and techniques from the performing art can inform the design process of analyzing and developing the service robot in the hotel restaurant context. With the experiential and participatory approach, the project aims to envision the expressive movements of the hotel restaurant robot, considering its interaction/collaboration qualities with human actors, including guests and restaurant employees.

1.2 Project Framework

Research Questions

The project is driven by two pivotal research questions aimed at unraveling the nuanced facets of robot movement design within the hospitality context.

> RO.1 What kind of interaction/collaboration qualities should the movement of robots accommodate regarding the dining/serving experience in hotel restaurants?

RQ1 addresses the interaction and collaboration qualities that non-verbal expressions within robot movements should enclose to foster enhanced engagement with both human guests and employees of hotel restaurants. Understanding and identifying these nuanced qualities are paramount in the development of robots seamlessly integrating into the dynamic hospitality setting. The project aims to shed light on designing the robot's movement, elevating the customer experience and staff collaboration experience, and ensuring an environment where technology augments rather than disrupts hospitality.

> RO.2 How could we design the movement of robots with a dramaturgic performative approach?

RQ2 focuses on the incorporation of a dramaturgic performative approach in robot movement design. This inquiry delves into the intersection of technology and performative art, exploring how leveraging dramaturgy can inspire designing robot movements with meaningful interactions. Additionally, the extended reality(XR) technology supports the approach, offering an immersive environment for participants to engage in the design process. Avoiding being captivated by predefined technical limitations, the approach is expected to help design the robot's sophisticated expressivity to accommodate the nuanced interactions and expectations in the hotel restaurant setting.

Project structure

The project report is structured into four key phases:

Defining Phase: This initial phase sets the groundwork for the study. It encompasses a comprehensive literature review focusing on understanding the concept of hospitality, Human-Robot Interaction (HRI) within the context, and the performative approach in HRI design. The ethnographic study follows, observing interactions with human users. The findings are analyzed with a dramaturgical approach to comprehensive knowledge and ground the design intervention.

Ideation Phase: Building upon the defining phase, design interventions for the robot's movement for the hotel restaurant are ideated. The scene of the robot restaurant is framed with research questions. Enactment sessions with the speculative scenario explore the robot's movement, affording interaction/collaboration qualities in this context. The insights from these sessions converge into design concepts.

Evaluation Phase: Aligning with research questions, it employs eXtended Reality (XR) technology to assess designed concepts and experiences from various perspectives. The data from the experiment are analyzed to validate the effectiveness of the designed robot movements and gain multifaceted insights for creating a desirable hotel restaurant experience with the robot.

Reflection Phase: Concluding the project, this phase engages in discussion, reflecting on Human-Robot Interaction dynamics in the hotel restaurant. , reviews methodologies employed throughout the study, examines contextual factors within the restaurant, and offers comprehensive reflections on the project's overall journey.

2 Defining Phase

This initial phase sets the groundwork for the study. It encompasses a comprehensive literature review focusing on understanding the concept of hospitality, Human-Robot Interaction (HRI) within the context, and the performative approach in HRI design. The ethnographic study follows, observing interactions with human users. The findings are analyzed with a dramaturgical approach to comprehensive knowledge and ground the design intervention.

2.1 Literature study

A literature study was conducted to understand the current state of research in the field of hospitality and human-robot interaction. It navigates fundamental aspects: defining hospitality, exploring conceptual models, analyzing Human-Robot Interaction in hospitality services, and discussing performative HRI design approaches. The study ends with conclusive insights and limitations to set a foundational understanding for further exploration.

Hospitality and the measurement

According to the dictionary definition, 'hospitality' is described as 'the act of being friendly and welcoming to guests and visitors' (Cambridge University Press, n.d.). However, when it comes to an industry providing customer service, it gets a multifaceted concept, encompassing various perspectives that highlight its diverse dimensions. Teng (2011) introduces different perspectives to describe commercial hospitality on which they put emphasis, such as interpersonal relationships, individual behavior, the physical environment, or customer value. To explain the dynamic relationships between the factors, the author proposes the 'commercial hospitality model' Figure 2.2.1. The model illustrates how these different dimensions interact and contribute to the overall hospitality experience.

This model comprises several components: Firstly, it involves the 'hospitality provider,' encompassing host employees and sensory inputs crucial to hospitality delivery within the environment. Secondly, it addresses 'consumers,' which not only

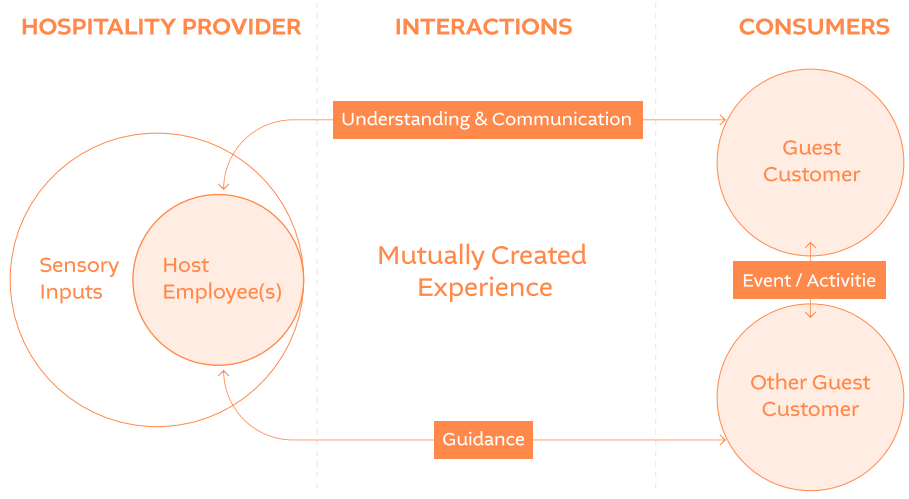


Figure 2.1.1. Commercial Hospitality Model illustrated by Teng(2011)

include guest customers but also other guests participating in the experience. Thirdly, it emphasizes 'interactions,' shaping the overall experience derived from the actions of both the hospitality provider and consumers. Central to the concept of commercial hospitality are the experiences crafted by the hospitality provider and guest customers. These experiences serve as the core determinants of customer-perceived value, offering diverse benefits that influence and shape customer perceptions within this multifaceted industry.

Thus, from a commercial standpoint, measuring the customer's hospitable experience is paramount for ensuring satisfaction with the provided service. One of the most prominent tools is the SERVQUAL framework, originally devised by Parasuraman et al. (1988) for assessing service quality from the customer's perspective. This framework identifies and emphasizes five key components as determinants of service quality: tangibles, reliability, responsiveness, assurance, and empathy. Pijls et al. (2017) developed a comprehensive scale to gauge how people experience hospitality, including care, comfort, and inviting dimensions. 'Inviting' pertains to feelings of openness and freedom, 'care' involves experiences of empathy and acknowledgment, and 'comfort' relates to a

sense of ease and relaxation. In essence, these three dimensions resonate with the fundamental values customers seek in their hospitality experience, allowing businesses to tailor their services to align more effectively with the customer's expectations.

Drawn attention to the behavioral aspect

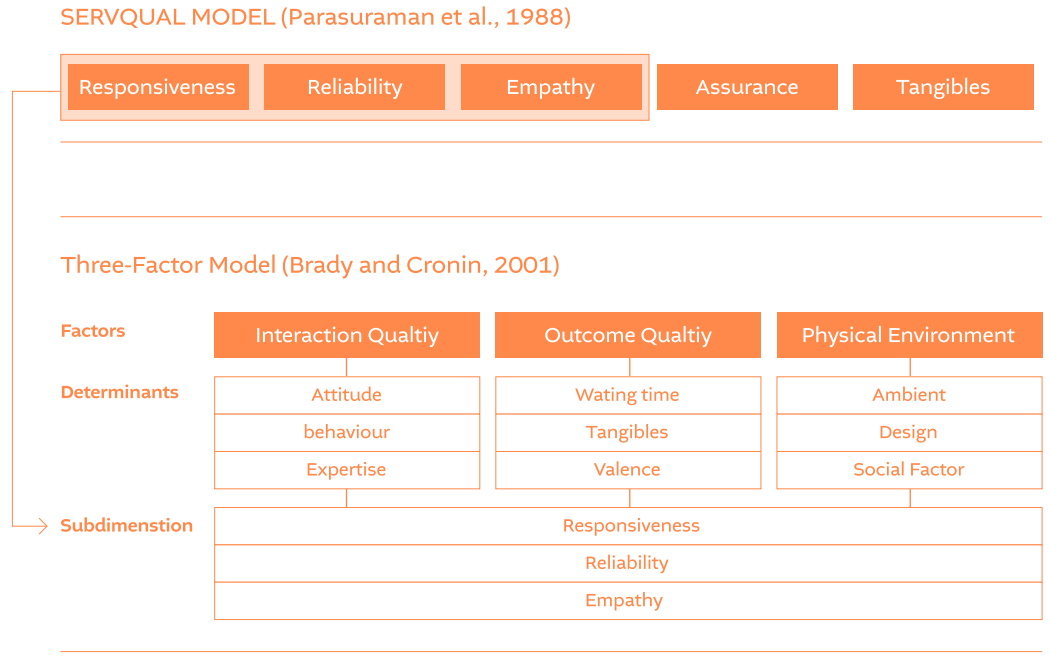
Beyond measuring customer values in the hospitality industry, an essential focus emerges on the behaviors displayed by service providers. As Teng(2011) put the interaction at the center, engaging the service providers and consumers together in the hospitality experience, it is highlighted that the host's performance, which includes both host employees and sensory inputs during transactions, is shaped by customer perceptions of value through the exchange experience. Rather than concentrating solely on the service, hospitality pivots toward how it is performed.

Pijls et al. (2021), who developed a hospitality measurement model(2016), further emphasize the behavior of employees as a key to hospitable performance Figure 2.1.2. The authors elaborate on the four nonverbal aspects that influence hospitable performance, such as Kinesics (body movements or gestures), Proxemics(use of space and physical distance), Paralanguage (vocal characteristics such as pitch, loudness, or pauses), and Appearance(visual presentation of an individual). Their study underscores that customers perceive service employees favorably when they display modest representativeness through hospitable non-verbal behaviors.

Figure 2.1.2
Shifted focus from measurement toward the behavior by Pijls et al. (2017, 2021)

It is also noteworthy how the traditional SERVQUAL model is revised to define the subjects to deliver hospitable qualities. Brady and Cronin (2001) have delved into the factors influencing customers' perception of hospitality. The three-factor model of service quality encompasses interaction quality (the interpersonal quality during service delivery), outcome quality(the technical quality of the service outcome), and the physical service environment (the service environment in which the service is delivered). The model embraces the behavior of the service provider, including the attitude and expertise, as a sub-dimension of the interaction quality. Thus, the behavior that delivers reliability, responsiveness, and empathy of service providers becomes an important determinant of the provision of superior service quality.

Figure 2.1.3
From SERVQUAL Model(Parasuraman et al., 1988) to the Three-Factor Model(Brady and Cronin, 2001)



Highlighting the impact of service providers' behaviors, there were efforts to bridge the gap between hospitality's theoretical concepts and practical application. The shift from traditional service metrics to a more behavior-focused approach sets the stage for examining Human-Robot Interaction (HRI), where similar principles are applied to service robots in hospitality environments.

Human-robot interaction(HRI) for service robots in hospitality

Unlike industrial robots, which typically perform specific tasks in highly structured environments, service robots are deployed to carry out practical tasks in dynamic and complex human spaces. Collins (2020) notes that these robots operate in ever-changing environments, necessitating advanced navigational capabilities to maneuver through crowded and sometimes confined areas. Their tasks often involve interacting with people, demanding various levels of capability and artificial intelligence (AI). As a result, the interactive capability of service robots becomes particularly prominent in these mundane but human-centric settings. As previously discussed, the interaction between the service provider, where the robot will be allocated, and the guest is a critical factor in shaping the perceptions of hospitality. Additionally, given that these robots collaborate with human employees, the interactions between the robots and the human staff are critical as well for successful service delivery. Therefore, effective human-robot interaction(HRI) design is essential for the successful adoption of service robots in the hospitality sector, considering their dynamic relationship with both guests and staff.

GUEST-ROBOT INTERACTION

The intersection of Human-Robot Interaction (HRI) and the hospitality experience of the guest has been explored in previous research, particularly in relation to service quality within the hospitality sector. Choi et al. (2019) conducted a study adopting the three-factor model(originally proposed by Brady and Cronin (2001)) to examine how guests and hoteliers perceive service robots in hotels. The study revealed high expectations regarding outcome quality attributed to the robot's consistent and accurate task delivery. However, it also indicated lower quality in the interaction between guests and service robots, emphasizing the robot's limitations in providing personalized and hospitable interactions similar to human staff. Hoteliers were concerned about the physical environment, specifically the harmony between the robots and the hotel's ambiance. Furthermore, the study addressed practical aspects, including rearranging the physical layout to ensure efficient robot operation.

The SERVQAUL model, previously introduced, is also adapted to experiment with the performance of service robots and analyze their influence on the customer experience within the domain of hospitality. Collins(2020) takes the qualities of reliability, responsiveness, empathy, assurance, and tangibles from the SERVQUAL model as service performance variables and proposes the guidelines for designing effective autonomous service robots in the hospitality industry. Kharub et al. (2021) modified the model to assess the perceived service quality provided by social robots, incorporating existing rem with the entertainment dimension. The tailored model, called SERVBOT, encompasses emotional engagement as a critical component in assessing the perceived service quality provided by social robots. Interestingly, the studies note that the robot's movement impacts the customer's perception of service quality, often relating it to 'empathy.' Kharub et al. (2021) highlight its affective capability to build a rapport, and Collins (2020) exemplifies the robot's eye contact, head movements, and proximity to establish an interactive understanding with customers.

EMPLOYEE-ROBOT COLLABORATION

Furthermore, it is essential to recognize that the robot's communication extends beyond interactions with guests; it also encompasses collaboration and communication with human employees as an integral part of the service provider team. Khoa et al.(2022) emphasize the collaborative perspective to implement the human employee and robot team effectively in the hospitality sector. It addresses the importance of training the employees and building trust in working with robot partners. While little study suggests the practical framework for designing the employee-robot collaboration in hospitality specifically, Cila's work (2022) on designing human-agent collaboration informs the critical qualities to be considered. It highlights that successful collaborations between humans and robots hinge on mutual awareness of each other's strengths and limitations, the negotiation and alignment of intentions, and reciprocal support. Cila's emphasis on 'mutual responsiveness' in task execution underlines the importance of both the robot and human employees responding to each other's actions and intentions. This mutual responsiveness underscores the collaboration qualities, such as 'autonomy and control' and 'intelligibility.' 'Autonomy and control' addresses the right level of autonomy of the agent while ensuring human control over it. Designing a flexible autonomy allows active engagement of humans in performance with the robot and enhances their feeling of control. 'Intelligibility' of the agent attends to its behavior designed to express its intentions so that actions are understandable by the human partner. It promotes effective and efficient collaboration and prevents situations of disuse or over-control. Importantly, this does not imply that behavior always prioritizes accuracy. In complex systems where uncertainty is inherent, actions that convey a state of ambiguity also contribute significantly to successful collaboration. For instance, research by van den Brule et al. (2016) demonstrates that when a robot signals potential low performance, it can enhance trust in the system by allowing people to anticipate and proactively address anticipated issues. Ultimately, the core of intelligible movement lies in its ability to enable humans to understand the situation better and identify appropriate reactions, thereby fostering harmonious and productive human-robot collaborations.

This section underscores the importance of effective HRI in hospitality, emphasizing the need for robots to navigate and interact in human-centric settings. The discussion on guest-robot interaction and employee-robot collaboration leads the study to the next crucial aspect: the design of robot movements and their performative capabilities in real-world environments.

Designing a robot with the performative approach

Traditionally, the robot's movement was primarily driven by mechanical engineering principles and aimed at fulfilling practical objectives, often involving basic actions like rotating limbs. These actions were typically observed and assessed by trained personnel within the industry. However, as service robots are deployed in real-world environments and interact with people, the significance of their movements takes on a new dimension. As Hoffman and Ju (2014) noted, the movements become instrumental in shaping human-robot interaction and play an essential role in communication and perception. The movement quality can give the robots a dynamic range of expression and enables dynamic affordances informing what actions and interactions are possible in ever-changing situations. This emphasis on movement design aligns with the notion of performativity. As articulated by Bleeker and Rozendaal (2021), performativity underscores how the behavior of an object, in this case, a robot, influences and brings desired changes within a specific context. Accordingly, the performative approach takes an ecological perspective, drawing attention to the environment in which the robot will

perform and the relationship that it will shape with others in the situated context.

The application of the performative approach in the design of a robot's movements encompasses various methods aimed at enriching the interactivity and situational adaptability of these technological agents. Bleeker and Rozendaal (2021) introduced how dramaturgical insights from theatre art, such as mise-en-scène, performativity, presence, and address, can provide conceptual tools to design smart objects with ecological approaches. Rozendaal et al. (2023) employ speculative enactments as design methodologies in HRI. The enactment involves theater professionals who enact encounters between humans and robots in a virtual supermarket environment to explore the range of possible interactions and identify design features that facilitate or hinder specific responses. Additionally, Porfirio et al. (2019) propose bodystorming as a design technique to leverage the body in the interaction design process. Bodystorming involves designers situating themselves physically within the context of the interaction being designed, thereby gaining insights into the user experience through embodied participation.

The emphasis on a performative approach in robot design sheds light on the importance of movement and interaction beyond mere functionality. By integrating theater and dramaturgy concepts, methods like speculative enactments and body storming highlight the potential for creating adaptive, engaging service robots. Such an approach marks a shift from traditional robotic design, aiming for robots that are embeddable in real-world interaction.

Conclusion and Knowledge Gaps

The literature review has yielded valuable insights into several key aspects. Firstly, it underscores the importance of understanding hospitality as an interactive relationship between actors, including guests, service providers, and the surrounding environment. Service robots deployed in dynamic ecosystems must be designed with a focus on enhancing Human-Robot Interaction (HRI).

Various models for measuring service quality perception have been adopted in HRI of hospitality settings, including the three-factor model (comprising Interaction Quality, Outcome Quality, and Physical Environment) and the SERVQUAL framework (encompassing five dimensions of interaction quality: reliability, responsiveness, assurance, tangibles, and empathy). Moreover, the expressive movement of service robots has the potential to enhance HRI. Leveraging the performative approach, the study explores methods like dramaturgy, speculative enactments, and body-storming to enrich robots' interactivity and contextual adaptability.

However, the review also exposes several knowledge gaps and areas that require further exploration. While the models introduced from the previous works suggest the concept of multi-dimensional qualities, the significance of each quality dimension can vary depending on the specific type of service encounter (Chiang, 2020). How these qualities will correlate with each other and can be delivered in the robot-equipped hotel restaurant setting remains less explored. Furthermore, although there's been considerable exploration into guest perceptions and expectations concerning service robots, there's been a noticeable absence of research focusing on the perspectives of the human staff who collaborate with these robots daily. Understanding the experiences, challenges, and insights of staff interacting with robots in a hospitality setting is crucial to comprehensively grasp the intricacies of HRI. Moreover, the existing descriptions of robot movements are often related to empathy, and their influence on the overall hospitality experience remains somewhat limited. Under-

standing how these movements could influence the experiential dimensions of HRI is essential for optimizing robot design and enhancing the overall guest and staff experience in hotel restaurant settings.

The investigation will delve deeply into how expressive robot movements, guided by principles like dramaturgy, influence experiences for both guests and staff. By embracing the performative approach, the research aims to bridge these gaps, delving deeper into the intricate relationship between robot movements and the overall hospitality encounter. Exploring the situated knowledge within this context will enrich the understanding of how the service robot's movements contribute to guest experiences and staff collaborations, ultimately shaping the future of HRI in hotel restaurant settings.

2.2 Ethnography

Objectives

Moving forward from the theoretical findings from the literature study, ethnography is conducted in a real-world setting at two different types of restaurants in Amsterdam*. As Kamino and Sabanovic(2023) employed the ethnographic method to study the robot cafe in Japan, qualitative research can offer valuable insights into the intricate dynamics and complexities of human-robot interaction (HRI). The ethnography aims to address the identified knowledge gaps highlighted in the literature study by providing a deeper understanding of the nuanced interactions and experiences within hospitality settings, specifically focusing on the integration of service robots. This research provides qualitative insights through real-world observations and interviews within hospitality environments.

*The observation at the fine dining restaurant was conducted in the research elective prior to the graduation project.

Methods

PLACE RECRUITMENT

Given that it is rare to find a fine-dining restaurant equipped with service robots, the ethnography is conducted in two different restaurants—a fine-dining restaurant without any robots and a semi-upscale restaurant with service robots. The fine dining restaurant, named Le Début, is run by Hotelschool the Hague (a hotel management institution). Public guests are served the fine dining menu by the professional instructors and students. Another restaurant was recruited, which employed a service robot to deliver the dishes from the kitchen to the dining area. The restaurant is located in the central area

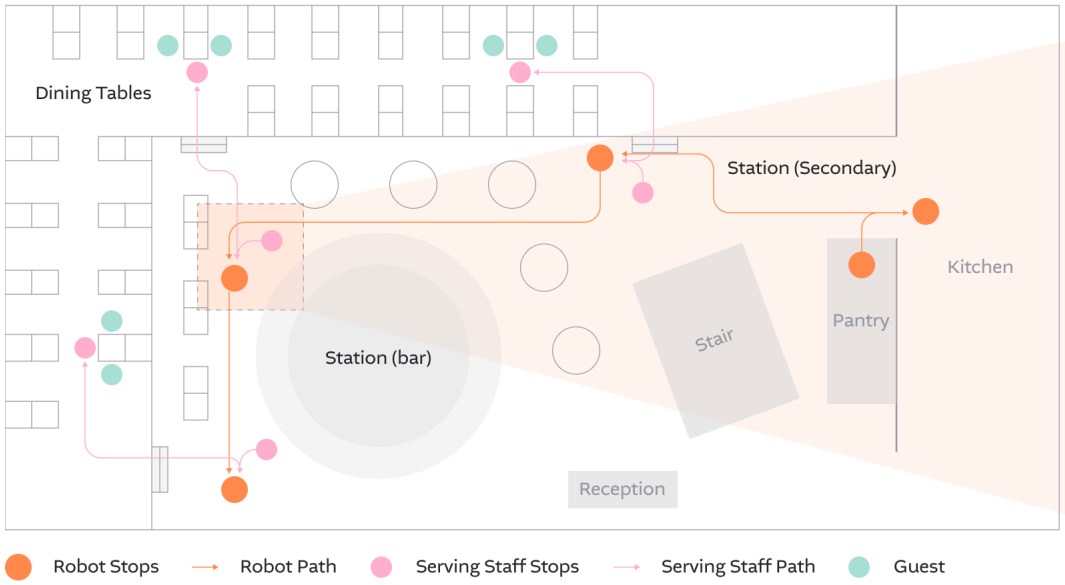
of Amsterdam, taking a large number of guests all day and serving Chinese cuisine.

