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Brave new world: service robots in the frontline

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Received 30 April 2018
Revised 17 July 2018
Accepted 27 July 2018

Abstract

Purpose – The service sector is at an inflection point with regard to productivity gains and service industrialization similar to the industrial revolution in manufacturing that started in the eighteenth century. Robotics in combination with rapidly improving technologies like artificial intelligence (AI), mobile, cloud, big data and biometrics will bring opportunities for a wide range of innovations that have the potential to dramatically change service industries. The purpose of this paper is to explore the potential role service robots will play in the future and to advance a research agenda for service researchers.
Design/methodology/approach – This paper uses a conceptual approach that is rooted in the service, robotics and AI literature.
Findings – The contribution of this paper is threefold. First, it provides a definition of service robots, describes their key attributes, contrasts their features and capabilities with those of frontline employees, and provides an understanding for which types of service tasks robots will dominate and where humans will dominate. Second, this paper examines consumer perceptions, beliefs and behaviors as related to service robots, and advances the service robot acceptance model. Third, it provides an overview of the ethical questions surrounding robot-delivered services at the individual, market and societal level.
Practical implications – This paper helps service organizations and their management, service robot innovators, programmers and developers, and policymakers better understand the implications of a ubiquitous deployment of service robots.
Originality/value – This is the first conceptual paper that systematically examines key dimensions of robot-delivered frontline service and explores how these will differ in the future.

Keywords Consumer behaviour, Ethics, Artificial intelligence, Privacy, Service robots, Markets

Paper type Conceptual paper

Journal of Service Management
Vol. 29 No. 5, 2018
pp. 907-931
Emerald Publishing Limited
1757-5818
DOI 10.1108/JOSM-04-2018-0119

Introduction

The service sector seems to be at an inflection point with regard to productivity gains and service industrialization similar to the industrial revolution in manufacturing that started in the eighteenth century. Rapidly improving technology that becomes better, smarter, smaller, and cheaper will transform virtually all service sectors (Wirtz and Zeithaml, 2018). Especially exciting are the opportunities offered by robotics in combination with cameras, sensors, speech recognition, big data, analytics, artificial intelligence (AI), mobile and cloud technology, geotagging and biometrics. The likely impact of the infusion of robots in conjunction with AI and machine learning on frontline employees across industries and settings has attracted significant attention from business practitioners (Lelieveld and Wolswinkel, 2017; Manyika *et al.*, 2017; Microsoft, 2018) and recently also from service scholars (Huang and Rust, 2018; Marinova *et al.*, 2017; Čaić *et al.*, 2018; van Doorn *et al.*, 2017).

The aim of this paper is to explore the potential role service robots will play in the future. In particular, service robots will have important implications at the micro (i.e. individual customer experience), meso (e.g. the market for a particular service and market prices) and macro level (e.g. societal implications) for all key stakeholders. Figure 1 provides an overview of the key relationships and impacts of service robots that will be discussed and where this article makes the following three contributions. First, it provides a definition of service robots, describes their key attributes, contrasts the key features and capabilities of service employees and service robots, and provides an understanding for which types of tasks robots will dominate and where humans will prevail. Second, this article examines consumer perceptions, beliefs and behaviors as related to robot-delivered service and advances the service robot acceptance model (sRAM). Third, it provides an overview of the ethical questions surrounding robot-delivered service at the micro, meso and macro level.

For the purpose of this paper, the terms "customer" and "consumer" are used interchangeably, and the terms robots and employees refer to service robots and frontline employees unless otherwise specified.

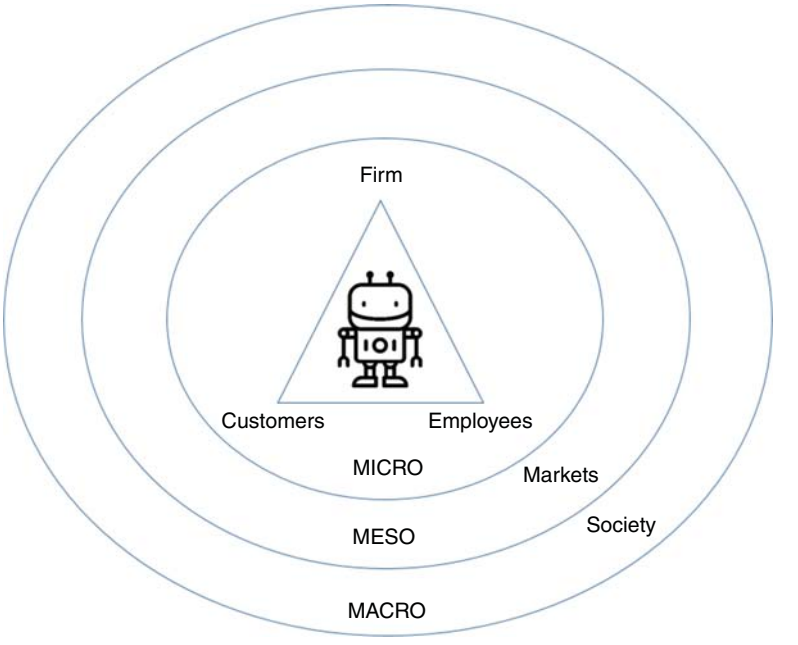

Figure 1.
The impact of service robots on key stakeholders

Characteristics and capabilities of service robots

Definition of service robots

As this paper focuses specifically on frontline service, the following operating definition is used: service robots are system-based autonomous and adaptable interfaces that interact, communicate and deliver service to an organization's customers.

Robots are widely seen as machines capable of carrying out complex series of actions (Singer, 2009). They are capable of autonomous decision making based on the data they receive by various sensors and other sources (i.e. the sense-think-act paradigm) and adapt to the situation, thus they can learn from previous episodes (Pagallo, 2013; Allen *et al.*, 2000). In a frontline service setting, they represent the interaction counterpart of a customer and therefore can be viewed as social robots. Important in the context of social interaction is often that the robot can create some degree of automated social presence (ASP) during the services encounter, which refers to the ability to make consumers feel that they are in the company of another social entity (van Doorn *et al.*, 2017).

It is important to stress that in the future virtually all service robots will be connected and embedded into a bigger system (e.g. via knowledge bases and cloud-based systems; Pagallo, 2013). That is, in addition to their local input channels (e.g. cameras, microphones, and sensors) they can access data from a wide range of other sources including the internet, the collective organizational knowledgebase and its customer relationship management (CRM) system which contains customer background, preference and transaction data. Combined with biometrics (e.g. facial and voice recognition systems), a service robot will be able to identify a customer and provide highly customized and personalized service on scale at negligible marginal cost.

Design attributes of service robots

Robots can be differentiated along various attributes, and we consider the following three design attributes as particularly relevant in a service context: representation, anthropomorphism and task orientation. Service robots can have a physical representation (e.g. Pepper) or are only virtually represented (e.g. Alexa). Thus, we argue that virtual AI software that works autonomously and learns over time can be also categorized as a service robot. Service robots can be designed as humanoid (i.e. anthropomorph) simulating a human appearance (e.g. Sophia) or as a non-humanoid (e.g. Roomba cleaning robot). Finally, service robots can do cognitive-analytical tasks due to underlying computer power (e.g. image analysis software assistant for medical diagnosis) or emotional-social tasks (e.g. reception robots).

