An Ethnography of Restaurant Robots in Japan: Promises, Perceptions, and Impacts

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Abstract

Robots are increasingly being used in restaurants to assist with service and increase efficiency. Yet, their impact on the daily work of restaurant workers, customers' perceptions, and robots' limitations are poorly understood—and so is the gap between these and official marketing narratives. In this paper we conduct an investigation of the impact of restaurant robots in a set of restaurant chains in Japan, through a combination of in-person ethnography and analysis of online customer reviews and news articles. We show how robots are used in practice, how they structure work, and their impact on workers and customers. In particular, while we find robots to be well integrated and 'invisible', and majorly well received by customers and management, we also find they lead to a customer-perceived loss of human contact, a restructuring of work, an incentive for shortstaffing, deskilling of workers, and several technical challenges that are collectively addressed by workers and customers in work-like tasks. We compare these findings with marketing and management-led narratives, identifying gaps consistent with labor and power-centered critical studies.

CCS Concepts

• **Human-centered computing** → **Field studies**; **User studies**;
• **Computer systems organization** → **Robotics**.

Keywords

Robots, Restaurants, Ethnography, Labor, Workers, User study

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1 Introduction

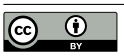
Public space service robots are increasingly being deployed in streets [11, 24, 29] and commercial spaces [20, 37]. Concretely in restaurants, order-delivery robots have started being widely used around the world, such as in China [42, 45], US [37] and Japan [37]. Restaurant robots are often claimed to improve service efficiency and quality of work [36, 37], even though these claims are at odds with recent critical studies of robotics and labor [23, 24, 41]. Their impact on service, work, and customers is still unclear, and so are the robots' limitations and the gaps between these and marketing narratives [2]. This knowledge is important to understand the real impact of robots in society, as well as to inform the development of new methods in technical and social robotics.

In this paper, we investigate the promises, perceptions and impact of robots in a set of restaurants in Japan, all of which use the same robot platform for order delivery. While existing work on restaurant robots is focused on managers' perspectives, various studies in HRI have shown that managers' views tend to be in conflict with workers' [23], not necessarily aligned with customers' [41], and not capture important parts of daily-use [1, 17, 19, 41]. Therefore, we use a combination of in-person passive participant observation, document analysis, and digital ethnography of online customer reviews, in order to get a holistic understanding of perceptions and impact of restaurant robots—while at the same time overcoming issues with response bias and access to workers, which can be a challenge due to power relations in the workplace [23]. We make empirical and methodological contributions: **1)** We show how robots are used in practice in restaurants, how they affect work, how customers perceive them and what technical challenges arise. We find evidence that contradicts theoretical models of the roles of robots in service encounters [37], showing the need to go beyond marketing-aligned 'upskilling' narratives and towards more realistic models reflecting the reality of labor, capitalist incentives, and *deskilling*; **2)** We compare management-led narratives of restaurant robots with the reality of daily use and customer perceptions, contributing to the body of work on robotics narratives [2]; **3)** We make a methodological contribution: of leveraging online customer reviews as a method of HRI evaluation in public commercial spaces.

2 Related Work

2.1 Restaurant and Hospitality Robots

Recent studies have been conducted on the perceptions of restaurant and hospitality robots. Tuomi et al. [36] and Tuomi et al. [37] used interviews with managers, investors, founders and developers to identify potential roles for hospitality robots. They proposed five roles for these robots: support, substitute, differentiate, improve,



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and upskill. They claimed that robots can free employees from mundane tasks to focus on 'more complex' tasks. This claim is similar to those of other authors, who claim robots allow workers to spend more time on guests' experiences [9] and proactive interaction [36], or that AI allows them to focus on 'emotional intelligence' tasks [16]. de Kervenoael et al. [9] conducted interviews with managers of hotels and restaurants deploying robots, and a survey with customers, to characterize perceptions of robots. They found that intentions of customers to use robots were associated with perceived usefulness, ease of use, safety, appropriateness, engagement, empathy, value and other factors. Similarly, Xu et al. [42] conducted a literature review to identify hospitality workers' perspectives on robots, and found that they perceive robot adoption to depend on various factors, from job impact and cost, to functionality, usability and impact on work conditions. And Fu et al. [15] used interviews with hotel workers in order to investigate the reasons for resistance to robot adoption. They found usability and workload associated with robot usage and maintenance was also a concern. In this paper we focus specifically on restaurant robots in Japan. While the above studies provide useful initial models of factors affecting perceptions, they fail to take a critical look at work conditions and customer perceptions due to their research designs (e.g. manager interviews, researcher-administered customer surveys), which may not correspond to true perceptions and behavior [17, 18].

2.2 Restaurant Ethnography

In-person ethnography [12] and digital ethnography [6, 22, 26, 27, 44] have been used to analyze experiences in (traditional) restaurants. In particular, digital ethnography of online customer reviews has the advantage of being voluntary and unprompted by researchers, and decreasing response bias associated with proximity to service providers [22, 26]. It has also been shown to provide rich insights into experiences and perceptions of restaurant customers, such as authenticity perceptions [22], responses to marketing [26], and cross-cultural dimensions of restaurant evaluation [27]. We adopt a combination of these methods (in-person and digital) so we can triangulate information and overcome blindspots of each method. To the best of our knowledge, online customer reviews have not yet been used to investigate restaurant customers' perspectives of robots and their impact on service and work.

