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Do We Need Artificial Dining Companions? Exploring Human Attitudes Toward Robots in Commensality Settings

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ABSTRACT

Artificial companions (mainly social robots) are being introduced into various aspects of human life, including food-related and dining experiences. In this line, the researchers [15, 16] postulated creation of Artificial Commensal Companions that would keep company to lonely eaters. However, there is a significant gap in understanding user attitudes, expectations and concerns towards this technology.

In this paper, we present the first version of a questionnaire designed to address this shortcoming, which was tested on thirty-one participants in an exploratory pilot study. A forthcoming aim of the proposed iterative research is to define specific guidelines for designing an ideal agent for human-robot commensality. Our mixed-methods survey addresses a broad array of attitudes spanning aspects such as embodiment, appearance, skills, preferred ways of communication, risks and applications, and preferred social settings. Our survey revealed a strong preference for multimodal communication, abstract-shape and/or virtual embodiment. The main concerns are related to potential use are related to social ostracism and alienation. At the same time, a lack of public familiarity with the idea of an eating companion was revealed, resulting in discussions about both discomfort and curiosity. Interestingly, majority of participants see robots as machines that should be, first of all, helpful in manual tasks related to food preparation and serving.

CCS CONCEPTS

• **Human-centered computing → HCI design and evaluation methods**.

KEYWORDS

Human-Robot Interaction, Social Robots, Inclusive Technology, Dining Companion, Commensality

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1 INTRODUCTION

The application of social robots into the realm of food and dining is a relatively new area of interest, gaining momentum quickly. The possible applications vary from robotics waitstaff that appear in some bars and restaurants across the world, to cooking or kitchen cleaning assistants, to the robots providing the physical support to people with physical accommodations required for eating. One of the currently less-considered applications of social robotics in dining contexts is the creation of Artificial Commensal Companions (ACCs). These embodied agents being "an active partner during meal time, able to interact with a human partner and influence their eating experience" [15]. It is postulated that interacting with such companions can be beneficial, especially to people that for various reasons are constrained to eating alone (e.g., elderly or ill persons)[15]. Few attempts to implement such companions have been performed so far [9, 11, 13, 13], and very little is known about potential users' expectations and acceptance of such technology in the specific context of shared meals. This work aims to fill this gap by exploring users' ideas and expectations towards this technology. For the purpose of this study, we have created a questionnaire that addresses several aspects of human-robot interaction in the context of food and eating. Among others, we ask about the physical appearance, skills including communication modalities, and situations in which one may feel uncomfortable when interacting with ACC.

Our main aims are:

(1) To learn whether ACCs are of interest, and if so, to which specific groups or populations.
(2) To understand attitudes, doubts, and fears that people have regarding ACCs.
(3) To collect a set of specific guidelines that can be used by the developer to create some properties of the ACCs.

Our work is following an iterative approach, and the results of this study will be used to improve the questionnaire and identify the target groups of potential users. This work is a part of the Italian PRIN 2022 project "COmputational Models of COmmensality for artificial Agents (CoCOA)"[1] aims at the development of robotic commensal companions that are in-line with user expectations.

[1] https://cocoa-research.github.io/

2 BACKGROUND

Sharing a meal is an important pillar of human sociality [7]. It brings people together, fostering closer relationships and enhancing social bonds. It provides a setting for communication, allowing individuals to share stories, experiences, and emotions, thereby creating a sense of intimacy and trust [6]. Meals often reflect cultural heritage and traditions. Sharing traditional foods during holidays, festivals, and rituals helps preserve and transmit cultural knowledge and practices from one generation to the next. Moreover, sharing meals often leads to healthier eating habits. Family meals, for example, are associated with better nutrition and eating patterns, including higher consumption of fruits, vegetables, and balanced diets [5, 19, 20]. Nonetheless, our society has changed in the past decades towards a more isolated community. Changes in social participation, social demographics, community involvement, and use of technology over time suggest overall societal declines in social connection [5]. All of these factors have influenced the way people navigate their everyday lives–an indicator of which is the rise of solo dining and overall loneliness [17]. The rise in solo dining, particularly among urban populations, reflects broader societal changes, including the increase in single-person households and the decline of traditional family structures [19]. This shift not only affects individuals' emotional well-being, but it also has broader implications for public health and social cohesion [20]. Multiple studies indicate how eating alone can pave the way to long lasting health problems such as cardiovascular diseases [4] and risks of metabolic syndrome [12].