Characteristics of service robots vs frontline employees

Table I provides an overview of the key differences between frontline employees and service robots that were identified at the micro, meso and macro level.

Micro level: service training and learning. An important micro-distinction is that employees are individuals with their own capabilities, perceptions and biases and people-delivered service shows heterogeneity over time and across individuals. Employees need to have a deep understanding of their customers and service processes to deliver results for customers and the organization. That is, people need to learn the routines, memorize relevant information, and learn to use IT systems. To achieve this, training is needed. Furthermore, connecting employees to knowledge bases and CRM systems requires added work steps, time and effort. This takes time and is not entirely seamless.

In contrast, robots are likely to be the visible and customer-facing part of a large and integrated service system (including knowledge bases and CRM systems). Robots do not learn in the same way as humans do. Acquiring knowledge and learning can be

Dimension	Service employees	Service robots
Micro: service training and learning	Act as individuals	Act as part of systems, are connected
	Need training	Upgradable, system-wide
	Individual learning	System learning
	Limited memory and access	Virtually endless memory and access
	Understanding needed	Pattern recognition
Micro: customer experience	Heterogeneous output	Homogenous output
	Customization and personalization depend on employee skill and effort	Customization and personalization can be delivered on scale at consistent quality and performance
	Unintended biases	Potentially no biases
	Have genuine emotions	Can mimic emotions
	Can engage in deep acting	Can engage in surface acting
	Can engage in out-of-box thinking and creative problem solving	Limited out-of-box thinking, has rule-bound limits
	Good in professional service roles (PSRs)	Good in subordinate service roles (SSRs)
Meso: market level	Service employees can be a source of competitive advantage	Service robots are unlikely to be a source of competitive advantage
	High incremental cost	Low incremental cost
	Low economies of scale and scope	High economies of scale and scope
	Differentiation on service can be based on better hiring, selection, training, motivation, and organization of service employees	Economies of scale and scope and related network and service platform effects will become important sources of competitive advantage
Macro: societal level	Important services are expensive and scarce if delivered by service employees (e.g. healthcare)	Cost savings of robot-delivered services will be competed away, leading to lower prices, and increased consumption and higher standards of living
	Many service employees work in unattractive jobs (e.g. call center agents and cashiers)	Mundane and unattractive service jobs can be robot-delivered

Table I.
Contrasting frontline employees with service robots

done in various forms, is almost instantaneous and system-wide. For example, service robots can learn through first, updating codified knowledge, pattern recognition and "training" of AI whereby a system compares millions of scenarios and determines a cause of action based on the distance to a given optimal result, and second, machine learning approaches that use computing power to determine an optimal solution by playing through millions of scenarios in a structured setting in a systematic trial and error approach (Bishop, 2006).

Micro level: customer experience. Service robots do not show heterogeneity over time and across robots. If so designed, service robots will behave identically across a service delivery system, providing highly predictable and homogeneous service interactions and solutions. Service robots are free from human error and fatigue and respond to their service environment in a highly reliable manner (Huang and Rust, 2018).

As service robots will be connected to CRM systems and can identify customers, they can provide customized service on scale. Furthermore, service robots can be designed to have no biases (e.g. by ethnic group, gender, age and social status) unless so programmed (e.g. to treat more "valuable" customers special).

Service robots are unlikely to be self-determined with genuine emotions in the foreseeable future (Picard, 2013). As such, service robots will not be able to feel and express real emotions. Nonetheless, robots can mimic the expression of emotional responses (e.g. using facial expressions and body language), and it has been found that robots that mimic the emotional expression of their counterpart are perceived as more pleasant

(Tielman *et al.*, 2014). As such, mimicked emotional responses might be sufficient to support many types of the more mundane service encounters. In longer and high involvement encounters, it may become more easily apparent that the expressed emotions are not genuine. This is important as the service management literature distinguishes between deep acting where employees' true emotions are displayed and perceived by their customers, and surface acting where employees do not feel the displayed emotions and customers understand that these emotional displays are superficial (e.g. Grandey, 2003; Mesmer-Magnus *et al.*, 2012; Wirtz and Jerger, 2017).

Robots' expressed emotions will remain surface displayed for the foreseeable future. Consumers are likely to know this, perceive it and respond accordingly. At the surface, robots are likely to read, respond and express emotions, as was displayed in the Hollywood feature "Passengers" where the robotic bar tender provided counseling and advice to the desperate traveler, but even in the movie as the robotic bar tender was damaged and lost part of its face and body, the actors displayed no emotions toward the robot. That is, surface-acted emotions are noted, but deep inside customers are likely to know that these emotions are not real. In other words, customers are unlikely to respond to robot-displayed emotions as they would to heartfelt and authentic emotions from human frontline employees.

To see the strengths of service employees and robots better, a helpful distinction is between professional service roles (PSRs) and subordinate service roles (SSRs). Emotional-social capabilities seem particularly important for PSRs. Here, complex cognitive tasks are combined with emotional and social tasks that often involve a high degree of flexibility, out-of-the-box thinking, and creative problem solutions (e.g. as for a divorce lawyer, a PhD supervisor or a surgeon). Robots are only flexible within the defined limits and out-of-box thinking seems unattainable for now. Furthermore, robots can make "optimal" decisions by optimizing underlying mathematical structures, but they can usually not explain afterward why this solution is optimal. It seems therefore that such services are unlikely to be delivered solely by robots until they can feel and respond with real emotions (c.f., Rafaeli *et al.*, 2017), and have mastered key dimensions of social intelligence, including people's emotions, negotiating with and between people, persuading people, explaining their behavior, and providing emotional support (c.f., Frey and Osborne, 2017; Metzler *et al.*, 2015).

In SSRs, employees are often lowly paid, have low education, receive little training, have little decision discretion and empowerment, have low engagement and are often not motivated (Wirtz and Jerger, 2017). Employees in such positions tend to engage merely in surface acting (if they "act" at all). In such positions, robots may well provide better service compared to employees, and in fact, may even be better at displaying surface-acted emotions. That is, robots may outperform people in routine service encounters (e.g. a ticketing clerk or bank teller) due to their consistently pleasant surface acting that is unaffected by moods, health, or stereotypical biases. Thus, for low level, low-pay SSRs, robots may become the preferred method of frontline service delivery.

Meso level. Service robots will have a significant impact at the market level. In people-intensive service industries, employees are often viewed as an organization's most important asset. Following the current dominant service philosophy of the service-profit-chain (Heskett *et al.*, 1994; Hogreve *et al.*, 2017), competitive advantage is built through the painstakingly careful recruitment, training and motivation of employees (Wirtz and Jerger, 2017). In fact, it has even been suggested that high-performing human assets in service organizations are harder to duplicate than any other corporate resource and are therefore frequently an important source of an organization's sustainable competitive advantage (Wirtz and Lovelock, 2016, p. 443).

