The Future of Home Appliances: A Study on the Robotic Toaster as a Domestic Social Robot

Meryl Ye[1], Eike Schneiders[2], Wen-Ying Lee[3], Malte Jung[4]

Abstract— **Robotic appliances are continually being adopted into private homes. However, users have yet to exhibit the same acceptance towards domestic social robots. In this paper, we seek to bridge this issue by augmenting already-existing home appliances with capabilities mimicking social robots. We present a robotic toaster designed with animated movements to enhance and personalize the toast-making experience. Not only does the robotic toaster assist in completing the task itself, it also acts as a conscious agent with whom users may interact in a social and playful manner. Using a series of video vignettes, we identify three key themes of the robotic toaster that influence its relationship with users: these are related to (1) context awareness, (2) increased interactivity through initiative action, and (3) expression of personality despite limited degrees of freedom. Lastly, we discuss how the portrayal of home appliances with social characteristics can potentially serve as an introductory step for social robots in the home.**

I. INTRODUCTION

With the advancement of smart gadgets and home automation systems, the presence of robots in the domestic context has become a prevalent reality. From robotic vacuums to smart coffee makers, there are modern appliances that expedite a multitude of household chores. Meanwhile, there have also been several attempts to introduce social robots into homes to act as assistants, companions, or playmates [1], [2]. These devices, however, have not been as well-received by users despite offering benefits in improving everyday life [3], [4]. Though they share the objective of engaging and assisting users, smart appliances and social robots still face varying levels of receptivity from users. Thus, it becomes critical to understand what attributes of these technologies affect user expectations and attitudes, as well as how they influence the social dynamic under designated contexts. Furthermore, it could be beneficial to examine how certain features of social robots can be adapted to smart home appliances to make users more receptive towards social robots in domestic contexts.

In this paper, we describe a video vignette study, in which we investigate people's perceptions of a robotic toaster. The toaster is a common household appliance with users of various ages, abilities, and backgrounds [5]. We seek to investigate the robotic toaster's ability to influence the mundane task of toasting bread and how this experience could potentially be enhanced. We consider how to improve the design of domestic robots to serve their purpose as a tool while simultaneously doubling as a social agent (i.e. having social awareness and capabilities). Through thematic analysis of open-ended survey responses from voluntary participants, we determine which features and behaviors of the robotic toaster distinguish it as an active social agent instead of a passive appliance. This paper contributes to current human-robot interaction literature by presenting three main design themes identified from participant responses that center around context awareness, initiative action, and personality. The primary objective of this study is to better understand how people may perceive smart home appliances and how these perceptions can inform future design of domestic social robots.

[1]Meryl Ye is with the Department of Computer Science, Cornell University, New York, USA, may43@cornell.edu

[2]Eike Schneiders is with the Department of Computer Science, University of Nottingham, UK, eike.schneiders@nottingham.ac.uk

[3]Wen-Ying Lee is with Exponent, Massachusetts, USA, wlee@exponent.com

[4]Malte Jung is with the Department of Information Science, Cornell University, New York, USA, mfj28@cornell.edu

II. RELATED WORK

Domestic robots such as vacuum cleaners and lawnmowers are becoming more popular in private homes as robotic variations of many common household appliances are continually being developed [6]. Recent research has shown that domestic robots have the potential to distribute responsibilities and disrupt classical roles assigned in the household [6], [7]. They can also affect relations between the users themselves [8]. Similarly, devices with agency have demonstrated the ability to alter interaction patterns and perceptions [9], [10]. As these technologies influence conventional household dynamics, it becomes increasingly important to study how users interact with robotic appliances and what improvements or disruptions they may anticipate when inviting domestic robots into their homes.

Living spaces are personal environments. In adopting a domestic robot that may display traits of intelligence and sociableness, users are establishing a relationship with the robot that can promote its acceptance and continued use [11]. Previous studies revealed that the role that users prefer robots to take is dependent on factors such as appearance, purpose, and behavior [12], [13]. In most cases, it seems that the more human-like a robot is in appearance and behavior, the more users are willing to view it as a friend or companion [13]. Conversely, the more practical the robot's purpose, the greater the preference is for it to appear and behave like a mechanism [14]. Clavel et al. found that users are open to robotic companions but preferably ones with limited autonomy and non-dominant behavior [15]. Moreover, users would rather view these robotic companions as tools rather than friends.

