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REVIEW PAPER

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A transdisciplinary review and framework of consumer interactions with embodied social robots: Design, delegate, and deploy

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Abstract

Social robots are gradually entering the organizational frontline, and research is beginning to unveil the implications for consumer–firm interactions. While empirical studies on human–robot service interaction (HRSI) are scarce in business literature, other scientific fields have generated an abundance of empirical findings that can inform consumer research on successfully integrating embodied social robots in consumer-facing services. In this light, a systematic literature review was conducted across scientific fields, screening over 13,500 research articles. Through a thorough review process, 199 service-relevant *empirical* research articles were identified. Emanating from these data, an organizing meta-framework is advanced (D^3: design, delegate, and deploy). Leveraging this D^3 framework, a comprehensive overview of several dimensions of the literature is provided, and key insights for each framework dimension are presented. Based on this overview, implications for whether, how, and when to integrate social robots in practice and a comprehensive future research agenda are developed.

KEYWORDS
consumers, embodied social robots, future research agenda, human–robot service interactions, systematic literature review

1 | INTRODUCTION

Social robots are increasingly being deployed in a wide variety of consumer-facing services, where they co-create value with and for the benefit of the consumers they interact with (Lu et al., 2020; Wirtz et al., 2018). Robots welcome customers to restaurants and hotels, entertain children, read cooking recipes at home, give additional information about products in stores, or assist the elderly with walking to support their health (Henschel et al., 2021; KPMG, 2016). What all these robots delivering services to consumers have in common is that they represent an "information technology in a physical embodiment, providing customized services by performing physical as well as non-physical tasks with a high degree of autonomy" (Jörling et al., 2019, p. 405). This integration of robots into the marketplace reshapes service interactions and also challenges some fundamental principles of consumer–firm interactions (Kaartemo & Helkkula, 2018; Subramony et al., 2018). While service robots come with different levels of intelligence (Huang & Rust, 2018) and in various manifestations (Wirtz et al., 2018), embodied robots engaging in social interactions with consumers are expected to ignite what could be the most dramatic transformation of the consumer service landscape in the age of service robots (Mende et al., 2019; Wirtz et al., 2018).

Thus far, research on the integration of embodied social robots in consumer-facing services is predominantly of conceptual nature (Čaić et al., 2019; De Keyser et al., 2019; Larivière et al., 2017; Lu et al., 2020; van Pinxteren et al., 2020; Subramony et al., 2018; Xiao & Kumar, 2021). As a consequence, calls for studies of success drivers for the integration of artificial intelligence-based technology, such as social robots, into services are repeatedly echoed as a chief research priority (Paul & Bhukya, 2021; Subramony et al., 2018; Wirtz et al., 2018). Seminal service work has yet to empirically explore consumer interactions with embodied social robots in general (e.g., Kim et al., 2019) or in particular contexts, such as hospitality (e.g., Choi et al., 2019), healthcare (e.g., Lee et al., 2017), food and status consumption (Mende et al., 2019), and elderly care (Čaić et al., 2018).

Meanwhile, empirical research on human–robot interactions (HRI), in which humans and robots coordinate their actions face to face in real time and in a shared environment (Dautenhahn, 2007), has been widely conducted in other scientific disciplines. For instance, it is well represented in fields such as robotics (e.g., Torta et al., 2014), medicine (e.g., Chita-Tegmark et al., 2019), information systems (e.g., Mettler et al., 2017), and psychology (e.g., Gallimore et al., 2019). The respective empirical findings amount to a wealth of knowledge on various social robot types interacting with consumers in different service contexts, studied with diverse scientific methods. Synthesizing the results of these studies promises implications for the design of successful interactions between consumers and social robots in service settings in general.

Because HRI is a growing multidisciplinary field, a variety of systematic literature reviews have been produced. However, none has been transdisciplinary in nature and taken a service focus. Most reviews have restrictive foci: non-verbal robotic communication (Saunderson & Nejat, 2019), emotions in HRI (Stock-Homburg, 2021), service failure (Honig & Oron-Gilad, 2018), first encounters (Avelino et al., 2021), ethical considerations related to HRI (Boada et al., 2021; Tan et al., 2021), social acceptance of robots in different occupational fields (Savela et al., 2018), social robots to combat loneliness (Gasteiger et al., 2021), or quantifiable evidence of human attitudes toward social robots (Naneva et al., 2020). Others have been restricted to a specific social robot model (i.e., NAO; Robaczewski et al., 2021) or context, such as elderly care (i.e., socially assistive robots [SAR]; Kachouie et al., 2014; Vandemeulebroucke et al., 2021; Wang et al., 2022), education (Woo et al., 2021), or hospitality (Ivanov et al., 2019).

Our extensive literature search identified four notable exceptions of literature reviews adopting an unrestrictive view of consumer interactions with robots. However, Lu et al. (2020) and Xiao and Kumar (2021) both predominantly derived their inferences from conceptual articles restricted to marketing and business outlets and thus based their implications on only a very limited set of empirical findings. Ameen et al. (2021) offered a comprehensive literature review of HRI across scientific disciplines, which did not, however, focus on consumer interactions with embodied social robots per se, but rather with smart technology in general. Finally, Lambert et al. (2020) included research articles in which users did not interact with social robots in service contexts and offered no structuring framework.

In summary, while the existing reviews each provide an overview of the HRI context of their particular focus and, in part, provide structuring frameworks, they mostly reveal a narrow perspective, either with respect to the literature stream they source from (e.g., marketing literature), the focal topic (e.g., service failure), or the robot types they studied (e.g., SAR). In consumer and marketing research, in particular, empirical research on consumers' interactions with social robots that are suitable for deployment in services is in undersupply compared to studies on other technologies, such as the Internet of Things (e.g., Kasilingam & Krishna, 2021; Nguyen & Simkin, 2017) or augmented and virtual reality technologies (e.g., Hilken et al., 2017; Shahab et al., 2021). Thus, we extend previous knowledge by reviewing the extant HRI literature from an all-encompassing perspective. We identified and mapped the empirical body of state-of-the-art knowledge on consumer interactions with social robots across scientific fields, developed a new and integrative framework to synthesize the literature on HRI in consumer-facing service contexts, and pinpointed future research avenues around consumer-facing service interactions.

2 | THIS REVIEW

The focus of this review is on human interactions with autonomous, embodied social robots providing services for and in co-creation with consumers, which we coin human–robot service interactions (HRSI). While established definitions of service robots in the business literature include autonomous smart objects (e.g., autonomous vacuum cleaners and self-driving cars; Jörling et al., 2019; Wirtz et al., 2018), the current systematic literature review aims to synthesize empirical findings on robotic complements or substitutes for employees in consumer-facing service contexts. Therefore, we reviewed only studies on embodied and autonomous robots that can interact socially with consumers. Because such robots are able to exhibit non-verbal and verbal cues to express emotions and intentions in a human-like manner (Breazeal, 2003), consumers accept them as peers and interaction partners (Fong et al., 2003). Hence, such social robots can be effectively integrated into services, where they augment or substitute service employees (Čaić et al., 2019).

Considering the wealth of empirical studies on HRI in consumer-facing service contexts in different scientific disciplines, paired with the paucity of systematic reviews of extant research on actual consumer psychological and behavioral responses to interactions with embodied social robots, this study aimed to establish a comprehensive, transdisciplinary overview of empirical insights on HRSI. To this end, we undertook a systematic review of HRSI studies across scientific disciplines to structure the available information from a consumer research perspective around three central research questions:

1. What is a guiding structure emerging from the extant HRSI literature?
2. What is the status quo of empirical insights on HRSI across scientific fields, and how can these insights be synthesized to inform researchers and practitioners on the successful integration of embodied social robots in consumer-facing services?
3. What future research avenues emerge from an integrative perspective on HRSI?

3 | METHODOLOGY

We used a systematic narrative literature review following the key stages suggested by Siddaway et al. (2019). This approach represents the most informative, thorough, and well-justified method (Paul & Criado, 2020; Paul et al., 2021) of identifying relevant studies, with minimal biases and errors (Jesson et al., 2011), and for critically evaluating and integrating the search results (Siddaway et al., 2019). Our systematic review, in particular, encapsulates studies on human–robot service interaction across disciplinary boundaries to gain deep insights from the existing literature through a systematic and structured content analysis of the identified papers (Lim et al., 2021; Seuring & Gold, 2012). Thereby, we investigate the data according to various dimensions, such as methodology, study contexts, characteristics of robots and consumers, and key constructs (Paul & Rosado-Serrano, 2019).

Next, we discuss our review process according to two main phases: (1) the systematic search and data extraction process and (2) the systematic review and analysis process. While steps in the former phase pertain to data collection, steps in the latter relate to data screening, cleaning, and coding. Figure 1 provides a detailed summary of our systematic review process.

3.1 | Systematic search and data extraction process

3.1.1 | Database search

The body of literature pertaining to robotics and HRI is broad in scope and incorporates a wealth of studies across a wide quality spectrum. In line with previous systematic reviews (e.g., Montoro-Pons et al., 2021), we used the Web of Science (WOS) database to source only articles that reflect on our research questions and meet a minimum quality standard (e.g., Kapoor & Banerjee, 2021). The WOS database includes the main corpus of HRI research in diverse scientific fields published in scholarly qualified, peer-reviewed journals (Antons & Breidbach, 2018). Thus, in line with our inclusion criteria, WOS helps to avoid low-impact, non-peer-reviewed sources (Martín-Martín et al., 2018).