Furthermore, frontline employees are not scalable. Every incremental headcount adds significant cost. In contrast, robot-delivered service is likely to show enormous economies of scale and scope as much of the costs are likely to incur at their development and in the back office (e.g. in AI and knowledgebase development). Physical robots have incremental costs, even though they are at a fraction of adding headcount. Interestingly, virtual robots are likely to be able to be deployed at negligible incremental costs. For example, a holograph-based robot that could "man" an information counter will just require a video, speaker, camera, and microphone system to be effective, and the costs of these components are already low compared to those of a physical robot. Note that fully virtual robots (e.g. voice- or text-based chatbots) already have close to zero incremental costs.

However, service robots are unlikely to become a key source of competitive advantage, at least in the medium to long term. For example, ATMs largely replaced human tellers, and today, hardly any bank positions itself on better ATM-delivered service. Rather, ATMs have become a commodity. The same is likely to happen regarding service robots which will be developed and manufactured by organizations that sell frontline service solutions to service organizations. The implication of the reduced importance of frontline employees as a source of competitive advantage and the economics of robot-delivered service means that economies of scale and scope (e.g. in data and knowledge bases and training of AIs), and related network and platform effects, are likely to become important sources of competitive advantage with the risk of "winners taking it all" markets. In addition, the remaining factors for potential competitive advantage should also increase in importance and are likely to include brand equity, owning the customer relationship, owning the point-of-sale, an organization-wide service culture, its customer centricity and innovation capabilities (Wirtz and Ehret, 2018) and require significant business model innovation (c.f., Andreassen *et al.*, 2018; Edvardsson *et al.*, 2018).

Macro level. In a market economy, cost savings of moving service delivery from frontline employees to service robots can be assumed to be largely competed away and lead to lower prices, increased consumption and improved standards of living. Robot-delivered services have the potential to dramatically improve the quality and availability of currently expensive and therefore scarce services that are increasingly important to a society's well-being, including healthcare, education, and public transportation. Furthermore, many mundane services can be robot-delivered, including cashiers and call center services.

Categorizing service robots by type of service

Task-type and recipient of service. A widely used service categorization is Lovelock's (1983) recipient of service and task-type matrix which distinguishes whether a service is targeted at people or their possessions, and whether these services are tangible or intangible in nature. This two-by-two matrix seems a useful classification to examine the types of services that can be provided by different types of service robots. Figure 2 shows that tangible actions will have to be performed by tangible robots that can touch, move, process people (e.g. a haircut, provide passenger transport or deliver a physiotherapeutic massage) or possessions (e.g. to clean a car, deliver a parcel or repair a suitcase).

In contrast, intangible actions can be provided by a range of robot-types, including virtual robots such as text-based (e.g. chatbots), voice-based (e.g. Siri and Alexa), video-based and three-dimensional virtual robots (e.g. holograph-based robots). However, a physical appearance might support the consumer experience (van Doorn *et al.*, 2017). That is, giving robots a physical and/or humanoid appearance for intangible services depends much on customer preferences and cost considerations. Note that virtual robots have

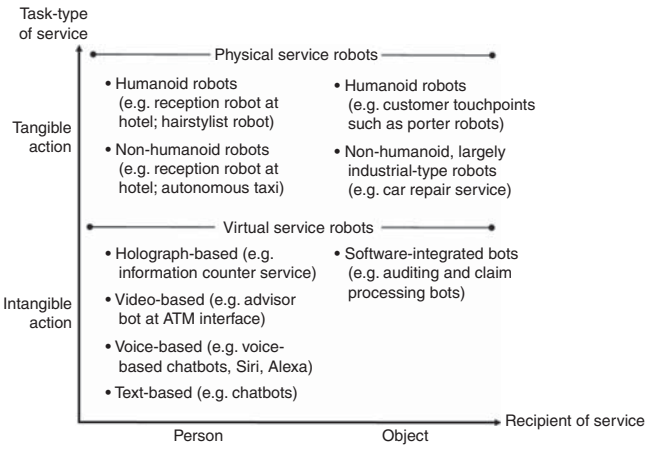

Figure 2.
Service robots categorization by task-type and recipient of service

negligible incremental costs. For example, airports could install a holograph-based humanoid robot every 50 meters to assist passengers, which would probably provide more customer value than centralized counters with a physical robot.

Emotional-social and cognitive complexity. It can be assumed that robots in the coming decades will master cognitive and analytical tasks of unprecedented complexity (Manyika *et al.*, 2013, 2017). Huang and Rust (2018) distinguishes four levels of analytical intelligence: mechanical, analytical, intuitive, and empathetic intelligence. First, mechanical intelligence relates to routine and repeated tasks (e.g. many tasks in call centers are routine). Second, analytical intelligence relates to information processing for analytics, problem solving and machine learning that performs complex, yet systematic and predictable tasks (also called weak AI). Analytical intelligence relies mainly on algorithms to learn from data (e.g. accounting and robot-advisory services). Third, intuitive intelligence refers to the ability to process complex information, think creatively and holistically, and to be effective in novel situations that require understanding (also called strong AI). Typical services that require intuitive intelligence are legal advice and medical diagnostics. Finally, empathetic intelligence relates to the ability to read, understand and respond to people's emotions. Huang and Rust (2018) consider the ability to experience things as the defining characteristic of empathetic AI. There is agreement in the literature that the first three levels of AI will develop to a high level in the near future, and that robots will become the dominant delivery mechanism of services requiring these. However, there is considerable debate about whether robots will be effective in providing emotional and social services at a level humans can.

As discussed earlier, robots will be able to mimic surface acting-type emotions to a high level, but deep acting and out-of-box thinking at a human level are not attainable in the foreseeable future. As such, it is expected that cognitive and analytical tasks with low emotional or social complexity will be largely executed by service robots. In contrast, services that are mainly emotional or social in nature and require true emotions will be mostly delivered by humans (see Figure 3).

Tasks that are cognitively highly complex with high emotional needs are likely to be delivered by humans supported by robots – it is apparent that robots already or will shortly outperform humans on cognitive tasks and that optimal solutions will include humans to deliver the emotional tasks while being supported by powerful service robots to provide additional analytical and cognitive power (c.f., Lariviére *et al.*, 2017).