While there is extended literature on user experience and expectations towards social robots (e.g., [1, 2]) and some questionnaires on commensality [3, 8, 10], the only work that addresses both is [15]. The authors propose a first prototype of robotic ACC and evaluate the user experience and attitudes with 10 questions. Among others, they ask about potential applications and benefits of this technology, as well as whether the participants would like to use ACC more or eat alone. Consequently, this work extends previous efforts by proposing structured and thorough data collection on potential users of ACCs. Considering that developing an ACC is a very time- and resource-consuming endeavor, it is fundamental to understand the potential users beforehand.

3 QUESTIONNAIRE

To address our research questions, we designed a completely new survey. Our method is a combination of forced-choice, Likert scale, and open-ended questions that allow for both quantitative and qualitative analyses of the participants' answers. To validate group differences in preferences and expectations, quantitative scales were constructed and administered, and will be validated for future use. At the same time, open-ended response questions were used in each subsection of this study to glean more information about participants' responses.

The questionnaire is composed of 98 items, and can be divided into 6 sections: The first section covers demographic questions, general feelings towards the technology, and previous interactions with similar technology. The second section is dedicated to participants' views on the potential roles of robots in the context of food and eating, while the third section delves into preferences and expectations towards artificial dining companions, specifically. The fourth section explores participants' attitudes toward dining companions and their possible applications, while the fifth section focused on eventual concerns regarding them. The final section [S1-S33] presents various scenarios involving robots in different food settings to capture general attitudes in specific situations [2]. The full questionnaire can be found in Supplementary Materials.

Demographic and Attitude Baseline Questions. We collected data on age, gender, and professional background (Questions D1-D4), as well as attitude towards new technologies. Additionally, we gathered insights into how prior experiences with robots may impact attitudes toward ACCs (A1-A2). In particular, the researchers were concerned with how negative past experiences with robots could bias participants' perceptions and desired features of ACCs. Finally, participants were asked whether "If you think about robots in the context of eating, do you see the robot more as a machine or device, or more as a companion or buddy?" (A3). This aspect was thought to likely have a particular impact on the answers in next Sections.

Applications of Robots in Food and Eating Contexts. This section contains 10 Likert scale (1-5 importance) and 1 open-response question. We explore which possible applications of robots in the context of eating seem to be important (A4, A0).

Characteristics of Ideal ACCs. We assess the participants' preferences regarding the appearance (A7) and the skills (A6; B4; B10-B11) of the ideal robot dining companion. While there is long debate in the literature [21–23] on advantages and disadvantages of physical (robots) and virtual (virtual agents, embodied conversational agents, etc.) companions we ask about it in the context of sharing meals (A5). Next, we explored further on the appearance preferences of the ACC in three different contexts (B1): restaurants (B1a), food preparation at home (B1b), social isolation at home (B1c). Users had 6 appearances options, ranging from "least humanoid" to "most humanoid": (1) Static abstract-shape robot, (2) Mobile abstract-shape robot, (3) Abstract mobile creature-like robot, (4) Realistic animal-like robot, (5) Abstract Human-like Robot, (6) Realistic humanoid robot. Following the methodology proposed in [18] to clarify the terms, we use images of some well known robots of each type, such as: Sophia robot, Pepper or a dog from Boston Dynamics. Users were then asked, referring to the same six robot appearance options, "Which appearance is most appropriate according to you for a robot dining companion?" (B2).

