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Robots in gastronomy: Psychological and financial considerations

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ABSTRACT

Both the popular press as well as a number of academic researchers have enthusiastically endorsed the possibility/prediction that (service) robots will come to play an increasingly important role in the world of quick service restaurants and/or gastronomy in the years ahead. This development, or so it has been suggested, may potentially help to address the seemingly ubiquitous staffing issues that are proving problematic for many in the hospitality industry nowadays. However, until the costs of installing, running, and maintaining such high-tech devices fall, and until such time as consumer opinion changes, such technology (be it robots for food preparation or else service robots) is unlikely to find a place in the market for fast food never mind in the world of fine dining (gastronomy). While robot bartenders and chefs would currently appear to have a certain novelty and/or experiential value, the financial case for their incorporation into the hospitality setting has yet to be convincingly demonstrated, even once the technical challenges have been addressed. As such, there is little sign that such automation will make its way (either in the front or back of house) into the world of either quick-service restaurants or high-end gastronomic establishments.

1. Introduction

Researchers have become increasingly interested in the role that robots might play in food provision in the years ahead. Indeed, fascination with the area of robot chefs, artificial intelligence, and service automation (Seyitoğlu et al., 2021), not to mention digital commensality in restaurants (gastronomy) has grown rapidly over recent years (e.g., Berezina et al., 2019; Ruggless, 2018). At the same time, however, many of the headline-grabbing press reports threatening/promising that the robots are coming – and will possibly replace jobs in the restaurant sector (e.g., see Burn-Callender, 2015; Reiley and Powell, 2022; Robinson, 2017) – would appear to have been overly pessimistic/optimistic (see Petre, 2023, for a recent opinion from the restaurant trade press). While the ongoing staff shortages in the restaurant/hospitality sector that have been documented in many parts of the world (see Mathath and Fernando, 2015), not to mention the long-term impact of the Covid pandemic, have undoubtedly stimulated interest in this area, the financial case for the introduction of robots (especially in the context of fine-dining restaurants) has yet to be made convincingly (see also Pouliot, 2016; though see Ivanov and Webster, 2019; Mathath and Fernando, 2015; Shimmura et al., 2020). Even in the context of fast food, the business case for robots to flip your burgers isn't obvious. For example, only last year, McDonalds CEO Chris Kempczinski was quoted as saying that: "It's great for garnering headlines, it's not practical in the vast majority of restaurants … The economics don't pencil out, you don't necessarily have the footprint." (Targett, 2022).

1.1. *On the rise of automation in the context of the restaurant*

There are a number of areas in which innovation (and automation) might and in some cases already is occurring. That said, the response of consumers to the introduction of automation and/or the use of artificial intelligence (AI) in both luxury and non-luxury (i.e., quick service) restaurants is by no means always uniformly positive (see Nozawa et al., 2021; Zemke et al., 2020). To date, a few operators in the restaurant industry have already adopted chatbots, voice-activated and biometric technologies, robot hosts, food runners (see also Wood, 2021), chefs/bartenders, as well as tableside ordering (and even drive-thru ordering at ten McDonalds sites in Chicago; see Lucas, 2021a; see also Victor, 2014), food conveyors (which, note, first appeared in Japan in the 1950s; see Sitwell, 2020), and robotic food delivery (e.g., Berezina et al., 2019; Eksiri and Kimura, 2015; see also Byrd et al., 2021). In fact,

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Genroku Sushi, which opened in Japan in 1958, was the first (sushi) restaurant to use a conveyor belt to move the plates of food along in front of the diners (see Sitwell, 2020, p. 164), and thus in some sense to automate the delivery of food to the customer.[1] This was a precursor of the hugely successful international Yo Sushi! chain (Issenberg, 2007). The introduction of the food conveyor represents one of the first examples of the automation of food service. According to Ritzer (1993), Burger King has long used conveyor belts to cook its hamburgers.