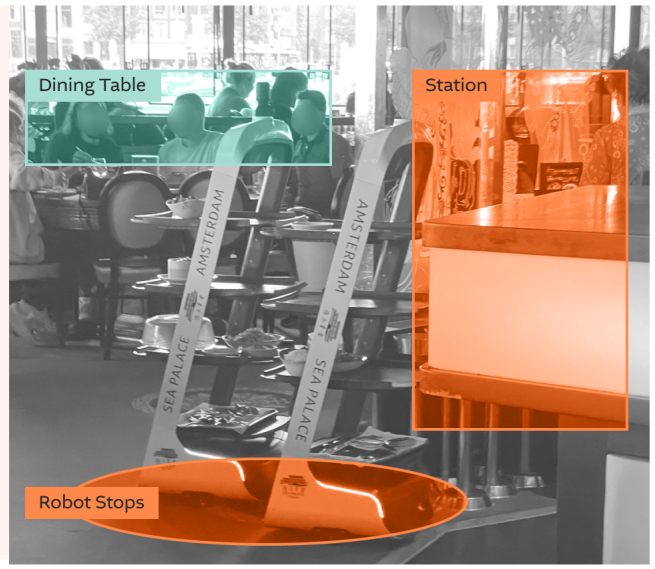
Figure 2.2.1
Le Début- Fine Dining Restaurant without robots(Left), Chinese Restaurant equipped with robots(Right)

OBSERVATION

The observation began with the fine dining restaurant. As an observer, I sat at a dining table at the corner of the restaurant, taking a comprehensive stance to capture the holistic journey of both guests and staff members. Grounded in the works of Pijls et al. (2021), which emphasize non-verbal communications, it concentrated on unraveling the subtleties of staff behavior, affording interpersonal interactions with guests and colleagues. The observation during the restaurant's running was conducted once for 2.5 hours. In a semi-upscale restaurant integrating service robots, the observational scope expanded to encompass the interactions between guests, staff members, and the service robots. The observation focused on how the robot's performance influenced the restaurant experience. The observation was conducted for three days, 1 hour per day. In both restaurants, the physical environments were observed. It included factors such as architectural structure, furniture, seating arrangements, and overall ambiance, which can greatly impact the dining and serving experience.

Figure 2.2.2
A visualization of the field note for the physical setting

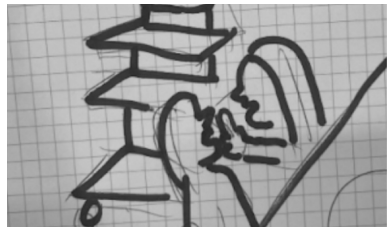




INTERVIEW

In parallel to the observation, interviews were conducted with the people on-site, including the guests, employees, and managers. Given the busy situation, the interviews with the staff(n=3) were conducted as short conversations, asking about their perception of working with robots and (dis)likeness about the experience. Also, the guests who finished their dining(n=4) were asked in the form of a short conversation about their perception of dining in a robot restaurant. One guest(n=1) participated in an in-depth interview while dining. The interview consisted of questions about service perceptions with generative tools like drawing(Sanders & Stappers, 2012) and metaphoric assignments(Brotherton, 2008). It aimed to explore their deeper feelings, opinions, and attitudes toward the dining experience in the robot restaurant. (The in-depth interview material can be found in the Appendix.)

Additionally, in-depth semi-structured interviews were conducted with the instructors of the fine dining restaurant (n=2) and the robot restaurant manager (n=1). The instructors were asked about the difference between casual and fine dining, physical settings and their implications, and the appropriate behavior of serving staff. For the manager of the robot restaurant, the questions focused on the organizational perspective on the robot deployment, such as the motive for the robot adoption, adjustment of the physical setting, and task delegations.



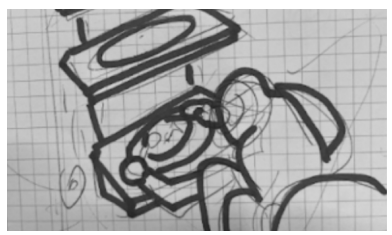


Figure 2.2.3
In-depth generative interview in a robot restaurant

2.3 Scene of Robot Restaurant

Analysis Approach

In this chapter, the outcomes stemming from both the literature review and the ethnographic research are analyzed, adopting a dramaturgical approach. As suggested by Bleeker and Rozendaal (2021), employing theatrical principles provides a powerful lens through which the research can understand the intricate dynamics of real-world interactions. This dramaturgical perspective unveils the complex ecology of interactions, where human and non-human entities are inherently intertwined. Within this framework, dramaturgy becomes a powerful tool for disclosing the performativity of robots and understanding how their behaviors contribute to the desired changes within a given hospitality setting. This performativity, in essence, suggests that the robot's actions should co-shape an enhanced experience during interactions with human actors.

Through the lens of this ecological perspective, the exploration is initiated by identifying the diverse actors present in the robot restaurant and delving into the relationships and values that underlie them. This initial phase aims to provide a comprehensive view of the actors' roles and motivations within this dynamic context. Subsequently, the study delves deeper into the concept of interaction qualities, examining how the performances of these actors accommodate and contribute to these qualities. The analysis seeks to uncover the nuances of these qualities and how they manifest in the interactions between human and non-human entities. Furthermore, it closely examines the spatiotemporal settings in which these interactions and behaviors between human and nonhuman entities unfold, a concept akin to the theatrical notion of "Mise-en-scene." The analysis explores how the physical and temporal aspects of the environment influence the performances and behaviors of the actors, shedding light on the critical role of context in shaping the overall experience.

Ultimately, the analysis aims to frame both the problem and solution spaces within the robot restaurant. By discerning the intricacies of interactions, understanding the interplay of actors and their values, and recognizing the significance of Mise-en-scene, it uncovers opportunities for designing the movement and responsiveness of service robots.

Identifying Actors and Realms

In the context of robot restaurants, several key actors play vital roles, and their interactions shape the overall dining and serving experience. These actors can be broadly categorized into two sides based on their roles: consumers and service providers. Within these categories, different actors are involved in various realms of the experience, including customer service, collaboration, and organization, each contributing uniquely to the ecosystem Figure 2.3.1.

CUSTOMER SERVICE REALM

Customer service in the context of hospitality is where guests and serving staff come face to face. Guests are the primary consumers of the hospitality provided by the restaurant. They enter with certain expectations, as outlined by Pijls et al. (2021), which encompass the values of 'comfort,' 'care,' and 'inviting.' 'Inviting' pertains to the experience of openness and freedom; 'care' involves experiencing empathy, servitude, and acknowledgment; and 'comfort' relates to feeling at ease, relaxed, and comfortable. The guests' perception of hospitality is influenced by a multitude of factors, including the func-

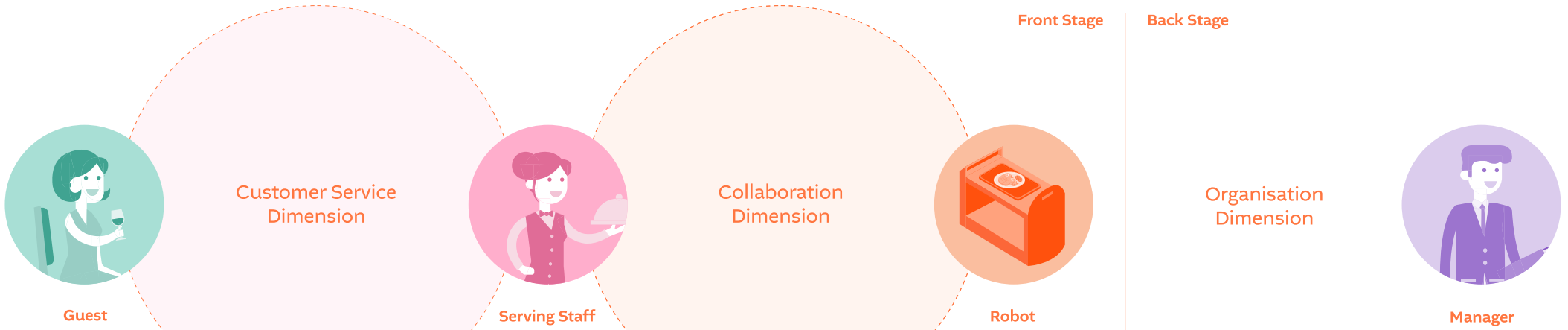
tional outcome of the service (such as food quality, waiting time, and hygiene), interactions with service providers, and the ambiance and layout of the physical environment. Guests often arrive at the restaurant with others, like friends, family, colleagues, or loved ones, seeking not only delicious cuisine but also a social platform to nurture their interpersonal interactions. It's crucial to recognize that guests view dining not merely as a culinary experience but also as a social activity that connects them with others.

On the service provider side, the serving staff takes on a prominent role in the customer service realm. They bear the responsibility of serving the guests by delivering the desired service outcomes, which primarily encompass food and drinks.

Moreover, they are instrumental in satisfying the expectations that guests have concerning the way they are approached, addressed, and interacted with. As previous studies have highlighted (Pijls et al., 2021), the serving staff possesses the capacity to exhibit hospitable behavior, ensuring that guests have an inviting, caring, and comfortable experience.

The findings above are commonly observable from both restaurants, which are equipped with and without robots. The guests and staff members actively engage in various interactions and exchanges that contribute to the overall customer service experience. Even at the robot restaurant, the robot does not play an explicit role, yet indirectly influences the interactions within the customer service realm. The robot's

Figure 2.3.1
Actors of the robot restaurant



Pijls (2021)	Inviting	Comfort	Care		Productivity	Job Satisfaction			Profitability	Sustainment
Three Factor Model (Brady & Cronin, 2021)	Interaction Quality	Outcome Quality	Physical Environment		Automation	Empowerment	Meaningfulness		Guest Satisfaction	Resource Allocation	Task Delegation	Physical Arrangement

presence adds a unique element to the ambiance and layout of the physical environment, shaping the guests' perception of the hospitality provided. However, the robot's role gets more explicit when it interacts with the serving staff in the 'collaboration realm,' which will be explained in the following section.

COLLABORATION REALM

Within the realm of collaboration between service providers, a dynamic interplay unfolds, involving both human serving staff and robots as integral team members. Central to their collaboration is a shared value for the productivity of their work, aimed at providing accurate and efficient service to customers. This collaborative effort becomes particularly crucial given the relatively small number of staff members tasked with serving multiple guests, prompting collaborative tasks with robots to enhance overall productivity. To ensure the productivity, the division of tasks is carefully orchestrated. For example, at the observed restaurant equipped with robots, human staff are primarily responsible for loading and unloading items and serving them to the guests at the final stage. Meanwhile, the robots seamlessly navigate the front- and backstage of the restaurant, taking on the role of food runners. This automation of repetitive delivery tasks, once handled exclusively by human staff, has several significant implications. First and foremost, it streamlines the workflow, minimizing the absence of serving staff from the dining area. This, in turn, enhances the efficiency of service provision and ensures that guests receive prompt and accurate service. Additionally, the introduction of robots into the service process alleviates the physical labor demands on human serving staff. This aspect is closely tied to the perceived meaningfulness of the serving staff's job. By assigning repetitive and labor-intensive tasks to robots, serving staff can redirect their energy and focus toward more meaningful and engaging aspects of their role. This shift also empowers human staff to provide a higher level of personalized service and attention to the guests, ultimately elevating the overall quality of the dining experience.

ORGANIZATION REALM

Within the organizational realm of the robot restaurant, the restaurant manager's role becomes evident, even though their actions might be discreetly orchestrated backstage. In this domain, managers play a crucial administrative role, contributing to the overall profitability and sustainability of the business. The primary responsibility of restaurant managers is to ensure the profitability of the establishment while simultaneously attending to guest satisfaction. This dual focus requires careful consideration of how to optimize limited resources to deliver exceptional service. Restaurant managers must make informed decisions regarding task delegation between the serving staff and robots, all while taking into account the unique physical layout and setting of the restaurant. For instance, decisions about which tasks should be assigned to human employees and which to robots necessitate a comprehensive evaluation of the capabilities of both human and robotic workers. This evaluation extends to factors such as the presence of stairs, table arrangements, and the perceptual aspects of service from the guests' perspective. Furthermore, the physical arrangement of the restaurant is closely tied to its profitability, as emphasized by the hotel restaurant instructor. Any modifications to the restaurant's layout must be carefully weighed against the functionality of the robots and the potential impact on guest capacity and, consequently, profit per area. The organizational realm of the robot restaurant encompasses a strategic balancing act, where restaurant managers must navigate the complexities of resource allocation, task delegation, and physical arrangement to ensure both guest satisfaction and business viability. This realm underscores the pivotal role played by organizational decisions in shaping the overall hospitality experience within robot restaurants.

In summary, the exploration has brought to light the key ac-

tors within the robot restaurant and delineated three distinct realms characterizing their relationships. Each realm unveils different values, roles, and characteristics inherent to the actors involved. The customer service realm emphasizes the expectations and experiences of guests, positioning them as primary consumers seeking comfort, care, and an inviting atmosphere. The staff's role is prominent in ensuring customer satisfaction with the interaction and outcome quality of the service. Meanwhile, the collaboration realm delves into the symbiotic relationship between human serving staff and robots, focusing on enhancing productivity and service efficiency. Moreover, the collaboration is expected to enhance the human staff's perceived job meaningfulness and satisfaction. Lastly, the organizational realm sheds light on the strategic decisions made by restaurant managers, balancing guest satisfaction, resource optimization, and the physical layout to ensure profitability.

Transitioning to the next section, the study shift the focus to the interactions exhibited in the front stage of the restaurant, namely the Guest-Serving Staff interaction and the Serving Staff-Robot collaboration. Here, it will delve into the qualities associated with these interactions and explore how the behaviors of the actors accommodate and shape these qualities, offering valuable insights into the dynamics of the robot restaurant's hospitality experience.

Interaction & Collaboration Quality and Behavior

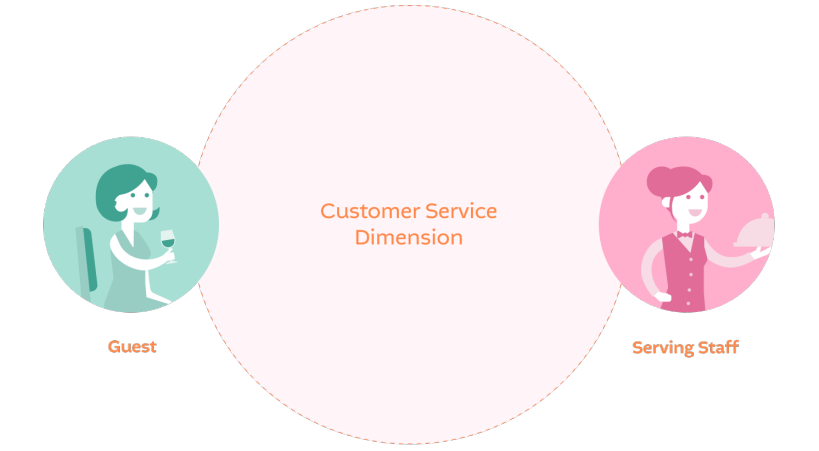
GUEST-SERVING STAFF INTERACTION

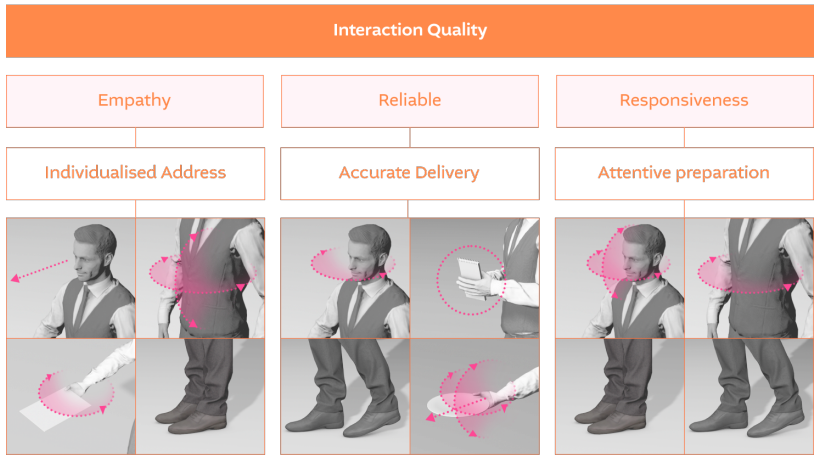
In the realm of guest-service staff interaction, a multifaceted understanding of interaction qualities and associated behaviors comes into play. The literature study introduced the three-factor model by Brady and Cronin (2001), which highlighted the three sub-determinants, responsiveness, reliability, and empathy, expressed by service encounters. It is noteworthy that the determinants were used to describe the service quality comprehensively, including interaction, outcome, and physical environment quality. Thus, delving into the expressive movement of service providers, the analysis adopts the determinants as three primary qualities to find the behaviors underpinning them.

The ethnographic data on the serving staff's behavior, 'Body journey' can be found in the Appendix.

Responsiveness: It is a key interaction quality that pertains to the service provider's willingness to assist customers promptly and effectively. To achieve this, staff must be prepared to serve customers and respond swiftly to their needs and requests. This responsiveness is conveyed through the attentive behavior of the serving staff toward the guests. Observations at the Le Début restaurant revealed that serving staff move deliberately around the dining area, gently turning their heads to scan the surroundings. Upon receiving a signal from a guest, the staff quickly adjust their orientation toward the table, adapting their pace to address the guest's request or requirement. With the movements of staff, the responsiveness is expressed throughout the service, not only addressing the guest's request at the moment but staying available to them. This behavior reassures guests that their requests are ready to be acknowledged and will be promptly attended to.

Reliability: It is another crucial interaction quality that denotes the ability to consistently and accurately deliver the promised service. It is closely linked to the dependable delivery of requested service items. During observations, serving staff demonstrated reliability not only through their careful orientation but also by effectively controlling proxemics (use of space and physical distance) and kinesics(body movements or gestures) to address guests properly. Serving staff used proxemics to approach guests' tables with the right distance and orientation, respecting guests' personal space while also being readily available for assistance. Their kinesics, including gestures and posture, conveyed attentiveness and dedication





Informed by The Three factor model (Brady and Cronin ,2001)

Figure 2.3.2
Staff's behavior accommodating the interaction qualities of customer service

to fulfilling guest needs accurately, further enhancing the reliability of their service. These non-verbal communication cues complemented the overall reliability of the guest-service staff interaction, contributing to a seamless and enjoyable dining experience.

Empathy: Lastly, empathy, the third quality, refers to the individualized attention and care extended to guests. While crucial for enhancing the hospitable experience, empathy must be expressed thoughtfully, particularly in a fine dining setting like a hotel restaurant. Here, the serving staff strikes a delicate balance, as forming overly personal connections with guests is discouraged to respect the guests' personal dining experiences. Nonetheless, guests still expect a certain level of individualized service delivered with care. Empathetic behavior in this context often takes a subtle form of being sensitive to guests' emotional and social circumstances, such as politely addressing each table member and thoughtfully orienting service items to enhance guest comfort. This nuanced approach allows for the expression of empathy while preserving the dignity of the guest's dining experience.

SERVING STAFF-ROBOT COLLABORATION

Collaboration between serving staff and robots introduces a distinct dynamic, necessitating a nuanced perspective focused on human-agent collaboration. Cila (2021) underscores the significance of 'mutual responsiveness' in this collaborative context, particularly during task execution. This dimension highlights the qualities that enable each party to respond to the actions and intentions of the other throughout the collaboration. Examining the collaborative qualities, the study delves into the behaviors exhibited by both serving staff and robots.

Autonomy and Control, Flexible Autonomy: In the observed robot restaurant setting, the robots operate at a semi-auton-

omous level. They autonomously transport dishes from the kitchen to designated spots in the dining area, with a primary focus on stable delivery through locomotion. However, human staff control is still required for (un)loading items and confirming the progression of subsequent tasks. While the autonomy of the robot enhances the efficiency of the serving process, certain limitations become apparent upon reaching the designated locations. The robot's parking movement at a service stop takes a while – slowing down, stopping, and rotating toward the staff. Experienced staff often override the robot's arrival behavior by intentionally obstructing its path by putting its foot before it. This demonstrates the need for serving staff's ability to adjust the robot's autonomy flexibly, further optimizing collaboration under their control.

Intelligibility: The intelligibility of the robot informs serving staff (but also guests) about its state and intentions, enabling staff to take appropriate actions. The robot's behaviors contribute to this intelligibility. Its asymmetrical front and back appearance, coupled with rotating movements, indicate its orientation and direction. The robot can adjust movement speed, signaling its current state. However, the robot's movements follow a limited repertoire, involving waiting at a spot, steering, temporally stopping to avoid obstacles, steering again, and returning to wait at another spot. To enhance communication of its intentions, the robot utilizes additional sensory channels, such as bottom lights and sounds. These elements collectively contribute to a more nuanced and effective collaboration between the serving staff and the robot in the dynamic restaurant environment.

In summary, the interaction and collaboration qualities exhibited in the front-stage service provision in a restaurant have been explored. Focusing on the interaction between guests and serving staff, the study emphasized the importance of responsiveness, reliability, and empathy as three core quali-

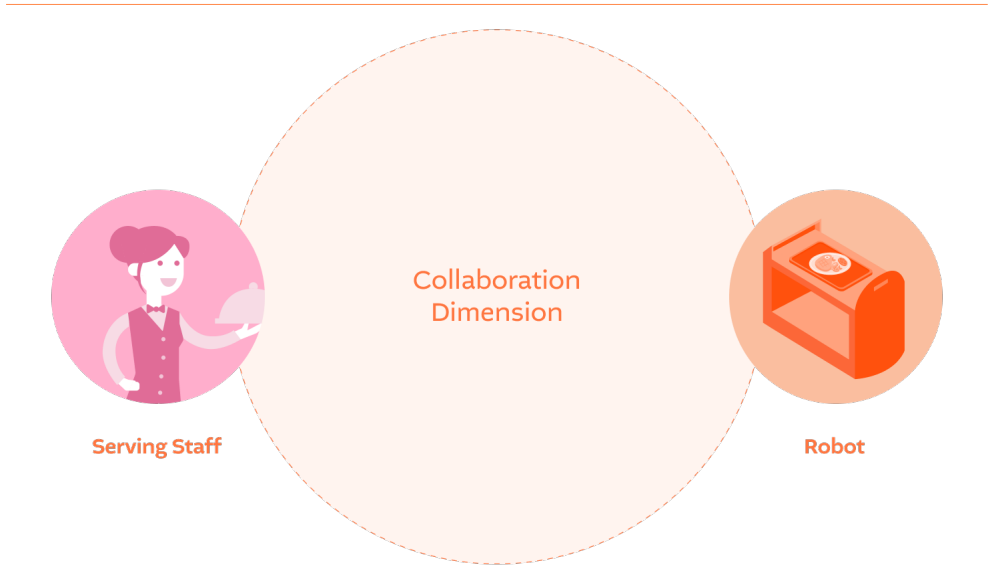


Figure 2.3.3
Staff's and the robots' behavior related to the collaboration qualities

ties. These qualities manifest in the attentive, accurate, individualized caring behaviors of the serving staff, in which the introduction of robots is expected to have an effect. Transitioning to the collaboration between serving staff and robots, the study introduced the concept of 'mutual responsiveness,' highlighting how it plays a pivotal role in task execution. It discussed the robot's autonomy, control, and flexible autonomy, noting that while robots bring efficiency to the serving process, human staff members play a crucial role in optimizing the collaboration. Additionally, the robot's intelligibility has been examined, which informs the serving staff about its state and intentions, facilitating smoother collaboration.

However, to understand the interaction and collaboration comprehensively, it is required to look at them together with the spatiotemporal arrangement. This is called Mise-en-scene, which will be analyzed in the following section.