Scenario name	**Description** (`URL to video vignette`)
Just Checking	Two users sit at a table with a four-slice slotted robotic toaster. Each user inserts a bread slice into the toaster, pushes down their respective handle, and begins to perform secondary tasks. In regular intervals, each user pauses their task and looks up at the toaster. Synchronously, the toaster raises the corresponding user's toast. Eventually, both users become satisfied with their toast's browning and remove it from the toaster. (`https://youtu.be/IKBE388E1Bg`)
Be Polite	Two users sit at a table with a four-slice slotted robotic toaster. One user roughly inserts a bread slice into the toaster and haphazardly attempts to push down the handle without success. The other user carefully inserts a bread slice into the toaster. They gently push down the respective handle with success. The first user tries again, emulating the other user's movements, and succeeds. The users wait for their toasts and remove them once they pop up. (`https://youtu.be/2HD8tNWdwJk`)
Causing Trouble	Two users sit at a table with a four-slice slotted robotic toaster. Two toast slices are in the toaster. One toast pops up. When its corresponding user reaches for the toast, the toaster retracts it and prevents the user from attaining their toast. The two users take turns in attempting to grab each of their toasts, without success. After several back and forths of this occurrence, the toaster wiggles its handles to imitate laughter and finally allows the users to take their toasts. (`https://youtu.be/GtFPAF83ncs`)
Toast Security	A user enters the scene, inserts a bread slice into a four-slice slotted robotic toaster, and pushes down the respective handle. After some time, the slice of toast pops up. A second user enters the scene and attempts to take the slice of toast, but the toaster retracts the toast into the slot, preventing them from removing the toast. The first user returns and the toast pops back up for them, allowing them to take it. (`https://youtu.be/qvKNWCNGchc`)
Which Toast	A user enters the scene and inserts a bread slice into a four-slice slotted robotic toaster and pushes down the respective handle. A second user enters the scene and inserts a bread slice into a slot and pushes down the respective handle. After some time, both slices of toast pop up. The first user returns and is unsure which toast is theirs. The toaster moves the first user's toast up and down. The original user takes this toast. (`https://youtu.be/mrNjdNbwBCg`)

TABLE I: Descriptions of the five scenarios, as presented by Ye et al. [5], depicted in the video vignettes.

III. DESIGN

In our design process, we held multiple workshops involving a team of Human-Robot Interaction (HRI) researchers and toaster users to determine user needs and ideal functionalities of a robotic toaster. The main objective of these workshops was to conceptualize scenarios that portrayed the robotic toaster as an animate agent with its own thoughts and behavior that guided both playful and practical interactions. Though the purpose of robotic appliances is typically to help users perform a household task, by incorporating a ludic aspect to the interaction scenarios, we aimed to design the robotic toaster to elicit emotionally and socially richer experiences [16]. Consequently, the following questions guided our design process:

- How would a robotic toaster communicate its intention and express its state (e.g., mischievousness or happiness) given its low degree of freedom?
- How may users interpret different robotic toaster behaviors?
- How can we leverage certain robotic toaster behaviors to contribute utility and enjoyment to the toast-making experience?

From these workshops, we were able to draw up a series of storyboards illustrating scenarios of action-reaction, safety concerns, multi-user toaster usage, and playfulness [5]. The use of storyboards to illustrate application scenarios has been shown to be an effective strategy in exploring potential designs in HRI [17].