This review encompasses studies on consumer interactions with embodied social robots in a service context. Accordingly, we formulated Boolean phrases to systematically search the WOS database

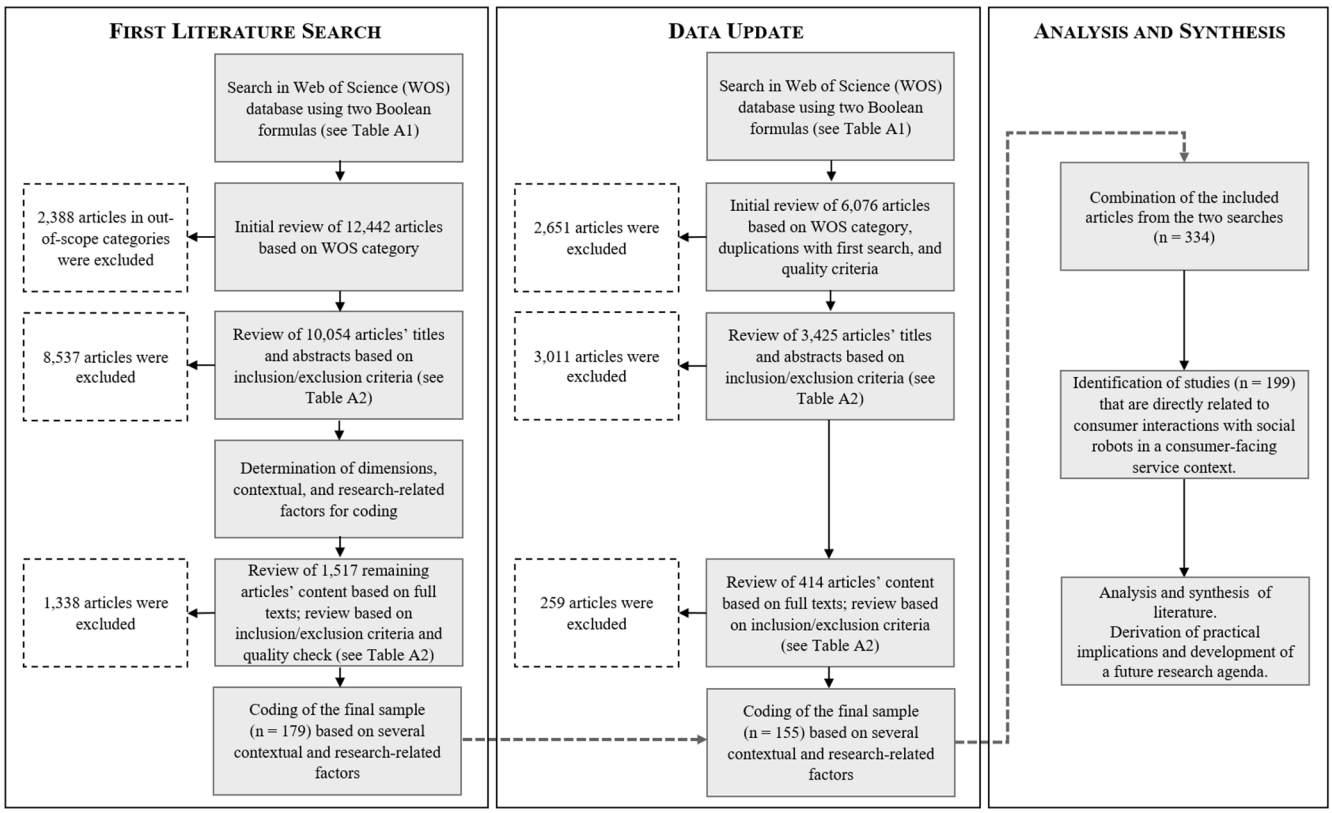

FIGURE 1 Systematic review and synthesis process

for suitable research evidence written in English (see Table A1 in Appendix S1 for a detailed overview). The first Boolean phrase included 28 terms used in prior literature to refer to robots deployed in different consumer-facing services, such as social robots, care robots, and assistive robots. We anticipated that in some neighboring disciplines (e.g., psychology and management), "robot" might also be used without further specification but still refer to social robots. Therefore, we developed a second Boolean phrase that included the term "robot*" on its own. With this phrase, we searched WOS again, focusing on selected categories (i.e., "psychology," "business," and "management").

The Boolean searches, conducted in May 2019, together revealed 12,442 articles (9,861 + 2,581), across 205 different WOS categories. After excluding WOS categories outside the scope of our review (e.g., astrophysics, physics, and thermodynamics), 10,054 articles remained. Then, in November 2021, we updated our data and re-ran the Boolean phrases, which resulted in 6,076 additional articles. After excluding irrelevant WOS categories, duplicates to the first search, and articles published in journals that did not meet the quality criteria, we added 3,425 of these articles to the data set.

3.1.2 | Data extraction

We used self-developed data extraction sheets to warrant transparency in our data, search, and analysis processes and to provide a control mechanism for the entire systematic review process (Rashman et al., 2009). We merged all article information resulting from the different WOS searches into one spreadsheet, which then served as a basis for all screening, coding, and information extraction processes.

3.2 | Systematic review and analysis process

3.2.1 | Initial screening

In the first screening round, two independent coders assessed each article's title. If an allocation based on the title alone was not possible, they reviewed the abstract to determine if it fit the scope of our research (Calabrò et al., 2019). The intercoder reliability exceeded the suggested threshold of 0.70 for both the initial (I_r = 0.92) and updated (I_r = 0.94) data screening (Perreault & Leigh, 1989; Rust & Cooil, 1994). Articles that received inconsistent codes were screened by a third coder from the author team. In this step, we excluded 11,548 articles (8,537 from the first and 3,011 from the second search data set) because they were not empirical (e.g., conceptual papers and reports) or did not study human behavioral or psychological outcomes resulting from direct or scenario-based interactions with embodied social robots. For example, some of the excluded papers focused on technical and engineering issues (e.g., Kim et al., 2009) or scale development objectives (e.g., Banks, 2019). We also excluded studies involving individuals with specific needs or limited agency (e.g., patients with Alzheimer's disease, children with autism, and infants <5 years old) because such actors co-create value in fundamentally different ways. Following this initial screening of titles and abstracts, we consulted the full text of all remaining articles (n = 1,931). If they did not meet the inclusion criteria (see Table A2 in Appendix S1 for a detailed overview), we excluded them (n = 1,597).

3.2.2 | Quality assessment

As a first measure for quality control, we included only peer-reviewed journal articles because the review process provides a quality control mechanism that validates the results that such articles afford (Ordanini et al., 2008). Using a conservative approach when excluding articles in fields for which the research team had less familiarity, we initially did not exclude any articles on the basis of journal quality. However, upon obtaining an overview in the full-text coding process, we noticed a substantial variance in scientific rigor across disciplines. Therefore, in line with other systematic reviews that investigate broad multidisciplinary fields (e.g., Follmer & Jones, 2018), we turned to other objective quality criteria, including the WOS index, impact factor, Scopus CiteScore, and Scopus journal quartile, all of which apply to the relevant scientific fields. We then included only those articles published in journals that appear in the Science Citation Index Expanded (SCI-E), and Social Sciences Citation Index (SSCI), with impact factors and Scopus CiteScores exceeding 1.00 and a ranking in the first quartile in one of Scopus's scientific categories.

3.2.3 | Coding

After this screening and quality assessment, the sample consisted of 334 articles. In line with previous systematic literature reviews (e.g., Babić Rosario et al., 2020), we first performed content analysis of these articles, coding them according to 13 dimensions: (1) aim of the study, (2) research method, (3) methodological nature (i.e., qualitative/quantitative), (4) sample characteristics, (5) study country, (6) study context, (7) robot brand/name, (8) robot type, (9) robot morphological characteristics, (10) independent variables, (11) dependent variables, (12) moderators and mediators, and (13) key findings. To determine if an article relates to HRI in a consumer-facing service context (i.e., HRSI), we categorized the underlying study contexts based on the North American Industry Classification System (e.g., healthcare, arts and entertainment; 2017). This effort revealed a total of 199 articles directly related to interactions of social robots and consumers in consumer-facing service contexts. All the codes were checked again by a separate coder from the author team, and any inconsistencies were discussed and resolved by consensus.

3.2.4 | Bottom-up thematic analysis

Following previous transdisciplinary reviews (e.g., Rietveld & Schilling, 2021), we performed an inductive, bottom-up analysis of

the final 199 articles to identify themes to structure HRSI literature. Inductive bottom-up approaches are especially suitable for producing an overall description of dispersed data compared to deductive top-down methods, which allow for more detailed analyses of more closely related data (Nowell et al., 2017). This is in line with our aim to develop a new, integrative framework emerging from our transdisciplinary data. After familiarizing ourselves with the data through content analysis, we identified common themes to cluster the articles in our data set (e.g., robot appearance, robot non-verbal behavior, and human versus. robot), which we iteratively synthesized until three overarching themes emerged that incorporated all previous subthemes (see Section 4). While we developed the themes without using a specific theory or framework as a blueprint, elements of the framework were drawn from previous work (Puntoni et al., 2021; Wirtz et al., 2018).

3.2.5 | PRISMA protocol

Finally, as suggested by Siddaway et al. (2019), we confirmed the suitability of the review and analysis processes by checking all items on the PRISMA 2020 protocol checklist, except for preregistration (see Appendix S1, Table A3; Page et al., 2021).

4 | RESULTS

4.1 | D³ as a guiding framework of HRSI research: Design, delegate, and deploy

With a bottom-up thematic analysis of the coded data, we developed a general, integrative framework to structure the HRSI literature (Figure 2) according to three overarching themes that emerged from the analysis of the 199 articles included in our review: *design*, *delegate*, and *deploy*.