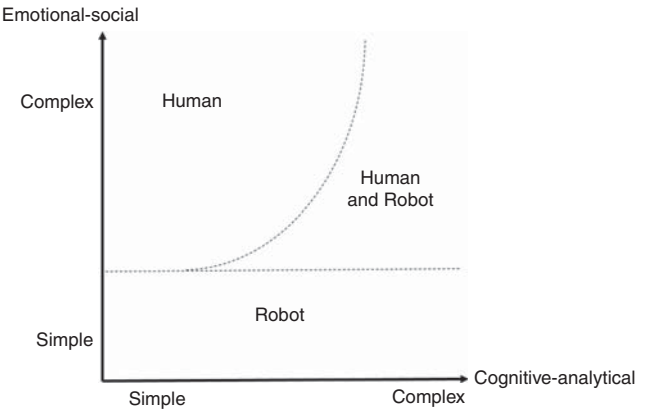

Figure 3.
Service delivery based on the complexity of emotional and cognitive tasks

Physical task functionality and service volume. Finally, for physical tasks, service robots require the needed physical functionality (also referred to as finger and manual dexterity; Frey and Osborne, 2017). In the foreseeable future, it seems unlikely (or it may be prohibitively expensive) that robots will be equipped to handle a wide range of diverse services that are not required on a reasonable scale. Each robot deployed would have to be equipped to handle a wide range of physical tasks. For example, it may prove too costly to equip every robot with all the tasks required for a technician in a hotel or serviced apartment to do. These tasks can range from opening locked doors for tenants who lost their keys, climb ladders and replace light bulbs, to getting their hands dirty when providing emergency plumbing services (see Figure 4). For high-frequency tasks, however, one can expect that robots are likely to be developed and deployed to handle them (e.g. bringing guests' luggage to their rooms and delivering room service). Also, it is conceivable that service employees will work in teams with robots taking on the heavy or otherwise for people unpleasant, difficult or even dangerous tasks. Such service robots perhaps can be viewed as smart and autonomous tools that work hand-in-hand with employees, each playing to their strengths.

Contrasting tangible actions with intangible ones, one can deduct that robots will be equipped to handle the latter even if they are infrequent for an individual robot, but

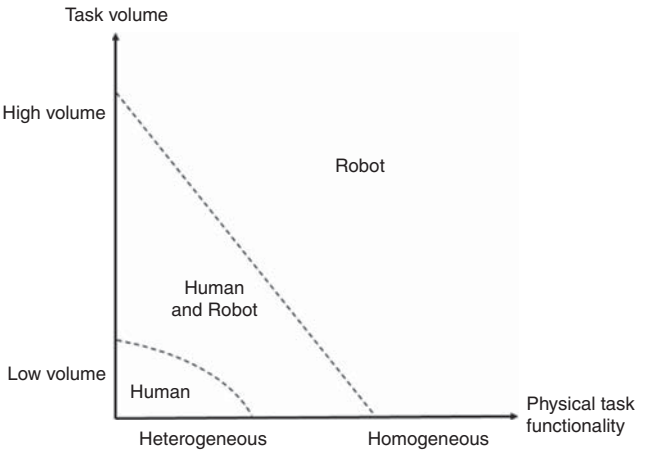

Figure 4.
Service delivery based on volume and heterogeneity of physical tasks

nevertheless will be required at a higher frequency system-wide. As no physical distributed robot capabilities are needed, a central module (or AI) can be developed for such tasks.

In sum, service robots will increasingly be deployed where they can make service delivery significantly cheaper and better. The next section discusses the customer perspective and how it is related to the characteristics of service robots.

The customer perspective on service robots

Research has demonstrated that a quality core service is necessary but not sufficient for achieving a competitive advantage (e.g. Bharadwaj *et al.*, 1993). During the service encounter, customers often place a premium on pleasant relations with service employees – sometimes described as rapport, engagement and trust, and so providing emotional and social value. However, by 2020, it is estimated that 85 percent of all customer interactions will take place without a human agent (Schneider, 2017).

According to the technology acceptance model (TAM; Davis, 1989), a customer's intention to use a new technology depends on the cognitive evaluation of its perceived usefulness and ease of use. However, the service must not just deliver the core, but frequently also social-emotional and relational elements of the service (Stock and Merkle, 2018). Furthermore, Fiske *et al.* (2007) suggest that warmth and competence are two fundamental dimensions of social perception that, "together, account almost entirely how people characterize others" (p. 77) and shape their behaviors (Cuddy *et al.*, 2008). Dominance is generally related to the functional outcomes of an interaction and warmth to its social outcomes (c.f., Ames and Flynn, 2007).

Furthermore, role theory (Soloman *et al.*, 1985) provides a useful additional theoretical foundation to consider how customers will evaluate service robots. A role is a cluster of functional, social and cultural norms that dictate how interacting parties (i.e. service provider or service robots and customers in the context of this paper) should act in a given situation (Giebelhausen *et al.*, 2014). Role theory posits that both actors should act in accord with socially defined roles for role congruency to emerge, or if an actor is not aligned with the prescribed role then role incongruency emerges.

In sum, it seems reasonable to assume that consumer acceptance of service robots depends on how well robots can deliver on the functional needs (i.e. related to dominance) and the social-emotional and relational needs (i.e. related to warmth) to achieve role congruency. This view is consistent with that of Heerink *et al.* (2010) who extended TAM by including a range of social-emotional and relational variables in the context of eldercare. Therefore, the sRAM is advanced that builds on the original TAM by adding social-emotional and relational needs (Figure 5).

Functional dimensions and self-service technology (SST)

The functional dimensions and subjective social norms of technology adoption are well understood and represent the core of the technology acceptance model (TAM; Davis, 1989; King and He, 2006; Schepers and Wetzels, 2007). We will not introduce the TAM here again. Furthermore, it is assumed that service robots will perform well on the functional dimensions and, therefore, will not hinder adoption (c.f., Huang and Rust, 2018). In fact, this is an important difference to customers' technology acceptance in a service context, that is, the adoption of SSTs. Specifically, SSTs face frequently a long adoption period by customers who often fear they do not know how to operate an SST, may get stuck and cannot complete a transaction (e.g. on a ticketing machine or app) (c.f., Meuter *et al.*, 2005). It can be assumed that the adoption of service robots will be faster and smoother than for most SSTs (for a contrast of service robots and SSTs see Table II). Service robots have an unstructured interface and guide customers through the process. Even customer errors can

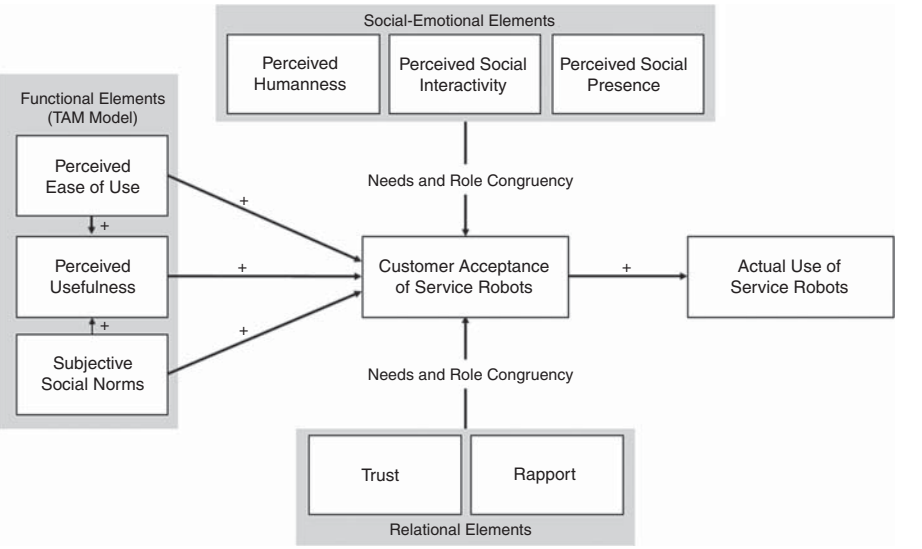

Figure 5.
Service robot acceptance model (sRAM)