2.3 Ethnography in HRI

As robots start being deployed in the real world, researchers have argued for the need for ethnography as an HRI evaluation method [1, 17, 19, 29, 43]. Ethnography can contribute to a better understanding of impact on daily-life and in society [1, 17, 19], though it comes with challenges of site selection and ethics [43]. Jacobs et al. [17] defends the need to use critical multiplism [28] and triangulation for data quality, which in this paper we achieve through in-person observation, news articles, and online customer reviews.

The introduction of robots in public spaces and in homes has recently led to a surge in HRI ethnography research. In street delivery robots, Pelikan et al. [29] used video ethnography to investigate interactions between robots and pedestrians. They found these robots are treated as 'unremarkable', though they often require pedestrians to conduct mundane work for them, which was an aspect found by other authors as well [11, 24]. In the context of home robots, multiple studies have analyzed the use of vacuum-cleaning robots ("Roombas") [13, 34, 35]. Sung et al. [35] used digital ethnography to identify perceptions, failures, and user practices. Forlizzi and DiSalvo [13] conducted interviews and ethnography through home tours, and identified expectations, uses, and the impacts of robots on human practices. In care contexts, Blond [1] conducted participant observation in a care home, and identified multiple hardware, software and usability problems of robots used in group games. Wright [41] conducted participant observation in care homes in Japan, and found they led to deskilling and to a need for care workers to swap human care time for 'robot care' time. Similarly, Lee et al. [24] found that robots often lead to a decrease of *worker* efficiency due to the need to manage robot failures, across multiple contexts. This work of Wright [41] and Lee et al. [24], which also discusses the politics of robots, is perhaps the closest to ours in critical analysis and work-focus—even though here we focus on restaurant robots.

2.4 Worker-Centered Robotics

Current ethnographic work in HRI often focuses on users and passersby but, with few exceptions [23, 24], rarely on workers. For this reason, there have been calls to study the impact of robots on workers and on work [10]. In this direction, Lee [23] conducted a powerful and critical analysis of the relationship between warehouse robots and power relations. For example, they found worker views to be varied and dependent on decision-making power, and that robots reduced human control and perceived efficiency for some workers. Similarly, Malik et al. [25] investigate farm workers' perceptions of farm robots and their impact on work conditions. In restaurants, however, interviewed participants are commonly managers rather than waiters, potentially biasing the analysis. Dobrosovestnova et al. [10] similarly claims that employees in hospitality and entertainment are under-represented in HRI studies. Aligned with this body of work, we are interested not only in managers' and customers' perceptions, but also on worker impact.

3 Methodology

We used a combination of methods to characterize the uses, perceptions, impacts, and promise-reality gaps of robots deployed in restaurants. Concretely, our goal was to answer the following five research questions. **RQ1: How are robots being used in restaurants in practice?** Our goal was to understand how robots are used, what tasks they perform, and how they interact with customers and staff. **RQ2: What is the impact of robots on workers?** This involves understanding how robots shape work and the work environment, for example in terms of the nature and quality of work. **RQ3: What is the impact of robots on customers, and how are they perceived by customers?** This is similar to RQ2, with a focus on customer impact and perceptions. **RQ4: What kinds of technical limitations do restaurant robots have in practice?** Our goal was to identify current flaws of restaurant robots, to potentially inform future robotics research. And finally, **RQ5: What were the official promises and stated impacts of the introduction of robots, and how are those different from reality?** The goal was to compare the narratives used by restaurant management and marketing about robots, against the realities identified in RQ1-4.

To answer these RQs, we used a variety of methods: in-situ participant observation in restaurants deploying robots, digital ethnography and thematic analysis of online customer reviews, and document analysis of news articles about the same restaurants. We found the methods complemented each other by allowing to capture context and various perspectives.

We selected a set of restaurant-chains (i.e. a set of restaurant brands, each with multiple physical locations) due to their large number of physical locations, widespread use of a single robot platform in almost all locations since 2021, and availability of a large number online restaurant reviews. The restaurant-chains were: Shabuyo (an all you can eat buffet), Gusto (a Western-style food restaurant), Jonathan's (a Western-style food restaurant), and Byamin (Chinese-style food restaurant), all of which belong to a single corporate group "Skylark". All these chains had multiple locations and deployed the same delivery robots "BellaBot". BellaBots are commercial mobile robots with multiple trays for transporting orders or dirty dishes, and a cat-like face (figure in Supplementary Material). We avoided analyzing restaurants with other types of robots in order to avoid differences in results related to robot design or capabilities. We now describe our methods in more detail.