4.1.1 | Design

A little more than half of the articles in our data set could be clustered under the design theme (n = 100 articles; n = 121 studies). Studies in these research articles aimed to understand the effects that the design of a robot's behavior (i.e., software) and appearance (i.e., hardware) might have on consumers. For example, studies of how a robot's behaviors, such as politeness (e.g., Lee et al., 2017), verbal or non-verbal emotion expression (e.g., Johnson & Cuijpers, 2019), and personality (e.g., Meerbeek et al., 2008), affect consumers fall under the

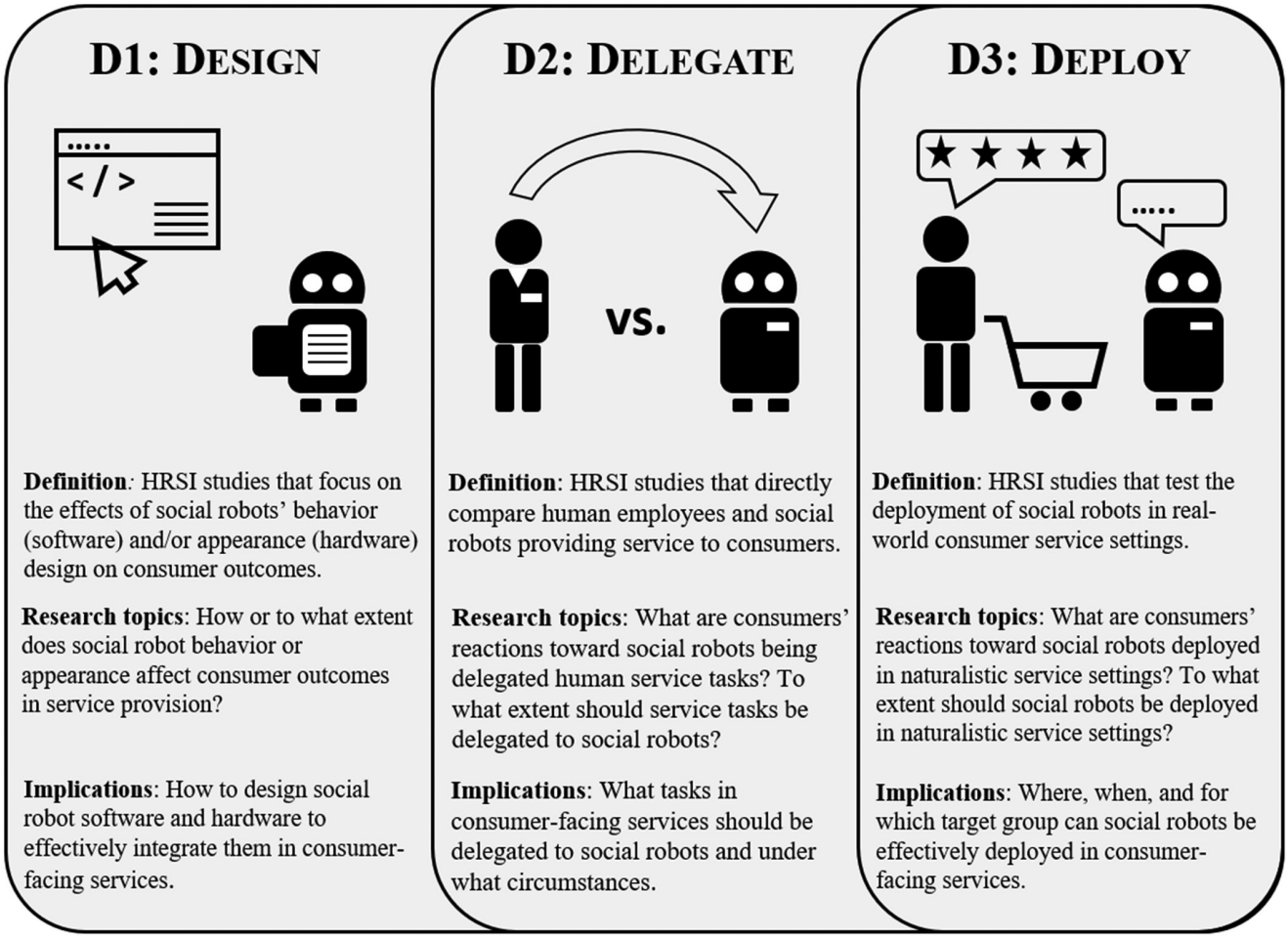

FIGURE 2 D³ framework of literature on consumer interactions with embodied social robots

design–software theme. Its design–hardware counterpart theme complements this perspective with a focus on how robot morphology (i.e., android versus. humanoid versus. machine-like; e.g., Qiu et al., 2020) or perceived gender (e.g., Stafford et al., 2014) informs consumer outcomes. Studies focused on design aspects mostly relied on laboratory or online experiments because they required high degrees of control.

4.1.2 | Delegate

The 32 articles covering 52 studies clustered under the delegate theme directly compared human and robotic service provisions in efforts to determine how delegating service tasks traditionally performed by humans to social robots affects the perceptions and behaviors of consumers (Puntoni et al., 2021). For example, researchers have assessed the relative performance of robots versus humans, measured in terms of information comprehension (e.g., Palanica et al., 2019), performance of clinical tests (e.g., Desideri et al., 2019), or guidance of crowds (e.g., Kanda et al., 2008). These studies mostly relied on between-subjects laboratory, field, or online experiments.

4.1.3 | Deploy

Finally, the third theme clustered 67 articles, including 77 studies of the deployment of robots in real-world settings. Rather than contrasting robots with human service providers, these studies attempted to establish the global effectiveness of social robots in consumer service environments. They might have compared robots being deployed across different environments (e.g., teaching science in an interactive laboratory or studio; Verner et al., 2016), offered general evaluations of a robot's long- or short-term deployment (e.g., Serholt, 2018), or suggested effective ways to introduce robots to stakeholders in the field (e.g., Winkle et al., 2020). In line with their predominantly exploratory nature, these studies mostly relied on (longitudinal) field trials, based on observations, interviews, or case studies.

These three themes also build on one another, such that each theme provides implications for the others. Researchers and managers interested in consumer interactions with social robots might first consider a robot's design aspects to predict their effects on consumers and then assess the effectiveness of delegating certain tasks in consumer service to a robot with this design before they finally deploy the robot to perform those tasks in a real-world environment.

4.2 | Status quo of empirical research on HRSI

In response to our second research question, we established the status quo of empirical insights into consumer interactions with social robots from a D^3 perspective. To this end, we first developed charts based on our descriptive analyses of (1) developments in article publications featuring empirical HRSI research over the years (Figure 3) and (2) the research fields represented in our data set (Table 1). To gain deeper insights into research settings, we next summarized and analysed information on (3) the methods applied and sample characteristics, (4) the geographic regions for the data collection, (5) the study settings, and (6) the types of social robots used (Table 2). Finally, we provide (7) an overview of variables studied in the HRSI literature (Figure 4).

4.2.1 | Publication development

Concomitant with technological advancements in artificial intelligence (Huang & Rust, 2020) and mechanical engineering

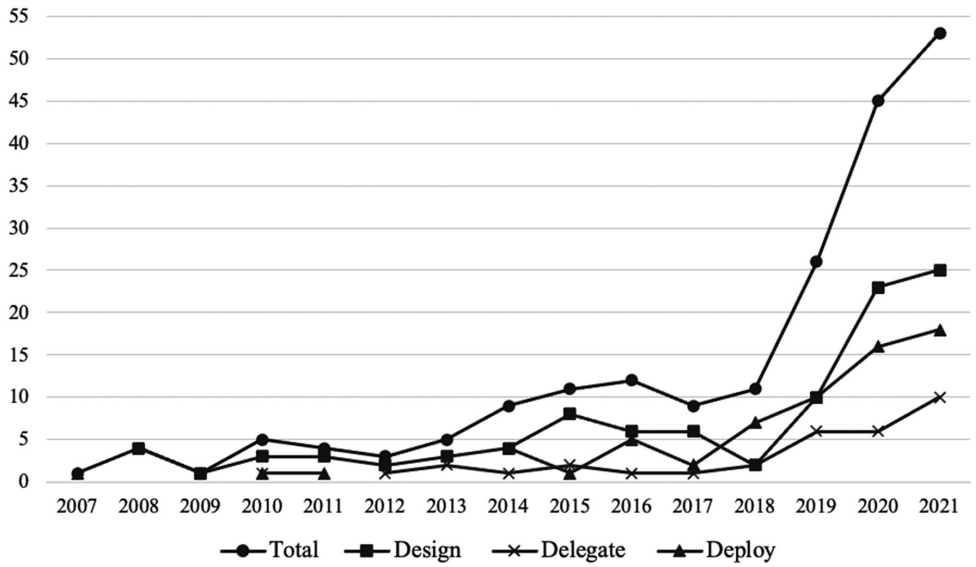

FIGURE 3 Publication development in total and by D^3 framework themes
Note: The graph presenting the development of article publications over time includes articles published in 2021 up to November 7

(Ghaffarzadeh, 2018), empirical research on human interactions with social embodied robots has increased significantly in the past decade (Figure 3). The first studies appeared at the beginning of the 21st century, but the majority of articles (84%; $n = 167$) in the final data set were published in 2015 or later. The topicality of HRSI is thus apparent: The years 2020 and 2021 (until November 7) account for 49% ($n = 98$) of all articles in the data set. The publication development is similar across all D^3 themes. However, the majority of articles under the delegate and deploy themes emerged from 2013 onward.

4.2.2 | Research fields

This review includes articles from multiple disciplines and across a variety of research fields: 199 articles published in 81 journals spanning 47 WOS categories. We identified 17 clusters of WOS categories, highlighting the multidisciplinary nature of our final data set (see Table 1 for an overview). The three most represented categories—robotics, psychology, and hospitality—account for almost half (48%) of the articles in the final data set. The other half encompasses diverse fields, including natural sciences (e.g., medicine, chemistry, and physics), social sciences (e.g., business & management, sociology, and behavioral science), humanities (e.g., arts, philosophy, and ethics), and other service-related disciplines (e.g., education & educational research). Articles under the design and deploy themes are predominantly related to the robotics category, while the delegate theme is mainly represented in the psychology category.