Dimension	SST	Service robots
Service scripts and roles	Customers have to learn the service script and role, and follow it closely	Flexible interaction and scripts are supported
	Are ideally self-explanatory and intuitive, but customers still have to navigate through the interaction	Can guide the customer through the service process very much like a service employee would
Customer error tolerance	Generally do not function well when customers make errors or use the SST incorrectly	Will be error tolerant
	Generally are not effective in recovering customer errors	Can recover customer errors and guide the customer
Service recovery	The service process tends to break down when there is a service failure; recovery is unlikely within the technology	Can recover the service by offering alternative solutions very much like a service employee could

Table II.
Contrasting self-service technologies (SSTs) with service robots

be corrected by the robot, making robot-delivered service much more robust than existing SSTs. That is, getting stuck at a machine because of a customer making a wrong entry or not understanding instructions will be a thing of the past. Customers will be able to interact with the robot much like with a service employee (e.g. "I need a return ticket for two and want to pay with this credit card"). That is, usefulness and ease of use seem to be a given in most cases but would be a barrier if not provided at a level required by customers.

Furthermore, the relationships between the functional elements and customer acceptance are positive as increased ease of use, increased usefulness and increasing congruency with social norms lead to greater customer acceptance (Schepers and Wetzels, 2007). For social-emotional and relational elements, however, more is not always better. Customers may not want to have social interactivity or rapport with a ticketing robot. Therefore, it is important that service robots deliver on those elements according to customer needs and wants, and it is this needs congruency (c.f., Wirtz and Mattila, 2001) and role congruency (c.f., Soloman *et al.*, 1985) that drive acceptance rather than a high or low level on those elements.

Social-emotional dimensions

Stock and Merkle (2018) argue that customers' acceptance of robots will not only depend on their perceived functionality but also on social-emotional elements (see also Heerink *et al.*, 2008; van Doorn *et al.*, 2017) such as perceived humanness (Tinwell *et al.*, 2011), perceived social interactivity and perceived social presence (van Doorn *et al.*, 2017). Each of the three sub-dimensions will be discussed below.

Humanness. Robots can become almost indistinguishable from humans, especially on phone and text interactions. For example, a recent study found that 38 percent of chat users were uncertain whether they interacted with a human or chatbot, and 18 percent guessed wrong (Wünderlich and Paluch, 2017).

For face-to-face service encounters, social robots are likely to reflect humans closely and possess sufficient levels of anthropomorphism. Duffy (2003) states that in order for meaningful social interaction to occur between a human and a robot, the deployment of anthropomorphic qualities is necessary, either in form or behavior. However, strong anthropomorphic qualities lead to people having overly optimistic expectations about a robot's abilities which can then be disappointed. That is, the more realistic a robot face is, the more a person expects it to behave like a real human. For this reason, Duffy (2003) suggests that the ideal social robot should not be a "synthetic human."

This line of argument is also supported by the uncanny valley theory which posits that the closer an artificial face becomes to looking human, the more it is preferred, just before the point when it is almost indistinguishable from a human's (Mori, 1970). At this point, the face begins to look strangely familiar but at the same time unnatural and creepy, can be unsettling, and can deter people from being willing to interact with robots (Tinwell *et al.*, 2011). Therefore, small deviations from humanness can make a big difference.

Social interactivity. Breazeal (2003) suggested that the design of robots does not have to be humanlike in order for a robot to be seen as competent in a social situation. For example, a robot can be credible if it appears to have social intelligence (Bates, 1994). Nevertheless, humans generally apply a social model when interacting with autonomous robots, which includes the perception that robots have intentions behind their behaviors (Breazeal, 2003). Therefore, for humans and robots to be able to interact effectively requires robots to observe accepted social norms, including displaying the appropriate actions and (surface) emotions. It is important that customers' needs, their perceptions of a robot's social skills and robot performance are aligned for a wide adoption of service robots.

Social presence. Social presence refers to the extent to which a human believe that someone is "really present" (Heerink *et al.*, 2008). In the context of service robots, ASP is defined as the extent to which customers feel that they are with another social being (Heerink *et al.*, 2010; van Doorn *et al.*, 2017). Social presence has been shown to affect trust building since individuals are more likely to develop trust in another person when they meet personally. It can be assumed that social presence, or the feeling that "someone is taking care," affect the acceptance and has consequently an influence on customer behaviors.

Relational dimensions

Besides social-emotional aspects, two important relational dimensions (i.e. trust and rapport) were identified to be linked to robot acceptance (Heerink *et al.* 2010; Nomura and Kanda, 2016) and are discussed next.

Trust. Trust is the perceived competence (i.e. credibility) and benevolence of a target of trust (Doney and Cannon, 1997). The information systems literature added emotional trust

as a third dimension (Komiak and Benbasat, 2006). Emotional trust is the extent to which one feels secure and psychological comfortable about depending on the trustee (i.e. the robot in our context). Robots with humanlike attributes appear more likely to inspire trust, but only up to a certain level of humanness due to the uncanny valley theory (Tinwell *et al.*, 2011). In fact, research suggests an undercurrent of apprehension, unease, and distrust toward robots (Gray and Wegner, 2012).

Benevolence trust pertains to the care and concern that the trustee (robot) for the genuine welfare of the other party (customer). The extent to which service robots can display the emotions (empathy, compassion) and behaviors that give the impression that they truly have the customer's interests at heart may prove to be a challenge. It seems easier for customers to believe and trust that a service employee understands them, feels with them and is on their side (e.g. sometimes even bending company rules to accommodate a customer). It remains to be seen whether a robot can provide the same emotional connection and the resulting trust, and not be seen as being an extension of the organization's machinery (i.e. as one would view an SST).

Finally, people were shown to have a general aversion toward algorithms, especially when they have seen an algorithm making a mistake, which inevitably will happen. Algorithm aversion holds even in situations where evidence-based algorithms consistently outperform humans (Dietvorst *et al.*, 2014, 2016). People seem to forgive people, but quickly lose trust in AI. As such, the more a robot is viewed as trustworthy and as having the customers' best interests as a priority, the higher seems the likelihood of adoption.

Rapport. Rapport can be characterized as the customer's perception of an enjoyable interaction with a service robot (i.e. a feeling of care and friendliness, robot's ability to stimulate curiosity, and meeting customer needs for achievement) as well as a personal connection between the customer and the robot. Building rapport seems essential where social closeness and affiliation are central to a service, which is often the case for services such as education, elderly care and high-risk financial services.

Robot design can help to build rapport. For example, Wilson *et al.* (2017) found that both hand gestures and verbal acknowledgment can improve human-robot rapport. In other studies, participants' rapport, cooperation and engagement were enhanced when they engaged in collaborative tasks with robots (Seo *et al.*, 2018) and when interactions with the robots were personalized (Lee *et al.*, 2012). These findings are consistent with a study in aged care facilities where residents embraced daily interactions with robots which included rehabilitation assistance, playing games, having conversations and having exercise classes led by robots. As one resident noted, "Even when we can just watch them, they make us laugh and feel happier" (Disability Support Guide, 2017), while another referred to the robot "as their friend" (Creative Digital, 2017). In sum, for some services acceptance of robots will depend on the extent to which service robots can fulfill consumers' need for rapport.