In his 1993 polemic *The McDonaldization of Society,* George Ritzer mentions a robot having been installed to flip burgers in a university canteen setting (see Greer, 1987, for original report). He describes how the University of Wisconsin at Stout built a robot that served hamburgers at the campus restaurant, writing:

> *"The robot looks like a flat oven with conveyor belts running through and an arm attached at the end. A red light indicates when a worker should slide in a patty and bun, which bob along in the heat for 1 minute 52 seconds. When they reach the other side of the machine, photo-optic sensors indicate when they can be assembled.*
>
> *The computer functioning as the robot's brain determines when the buns and patty are where they should be. If the bun is delayed, it slows the patty belt. If the patty is delayed, it slows bun production. It also keeps track of the number of buns and patties in the oven and determines how fast they need to be fed in to keep up speed."* (Ritzer, 1993, pp. 106–107).

1.2. Review outline

In the sections that follow, I want to take a closer look at a number of these areas in order to assess what progress has been made, and highlight the problems/barriers, technical, financial, and psychological, to adoption that have been encountered. This narrative historical review discusses a number of the key areas where robotics may increasingly be seen in the restaurant sector, ranging from the automation of specific functions to the complete automation of the front or back of the house (e.g., Eatsa, https://www.digitalfoodlab.com/en/foodtech-database/eatsa, or Spyce robotic kitchen, respectively; see Lucas, 2021b).

It is, though, important to stress at the outset that the trade/popular press articles that are cited are primarily from the UK/North America (even if often describing the introduction of robots in Asia, e.g., Ward, 2013). It should be acknowledged that Asian press coverage may provide a somewhat different angle on a number of the issues discussed here. First, though, it is important to be clear about what constitutes a robot, given the sometimes euphemistic/imprecise use of the term in the popular press.

2. What exactly is a (service) robot?

According to the International Organization for Standardization (2012), a robot is defined as an ""actuated mechanism programmable in two or more axes with a degree of autonomy, moving within its environment, to perform intended tasks". It is possible to distinguish between service and industrial robots based on their intended application. Service robots perform: "useful tasks for humans or equipment excluding industrial automation applications". It has been suggested that two main features characterise robots, namely autonomy and the ability to sense and manipulate the environment (Yamazaki et al., 2010). Autonomy refers a robot's ability to sense the environment, plan its actions based on the data obtained, and act accordingly to achieve specific goals (Beer et al., 2014). In the restaurant setting, the goal may be to deliver the food from point A to point B, flip the burger, clean the floor, etc. Obtaining data from the environment takes place with sensors for identifying faces and objects, location and distances, temperature, sound and voice, etc. The robot influences the environment through actuators such as a motor, screen, lamp, speakers, robotic arm, etc. (Ben-Ari and Mondada, 2018). Meanwhile, Wirtz et al. (2018, p. 909) define service robots as: "system-based autonomous and adaptable interfaces that interact, communicate and deliver service to an organization's customers".

2.1. When is a robot not a robot?

A few years ago, the government-funded Thai Delicious Committee oversaw the development of a machine, described as "an intelligent robot that measures smell and taste in food ingredients through sensory technology in order to measure taste like a food critic." (see Fuller, 2014).[2] The e-delicious machine contained range of sensors and micro-chips and scans foods to assess chemical signatures to compare them to the preferred taste of human tasters. Of course, given the sometimes culture-specific ways in which food aromas can come to take on the associated taste qualities (see Spence, 2022, for a review), it becomes important to reference the preferences of human tasters rather than going directly off the results of robot tongue/nose (and possibly also their interaction). Generally-speaking, quality control (e.g., as promised by e-tongue and e-nose type devices) tend to be more useful in the detection of faults (e.g., cork taint for wines) than anything else (Cho and Moazzem, 2022). According to the results of a number of studies, the e-tongue, e-nose, or a combination of the two can be an effective and powerful tool for rapid assessment of sensory profiles and quality detection with significant correlations with human sensory data (see also Sochacki et al., 2022). However, there is little evidence of digital food tasters being used in the restaurant sector currently. In many such cases, however, it is unclear from the description whether the term 'robot' actually meets the definition given earlier, or whether instead the term is really being used as a euphemism for digital technology (Beullens et al., 2008). Note that a similar criticism can also be levelled at a number of other uses of the term 'robot' that have appeared in the academic literature over the years (Bardot et al., 1992).