The best represented WOS categories are mirrored in the number of articles in journals associated with these fields across D^3 themes. In particular, the top five journals (i.e., *International Journal of Social Robotics*, *Computers in Human Behavior*, *International Journal*

TABLE 1 Overview of WOS categories

	WOS category cluster	Total	Design	Delegate	Deploy
1	Robotics, automation & control systems	63 (19%)	37	8	18
2	Psychology	55 (17%)	23	15	17
3	Hospitality, leisure, sport & tourism	40 (12%)	25	11	4
4	Business & management	39 (12%)	18	7	14
5	Healthcare sciences; medicine; neurosciences	24 (7%)	16	6	2
6	Communication, linguistics & language	21 (6%)	10	2	9
7	Computer science	20 (6%)	10	2	8
8	Education & educational research	18 (5%)	8	3	7
9	Engineering	10 (3%)	6	0	4
10	Geriatrics & gerontology	10 (3%)	5	0	5
11	Ergonomics	8 (2%)	5	0	3
12	Information science & library science	5 (2%)	2	0	3
13	Environmental studies, regional & urban planning	5 (2%)	3	1	1
14	Social sciences, sociology, behavioral science	4 (1%)	2	0	2
15	Chemistry, physics, materials science	3 (1%)	0	0	3
16	Multidisciplinary sciences	3 (1%)	1	0	2
17	Philosophy, ethics, art	2 (1%)	1	0	1

Note: One article can be allocated to up to three Web of Science (WOS) categories. Hence, the total count is higher than the total number of articles analysed.

TABLE 2 Overview of methods, sample characteristics, geography, study contexts, robot morphologies, and robots

Dimension	Total	Design	Delegate	Deploy
Total no. of articles	199	100 (50%)	32 (16%)	67 (34%)
Total no. of studies	250	121	52	77
Method				
Quantitative				
Field study	77	28	14	35
Online experiment	64	37	26	1
Lab experiment	47	32	9	6
Survey	26	13	1	12
Secondary data	6	1		5
Qualitative				
Interviews	20	8	1	11
Focus groups	5	2	1	2
Case study	5			5
Sample characteristics[a]				
Consumers	144	70	28	46
Vulnerable consumers[b]	68	29	8	31
University students	50	26	18	6
Geography[c]				
Asia Pacific	86	41	16	29
Europe	64	32	23	9
North/South America	62	32	6	24
Oceania	16	9	2	5
Cross-continental	13	6	3	4
Cross-country		1		5
Study context				
Hospitality & tourism	65	29	15	21
Education	50	22	11	17
Elderly care	38	18	3	17
Healthcare	37	14	10	13
Domestic services	21	20	1	
Public services	14	9	2	3
Cross-context	14	4	10	
Retail	8	3		5
Arts & entertainment	3	2		1
Robot morphology with example social robots[a]				
Humanoid				
NAO, Pepper, Robovie	207	98	37	72
Machine-like				
PeopleBot, Baxter, Care-O-bot 3	52	32	5	15
Zoomorphic/Cartoon- & Puppet-Like				
iCat, Tega Patricc	41	22	2	17
Android				
Geminoid DK, HRP−4C, Repliee	18	10	3	5

Note: Numbers reflect the number of studies.

[a] Numbers reflect the number of studies, but if one study considered different sample characteristics (e.g., university students and consumers) or used more than on robot (e.g., humanoid versus. machine-like) they were counted more than once. Thus, we systematically reviewed 199 articles, but the total counts refer to the number of studies.

[b] Vulnerable consumers include children and older adults (c.f., Henkel et al., 2020).

[c] In three studies, no country was stated; no study was conducted in Africa.

D³-RELATED ANTECEDENTS

DESIGN

[STUDIES FOCUSING ON ROBOT DESIGN ASPECTS]

Software (Behavior): Verbal and Nonverbal Communication: Expressing Emotions, Touch, Social Gestures (Gaze, Facial Expressions, Eye Contact, Forward-lean, Greeting, Polite Gestures), Privacy Protecting, Cultural Competence, Empathy, Friendliness, Politeness, Positive Language (Complimenting), Faulty Behavior, Helpfulness, Coolness, Interactivity, Autonomy, Motivational, Engaging, Laughing, Comforting, Playfulness, Entertaining, Self-disclosure, Friendliness, Authority, Adaptability, Level of Expertise, Personality, Intelligence, Mind-perception, Human-likeness, Social Presence, Trustworthiness, Learning Competency, Self-efficacy, Supportiveness, Emotional Engagement, Teaching Style, Utterance, Voice Type, Language, Service Failure Recovery, Introverted, Extroverted

Hardware (Appearance): Embodiment, Robot Morphology (e.g., Android, Humanoid, Zoomorphic, Machine-like), Robot Gender, Attire, Human-likeness

DELEGATE

[STUDIES FOCUSING ON DELEGATING HUMAN TASKS TO A ROBOT]

Human vs. Robot Delivering Different Services (e.g., Teaching, Clinical Tests, Rehabilitation, Serving, Kitchen Assistant, Reading Companion, Medical Assistance, Sightseeing, Public Service, Therapy), Human vs. Robot in Service Failure Situations / in Embarrassing Service Situations, Human Augmented or Substituted by Robot, Agency/Lying Perceptions of Human vs. Robot

DEPLOY

[STUDIES FOCUSING ON ROBOT DEPLOYMENT IN NATURALISTIC SETTINGS]

Robot exhibiting different behaviors or taking on services roles in the field (e.g., Shopping Mall, Retail Stores, Hotel Lobby, Museums, Therapy, Rehabilitation, Care Facilities): Active Communication, Relationship Forming, Emotion Expression, Giving of Meaning, Learning Companion, Collecting Medical Data, Social Assistance in Therapy, Serving, Guiding, Promotion, Entry Control, Long- vs. Short-Term Interaction, Classroom Environment: Studio vs. Interactive Laboratory, Robot Inside or Outside Store

MODERATORS

Robot-related: Aesthetics, Morphology (Human vs. Robot vs. Kiosk/Tablet), Human-likeness, Gender, Engagement, Sense of Humor, Service Failure Recovery Strategy

Human-related: Age, Gender, Personality Traits, (Preexisting) Attitude towards Service Robots, Emotional Stability, Interaction Comfort, Familiarity w. Robot, Differences In Learning, Knowledge Status, Learning Difficulty, Openness to Change, Preference for Ethics, Responsible Business, Customers Attributions (Service Enhancement, Cost Reduction), Use Experience, Personal COVID-19 Condition, Need for Human Interaction, Anxious Attachment Style, Personality Type

Situation-related: Task Similarity/Difficulty, Hotel Segment, Interaction Time/Quality, Group Size, Pandemic Situation, Human Staff Present, Service Failure Type, Industry Context

MEDIATORS

Robot-related:
Robot Human-likeness, Social Presence, Anthropomorphism, Mind Perception, Perceived Credibility/Sincerity, Ability, Eeriness, Performance Expectancy, Satisfaction w. Robot, Warmth, Competence

Human-related:
Enjoyment in Interaction, Perceived Benefit, Consumer Innovativeness, Identity Threat, Perceived Robot Innovativeness, Perceived Ethical and Societal Reputation, Control, Value Perception, Attitude, Effort Expectancy, Positive Emotions, Acceptance, Usefulness, Trust, Emotional Appeal, Psychological Risk, Ambiguity, Pleasure

INDIVIDUAL CONSUMER OUTCOMES

AFFECT

- Physical Response: Physical Stress, Pain, Galvanic Skin Response, Blood Pressure, Heart Rate, Proximity to Robot
- Verbal Response: Affective States, Emotional Response, Enthusiasm, Connectedness, Enjoyment, Surprise, Amazement, Confidence, Well-being, Feeling of Co-presence, Fear of Job Loss, Intrinsic Motivation, Affective Trust, Fear, Pain, Anxiety, Discomfort

BEHAVIOR

- Social/Interaction Behavior (e.g., Sending Social Cues, Talking to Robot, Laughing, Smiling), Taking Robot Advice, Self-disclosure, Social Conformity, Compliance, Abusive Behavior, Engagement, Proximity to the Robot, Social Distance, Hesitation
- Learning, Retention of Messages, Intention to Stay in Hotel, Task/Test Performance, Compensatory Behavior, Taking Additional Medicine
- (Intention to/of) Use/Future Interaction, Brand Usage Intent, Word of Mouth, Willingness to Pay

COGNITION

- General Perception of Robot Service: Usefulness, Robot Task Performance, Satisfaction, Acceptance, User Expectations, Use Cases, Novelty, Service Experience/Quality, Brand Experience, Positive/Negative Attitudes, Value Added, Responsibility Attribution, Blame for Lying, Anticipated Embarrassment, Loyalty
- Related to Robot Appearance: Aesthetics, Physical Attraction, Anthropomorphism, Texture, Physical Presence, Immediacy
- Related to Robot Behavior:
  - Preferences for Verbal (e.g., Speech Rate) and Nonverbal Behavior (e.g., Social Cues, Gaze), Perfect Automation Schema
  - Social Presence, Human-likeness, Mind Attribution, Animacy, Intelligence, Social Skills, Agency Ascription, Autonomy, Adaptability, Sociability, Rapport Building Capabilities, Helping Behavior
  - Sympathy, Politeness, Likeability, Warmth, Competence, Perceived Personality, Responsibility Attribution, Trust, Empathy, Deceiving Intent
  - Perceived Safety, Capability, Consumer Self-efficacy and Relations when Interacting with Robot, Privacy Concern, Sharing Personal Information

FIGURE 4 Overview of focal variables studied in HRSI research

Note: This comprehensive overview pictures all variables by indicating the terminology used in the respective study. Hence, while variables such as anthropomorphism and robot human-likeness, in essence, can be regarded as identical constructs, their definition may differ from article to article. Further, some constructs appear in more than one variable category (i.e., antecedents, moderators, mediators, and outcomes) as they have been adopted in different ways in the underlying research models of the various studies analysed

of Contemporary Hospitality Management, *Frontiers in Psychology*, and *Interaction Studies*) accounted for 42% of all articles included in the final review. As an emerging research field in its nascent stage, it is not surprising that the remaining 112 articles appeared in 76 different journals, each of which has published five or fewer empirical studies on HRSI. Outlets related to consumer research in general included the *Journal of Business Research*, *Journal of Marketing Research*, *Journal of Service Management*, *Journal of Services Marketing*, and *Journal of Service Research*. The importance of studying consumer interactions with social robots in diverse research fields, thus, becomes evident, especially as robots take on increasingly complex social roles (e.g., receptionists, caretakers, and teachers). While marketing/management journals are slowly entering the HRSI arena, robotics, computer science, and psychology journals already offer potentially valuable insights for studying social robots in consumer-facing service contexts.