Mapping customer needs against robot capabilities

Building on robot vs human capabilities in Table I, its synthesis in Figure 3 and sRAM, customer needs and wants are mapped in Figure 6 to show from a consumer perspective when humans, robots, or human-robot teams will be best at achieving needs congruency on the functional, social-emotional and relational dimensions of sRAM.

Simple cognitive/analytical and simple emotional/social tasks. Buying train tickets, renting a car, booking a courier service pick-up, and supermarket checkouts fall into this category. Here, customers generally want reliable, fast and convenient core services. In these services, customers may even be indifferent to emotional displays (Rafaeli *et al.*, 2017) and other

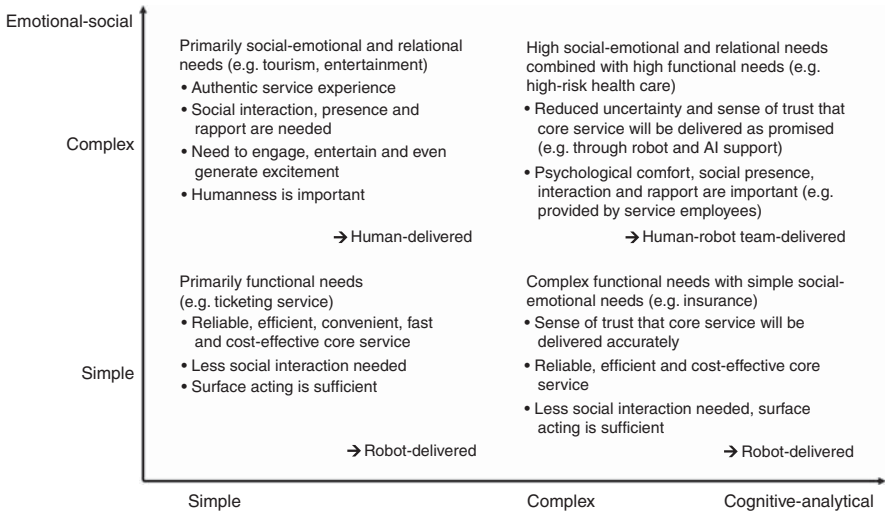

Figure 6.
Service delivery examples based on the complexity of emotional and cognitive tasks

social-emotional and relational elements. Robots will be the dominant delivery mechanism for these services.

Complex cognitive/analytical and simple emotional/social tasks. Typical examples of services in this category include insurance, government services, stockbroking, communications and other services with a strong back office analytical capability but with a negligible front office. Here, consumers seek a competent and reliable core service with convenient customer service. There is little need for social interaction, social presence and rapport. Robots will increasingly deliver such services.

Simple cognitive/analytical and complex emotional/social tasks. Tourism, sporting and entertainment services and service recovery situations would fit this category. Here, the core service is often an experience rather being the outcome- or problem solving-focused, and the service delivery can take place over multiple touchpoints (e.g. a day in a Disney theme park). Customer expectations are frequently high for social presence, pleasant social interaction and rapport, and even authentic experiences with real shared emotions. These services will by and large continue to be delivered by people.

Complex cognitive/analytical and complex emotional/social tasks. These services require service providers to possess both complex cognitive/analytical and complex emotional/social skills, such as in many high involvement healthcare, nursing, and higher education contexts. Most services in this category are highly customized and the service delivery process and its outcomes are often uncertain. It seems unlikely that robots would possess the social intelligence and communications skills to deal with the complex emotional issues involved adequately.

Likewise, these services are so complex that it seems unlikely that human providers will feel comfortable to offer such services without AI support. For example, a medical doctor will have never diagnosed many of the rare diseases, but a service robot will be able to map all patient data and symptoms against its knowledgebase and provide probabilities of even the rarest diseases for a doctor to consider and explore further. Likewise, a robot may well take blood pressure, assess other patient health indicators and prepare medication while a nurse performs the soft skills (e.g. displaying empathy, caring and affiliative communications to reduce psychological discomfort; Roongruangsee *et al.*, 2016). Such services are likely to be increasingly delivered by human-robot teams.

Ethical and societal implications of service robotics

Robots will not only impact customers but are likely to touch all strata of society (Delvaux, 2017), which makes it important to examine their ethical and societal implications. Ethical and moral principles guide human interaction and agency, and influence decision making and behavior. The purpose of ethics is the improvement of the general well-being of all participants in society (Kuipers, 2016). Ethics especially focuses on protecting and improving the personal integrity, and human dignity makes sure that the rights of the weakest in society are protected and aims at limiting possible inequalities caused by the advancement of robotics (Veruggio and Abney, 2012). As summarized in Figure 1, the increasing use service robots will provide a series of ethical and societal challenges across the micro, meso and macro level that require critical reflection.

Micro level: implications for consumers

Service robots can have many positive outcomes for consumers. There are, however, several ethical issues that need to be addressed as well.

Privacy and security. Service robots are by nature able to "sense, process, and record the world around them" (Calo, 2012, p. 187), allowing them to record anything and everything in minutiae detail. Robots' ability to not only store data but also connect to and retrieve data from other sources provide additional concern. Article 12 of the United Nations Universal Declaration of Human Rights postulates: "No one shall be subjected to arbitrary interference with his privacy, family, home or correspondence […]" (UN, 1948, p. 4). Furthermore, government authorities might want to access recorded data, which would be an intrusion into an individual's privacy if there is no valid reason for the information to be obtained (Holder *et al.*, 2016). This would be in direct breach of Article 12. Privacy will be a major ethical challenge to be negotiated at increasing robot deployment.

Denning *et al.* (2009) outline several security risks. For example, sensitive data may be stored in the cloud where criminals could conceivably access the data and use them to blackmail users (Holder *et al.*, 2016). Furthermore, robots could be hacked and accessed remotely to cause physical harm and destruction in the home space. With a person's life, behaviors and preferences so closely monitored, recorded and potentially accessible by anyone, securing and safeguarding personal information and physical safety is therefore of utmost importance.

Dehumanization and social deprivation. Veruggio *et al.* (2016) explored dehumanization in a healthcare context raising questions around emotional attachment of patients toward their robotic carers but also patient's reactions (i.e. anger and frustration) to robotic care: will, for example, a patient accept medicine been given to them by a robot rather than a nurse? Other examples mention that the replacement of carers with robots would dehumanize care by depriving people of human contact (Delvaux, 2017) and could even be considered a form of cruelty (Sharkey and Sharkey, 2012). Loneliness is a known problem especially for the elderly and in a recent study by Čaić *et al.* (2018), the elderly voiced concerns that their usual social networks may start neglecting them as they would assume that the robot would be there to take care of them thus increasing social isolation. Even replacing a human cleaner with a robot vacuum cleaner would take the opportunity for an elder to interact with a human being (Sparrow and Sparrow, 2006).