Mise-en-scene

In this section, the study delves into the concept of Mise-en-scène, a term introduced by Bleeker and Rozendaal(2021) in the context of dramaturgy. Mise-en-scène refers to the arrangement of resources in a performance, highlighting the significance of how human and nonhuman entities are composed in time and space, thus influencing the unfolding of action. It may not be directly connected, but the 'spatiotemporal affordance' of the movement, introduced by Hoffmann and Ju(2014), also draws a notion of the spatial relationship that the movement should consider when the action is performed at the moment. For example, the authors introduce a case study of designing a Marimba-Playing Robot Head. During the process, the physical stage that the robot performs is critically concerned, including the instruments set on it, the human performers beside whom it plays, and the audience

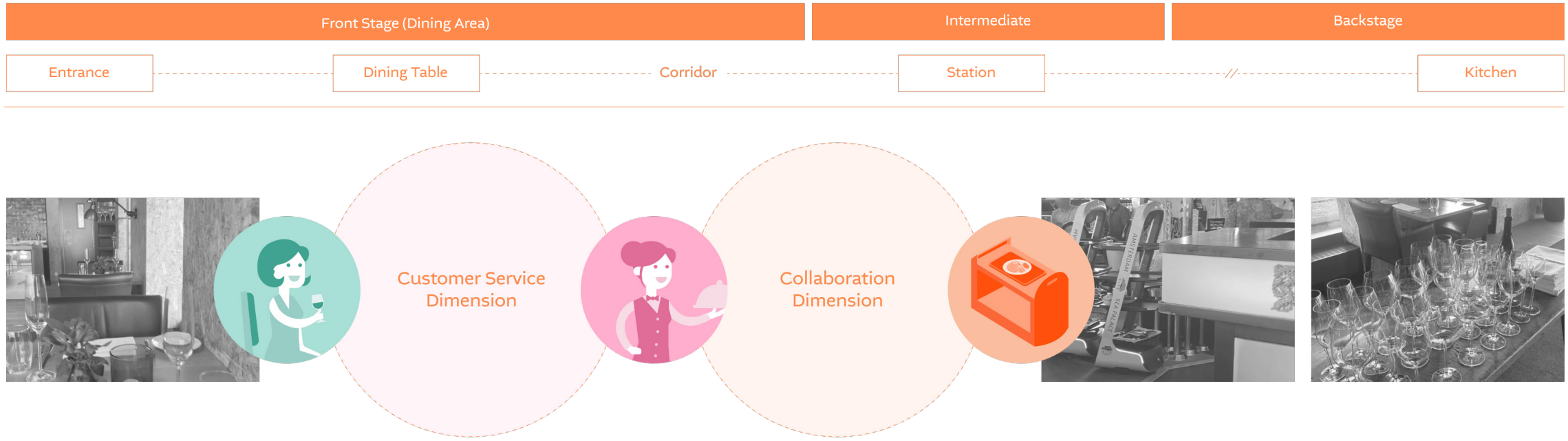


Figure 2.3.4
Overview of the physical setting of the robot Restaurant

who watches the performance. Drawing from these studies, the Mise-en-scène of the dining area is analyzed. Through the observations, two significant places, the Station and Dining table, are noted as being a stage for each realm from the previous section. Their interplay with the interaction and collaboration between the actors ultimately shapes the overall hospitality experience.

STATION

The dining area, characterized by its open structure consisting of stations, tables, and the spaces in between them, holds a pivotal role in the restaurant's dynamics. Stations, in particular, occupy a multifaceted position within this arrangement. Situated between the kitchen and the dining tables, these stations act as intermediaries between the front- and backstage areas where service items are delivered and prepared. Typically, a station comprises a long table adorned with essential service items like cutlery, glasses, menu cards, and napkins. Here, serving staff perform final quality checks on dishes, ensuring that everything is in order before they collect the necessary items alongside the dish. The strategic placement of stations within easy reach of the serving staff in the dining area optimizes their workflow. It is no coincidence that at the observed robot restaurant, the robots are strategically positioned around the station, making it a hub where service providers and items, such as cutlery, napkins, or additional glasses, etc., seamlessly come together. This is where communication and collaboration between human employees and robots take place, enhancing the effectiveness and efficiency of service delivery.

While stations primarily serve functional purposes, they are located within the dining area, in full view of the guests, contributing to the atmosphere. From their dining tables, guests can observe how both human employees and robots at the station are preparing services. Although the guests' visual perception may not directly influence interaction qualities, it is intricately linked to overall service satisfaction, including outcome and physical setting qualities. For instance, guests who witnessed a well-coordinated team of human staff and robots may expect shorter waiting times for service. Conversely, if a guest observes an idle robot without active engagement with staff, their expectations for efficient service may diminish, and they might even become skeptical about food quality, perceiving it as abandoned without responsible personnel nearby. If not well-managed, it might convey a message of inadequate hygiene. It is also related to the quality of the physical setting, as its appearance is appreciated whether it fits the ambiance of the restaurant. For instance, a participant noted the too-modern appearance of the robot in the Chinese restaurant, which does not fit the overall interior of the restaurant, overshadowing the dining atmosphere. Thus, the visual representation of collaboration between serving staff and robots at the station significantly influences guests' outcomes and physical setting quality of service satisfaction.

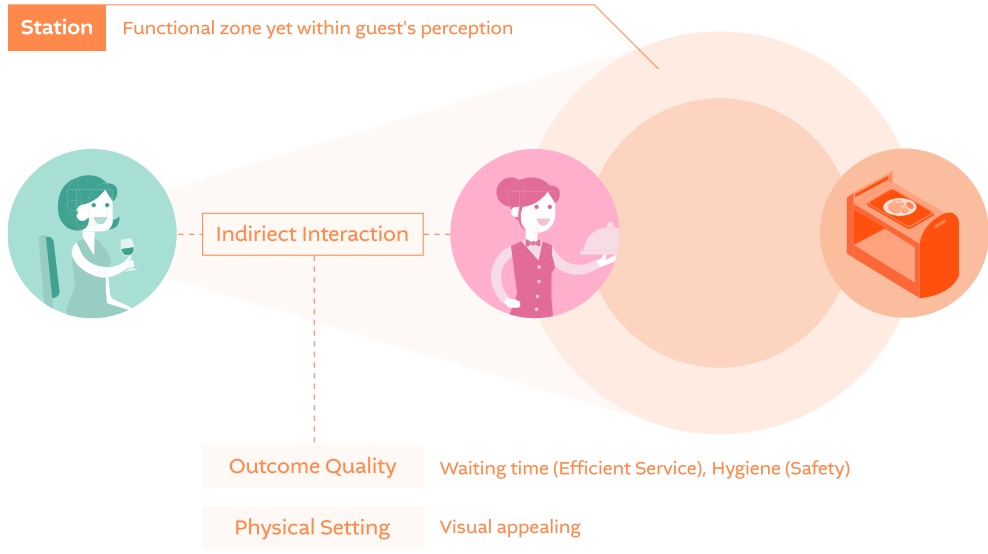


Figure 2.3.5
The interaction dynamics at the station

DINING TABLE

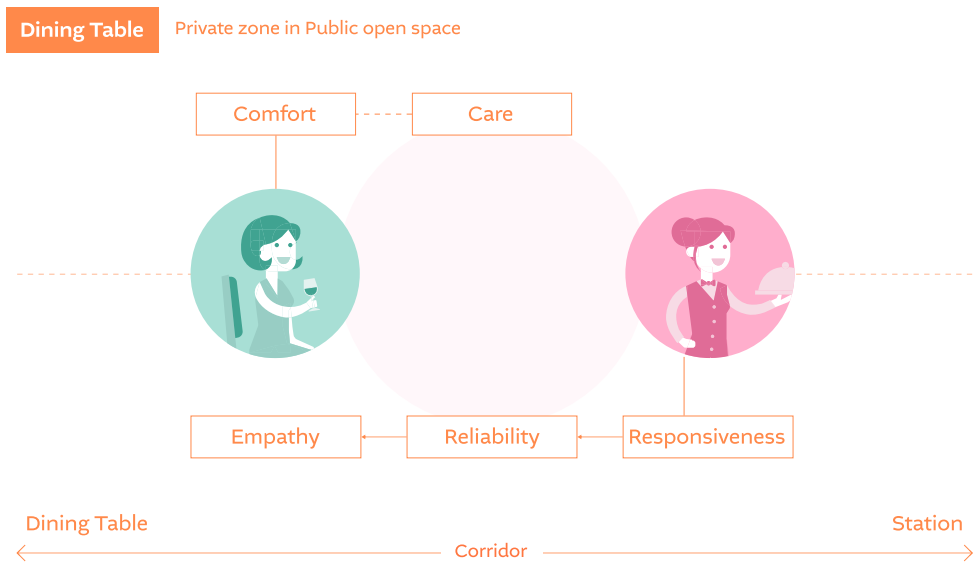
The dining table holds a central role in the guests' dining experience as it is where they spend the majority of their time. Despite the open and unpartitioned structure of the dining area, each table and its seating arrangement are designed to provide a degree of privacy to the guests. Tables are spaced at intervals, allowing both guests and staff to move comfortably while maintaining a sense of personal space. The arrangement of seats, typically facing one another, optimizes the guests' direct interaction with each other, facilitating an environment where they can focus on their dining experience. Within this private dining space, guests engage in direct interactions with the serving staff. While the front view from their seats emphasizes personal space, the side view connects them to the common dining area.

Guests may signal for assistance by turning to the side and making eye contact with nearby serving staff. Serving staff visit the tables to take orders, deliver service items, and address any needs the guests may have. These interactions primarily occur at the side of the table, allowing the staff to maintain an appropriate distance while serving each member of the party. The unique characteristics of the dining table as a private zone within an open service space align with the previously mentioned hospitality values. While "inviting" serves as the overarching value guiding the general behavior of service providers and their interactions with guests, "comfort" and "care" are nuanced and carefully balanced within the dining area. These values are not necessarily mutually exclusive; rather, they are incorporated into the nuanced behavior of the serving staff. For instance, the caring behavior of the serving staff around the dining table is crucial for expressing empathy, servitude, and acknowledgment. However, staff must also consider the personal "comfort" of the guests at the table and avoid disrupting their experience. This concept aligns with what Le Debut instructors described as a "silent, frequent visit" – an important behavior in fine dining settings. Instead of engaging in excessive conversation at the dining table, being quietly present around the table from time to time communicates care for the guests while respecting their comfort.

Furthermore, the interaction qualities are closely related to the distance between guests and serving staff. "Responsiveness" is expressed from a moderate distance, signaling the staff's readiness to provide service in a non-intrusive manner. "Reliability" often comes into play as the staff with service items approaches the guest, ensuring accurate and dependable service delivery. Finally, "empathy" requires closer proximity, allowing for the expression of individualized care and addressing the specific needs of the guests. The dining table serves as a focal point where these interaction qualities come into play, enriching the overall hospitality experience.

Moreover, when considering the Mise-en-scène of the dining area, it becomes evident that social factors are at play, influencing the guests' perceptions and evaluations. According

Figure 2.3.6
The interaction dynamics at the dining table



to Choi et al. (2019), referencing the CASA (Computers Are Social Actors) paradigm by Reeves and Nass (1996), guests are likely to evaluate the performance of the robot based on pre-established social norms. This evaluation is particularly critical in an upscale hotel restaurant, where guests expect a luxurious and refined experience. While the observations at the robot restaurant provided valuable insights, it is reasonable to assume that service providers' performance, including both human staff and robots, will be assessed with higher standards in upscale establishments. Whether pragmatic or emotional, the behaviors exhibited in the dining area should make the belief that the service provider is dedicated to maintaining the highest standards of hospitality for the guests. The social context, as implied by the Mise-en-scène, plays a crucial role in shaping the overall dining experience and influencing guests' perceptions of the service quality in the hotel restaurant setting.

In conclusion, the concept of Mise-en-scène offers a valuable lens through which to examine the intricate dynamics of a restaurant's physical setting and its profound impact on the interaction, collaboration, and overall hospitality experience. The station, strategically positioned as a hub of communication and collaboration between human staff and robots, not only serves functional purposes but also significantly influences the outcome quality of guest satisfaction through visual cues. Likewise, the dining table, designed to provide both personal space and direct interaction, plays a pivotal role in expressing hospitality values such as "comfort" and "care." The distance between guests and serving staff at the table dynamically shapes the interaction qualities, enriching the overall dining experience. Furthermore, the social context embedded in the Mise-en-scène, including guests' perceptions, expectations, and evaluations, cannot be underestimated, especially in upscale hotel restaurant settings where refined experiences are paramount.

Conclusion for Defining Phase

The comprehensive review of existing literature has shed light on crucial facets of Human-Robot Interaction (HRI) in the context of hospitality settings, emphasizing the importance of understanding this interaction as a multifaceted relationship among actors. Models for measuring service quality perception, expressive movements of service robots, and performative approaches have surfaced as essential elements warranting further investigation. However, identified gaps in research, particularly regarding the varying significance of interaction qualities in different service encounters and the lack of emphasis on staff perspectives interacting with robots, highlight areas necessitating deeper exploration. The ongoing ethnographic study, conducted across two diverse restaurants in Amsterdam, endeavors to bridge these gaps. Through observations and interviews involving guests, staff, instructors, and managers, The study inspected the holistic journey within these settings, focusing on non-verbal communication, contextual influences, and the impact of robot deployment. Moreover, the dramaturgical analysis in the 'Scene of Robot Restaurant' section unravels the intricate dynamics among consumers, service providers, and organizational decisions across different dimensions. This exploration into interaction qualities and the role of Mise-en-scène enriches the understanding of how robot movements, staff behaviors, and physical settings converge to shape the overall hospitality experience, including multiple perspectives.

With a nuanced understanding of the hotel restaurant setting and underlying guest dining and staff collaboration experience, the study transitions to the ideation phase to generate creative design interventions.

3 Ideation Phase

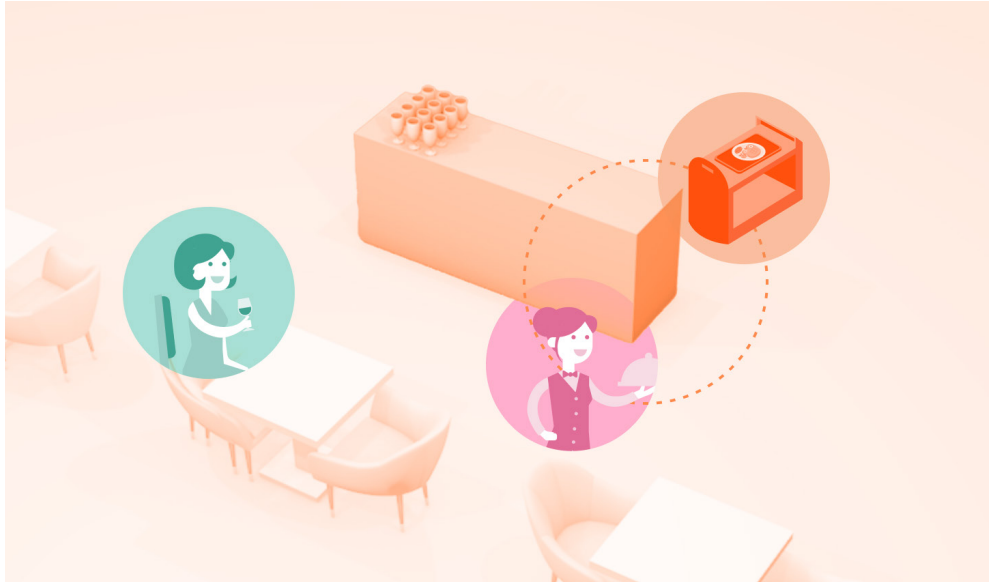
Building upon the insights from the defining phase, the study ideates design interventions for the robot's movement for the hotel restaurant. It first frames the scene of the robot restaurant to define the entry points for the interventions with research questions. Employing the performative and participatory approach, enactment sessions explore the speculative scenario to find the proper robot's movement, affording the interaction/collaboration qualities in the context. The insights from the sessions converge into the design concepts.

3.1 Framing

In the previous phase, a comprehensive analysis was undertaken exploring the interactions, collaborations, and intricate interplay of the Mise-en-scene of the hotel restaurant's environment. As the study moves forward into the ideation phase aimed at designing the service robot's movement, it will focus on three distinct scenes: around the station, in between the station and table, and at the dining table. Each of these scenes presents a frame scoping unique challenges and opportunities.

Figure 3.1.1 Scene 1: Collaborating Serving Staff and Robot around the Station

Scene 1: Collaborating Serving Staff and Robot around the Station

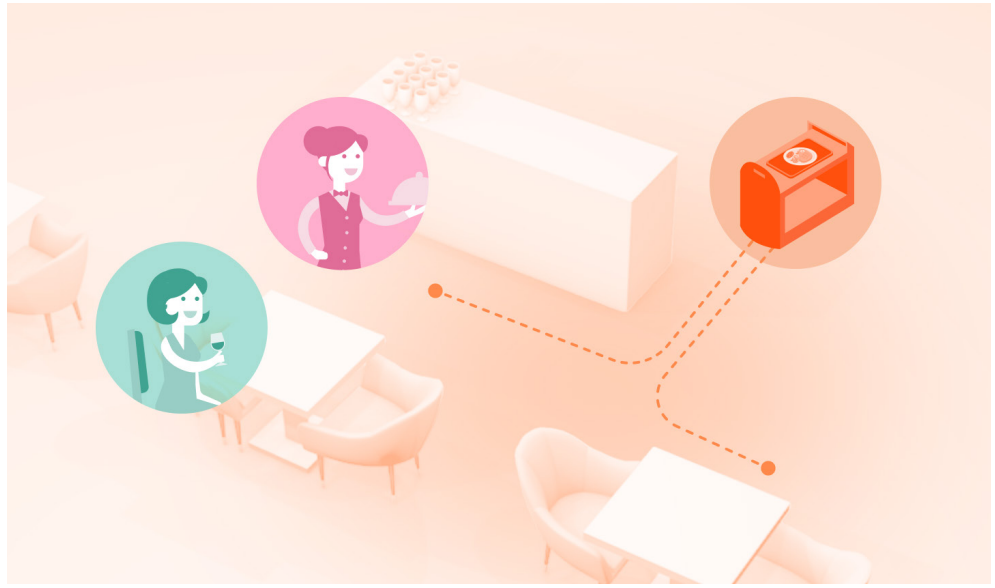


How might the robot's performance at the station enhance the seamless workflow with collaborating serving staff, yet remain acceptable to guests in terms of outcome quality (waiting time, hygiene) while adhering to the social norms implied by the physical setting?

Insights from the previous analysis suggest that the station is a critical hub where human staff and robots collaborate to optimize service delivery. Guests' visual perceptions of this collaboration significantly influence their expectations of and satisfaction with the service. Therefore, the robot's movements should be designed to align with the seamless workflow of human staff while ensuring that it contributes positively to the overall outcome quality as perceived by guests. Also, the movement should be aligned with the physical setting, implying certain social norms which must be respected. This scene explores how the robot can effectively collaborate with the staff to ensure guests' perceived outcome quality in an appropriate manner.

Figure 3.1.2 Scene 2: Robot's presence in between the Station and Table

Scene 2: Robot's presence in between the Station and Table



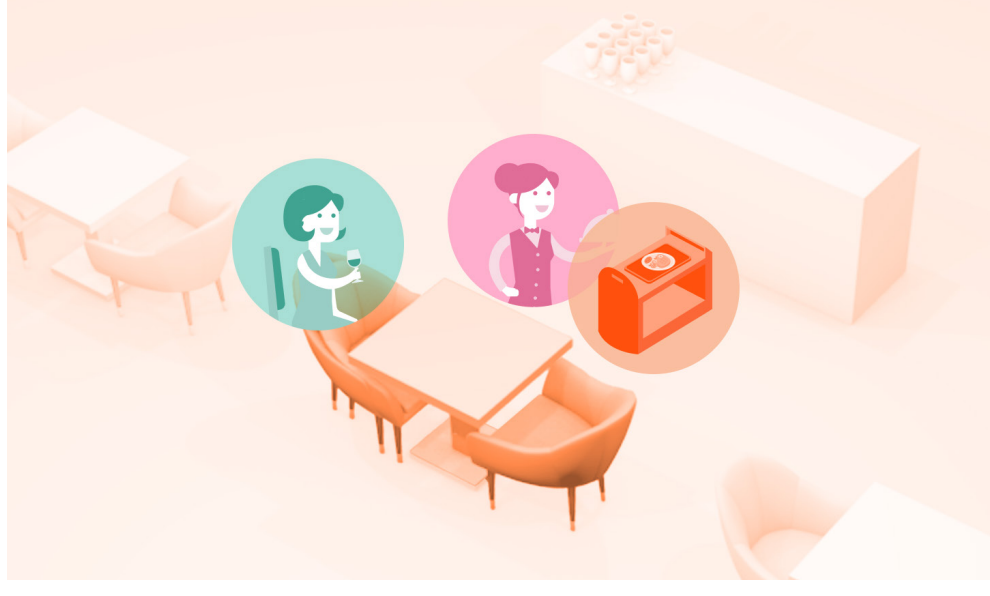
How can the robot's movements in the transitional space between the station and dining table enhance 'responsiveness' while maintaining a delicate balance between the values of 'comfort' and 'care' for guests?

In the transitional space between the station and the dining

table, the robot's movements hold the potential to impact the guest experience significantly. As emphasized by participants from the ethnography, the presence of the service provider in this area is vital to ensure responsive and reliable service for guests. Thus, the robot's movements here should be designed to contribute to the attentive service provision process so that guests perceive the actions as reliable and their needs will be met without delay. However, achieving this while upholding the values of 'comfort' and 'care' is a delicate task. The robot's movements must convey availability and attentiveness without overwhelming or intruding upon guests' personal space. Striking the right balance between these values is essential for creating a guest-centric environment that enhances overall satisfaction. It frames a scene to explore how the robot's movements in this transitional zone can achieve the desired level of 'responsiveness,' ensuring both 'comfort' and 'care' are upheld throughout the dining experience.

In the transitional space between the station and the dining table, the robot's movements hold the potential to impact the guest experience significantly. As emphasized by participants from the ethnography, the presence of the service provider in this area is vital to ensure responsive and reliable service for guests. Thus, the robot's movements here should be designed to contribute to the attentive service provision process so that guests perceive the actions as reliable and their needs will be met without delay. However, achieving this while upholding the values of 'comfort' and 'care' is a delicate task. The robot's movements must convey availability and attentiveness without overwhelming or intruding upon guests' personal space. Striking the right balance between these values is essential for creating a guest-centric environment that enhances overall satisfaction. It frames a scene to explore how the robot's movements in this transitional zone can achieve the desired level of 'responsiveness,' ensuring both 'comfort' and 'care' are upheld throughout the dining experience.

Scene 3: Co-serving Staff and Robot at the Dining Table



How can collaborative movements between the robot and serving staff at the dining table enhance the qualities of reliability and empathy in guest interactions, fostering a sense of trust and individualized care?

Figure 3.1.3 Scene 3: Co-serving Staff and Robot at the Dining Table

In this scene, the focus shifts to the interactions occurring directly at the dining table, where guests engage with both the robot and serving staff. While Scene 1 primarily explored collaboration around the station, this scene delves into a more intimate setting. The movements of the robot and staff should not be seen as isolated actions but as part of a co-performance aimed at delivering exceptional service. The co-performance should embody the qualities of reliability and empathy, ensuring that service is not only dependable but also deeply attuned to the individual needs and preferences of the guests. Collaborative behaviors between the robot and staff should be explored, considering its seamless integration with a sense of trustworthiness and personalized care.

These three scenes, along with the research questions, pro-

vide a comprehensive framework for exploring the impact of robot movement on the guest and employee experience in the hotel restaurant setting. They are used as entry points for the following enactment session for participants to engage in speculative scenarios and reflect on the potential benefits and challenges of the robot's movements in the restaurant.

3.2 Speculative Enactment

Objectives

Designing the robot's movement with its nuanced communicative capability in mind can be more of an art than a science (Hoffman & Ju, 2014). The authors suggest the participatory approach, working with people with their knowledge or intuition about how the robots should perform in the restaurant. The notion of the artistic approach and involving people is aligned with how dramaturgy informs the design of smart objects(Bleeker & Rozendaal, 2021). The performative approach allows designing a robot's behavior with relational thinking, taking into account the impacts it will bring on the other actors in the environment.