3.1 In-Situ (In-Restaurant) Ethnography

We visited 8 different restaurant locations, belonging to the 4 chains, throughout a period of 6 weeks. In each visit we conducted passive participant observation, not interfering with the usual operations of the restaurant. In order to avoid behavior bias due to being observed (Hawthorne effect [18, 37]) participant observation was covert—meaning both workers and customers were unaware they were being observed for a study. This fieldwork was conducted by the authors of this paper, two of whom are fluent in Japanese language. Each restaurant was visited by a single researcher each time. We visited restaurants at different times of the day, from early morning to evening, both during peak and non-peak hours. During participant observation, we sat and used the restaurant as regular customers, for about 1-1.5 hours in each visit. During our stay we observed the robots, their interaction with workers and customers, and the way the workers conducted their work. We took notes in text form on a mobile phone, recording: 1) basic visit description such as date/time, type/size/organization of restaurant; 2) how robots were used, their placement, materials about them, role assignment, worker workload; 3) event logs of interactions, incidents and challenges. We walked around regularly (refilled drinks, got tableware, used toilets) to get more natural chances to observe robots and workers. Note volume was 1384 characters on average—higher in first visits and decreasing over time as non-event sections could be noted as "same as visit X". Since observations were made independently by different researchers, we exchanged and discussed them after each visit, clarifying what was meant by notes, adding any aspects which were observed but not originally written—and merging notes to answer RQ1-5.

3.2 Customer Reviews

We used customer reviews from online review-websites, which allowed us to analyze customer perspectives while avoiding issues of bias associated with proximity of the restaurant or the researchers [22, 26]. We searched for customer reviews for the same set of restaurant-chains visited, and gathered those that mentioned the word "robot" (ロボット). We used the website "tabelog"[1], as this is the most popular restaurant reviews website in Japan. We found 140 unique reviews matching these criteria, all published before July 2024. Sharko (Author 2) conducted an inductive thematic analysis following Braun and Clarke [3]'s framework. They first read the reviews to familiarize themselves with the data, then they manually and iteratively coded the reviews, meeting regularly with Brandão (Author 1) to discuss and refine coding decisions, until reaching code saturation. We conducted a reliability check with an independent coder on a random set of 20% of translated reviews (N=26). Inter-rater agreement was 76.9%, indicating satisfactory consistency. Finally, Sharko and Brandão grouped codes into themes reflecting meaningful patterns in the data, and selected quotes illustrating each theme. In the paper we will use quotations translated to English, even though they were written in Japanese on the website. Translations were done by Sharko and checked by Brandão. Relative theme frequency is in Supplementary Material.

3.3 News Articles

We used news articles to obtain restaurant management's public position regarding the promise and impact of the robots in their restaurants (RQ5). Using Google, Maisaku and Yomidasu[2], we searched (in Japanese) for online news articles which simultaneously mentioned any of the visited restaurant-chains and the keyword "robots" (ロボット). We excluded duplicate articles and articles from blogs and local newspapers (i.e. we considered only major newspapers and news websites). We also excluded articles that did not have any of the following: 1) quotes or paraphrases from restaurant representatives about the robots; 2) statistics of the use or impact of robots. This led to a selection of 5 core articles from major news media—these were 'core' articles in the sense that they had the original quotes and information that were then repeated or referred to in other articles as well. The list of articles is available in References A. Sharko and Brandão then analyzed any quotes or paraphrases that related to RQ5 (official promises and impact), using a similar process to the one used for customer reviews, and gathered impact-related statistics mentioned in the articles.

3.4 Positionality Statement

We are a team from diverse backgrounds and non-Japanese nationalities. Brandão is a Computer Science academic, from Europe, with 8 years lived experience in Japan. Sharko holds a PhD in Social Science from a Japanese university, a BSc in Japanese Culture, and lived in Japan for 10 years. Sharko is native-level fluent in Japanese, while Brandão is an intermediate speaker. Evans, Wu and Ghoshal are PhD students with CS/CS/HCI backgrounds, from Europe/East Asia/South Asia, no lived experience in Japan. Tshuma is a PhD student with Social Science background, of African origin, and 8 years experience in ethnography. We acknowledge limitations arising from our personal and professional backgrounds, which we strove to address by regularly reflecting on potential biases, cultural assumptions, and values that might have influenced interpretations.

[1] https://tabelog.com/

[2] Databases of two major Japanese newspapers (Mainichi and Yomiuri Shimbun).

3.5 Ethics

The research ethics committee of King's College London approved this study. The in-person participant observation component of the study involved covert and passive observation, meaning both customers and workers were unaware that they were being observed for a research study, though their activities were also not interfered with. We opted for covert participation since debriefing waiters could affect behavior [18, 37], and debriefing shop managers could put social pressure and risk on managers and workers—due to relationships with their superiors and the Japanese corporate culture context. Due to this, we found covert observation to be not only more ecologically valid but also lower risk than overt. No image or audio data were taken that could identify individuals, and neither notes nor results name any individual or restaurant location, in order to protect against potential worker or manager retaliation.

4 Findings

4.1 Restaurant and Robot Background

All four restaurant-chains visited are described as "family restaurants" in Japan. These are American-style restaurants with booths that can seat 4-6 people, and they all involve some aspect of self-service such as for a drink bar. Most restaurants were of similar size, with around 50 tables and narrow corridors between them, and they all used BellaBot robots. These robots have multiple capabilities. They allow kitchen staff to put orders for different tables in each tray, which the robot can deliver in a sequence. They can also be configured so that they deliver items from customers to the kitchen—though they were not used this way in the restaurants visited. When robots arrive at a destination they flash a light on the tray that items should be picked from. Robots have a map of the restaurant with mapped table numbers. They can also coordinate not to bump into each other, so one of them may stop for others to go through. And finally, they can play sounds or music as they move, or to customers when they arrive at a destination.