3. Predictions and pitfalls concerning service robots in a food/restaurant setting

According to the results of a 2017 report from McKinsey Global Institute (https://www.mckinsey.com/featured-insights/future-of-work/jobs-lost-jobs-gained-what-the-future-of-work-will-mean-for-jobs-skills-and-wages), jobs involving "predictable physical activities" – such as cooking or serving food, cleaning kitchens, collecting dirty dishes and preparing beverages are most susceptible to future automation (Holley, 2018). Meanwhile, the top prediction from restaurant operators concerning the future of robotics in their sector was that 47% thought that robot cleaning would be mainstream or, at the very least, in mass adoption by 2025 (see Oracle, 2017). The other top uses for robotics foreseen by the restaurant operators who were quizzed in this particular survey included kitchen preparation, quality checking in the kitchen, staff training, serving, and/or seating guests (see also Seyitoğlu et al., 2021).

Automation, and the introduction of robots, has also taken place in the world of vertical farming (Namkung, 2022). However, to the extent that such technological innovations are not necessarily visible, nor advertised, to the end consumer, they will not be discussed any further here. Several companies have come out with commercial robots for

[1] The sushi conveyor was programmed to move past customers at a speed of exactly 8 cm per second. Any slower would apparently have been frustrating, any faster too frantic.

[2] Importantly, however, given that 75–95% of what we think we taste actually comes from (retronasal) olfactory cues much of what we taste derives from the sense of smell (Spence, 2015) the olfactory sensors are likely to be especially important.

cooking/washing. While a few fully automated fast food restaurant branches have opened (Liberatore, 2016a, 2016b), there have also been a number of high-profile closures in the food sector. For example, Zume the robot pizza business, once valued at $4 billion (Lalley, 2020) received $375 million in funding from SoftBank in 2018 The company used robots and high-tech trucks with ovens to prepare, cook, and deliver its pizzas. In 2020, the struggling robot-enabled restaurant start-up fired the majority of its staff and pivoted its focus onto food packaging, preparation, and delivery systems instead. The future for robots in gastronomic (or even fast service restaurants) settings is a complex issue to predict currently.

In recent years, there has been a growing interest, both academic and commercial, in the use of service robots to help take food and drink orders and/or to deliver dishes direct to the customers (e.g., Seyitoğlu et al., 2021). According to Markets and Markets (2020), the market for service robots was estimated to grow rapidly from USD 37.0 billion in 2020 to a projected value of USD 102.5 billion by the end of 2025 (representing a compound annual growth rate of 22.6%). In 1983, the Two Panda Deli in Pasadena, California used robots to move Chinese food from the kitchen to customers (Novak, 2012; Reiley and Powell, 2022) (see Fig. 1). More recently, much of the research interest has been on the delivery of food to customer service robots instead (e.g., see Eksiri and Kimura, 2015, for a number of service robots trialled in a Bangkok restaurant chain). It is, though, interesting to see how the articles describing the introduction and evaluation of these restaurant service robots have primarily been framed in terms of a technical challenge for robotics researchers rather than necessarily as addressing a pressing managerial issue or financial question for restaurateurs (e.g., see Yu et al., 2012).