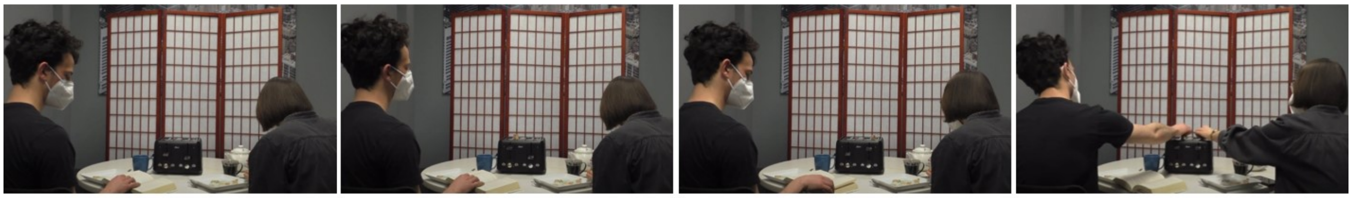
We selected five of these storyboards to be realized as video vignettes, a common methodology for the investigation of HCI and HRI (e.g., [18], [19]), in order to envision the interactions in a live setting. These interactions were selected based on their depiction of the robotic toaster in a variety of roles (e.g. assistant, conflict mediator), intentions (e.g., help, cause trouble), and moods (e.g., playful, upset) as differentiated by the storyboard categories [5]. For a description of all video vignettes see Table I. As an appliance that is often shared among multiple users (i.e. in the context of a shared kitchen or dining area), we designed the video vignettes to illustrate anthropomorphized toaster behavior during interaction in non-dyadic configurations (see Fig. 1) to further study the robotic toaster's impact on group dynamics [20].

We employed Wizard-of-Oz techniques in the making of these vignettes to realistically portray how the robotic toaster behaves in different scenarios without having to construct a fully functioning prototype [21]. Each vignette features two users (played by members of our lab) and a toaster controlled by a "wizard" behind the scene. Similar to past HRI studies [22], [23], our goal in using these video vignettes is to better understand how people may perceive and interpret the robotic toaster technology and behavior.

IV. STUDY

A. *Participants*

We recruited 93 participants (26 male, 65 female, 2 non-binary) from Cornell University in Ithaca, NY. Participant age ranged from 18 to 53 (average: 21.2, std: 4.07). Participants were recruited through flyers in campus buildings and the Sona Research Participation System (sona-systems.com)



1 2 3 4

Fig. 1: Illustration of key moments in the "Just Checking" video vignette. (1) Both participants have placed their toast in the toaster and their gaze is averted, (2) the left participants looks at the toaster which lifts the corresponding toast, (3) both participants continue focusing at their task at hand (e.g., reading), and lastly (4) both participants look up and pick up the toast as they deem it ready. The actors gave consent to being shown in the vignettes and in the paper.

for the Departments of Communication and Information Science. Participants were compensated with either course credit or entry into a gift card raffle.

B. Procedure

A Qualtrics survey was distributed to participants in order to collect data. To evoke a broad range of perceptions towards the device, we created three slightly different variations that were presented—in balanced groups—to the participants. Specifically, the survey would refer to the robotic toaster using a different label: "toaster", "smart toaster", or "Toasty". Other than the label of the robotic toaster, the variations of the survey were identical in structure and content. The survey consisted of three sections: 1) study information and informed consent, 2) viewing of the five video vignettes—each followed by qualitative data collection, and 3) collection of general demographic information. The Qualtrics survey began by informing the participants about the purpose of the study and asking for their consent to the fully anonymized data collection. Then the five video vignettes (average length 34.2 seconds) were presented to the participants in a random order. After each video, the participants were asked to answer three open-ended questions: 1) *"Briefly describe what happened in the video you just watched."*, 2) *"What did [the robotic toaster] contribute to the scenario you described in the previous question?"*, and 3) *"What do you believe [the robotic toaster] is intending to communicate?"*. Lastly, we inquired about demographic information including gender, age, and ethnicity.

V. FINDINGS

We conducted a thematic analysis on the open-ended survey responses to identify underlying themes and patterns in user perception [24]. Using Taguette (taguette.org), a free and open-source qualitative data analysis tool, two researchers independently read participant responses and generated initial codes such as "attention-seeking", "intelligent", or "helpful". To create a flexible yet reliable codebook and ensure its consistent application, we utilized two coders. The codes were then grouped into initial themes like "practicality" or "toaster cognition", which were iteratively revised until we identified three primary themes related to context awareness, initiative action, and personality.