4.2 How Robots Are Used (RQ1)

Restaurant-robot system. Robots were used similarly in all four chains. Each restaurant had 1-3 robots. Food was ordered by customers on tablets available at each table, though it was also possible to press a buzzer to call a waiter. Customers rarely did this (0-5 times across the restaurant per visit). Robots brought food from the kitchen to the tables, and then customers had to take their items. Dispatching to tables was done by the kitchen staff by pressing a table number on the robot's touchscreen. Robots also played music and sounds for awareness of their presence. Some restaurants had a large kitchen and could hold all robots in the kitchen, while others were narrow, and so only one robot could be in the kitchen at once. In these cases, the other robots would stay "parked" outside the kitchen but close to its entrance, waiting for their turn to go into the kitchen. Restaurant floors were flat and did not have any bumps, steps or gaps that would impact the stability of the robot.

Order delivery. In our visits, robots never used the capability to deliver to multiple tables in a sequence even though this exists. They always made a single delivery. Waiters and kitchen staff had discretion on whether to send off an order by robot or a waiter, though they preferred to use robots to deliver orders unless this was not possible. Sometimes this was not possible because the order did not fit the robot (e.g. a wine bottle), or because the pace of orders was too fast for robots to handle by themselves. In restaurants with a high volume of orders, waiters adopted strategies of order allocation that seemed most efficient to them. For example, a common strategy was to manually deliver orders to tables that were close to the kitchen, and to leave orders to more distant tables for the robots. This meant that customers sitting close to the kitchen often did not get served by robots. Some customer reviews mention this: "*Perhaps because my table was near the kitchen, the cat robot never served me. This is a secret, but I was actually looking forward to it.*".

Used even out of peak. Robots were used for all orders in early morning (as early as 6am), even when there were only few customers (4-7). At these times restaurants had a calm atmosphere, of a handful of people reading newspapers, sitting alone and eating breakfast before work. Only robots made loud noises to alert customers of their presence, though customers did not visibly express displeasure or dissatisfaction, nor did they complain.

Good integration, invisibility. Overall, whether at peak or off-peak times, and whatever the restaurant chain, robots were well integrated, seeming 'unremarkable' and almost 'invisible' to both customers and waiters. They felt to us like just another technical device in addition to tablets at tables for ordering food. Robots were not advertised anywhere on the restaurants. Only one restaurant-chain (Shabuyo) displayed instructions for how to use the robot, though these were tied with instructions of the buffet (e.g. how to get additional portions of meat, how long the buffet lasts).

Removal of human contact. Most restaurants (6/8) had self-checkout kiosks, for customers to pay the bill, and a sign was displayed at the entrance to inform customers they could sit anywhere. Therefore, in many of the restaurants it was possible to never speak with a waiter throughout the duration of the stay.

Social interaction. Robots interacted with customers by playing music and sentences to alert customers of their presence, they displayed an explanation on-screen when waiting for another robot to pass, and they asked customers to take their dishes when arriving at the table. Although we did not witness this in our physical visits, some customers in online reviews mention social interaction capabilities related to touching the robot: "*I searched (...) and found out that they can say 'Your hands are warm, meow', 'Stroke me'... but if you touch it too much it gets grumpy and says 'That's enough, meow'... Oh, I want to touch it!*".

4.3 Worker Impact and Perceptions (RQ2)

The tasks of waiters. In all restaurants we visited, waiters spent most of their time cleaning tables, manually taking dirty dishes to the kitchen (carried by hand or on a traditional wheeled tray), and cleaning and restocking the drink bar and buffet section of the restaurant. Only in a few restaurants (2 visits) did the waiters also welcome customers to the shop and guided them to a seat. Many of the visited restaurants had a single waiter for all 50+ tables, so waiters were typically too busy to welcome customers. Waiters interacted with customers only in the rare events when they brought an order manually to a table, or when they were called to the table to answer a question or a custom request.

Caring for the robots (new work). Waiters also kept an eye on the robots, since they often got stuck or became too slow—either around congested areas or when people were trying to get through. In such situations waiters quickly approached the robots and "helped" them, sometimes pushing them when they got stuck or immobilized, or gently squeezing through people together with the robot and taking it until the kitchen (2-3 times per visit). When customers were not present at the table, waiters noticed from a distance and approached to unload the order from the robot to the table themselves. Sometimes robots also froze and required simple intervention on the screen for re-initialization.

Short-staffing. Especially at peak times, waiters were extremely busy. Most often there was a single waiter for the whole restaurant (50-60 tables), and they constantly ran back and forth at high paces. Some customers also perceived the restaurants to be short-staffed, matching our own perceptions, e.g.: "*I thought there were hardly any staff*", and "*I looked around, but couldn't see any staff. I pressed the button, but there was no sign of anyone coming...*". As we will see later, manager motivations for deploying robots, as expressed in news articles, also validate these observations (Section 4.6).