Eksiri and Kimura (2015) document a collaboration between the Department of Engineering at Bangkok University and the MK Restaurant Group Public Company Limited (an operation with 40 restaurant branches spread across Thailand). The researchers developed two order robots (designed to take orders from the customer) and five server robots (designed to deliver an order to the customers' table). In the latter case, the staff placed the food inside the server robot, before entering the table number into the system. The robot then moved along the lines on the floor to the appropriate table, where the server would remove the food from inside the robot before placing it on the table. Given that the server robot merely transports the food from one place to another, this technical solution can be seen as serving essentially the same function as the conveyor belt mentioned earlier (the main difference being in terms of the humanoid (or anthropomorphic, appearance of the delivery mechanism/device). Over the four-year period from 2009 to 2012, these service robots were apparently involved in 14,280 service encounters with interest being registered by approximately a quarter of a million customers. In their report, however, Eksiri and Kimura make no mention of the financial plausibility of the introduction of service robots in this case. Indeed, their description focuses primarily on the technical challenges associated with the project. Meanwhile, in a survey of Turkish restaurant managers and their customers (Seyitoğlu et al., 2021), those quizzed agreed that service robots improved service quality.

Fig. 1. A Star Wars R2D2-inspired robot server at the Two Panda Deli in Pasadena, California from the mid-1980s (Reprinted from Novak, 2012).

4. Robots in food preparation

The interpretation and execution of recipes with a cooking robot has long been seen as one of the grand challenges amongst those researchers working in the field of robotics (e.g., Bollini et al., 2013). It is important to remember that just because the technical challenges have proved inspiring to many of those working in the robotics/AI community that doesn't necessarily mean, from a managerial perspective, that the adoption of robots in gastronomy represents a sound business decision. Possibly hinting at the growth in the market for food service robots, Bear Robotics, who produced the robot food runner called Penny, received $32M investment led by Softbank (Luna, 2020). According to the report from the Nation's Restaurant News: "Penny is currently being used at Amici's Pizza in Mountain View, Calif., in banquet rooms in Sunnyvale, Calif., a casino in Los Angeles, a senior living center in Cupertino, Calif., and restaurants and cafés in Tokyo, Japan and Seoul, South Korea." At the same time, however, large amounts of (venture capital) funding have gone to a number of the companies producing these robots. For instance, Creator, formerly known as Momentum Machines, secured over $18 million in financing in 2017 (Robinson, 2017; see also Troitino, 2018). Meanwhile, since its founding in 2015, Spyce has raised almost $25 million from investors (Lucas, 2021b). A growing number of companies are currently producing robots in this space, including Moley robots, and several others that will be mentioned below.

4.1. *Robotic kitchen aids/cooking assistants in fast food (quick service) setting*

More recently, Miso Robotics developed three robots by the names of Flippy,[3] Sippy, and Chippy to handle a range of repetitive tasks at fast food restaurants (see Carbone, 2022; Reiley and Powell, 2022). These robots can cook fries, pour drinks and make tortilla chips. Once again, the business case for their introduction was framed in terms of the nationwide labour shortage (or crunch) in the US. That being said, Jack's VP of operations services, presumably sensitive to the threat of automation to job security (see McClure, 2018), was keen to stress that: "This is an enhancement, not a replacement … Our fry person is getting promoted and Flippy is their assistant" (quoted in Carbone, 2022). The robotics company has apparently been working with WingZone, Jack in the Box, Chipotle and White Castle. Restaurants have to pay $3500 per month to rent the kitchen bot Flippy 2 in addition to the installation costs of $5000 (Carbone, 2022; Reiley and Powell, 2022).

Working together with a group of students (robotics engineers) from Massachusetts Institute of Technology (MIT), the celebrity Michelin-starred chef Daniel Boulud, developed a restaurant concept in

[3] Flippy was first introduced in 2017, cooking c. 300 burgers a day (Jennings, 2017).

downtown Boston (Spyce) a few years ago where the food is cooked by robots in a fully automated kitchen (Doyle, 2018). Multiple people are, however, nevertheless still employed in this operation: There is the friendly guide to greet customers and assist them with ordering via one of the touch screens, while other staff prepare the food overnight and a 'garde manger' adds toppings such as pumpkin seeds, cilantro, and crumbled goat's cheese before the meal is served (Holley, 2018). The ingredients are tumbled at 450 °F then the wok is tilted downward so that the customer's order ends up in a bowl. Eventually, conveyor belts allowed the food (warm bowls and salads) to be transported from the eight wok stations to the waiting customers.