Meso level: implications for markets and organizations

The economics of robot-delivered service and its related research and development, protection of IP and potential liability issues raise concerns at the meso level.

Winner-take-it-all markets. Robot prices have decreased at a constant rate of 10 percent annually over the last decades, and may again half by 2025 (Manyika *et al.*, 2013). The declining cost of service robots is making this technology viable for an increasing range of service contexts. As identified in Table I, in comparison to people-delivered service, robot-delivered service is based on economies of scale, scope and network effects. From a customer perspective, this can lead to cost-effective, personalized and efficient services. However, price reductions depend on how much of the cost savings are competed away and transferred to the customer. There is the danger that "winner-take-all-markets" are created as scale and network effects will lead to a small number of winning service providers and a large number of losers (c.f., Fehrer *et al.*, 2018).

In addition, with the increasing speed of technological advances and the enormous potential market for robotics, it is perceivable that robot manufacturers, robot developers, and programmers may be able to take advantage of proprietary IP, standard-setting power and scale to create monopolies or oligopolies in certain industries and contexts. Trehan and Dunn (2013) provide an example in the medical industry with soft tissue robotic surgical equipment. Here, they postulate that price points depend on the bargaining power of the state. In the USA, for example, where healthcare provision is primarily private, fragmented and competitive, the chances of monopolization are higher than in the UK where healthcare regimes are (at least partially) state-managed.

Investment, innovation and liability regimes. For service robots to be successful, organizations are required to invest in innovation that integrates service robots into their offerings. However, not every service robot innovation will be successful. In worst case scenarios unsuccessful service robot offerings could be followed by legal action in addition to the loss of the initial investment (Dyrkolbotn, 2017).

If the liability regimes surrounding the usage of service robots are too strict, private sector investment will be reduced due to the potential liability implications. This, in turn, could impede service robot innovation and implementation overall. However, the challenge is to establish a liability regime that is designed well enough to not dwarf investment into innovation due to fear of failure and subsequent legal action whilst at the same time upholds ethical standards of safety and security for customers and other stakeholders (Dyrkolbotn, 2017).

Meso level: implications for markets and organizations

Synthesizing the micro and meso level of implications of robot service delivery, several societal implications arise relating to employment and inequality within and across societies.

Robotics and employment. With every new technology, discussions are fought over how it will impact jobs and wages. For customers to be able to consume, they need to have sufficient disposable income, which is normally provided by well-paid jobs. However, it is expected that most low skill and low wage (service) jobs will be automated in the near future (Frey and Osborne, 2017; Huang and Rust, 2018). The exponential progress observed in robotics is feared to lead to higher unemployment, which could then result in more economic inequality as fewer and fewer people would be beneficiaries of the wealth that these technologies create (Nourbakhsh, 2015). Some authors even warn of "a fundamental threat to human employment" (Huang and Rust, 2018, p. 34), but they also see great opportunities for humans and machines providing service together. By pairing robots and humans, they can complement each other, make work more productive and interesting, and provide better service at a lower cost (Decker *et al.*, 2017). Looking more closely at tasks instead of jobs, service robots are likely to be increasingly used for tasks that would cause health problems, are strenuous or are a physical burden for humans (Delvaux, 2017).

Nourbakhsh's (2015) study suggests that occupations that require workers with a high degree of creative and social intelligence will probably not be automated in the next decades

as human employees still possess a competitive advantage in these tasks (see also Table I). However, although these unique human abilities remain, they will become fewer and less pronounced (Belk, 2017). Similarly, Huang and Rust (2018) predict that service workers who want to stay in their jobs will have to upgrade their empathetic and intuitive skills as "soft" people skills will be of crucial importance for employability.

In balance, the assessment by Decker *et al.* (2017) seems right in that "generalizing statements cannot be made – neither from an economic nor from a work science point of view" (p. 353). It is likely that workers will find ways to adjust to changing technological endowments by carrying out new tasks and thereby avoid unemployment. New technologies will also create new jobs (Arntz *et al.*, 2016) and very different employment ecosystems (c.f., Subramony *et al.*, 2018). However, Huang and Rust's (2018) conclusion rings true in that there are major employment challenges ahead, especially for low-skilled service workers. These challenges have the potential to increase inequality with all its negative societal consequences.

Inequality within and across societies. There is a plausible concern for the availability and affordability of robot-delivered services across society. Whilst a decrease in cost of robot technology will lead to an overall cost reduction in robot-delivered services, it is perceivable that parts of society and of the world community will be left behind. Freeman (2015) discussed the difference between capital and labor income and how a robot-driven society will support the former rather than the latter, thus raising inequality amongst countries based on the accessibility of robot technology. His prediction is bleak: "If the trend toward greater inequality continues, our societies will turn into a modern form of feudalism, with a few billionaires and their ilk dominating economic markets and governments as well, just as the lords and ladies of medieval Europe dominated their societies" (p. 6). Equitable technology ownership is the key he proposed to the continued well-being of humanity across the globe (see also Fisk *et al.,* 2018 on inclusive service systems).

Maloney and Molina (2016) also raised concerns regarding international equity. Developing economies traditionally have been on the receiving end of lower skilled manufacturing and outsourced services within the value chain which allowed economic progress within these countries. However, with these activities being taken over by robots, this so-called "flying geese" pattern will be halted and developing economies will have fewer chances for economic progress.

Conclusions, implications and further research

This paper explored the role of service robots in three main parts. First, it provided a definition of service robots, described their key attributes, contrasted the features and capabilities of service robots and frontline employees, and provided an understanding for which types of tasks robots will dominate in service delivery, where humans will dominate, and areas where humans and robots will be likely to collaborate. Second, it examined the implications for consumer-adoption in a sRAM. Third, it provided an overview of the ethical and societal issues surrounding robot-delivered services at the micro, meso and macro level.

The field of service robots is still in its infancy and there are exciting opportunities for research in all the areas that were touched on in this article. Table III provides research questions at the micro, meso and macro level related to the issues discussed in this article. It is hoped that this article will help academics and practitioners alike to understand better the opportunities and challenges involved in the introduction and adoption of service robots and that this conceptual study will offer a foundation and impetus for further research in this rapidly evolving field.