A. Awareness Exhibited By Personal Home Appliances

The first theme refers to the robotic toaster's context awareness. P13 described the robotic toaster to be *"aware of its surroundings and interactions"*. Several participants attributed this awareness to the robotic toaster having a natural intuition or sense about its environment. For instance, for the "Just Checking" scenario, P86 recognized that *"[the robotic toaster] could tell when [the users] looked at the bread,"* while P92 stated that *"it was able to sense whether the man or woman was looking at them"*. Other participants, however, described this behavior as a merely computerized functionality. P43 said that *"the [robotic] toaster motion detects when [a] person looks up or looks down."*, and P59 speculated that *"it responded to the finger-pointing of the original owner of the toast in a matter that showed signs of memory and data storage."* The impression that the robotic toaster has memory, as either a cognitive or computational feature, is particularly noteworthy.

The same pattern is also exhibited in the "Toast Security" scenario. Since *"the [robotic] toaster knows which piece belongs to a specific owner"* [P2], it is seen to be capable of recognizing different users and treat them uniquely. This personalization of the interaction for an individual user is critical in forming more personal human-robot relationships [25]. In fact, a handful of participants interpreted remembrance of the user as loyalty, in that the robotic toaster is acting *"protective and loyal towards its owner"* [P22]. This trait arguably strengthens the user's attachment to the robotic toaster. Adhering to this line of reasoning, P90 mentioned a formation of trust towards the robotic toaster, noting *"the [robotic] toaster was reliable because the people were able to leave the room while the breads were toasting"*.

B. Initiative Action Increases Interactivity

The second theme applies to the manner in which the robotic toaster utilizes the knowledge acquired through its awareness to execute actions, which also addresses its display of active or passive behavior. Autonomy, or "having the technological capabilities to act on behalf of humans without direct input from humans" [26], is a contributing component to the robotic toaster's activeness. Multiple participants described the robotic toaster to exhibit autonomy, For instance, P54 stated that *"the [robotic] toaster [can start] by itself"*.

As a result, this demonstration of active behavior made the robotic toaster appear to have *"a mind of its own"* [P40] since it did not require the user to initiate the interaction.

Referencing the "Be Polite" scenario, P4 implied that the robotic toaster has capability of judgement in that *"the [robotic] toaster was able to choose to accept/reject bread based on how it was being handled by the user"*, further showcasing the robotic toaster's ability to act autonomously based on its awareness. A handful of participants viewed this behavior as dominant or controlling, declaring that the robotic toaster *"protected one person's toast from being stolen by a different person,"* [P32] in the "Toast Security" scenario or that *"[the robotic toaster] seemed to control whether the toast was accessible"* [P4] in the "Causing Trouble" scenario. Other participants perceived the robotic toaster's actions to resemble gentle help. For example, in the "Toast Security" scenario, P90 stated that *"the [robotic] toaster helped ensure that the right person took the toast"*. Another participant thought the robotic toaster *"guid[ed] the user to make the right choice"* [P33] in the "Which Toast" scenario. Nevertheless, in either perception, the robotic toaster establishes a level of authority or influence over the user, which elicits greater interactivity or causal behavior from the user [26].

As the robotic toaster appears to make judgements and act according to some standard, P33 claimed that it abides by *"social rules"*. Participants perceived the robotic toaster to demonstrate an understanding of social rules in the "Be Polite" scenario. For instance, P84 remarked that the robotic toaster *"only allow[s] the toast to be given if the users followed a certain behavior"*, and P59 observed that *"[it] only works when [it is] used with care"*. Considering *"if it [is] treated politely, it [does] its job as a toaster"* [P32], the robotic toaster seems to have its own preference of how interactions are carried out, which influences users to act accordingly and treat it respectfully. Given that the majority of participants accurately interpreted this scenario the way we intended (see Table 1 for description), it shows that robotic toaster's action can lead to a more active role in the interaction.