4.2.3 | Methods and sample characteristics

Previous HRSI research features diverse methodological approaches. Table 2 lists the main methods applied, grouped as quantitative (e.g., field trials, laboratory or online experiments, and surveys) or qualitative (case studies, interviews, and focus groups). Most research relies on quantitative methods (88% of studies analysed), dominated by field studies, especially under the deploy theme, and online experiments under the design and delegate themes. In terms of sample characteristics, we found that most studies across D^3 themes included adult consumers. Others relied on vulnerable consumers (older adults, children; c.f., Henkel et al., 2020) or university students.

4.2.4 | Geography

The geographic patterns of research can indicate the generalizability of the results. Most empirical HRSI research across all D^3 themes has predominantly been conducted in Asia, Europe, and North and South America. While we found a smaller number of studies conducted in Oceania, none took place in African countries. Some results have been based on cross-continental (e.g., participants from the United States and Europe) and cross-country (e.g., participants from China and Taiwan) samples. The more frequently studied regions may have greater access to robots for empirical research. Research with real-life, embodied robots tends to be costly and resource intensive, and developed countries have greater access to financial resources to realize such studies. Furthermore, the greater need for introducing robots in services in these regions, due to demographic changes (United Nations, 2019) and nursing crises (Marć et al., 2019), might evoke more research attention. This latter explanation appears to be supported by the many articles linked to education, elderly care, and healthcare study contexts. Finally, many research facilities and researchers active in HRSI are located in these areas, which support local data collection. Regardless of the reason, however, significant opportunities for global, cross-country research on HRSI clearly remain.

4.2.5 | Study contexts

Our analysis of extant HRSI literature reveals eight distinct study contexts in which consumer interactions with social robots are studied: (1) hospitality and tourism, (2) education, (3) elderly care, (4) healthcare, (5) domestic services, (6) public services, (7) retail, and (8) arts and entertainment. In addition, 14 studies related to multiple contexts. The distribution of study contexts across the D^3 themes was fairly similar. Notably, however, the domestic service context has predominantly been studied under the design theme, and we found a great majority of cross-context studies and a lack of studies in an elderly care context under the delegate theme. Zooming in, we found that, with the possible exception of retail, public services, and arts and entertainment, these contexts all represent highly interpersonal consumer service domains that require guidance from a service professional (Solomon et al., 1985). Such services are defined by frequent face-to-face interactions, close physical proximity, and low degrees of automation (National Center for O*Net Development, 2020b). They require intensive co-creative efforts by service providers and consumers to deliver value in the form of personal care, assistance, or emotional support (National Center for O*Net Development, 2020a, 2020c, 2020d).

It is no coincidence that the contextual scope of our review is almost exclusively defined by services with a strong emphasis on interpersonal exchanges. From a service provider perspective, the interpersonal role cannot be easily replaced by technology, unlike service domains that rely less on interpersonal value creation, such as financial, consulting, or telecommunication services, which are hence not represented in our data set (De Keyser et al., 2019). Because the interactive element assumes such a central role in the domains under investigation, only an autonomous, embodied, and social technology that mimics the human service role as closely as possible (i.e., social robots) provides value-creating service to consumers. This factor helps explain the strong research interest in social robots in interpersonal service contexts; however, it cannot explain why other, arguably similar contexts have received little research attention (e.g., legal and insurance services and internal human resources).

4.2.6 | Social robot types

To identify which social robot types have been studied, we extracted the names and morphologies (i.e., humanoid, machine-like, zoomorphic/cartoon/puppet-like, or android) of the robots used in each study. Table 2 lists the numbers of robots with different morphologies and common examples of such robot types. Across the D^3 themes, most of these robots take on humanoid appearances (65%), but others

are machine-like (16%), zoomorphic, cartoon-, and puppet-like (13%), or android (6%). However, research under the deploy theme relied slightly more often on zoomorphic, cartoon-, and puppet-like rather than machine-like robots. This distribution may reflect the scope of our review because, for HSRI, humanoid robots might represent more natural sparring partners for consumers when compared with machine-like or zoomorphic robots. The latter might be specifically suitable for specific contexts, such as education and elderly care, where they have been heavily studied under the deploy theme.

We also limited our data set to mobile embodied social robots that exhibit human-like behavior. We excluded articles studying HRSI with only zoomorphic (e.g., *Paro*, a robotic pet seal; Baisch et al., 2017) or machine-like robots in industrial settings (e.g., Granulo et al., 2019), which do not exhibit human-like behavior in interactions with consumers. The few studies with android robots may reflect the limited availability of these robot types. Another explanation might rely on the uncanny valley theory (Mori et al., 2012), which predicts that androids evoke a high degree of eeriness that limits their suitability for service interactions with consumers (Mara & Appel, 2015). Overall, we identified over 70 different robots deployed in HRSI studies, including popular uses of the humanoid robots NAO ($n = 62$) and Pepper ($n = 38$), by the French company SoftBank Robotics, and different versions of the humanoid robot Robovie ($n = 12$), designed and produced by the Japanese company Vstone.

4.2.7 | Comprehensive overview of variables in HRSI research

To gain a detailed overview of existing HRSI literature, we, now, present a comprehensive overview of variables studied based on our overarching D^3 framework as well as the affect–behavior–cognition (ABC) model (Breckler, 1984). For a synopsis of the variables, we consider service robot-related antecedents, mediators, moderators, and individual consumer outcomes. For each variable type, we identify subthemes and patterns that can help integrate the dispersed findings (see Figure 4 for an overview).

D^3-related antecedents. We classified the independent variables in our data set as robot-related antecedents that clustered around the D^3-overarching themes. Design-related antecedents refer to different robot behaviors (e.g., displayed politeness, expression of social cues, and degree of playfulness) and morphologies, antecedents related to the delegate theme pertain to different tasks and services delivered by a robot versus a human (e.g., teaching, performing clinical tests, and service failure recovery), and deploy theme-related antecedents encompass those where robots themselves depict the sole central focus in applied real-world settings (e.g., providing information to consumers in shopping malls or hotel lobbies).

Our analysis also revealed some studies capturing antecedents on individual consumer characteristics (e.g., gender and preexisting experience with robots) and situational factors (e.g., hotel segment and service organization information sharing). As such, they cannot be allocated to any of the robot-centered themes. However, while these studies help with understanding consumers' predispositions toward social robots in general, they reveal few insights into how to design, delegate, or deploy robots in consumer-facing services. Rather, they represent typical boundary conditions on when to design, delegate, or deploy service robots, also partly captured in the moderator studies. Due to their subordinate role, these variables are not depicted in Figure 4.

Individual consumer outcomes. Reflecting the variation in disciplines, the literature on HRSI has focused on a wide variety of individual consumer psychological and behavioral reactions to the design, delegation, and deployment of service robots. Our analysis of these outcome variables revealed that they map on the ABC model (Breckler, 1984). This tripartite model of human responses to environmental stimuli has been widely adopted to explain the components that reflect inter-individual attitudes (Haddock & Maio, 2019), customer engagement (Brodie et al., 2011), consumer-related consequences of flow in computer-mediated environments (Valinatajbahnamiri & Siahtiri, 2021), and consumer brand engagement (Hollebeek & Macky, 2019). In our review, the stimuli represent consumers' exposure to social robots in studies under one of the three overarching themes of design, delegate, or deploy. The variety of consumer reactions, in turn, can be clustered as affective, behavioral, or cognitive outcomes. Affect refers to "an emotional response, a gut reaction, or sympathetic nervous activity" (Breckler, 1984, p. 1191). It can be measured by monitoring physiological responses (e.g., blood pressure) or collecting verbal or written reports of feelings or mood. Behavior reflects exercised actions or verbally expressed behavioral intentions (Breckler, 1984), which can then be measured through observations in (field) experiments or approximated in surveys of behavioral intentions. Finally, the cognitive component comprises beliefs, knowledge structures, perceptual responses, and thoughts; these measures require verbal or written statements from participants (Breckler, 1984).

As suggested by Breckler (1984), we further partitioned affective reactions into physical responses (e.g., blood pressure and heart rate) and verbal reports of emotional states (e.g., enjoyment and fear) expressed by consumers when they interact with an embodied social robot. Studies with a behavioral focus mostly related to the exhibited social behavior of the robot's interaction partner (e.g., displaying social cues and engagement with robots), context-specific service outcomes (e.g., learning and test performance), or usage intentions. Cognitive outcomes can be partitioned into three subcategories of consumer perceptions of general robot service provision (e.g., usefulness and attitudes toward robot), robot appearance (e.g., perceived esthetic and physical attractiveness), and robot behavior (e.g., speech and gaze behavior and human-likeness).

Finally, a few studies have also assessed consumer outcomes on a global rather than individual level. Findings usually addressed both

the barriers and facilitating conditions of designing, delegating, and deploying social robots (e.g., technical issues and robot capabilities) with others. They also focused on general and specific use cases for social robots in different consumer-facing service settings. Because such global outcomes only play a minor role in the HRSI literature, they are not depicted in Figure 4.