4.4 Customer Impact and Perceptions (RQ3)

Cute and impressive. Most online customer reviews (50/143) mentioned the 'cuteness' or 'coolness' of the robots, e.g., "*The 'cat-shaped catering robot' was so cute that I thought about hugging and kissing it*", "*The cat ear robot is kawaii!*". Some reviews mention the robots were impressive and made the restaurant experience "high-tech" and futuristic, e.g. "*having meals served by a robot somehow reminds me of those futuristic restaurants I saw when I was a kid!*".

Good for children and families. Various online customers (12/143) said that robots were fun and exciting for children, and recommended visiting with children: "*It is surprisingly fun to have a robot serving food, must be great for families with young children!*", "*The robot brought the meal! My daughter is overjoyed!*". A few reviews (3/143) mention babies being scared by the robots, though customers mention this as a funny event: "*The kids cried because they were scared of the robot (lol)*".

Relaxing. A few customers (4/143) found robots to be relaxing: "*It was a weekday afternoon, so there were few customers, and only the cheerful voice of the cat robot echoed through the place. I was able to relax*", "*I was mentally tired that day, so I went looking for healing. To be honest, the taste didn't matter. I came to see the cat robot*".

Usage difficulties. Some customers (12/143) struggled to use the robot. For example, one resigned customer identifying as an older person wrote "*When the robot was facing the other way, I didn't know where to press, so I had to get up and wander around looking for it*", while another described issues of inclusivity and accessibility towards older people: "*this tablet & serving robot system seems rather challenging for elderly customers. The couple sitting next to me called the waiter to place their order, and I had to meddle and help them because they couldn't get their food from the robot. It's simply too much for them–hot soups are dangerous and heavy*".

Self-service inconveniences. A few customers were bothered by the self-service aspect of the robots, and expressed that it was inconvenient, e.g.: "*It was somewhat troublesome to get up and fetch it myself*", or "*It is too far away for you to lean over and take it, so you end up having to stand up and take the food out of the robot. Nah... It's too bad*". Importantly, some reviews explicitly state how this aspect can be physically hard and even unsafe: "*the act of standing up to receive the food from the robot every time is a hassle, and there are likely to be accidents when moving the food to the table*".

Labor perceptions. A few customers (3/143) expressed their perceptions of the impact of robots on labor. They wrote that "*this is an excellent labor saving system*", though they also had mixed feelings about the robots' positive impact, related to job replacement and cost: "*I have mixed feelings when I think that in the future many robots like this will be deployed in place of people!*", "*I heard that each robot costs about 3 million yen, but wouldn't the labor cost be cheaper?*". Therefore, robots made customers reflect about the future of restaurants and automation, often leading to the expression of reservations regarding their impact: "*I wonder if we will soon have unmanned restaurants. Our human jobs will also disappear one day*".

No human interaction. Customers had rare if any interaction with waiters. In most restaurants, customers entered, sat, ordered, served items onto their table, and paid—all without human interaction. Customers only rarely called waiters to the table, such as to ask them to clear the table or to request plates or spices. Some customers (7/143) left online comments related to lack of human interaction: "*Except for the checkout, the restaurant has become a place where you don't have to deal with people*", "*there has been absolutely no contact with the restaurant staff*". A few customers (5/143), some of whom self-identifying as older people, explicitly comment on how the lack of interaction leads to feelings of loneliness or sadness. For example, they wrote "*you order on a tablet and the food is served by a robot... It's a bit tasteless and sad for me. I thanked the robot politely and said goodbye*", and "*When I entered the restaurant, I didn't hear any human voice, only a sign saying 'Please come to your seat of choice'. The only sound was the cheerful robotic voice, and to be honest, it felt a bit lonely*". However, some also found the lack of human interaction to be positive, since robot delivery does not disturb or interrupt an ongoing conversation between customers: "*After a short while, a robot came over and stopped. It placed my order on the table and then departed (...) I suppose this way is better, as the conversation doesn't get interrupted*".

4.5 Technical Limitations (RQ4)

Robots being slow and getting stuck. The most common technical issue was for robots to get stuck with each other, with people (e.g. in narrow corridors), or against furniture (1-4 times per visit). In these situations robots had to be "unstuck" (i.e. pushed) by staff, as discussed in Section 4.3. Customers in online reviews also noticed and commented about these issues and their impact on customer navigation. They said, for example, that "*the aisles are rather narrow, so if you happen to bump into a cat robot, you'll get stuck*".

Robots getting "lost". Another common issue was for robots to get "lost"—arriving at the wrong table, or unable to return to the kitchen—likely due to localization problems. This led robots to mistake tables, the dishes being taken by the wrong people, and waiters having to solve the situation. We did not witness this in our visits, though customers in online reviews commented (and complained) about this issue. For example, one customer wrote: "*Even cat robots get lost. Our neighbor says, 'This is not ours'. I looked inside and saw*

that it was our fried oysters! I apologized for the cat-robot's mistake and placed the rice and fried oysters on our table.". Such behavior also led to frustrations, as exemplified by the following customer: "*for some reason it arrived at a neighbor table. Whether it was the robot's mistake or a human error, I couldn't tell. In the end, a member of staff brought it over. What on earth was that about?*".