C. Conveying Personality through Movement-Based Behavior

The third theme focuses on the robotic toaster's expression of personality and emotions. Van Otterdijk et al. emphasized the influence of movement speed and size when conveying personality through robot movement [27]. For the "Just Checking" scenario, P49 noted that *"it is able to 'nod' unlike a regular toaster"*. P20 commented *"the rhythmic retraction was slightly [humorous] and gives the [robotic] toaster some personality and lifelike characteristics*". After watching the "Causing Trouble" scenario, P51 likened the robotic toaster's wiggling motion to *"a little dance"*, and P46 even associated it with a *"carnival game where you hit the hedgehogs that keep popping up"*. Thus, despite the limited degrees of freedom, the robotic toaster's gestures are comparable to full-bodied and coordinated movements, enabling the robotic toaster to express a unique personality. In describing the robotic toaster as a whole, P62 and P13 respectively called the robotic toaster "*the main antagonist*" or "*a character*" to point out its unconventional behavior and how the robotic toaster's personality affects interaction with the user. As an example, for the "Causing Trouble" scenario, some participants saw the robotic toaster's behavior as endearing: *"[the robotic toaster] seemed to try to be funny and playful to the participants and communicate a joke"* [P80], but others found it frustrating: *"[the robotic] toaster was contributing an annoyance"*[P14].

In the presented scenarios, participants described the robotic toaster to display a wide range of emotions. P37 interpreted the robotic toaster to exhibit satisfaction in the "Be Polite" scenario when *"A guy tried to put his toast in the [robotic] toaster but didn't do it nicely. A woman tried next and the [robotic] toaster liked how she did it much better"*. For the "Causing Trouble" scenario, P32 implied that the robotic toaster exhibits enthusiasm because *"the [robotic] toaster wanted to have a bit of playful fun with the users"*. P9 identified signs of boredom in the "Just Checking" scenario as *"the [robotic] toaster seemed bored when the individual performed other tasks and were not paying attention to [the robotic] toaster"*. P2 described a situation in which the robotic toaster is upset for the "Be Polite" scenario since *"[it] looks like the [robotic] toaster does not like to be abused, and refuses to work when being abused"*. Lastly, the robotic toaster also appears to display hesitance in the "Which Toast" scenario. P74 described *"One girl put in her toast and then another girl did after the first girl left. Once the first one returned, she was confused about which one was her toast. [The robotic toaster] was hesitant to give it and then once she took the correct one, she was given it without hesitation."* As participants perceived the robot toaster to exhibit a diverse range of emotions across the scenarios, the robotic toaster demonstrates that two degrees of freedom are sufficient to portray a changing personality.

VI. DISCUSSION

A. Home Appliances as Social Robots

Our findings about user perceptions towards the robotic toaster suggest that common home appliances can be implemented as social robots in domestic settings.

The first theme describes that by displaying an awareness of its surroundings and users, the robotic toaster is able to engage in more meaningful interactions and thus foster a more personal relationship with users. This finding offers insight into how personal home appliances can be designed to encourage stronger bonds between users and appliances. Fox et al. suggested that robots are often limited in how they can personalize interactions with users due to their lack of memory and ability to perform conditional actions [25]. This shortcoming is particularly consistent with usage of most robotic appliances. The user remembers its experience with the robotic appliance, but the robotic appliance's behavior is independent of prior interactions. If a robotic appliance possesses a sense of awareness, however, it can adjust its behavior accordingly to certain users and the interaction is no longer unidirectional but bidirectional. Whether with humans or robots, relationships are cultivated over time and require efforts of maintenance on both ends [25]. By designing a robot to exhibit awareness, there is mutual engagement in human-robot interactions, which in the case of our study, participants associated with greater attachment and loyalty in the relationship with the robotic toaster.

The second theme is enabled by the robotic toaster's demonstration of context awareness. Due to its awareness, the robotic toaster can act based on its context and users, similar to what has been described as social norms [26]. Bartneck et al. highlighted a factor of reciprocity in social norms, which participants perceived from the robotic toaster through its initiation of action and active effort to engage with the user. Display of initiative action and autonomy further allowed it to establish a level of authority in its role. This finding aligns with past work showing that more active behavior causes the robot to be viewed more as a social agent and less like a passive tool [28].