Acceptability and Applications These questions focus on user interest (B5-B6) and hypothetical frequency in using a robot dining companion (A10). Additionally, we explore the contexts in which such companions can be particularly useful (A8).

Concerns Regarding the Use of ACCs. This next section addresses user concerns about ACCs. Several studies focus on analyzing the situations in which people have negative reactions toward social robots from feeling uncomfortable [18] to shame [14] due to robots' actions. In this line, we assess users' general comfortability regarding interacting with an ACC, as well as some specific actions that may increase discomfort (A9; B7-B9).

Specific Interactions with Commensal Robots. Twenty-two

[2]This part is not discussed in this paper

positive (e.g., customization features) and 11 negative (e.g., malfunction) specific situations and cues are described in this final section (S1-S33), as we aim to understand user expectations and their level of tolerance in specific situations.

In the initial phases of the project, a comprehensive planning and development process was undertaken to ensure the creation of a robust and effective questionnaire. A questionnaire allows for the efficient collection of data from a large number of participants within a relatively short time frame. Online questionnaires can be completed anonymously, which can encourage more honest and candid responses from participants. This is particularly important when exploring attitudes and perceptions, as participants might feel more comfortable expressing their true opinions without fear of judgment. The project began with a thorough literature review to identify existing research on robots in social contexts, particularly in dining settings. This review helped in understanding the current state of knowledge, identifying gaps, and informing the design of the questionnaire. Before publishing it, the draft underwent several iterations, with revisions based on feedback from pilot testing. The pilot tests involved a small group of participants who provided insights into the clarity, length, and overall comprehensibility of the questionnaire. Their feedback was instrumental in identifying any ambiguous or confusing questions, leading to further refinements. Further, ethical considerations were addressed in the early stages of the project. Overall, the initial phases of the project were marked by a systematic and iterative approach to questionnaire development, involving extensive research, pilot testing, and ethical planning. This careful preparation laid a solid foundation for the successful collection and analysis of data in the later stages of the project.

4 DATA COLLECTION AND PARTICIPANTS

We collected data from participants through an online questionnaire that was divided into the six sub-sections described in detail in the previous section. The questions were in fixed order, and the study took 20 minutes to complete. The participants were required to answer all questions without the option to change responses once submitted. Participants (n=31 for qualitative questions, n=24 for quantitative analyses, 44.1% female, ages 16-54; n=3 removed due to failure to respond to required attitude questions, and an additional n=7 due to missing quantitative data) were recruited from various university communities. The survey was then shared by some participants on their personal social media spaces. Participants were required to be fluent in English, and provide informed consent.
The the data are provided as a part of Supplementary Materials.

5 RESULTS

5.1 Demographic and Attitude Baseline Questions

Participants (n=31) were divided as follows: 44.1% females and 55.9% males. Most of them work/study in the following fields: Business 23.5%, Education/Academia: 26.4% and Engineering/Technology: 23.5%. They were mainly in the age group (D1): 16-24 (58.8%), followed by 25-34 (26.5%) and 45-54 (15.7%). When it comes to their general attitude towards new technologies (A0): 2.9% declared themselves skeptical, 2- 2.9%, 3 - 5.9%, 4 - 11.8%, 5 - 25.5%, 6 - 41.2%, while 8.8% declared themselves as very trusting. 70.6% had prior experiences with a robot (A1a), and out of them, 62.5% declared to interact with social robots (A1b). Finally, 72.7% (A3) considered the robots a machine rather than a buddy. Interestingly, a significant correlation was observed between considering a robot a buddy and preferred embodiment. While, in general, a humanoid robot was not the preferred choice (see Section 5.3), apparently, the more one sees robots as buddies rather than machines (A3), the more likely they are to imagine a humanoid robot in a restaurant (B1a) ($r^2 = 0.5037$).