Interestingly, the venture was described by one of its founders as "the world's first restaurant with a robotic kitchen that cooks complex meals" (Holley, 2018); The latter phrase presumably carefully chosen to try and distance the operation from fast food robots such as Flippy (see above).[4] It is interesting to note how the robot chefs in this case of the Spyce restaurant (the eight Wok 'cooks') were placed in full view of the customers, with the latter's names appearing on an electronic display over their wok. According to Holley (2018), new restaurant openings were supposedly soon coming around the world, though the restaurant was temporarily closed to 'reconcept' in November 2019 (Lalley, 2020). According to an article that appeared three years later on CNBC, Spyce bought by the salad chain Sweetgreen in 2021 (see Lucas, 2021b). Meanwhile, another company, Creator (https://www.creator.rest/), uses its robot chefs/cooks to tackle unique culinary tasks that human cooks cannot easily perform, such as sensing the perfect level of cooking of a burger (Zeveloff, 2016; Troitino, 2018).

Cafe X (https://cafexapp.com/), a robot coffee chain, has been building standalone kiosks featuring a robotic arm that serves up a range of both hot and cold beverages (Albrecht, 2020a). As with other ventures, there is a human assistant to help guide customers through the process of interacting and/or ordering. However, the company closed its three downtown San Francisco locations at the start of 2020. According to Albrecht, the company was opening new venues in airports and trying to get approval to be classed as vending machines (with a coffee kiosk costing c. $200,000),[5] so that there would be no need for staff. According to the company's own website, there are currently only a couple of kiosks operating commercially in San Francisco airport terminals as of the start of 2023 (after having been closed during COVID pandemic; Albrecht, 2020b) (see Fig. 2), thus suggesting limited market penetration.

Outside of the commercial setting, there have also been developments in terms of the introduction of robots into the home kitchen environment (Castenson, 2021). However, the extravagant prices being charged in the latter case would seem to preclude all but a tiny minority of the world's richest individuals from availing themselves of such technology, as hinted at by the title of one recent press article: "My date with Robochef: The £250k kitchen gadget that makes your dinner" (Sitwell, 2021). Here, it is interesting to consider where 3D food printers sit within such discussion of robots in gastronomy (e.g., Fernandez, 2015; Prisco, 2015). Such devices obviously lack anthropomorphic features than help to improve the perceived quality (and presumably naturalness) of the dishes prepared by humanoid robots. While food printers have yet to find a widespread use/place, they have been introduced into the kitchens of several high-end chefs (e.g., Koenig, 2016). Much of the discussion considers a future in which such devices are a ubiquitous feature of the home kitchen, although the very slow rate of food production currently offered by such devices currently clearly

Fig. 2. Robotic coffee maker currently positioned in San Francisco airport. (Photo taken February 2023, courtesy of Steve Keller).

limits their potential use (be it in the commercial or home kitchen). What is more, unlike the front of house positioning of the robots at Spyce, 3D food printers tend to be kept out of sight in the kitchen in commercial (gastronomic) restaurants, with only their artistic creations visible to customers.

There has also been recent interest in the use of robots (e.g., Connected Robotics OctoChef™; https://connected-robotics.com/products/octochef/) to help plate food in a most attractive manner (see Nagahama et al., 2022). One could imagine the technology being used either being used to determine the most attractive plating arrangement or else to perfectly reproduce a chef's signature plating arrangement (e.g., see Michel et al., 2015).