The third theme complements the robotic toaster's context awareness and initiative action in motivating user acceptance as portrayal of personality can provide an aspect of amusement to an otherwise banal task. This unpredictable element also adds excitement to the interaction, which can boost user morale. As P16 remarked that the robotic toaster *"contributed [an] eagerness to get on with daily life"*, depiction of the robotic toaster as a character can make the toast-making experience more enjoyable and provide users with benefits beyond practicality. In essence, by "bringing the appliance to life", it has potential to become a principal member of the domestic environment, connecting with users in a more personal manner than ordinary appliances.

Though not classified as social robots, this study has shown that home appliances can successfully adopt characteristics of social robots (e.g., anthropomorphism or emotion) while still fulfilling a utilitarian need (e.g., toasting bread). By implementing this strategy, which uses ordinary home appliances as a transitional step towards domestic social robots, we hope to gradually increase user acceptance and adoption of domestic social robots.

B. Limitations and Future Research

Since this study was conducted as a video vignette study, no real-life interactions between the robotic toaster and users occurred. Future work could address this limitation by developing autonomous toasters that could be used for longitudinal deployments in real-world households, ultimately revealing insights beyond the novelty effect with higher ecological validity. Furthermore, the study was conducted with a homogeneous participant population in relation to participant age group and, to a lesser extent, gender (70% female). Therefore, follow-up studies would need to identify the generalizability of the findings presented here.

VII. CONCLUSION

In this paper, we described a video vignette study using a bespoke kitchen appliance – the robotic toaster. Through thematic analysis on participants' responses to the two open-ended questions following each video vignette, we highlighted three key themes distinguishing the robotic toaster that pertain to context awareness, increased interactivity through initiative action, and expression of personality. We showed that a low degree-of-freedom appliance (2 DoF) can generate a feeling of awareness and seemingly understand the context around it. The robotic toaster was able to utilize this capability and present an impression of autonomy by acting upon the social queues observed. Furthermore, the thematic analysis demonstrated that even 2 DoF are sufficient to express a wide range of human emotions. Lastly, we considered the addition of social behaviors to home appliances as a way of potentially increasing the acceptance of social robots in domestic contexts.

ACKNOWLEDGMENT

This project was in part sponsored by the Office of Naval Research (#N00014-19-1-2299) and by the National Science Foundation (#1925100). Furthermore, this work was supported by the UK Engineering and Physical Sciences Research Council (EPSRC) through the Trustworthy Autonomous Systems Hub (EP/V00784X/1). Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the funding agencies. We thank Johan Michalove and Jessie Wong for their support in preparing this paper. We are also grateful to Hannah Pelikan, Asher Lipman, and Kelly Hu for starring in the vignettes.

REFERENCES

[1] G. Hoffman, "Anki, jibo, and kuri: What we can learn from social robots that didn't make it," Jul 2021. [Online]. Available: https://spectrum.ieee.org/anki-jibo-and-kuri-what-we-can-learn-from-social-robotics-failures

[2] E. Schneiders, E. Papachristos, N. van Berkel, and R. M. Jacobsen, ""Briefly Entertaining but Pointless": Perceived Benefits & Risks of Social Robots in the Home," in *Extended Abstracts of the 2023 CHI Conference on Human Factors in Computing Systems*, ser. CHI EA '23. New York, NY, USA: Association for Computing Machinery, 2023. [Online]. Available: https://doi.org/10.1145/3544549.3585696

[3] A. Y. M. Leung, I. Y. Zhao, S. Lin, and T. K. Lau, "Exploring the presence of humanoid social robots at home and capturing human-robot interactions with older adults: Experiences from four case studies," *Healthcare*, vol. 11, no. 1, 2023. [Online]. Available: https://www.mdpi.com/2227-9032/11/1/39