5.1.1 *Robots in Dining Contexts.*

When asked what comes to mind when robots and eating are mentioned together, robot cooks and servers (including ordering and cleaning) made up over half of free-form responses (A0). People mentioned things like "Technology that measures the health benefits or lack thereof of any meal. A robot that prepares your food.", with some participants acknowledging both the non-social and social potentials for robots within the dining experience: "Cleaning and serving in the food chain for non-social activities. Allergenic foods and healthy food assistant for social activities."; and yet, others found robots within a dining context unnerving, saying that it "Sounds weird." Most participants imagined and/or had encountered tablets or non-humanoid robots (A2).

5.1.2 *Expectations and Trust.*

Gender and Discomfort were correlated, with females scoring higher (mean of B8) for potential causes for discomfort ($r^2 = .5413$)(D2, B8). People who had experienced non-social interactions with robots had higher discomfort levels ($r^2 = .5413$) (A1b and mean of B8).

5.2 Applications of Robots in Food and Eating Contexts

In (A4), participants were presented with ten different roles that robots may have in the context of food and eating. According to the results, participants consider receiving manual help from the robot (e.g., cleaning dishes, sorting food) as more important. In this context, commensal companions are not considered particularly important, with more responses in the 1-2 range than in the 4-5 range of 5-point Likert scale.

This idea is highlighted by users who stated they do not imagine a humanoid robot in a dining context (as they likely are not imagining them as companions): "Doesn't have to have a human face."; "Like a tablet."; "Subtle and non-intrusive, so it can be ignored if I don't want it now."; "Bring my food, like a waiter." ;"Not like a human, that would be creepy." ;"I don't have something in mind on how they should look like. I can only say that if they look like humans, I would be a bit apprehensive or not comfortable with it.", and explicit mentions of a distaste for a commensal companion at all: "I don't like the idea of interaction with a robot as a dining companion during my meal."; "Simply a robot, I should manage to see it's not a real person." ; "Don't like it." (A7).

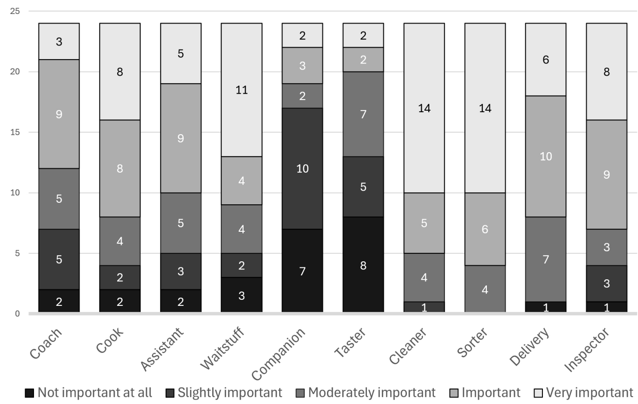

Figure 1: Answers to the question A4: If someone asks you, what are the possible applications of robots in the context of eating, which roles do you think about? Please choose which possible roles (listed below) you consider to be important applications according to you.

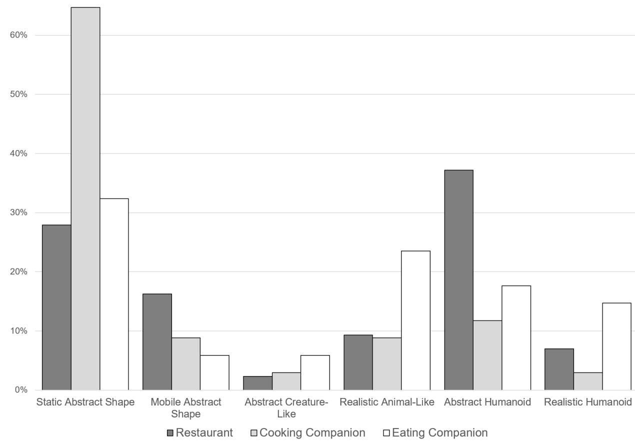

Figure 2: Answers to the question (B1): How do you expect the robot to look like?