The speculative enactment aims to design the performativity of the robot rather than a sole product, where participants can engage in speculation and experience its consequences (Elsden et al., 2017). With the participant's knowledge embodied in their movement and insights from the collective reflection, the goal is to collaboratively envision the potential movements of the robot in the hotel restaurant setting.

Methods

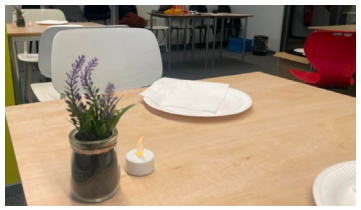
SPECULATIVE PROTOTYPE

Simple, low-tech prototypes of the robot and restaurant setting are designed for the participants to engage in the speculative scenario. The prototype robot made of cardboard has a simplified appearance following the physical dimension of Rober. It is designed to be wearable and moveable by the

participants so that they can speculate the movement of the robot by 'being a robot' (Dörrenbächer et al., 2020).

The prototype restaurant has also been set with a similar layout to the real environment. It consists of the tables representing the station and the dining tables in the restaurant. They are decorated with props like paper plates, glasses, and napkins. While giving a sense of realism, the prototypes are intended to help the participants imagine the experience in the fine-dining restaurant with the service robot.

Figure 3.2.1
Speculative
Prototype



PARTICIPANT RECRUITMENT

Student participants are recruited internally from IDE faculty in TU Delft. The recruitment considers their experience as service providers or guests in the restaurant. Additionally, two participants are involved, considering their performative art background (Acting or Cinematography). In total, 9 participants are selected and distributed in two groups and invited to a session on a separate day. Each group has a diversity of the participant's background experience and gender.

DURATION

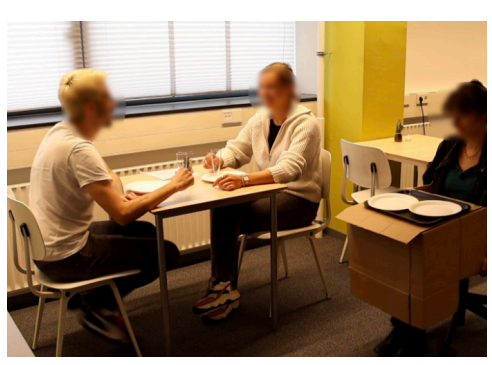
The participants are given the sensitizing questionnaire 3 days prior to the session. The questionnaire consists of open

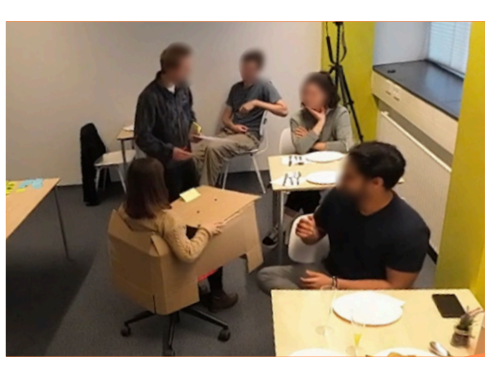
questions asking about their previous experience in the fine dining restaurant. Each session takes 150 minutes, including the actual enactment and the collective reflection.

SPECULATIVE ENACTMENT AND REFLECTION

After the introduction, the participants enact the situations of the robot restaurant, using the framed scenarios as starting points. Each participant plays the role of guest, employee, and robot and interacts with each other. The robot performer is asked not to use verbal expressions during the enactment. After the enactment, the participants reflect on the previous performance and share their experiences. A collective decision is made to develop further the scenarios in the next enactment. The iterative process of the enactment and reflection continues for the three scenarios. The session is concluded with a plenary discussion, envisioning the robot's movement and required capabilities to achieve the desired changes.

Figure 3.2.2
Speculative
Enactment





The whole session is video and audio recorded to capture the participant's enactment and reflections. The collected data are reviewed and clustered based on the framing and associated concepts about the guest and employee experience. Also, the enacted robot's movement is analyzed by parameters such as speed, position, and orientation. The insights feed the following conceptualization by finding the relation between the movement and the experiential qualities.

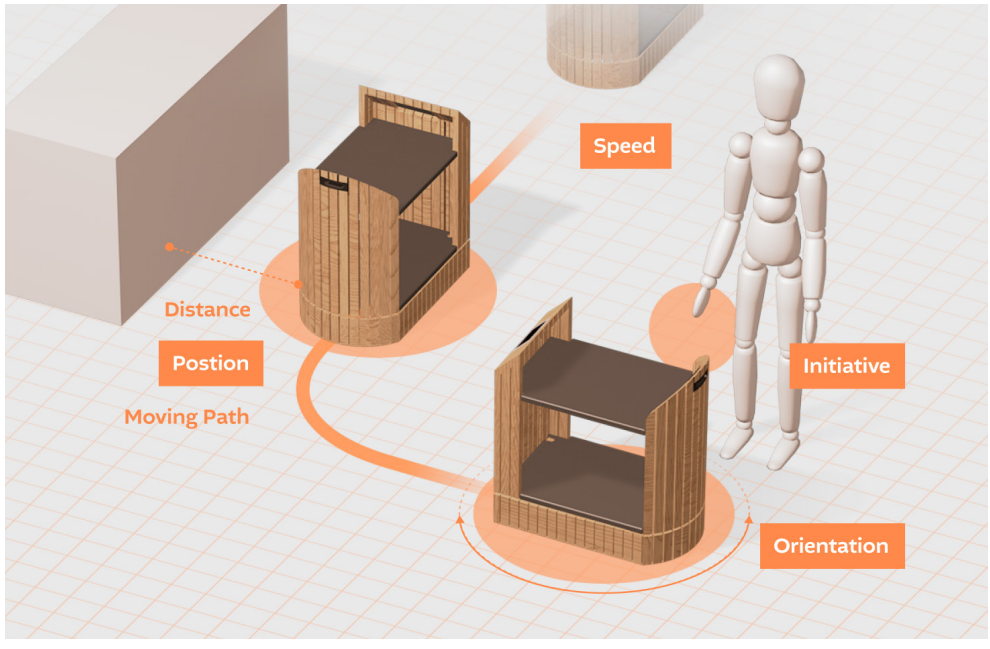
3.3 Conceptualization

The conceptualization phase of the study involves analyzing the data collected from the participant sessions and identifying key movement qualities related to the guest and employee experience in the fine-dining restaurant with robot service. The insights converge to generate design concepts that address the desired changes that the robot's behavior can bring.

Movement Parameters and Implications

Movement parameters, such as position, speed, orientation, and initiatives, were identified by analyzing the enacted scenes Figure 3.3.1. The parameters determining the robot's movement had significant implications on the guest and employee experience.

Figure 3.3.1
The movement parameter



Position: The robot's position was related to where it made its presence along the moving path in the restaurant environment and its proximity to guests and employees. Positioning the robot strategically throughout the restaurant enhanced guest interaction and provided efficient service to employees.

> *"I need to be aware of where I can find a robot"*
> *"It is too much to take care of both the robot and the guest at the same time"*
> **participants enacting staff**

These statements highlight the importance of the robot's position in managing employee workload while collaborating with it. Thus, the robot's path from the kitchen to the dining area and where it stops could enhance the intelligibility of the robot and improve the efficiency of service-providing tasks.

> *"I do not want to get disturbed by the robot coming closer to me."*
> *"When I know where the robot is present, I feel more comfortable and safe."*
> *"I can be more careful not to disturb the robot."*
> **participants enacting guest**

These statements emphasized the impact of the robot's position on the guest's comfort and perception of safety. The robot's position should be strategically located to avoid causing discomfort or disruption to the guests while also ensuring that it is easily visible and predictable for them to decide how to interact with or avoid the robot as needed.

Figure 3.3.2
The robot enacted positioning directly and closely to a guest

Additionally, when the employee and the robot served a table together, it was important to set the robot's position in relation to the employee. Depending on who stood closer to the table, the interaction

between the guest and the service provider team could vary. It was common to hear the participants mention that when the human employee was positioned closer to the guest, they felt more comfortable and at ease, as they had a familiar and human presence attending to their needs.

Orientation: The robot's orientation refers to the direction it faces or its alignment in relation to guests and employees. The robot's orientation played a crucial role in facilitating effective communication and appropriate engagement with guests and employees.

> *"The robot following me feels like a pet that supports me."*
> *"I can already know it is coming towards me, so I can prepare for interaction."*
> **participants enacting staff**

These statements highlight the importance of the robot's orientation in establishing a sense of support and predictability for employees. The robot should be oriented in a way that allows employees to easily anticipate its movements and interact with it more effectively.

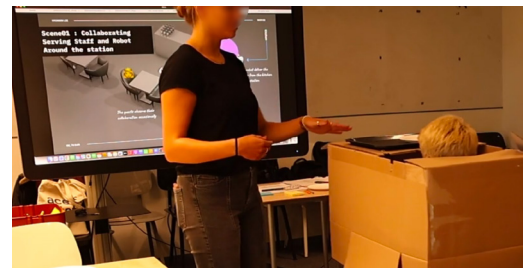
> *"I like the robot seems like saying hi to me"*
> *"It is confusing when the robot directs toward me. Should I do something or not?"*
> *"I could pick up the dishes myself, but should I?"*
> **participants enacting guests**

These statements emphasize the impact of the robot's orientation on guest perceptions and interactions. On the one hand, the robot facing the guest created a friendly and approachable atmosphere. On the other hand, guests felt uncertain about how to respond or engage with the robot. Furthermore, some guests experienced the movement as inappropriate, feeling forced to serve themselves.

Speed: The speed at which the robot moves had implications for both the guest and employee experience. The speed of the robot's movements should be carefully considered to balance efficiency with guest and employee comfort. Even though the participants have not explicitly mentioned the robot's speed, the enactments hint at the importance of a moderate and controlled speed for both guests and employees. The participants who enacted the robot controlled the speed depending on the situation and task, such as slower speeds around the dining area to avoid collisions or faster speeds when leaving to maximize efficiency. The guest participants were sensitive to the robot's speed, as they mentioned not wanting to be disturbed by a robot moving too quickly.

Initiative: Even though it may not be a movement parameter itself, how the movement parameters are initiated can greatly impact the guest and employee experience. It is related to the level of the robot's autonomy and human control. In general, the automated navigation and food delivery of the robot were appreciated by both guests and employees as they added efficiency and convenience to the restaurant experience. The participants who enacted the robot sensed the state of dining and serving and initiated the movement. For example, when the staff was busy with other tasks, the enacted robot waited at the side until the staff member was available. Also, when the dishes were unloaded from it, the robot left the location automatically to enhance the workflow and let guests enjoy their dining.

Figure 3.3.3 The enacted staff stopping the robot with a hand gesture



Some situations emerge where the robot's movement is desired to be more controlled by the staff. For example, some participants who acted as staff attempted to stop the robot when it seemed to be moving inappropriately. Using their hand

gestures gently, they adjusted the robot's autonomous movement according to their needs and the specific situation.

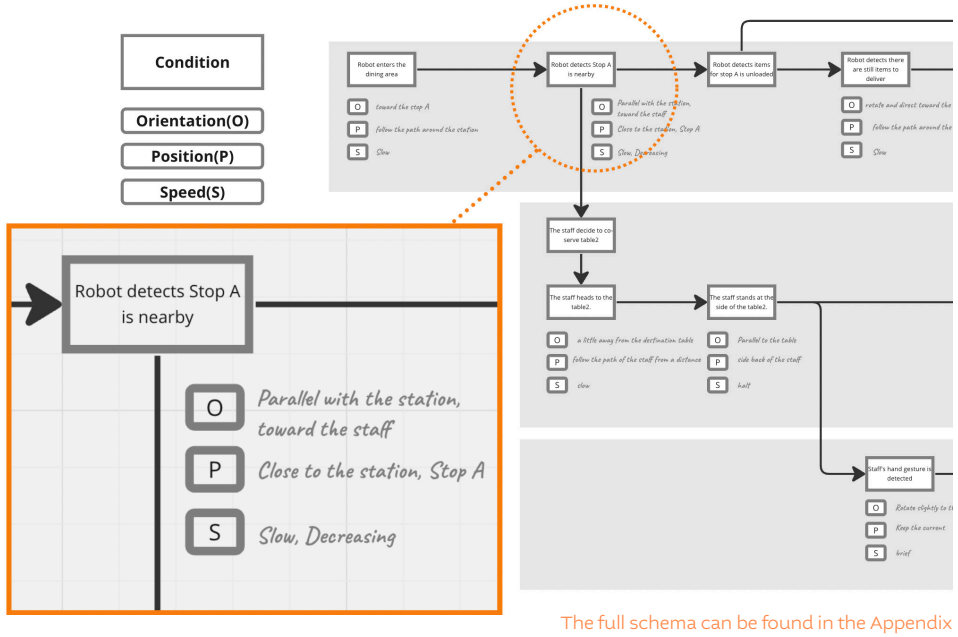
> *"It felt like a theater to watch their performance. Something more than just a dining."*
> participants enacting guests

Interestingly, the guest participants perceived the collaborative movement as entertainment. They saw it as a unique and engaging experience that goes beyond just dining, adding an element of theater and excitement to their visit.

Design Concepts

The parameters, together with position, speed, orientation, and initiative, get the ingredients to design the robot's movement. As the movement should be described by the changing states over time, it is important to consider how the parameters alter and what triggers the transition. Figure 3.3.4 shows how the robot's dynamic can be illustrated with the variables;

Figure 3.3.4
The robot's movement described with a sequence of changing parameters

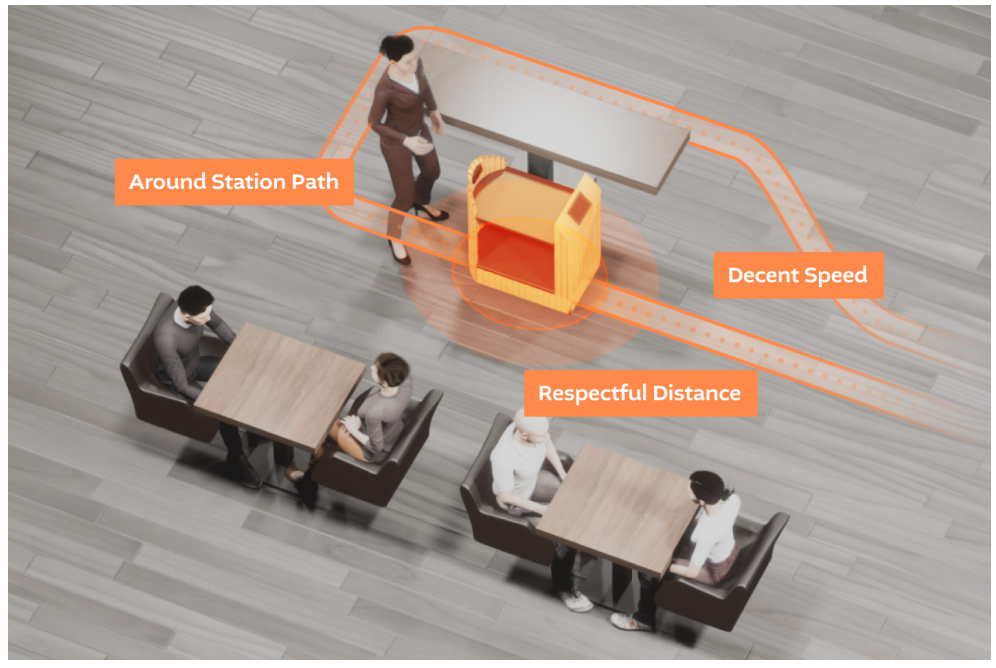


The full schema can be found in the Appendix

the initiative becomes a condition to make the movement, changing the position, seed, and orientation of the robot. However, its implication to the experience is not made by a piece of gesture but by a narrative where the changes are arranged and connected. Thus, the robot's movements are designed as sequences incorporating not only the physical changes but also the desired changes they bring to the guest and employee experience.Each concept is introduced with the designed movement of the robot and desired changes in the guest and employee experience.

Concept 1: Robot-zone

Figure 3.3.5
Concept 1: Robot-zone



The Robot Zone is a designated area within the restaurant where the robot autonomously carries dishes. This zone concept consists of the robot's path, stops, and the robot's responsive movement. Most parts of the path are a one-directional loop connecting the kitchen and the station. Stops

are strategically located around the station, ensuring close access to the tables that require service. These stops are positioned before any corners in the path, allowing for smooth navigation. The robot's speed changes based on its location within the zone, reducing speed as it enters the dining area and halting at stops. It automatically steers following the path to collaborate with the staff and leaves the dining area when the tray is empty.

DESIRED CHANGES FOR GUESTS

Comfortable dining: Setting the zone from a distance from the dining table and closer to the station would keep the guest away from the functional preparation of the service provider. The path around the physical structure could make the robot's presence harmonious with the restaurant environment. Also, the robot's movement speed reduces when it enters the dining area so that the guests can enjoy their meals without feeling intruded upon by the robot's movements.

Perceived Efficiency: Guests would appreciate the efficiency implied by the robot's autonomous departure from the dining area. An idle robot lingering around the dining area could lead to concerns about service efficiency. Thus, when the robot autonomously leaves after completing its task, guests would be reassured that their dining experience is well-organized, leading to a more positive perception of the restaurant's service quality.

Safety and Predictability: The predefined path of the robot could add a sense of safety and predictability for guests. They could navigate the restaurant with confidence, knowing the robot's movements and avoiding any potential interactions. This could contribute to a more relaxed and enjoyable dining experience.

DESIRED CHANGES FOR STAFF

Enhanced Awareness: By having a certain area with a predefined path and stops, the robot could communicate its intention by its position and moving direction. The stops where the robot is present get to a committed place to collaborate with human staff, indicating who the responsible human partner is. For example, the robot approaching 'stop A' could communicate that the staff who is in charge of the tables around it should come and prepare the serving. When it moves to 'stop B,' the other server responsible for an opposite area could be aware of the upcoming tasks. This clarity in communication and role allocation could enhance the efficiency of the serving staff's work. The participants who enacted staff emphasized certain positions that they could expect to encounter with the robot so that they could keep the natural workflow between the station and the dining table.

Optimized Workflow: The loop path around the station would be well-aligned with the staff's service preparation, so the additional items to be served could be arranged easily. Also, the one-directional robot's movement could prevent redundant presence and interference from it. Setting the stops before the corner could reduce the delay in the collaboration.

More attention to Guests: The Robot Zone could allow the serving staff to provide guest-centric service. The robot's considerate presence and autonomous leaving let staff focus on ensuring the guests' needs promptly and avoid unnecessary interruptions.

Concept 2: Side(back)-kick Robot

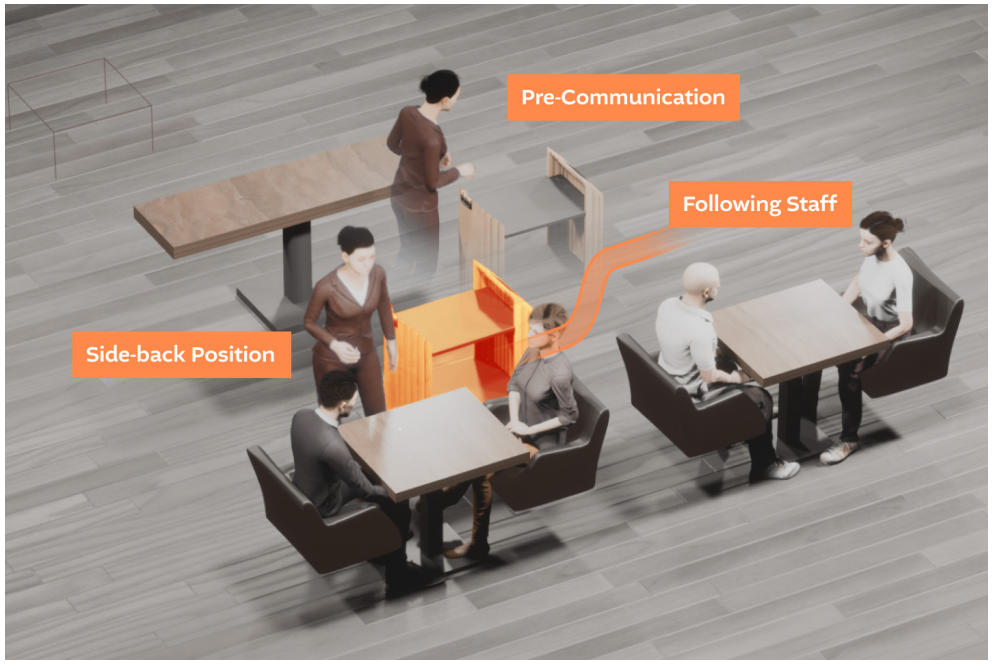


Figure 3.3.6
Concept 2:
Side(back)-kick
Robot

The Side(back)Kick concept envisions the robot as an active sidekick to human serving staff. When there are multiple dishes to be served simultaneously, the serving staff member and robot engage in pre-communication in a designated robot zone to confirm the destination and serving items. The serving staff member first approaches the dining table and initiates the conversation with the guest. While the staff interacts with the guests, the robot approaches the table slowly and positions itself at the side-back of the staff. Instead of orienting the guest directly, it adjusts its direction to be parallel to the guest's sitting. Once the staff unloads all the items from the tray, the robot slowly leaves and returns to the robot zone.

DESIRED CHANGES FOR GUESTS

Served by a human: Guests would typically prefer a human staff member to take responsibility for delivering a sophisticated dining service. They could expect a level of expertise and personalized service that only a human can provide. The robot moving behind the staff would make it clear that the guests are being cared for by reliable human staff.

Role identification: The robot's orientation could be directed towards the staff, not the guests. This would prevent the misunderstanding that the robot is the main service provider with whom the guest should interact directly. Instead, it could indicate the robot's role as a smart sidekick that complements the human staff to provide prompt and reliable service.

Respectful service: The silent and unobtrusive approach and departure of the robot would further demonstrate respect for the guest's comfort. The robot could take a natural path to return to the Robo-zone to avoid distractive movements, such as loud turning back. This would ensure that guests can enjoy their meals in a relaxed and undisturbed setting.

DESIRED CHANGES FOR STAFF

Control and Coordination: The preliminary communication in the robot zone would ensure that the staff and robot are on the same page before approaching the dining table. This control and coordination could enhance the staff's confidence in providing seamless service and contribute to a more organized workflow.

Supporting, not overtaking: The robot following and standing back from the staff could allow enough room for the human staff to perform its expertise to serve the guests. It takes a position to support the staff nearby but not intrude on the staff addressing the guests. It could positively affect the staff's job satisfaction that they are still in charge of the service. It highlights the staff's role to engage with guests on a personal level and makes the job more meaningful and rewarding for the serving staff.

Concept 3: Magic hand

Figure 3.3.7
Concept 3:
Magic hand

The robot is capable of reacting to the gestures made by human staff. This interaction is orchestrated like a choreography, creating an elegant and engaging display of collaboration between the staff and the robot. Staff members use gestures to influence the robot's movements. For instance, a staff member can gently hold their hand in front of the robot to signal it to stop its movement. Staff gestures can also trigger more advanced behaviors. A staff member can introduce the robot with an open-arm gesture, and the robot responds by slightly changing its orientation as if it were greeting the guests.

DESIRED CHANGES FOR GUESTS

Elegant gesture: In a fine dining environment, even functional movements should be executed with nuance and precision to maintain the desired ambiance. Even before the guests receive their meals, they would be highly attuned to how service providers behave during the preparation stage. The refined and professional gestures of the staff interacting with the robot could positively influence the guest's perception of the service.

Enhanced Trust: By witnessing the robot's responsiveness to the refined gestures of the staff, guests could develop a deeper trust in the service provided together with the robot. This would assure guests that their dining experience is in capable hands, where every detail is being cared for.