[4] M. Carradore, "Social robots in the home: What factors influence attitudes towards their use in assistive care?" *Italian Sociological Review*, vol. 11, no. 3, pp. 879–901, 2021, copyright - © 2021. This work is published under https://creativecommons.org/licenses/by/3.0/ (the "License"). Notwithstanding the ProQuest Terms and Conditions, you may use this content in accordance with the terms of the License; Last updated - 2022-12-18. [Online]. Available: https://www.proquest.com/scholarly-journals/social-robots-home-what-factors-influence/docview/2583607754/se-2

[5] M. Ye, R. W.-Y. Lee, J. Michalove, and J. Wong, "Toaster bot: Designing for utility and enjoyability in the kitchen space," in *Companion of the 2023 ACM/IEEE International Conference on Human-Robot Interaction*, ser. HRI '23. New York, NY, USA: Association for Computing Machinery, 2023, p. 787–790. [Online]. Available: https://doi.org/10.1145/3568294.3580182

[6] E. Schneiders, A. M. Kanstrup, J. Kjeldskov, and M. B. Skov, "Domestic robots and the dream of automation: Understanding human interaction and intervention," in *Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems*, ser. CHI '21. New York, NY, USA: Association for Computing Machinery, 2021. [Online]. Available: https://doi.org/10.1145/3411764.3445629

[7] J. Forlizzi and C. DiSalvo, "Service robots in the domestic environment: A study of the roomba vacuum in the home," in *Proceedings of the 1st ACM SIGCHI/SIGART Conference on Human-Robot Interaction*, ser. HRI '06. New York, NY, USA: Association for Computing Machinery, 2006, p. 258–265. [Online]. Available: https://doi.org/10.1145/1121241.1121286

[8] K. Jeong, J. Sung, H.-S. Lee, A. Kim, H. Kim, C. Park, Y. Jeong, J. Lee, and J. Kim, "Fribo: A social networking robot for increasing social connectedness through sharing daily home activities from living noise data," in *Proceedings of the 2018 ACM/IEEE International Conference on Human-Robot Interaction*, ser. HRI '18. New York, NY, USA: Association for Computing Machinery, 2018, p. 114–122. [Online]. Available: https://doi.org/10.1145/3171221.3171254

[9] B. Mok, S. Yang, D. Sirkin, and W. Ju, "A place for every tool and every tool in its place: Performing collaborative tasks with interactive robotic drawers," in *2015 24th IEEE International Symposium on Robot and Human Interactive Communication (RO-MAN)*. IEEE, 2015, pp. 700–706. [Online]. Available: https://doi.org/10.1109/ROMAN.2015.7333680

[10] D. Sirkin, B. Mok, S. Yang, and W. Ju, "Mechanical ottoman: how robotic furniture offers and withdraws support," in *Proceedings of the Tenth Annual ACM/IEEE International Conference on Human-Robot Interaction*, 2015, pp. 11–18. [Online]. Available: https://doi.org/10.1145/2696454.2696461

[11] J.-Y. Sung, L. Guo, R. Grinter, and H. Christensen, ""my roomba is rambo": Intimate home appliances," vol. 4717, 09 2007.

[12] K. Dautenhahn, S. Woods, C. Kaouri, M. Walters, K. L. Koay, and I. Werry, "What is a robot companion - friend, assistant or butler?" in *2005 IEEE/RSJ International Conference on Intelligent Robots and Systems*, 2005, pp. 1192–1197.

[13] S. Wu, S. He, Y. Peng, W. Li, M. Zhou, and D. Guan, "An empirical study on expectation of relationship between human and smart devices—with smart speaker as an example," in *2019 IEEE Fourth International Conference on Data Science in Cyberspace (DSC)*, 2019, pp. 555–560.

[14] M. M. A. de Graaf and S. Ben Allouch, "The evaluation of different roles for domestic social robots," in *2015 24th IEEE International Symposium on Robot and Human Interactive Communication (RO-MAN)*, 2015, pp. 676–681.

[15] C. Clavel, C. Faur, J.-C. Martin, S. Pesty, and D. Duhaut, "Artificial companions with personality and social role," in *2013 IEEE Symposium on Computational Intelligence for Creativity and Affective Computing (CICAC)*, 2013, pp. 87–95.