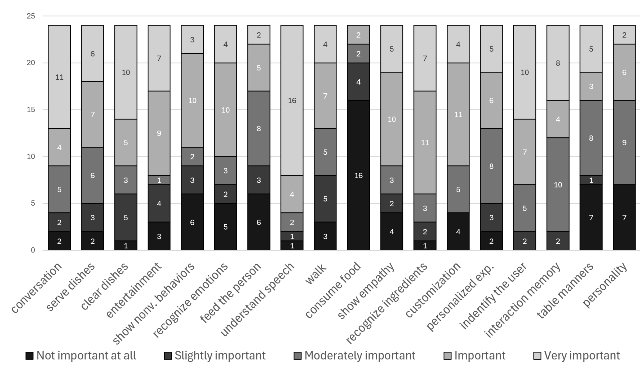

Figure 3: Answers to the question B4: How important is it for you that a robot, being a dining companion, has the following skills/characteristics?

5.3 Characteristics of Ideal ACCs

Then comes the distinction between virtual and physical embodiment of commensal agent (A5) 61.8% preferred the virtual experience. Additional questions A6, B1-B2, B4-B6, and B10-B11 further exploit the expectations towards dining companions. The participants indicated mixed preferences for social capacity of robots in dining contexts (A6), with some expressing a distinct lack of desire to have communicative abilities beyond being informative: "Maybe it could tell me culinary facts about my dishes…", or "Do its job and nothing more." While other users mentioned wanting social, polite, and friendly capabilities: "Keep a conversation", "Empathy, makes questions, great listener.". Next, we focus more on the robot's appearance asking to express the preference towards 6 specific appearances in 3 different settings at the restaurant (B1a), food preparation (B1b), social isolation (B1c). From the Figure 2 can be seen the overall preference for static abstract-shaped robots (similar to, e.g., Alexa) and abstract human-like robots (similar to, e.g., Pepper).

In-line with the common desire to have a robot capable of doing service tasks (B1a), there was a strong preference for non-humanoid, even tablet/chatbot exclusive robots (static abstract-shape robot), even if they were to be social (62% of participants). The second-most desired was an abstract Human-like robot.

The question B4 (see Figure 3) focuses on companion skills in more detail. Manual help like help with cleaning, organizing and recycling are the most sought after. In terms of communication, mutually verbal communication (the robot and the user have a conversation in an open public space) has gathered a lot of skepticism, partially because of peer criticism. 41.2% of users value conversational practices as a fundamental part of the robot and out of all the skills presented to the participants, the ability to understand human speech is the highest valued skill, followed by the ability of the robot to recognize the user, and distinguish the user from other humans. While some participants acknowledged a desire for both, most commonly there could be seen a dichotomous split between expecting a dining companion robot to be purely servile in nature, and social only in the context of being knowledgeable about the food/dining experience, and wanting an ideal robot to possess the ability to have meaningful/logical/"realistic" conversations (A6).

From above analysis it comes out that verbal communication between the dining companion and the user(s) results as an integral part of the experience after all. Thus, we also asked what can be topics of conversations (B10-B11). The preference is on general facts, food/diet information, and news topics (see Figure 4). Participants are averse to engaging in personal and intimate conversations (B10) and would much rather interact when conversing about local news and events or gastronomy related topics.

5.4 Acceptability and Applications

When asked about in which setting they would prefer to interact with ACC, the majority of users showed a preference of having both the robot and another person in their commensal experience (B5). Only less than one third of participants would prefer to eat solely in the company of ACC. The reasons (B6) include a preference for