Mediators and moderators. In our data set, 60 articles reported on how (29) and when (31) designing, delegating, and deploying social robots in service leads to different consumer outcomes. Resulting from our bottom-up analysis, we clustered these mediators and moderators into robot-, human-, and situation-related variables. Robot-related mediators refer to processes centered around the robot, including its perceived human-likeness or social presence; human-related mediators take the perspective of a robot's interaction partner, such as perceived enjoyment or human identity threat. Similarly, the moderators may be robot-related (e.g., esthetics and morphology), human-related (e.g., age, gender, personality traits, preexisting attitudes toward social robots, interaction comfort, and familiarity with a robot), or situation-related (e.g., task difficulty and group size). Some studies include human-related, context-specific moderators as well, such as students' learning difficulties in an educational context.

4.3 | Key insights and implications along the D^3 framework

We next zoom in to discuss key insights related to consumer preferences when interacting with embodied social robots according to the three themes of our newly developed D^3 framework (i.e., design, delegate, and deploy) and derive practical implications therefrom. In Appendix S2, we provide the basis of this analysis in tables presenting specific information about study designs of each included article in our final data set (i.e., antecedents, robots deployed, and ABC model outcome variables) and key findings, first by each D^3 theme and second by study context.

4.3.1 | Key insights from design theme

Studies about the software designs for social robots in different service contexts mainly aimed to understand the effects on consumer outcomes of either the robot's behavior or its appearance to identify consumers' preferences.

Behavior

Depending on social robots' human-like communication behavior (e.g., politeness, benevolence, voice pitch; Lee et al., 2017; Lyons et al., 2020; Zhu & Kaber, 2012) and the message content (i.e., self-disclosure; Johanson et al., 2019), consumers engage more with the robots and find them less intimidating and more trustworthy (Lyons et al., 2020). If the robot's human-like behavior evokes perceived intelligence and human-likeness in consumers, it contributes to building consumer rapport and hospitality experiences (Qiu et al., 2020). In terms of language style, research has found that using a native (versus. non-native) accent evokes more positive emotions among consumers toward social robots in a healthcare context (Tamagawa et al., 2011). Furthermore, consumers prefer social robots speaking in a literal, direct language and at a moderate pace (Choi, Liu, et al., 2019; Pan et al., 2015; Shimada & Kanda, 2012). The presence of non-verbal behavioral patterns (e.g., gestures, gaze, and changing eye color) encourages consumer interactions with social robots (van Pinxteren et al., 2019) and consumer perceptions of hedonic values (e.g., Johnson et al., 2016).

Research shows that when robots act according to the consumer's expectations for a certain task, the interaction outcomes are more positive. For example, findings indicate that if a robot's programmed personality and demeanor are customized to the task at hand, it promotes consumers' perception of the robot's social attractiveness and limits perceived eeriness (e.g., Sundar et al., 2017). Another example in a healthcare context shows that a robot's patient-centered (versus. task-centered) behavior also positively affects perceived emotional intelligence (Chita-Tegmark et al., 2019). Moreover, when robot behaviors signal personalization, the provision of service to consumers is more successful. For example, personalized behavior improves learning outcomes for children (e.g., Baxter et al., 2017).

Appearance

Studies that focused on hardware design suggest that consumers prefer humanoid social robots over zoomorphic- and machine-like robots (e.g., Belanche et al., 2020; Chu et al., 2019; Tu et al., 2020; Walters et al., 2008). A potential explanation for this preference might be that an embodied, humanoid robot increases consumers' mind perceptions and positive personality attributions (e.g., Broadbent et al., 2013). Moreover, different robot morphologies (humanoid, zoomorphic, and machine-like) also seem to evoke different cognitive processes and behaviors in consumers. Specifically, humanoid and machine-like robots are perceived as credible, and humanoid and zoomorphic robots are more easily adopted as companions by children in education services (Broadbent et al., 2018; Edwards et al., 2016).

Although general studies reported a positive effect of human-like appearances (e.g., Belanche et al., 2020; Walters et al., 2008), other studies found that in certain roles in services, other morphologies are preferred. For example, a caricatured robot appeared to be preferred over a humanoid one when robots took on concierge roles (Shin & Jeong, 2020). Furthermore, machine-like robots seem better suited for executing security tasks than humanoid or zoomorphic robots (Li et al., 2010), and small robots are more effective in promotional tasks than human-sized ones (Shiomi et al., 2013), while human-sized robots are preferred in guidance tasks (Kanda et al., 2008). We also noted evidence of the positive effects of gender-stereotypical occupational role matching (i.e., male robots for domestic security and female robots for domestic care; e.g., Kuchenbrandt et al., 2014) in terms of robot hardware design.

As outlined above, morphology has a strong impact on consumer interactions with social robots in services. However, research

also finds that individual consumer differences (i.e., general trust in technologies and affinity for the robot) might mitigate the effects of morphology on, for example, adoption intentions (e.g., Belanche et al., 2020; Tussyadiah et al., 2020).

Summary of implications from design theme

Across the results clustered under the design theme, we derived concrete implications for robotic software (i.e., behavior) and hardware (i.e., appearance) design to match consumer preferences around three subthemes: (1) human-like verbal and non-verbal behavior, (2) task-related/personalized behavior, and (3) appearance. First, research conducted in various services suggests that robots should be designed to actively engage with consumers, encourage interaction, show empathy, be sociable, and exhibit emotional relationship-building capacities. Ideally, they should exhibit a range of non-verbal, human-like behaviors (e.g., gaze and social gestures) to foster interaction comfort. Furthermore, the designs should ensure robots act politely and in a consumer-centered manner.

Second, robots should be able to provide personalized services, adapted to individual preferences (e.g., speech pace) or learning stages. A robot's personality, demeanor, and gender design should fit the task at hand. However, executives are advised to be cautious with respect to the wider context of gender and stereotype effects. Robots should also be able to explain their own, task-related use to individual users.

Third, we derived implications for a robot's hardware design, but caution executives to recognize the mixed results regarding human-like appearances. In most cases, humanoid robots are preferred to machine-like or zoomorphic robots, but prior research has also revealed individual differences in these preferences in different services (e.g., hospitality and domestic services). For example, in hospitality contexts, executives should acknowledge the varying expectations of guests in diverse hotel segments. Task delegation to a machine-like service robot could be viable for budget hotels; in premium segments, however, consumer-facing tasks should be delegated to humanoid robots (Chan & Tung, 2019). Moreover, morphology preferences in terms of the robot's height seem task dependent. With guidance tasks, for example, users want human-sized robots, but small robots are preferable for conducting promotional activities in a retail context. Androids can evoke feelings of eeriness and high user expectations that current state-of-the-art technology cannot yet attain for most service tasks (Mori et al., 2012). Thus, at the current stage of robot development, it does not seem advisable to equip social robots with android hardware for consumer-facing services.

Overall evaluation of the contribution and gaps in knowledge associated with the design theme

Studies under the design theme contribute to the literature by shedding light on the effects on consumers of robots' different behavior and/or appearance in internal and external service encounters. Although most of the studies in our data set fell under the design theme and research has created a solid knowledge base, some gaps remain. While prior research has predominantly relied on laboratory, online, and field experiments with adult consumers in Asia, Europe, and North America having interactions with humanoid social robots, longitudinal designs are underutilized, as are studies of consumer interactions with robots in cross-regional settings and with different consumer types. Moreover, investigations to date of the effects of non-humanoid robot morphologies and some service contexts, such as retail or arts and entertainment, have been neglected by research under the design theme. Apart from research opportunities related to the study settings, we also identified additional avenues for research based on our analysis of the key findings pertaining to (1) consumer preferences and (2) consumer–robot collaboration. We discuss these research avenues in detail in Section 4.4.

4.3.2 | Key insights from delegate theme

Delegate studies, in which human employees and social robots are directly compared in providing services, show that robot performance matches or even exceeds human employees' performance (e.g., in terms of teaching outcomes and students' learning performance, kitchen assistance, or taking medical tests; Desideri et al., 2019; Mann et al., 2015; Thellman et al., 2017; Wu et al., 2015; Yueh et al., 2020). Moreover, Broadbent et al. (2010) showed that blood pressure levels do not differ in response to a robot or human nurse, so there is no evidence that social robots cause extra stress, even in highly personal services.

However, depending on the context and task, we also found that robots are not preferred over human employees. On the one hand, delegating assistive living tasks such as domestic chores (e.g., shopping, garbage disposal, delivering food; Smarr et al., 2014) or troublesome tasks (e.g., dealing with complaints, picking lost items out of the trash; Hayashi et al., 2012) to robots is positively perceived, and robotic service providers are preferred over humans in potentially embarrassing service encounters (Pitardi et al., 2022). On the other hand, humans are perceived as irreplaceable when it comes to socially assistive and interactive services such as personal care and leisure tasks (Smarr et al., 2014). Moreover, in hospitality contexts, the interaction quality that guests perceive is better when they interact with human service providers rather than robotic ones (Choi et al., 2019). These effects might be due to the different attributions humans and social robots evoke in consumers. As Čaić et al. (2020) showed, consumers attribute slightly less competence and warmth to robot coaches than to humans, which influences consumers' behavioral intentions related to physical activity.

As another cautionary finding related to task delegation to social robots in services, Mende et al. (2019) revealed perceptions of greater eeriness and identity threats in response to robots versus human staff, which can cause consumers to engage in status consumption or choose unhealthy options. Additionally, substituting for human staff can also damage the service organization's ethical and societal reputation in the eyes of consumers (McLeay et al., 2020). Finally, Rainear et al. (2019) found that risk message retention is lower if the message is delivered by a robot rather than a human.

Consumers seem to ruminate on visual stimuli and the content delivery medium rather than the content and behavior during message delivery, such that the robot functioned as a technological distractor.