[16] W.-Y. Lee and M. Jung, "Ludic-hri: Designing playful experiences with robots," in *Companion of the 2020 ACM/IEEE International Conference on Human-Robot Interaction*, ser. HRI '20. New York, NY, USA: Association for Computing Machinery, 2020, p. 582–584. [Online]. Available: https://doi.org/10.1145/3371382.3377429

[17] D. Sirkin, N. Martelaro, H. Tennent, M. Johns, B. Mok, W. Ju, G. Hoffman, H. Knight, B. Mutlu, and L. Takayama, "Design skills for hri," in *2016 11th ACM/IEEE International Conference on Human-Robot Interaction (HRI)*, 2016, pp. 581–582.

[18] C. Torrey, S. R. Fussell, and S. Kiesler, "How a robot should give advice," in *2013 8th ACM/IEEE International Conference on Human-Robot Interaction (HRI)*, 2013, pp. 275–282.

[19] E. Schneiders, E. Papachristos, and N. van Berkel, "The effect of embodied anthropomorphism of personal assistants on user perceptions," in *Proceedings of the 33rd Australian Conference on Human-Computer Interaction*, ser. OzCHI '21. New York, NY, USA: Association for Computing Machinery, 2022, p. 231–241. [Online]. Available: https://doi.org/10.1145/3520495.3520503

[20] E. Schneiders, E. Cheon, J. Kjeldskov, M. Rehm, and M. B. Skov, "Non-dyadic interaction: A literature review of 15 years of human-robot interaction conference publications," *J. Hum.-Robot Interact.*, vol. 11, no. 2, feb 2022. [Online]. Available: https://doi.org/10.1145/3488242

[21] L. D. Riek, "Wizard of oz studies in hri: A systematic review and new reporting guidelines," *J. Hum.-Robot Interact.*, vol. 1, no. 1, p. 119–136, jul 2012. [Online]. Available: https://doi.org/10.5898/JHRI.1.1.Riek

[22] D. Sirkin and W. Ju, "Consistency in physical and on-screen action improves perceptions of telepresence robots," in *Proceedings of the Seventh Annual ACM/IEEE International Conference on Human-Robot Interaction*, ser. HRI '12. New York, NY, USA: Association for Computing Machinery, 2012, p. 57–64. [Online]. Available: https://doi.org/10.1145/2157689.2157699

[23] L. Takayama, D. Dooley, and W. Ju, "Expressing thought: Improving robot readability with animation principles," in *Proceedings of the 6th International Conference on Human-Robot Interaction*, ser. HRI '11. New York, NY, USA: Association for Computing Machinery, 2011, p. 69–76. [Online]. Available: https://doi.org/10.1145/1957656.1957674

[24] V. Braun and V. Clarke, "Using thematic analysis in psychology," *Qualitative Research in Psychology*, vol. 3, pp. 77–101, 01 2006.

[25] J. Fox and A. Gambino, "Relationship development with humanoid social robots: Applying interpersonal theories to human–robot interaction," *Cyberpsychology, Behavior, and Social Networking*, vol. 24, no. 5, pp. 294–299, 2021, pMID: 33434097. [Online]. Available: https://doi.org/10.1089/cyber.2020.0181

[26] C. Bartneck and J. Forlizzi, "A design-centred framework for social human-robot interaction," in *RO-MAN 2004. 13th IEEE International Workshop on Robot and Human Interactive Communication (IEEE Catalog No.04TH8759)*, 2004, pp. 591–594.

[27] M. v. Otterdijk, H. Song, K. Tsiakas, I. van Zeijl, and E. Barakova, "Nonverbal cues expressing robot personality - a movement analysts perspective," in *2022 31st IEEE International Conference on Robot and Human Interactive Communication (RO-MAN)*, 2022, pp. 1181–1186.

[28] O. Mubin, T. D'Arcy, G. Murtaza, S. Simoff, C. Stanton, and C. Stevens, "Active or passive?: Investigating the impact of robot role in meetings," in *The 23rd IEEE International Symposium on Robot and Human Interactive Communication*, 2014, pp. 580–585.