Delightful Experience: While fine dining typically discourages gimmicky behaviors, these subtle interactions could add a layer of sophistication and intrigue for the guests. It could transform the act of receiving service into a captivating performance, where the guests become part of an engaging narrative. This element of surprise, executed with finesse, might leave a delightful impression and contribute to the overall satisfaction and memorable dining experience.

DESIRED CHANGES FOR STAFF

Enhanced Professionalism: The use of choreographed gestures could add an element of sophistication to their interactions with the robot, reflecting well on their professionalism and dedication to providing exceptional service. It could encourage staff to perform their duties with heightened professionalism.

Empowerment: By giving the staff the ability to influence the robot's behavior through gestures, they could feel empowered. This empowerment might lead to a sense of ownership over the service process and a feeling of control in serving the guests.

Conclusion for Ideation Phase

During the Ideation phase, the project delved deep into conceptualizing the dynamics of non-anthropomorphic robots in a hotel restaurant setting. Building upon the insights from the defining phase, the scenes were framed where the robot's movement got critical to the guests' and staff's experience. Through speculative enactments informed by a performative approach, it explored various movement parameters and their implications on both the guest and staff experience. Compositing the parameters as comprehensive sequences, it derived a set of movement concepts for the service robots: Robot-zone, Side(back)-Kick, and Magic hand. This process illuminated the subtle yet crucial aspects of human-robot interaction – the need for robots to exhibit movements that are fluid and intuitive yet non-intrusive and in harmony with the restaurant's ambiance. Additionally, it is anticipated that the robot's well-coordinated movements could significantly enhance staff productivity and job perception, thereby enhancing overall customer satisfaction. Moving into the Evaluation phase, the focus will shift to empirically testing these movement concepts in real-world restaurant settings. The evaluation is not only to assess the validity of the design concepts but also to deepen the understanding of the nuanced interplay between robots and humans in a hospitality context.

4 Evaluation Phase

In the Evaluation, the study aims to comprehensively assess the impact of the robot's movement, engaging multiple actors such as guests, employees, and restaurant managers in a real-world hotel restaurant setting. This phase is not just about validating the design concepts with potential end-users but also co-exploring with them to deepen the understanding of the implications of these movements. To facilitate effective empirical exploration, the study will adopt Extended Reality (XR) technology. This approach allows extracting multifaceted insights from customer, staff, and organizational perspectives, bringing insights into the most desirable values expected for the service robots in the hotel restaurant setting.

4.1 Extended Reality Experiment

Objectives

The study has deepened the exploration based on the research question: “What kind of interaction/collaboration qualities should the movement of robots accommodate regarding the dining/serving experience in hotel restaurants?”

The approach, grounded in a performative design framework, focuses on understanding the ecological impacts of the robot’s behavior on the complex dynamics of a hotel restaurant. The evaluation extends beyond assessing individual features and aims to generate the situated knowledge of how these robotic interventions can be seamlessly integrated, both technically and socially, into the unique setting of the hotel restaurant.

Methods

EXTENDED REALITY (XR) PROTOTYPE

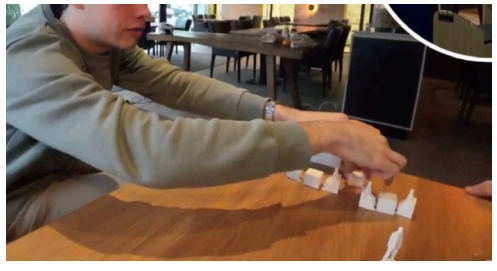
In the study, Extended Reality(XR) technology is employed as a pivotal methodological tool, following the experiential approach outlined by Rozendaal et al. (2023) for understanding emergent human-robot interactions (HRI) in situated encounters. XR is expected to offer a research environment enabling the realistic simulation of human-robot encounters in a hotel restaurant setting, facilitating a deeper exploration of potential interaction dynamics.

To facilitate the experiment practically, the movement design concepts from the ideation phase translate into two scenarios, allowing empirical assessment of the impact of the robot’s movement on the multi-dimensional perspectives. For Scenario 1, most features from Robot-zone and a functional movement from Magic Hand are incorporated to create a scene with minimal robot presence. Scenario 2 is expanded with Side(back)-Kick’s movements and an engaging choreography from Magic Hand, creating a situation where the robot is more visible and active. The two scenarios are further developed in the XR environment with Unreal Engine software and Meta Quest 3 hardware. The real-time interactiveness is limited at this stage for rapid prototyping; however, participants can immerse themselves in scenes where they can experience the virtual robot’s movement along with the staff’s service provision augmented with the real-world environment of the hotel restaurant.

Figure 4.1.1
XR Prototype from a guest perspective

A scale model of the scene, including the robot, guests, staff, tables, and the station, is provided to participants alongside the XR prototype. This compensates for the limited interactivity of the XR prototype and offers an opportunity to assess the scenario from a different perspective. The scale model provides a tangible representation of the hotel restaurant setting, allowing participants to physically interact with and examine the robot’s placement, movement, and overall impact on the environment.

Figure 4.1.2
Scale Model



RECRUITMENT

Cooperating with Hotelschool the Hague, the study is conducted at the same fine-dining restaurant in Amsterdam, Le Début, where ethnography was previously carried out. Ten participants are recruited, including seven students from HtH and three instructors from the restaurant. Due to challenges in involving paying guests, student participants are selected. The participants have experience as upscale restaurant customers. Also, they get practical training to run a fine-dining restaurant, including serving staff roles. Their diverse backgrounds will provide insights from both guest and staff perspectives. Additionally, experienced instructors who have worked as professional restaurant managers are recruited to offer insights at the management level.

EXPERIMENT PROCEDURE

Each student participant is invited to an individual experiment. (Except p5 and p6, who are invited as a pair due to their availability constraints.) After signing informed consent forms, participants are introduced to the study objectives and briefed on the experimental procedure. They are then given time to familiarize themselves with the topic by being asked about their previous experience as fine-dining consumers and providers. Following the briefing, participants are presented with the XR prototype, demonstrating its features. They could experience it from two positions: sitting in the perspective of a guest at the dining table and standing in the perspective of a staff member at the station. After exploring the first XR scenario, the interview follows to gather their perceptions, thoughts, and opinions about the experience, reflecting on the robot's movement from the guests' and staff's perspectives. During the interview, the scale model is used to assist participants in visualizing and discussing the robot's placement and impact on the experience. The same procedure is repeated for the second XR scenario. Each session lasts approximately 60 minutes, including the briefing, XR experience, and interview.

For the instructor participants, the study is conducted in a simpler format (approx. 30 minutes), considering their busy schedules. They are given a brief introduction to the study objectives and are presented with the XR prototype showing two scenarios in a row. The interview with the instructors focuses on their expertise and previous experience in managing a fine-dining restaurant and their thoughts on how the robot could be integrated into such a setting at the management level.

The interview script can be found in the Appendix.

DATA COLLECTION AND ANALYSIS

The data are collected through audio recordings of the interviews with participants and video clips of the XR experiment from the headset gear and external camera. As the study aims both to validate the design concepts and to explore the emerging values from various perspectives, the inductive/deductive Hybrid Thematic Analysis(Proudfoot, 2023) informs the data collection and analysis. The interview questions are designed to touch upon the general concepts from the literature review related to HRI in the guest and staff experience. It was a strategic choice to assess the designed movement with the desired changes in the guest and staff experience (deductive) while allowing for open-ended responses and capturing deeper insights and perspectives (inductive).

The audio transcription of the interview is mainly analyzed, while the video clips are used to provide additional context and insights. The deductive coding approach is used to identify the design accomplishment of the desired changes in the guest and staff experience. Additionally, the inductive coding approach is employed to uncover emerging themes and perspectives on how the robot's movement impacts the overall hotel restaurant experience.

4.2 Results

The analysis presents the perception of the participants of the design concepts from the ideation phase (Robot-zone, Side(back)-Kick, and Magic Hand) by validating the desired changes of the concepts from the guest's and staff's perspectives. The responses during the XR experiment and the following interview are used to assess whether the robot movements align with the expectations. Moreover, the in-depth analysis of the responses focuses on the values emerging from the guests', staff's, and managers' perspectives. The insights are synthesized by exploring the synergies or tensions between the values in relation to the robot's movement.

The source of the quotations below is marked as pN for the student participants and pmN for the instructor participants.

Validation of the concepts

CONCEPT 1: ROBOT-ZONE

Impacts on the Guest Experience

Comfortable Dining: Unintrusive Robot's Presence

"The robot blended well with the restaurant's atmosphere." p1

"It maintained a respectful distance from guests." p7

"Its movement speed matched that of the human servers." p4

The Robot-zone concept was perceived positively in enhancing the dining environment. Participants appreciated the robot's subtle presence with decent speed, and proper distance from them, contributing to the ambiance without being intrusive or overwhelming. This integration into the restaurant setting was crucial in maintaining the desired fine dining atmosphere.

Safety and Predictability: Structured Robot's Presence

"It moves pretty structurally. I could predict its movement, so I would be less likely to run into it." p1

"The layout of the robot's moving did not make me worried about it having something dangerous." p4

The robot's movement within the dining area was generally considered safe for the guest's dining experience. Its structured navigation and decent speed allow the guests to predict the robot's performance, contributing to a sense of security and comfort.

Perceived Efficiency: Effective yet Rigid Service

"Everything is already here, so it goes quicker. We, as the guests, can have all the food we ordered." p2

"It is using quite a lot of space and time around the station." p2

"The waiter could take too much time to wait for the robot, and the robot could take too much time to come." p6

Participants recognized the robot's role in improving service efficiency, particularly its timely and reliable delivery of dishes. They appreciate that the robot made the synchronized service available, reducing the waiting time. However, concerns about the operational adaptability between the staff and the robot were raised, potentially leading to delays. As noted by p2 and p6, the structured movement of the robot could be perceived as less flexible, so they expect it might hinder the staff's service efficiency.

Impacts on the Staff Experience

Enhanced Awareness: Predictive Collaborative Points

"When the robot approached, it was clear it needed my attention for

service." p1

"Observing the robot's journey from one point to another helped me understand its purpose." p7

"The robot's approach from the kitchen towards a specific table made it clear which area I needed to focus on for service." p3

The Robot-zone's path and orientation played a key role in enhancing staff awareness. The robot's movements were clear and predictable, allowing staff to easily anticipate where and when to interact with it. This predictability in the robot's behavior improved role clarity and efficiency in the service process, facilitating smoother collaboration between staff and robot.

Optimized Workflow: Efficiency with Adaptation Needs

"The robot's smooth and consistent positioning near the station streamlined my workflow." p4

"If the robot is following the regular pace, but I need the food now, then I need to be able to stop it. We should be very snappy." p2

The robot's consistent movement patterns and specific stopping points contributed to a more streamlined workflow for staff. However, the routine path of the robot worried the participants about its inflexibility, which might hinder the efficient workflow. It highlighted the need for greater adaptability in the robot's operational movement.

More Attention to Guests: Enhanced Focus with Distraction Risks

"The robot taking over food delivery duties allowed me to better engage with guests." p3

"There is a risk of being preoccupied with the robot's functioning instead of focusing on guests." p5

Staff found that the robot's assistance in carrying food enabled them to devote more attention to guests, enhancing the overall dining experience. Yet, some staff expressed concerns about

potential distractions caused by monitoring the robot, suggesting a need for a more autonomous and reliable system.

CONCEPT 2: SIDE(BACK)-KICK

Impacts on the Guest Experience

Served by a Human: Maintained Sophistication

"As a guest, I'm still being served by humans, which is nice." p2

"Staff still provide personal service, explaining about the robot." p1

"I appreciate the human interaction in service, and it is not just with the robot." p4

The presence of staff for personal interaction, supplemented by the robot, ensured a sophisticated and personalized service. Guests appreciated the human-led service, which the robot supported unobtrusively, fulfilling their expectations for a fine dining experience.

Role Identification: Mitigated Confusion

"The staff and robot worked well together, maintaining the human touch in service." p5

"It was clear the robot was supporting, not taking over the waiter's job." p7

"It would be awkward if the robot had already come to the table and waited. Do I have to grab it myself?" p4

The concept effectively communicated the robot's role as a supportive sidekick. The robot's orientation and presence after the staff made it clear to guests that the primary service provider was the human staff, not the robot. This approach successfully mitigated any potential confusion about the robot's role and maintained the traditional aspects of fine dining service.

Respectful Service: Discreet Presence with Varied Preferences

"The robot still moved behind the staff, not really at our table. There was nothing to be concerned about." p2

"Guests have personal tastes; some might not like the robot for various reasons." p7

"As a guest visiting the robot restaurant, I would want more of an experience with the robot near me." p6

The robot's respectful service, characterized by its discreet approach and leaving, was generally well-received and perceived as appropriate for the fine dining atmosphere. However, guests' preferences varied, with some desiring more active engagement with the robot. This variation underscores the importance of flexibility in the robot's interaction style, allowing customization to match individual guest preferences. The ability to adapt the robot's role – from a subtle background presence to a more engaging element – could cater to a wider range of guest expectations.

Impacts on the Staff Experience

Supporting, not overtaking: Collaborative Support

"It enhanced my workflow and efficiency without altering my primary role." p3

"The robot's role in carrying plates beside me felt like a helpful support. It lets us focus more on customer care." p7

These comments reflect staff appreciation for the robot's role as a supportive tool rather than a replacement. The robot's assisting movement oriented to the staff was seen as enhancing the staff's ability to provide attentive service and manage tasks efficiently, reinforcing their central role in guest interaction.

Control and Coordination: More control for reliable and personalized service

"I am in control of the robot a lot. Because I gave some movement, the robot followed me accordingly." p3

"I would prefer to be the one to decide when the robot goes when I am serving. Otherwise, I would feel out of control of the situation." p2

"I need to know how I can communicate to the robot, okay, come closer to me or the table." p7

As noted above, the participants appreciated the robot's following behavior, which enhanced their sense of control over the service process. Their feedback, however, highlights a desire for even more control to ensure seamless coordination. It includes controlling the robot's departure and proximity, allowing for reliable serving and personalized service tailored to guest preferences.

CONCEPT 3: MAGIC HAND

Impacts on the Guest Experience

Enhanced Trust: Responsive Robot to Staff Cues

"It was comforting to see the waiters using gestures to control the robot's actions, like stopping or following." p3

"The staff appeared knowledgeable about operating the robot, using gestures for various commands." p1

"Knowing that the waiter can immediately control the robot, like stopping it if needed, made me feel more at ease." p7

The visible interaction between the staff and the robot, through refined gestures, reassured guests of the staff's control over the service process. Displaying the seamless collaboration between human staff and technology not only enhanced guests' comfort but also contributed to trust in the service perception.

Delightful experience: Enriching the dining narrative with variability

"Its interactive movements make the service feel more engaging and

inviting." p4

"It is still far from the table and does not feel like part of the experience. It is more like a decoration." p5

"Guests at different tables might already be familiar with the robot's actions, so they might not feel interested anymore." p3

The concept was generally perceived as a delightful and intriguing dining experience, making the restaurant more memorable. However, as mentioned in the previous concept, the need for flexibility in robot interaction was also highlighted, recognizing that guest engagement preferences may vary. Additionally, the need for variability in the robot's behavior is noted to maintain interest, especially for repeat those who have observed the robot's interactions at other tables.

Elegant gesture: Choreography for the Sophisticated Performance

"The staff's gesture to the robot was nice. It is what I would expect from a server in a fine-dining restaurant." p6

"I would be worried about the items when the robot spins. it could be unstable." p7

"We saw the movement to stabilize itself to make itself straight." p5

The choreographed interaction between staff and robots was perceived positively, contributing to an elegant service ambiance. However, concerns were raised about the robot's stability during the responsive movements. Additionally, some guests misinterpreted these movements as erratic. When the robot briefly changed its orientation to the guests to address them, they thought the robot was out of control and tried to reset the position, which could detract them from the refined atmosphere. For optimal effectiveness, it is suggested that the gesture-driven interaction be finely tuned and well-coordinated with staff movements to maintain the desired sophisticated dining experience.

Impacts on the staff's experience

Empowerment: Enhanced Staff Agency, Need for Refined Interaction System

"My gesture decided when the robot accompanied me to the table and introduced itself. It gave me a good sense of control." p2

"Using gestures could be risky because then anyone can control the robot. The robot should only react to the staff." p4

"It still should have something to know that it listens to me. Otherwise, I have to rush behind the robot. It is importnat that we work together." p4

The participants felt empowered by their ability to control the robot's actions through gestures. This control enhanced their sense of ownership and involvement in the service process. However, there were concerns about the accessibility of gesture control, suggesting a need for a more exclusive or refined system to ensure proper responsiveness to the staff. Additionally, the need for clear indications from the robot was noted, signaling its understanding of staff inputs. The requirement emphasizes the importance of clear communication between staff and robot, where the robot not only reacts to staff actions but also visibly acknowledges their commands to ensure smooth and coordinated service execution.

Enhanced Professionalism: Sustained Staff Expertise, Enhanced Service Role

"My professionalism is more about how I act as a person and serve the guests." p5

"The robot would not change my job, but it is just helping me to work better." p3

"If the robot doesn't go well, I will be the one to take care of it." p6

"I have to pay extra attention to make sure whether the dishes are delivered correctly. So it's going to be a new role for me." p2

The responses suggest that the Magic Hand concept supports

their professional role without diminishing it. The robot aids workflow efficiency, but staff still retain their core responsibilities to interact with guests. The concept is seen as an addition that enhances job performance rather than detracts from the server's professionalism. However, there is an acknowledgment that extra attention is required to ensure service quality, as any mistakes with the robot's assistance become more visible in the dining area. Staff view this as an additional role to ensure the guests' hospitable experience.

MANAGEMENT PERSPECTIVE

Unlike student participants, instructor participants were asked to evaluate the robot's movement from the management perspective of running a restaurant. Therefore, rather than evaluating the validity of the desired changes from the design concepts, their responses from the interview were analyzed, focusing on which aspects they considered important to introduce the robot into hotel restaurants.

Some student participants' responses representing the management perspective were also included in the analysis.

Business Benefit: Operational Efficiency & Marketing

"It could help deal with staff shortages." pm2

"A lot of staff would like to work with it because their work gets less tiring." pm1

"We could cut costs on labor." pm1

From a management perspective, integrating robots into the restaurant was seen as a strategic move to enhance business operations. By leveraging robotics, management would aim to alleviate the workload of service staff, which is eventually beneficial in mitigating staff shortages. Such improvements in operational efficiency were expected to optimize operational costs.

"It would give the restaurant a selling point." p1

"The robot will allow the customer to remember about the restaurant and the experience. He might bring some people due to the robot." p7

Furthermore, the presence of robots in a dining setting could serve as a unique selling point. This distinctive feature not only differentiates the restaurant in a competitive market but also attracts guests intrigued by the fusion of technology and traditional dining. The blend of improved operational efficiency and the attraction of technological novelty is expected to put the restaurant on a unique edge in the hospitality industry.

Applications in Practice: Space configuration, Coordinated Workflow & Maintenance

"We could think of adapting the interior to make the robot work easily, such as the tables' height, arrangement, etc." pm1

"The size of the restaurant could affect. Robots could make a small restaurant even more crowded." p4

"I like the design of the robot fitting with the furniture." pm1

The instructor participants emphasized practical consideration of how the robot is feasible in the actual restaurant setting. They noted the importance of configuring dining areas to be robot-friendly, ensuring that these changes complement the aesthetic and functional demands of fine dining. Critical decisions about the robot's routes and areas of operation should be made to maintain the desired ambiance and avoid disruptions in guest experience or service flow.

"The service should be tightly coordinated. The staff member should not be waiting for the robot." pm2

"Every guest is different. Adaptations need to be made very often as well. It would mean that you might have to program the robot differently every time. You cannot use a robot like that." pm3

"The restaurant looks different every day, and the robot should be able to find its way through the changed setting. So, it has to be very adaptable to the situation." pm1

"The reliability in the operations could have some issues. If it doesn't function properly, there might be a risk that guests are going to see it as an unnecessary gimmick." pm2

The notion of seamless integration of the robot was paramount, demanding precise coordination with staff for efficient, timely service. The participants expected the robot's adaptability to be challenging, with daily variations in guest numbers, preferences, and seating arrangements requiring a robot that staff can easily control and adjust as needed. Management also underlined the reliable performance of the robot, which is directly tied to sophisticated service quality.

"I don't want to call a technician every day to reprogram it. I should easily set and be able to let it go." pm1
"So it should be somehow really easy to use so that staff don't even have to learn." pm3
"As any waiter or waitress is able to work with the cash register, its functions should be easy for them to perform with the robots as well." pm2

Furthermore, the ease of in-house maintenance and minimal training requirements were essential considerations, as they ensure that the implementation of robotic technology does not disrupt operations or strain resources.

Strategic Technological Integration in Hospitality

"We will see for sure more robots in hospitality, so we are going to get used to it." pm1
"I think it is not disturbing anymore these days to use a robot helper. We should use the technology to its best purposes." pm1

The necessity of adopting technology in the hospitality industry was acknowledged, with increasing recognition of its role in enhancing operational efficiency. The managers expected the hospitality industry to accept the robot as a supportive thing, not as a disturbance.

"I'm from a very traditional part of hospitality. The liveliness of people working together to enhance the guest experience is something that speaks more to me." pm3
"If I'm paying 200 euros for a meal, I don't want to take the plates from the robot myself. There should be a human staff to serve me personally." p2

However, strong advocacy lies in preserving the human service in fine dining. It emphasizes the irreplaceable value of human interactions, which are fundamental to the warmth and personal touch characteristic of fine dining experiences.

"If efficiency is the only value it brings without using it as an opportunity to have more quality time at the table, enhancing the guest interaction, then I would not adopt the robot." pm2
"It should not take away the human part in service, but help giving staff even more time to serve guests." pm1
"In the fine dining, a lot of personal interactions are done at the table, where you explain about the food, or about the wines. Robots should not take it away." pm3

The instructor participants highlighted the goal of integrating technology extends beyond mere efficiency. The enhanced efficiency is not an end in itself but a means to enrich guest experiences with an added layer of sophistication. This approach seeks to harmonize the efficiency of technology with the nuanced, personal engagement of human service.

The robot's movement and the performativity

The validation of the design concepts has provided insights into their potential to achieve desired changes in the guests' and staff's experience in a fine dining context. Besides, the management perspectives revealed what aspects should be considered when adopting the service robot in the fine dining setting. The insights serve as a starting point for analyzing the implications of the robot's movement in fine dining, taking into account the perspectives of guests, staff, and management. As Bleeker and Rozendaal (2021) emphasize the performativity of the smart object, it is crucial to explore how specific qualities of robot movement align with or potentially conflict with various values that are intricate in the scene of the restaurant.

1. REFINED PRESENCE: STRUCTURED MOVING PATH AND DISCREET SPEED

When the robot makes its presence, it follows a pre-defined, structured path within the dining area, moving at a consistent and discreet speed. The refined presence expresses the respectfulness to minimize disruption and maintain a smooth flow of service.

Figure 4.2.1

Aligned Values: The movement quality creates a sense of harmony and order within the dining area. For guests, it translates into a comfortable dining experience where the robot's presence does not disturb their meal or conversation, maintaining a calm and relaxed atmosphere. It enhances their sense of safety, as the predictable nature of the robot's movement reduces the risk of unexpected interactions. Staff find these qualities helpful in planning their service routines, making the collaboration more intelligible. They can anticipate the robot's position and coordinate their tasks accordingly. Managers appreciate this aspect as it simplifies the implementation process. The robot's path ensures that the transition does not disrupt the established dining environment or require extensive rearrangement.