4.2. *Robot chefs and bartenders*

Makr Shakr, the robotic cocktail maker installed on the Royal Caribbean's cruise ship, The Quantum of the Seas, in 2014. In this case, drinkers ordered via a tablet computer. While this robotic bartender could initially mix and serve one cocktail a minute, that figure soon doubled (according to the company making these robots; http://www.makrshakr.com/). One of the Unique Selling Points (USPs) is that this robot bartender can deliver a perfectly consistent serve every time (Curtis, 2014). At the same time, however, it is questionable whether this is necessarily what consumers want from a high-end (i.e., gastronomic) food or drink experience (see Hayward, 2014; Spence and Piqueras-Fiszman, 2014; https://globetrender.com/2022/12/02/makr-shakr-unveils-robotic-bar-at-new-resort-in-bali/quantum-of-the-seas-launch-photos/). Note here also the similar emphasis on exactitude from the Creator website ((https://www.creator.rest/), where the claim is made that their robotic burger maker: "One of the most precise culinary tools on earth." It should, though, be acknowledged that this is one of the areas where gastronomic restaurants may differ from fast service establishments.

Meanwhile, an $82,000 robot bartender was installed in a small pop-up pub in Tokyo's busy Ikekeburo train station, called the Zeroken Robo

[4] According to Holley (2018), Flippy worked in Californian fast food kitchen before being suspended temporarily for being too slow.

[5] While the majority of vending machines technically fit the definition of a robot (see Nelson, 2020), a vending machine cup of coffee clearly doesn't have any of the cachet, nor experiential value, associated with a coffee made by one of Café X's humanoid robotic arms.

Tavern (and owned by restaurant operation Yoronotaki) in 2020 (Kelly and Tomoshige, 2020; Shaw, 2020). The robot, built by QBIT Robotics,[6] was able to pour a beer in 40 s while turning out a cocktail in a minute. According to Shaw (2020), the customers first paid for their drinks at an automated kiosk, receiving a QR code receipt that they then presented to the robot's scanner with the latter making the appropriate drink. Intriguingly, the robot used video recognition technology to assess whether customers were happy or irritated (though see Pettit, 2017).[7]

According to a report in Reuters, the robot bartender was installed for a three-month trial period before its success was to have been assessed (though there doesn't seem to have been any follow-up). What is certain, though, is that given the price in this case was equivalent to paying a human bartender for three years, staff shortages will presumably have to become a lot worse, before such an investment in technology starts to make financial sense for the majority of independent restaurateurs or bar owners. At present, the use of such front-of-house robot bartenders would seem to fit as delivering novelty and/or an experience to customers (cf. the literature on the 'experience economy'; Pine and Gilmore, 1998, 1999; Velasco and Obrist, 2020).

5. Psychological considerations associated with the introduction of robots in restaurants

5.1. On the benefits of 'handmade' and humanoid robots

When speculating about the future of robots in gastronomy, it is important to recognize the psychological influence of perceived human contact during the process of making food and drink on consumers' food quality expectations. For instance, according to the results of one study, imagined human contact during the making process increased the perceived naturalness of a drink (Abouab and Gomez, 2015). The researchers compared participants' ratings of grape juice after the latter had been told that the product had been machine-made versus after having being informed that it was handmade. In the latter case, the participants were told that the grapes had been harvested, sorted, pressed, strained, and bottled manually. The so-called 'handmade effect' is likely also relevant here: This is the name given to the fact that those products that are (or at the very least are claimed to be) handmade are valued more highly by consumers than those that are not (e.g., Fuchs et al., 2015; see also Granulo et al., 2021). Or, as one of the Turkish chefs interviewed by Bucak and Yigit (2021) put it: "*Cooking is directly proportional to hand taste. The dishes will turn into ordinary fabricated products without human touch.*"