Robots leaving early. Even though robot trays had weight sensors, they sometimes sensed orders had been taken away even when there were still light items on the tray. This led robots to return to the kitchen with a part of the order, and led customers to have to run after the robots or call the waiter. We witnessed this in one visit, and one customer review mentions such a situation as well: "*A robot delivered the food. I must have touched it somewhere, because the robot moved away before we could grab our items*".

Inflexibility. Sometimes (0-2 per visit) robots arrived at a table when customers were not present (e.g. because they went to the toilet or the drink bar) and so robots waited until a waiter realized the issue or the customer returned. This aspect lowered the efficiency of the system, and added to the work of waiters.

4.6 Promises and Reality Gaps (RQ5)

Improving service. According to our news article analysis, the main focus of the official messaging of the restaurant-chains about the introduction of robots was to "enhance service through collaboration between humans and robots" and to "improve customer satisfaction" [A-(1)]. Some articles mention various statistics (provided by management and the robot supplying company) related to customer satisfaction: one indicating that there is support from more than 90% of the customers, and another indicating that 50% of shop managers say 'customer satisfaction' is a reason why they are happy about the introduction of robots [A-(1)]. Management interpreted customer satisfaction as three aspects. First, lower waiting time: "*In order to improve customer satisfaction, we needed to be able to increase the turnover rate of seats without making customers wait during peak hours*" [A-(3)]. Low waiting times were indeed observed in our fieldwork, as well as noted in online reviews. This improvement arises from the increased number of deliveries per time made by the robots, and by the fact that waiters focus on clearing tables quickly as soon as customers leave. Second, management said the introduction of robots led waiters to have more time to keep the bar and restrooms cleaner. And third, management claimed that robots would "enhance services that only people can provide" [A-(4)], by allowing waiters to have more time for conversation with customers. In one article [A-(3)] they are quoted saying: "*during morning hours, we have many regular customers who come to the restaurant in the morning because they want to talk with the employees. Considering this, I think it is important to connect communication between employees and customers, and I believe that robots can help make this happen*". This statement was in stark contrast with our observations, where in the mornings there was a single waiter busy with various tasks, and no customer conversations, as well as in contrast with customer online reviews describing sadness and loneliness of lack of interaction (see Section 4.4).

Improving working conditions. Management also claims that the introduction of robots improves working conditions for waiters, saying that they create a "comfortable working environment" [A-(4)]. They claimed that robots reduce physical burden of waiters, especially senior staff, who do not need to carry as many things. This is an interesting perspective on the benefits of robots, which also widens the pool of candidates for hiring to older staff. Another aspect of improved working conditions, according to management, is the reduction workload of employees. They do not explain how robots lead to a reduction of workload, and this claim is partially contradicted by other statements referring to the reduction of the number of employees, and our and customers' online observations.

Controlling staff numbers. Management is careful not to say that robots reduce the number of employees: "*the reason is not to reduce the number of employees (...) but there is a chronic shortage of human resources*" [A-(3)], instead they claim that the goal of robots is to "*be able to handle the restaurants with the same number of employees as before covid, even though there are more customers*", so "*instead of hiring 4 workers, we hire 3 and a robot*" [A-(3)]. The statements also do not entirely match our observations and those of online customers—of a single waiter per restaurant–unless "workers" in the management's sentence is used to include both waiters and kitchen staff. The statements are also contradicted by statistics presented in one of the news articles [A-(1)], indicating that 64% of shop managers say that "being able to operate even if short-staffed", and 43% say that "reducing labor cost", are reasons why they are happy about the introduction of robots.

Increasing job application numbers. Management claims that having robots is an incentive for recruitment and retention: a competitive advantage. They say that some waiters are happy to try to work with a robot, and that they receive 14 times more job applications because of the presence of robots [A-(1)]. One of the reasons for this, as we have seen, is the ability to hire older staff, though management also mentions the ability to hire foreign staff [A-(4,2)]. Although they do not discuss this statement in the articles, it is clear that foreign (implying non-native speaking) waiters can work in the restaurants because human interaction is almost fully removed by the introduction of robots.

Initial marketing attention While robots were not advertised in the restaurants at the point of our fieldwork, they were part of marketing in the initial stages. In some articles, management stated that shop posters were initially used to advertise when robots would be introduced, and that they received much attention because of this, including people calling to ask when a shop would have robots. In a quote they say "*senior customers were unexpectedly receptive to the service. They were taking pictures and videos and looking at the robots with great interest (...) we received so much interest that we had inquiries at our customer center asking when the robot would be available*" [A-(3)]. However, this extra attention was not the main motivation for introducing robots, as only 7% of shop managers said "getting attention to the shop" was a reason why they were happy about their introduction [A-(1)].