Summary of implications from delegate theme

From research directly comparing humans with robots delivering services, we can derive implications regarding the effectiveness of human versus robot service provision and which tasks are accepted by consumers to be delegated from humans to social robots. Research suggests that various tasks can be successfully delegated to embodied social robots, including teaching, reading, assistive healthcare, household chores, kitchen assistance, and room service. Consumers also accept the delegation to robots of unpleasant tasks (e.g., trash picking and dealing with complaints), domestic chores (e.g., shopping and garbage disposal), and tasks in information management (e.g., emergency alerts). Further, delegating tasks in highly personal service encounters (e.g., elderly care) or potentially embarrassing ones (e.g., buying hemorrhoid crème) from humans to robots is well accepted and perceived as useful. However, tasks related to personal care and leisure should not rely solely on social robots. Moreover, robots can create technological distractions, so they should be used for risk messaging only very carefully.

Overall evaluation of the contribution and gaps in knowledge associated with the delegate theme

Studies under the delegate theme contribute to the literature by directly comparing human service providers to embodied social robots. The results provide implications on what tasks and under which circumstances they should be delegated from humans to robots. Based on our review, the fewest analysed studies fall under the delegate theme, which opens up avenues for future research. Prior research has predominantly relied on quantitative approaches using online and field experiments. Additionally, a great proportion of studies were conducted with university students interacting with humanoid social robots. Those studies mostly took place in Asia or Europe. Moreover, most studies thus far have been conducted in hospitality and education service contexts. Hence, opportunities for novel insights remain in using more qualitative methods and in quantitative methods apart from online and field experiments. Further, it would be valuable to study consumer interactions with robots in thus far neglected service contexts and with vulnerable consumers. This latter aspect is specifically relevant for ethical considerations when delegating service tasks from humans to social robots. Based on our analysis of key findings under the delegate theme, we identified two additional clusters for future research in relation to (1) consumer preferences and (2) situational factors in task delegation, which we discuss in Section 4.4.

4.3.3 | Key insights from deploy theme

Findings under this theme suggest whether, when, and how social robots should be deployed in services by studying consumer interactions with social robots in real-world settings.

Research shows that robots can be successfully introduced in different real-world consumer service settings. For example, when introducing a robot in a classroom, both teachers and students generally accept and adopt it and exhibit relationship-building behaviors (e.g., Michaelis & Mutlu, 2018). Moreover, field experiments with assistive robots, such as the Personal Robot (PR2) and Domestic Robot (DoRo), show that older consumers accept robots that help them with household chores in their own home (e.g., Di Nuovo et al., 2018). In hospitality contexts, consumers readily accept robots and routinely seek interaction opportunities with them (Tung & Au, 2018). Furthermore, introducing social robots in healthcare contexts can enhance the efficiency of service provision (e.g., rehabilitation, medical coaching, exercising, and medical recording). For young patients, social robots improve their engagement, independence (Butchart et al., 2021), and communication abilities during rehabilitation (Pulido et al., 2017). Adult patients also report more positive perceptions of social robots after (versus. before) actual interaction (Casas et al., 2019; Winkle et al., 2020). In shopping malls, social robots evoke curiosity and approach tendencies among children but abusive demeanors as well (Nomura et al., 2016; Sabelli & Kanda, 2016).

We found mixed results in terms of longitudinal effects. On the one hand, attitudes toward social robots tend to improve with time and interaction frequency (Stafford et al., 2014), which might explain why early studies yielded more negative attitudes and comparatively low intentions to use robots (e.g., Wu et al., 2014), but more recent studies signal greater perceived usefulness and attractiveness (Melkas et al., 2020). On the other hand, research indicates that consumers might interact less with a social robot once the novelty effect vanishes. For example, Kanda et al. (2007) found that two-thirds of students become bored with and consequently reject social robots over time.

Studies under the deploy theme further highlight that consumers display avoidance-related tendencies toward robots if not actively engaged with them or if they are not located in an easily accessible area (Pinillos et al., 2016; Rodriguez-Lizundia et al., 2015). Moreover, consumer value perceptions of robots in various consumer-facing services seem deeply rooted in their individual acceptance of technology (i.e., perceived usefulness, ease of use, and innovativeness) and service quality perceptions (e.g., personal engagement, tangibles; Cha, 2020; de Kervenoael et al., 2020).

Summary of implications from deploy theme

Our implications from the deploy theme are structured along two dimensions: (1) whether and when and (2) how to deploy social robots in services. Concerning the former, managers should consider the nature of the task when deploying robots. Preference should be given to assistive rather than social tasks. Educational organizations might anticipate mixed results in terms of learning outcomes and might be advised to refrain from deploying robots in higher education settings, at least with current state-of-the-art technologies. In terms of how, managers should familiarize consumers with robotic technology to overcome adoption barriers. Furthermore, robots should be placed in quiet, accessible areas in real-world contexts (e.g., hotel lobbies and train stations), and they should remain in an awake mode to foster interactions. In public, strict interaction rules

should be imposed, especially for children. Potential users should be clearly informed about diverse robot use cases and receive information about the affordability and entertaining value of robotic services. Further, it is advised to program robots to be able to explain their own uses when deployed in real-world consumer settings.

Overall evaluation of the contribution and gaps in knowledge associated with the deploy theme

Studies under the deploy theme contribute to the literature by studying consumer interactions with embodied social robots in naturalistic service settings. In so doing, research under this theme creates an understanding of when, where, and for which target groups social robots can be effectively deployed in consumer-facing service contexts. Against the background of the theme, it was to be expected that the majority of prior research relied on field experiments and interviews. Nevertheless, virtual reality technology could be an alternative for studying consumer interactions with social robots in naturalistic settings in the future. The majority of research has been conducted in Asia and North America with humanoid social robots; thus, gaps remain related to the deployment of other social robot types in other regions, which could shed light on intercultural differences and similarities when deploying social robots. Based on our analysis of key findings under the deploy theme, we identified three additional clusters for future research avenues relating to (1) consumer preferences, (2) consumer outcomes and mechanisms that explain the effects of robot deployment in naturalistic service settings, and (3) environmental factors to be considered. We discuss these areas for future research in detail in the next section.

4.4 | Future research agenda

Although our synthesis of extant HRSI research provides concrete insights into consumer preferences when interacting with embodied social robots, along with implications for successful integration of these robots in consumer–firm interactions, critical questions remain unaddressed. Thus, in direct response to our third research question, we pinpointed crucial research needs for future studies of consumer interactions with social robots in services. We first propose future research needs identified through our analyses related to methods and samples deployed, geographic regions, robot types, and study contexts, as well as focal variables across the D^3 themes. Then, we present future research avenues delineated from our analysis of the key findings of each theme of the framework, as detailed in Table 3.

4.4.1 | Future research needs according to methods, sample characteristics, geography, study contexts, social robot types, and focal variables

Methods and sample characteristics

Although our review reveals a great diversity in methodological approaches, longitudinal studies are still scarce. In light of reported habituation effects (e.g., Brandl et al., 2016), we urge researchers to conduct more longitudinal studies. Due to diverse validity demands across disciplines and challenging study conditions using social robots, studies with clear manipulations of robot behavior and appearance factors in controlled environments are scarce. We thus recommend that researchers address these internal validity concerns in future study designs. Noting the samples in the current, cross-context HRSI research, we also found many studies with relatively small sample sizes (e.g., Torta et al., 2014), which are potentially underpowered and hamper generalizations to the population in general. We thus urge researchers to gather larger samples when designing new and replicating previous studies. We also recommend scholars include understudied consumer groups. For example, adolescents have great purchasing power in retail stores (Olick, 2019), where social robots are increasingly adopted; however, their needs with regard to interactions with such robots differ from those of other consumer groups (Björling et al., 2020).

Geography

In our data set, we found no studies conducted in Africa and only a handful in South America. Yet, these regions host many consumers at the base of the pyramid, with specific needs and tremendous transformative potential for service robots (Fisk et al., 2016). We encourage researchers who study consumer interactions with social robots in these regions to acknowledge the potential cultural and structural differences in robot perceptions and consumer preferences. Furthermore, we advise scholars to conduct cross-regional studies to identify potential cultural influences. As social robots are integrated into consumers' daily lives, governments might need to enforce new regulations (Leenes et al., 2017). However, these might differ from region to region and might affect each of the D^3 themes differently. For example, in some countries, the deployment of social robots in care facilities (delegate and deploy) might be forbidden, while in other countries, android robots (design) might be prohibited due to ethical concerns. We urge researchers to investigate the influence of governmental regulations in the context of HRSI.

Study contexts

In our data set, eight distinct study contexts are represented, with a strong research focus on hospitality and tourism, education, and elderly care. However, some highly interpersonal service domains where social robots might be effectively deployed for service delivery (e.g., legal and insurance services and internal human resources) have received relatively little research attention, meaning that context-specific effects on HRSI pertain to only a subsection of contexts identified in prior studies. Continued research should pay particular attention to less investigated domains to expand the broader comparative framework and derive implications for the successful adoption of social robots in all contexts where such robots might potentially interact with consumers.