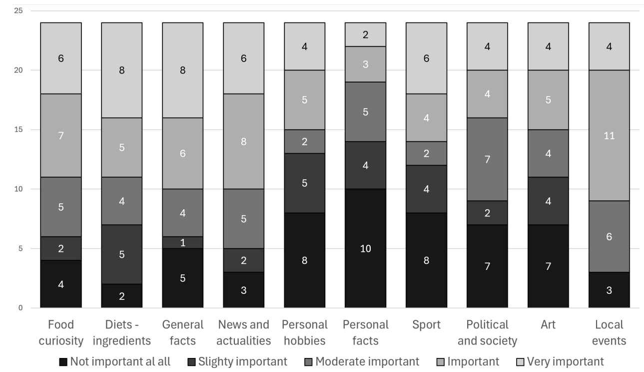

Figure 4: Answers to question B10: If a robot dining companion is able to talk, what would you like to talk with it about?

human interaction, and embarrassment and discomfort when interacting with a robot. Strikingly, less than 25% of participants believe that they would be willing to interact with a robot dining companion (A10). As far as expected context, outside of restaurants and meal preparation, a social dining companion robot was thought to also be useful in elderly care, hospitals, child care, foreign countries for visitors, for entertainment, and for aiding with mental health and loneliness in general (A8).

5.5 Concerns Regarding the Use of ACCs

We also collected responses about potential concerns. More specifically, when it comes to feeling uncomfortable with the ACC, the majority of respondents declared a low degree of uncomfortability (answers 1 and 2 summed together), and none of the participants declared extreme levels. Figure 5 shows specific reasons for eventual uncomfortability.

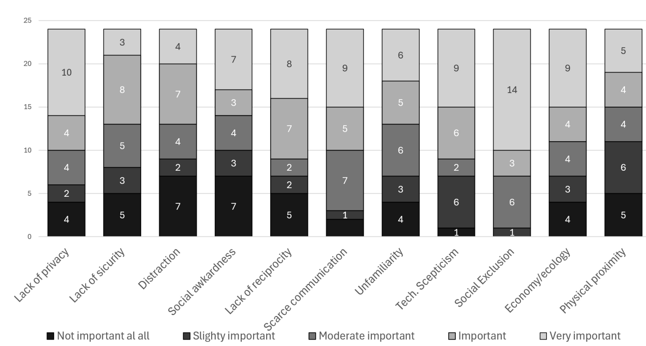

Figure 5: Answers to question B8: Which of the reasons listed below would make you feel uncomfortable when interacting with a robotic dining companion?

A lack of privacy and security are major concerns, as a scarcity of communication, or a social exclusion that may arise from above the increased integration of ACCs (see Figure 5). Further evidence for a general concern that having social interactions with robots would diminish humans' ability to interact with one another comes from our open response questions, and that there is a "Risk of not being able to have and/or keeping alive a conversation with another human anymore." One participant articulated this sentiment further by saying, "It might me feel isolated and lonely.", highlighting the idea perception that robots cannot have human emotions, and therefore interacting with them may weaken our own sense of humanity or connectivity with others. (A9). Additional fears also exist, however. Motivations for preferring a non-social robot were often fear of being judged (which was a primary blocker for users not wanting to adopt a robot (A10)): "It might make me feel isolated and lonely."; "It could be uncomfortable, if done in an open space with other people able to see that you are dining with a robot."; "Because it is still not common. It is like wearing a COVID mask before COVID happened.", and a general discomfort/lack of experience with robots Users expressed (1) disbelief that robots could ever truly possess/embody the emotional qualities of a human: "…it makes you lose touch with reality and feelings. As of now i dont believe that a robot can feel stuff and be empathic like a human being."; "…it doesn't have feelings."; "I don't like this type of interaction with non-real humans.", and "The lack of simple emotions."; or even far broader arguments, like "Because it's immoral."(B9). An interesting note is that even for participants who enjoy robots in a food environment and have had positive experiences, there is often mentioned a sense of a robot-human interaction being somehow of lesser social quality than that with another human. "I was once at a restaurant that had robots serve people the food and I actually found it more efficient and faster than having a human (only for this specific occasion). I strongly believe that having a human being to ask questions about something is very important. At the end of the day I chose a good restaurant equally because of quality of food and quality of servers." (A2) Statistically, self-explanatory relationships about concerns regarding ACCs could be seen, such as how appropriate one finds the appearance of a robot given its setting is positively correlated with how comfortable they would feel eating with a robot (r^2 = .5599) (B7,B2Mean).