At the same time, however, a separate line of empirical research published over recent years has demonstrated how the perceived quality of the food that is (or at least is believed to have been) prepared by humanoid robots having anthropomorphic features (e.g., human-like hands) are expected to be of higher quality (Zhu and Chang, 2020). Anthropomorphizing the robot chef's (or bartender's) actions has also been shown to help in terms of elevating the experience for consumers (see Anon, 2013). For example, across a series of three experiments, Xiao and Zhao (2022) demonstrated that their participants generally predicted that the food that they were led to believe had been prepared by a robot chef would be of lower quality than when they thought that the same food had been prepared by a human chef instead. Once again, increasing the anthropomorphic features of the robot chef seen in a photo/video led to increased ratings of the expected quality of the food. That said, it is important to stress that no food was actually tasted in either of these studies, thus potentially limiting the real-world (or managerial) implications that can be drawn from them. Given such findings, it is interesting to note how in this case the diners in the test restaurants studied by Eksiri and Kimura (2015), the customers themselves actually cooked the ingredients that were delivered by the service robots themselves at the table, thus presumably helping to introduce an essential human touch to proceedings (Spence, 2017).

5.2. Commensal robots

Although not directly relevant to the preparation or delivery of food or drink, digital commensality (i.e., social robots for companionship) nevertheless looks likely to be one of the largest growth areas for robots in the context of food consumption in the years ahead (Khot et al., 2019; Niewiadomski et al., 2022; Spence et al., 2019). However, at present, it is likely that such solutions will play more of a role in the (care) home rather than in commercial restaurant settings (e.g., for vulnerable and elderly isolated individuals; e.g., McColl and Nejat, 2013).[8] There has also been interest in the design of motivational robots to help encourage children to eat fruits and vegetables (Baroni et al., 2014; see also Randall et al., 2018). Indeed, it is interesting to note how the appeal of the robot bartender installed in the pop-up bar in Tokyo that was to one of those interviewed was precisely that it meant that you didn't have to talk to anyone (quoted in Shaw, 2020). One customer is reported as commenting that: "I like it because dealing with people can be a hassle." (as quoted in Shaw, 2020). A humanoid appearance for a robot is likely to be especially important in the case of digital commensality.

Focusing on the restaurant sector, researchers have investigated how varying levels of human-likeness of attributes (i.e., *visual, vocal* and *verbal*) of service robots influences consumption outcomes (e.g., the evaluation of the service encounter, revisit intentions, and positive word of mouth, WOM, intentions) and the underlying mechanisms through cognition (i.e., perceived credibility) and positive emotion (Lu et al., 2021). Lu et al. conducted a consumer study involving almost 600 participants. An online experiment was conducted simulating a casual dining event using experimental vignettes with pictorial, auditory, and textual elements, where you were greeted by human host and then served by a robotic server. These researchers found that a humanlike *voice* was the dominant attribute affecting all three consumption outcomes (see also Edwards et al., 2019; Qiu and Benbasat, 2009). The positive effect of humanlike *language style* and *voice* on people's evaluation of the service encounter was explained by both cognition (i.e., perceived credibility) and emotion.

5.3. Robots as novelty/experiential/tourist attraction

At present, interaction with robot chefs and service robots, especially if they have a humanoid appearance, can help to deliver a futuristic experience that diners may well be willing to pay for, at least in the short-term. Such restaurant experiences can clearly be seen as falling within the scope of the 'experience economy' (Pine and Gilmore, 1998, 1999; Velasco and Obrist, 2020). Indeed, according to Seyitoğlu et al. (2021), restaurant customers are willing to pay more for the robotic service experience (Seyitoğlu & Ivanov, 2022). Researchers have been investigating factors that influence willingness of certain types of consumers to pay a price premium for the experience of dining at a robotic restaurant (Chuah et al., 2022; see also Cha, 2020). Humanoid robots have entertainment value for many customers (Reiley and Powell, 2022). The robot wok cookers at Spyce in Boston were deliberately made visible in order to create an exciting experience for customers (see Holley, 2018). Looking to the future, one of the areas where robot chefs, and other front of house humanoid (or, for that matter, zoomorphic) robots, may make an impression is in the case of gastronomic tourism (Fusté-Forné, 2021). That said, once the initial novelty has worn off, it is unclear whether the expense of installing, operating, and moreover

[6] The company had also created a similar machine for a pasta restaurant in Tokyo (see Shaw, 2020).