Social robot types

We note a strong focus in the literature on humanoid robots, especially NAO and Pepper. We encourage future research to validate

TABLE 3 Future research agenda according to the D[3] framework themes

Design	Delegate	Deploy
Consumer preferences • Which robot characteristics (behavior and appearance) mitigate anxiety in interactions with robots? • How can robot hardware and software design foster trust and diminish privacy threats in consumers in different service contexts? How should these aspects be adapted for different cultures? • How should social robots use humor to evoke positive consumer outcomes and decrease stress and anxiety levels of consumers (e.g., in healthcare services)? • How should robot language and accent be adapted to the consumers' local culture? What are the potential threats for using specific accents in multicultural settings? • How should the interaction behavior of machine-like social robots be designed to evoke trust and engagement in consumers? • How should robotic hardware and software be designed to speak to both male and female consumers in different service contexts? • What are morphological and material characteristics of existing robot models that decrease consumers' contamination concerns during the pandemic and beyond? **Robot–consumer collaboration** • What human-like verbal and non-verbal behaviors specifically drive consumer engagement and relationship building in different consumer service contexts? • How can consumer collaboration with social robots be improved through robot behavior and appearance design?	**Consumer preferences** • What type of tasks can be effectively delegated to social robots to promote sales and customer experiences? • Are there any (and which) tasks that robots should never meddle in, such as elderly care or other personal contexts? For example, should a robot autonomously manage access control to private homes? What are potential security risks and ethical considerations? • Which services should be delegated to a robot interacting with vulnerable consumers? How will intensive task delegation to robots affect children's development and the elderly's maintenance of independence? • Why do robot-staffed hotels fail? What is an optimal human–robot ratio considering consumer preferences? **Situational factors** • From extant cross-sectional studies, we know that older consumers prefer humans over robotic assistance. Could this be due to the novelty effect? Would longitudinal studies confirm these results, or would a habituation effect set in? • How can tasks in emotionally charged situations be effectively delegated to social robots? • Does the COVID-19 pandemic support faster adoption of social robots (e.g., in healthcare contexts) and decrease ethical concerns related to delegation of tasks to robots on behalf of human staff?	**Consumer preferences** • How should robots be introduced to consumers? What information is most relevant for subsequent acceptance and use? • How should robots be marketed to consumers and introduced to staff for a successful deployment? • Which interaction rules for consumers (e.g., children) when interacting with robots in public services contexts are effective at promoting engagement, yet decrease the risk of abuse? **Consumer outcomes and mechanisms** • What are the long-term effects of engaging with socially assistive or interactive robots on the psychological well-being of consumers (e.g., in elderly care or education services)? • How do consumers' trust and commitment toward social robots change over time (e.g., in domestic care or elderly care contexts)? • What are the psychological mechanisms that drive consumer behavior (e.g., discrete emotional elicitation, engaging with robots) during and after the deployment of social robots? **Environmental factors** • How do business environments need to be designed to successfully deploy social robots? • How can robots be successfully deployed in special service environments such as luxury service contexts?

results and expand knowledge using different humanoid and non-humanoid robot types that exhibit human-like behavior, as they have proved to be effective sparring partners in some service contexts (e.g., Chan & Tung, 2019; Kory Westlund et al., 2017).

Focal variables

The synopsis of variables studied in previous research reveals a substantial number of studies devoted to robot design-related antecedents. Furthermore, despite including outcomes reflecting all ABC model components, we note that relative to cognitive consequences, the affective and behavioral outcomes are underrepresented, despite their central role for interaction success (Brodie et al., 2011). A particularly promising avenue thus lies in studying antecedents related to the delegate and deploy themes and the behavioral and affective reactions of service agents. Prior calls for research noted the need for studies on the impact of robots on marketing-related outcomes (e.g., service quality, loyalty; Wirtz et al., 2018), but such studies still remain a rarity. We encourage scholars to study these relationships to help clarify when and how to adopt social robots in services. In addition, even though studies including moderators and mediators have increased significantly in the last 2 years, <30% of the studies in our data set considered underlying mechanisms and boundary conditions of consumer outcomes. We thus recommend scholars include these variable types in their research designs.

4.4.2 | Future research needs according to the D[3] framework themes

Based on the analysis of key findings according to each D[3] framework theme, we developed concrete research questions that address critical future needs for consumer research, which we depict in Table 3. We further cluster these questions for each D[3] theme according to the intended study focus.

For all three themes (i.e., design, delegate, and deploy), we develop concrete future research questions related to a focus on *consumer preferences*. This future research needs all address consumer preferences with regard to various aspects of robot design (hardware and software), the delegation of certain tasks to robots, or

preferences regarding the deployment of social robots in real-world service settings. For example, under the design theme, we identify research needs regarding which specific robot characteristics (hardware and software) mitigate consumers' anxiety and foster trust and relationship-building behavior. Under the delegate theme, we offer open questions regarding what task types robots should never meddle in, considering consumer preferences, along with potential security risks and ethical issues, and we identify research gaps related to vulnerable consumers (i.e., the elderly and children). Finally, research avenues related to consumer preferences under the deploy theme include the investigation of how robots should be introduced to consumers and what interaction rules are accepted by consumers and are thus effective when deploying robots in different settings, such as in public.

Under the design theme, we additionally identify research needs related to the study focus of *robot–consumer collaboration*. Service provision is not a one-way street and depends on consumers' willingness to collaborate with a service provider (Vargo et al., 2008). Hence, we encourage scholars to investigate what verbal and non-verbal behaviors as well as what type of robot morphology encourage consumers to collaborate with social robots in service provision.

Under the delegate theme, we identified additional research gaps related to *situational factors*. For example, we know from cross-sectional studies that human staff are preferred over robots in certain settings, such as personal assistance tasks. However, this might be due to a novelty effect. Future research might investigate whether a habituation effect sets in and consumers' initial assessment with regard to the delegation of tasks related to personal care might change over time. Moreover, future research could investigate how the current COVID-19 pandemic might foster the acceptance of social robots and decrease ethical concerns related to the delegation of tasks to robots on behalf of human staff in different services.

Finally, under the deploy theme, we identify open questions related to two study foci: (1) *consumer outcomes and mechanisms* and (2) *environmental factors*. The former includes questions regarding the long-term effects of robot deployment, such as consumer well-being, the change of consumer trust during extended usage periods, and psychological mechanisms of consumer behavior during and after the deployment of social robots. The latter includes open questions related to how business environments need to be designed to ensure a successful deployment of social robots, as well as how social robots can be effectively deployed in special service environments (e.g., in luxury services).

5 | DISCUSSION

This systematic review aimed to integrate empirical findings from research addressing consumer service interactions with embodied social robots (i.e., HRSI) across scientific fields to provide academics a comprehensive assessment of existing knowledge, as well as to give managers insights into how to effectively introduce consumer-facing robots. To this end, we make four key contributions.

First, our comprehensive review of more than 13,500 articles represents the first systematic, integrative analysis of empirical HRSI studies across scientific fields focusing on a clearly defined robot type to inform the suitability of such robots for consumer-facing services. This holistic approach, paired with our detailed descriptive analyses, establishes a thorough overview of existing knowledge beyond the boundaries of the business literature.

Second, to structure the vast amount of extant HRSI literature, we developed a novel tripartite D^3 framework. As we showed, this framework can be deployed to derive detailed insights into consumer outcomes when interacting with social robots, and it also provides concrete implications for ensuring the successful integration of social robots in services. Our study thus directly responds to previous calls for assessing the roles and impact of social robots in service provision (Lu et al., 2020). This framework can further serve to structure and design future consumer research or to define strategies for including social robots in different services.

Third, based on our analysis of the consumer outcomes studied in extant research, we noted parallels with the ABC model advanced in social psychology. Employing this model in HRSI research offers an intuitive structure of the focal variables studied. Applying this lens in conjunction with a morphological classification of social robot types on a study's context-specific level yields a detailed overview of key insights per D^3 theme, as depicted in Appendix S2. Our work may thus serve as a comprehensive directory for researchers interested in understanding which variables have been studied in HRSI.

Fourth, practitioners still struggle to effectively integrate social robots in consumer-facing services (e.g., Shead, 2019). Our overarching D^3 framework of HRSI and its implications provide an initial guide to the pitfalls and opportunities associated with embodied social robots providing various services to consumers. However, critical questions remain unaddressed. From our review, we pinpointed research needs and formulated concrete research questions (Table 3). We thus contribute to the literature by providing new impetus for future research activities.

Although we executed our literature review with the highest level of diligence, we acknowledge some limitations of our approach. First, we do not claim to capture the entirety of research articles published on this topic. Rather, we bridged the impediment of the extensiveness of empirical evidence on HRSI across disciplines by restricting our sample to articles published in journals with specific quality standards. Second, in our data collection, we did not pre-register our review and relied on one search database, which stands in conflict with PRISMA (Page et al., 2021). Although the WOS database includes the main corpus of research in diverse scientific fields published in scholarly qualified peer-reviewed journals (Antons & Breidbach, 2018), we acknowledge that other databases and less strict quality criteria might have

flagged additional papers. Third, in scope with our review focus, we only included articles that investigated HRI in consumer-facing service contexts. Future reviews may integrate findings from research outside such settings (e.g., studies that investigate human behavior when playing strategic games with social robots; Cominelli et al., 2021). Fourth, even though we analysed the literature based on several dimensions, we neglected a detailed analysis of theoretical foundations. This is partly due to the transdisciplinary nature of our review because the identification of theoretical bases of studies in fields other than marketing, management, and psychology is not always straightforward. Still, future reviews may integrate this dimension. Fifth, our inclusion criteria specified a time span of published articles from the early 1970s onward. While sophisticated Wizard of Oz experiments were theoretically possible to conduct in an earlier time frame with respective social robot prototypes, we found that no articles published before 2007 fit the scope of our review. Future reviews should consider the technological advancements and specify the inclusion criteria related to the time span of published articles accordingly. Finally, we structured the literature under the design, delegate, and deploy themes according to the prevailing study focus. This approach harbors an interpretive element, and other coders may partly disagree with the D^3 theme we allocated to ambiguous articles (i.e., those combining more than one theme).

6 | CONCLUSION

This review contributes to the literature by providing scholars and practitioners with a comprehensive and structured overview of the great wealth of research from different scientific fields on consumer interactions with embodied social robots in service settings and identifies relevant gaps in the literature. Considering the growing market value of and interest in embodied social robots in consumer interactions and the increased relevance of robotic services provided by such robots, especially during the COVID-19 pandemic (Finsterwalder & Kuppelwieser, 2020), our review provides a comprehensive synthesis and a structuring framework of the extant HRSI literature, helping business managers make informed decisions on whether, when, and how to deploy social robots in consumer-facing services. It also gives researchers a sense of the status quo of research on HRSI and provides a basis for complementing our knowledge of how to effectively deploy social robots in service.

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CONFLICT OF INTEREST

The authors have no conflict of interest to disclose.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available in the supplementary material of this article.

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SUPPORTING INFORMATION

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