Table III.
Further research agenda for service research

Future research topics	Research questions
Micro-level perspective	
Service tasks, sRAM and robot design	How will the dimensions of cognitive and emotional-social complexity influence robot design? Which additional dimensions would be critical for effective service robot design (e.g. the role of digital density and physical complexity; c.f., Bolton *et al.*, 2018) and should be included in sRAM? How should service robots be designed to achieve needs congruency (Wirtz and Mattila, 2001) and role congruency (Soloman *et al.*, 1985; Giebelhausen *et al.*, 2014) in terms of their social-emotional (incl., humanness, social interactivity and social presence) and relational elements (incl., trust and rapport) in sRAM to achieve high degrees of customer acceptance and use? What are the service and industry characteristics that potentially moderate the impact of drivers of customer acceptance of service robots? Beyond the physical and virtual nature of service objects, what drives whether physical or virtual robots are preferred, and how can the more cost-effective virtual robots (e.g. holographs rather than physical robots at information counters) be designed to achieve greater consumer acceptance? What consumer and context factors determine the optimal level of humanoid appearance and social skills for service robots? How will technology adoption by organizations and customers change in general given the enhanced capabilities of robotics and AI (c.f., Larivière *et al.*, 2017)? How can service robots be effectively integrated into the servicescape? What will the new servicescape look like in a robot-dominated service environment?
Customer-service robot interaction	What determines the customer perceptions of the humanness, social interactivity and social presence of service robots? How do customers interpret robot-displayed surface emotions? How do the many robot design dimensions relate to customer responses? For example, initial research shows that people prefer non-verbal behaviors of robots to be humanlike rather than robot-specific (Rosenthal-von der Pütten *et al.*, 2018). Issues of robot gender and personality are likely to impact consumer responses (Belk, 2017), and preferences may depend on context-dependent stereotypes. For example, extrovert female robots were preferred in healthcare tasks and introvert male robots in security roles (Tay *et al.*, 2014) The uncanny valley theory needs further exploration and refinement (Wang *et al.* 2015) with regards to its causes and outcomes, and its boundary conditions. Which role do individual customer characteristics (e.g. need for control, technology anxiety, and situational involvement) play? Which service types and customer segments desire rapport with a robot? How can the service robot-customer interface be designed to be as easy, convenient, flexible and error tolerant as the interaction between service employees and customers? What drives customer trust and rapport with service robots?

(*continued*)

Table III.

Future research topics	Research questions
	How can and should service robots be designed so that customers perceive them to be "on their side", to be empowered, to allow (calculated) rule-bending, manage exceptions and handle service recoveries?
	How will customers adjust their expectations over time regarding their own roles and those of service robots? What will determine role congruence in service robot encounters?
	How will consumers respond to robot-displayed surface-acted emotions in the long run? Will such displays continue to have a positive impact or will they be ignored as the typical friendly face on an ATM screen?
Customer concerns	What drives a consumer's initial mistrust of robots and how can it be overcome?
	Given consumers' propensity for algorithm aversion, what will determine customers' acceptance robots for complex cognitive-analytical tasks? That is, how can algorithm aversion be mitigated (e.g. Dietvorst *et al.*, 2014, 2016)?
	How can consumer privacy be guarded and privacy concerns be mitigated given the constant observation of customers (e.g. through biometrics), the pervasive capturing of customer data, and the connectedness of service robots to large databases including CRM systems?
	What are the alternative theoretical approaches to explain consumer acceptance and satisfaction with robotic services?
Dehumanization and social deprivation	Will prolonged interactions of humans (esp. vulnerable groups such as children and the elderly) with service robots dehumanize human relationships? For example, what will children learn from robots that cannot show deeply felt joy in the children's achievements and never truly lose their temper?
	What will the impact be on people's well-being and psychology if a large proportion of daily service will be delivered in a highly predictable and standardized manner without deviations from service scripts and without human touch? Will service robots be designed to heterogeneity to avoid customer boredom?
	Will the introduction of sex robots and their potential influence on gender relationships see the potential dehumanization of very intimate encounters?
	Will service robots ever be able to have genuine emotions and thereby become authentic companions for humans, and what will the impact be for the human race as we know it?
Service robot and employee interaction	High emotional and cognitive service tasks will be delivered by service employee-robot teams. How can service robots effectively be integrated into such teams? What are the drivers of success and failure for such teams? What dimensions determine employee and customer acceptance of such service delivery systems? What will the work ecosystem look like for employees in such systems (c.f., Subramony *et al.*, 2018)?
Meso-level perspective	
Competitive advantage and service robots	Given that the hardware and much of the software of service robots will be provided by third-party vendors, how can organizations build a competitive edge on the knowledgebase, knowledge organization and application? Where is the scope to build a competitive advantage in the application of service robots and related AI for the individual organization, and how can organizations own and project this advantage?

(*continued*)

Future research topics	Research questions
	How will be the role of "large armies" of service employees in building competitive advantage be reduced? Will the impact be that a smaller group of employees becomes even more important for developing an organization's competitive advantage?
	Will other factors gain in importance in developing a competitive edge, and if yes, which ones (c.f., Wirtz and Ehret, 2018)?
Economics of service robots and winner-take-it-all markets	What will be the economics of robot and AI vendors and deploying organizations? How strong will economies of scale, scope, and network effects be, and will they drive consolidation of industries to the extent that competitive intensity is reduced and lead to 'winner-take-it-all markets?
	What mechanisms may be necessary and effective in making sure that cost savings due to economies of scale, scope and network effects are eventually transferred to customers so that they can benefit from lower prices and increased standards of living?
	How can regulation ensure that robot manufacturers, developers, and programmers cannot create monopolies or oligopolies in specific industries and contexts which would negatively impact deploying service organizations and their customers?
Investment, innovation and liability regimes	How can liability regimes surrounded the use of service robots to be designed so that they uphold ethical standards of safety and security for stakeholders but are also not too strict as this would reduce the investment of companies due to the potential liability implications?
Macro-level perspective	
Service robots and employment	How can training systems be designed to help current generations of frontline employees obtain the necessary skills to stay competitive? How to make sure that sufficient (re-)training opportunities will be offered especially to low-skilled employees?
	How can governments equip current and future generations of employees with valuable skills that are not at risk of being made redundant by service robots?
	As it is unlikely that all low-skilled service workers can be up-skilled or re-skilled, what will happen to the ones whose skills will not be in demand anymore and who cannot learn new skills? Can governments provide their citizens with an improved safety net (e.g. a universal basic income)?
	How, in a labor-light economy, can people still live fulfilling and dignified lives if these are not centered around work anymore? How would taxation, social safety, and education have to be rethought? How could or should the wealth created by robots, AI and automation be shared?
Service robots and inequality within and across societies	How can equitable access to robot technology be achieved so that parts of society and the world economy are not left behind?
	How can developing economies increase their skills base and participate in a robot-driven world?
	How can the trend toward greater inequality be arrested or reversed that, if unchecked, will be accelerated by robotics, so that our societies are not turning into a modern form of feudalism?

Table III.

Acknowledgments

All authors contributed equally to this paper. The authors like to acknowledge the following individuals for their valuable feedback to earlier drafts of this paper (in alphabetical order): Russell Belk, Martina Čaić, Julia Hagel, Tae Woo Kim and Jasper Teow. Furthermore, the authors thank the attendees of the presentations based on this paper (in chronological order) at the Thought Leadership Conference "Theorizing beyond the Horizon: Service Research in 2050" (Brisbane, November 2017), the Research Seminar Series, Marketing Division as Nottingham University Business School (Nottingham, April 2018), the 10th SERVSIG Conference (Paris, June 2018), and the 11th European Association of Consumer Research Conference (Gent, June 2018) for their lively discussions and helpful suggestions and ideas. Finally, the authors thank Pascal Bornet for presenting McKinsey and Company's approach and current projects on robotics and AI in service delivery and discussing the ideas with the authors (Singapore, May 2018).

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