5 Discussion

5.1 Roles of Robots & the Upskill Promise (RQ1)

In all locations we visited, robots were used mainly as self-service machines, and supported and replaced parts of the work of waiters. Our findings are consistent with four of the five roles of restaurant

robots introduced by Tuomi et al. [37]: support, substitute, differentiate and improve, though we find the opposite of the 'upskill' role—as we will discuss, we find evidence of deskilling instead. "Support" roles involve "dealing with routine tasks, freeing human employees to focus on more complex and dynamic situations" [37]. Our findings support this, since robots dealt with the routine task of delivery. However, our results do not show that the role necessarily leads workers to focus on "more complex" tasks: waiters spent most of the time on arguably equally-complex tasks of cleaning and maintenance. A new task was introduced: to maintain or debug the robots themselves, although this did not seem complex as the interface was simple and waiters could just push robots around when there was a problem. "Substitute" roles involve "replacing human employees completely in a sequence of service encounters" [37]. Several or most customers were served completely by robots, which substituted worker labor of delivery even if they sometimes required assistance. Robots additionally performed *job* substitution: they were used to run restaurants understaffed, therefore replacing workers in practice. "Differentiate" roles involve "offering service businesses a unique chance to attract customer interest" [37]. This role is overwhelmingly supported by our study, as robots attracted customer interest for their novelty, uniqueness, or suitability to children, as evidenced by customer reviews. And "improve" roles involve "utilizing resources more efficiently, allowing businesses to place a greater focus on improving service offerings" [37]. We saw that robots had an impact on the efficiency of *human* resources: robots allowed restaurants to operate understaffed, to deliver dishes more efficiently, and according to restaurant statistics they led to shorter waiting and seating times.

"Upskill" roles involve "changing service employees' required skill sets and transforming existing roles" [37]. The authors claim that robots allow staff to spend more time on research, creativity and technical tasks, and have "more interesting" jobs. Our results do not support this role in the restaurants we visited. In practice, humans were asked to perform any tasks that robots could not still perform, such as cleaning, delivering unfulfilled orders, or pushing or charging robots—and they did not lead to creative tasks nor increased communication. Technical repair was not done by restaurant workers but outsourced to a robot company. Furthermore, management claimed being interested in robots taking over affective roles such as conversation. Quite the opposite to upskilling, our findings point to management using robots to remove human contact and lower the barrier for waiter recruitment, so as to hire non-Japanese speakers and workers without experience, as evidenced by their own quotes (Section 4.6)—in effect eliminating skills that might provide worker bargaining power. Such practices align with Braverman's analysis of how capitalism fragments skilled labor to enhance managerial control [4], and are consistent with critiques of AI and robotics as leading to downskilling [23, 32] and being mainly driven by capitalist cost-saving and downskilling incentives [14, 23].

5.2 Impact on Waiters & Robot Care Work (RQ2)

We found that most restaurants were shortstaffed, and workers still performed mundane and repetitive work. While workers performed less carrying, they did more cleaning, restocking, and robot 'caring', therefore not leaving time for emotional intelligence tasks. This lack of positive impact on waiters' work was perceived both in physical and online ethnography. Therefore, our findings are consistent with the work of Wajcman [39], which shows how technology can change norms in a way that places higher demands on its users—workers in this case, though also customers. Our observation that waiters spent large amounts of time monitoring and caring for robots further aligns with recent findings in other contexts [9, 15, 23, 41]. For example, Fu et al. [15] showed that hotel workers found too much time was spent using, maintaining, and helping others use the robots, and de Kervenoael et al. [9] pointed out that malfunctions lead to extra work. In care homes, Wright [41] argues that work spent on maintaining robots is also 'care' work that shifts attention away from the tasks that workers find most meaningful. These findings demonstrate a lack of consideration of workers wants and needs, and concretely a need to involve them further in the development of restaurant robots [10]. Most decisions behind the use of robots seem to have an economic rationale instead of a waiter wellbeing one, as demonstrated by shortstaffed restaurants and waiters operating at extreme speeds.

We did not find strong resistance to the technology from workers, in the sense of workers sabotaging or refusing to use the robots. In general, resistance models such as Fu et al. [15] and others [42] either do not distinguish who is resisting (e.g. management, customer, worker), or they assume workers have the power to decide or resist in any way other than quitting the job—which is unlikely to be the case given workers' often precarious positions. The absence of worker resistance despite job displacement and intensified labor reveals deeper power dynamics than previous critical HRI literature acknowledges [40]. Our ethnographic observations also uncover "psychological redundancy", since workers may internalize their dispensability while becoming responsible for maintaining the technology that displaces them. This phenomenon arises from prioritization of robot needs over human needs—when robots malfunction, immediate human intervention is required—thus potentially creating alienated care relationships [30] where humans become responsible for technological failures without empowerment to address underlying causes.

5.3 Efficient but Lonely Exclusive Hassle (RQ3)

We identified various dimensions of robots' impact on customers, from efficiency and positive impressions, to user-provided work, lack of human contact and non-inclusivity. Users often perceived robots to be 'cool' and 'cute', matching positive feelings of novelty and excitement in the literature [45]. However, users also often portrayed robots as 'useless' due to the simplicity of their role and the need for frequent waiter intervention. Zhang et al. [45], through guest interviews, obtained similar findings of novelty, excitement, and inefficient reliance on waiter intervention, demonstrating the reliability of online reviews as a method of HRI evaluation in restaurants. Findings regarding service efficiency impact on customers were mixed: managers claimed lower waiting times, and in-person ethnography confirmed average low waiting times, but online reviews frequently complained of perceived inefficiencies and long waiting times due to robot glitches. Additionally, these glitches often led to inclusivity issues—penalizing older customers and those who struggled to self-serve from a sitting position. We found that

robots required attention not only from workers but also customers, who become part of the maintenance infrastructure of the robots. Customers unblocked robots, called waiters when they saw a problem, assisted other customers in using them, and sometimes had to be trained on how to use them. This means that robots introduce new work, not only for workers, as found by Wright [41] in the context of care robots, but also for customers themselves. Our findings thus highlight the impact of restaurant robots on customers' "consumptive labor" [21], i.e., customers are used by the service provider to perform work-like tasks as 'quasi-employees'. In robot-restaurants, customers perform work not only because they self-serve, as described by Koeber et al. [21], but even more actively by performing maintenance labor for the robot systems.