[7] Though there is no mention of how such information was used.

[8] Though see Fishwick (2014) for a low-tech solution to the problem of lonely customers/diners from Japan.

maintaining such robots can be justified on purely financial grounds.[9]

6. Conclusions

In conclusion, it would seem likely that service automation will continue to make inroads in the area of food provision, especially amongst the larger (i.e., international) fast-food (and quick service) chains (i.e., where many workers' jobs have been streamlined to a small number of repetitive actions/tasks; see Ritzer, 1993). This trend has undoubtedly been accelerated by the recent Covid pandemic (Morrison, 2022). However, as highlighted by the evidence reviewed here, the outlook concerning the introduction of service robots in the restaurant sector would appear far less certain/optimistic. Indeed, currently the costs associated with installing and running robots in the kitchen/bar would currently seem too high to be financially viable in the context of either rapid-service restaurants (Targett, 2022) or a fine-dining (gastronomic) context (see also Bishop, 2019). What is more, despite promises to the contrary, there are frequent reports of these robots not being either as rapid or reliable (with frequent break-downs and ongoing maintenance issues) as anticipated/advertised. This, note, a problem that has affected service robots in restaurants since their first introduction in California in the 1980s (see Novak, 2012). At the same time, however, over-and-above such technical and financial challenges, psychological factors will likely further limit the uptake of such technologies in the world of both rapid-service (i.e., fast food) and high-end gastronomy settings (cf. Nozawa et al., 2021). In fact, several laboratory studies have revealed that consumers simply attribute greater value to those food products that have been made by hand. Currently, therefore, one of the only justifications for the introduction of service robots into a restaurant setting would appear to be because of their experiential value – this linking to the literature on the experience economy (Pine and Gilmore, 1998, 1999).

Ultimately, therefore, the question of whether robots or humans make better chefs/bartenders cannot be answered solely on the basis of technical performance (Levy, 2015), given that psychological factors exert such an influence over people's expectations and subsequent enjoyment of food and drink. Perhaps more importantly, however, is the expectation amongst consumers, highlighted by several studies, that the food prepared by a robot chef will simply not taste as good as that prepared by human hands (see Xiao and Zhao, 2022; Zhu and Chang, 2020). Hence contrary to the press headlines, manual jobs in the gastronomy sector would appear to be safe for the foreseeable future. At the same time, however, there would appear to be much more interest currently in the introduction of service robots (and automation) in the world of hotel hospitality.

Implications for gastronomy

Automatization has made increasing inroads into the hospitality and fast food sectors of the marketplace. However, as yet, there has been little progress with the introduction of robots into the world of gastronomic hospitality. In this narrative historical review, a number of the key challenges and opportunities associated with the introduction of robots are highlighted. Several of the key roles/functions that robots can play are discussed: including robot chefs/bartenders, service robots (taking orders, delivering the food to table, and/or guiding diners to their seats), and commensal robots. Importantly, however, while the presence of humanoid robots in the restaurant setting undoubtedly has novelty/experiential value for customers, there would appear to be little evidence of the long-term economic viability (given the high costs associated with installation, running, and oft-reported maintenance issues) of robots anywhere but to aid in the most mundane and repetitive kitchen tasks in high volume fast-food chains. As such, and contrary to the claims that are so often made in the popular press, it seems unlikely that human labour will be replaced by digital robots/automatization in the restaurant sector anytime soon.

Declaration of competing interest

The author confirms that there are no known conflicts of interest associated with this publication and there has been no significant financial support for this work that could have influenced its outcome. The manuscript has been read and approved by all named authors and there are no other persons who satisfied the criteria for authorship but are not listed. I understand that the Corresponding Author is the sole contact for the Editorial process (including Editorial Manager and direct communications with the office).

Data availability

No data was used for the research described in the article.

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