Possible Tensions: Some guests expect novel experiences with the robot and desire more direct and engaging interactions with it. They could feel the structured movement is too segregated from the entertaining experience. Staff face challenges in situations that demand a deviation from the robot's routine. For example, in case of malfunction or incorrect delivery, staff would desire the robot's flexibility instead of waiting for the robot to finish following the script. Managers express concern about the robot's adaptability in changing environments depending on the reservations of the guests. The physical setup of the restaurant, such as table arrangement, changes from day to day, and so do the serving style and menu items. It is critical to how easily the manager can set the new routine of the robot's movement to accommodate these changes.

2. STAFF PROMPTED ACTION: GESTURE-GUIDED MOVEMENT

The robot orients itself toward the staff and expresses a state of waiting for the next movement to be initiated. By recognizing the gestures of the staff initiating movements, the robot responds to these cues in a coordinated manner.

Figure 4.2.2

Aligned Values: Guests feel a sense of trust and sophistication in the dining service, seeing the gesture-controlled robot as an entertaining element. Staff members also feel a greater sense of control and empowerment, as their elegant gestures influence the robot's actions to coordinate guest service. For managers, ensuring the control system is accessible by human staff is crucial for a smooth and efficient integration of technology into the service process, enhancing overall operational effectiveness.

Possible Tensions: As discussed previously, guests may have different expectations for interacting with the robot. Some might perceive the gesture-controlled movement as impersonal or lacking direct engagement. Staff members encounter difficulties in effectively communicating with the robot and ensuring the robot's accurate interpretation of the prompt. This can lead to an increased cognitive load on the staff, who must continually monitor and adjust their movements to ensure seamless coordination with the robot's actions. As it adds complexity to the workflow, managers face challenges maintaining the system. They should consider the stability of the robot's performance, the ease of troubleshooting, and training staff with new required skills as well.

3. ENJOYABLE ADDRESS: ENGAGING ENCOUNTER

Even a non-anthropomorphic robot can exhibit its delightful

personality with subtle movements when addressing guests. It can adjust its path to move closer to the dining table, accompanying the human staff. As the human staff makes eye contact with the guests, the robot can acknowledge their presence by subtly turning towards them.

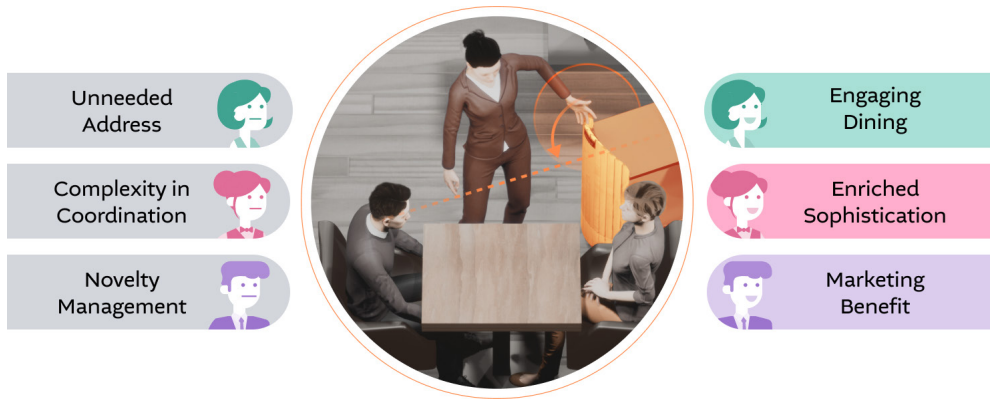


Figure 4.2.3

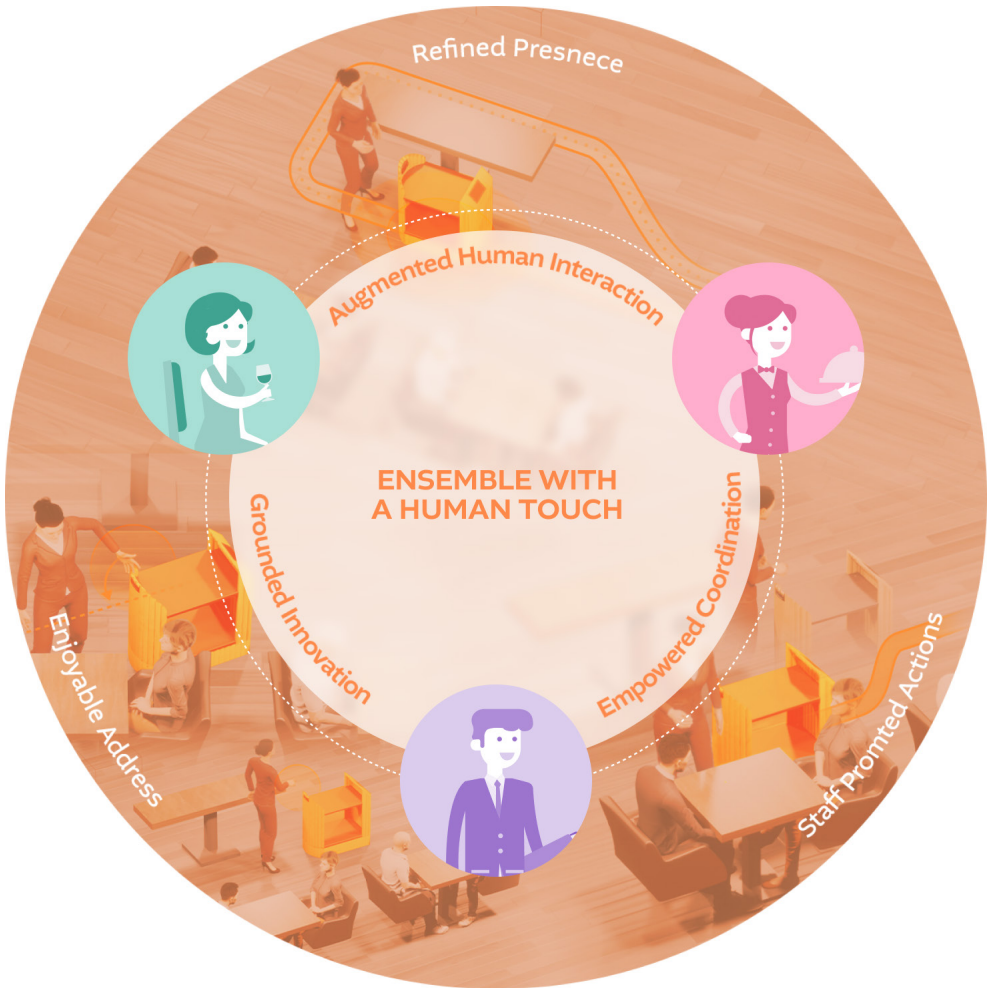
Aligned Values: Guests appreciate the addressing movement, feeling a sense of connection and enjoyment when the robot subtly acknowledges their presence. This aligns with their desire for a dining experience that is both refined and interactive. Staff members find that the robot's movements complement their interactions with guests, enhancing overall service performance. This supports their role in providing attentive and empathetic service while maintaining a decent manner of fine dining. Managers can expect marketing benefits from the robot's engaging presence and address, as it adds a unique and memorable element to the dining experience, attracting customers and setting the restaurant apart from competitors.

Possible Tensions: Opposed to the previous concerns, some guests, especially those seeking a traditional fine dining experience, may find the robot's addressing movements to be intrusive or disruptive to their dining experience. Even the guests who enjoy the engagement with the robot may find the addressing movements to be gimmicky after repeated en-

counters. Considering that the address happens during the dish delivery, staff members need to ensure that the robot's movements are coordinated and timed appropriately, as any delays or errors can disrupt the flow of service. For managers, the challenge lies in ensuring that the robot's interactive features consistently deliver the intended experience as a novelty without becoming a gimmick that overshadows the core fine dining experience. They must consider how these features fit into the restaurant's brand and service philosophy.

Figure 4.2.4

HARMONIOUS ENSEMBLE: COORDINATED PERFORMANCE WITH A HUMAN TOUCH



Analyzing the synergy and the tension around the robot's movement, the value of the human touch has been highlighted as an overarching quality in the hospitable fine-dining experience, acknowledged by guests, staff, and managers alike. Guests value the sophistication and personalization crafted by human staff, seeing it as essential to the quality of their dining experience. The robot's discreet and respectful movements complement this by enhancing the ambiance without detracting from the human element. Staff, who take pride in their professionalism and personal interaction with guests, find the robot's coordinated performance supports their role, allowing them to maintain their primary position in guest service. Managers appreciate how the robot's movements embody technological innovation while being grounded in the human touch, striking a balance between modern efficiency and traditional service values.

In synthesizing the insights, the value of human touch is weaved into the design of the robot's movement in fine dining. The "Refined Presence," with its structured paths and discreet speed, complements the staff's ability to provide a focused and personalized service to guests, augmenting the intimate and attentive nature of human interactions in fine dining. The "Staff Prompting Action," where staff guides the robot's movements, is not just about control but about choreographing a service that is visibly led by humans, thus highlighting their empowered role in creating a warm and engaging dining experience. In "Enjoyable Address," the robot's subtle acknowledgment of guests, timed with the staff's interaction, adds a layer of charm and engagement without detracting from the human element, ensuring that the technology enhances rather than replaces the personal touch provided by the staff. Each of these movements and interactions is designed to ensure that the robot's presence supports and amplifies the human touch, which remains at the heart of fine dining.

Conclusion for Evaluation Phase

The Evaluation Phase has bridged the design concepts of robot movement with their practical implications in a real-world hotel restaurant setting. Through the XR experiments and insightful feedback from guests, staff, and managers, it has been uncovered how the robot's movements could resonate with the critical qualities of fine dining.

In validating the three concepts, each displayed a mix of advantages and challenges for guests and staff. For Concept 1, Robot-Zone, guests enjoyed the unobtrusive presence enhancing their dining experience, but some found its movement too rigid, lacking personalization. Staff appreciated the predictability of planning but struggled with its lack of adaptability in service. Concept 2, Side(back)-Kick, was well-received by guests for keeping human-led service at the forefront, yet some desired more direct interaction with the robot. Staff valued the robot's support but sought more control for seamless service. Concept 3, Magic Hand, enchanted guests with engaging gestures, though a few felt the interaction could be more dynamic. Staff were empowered by the gesture control but faced challenges in ensuring smooth coordination with the robot.

Beyond the validation, the following in-depth analysis delved into the robot's movement quality with performativity. It showed how the robot's refined presence, staff-prompted action, and enjoyable address align with or conflict with various dining scene values of guests, staff, and managers. Central to these insights was the theme of human touch, highlighting the importance of the robot's movements complementing, rather than overshadowing, human-led service in fine dining. This analysis underscores the delicate balance between technological innovation and preserving traditional fine dining values.

The insights from the Evaluation phase, including the challenges and opportunities, will guide addressing the research questions in the following 'Reflection Phase.' This phase will envision the role of service robots in hotel restaurants, accommodating a fine dining experience. Reflecting on the methods, including the performative approach, and considering the broader implications of this project will inform future research.

5 Reflection Phase

In this phase, the insights from the previous phases are reflected to answer the research questions of the project. Discussing the role of the service robot in the hotel restaurant, designing the robot's movement to accommodate the fine dining experience is envisioned. Additionally, this phase reflects on the methodology employed throughout the project, examining their effectiveness and drawing conclusions that could inform future research.

5.1 Vision

Robot as an Ensemblist

In reflecting on the insight from the Evaluation phase, 'Harmonious Ensemble: Coordinated Performance for the Human Touch,' it becomes evident that the human touch is a pivotal element in integrating the robot into a fine dining environment. This perspective acknowledges the robot's role in supporting, not overshadowing, the essential human elements of fine dining. The robot's movements and interactions are carefully choreographed to complement human service staff, enhancing the overall dining experience and maintaining an atmosphere where human interaction and personal touch are central. The emphasis is on a balanced and coordinated performance, where technology seamlessly integrates into the rhythm of fine dining.

Drawing an analogy from musical theater, the service robot in a fine dining context can be likened to an ensemblist. In theater, an ensemblist plays multiple roles, switching between characters, contributing to musical numbers, and embodying various parts of the background world. (Ensemble Member (Musical Theater and Opera), 2024). This role involves a comprehensive understanding of different characters, choreography, and backstage dynamics. Similarly, in the world of fine dining, the service robot can be seen as playing a dynamic, multi-faceted role to facilitate the 'theater' of fine dining. Just as an ensemblist supports the principal actors and contributes to the narrative without overshadowing them, the service robot enhances the dining experience by supporting the main characters—the staff and guests– and their value. Its movements and actions are choreographed to blend seamlessly into the service, subtly enriching the ambiance without becoming the focal point.

Through exploration, it has been found that the robot's movement incorporates the interaction or collaboration qualities that the robot should accommodate as an ensemblist. While automating the delivery of dishes from backstage to the main stage, the robot's refined and non-intrusive movement path discreetly notifies both guests and staff of its presence. The robot's orientation indicates whom it is addressing at any given moment, enhancing guest comfort and facilitating intelligible collaboration with human staff. This benefit extends to improved care for guests, allowing staff to focus on personalized interactions and attentiveness. The robot's actions prompted by gestures from staff members and the sequence of presence support coordinated care for the guests while giving a sense of control to the staff who play a central role in proceedings. Lastly, through its movements, the robot expresses how it will engage with the narrative of guests and staff. By adjusting proximity and responding to different actors or situations, the characteristics of expression can vary from polite to entertaining. The appropriate manner of address contributes to creating an inviting atmosphere in the scene. In synthesizing the implication of the robot's movement in the fine dining experience, the robot's role can be envisioned as an ensemblist seamlessly integrating into the scene of hospitality, supporting the value of the human touch. However, this integration is not without its challenges. The next section, "Challenges and Opportunities," delves into these complexities, exploring the limitations and potential areas for improvement.

Challenges and Opportunities

The exploration of the movement design concept also dis-

covered the challenges and room for improvement to develop the robot as an effective ensemblist in fine dining settings. Adaptability was a common concern across all perspectives, requiring a nuanced approach to robot design for fine dining. Guests' diverse preferences for engagement called for a robot capable of both discreet and more lively interactions, depending on the context. Staff desired to prompt the robot with a flexible control system to deviate from its routine to deal with specific situations. Managers were concerned about the robot's capability to adapt to daily variations in restaurant settings. To address these challenges, the design consideration could involve equipping the robot with a detailed yet intuitive control interface. This would enable the staff to fine-tune the robot's performance on the fly, responding delicately to immediate service needs. For instance, staff could use a device to adjust the robot's speed, position, or moving path to align with specific dining scenarios.

The experiment with the XR prototype has demonstrated that the expressive movement of the non-anthropomorphic robot can communicate its intention effectively. Blind spots exist, however, especially before the robot makes its movements. For example, multiple participants who acted as staff members noted that it was unclear when the robot was about to respond to their commands or initiate autonomous movement. To make the communication more fluent, the robot could exhibit subtle anticipatory movements, such as a slight tilting or a gentle swivel, indicating readiness to respond or process commands. These movements bridge the gap between inactivity and action, providing a more fluid and natural transition.

While the project focuses on the potential of the movement quality of the robot utmost, integrating multi-sensory elements like ambient sounds or lighting could further elevate its communicative capacity. Even though loud expressions are generally perceived as inappropriate in the fine-dining context, well-orchestrated multi-sensory feedback could enrich the interaction without overpowering it. For instance, a gentle hum or a change in lighting color could signal the robot's transition from a waiting state to action, facilitating smoother collaboration. Also, it could give more variety to the entertaining expression through different sounds or lighting effects, adding a playful and engaging atmosphere to address guests.

Beyond improving the robot's functionality, however, an effective ensemblist robot should possess the capability to read the dining scene and perform proper expression. The active responsiveness beyond the functionality is aligned with the notion of a 'response-able' smart object for the co-performance between humans and technology, as noted by Giaccardi and Redström(2020). The authors highlight co-performance as a relationship between people and things shaping the world together, and the things should be designed beyond just giving the right response. It asserts the capability to respond with an understanding of what it enables in the interaction. In that sense, equipping the robot with sophisticated sensors and AI that can process service-related data could enable it to understand various dining scenarios and initiate the changed movement response-ably. For instance, the data from the restaurant reservation system collected could be fed to the robot. If the restaurant is expected to be unusually busy or have a special business event, the robot could adjust its movements to be less obtrusive for the guests and allow enough space for the staff workflow. Moreover, real-time responsiveness could address guests in a lively manner. When approaching the dining table, the robot could recognize the guests who show interest in the robot and be ready to engage with more expressive gestures. This approach could design the robot as an embedded ensemblist in the fine dining theater, enabling a narrative of hospitality with the human staff and guests.

The vision for the robot in hotel restaurants is conceptualized as an 'Ensemblist,' seeing the robot as an integral yet supportive participant in the fine dining experience. It envisions a scene where the robot supports the human touch in hospitality settings, embodying balanced and coordinated performance, seamlessly fitting into the rhythm of fine dining. The challenges identified, such as adaptability, gaps between the movements, and multi-sensory expression, offer opportunities for design improvements. These include sophisticated AI and sensor systems to enable the robot to read and respond dynamically to the dining scene and intuitive control interfaces for staff. The vision extends to crafting a performance beyond mere functionality, embedding the robot as a response-able entity within the co-performed narrative of hospitality, contributing to an enriched dining experience for guests, and supporting collaboration with the staff.

5.2 Reflection on the Methodology

The performative approach in this project was pivotal in framing the interaction between humans and robots in a fine dining setting. Utilizing dramaturgical concepts it provided a unique perspective on designing and evaluating the role of service robots' movement in human-robot interaction in a hospitality context.

In the defining phase, the project analyzed ethnographic data with concepts from literature studies through a dramaturgical lens. Terms like 'presence,' 'address,' and 'prompt' were instrumental in framing the intricate dynamics among consumers, staff, managers, and the robot. This approach helped in understanding the nuanced role of the robot within this complex system, setting the stage for further exploration.

The ideation phase employed speculative enactment, where participants interacted with simplified robot prototypes in a simulated environment. By being a robot, a guest, or a staff member, the participants could embody creative ideas to envision the design interventions. It facilitated exploring various movement parameters and their implications on guest and staff experience, providing a hands-on understanding of potential interactions.

Lastly, the evaluation phase employed XR technology to validate design concepts in simulated fine dining scenarios. This immersive approach allowed participants to experience the design concepts from the actual actor's perspectives within the scene. The combination of enactments and post-experiment interviews yielded in-depth qualitative data, offering

valuable insights into the participants' perceptions of desired interactions with the robot's movements.

Throughout the project, the performative approaches have provided a creative lens to envision human-robot interaction in fine dining. These approaches have successfully framed the complex dynamics of service robots and enabled co-exploration to ideate, conceptualize, and evaluate the robot's movement. Moving forward, the following sections will delve deeper into specific methods like speculative enactment and XR experimentation, analyzing their impact and potential improvements for future research in hospitality robots.

Speculative Enactment

The speculative enactment approach in this project facilitated a rich creative process. Its effectiveness lies in several key aspects:

Creative Exploration: The low-fidelity prototypes enabled participants to focus on exploring different robot movement parameters. This approach, informed by the concept of 'Becoming a robot'(Dörrenbächer et al., 2020), encouraged delving into various aspects of movement and its impact on dining experiences without being constrained by anthropomorphic characteristics.

Diverse Perspectives: The involvement of participants from various backgrounds, including guests and service providers, brought a richness of diverse viewpoints. This diversity was crucial in broadening the scope of ideas and understanding the multifaceted nature of robot integration in a fine dining context.

However, certain limitations were identified and should be addressed for future improvements:

Prototype Fidelity: While the intention behind using low-fidelity prototypes was to focus on movement qualities rather than appearance, some participants found it challenging to envision the full impact without a more realistic representation. Future research could consider a balance in prototype fidelity to provide an accountable context while keeping the focus on movement.

Role Immersion: The requirement for participants to rapidly switch roles (robot, guest, staff) during enactments sometimes hindered full immersion into each role. Future sessions could be structured with longer durations or smaller participant groups for more effective role-playing to allow deeper immersion and exploration of each role.

Leveraging Performative Arts Expertise: Although some participants had experience in performative arts, it was not clear how this expertise significantly influenced the enactment process. Organizing specialized sessions where individuals with a background in performative arts take a leading role could better harness their skills and experience, potentially enriching the enactment process.

XR Experiment

The XR experiment in this project provided a novel approach to evaluating design concepts, allowing for validating these concepts in a realistic and immersive environment. It also allowed participants to co-explore the implications of the robot's movement in possible situations in the hospitality context. Its effectiveness was demonstrated through several aspects:

Real-World Context Testing: Collaborating with Hotelschool The Hague, the XR prototype was tested in an actual hotel restaurant setting. This approach provided participants with a realistic context to experience and evaluate the robot's movements, which is crucial for understanding its impact in a nuanced fine dining environment.

Augmented Participant Experience: Incorporating actual dining tables and stations in the XR environment allowed

participants to experience scenarios from both guest and staff perspectives. This provided comprehensive insights into the interactions and dynamics between the robot and other actors in a hotel restaurant setting.

User-Friendly Technology: Compact XR headsets facilitated a comfortable and immersive testing experience. The light weight of the gear and ease of use engaged participants more deeply in the experiment without being afraid or overwhelmed by the technology involvement in the study.

Sustainable and Efficient Prototype Development: Utilizing animated scenarios in XR was more feasible than creating highly interactive physical prototypes. This approach was not only resource-efficient but also minimized waste, aligning with sustainable practices.

Complementary Use of Scale Models: Employing scale models, a physical representation of the scene, alongside XR helped compensate for the limited interactivity of animated scenarios. It allowed participants to revisit and re-examine their XR experience from a different perspective. This approach was particularly helpful for those less familiar with XR, making the evaluation process more inclusive and comprehensive.

The limitations of the XR experiment method in this project highlighted areas for future research consideration:

Limited Real-Time Interaction: The prototype, based on pre-animated scenarios, lacked the capacity for real-time interaction, which might have restricted participants' full engagement with the robot's movements. This limitation was particularly evident when some participants perceived the robot in the animation as static and could not further envision the possibility of interaction. Future research should focus on developing more interactive prototypes that allow real-time interaction, ensuring a more accurate and engaging evaluation process.

Recruitment Limitations: While students from Hotelschool The Hague provided valuable insights, their inclination towards a service provider perspective, due to their hospitality education, was noticeable. Additionally, the XR study did not include a wider variety of participants, such as performance artists, HRI researchers, or roboticists, limiting the transdisciplinary nature of the research. Future studies could include a more diverse group of participants to capture a broader range of perspectives. It could bring the richness of data from a creative expression embodiment to the technical feasibility.

Underutilized XR Gear Data: The data captured from the XR gear, such as participant view recordings, was underutilized and mainly served to support audio transcription. The data may include the cognitive reaction of the participants while interacting with the prototype. Future research could leverage this data more effectively to gain additional insights for designing HRI.

Conclusion

This project represented an exploration of the field of Human-Robot Interaction (HRI) within the hospitality industry, focusing specifically on the non-anthropomorphic robot's movement in hotel restaurant contexts. The exploration addressed two fundamental questions: Firstly, how could robot movement be designed to facilitate essential interaction and collaboration qualities during the dining and serving experiences? Secondly, how could these movements be crafted using a dramaturgic performative approach? The project traversed from theoretical underpinnings to practical applications, uncovering the nuanced dynamics of robot integration in hospitality environments.

By articulating the movement parameters, the design concept validated that certain movements performed by a service robot, such as refined presence, prompted actions, and enjoyable address, can accommodate the qualities of the dining and serving experience in the nuanced hotel restaurant. Moreover, the study found the all-encompassing value of the human touch in the fine-dining context. The role of the service robot was envisioned as an 'Ensemblist,' requiring it to be 'response-able,' capable of adapting to the 'rhythm of fine dining.' Together with detailing the robot's expressions, such as anticipating movements, or multi-sensory feedback, the integration of advanced AI was discussed to ensure that the robot not only performs its functional role efficiently but also becomes an integral performer in the fine dining scene.