6 DISCUSSION

Many insights regarding specific functionality and appearance preferences for dining companion robots in multiple contexts were unearthed, but the primary take-aways concern the unexpected preferences toward virtual representation and non-humanoid appearance, the conception of a companion robot as a machine more than a buddy, and the general skepticism users have concerning socially interacting with a robot (or even admitting that they want to)–regardless of age, gender, professional background, or general attitudes toward new technologies. Is a robot being a companion important to users? Many are unwilling to try it, because they are lacking experience, and what expectations they have are for service robots in the form of tablets or static devices. Currently, many potential users may not be able to see the value in having robot companions, in dining settings and otherwise. The main concerns focus on social stigmatization, the renunciation of human-human contacts, and scarce communication abilities of the companion. While the latter can be relatively easily addressed with technological progress, the other two concerns are not strictly related to the commensality setting, and should make us think about more about potential applications of social robotics in general.

The free-form ideas about applying robot companions to elderly, health, mental health, and child care, combined with the frequent mention of concern about judgment from others, suggests that users may care about and enjoy companionship as a functionality in their robots more than they are currently able to realize. Further development of companion robots in conjunction with continued user research to promote positive user experiences will hopefully reduce the existing stigma surrounding companion robots, and allow for an increase in their adoption.

6.1 Limitations

This study was exploratory in nature, and thus some limitations have been exposed. Data from this study is informing improved scale iterations for further research. Further, performance fatigue due to the length of the survey may have prevented some open-response data from being more in-depth. This, in addition to the results of the factor analyses, suggests that the number of questions can be reduced for future studies, while still obtaining the same key information from participants. Lastly, as this was meant to be a scale development, validation, and exploration study, the scales were not validated prior to conducting this study, and in the future validated, counter-balanced versions of the scales will improve the quality and consistency of the data.

6.2 Future Research

Further, in-depth qualitative analyses remain to be conducted on the data gathered in this study. Some information already uncovered, such as users' discomfort with/lack of desire to have robots eat or mimic eating, or their distaste for realistic humanoid robots are already informing the designs of in-progress dining companion robot research programs. Additional insights regarding physical and functional expectations for robots in commensal settings will be applied to future robotics work. Future studies need to be conducted with shortened and improved versions of the scales present in this study, with the inclusion of questions concerning instances in which people would try or purchase a dining companion robot (whether for themselves, or someone else). Additionally, as aforementioned, education and exposure to companion robots will improve user perceptions.

6.3 Suggestions for Design of Commensal Companions

Robots in dining environments is a relatively new concept, and as eating companion even more so. In the nascent stages of this societal transition, it will be necessary to educate the public about the abilities and functions of any companion robots for their comfort to gradually increase. Additionally, as our results indicated that "too humanoid" of a robot may trigger the Uncanny Valley Effect, or feel eerie to users–particularly those not familiar with this type of experience–we recommend designs of any future ACCs to begin with non-humanoid robots, or at least ones that are not terribly realistic. When it comes to interaction and skills, a strong preference was seen for multimodal systems able to communicate both verbally and nonverbally. Further, as the public perception of robots functions change (e.g., from assistive devices to also being companions), the social needs of users that are ever-changing will need to continuously be addressed. Even if research conducted in the present informs the social style and mannerisms of initial ACCs, the quickly changing nature of human interactions and needs will need to be considered for these robots to be remain relevant. Cohort, gender, etc. are also likely going to need to inform personalized ACC design.

Overall, our research provides valuable insights into the future design and development of dining companion robots, emphasizing the need for functionality, appropriate appearance, and nuanced communication capabilities. By understanding and addressing public attitudes and expectations, we can pave the way for the creation of inclusive and socially beneficial technologies that enhance communal dining experiences for all.

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