Another outcome of the introduction of robots in restaurants was loss of human contact, observed both in physical and online ethnography. Customers interacted less with waiters, or not at all: they found their own seating, ordered through interactive screens, received orders from robots, and paid through self-checkouts. Some customers pointed to a difficulty in finding staff, due to low staff numbers, and others inclusively described the experience as lonely. While loss of human contact has been one point of critique [33] and worker concern [8] regarding care robots, inclusively in Japanese settings [8], our findings show that similar concerns also apply to restaurant robots. Loneliness is more likely to be a problem in solo-dining customers, whose experience has been shown (in traditional restaurants) to be influenced by staff friendliness [7]—who mostly did not interact with customers in the restaurants we studied.

5.4 Technical Limitations & Implications (RQ4)

We identified various technical limitations of the robots we studied: from slowness of movement, getting stuck, and inflexibility, to getting lost and being unable to fully deliver orders. Excessive slowness of delivery robots has been reported in previous literature on hotel delivery [9, 15] and street delivery robots [5]. Getting stuck has also been reported in both settings [9, 11, 15, 29] as well as in home vacuum cleaning robots [35]. Getting lost and delivering to the wrong place has also been reported as an issue in delivery robots [9, 15, 36], with workers having to "chase" them [37] or reboot them [15] when this happens. Our findings of lack of flexibility (e.g. when users are not present at the table at delivery time) and the creation of inclusivity issues—are, to the best of our knowledge, novel. Robots were also incapable of traversing bumps, steps and stairs, placing limitations on the layout and design of the restaurant. The degree to which robot localization fails is also dependent on layout and the spread and uniqueness of visual features. Therefore, restaurant robots need a large investment in advance of their deployment: not only to purchase the robots and per-table touchscreens, to setup networks and create maps for localization, but also to adapt the physical world to the robots. This is similar to the 'roombarization' [35] of homes by vacuum cleaning robot users, who modify their homes so that they can traverse and clean effectively [13, 34, 35]. Future technical research towards more capable delivery robots should thus focus on solving our identified technical issues, by improving localization robustness, human congestion robustness (for example through social signals or soft nudging), investigating the social and technical acceptability of legged robots for bump and step robustness, manipulation-capable robots for complete and inclusive delivery and other accessibility adaptations such as multimodal communication and human hand-off options.

5.5 Promise-Reality Gaps (RQ5)

Our results show that restaurants' top management's narratives for the use of robots are that they improve service and working conditions, upskill workers, and attract customers. However, such narratives were at odds with reality. While they claimed improvement in waiting time, branch managers claimed the main motivation to use them was to reduce staff, and customers often complained of glitches leading to inefficiency. While top management claimed working conditions would improve, most restaurants were short-staffed (as per motivation), and workers were extremely busy. And instead of upskilling for better and more communication, there was a *deskilling* of workers (see Section 5.1). Managers' claims of improved service were also at odds with the lack of human contact, and with perceptions of robots as 'annoying' or a source of work for customers. Narratives of restaurant robots in news articles were therefore overly 'optimistic', which is consistent with narratives promoted by roboticists [2, 31] and by ideologies of technological progress [38]. However, not only were they optimistic, they were often in direct opposition with reality—which is a novel finding in our work, and shows the degree to which robotics narratives can be deceptive and a management of public opinion. Critically, while management was careful not to frame robots as job replacements, the de-facto normalization of understaffing legitimizes unsustainable labor arrangements by creating the appearance of efficiency—while intensifying worker exploitation. Single waiters managing 50+ tables becomes rationalized through robot "assistance", yet our observations show workers simultaneously perform increased cleaning, maintenance, and robot care tasks.

6 Conclusions

We investigated the promises, perceptions, and impact of restaurant robots in a set of restaurant chains in Japan, through a combination of in-person ethnography and analyses of online customer reviews and news articles. We found that, while robots were well integrated and received by most customers and management, they also led to a loss of human contact, restructuring of work, incentive for short-staffing, deskilling of workers, and several technical challenges that were addressed by workers and customers' consumptive labor [21]. We identified promise-reality gaps consistent with labor and power-centered critical studies. In particular, that robot adoption is driven primarily by capitalist cost saving and deskilling incentives [4, 14, 23]. Our insights on technical limitations indicate directions for future robotics research, such as congestion and terrain robustness, soft nudges, and inclusive delivery capabilities. Limitations of our study include the focus on a single corporate group, robot platform and country, and we therefore recommend future replication studies varying these factors.

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