Also, the project leveraged the performative approach to the design of robot movements. It allowed for a participatory exploration of how movements can be both expressively meaningful and contextually appropriate, resonating with the guests and staff. The dramaturgical concepts employed throughout the research stages enriched the design process providing profound insights into the robot's performativity in the fine-dining context. Both speculative enactment and XR experiments were effective in advancing the understanding of HRI in hospitality settings. The speculative enactment was effectively executed for initial concept ideation, fostering a creative and collaborative design process for the robot's movement. Extended Reality (XR) experiments offered an immersive way to evaluate the robot's movement concepts in real-world settings, allowing the deeper nuances of human-robot interactions to be captured. The methods can be further developed considering the appropriate fidelity of the prototype, participant recruitment, and advanced data treatment.

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Appendix

A. Design Brief
B. Ethnography In-Depth Interview Material
C. Staff Body Journey
D. Movement Design Schema
E. XR Experiment Interview Script
F. Evaluation Analysis Cluster

A. Design Brief

DESIGN FOR our future

TU Delft

IDE Master Graduation

Project team, Procedural checks and personal Project brief

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

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

USE ADOBE ACROBAT READER TO OPEN, EDIT AND SAVE THIS DOCUMENT

Download again and reopen in case you tried other software, such as Preview (Mac) or a webbrowser.

STUDENT DATA & MASTER PROGRAMME

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

family name: Lee — 6760
initials: H — given name: Hyunmin
student number: 5659132
street & no.:
zipcode & city:
country:
phone:
email:

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

IDE master(s): ( ) IPD (1) Dfl ( ) SPD
2nd non-IDE master:
individual programme: - - (give date of approval)
honours programme: ( ) Honours Programme Master
specialisation / annotation: ( ) Medisign
( ) Tech. in Sustainable Design
( ) Entrepeneurship

SUPERVISORY TEAM **

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

** chair: Cila, Nazli — dept. / section: HCD/HICD
** mentor: Rozendaal, Marco — dept. / section: HCD/HICD
2nd mentor: Koerten, Klaas
organisation: Hotelschool the Hague
city: Den Haag — country: The Netherlands

comments (optional): The supervisors will guide the project with each member's approach and expertise on the topic, from theoretical to pragmatic. The stakeholder (Hotelschool) will provide perspectives from the hospitality industry.

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

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

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

TU Delft

Procedural Checks - IDE Master Graduation

APPROVAL PROJECT BRIEF

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

chair: Cila, Nazli — date: 16 - 08 - 2023 — signature: Nazli Cila - IO — Digitally signed by Nazli Cila - IO Date: 2023.08.16 14:15:06 +02'00'

CHECK STUDY PROGRESS

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

Master electives no. of EC accumulated in total: 24 EC
Of which, taking the conditional requirements into account, can be part of the exam programme: 24 EC
List of electives obtained before the third semester without approval of the BoE:

(1) YES — all 1st year master courses passed
( ) NO — missing 1st year master courses are:

name: Robin den Braber — date: 23 - 08 - 2023 — signature: Robin den Braber — Digitaal ondertekend door Robin den Braber Datum: 2023.08.23 08:30:30 +02'00'

FORMAL APPROVAL GRADUATION PROJECT

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

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

Content: (1) APPROVED ( ) NOT APPROVED
Procedure: (1) APPROVED ( ) NOT APPROVED

comments

name: Paul Mommers — date: 05 - 09 - 2023 — signature:

Initials & Name: H Lee 6760 — Student number: 5659132
Title of Project: Designing the hotel restaurant service robot's expressive movement

Designing the hotel restaurant service robot's expressive movement — project title

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

start date 16 - 08 - 2023 — 30 - 01 - 2024 end date

INTRODUCTION **

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

Robots are increasingly being implemented in various working environments to undertake tasks assisting human employees. One of the active sectors is hospitality, which faces personnel shortages and high staff turnover[1]. Especially the service robots have been deployed in the restaurant assisting in transporting food and drinks for guests. However, it is still not guaranteed that both human employees and guests can accept robots as intelligent agents rather than gimmicks. The successful integration of robots in hotel restaurant settings poses challenges, particularly in relation to the overall ambience and interactions in the context. As Choi et al.[2] bring up the participants' sceptical reaction to the hotel service robots, the mismatch between robots and the conditions of hotels could harm the guest's perceived hospitality and hinder the successful collaboration with human employees.

Accordingly, service robots are being developed to meet human needs and expectations. Rober, a service robot developed by Dalco Robotics[3], stands out from prevalent social robots as it adopts a non-anthropomorphic appearance. As Hoffman notes in his paper[4], the non-anthropomorphic design has advantages, such as exploratory flexibility, economic feasibility, and the potential for greater acceptability. He also promotes its positive effects on interaction, such as lowering expectations based on anthropomorphic appearance or avoiding the uncanny valley. It is especially remarkable regarding the hotel context that the viewer can flexibly accept the less human-like appearance as attuned to a hospitable environment. While Rober's non-anthropomorphic design may be advantageous, it also raises concerns about the robot's ability to express its intentions, which humans often communicate implicitly through various non-verbal cues. Therefore, the robot's expressivity should be designed to compensate for the lack of human-like expressions and enhance its interaction qualities within the hotel restaurant setting.

Designing the robot's expressivity requires a creative approach to envision its movement relating to the situation and dynamic affordance. As Rozendaal et al.[5] introduce dramaturgy as a set of conceptual tools to design human-agent interaction, the principles and techniques from the performing art, such as 'Mise-en-scene', speculative scenario, and enactment, can inform the design process of analysing and developing the service robot in the hotel restaurant context. Thus, finding the appropriate expression can be more of an art than a science, and people's engagement helps gain insights about how the robot should move [4]. With the experiential and participatory approach, the project aims to envision the expressive movements of the hotel restaurant robot, considering its interaction/collaboration qualities with human actors.

[1] https://www.hotelschool.nl/evaluating-robots-for-hotels/
[2] Choi, Y. J., Choi, M., Oh, M., & Kim, S. (2019). Service robots in hotels: understanding the service quality perceptions of human-robot interaction. Journal of Hospitality Marketing & Management, 29(6), 613–635. https://doi.org/10.1080/19368623.2020.1703871
[3] https://dalcorobotics.nl/
[4] Hoffman, G., & Ju, W. (2014). Designing Robots With Movement in Mind. Journal of Human-Robot Interaction, 3(1), 89. https://doi.org/10.5898/jhri.3.1.hoffman
[5] Rozendaal, M. C., Marenko, B., & Odom, W. (2021). Designing smart objects in everyday life: Intelligences, Agencies, Ecologies. Bloomsbury Publishing.

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introduction (continued): space for images

image / figure 1: Two different appearance design of the service robots

image / figure 2: The movement qualities of human employee in the hotel restaurant

PROBLEM DEFINITION **

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

While the robot's non-anthropomorphic appearance has the potential to be more acceptable, being harmonious with the hotel environment, the challenges lie in expressing its intentions to guests and colleagues as human employees perform in a sophisticated way. Therefore, the robot's movement should be designed to compensate for the lack of human-like expressions and enhance its interaction qualities within the hotel restaurant setting.

RQ.1 What are the critical interaction qualities in the dining/serving experience in the hotel restaurant that the non-anthropomorphic robot's movement should accommodate?
The research addresses the interaction and collaboration qualities with human guests and employees that non-verbal expressions should accommodate and enhance. Critical situations in the dining and serving experience are further explored, and speculated where the intentions and expectations between guests, human employees, and robots might conflict. These situations turn into a set of scenarios to guide design interventions on the robot's expressivity, resolving misunderstandings and enabling it to deliver its intentions effectively.

RQ.2 How could we design the appropriate movement of the robot with a dramaturgic and participatory approach?
The project also seeks a creative approach to designing the interactive robot, leveraging its communicative capacity within the robot development process. The principles of dramaturgy and techniques from performing arts are employed as tools to co-design the robot's expressive movement. Additionally, augmented/virtual reality technology is integrated to offer an immersive environment for participants to engage in the process. By avoiding predefined technical limitations, this approach allows us to design the robot's sophisticated expressivity, accommodating the nuanced interactions and expectations present in the hotel restaurant setting.

ASSIGNMENT **

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

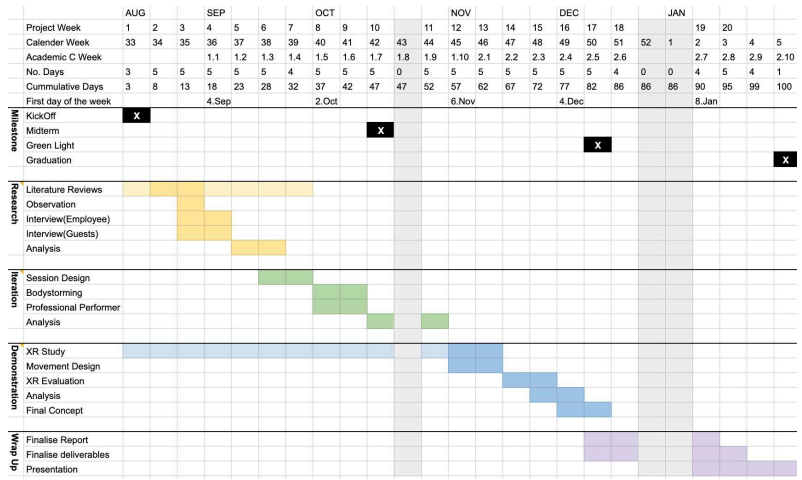
This study explores the non-anthropomorphic robot's expressive movement and the interaction with human actors in the hotel restaurant. Integrating dramaturgy and VR/AR as creative tools, the Research-through-Design and participatory design approach aims to generate knowledge to enhance human-robot interaction through collaborative iterations with stakeholders in the context.

This study aims to deliver a set of refined expressive movement patterns and interaction scenarios for the non-anthropomorphic robot in the hotel restaurant environment. These refined patterns will encompass subtle gestures, motions, and positioning that convey the robot's intentions effectively, enhancing its interaction with human guests and employees. The integration of virtual and augmented reality technologies will enable participants to immerse themselves in simulated scenarios, facilitating their engagement in the design process and validating the effectiveness of the proposed expressive movements.

PLANNING AND APPROACH **

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

start date 16 - 8 - 2023 30 - 1 - 2024 end date



The first phase, 'Research', focuses on defining the critical interaction/collaboration qualities in the hotel restaurant context. It takes an ethnographic approach to gain insights from the actual environment and stakeholders. Desk research investigates the relevant works and the methodologies used in the following iteration phase.
The second phase, 'Iteration', integrates stakeholders or performative art experts in prototyping. With the scenarios developed from the previous phase, the participants collaborate to ideate and evaluate the enacted robot's movement. The insights converge into design concepts to demonstrate.
In the last phase, 'Demonstration', the concepts are evaluated in a Mixed reality environment. The participants assess how the movements affect the interaction or collaboration with the robot and the overall dining/serving experience. Further discussion follows to converse about the implications of the results.

Personal Project Brief - IDE Master Graduation

TU Delft

MOTIVATION AND PERSONAL AMBITIONS

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

My journey in the design world, ranging from motion graphics and animation to media art and UI/UX design in the automobile industry, has underscored my commitment to crafting meaningful movements in various contexts. Despite the apparent diversity of these fields, a common thread runs through them all: the pursuit of designing movement with purpose and significance. This shared pursuit has driven me to initiate this project focusing on the expressive movements of non-anthropomorphic robots in the hotel restaurant setting.

Throughout my academic and professional experiences, I've been captivated by the potential of movement to convey messages and evoke emotions. These experiences have made me believe in the importance of addressing the design challenges posed by new capacities that objects, like robots, have. Integrating robots in human environments holds the promise of enhancing efficiency and experiences, yet the practical adoption of these technologies presents its own set of hurdles. I am drawn to confront these challenges head-on and explore innovative ways to creatively bridge the gap between technological capabilities and their seamless integration into real-life scenarios.

My pursuit of knowledge has led me to delve into elective courses such as 'Human-Agent Collaboration', 'Interactive Formgiving', and 'More-than-Human Design'. These courses have heightened my awareness of the intricate dynamics of designing for interactions between humans and non-human entities. They have also highlighted the importance of embracing a holistic approach to design—one that considers not only the technical aspects but also the emotional and experiential dimensions of human-robot collaboration.

In undertaking this project, I aspire to prove and enhance my competencies in devising creative and effective solutions for complex design challenges. I aim to learn more about the intricate art of crafting expressive movements that effectively communicate intentions in the absence of traditional anthropomorphic cues. The project's focus on integrating principles from dramaturgy and utilising VR/AR technologies aligns with my ambitions to stretch the boundaries of traditional design practices. I am excited to leverage these tools to envision and develop innovative movement patterns that resonate with the hotel restaurant context and effectively address the human-robot interaction challenges.

FINAL COMMENTS

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

Initials & Name H Lee 6760 Student number 5659132

Title of Project Designing the hotel restaurant service robot's expressive movement

B. Ethnography In-Depth Interview Material

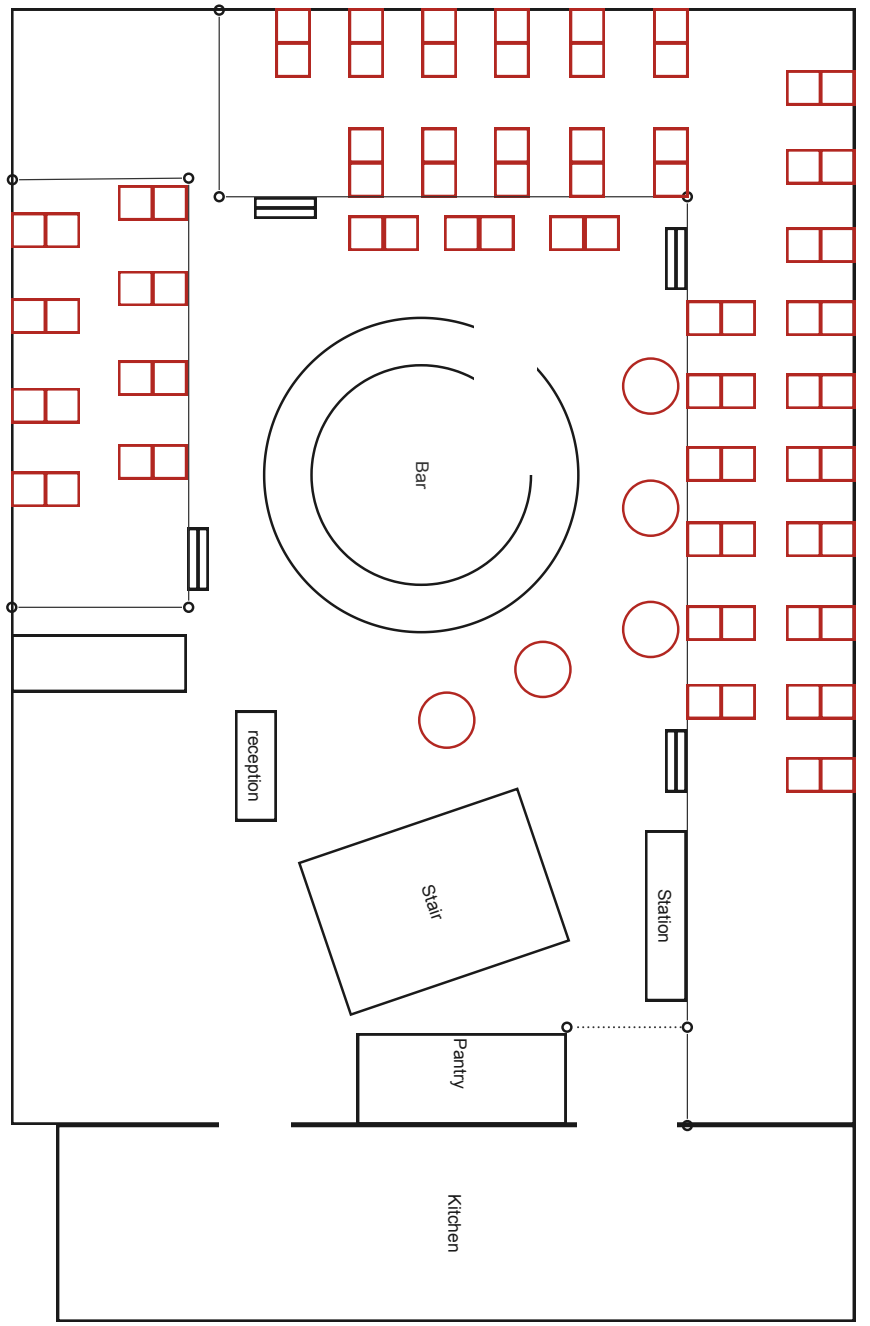
- What did you do so far since the last questionnaire?
- How was the service so far? like/dislike/interesting?
- Did you see, meet the robot? in which perspective?
  What were you and the robot doing? Please describe it by words or drawing.

- How would you score the current experience with the criteria below? You could consider the Atmosphere, Environment, Service, Employee, etc. (Doesn't need to be about the robot). Please explain the reason

	1	2	3	4	5	6	7
Inviting	o	o	o	o	o	o	o
Care	o	o	o	o	o	o	o
Comfort	o	o	o	o	o	o	o

- How much did the robot influence to the answer above?

o ..... o ..... o ..... o ..... o ..... o ..... o



C. Staff Body Journey

Guest	Enter	Sit	Select Menu	(Notify)	Make Order	Wait	Receive		Eat / Drink	Check	Leave
Staff	Greet	Introduce	Scout	Notice	Take Order	Prepare / Pick up	Serve		Visit	Check	Clean
Location	Entrance	Table	Station		Table	Station	Table		Table / Station	Table	Table / Station

**The gestures are made when a support is needed*

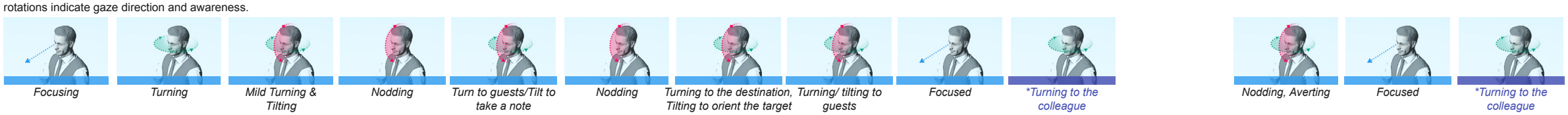
Lower body controls movement speed and responsiveness.

Static | *Normal* | *Slow* | *Normal* | *Very Slow* | *Moderate* | *Very Slow* | *Slow* | *Very Slow* | *Moderate*

Torso orientation and rotation convey attentiveness and personal care.

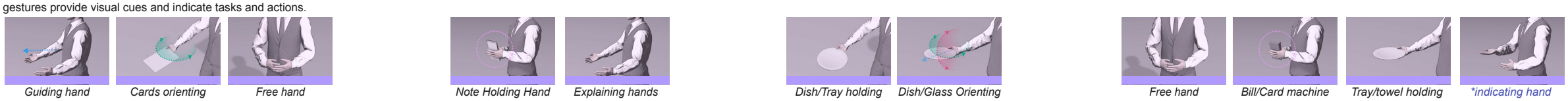
Orientating Body | *Y rot. to the table* | *Mild Y rot. wandering* | *Y rot. Orientating to the destination* | *X,Y rot. orienting to each guest* | *Delayed Y rot. to quite leave* | *Y rot.* | *Y rot. orienting to each guest* | *X rot. tacit Nearing/Leaving* | ** Mild Y rot. to the station* | *X rot. tacit Nearing/Leaving* | *X,Y rot. to Distancing* | *Y rot. Orientating to the destination*

Head rotations indicate gaze direction and awareness.



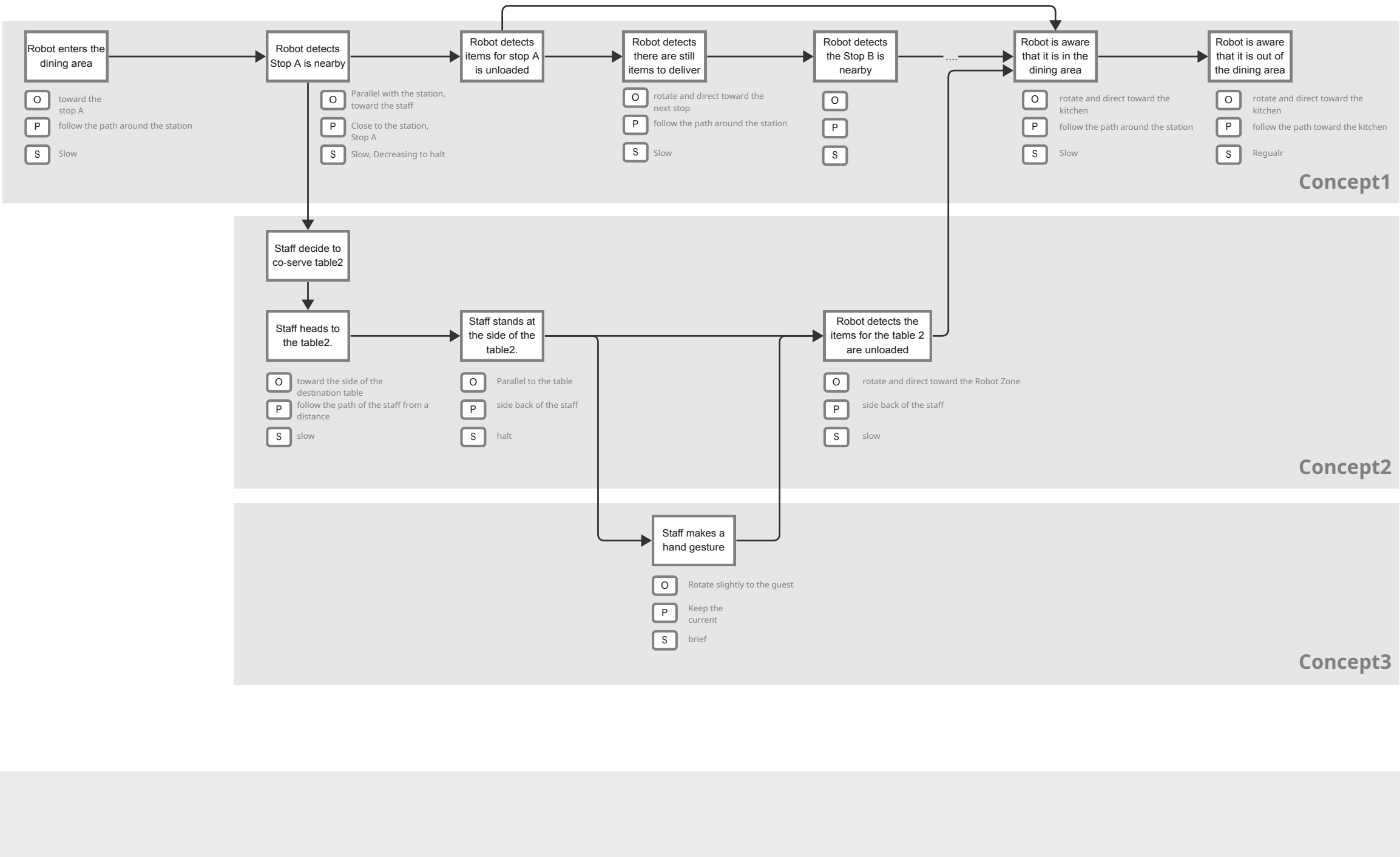
Focusing | *Turning* | *Mild Turning & Tilting* | *Nodding* | *Turn to guests/Tilt to take a note* | *Nodding* | *Turning to the destination, Tilting to orient the target* | *Turning/ tilting to guests* | *Focused* | **Turning to the colleague* | *Nodding, Averting* | *Focused* | **Turning to the colleague*

Arm gestures provide visual cues and indicate tasks and actions.



Guiding hand | *Cards orienting* | *Free hand* | *Note Holding Hand* | *Explaining hands* | *Dish/Tray holding hand* | *Dish/Glass Orienting* | *Free hand* | *Bill/Card machine holding hand* | *Tray/towel holding hand* | **indicating hand*

D. Movement Design Schema



E. XR Experiment Interview Script

Hotel restaurant robot's movement study in Mixed Reality
Session script
Expected duration per session : 45-60 min.

0. <u>Intro(10min)</u>

- Consent form
- The topic of the project and the aim of the study
    - The project explores the movement of a restaurant robot in a fine dining setting.
    - Movement can include its location, distance from you, orientation, speed, presence, etc.
    - We want to find out what kind of movement can enhance the experience of users, including guests and serving staff.
    - The concepts are not for judging just good or bad but for finding what is important for the robot's movement.
- Sensitising questions
    - Do you have experience working in the hospitality sector? Have you trained as serving staff? Or any other service provider? How long?
    - Do you have experienced dining in a fine dining restaurant? Have you been a guest of a fine dining restaurant? How often? With whom?
    - Have you ever encountered a robot in a restaurant?
- Introducing the XR study
    - We will start the XR experience, consisting of short situations. We will explore each situation from two perspectives, from guests' and serving staff'.
    - Even though it is a short experiment, you could feel motion sickness or discomfort from the XR. Please let me know, and then we can stop and have a break. If it continues, we can also end the experiment.
    - The XR setting is not perfect. Your imagination is required to fill the gaps, but more importantly, to trigger your creativity!
    - Keep imagining how it could be different in real life or how you would like to adapt.
    - Thus, I encourage you to think out loud while experiencing.

1. <u>XR experience – Concept1+stopping gesture (5min)</u>

- We start with a guest perspective. You already ordered your food and are waiting for your dish to come.
- Could you describe what is happening? (*Did you recognise the gesture of the serving staff?)* How does it feel?
- This time, try to be a real guest, don't focus too much on the robot, and act like you came here to dine

- You can now be a staff member and collaborate with robots.

- You find a robot waiting for you. You pick up dishes and serve them to the guests at table 2.
- Could you describe what has happened? How does it feel?
- This time, you have already found the robot's coming. How would you stop the robot?
- Could you describe what has happened? How does it feel?

2. <u>Interview for Concept 1 +Stopping Gesture (15 min)</u>

<u>*(M- Mandatory questions, A- Additional Questions)</u>

*	*Question*	*Intention*
	Guest Perspective	
M	How did you experience the movement of the robot from the perspective of being a guest?	the guest's perceived hospitality
A	Did you feel comfortable with the robot in the restaurant environment?	Regarding the perceived **hospitality** value (care,comfort,inviting)
A	Did you feel taken care of by the service providers, including the robot?	
A	Did the robot's presence contribute to creating an inviting atmosphere in the restaurant?	
M	As you were being served, could you share your thoughts on how you felt the **interaction** between the serving staff and you? Did the robot affect it?	Regarding the **interaction quality** (like responsiveness, reliability, and empathy.)
M	How did you perceive the serving staff working together with the robot affecting service quality?	Regarding the **outcome quality** (Safety, Efficiency, etc)
A	Were there any concerns or considerations regarding the robot's movement on working safely or efficiency?	
M		

	How suitable do you find this robot for the restaurant environment? Does it influence the attractiveness of the restaurant?	Regarding the **physical environment quality**
	Staff Perspective	
M	How did the robot's movement contribute to or hinder your tasks?	The staff's perceived collaboration quality
A	*Could you give more attention to the guests?*	
A	Were you able to **read** the robot's intentions and actions its movement?	Regarding the **mutual responsiveness** of the collaboration
A	To what extent did you feel in **control** while interacting with the robot?	
M	Did working with the robot shift your **perception** of your **role and responsibilities**?	**Job Satisfaction and Empowerment**
A	Did the robot's movements affect your confidence in working alongside of it?	

3. <u>XR experience – Concept2+introducing gesture (5min)</u>

- We start with a guest perspective. You already ordered your food and are waiting for your dish to come.
- Could you describe what is happening? (*Did you recognise the gesture of the serving staff?)* How does it feel?
- This time, try to be a real guest, don't focus too much on the robot, and act like you came here to dine

- You can now be a staff and collaborate with robots.
- You find a robot waiting for you and decide to serve table 2 together.
- You approach the table first and start interacting with the guests. You can serve the table by unloading the items from the robot and placing them on the table.
- Could you describe what has happened? How does it feel?
- This time, an intrigued guest asks about the robot. You can introduce it with a gesture, triggering the robot's reaction.
- Could you describe what has happened? How does it feel?

4. <u>Interview for Concept 1 +Stopping Gesture (15 min)</u>

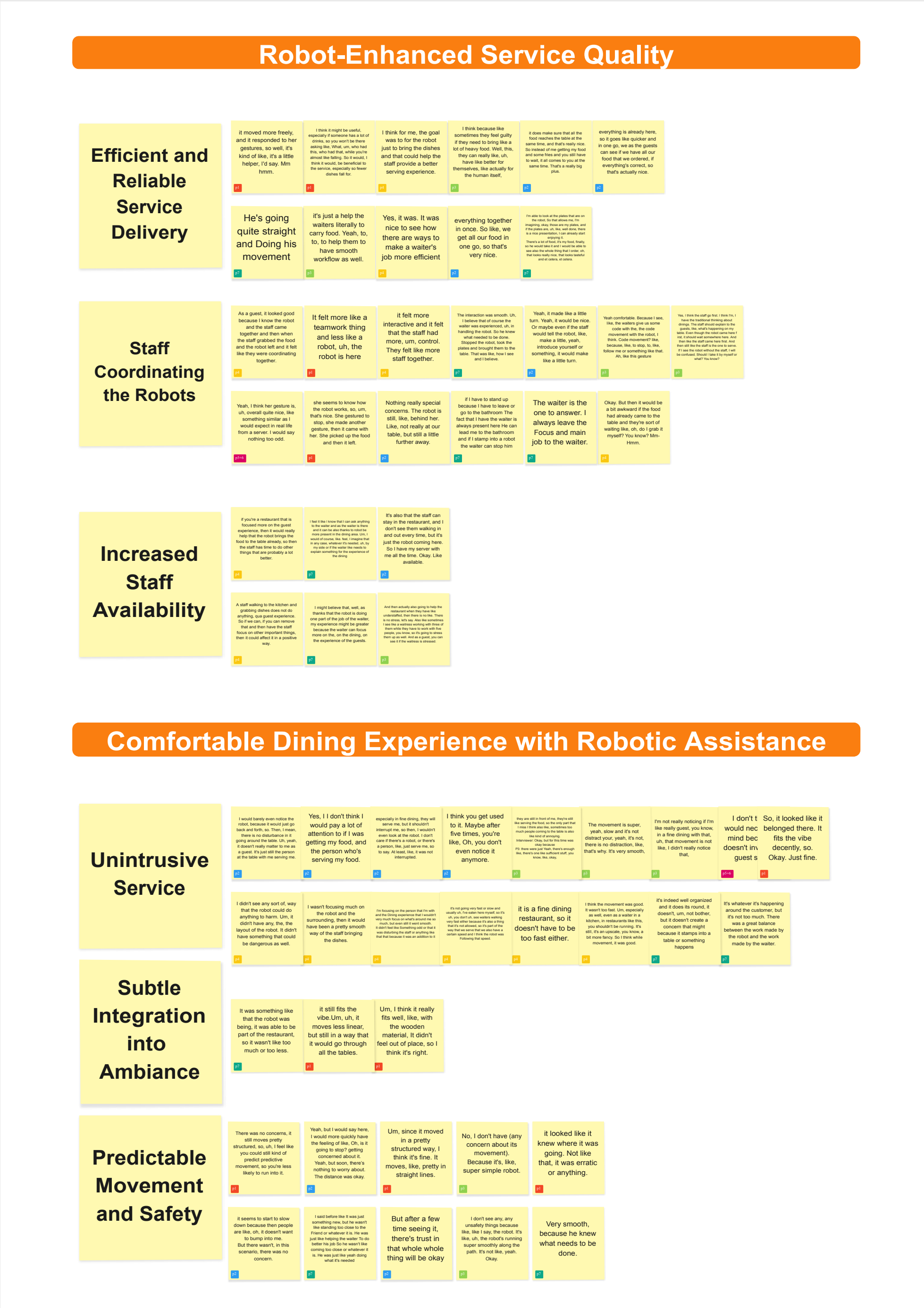
<u>(M- Mandatory questions, A- Additional Questions)</u>*

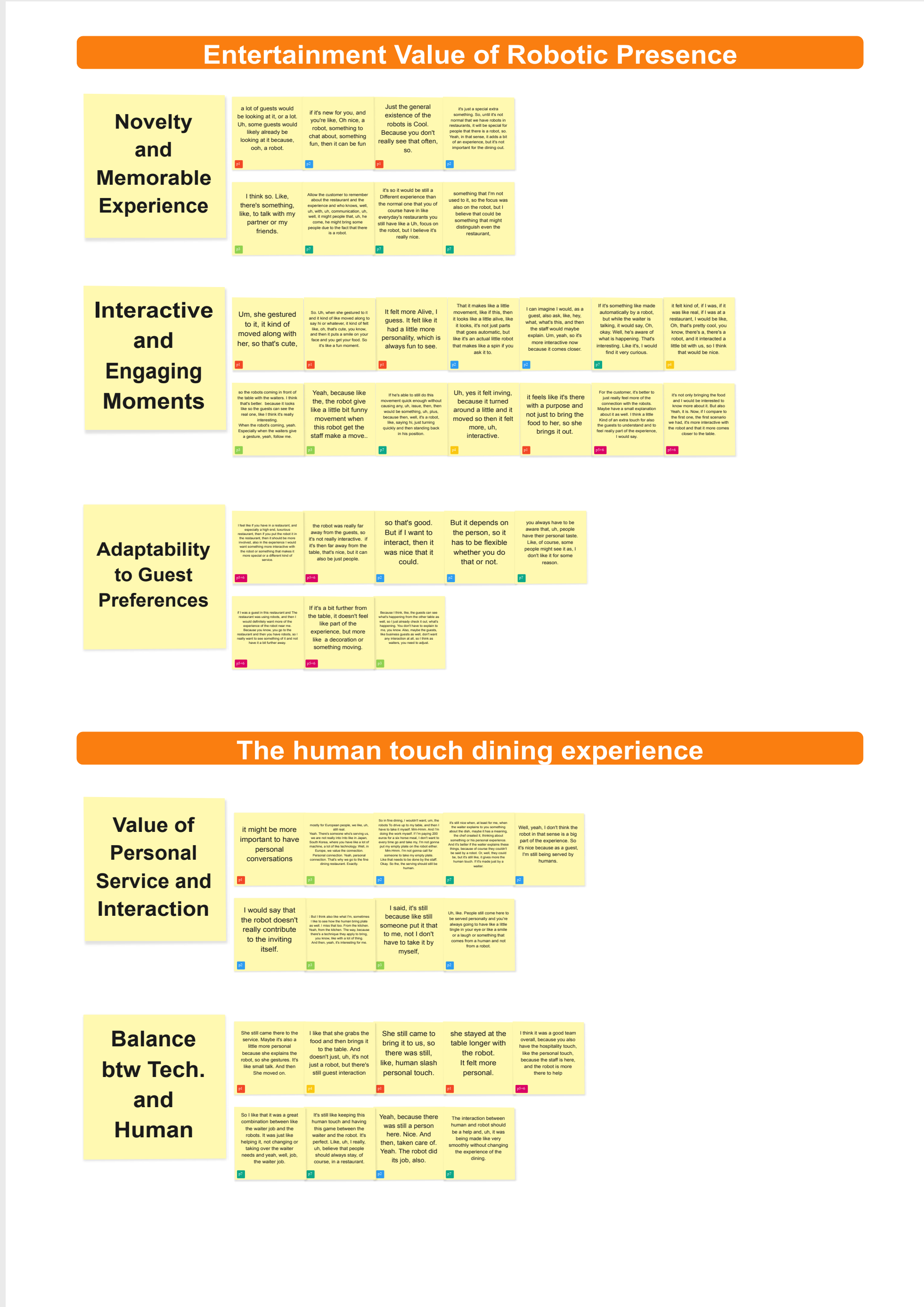
	Question	*Intention*
	Guest Perspective	
M	How did you experience the movement of the robot from the perspective of being a guest?	the guest's perceived hospitality
A	Did you feel comfortable with the robot in the restaurant environment?	Regarding the perceived **hospitality** value (care,comfort,inviting)
A	Did you feel taken care of by the service providers, including the robot?	
A	Did the robot's presence contribute to creating an inviting atmosphere in the restaurant?	
M	As you were being served, could you share your thoughts on how you felt about the serving staff and the robot, interacting with you?	Regarding the **interaction quality** (like responsiveness, reliability, and empathy.)
A	*Did the collaboration between the serving staff and the robot influence your overall dining experience? If so, how?*	

A	*Was it entertaining to witness the collaboration between the serving staff and the robot? If so, how?*	Added value to entertain the dining experience
M	How did you perceive the serving staff working together with the robot affecting service quality?	Regarding the **outcome quality** (Safety, Efficiency, etc)
A	Were there any concerns or considerations regarding the robot's movement on working safely or efficiency?	
M	How suitable do you find this robot for the restaurant environment? Does it influence the attractiveness of the restaurant?	Regarding the **physical environment quality**
	Staff Perspective	
M	How did the robot's movement support the actions you needed to perform or hinder you in your actions?	The staff's perceived collaboration quality
A	Were you able to **read** the robot's intentions and actions its movement?	Regarding the **mutual responsiveness** of the collaboration
A	To what extent did you feel in **control** while interacting with the robot?	
M	Did working with the robot shift your **perception** of your **role and responsibilities**?	**Job Satisfaction and Empowerment**
A	Did the robot's movements affect your confidence in working alongside of it?	

5. **<u>Closing (5min)</u>**
    - Thank you for your participation.
    - Do you have any final comments about today's experiment?

F. Evaluation Analysis Cluster






Enhanced Productivity through Robotic Assistance
Streamlined Service and Reduced Workload
Increased Interaction and Enhanced Guest Experience
Added Complication
Coordinated co-performance
Understanding the New Workflow with the Robot
Staff leading the co-performance:
Importance of Flexibility and Adaptability:
Upholding Fine Dining Nuances with Robotic Assistance
Adherence to Fine Dining Protocols and Elegance
Flexibility in Engagement
Staff's Sustained Professionalism, yet emerging roles
Maintaining Professionalism in Guest Interaction
Emerging Roles

Operational benefits

Operational Efficiency

- And then actually also going to help the restaurant when they have like understaffed, then there is no like. There is no stress, let's say. Also like sometimes I see like a waitress working with three of them while they have to work with five people, you know, so it's going to stress them up as well. And as a guest, you can see it if the waitress is stressed. (p3)
- Especially in large restaurants where you have to walk up and forth a lot. Like Sea Palace, for instance, that's huge. So then it would help (pm1)
- think a lot of people would like to work with it, because it Well, you have to walk less, so your legs are less tired at the end of the evening. (pm1)
- Absolutely. So, uh, staff shortages are a theme, a concern for many industries, also the hospitality industry. (pm2)
- you could cut costs on, uh, on labor (pm1)

Marketing Advantage

- it would give it a selling point. (p1)
- quite smooth. Um, it was, of course, as I said before, something that I'm not used to it, so the focus was also on the robot, but I believe that could be something that might distinguish even the restaurant, (p7)
- Allow the customer to remember about the restaurant and the experience and who knows, well, uh, with, uh, communication, uh, well, it might people that, uh, he come, he might bring some people due to the fact that there is a robot. (p7)
- I feel like if you have a concept, like a luxurious concept with really all the digital technologies involved, then it would be great to have a robot like that because that really enhances the experience. If the restaurant is not so focused on the new digital trends of the future and the technologies. That's the future brings, then I wouldn't do it in this restaurant. (p5+6)
- If that's what the restaurant is going for, yes. Interviewer: What kind of, what would be the aim of the restaurant? P4: Um, to be a bit more modern and Focus on other things that can help the staff. (p4)
- I think it sort of makes it more modern in a way and more aligned with like the current trends in the world. (p5+6)

Applications in Practice

Strategic Spatial Arrangement

- I think for a restaurant, you can easily adapt your interior to make the robot pass easily. (pm1)
- if you would work with a robot like this, you could also make the table be more approachable for the robot. So make it a bit higher or have a little, uh, curve in it so the robot can actually park like next to the table. (pm1)
- I don't dislike the design. It fits with the furniture and it does its purpose, you know. It has two levels and Yeah, that's great. (pm1)
- So then the robots may just seem like it's in the way or that it's very small restaurants or it's too crowded or something like that. (p4)
- I mean, here it's, it's spacious. Over there, I said you could have two stations. I wouldn't do a second station there because it's very tight. (p2)

Workflow Coordination

- The food, if the food's good, the drinks are on time. Wouldn't that matter? No, I don't think so. It would be, could be distracting, a little bit distracting as well, that you constantly see robots around. (pm3)
- So if the When a robot presents itself at the table, the timing with the staff member needs to be, uh, coordinated as well. Otherwise, the pancakes will get cold, (pm2)
- But still like it should be coordinated. So it's kind of, it needs to be tightly coordinated. That's great. And the staff member should not be waiting, right? So that's kind of crucial. Yeah, true. (pm2)
- So the robot would have to be flexible because The setup of the restaurant changes every evening, (p2)
- I would like to explore then. And, and eventually I would like to, uh, be able to, to program a part of it. So I can determine its route or, um, um, change, um, day by day, how you want to serve people (pm1)
- what I mainly would like is to, uh, for instance, not to have to call you every day to reprogram it, but to have it easy to use and to, uh, be able to let it go. (pm1)
- my restaurant looks different than yesterday, that the robot would still be able to find its way through the furniture, that would be important. (pm1)
- if you have to serve people quick, and there's a lot of plates on the robot, then you would have it closer by to the table, I think, what you already mentioned, because that's just quicker and more convenient. But if you want to be a bit more elegant situation, you may, maybe you want the robot a bit further away. (pm1)
- Because a robot is not a human being. So it's gonna, it's, it can, I can imagine it's got, it cannot adapt as quick as a human being can. It cannot walk as fast as a human can, and it cannot improvise as a human being can. The difference there is quite crucial, especially in a hospitality outlet. (pm3)
- so it has to be very adaptable to, uh, to the situation (pm1)
- Yeah, you know, you have, when you have a, quite a large restaurant with a lot of different guests, different plates, different menus, a lot of exceptions, guests not being allowed to have certain ingredients. Yeah, how would that work out? That is something I'm, I'm, I'm curious too. (pm3)
- I used to do when I worked in, in, uh, fine dining restaurants, um, We would do a briefing, and we still do that over here as well, before service starts. So we gather around and we discuss which guests are coming, what their preferences are, at what time they're coming. Uh, so what, what to focus on for that night. And, and in that briefing I would then also conclude the, uh, the, the robot's features and how to use it and, uh, when not to use it. So, yeah, that's probably (pm1)
- you have to adapt yourself to the route of the robot. So there is no real room for improvising and doing what you want to do because you need to take the robot into consideration. (pm3)
- Because if, if you're used to a certain way of working, it's part of your routine. But disruptions tend to, uh, throw people off. People are not that flexible. We try to think that we are flexible. We're not, right? We think in structures and, uh, habits and, uh, Um, so that could be something that potentially is a, uh, a risk. (pm2)
- if you have a big group, for example, like 10 people and are there, will there be multiple robots then? Um, will there be support from other staff members to take off the plates? Yeah, that could be a situation, maybe. (pm3)
- this restaurant is never the same, depending on the guests that you have. So sometimes You have to set the tables differently. If that also would mean that you have to program the robot differently, (pm3)
- Because you have guests with you. Every guest is different. Adaptions need to be made very often as well. for example, if a guest at the last minute mentions she did not know on the menu that there were oysters and she gets the dish at the table it contains oysters. the service staff, okay, I'm very sorry. Perhaps I was not clear, but I don't like oyster. Then you have to very quickly take it back to the kitchen, get something new. That is, I can imagine you don't. You cannot use that a robot for that. Mm-Hmm, . (pm3)

Reliable Maintenance and Implementation

- But is the gesture.., would it be more sensitive? If it goes wrong, the robot doesn't do what you want? Yeah, that could be the concern. (pm1)
- Um, if it's not functioning properly, there might be a risk that I'm going to see it as a gimmick, but as soon as it functions, then it would be a tool, something that would be accepted in the fine dining setting. it's still about the human touch, right? It is a Aid. (pm2)
- So reliability in the operations, um, there might be with a new introduction of a robot, there might be some issues. (pm2)
- That would be something that shift managers or the Restaurant manager, uh, would take care of, um, so, but to maybe, uh, uh, some of the more operational aspects, yeah, it's like a cash register. Any waiter or waitress needs to be able to work with the cash register. There might be some functionalities that he or she should be able to, uh, do. perform with the robots as well. (pm2)
- To what extent is a robot really supporting, and to what extent does it actually require even more work to function within a restaurant? And to what extent does it really take away from actual tasks and relieve the staff members? This is something really unveiled yet. (pm3)
- Maintenance. Well, If the robot doesn't function well every other evening, then we're going to need to spend too much time in fixing it, right? That is a, uh, a negative thing, right? (pm2)
- So it should be somehow really easy to use so that you don't even have to learn. It's functional. It needs to support humans in their basic tasks. (pm3)
- But yeah, what I said, we have to test it, see what actual staff likes. (pm1)

Grounded innovation strategy

preparing the restaurant in the future

- I don't think it's disturbing anymore these days to use help like a robot as such. (pm1)
- I like technology and we should use it, uh, to its best purposes. (pm1)
- Now this might be, uh, in the future as, um We will see for sure more robots in restaurants or in, uh, uh, hospitality, uh, um, so we're going to get used to it. (pm2)

sustained guest service with the human-touch

- It's going to be of value anyways in the efficiency. But if you talk about guest perspective, then you need to take other aspects into consideration. (pm2)
- If the efficiency is only used for business reasons, without using the opportunity to have more quality time at the table, right? Enhance the interaction. Then I would, uh, not, uh, be as, uh, happy (pm2)
- And that gives the waiting staff even more time to serve (pm1)
- You're not taking away the, the human part in service, but it's just helping service. (pm1)
- I absolutely understand that he doesn't need to do too much because he just needs to bring the plates to the waiter (p7)
- think that, um, no one would be interested in running plates to the dishwasher room, right? I like that. Yeah, so if it enhances their Uh, um, ability to spend time where it really matters. Be on the floor with guests (pm2)
- I'm from a very traditional part in hospitality where I think that, you know, the liveliness of people and actually people bringing the plates and working together to improve guest satisfaction and to enhance the experience, that is something that speaks more to me than, than a robot constantly moving from A to B (pm3)
- I'm more of a traditional, I like the more traditional kind of hospitality where you, where there are actually people working, you interact with. Um, I like the liveliness. So, Robo takes away from that if you ask me. (pm3)
- Yeah, and you know, uh, the fine dining part comes in where a lot of explanations are done at the table, where you interact about the food, about the wines. (pm3)
- that the guest would pick it off the robot themselves. Um, but this would not be something that I, uh, already think that the, uh, the guests would be ready already. (pm2)