Understanding Cultural Preferences for Social Robots: A Study in German and Arab Communities

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This article presents a study of cultural differences affecting the acceptance and design preferences of social robots. Based on a survey with 794 participants from Germany and the three Arab countries of Egypt, Jordan, and Saudi Arabia, we discuss how culture influences the preferences for certain attributes. We look at social roles, abilities and appearance, emotional awareness and interactivity of social robots, as well as the attitude toward automation. Preferences were found to differ not only across cultures, but also within countries with similar cultural backgrounds. Our findings also show a nuanced picture of the impact of previously identified culturally variable factors, such as attitudes toward traditions and innovations. While the participants' perspectives toward traditions and innovations varied, these factors did not fully account for the cultural variations in their perceptions of social robots. In conclusion, we believe that more real-life practices emerging from the situated use of robots should be investigated. Besides focusing on the impact of broader cultural values such as those associated with religion and traditions, future studies should examine how users interact, or avoid interaction, with robots within specific contexts of use.

CCS Concepts: • **Human-centered computing → Interaction paradigms**; *Empirical studies in collaborative and social computing*; • **Computer systems organization → Robotics**;

Additional Key Words and Phrases: Human-robot interaction, social robots, cross-cultural study, technology acceptance, cultural robotics

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1 INTRODUCTION

For decades, robots have been tools used primarily in factories. With the emergence of "cobots," they started to work collaboratively with humans but still remained in factory settings. In the last years, more and more robots have been designed explicitly to interact socially with humans (e.g. as seen in Figure 1) in everyday life [39]: Robots have been introduced as caregivers [37], tutors [19], housekeepers [10], and even intimate partners [40]. The emergence of these "social

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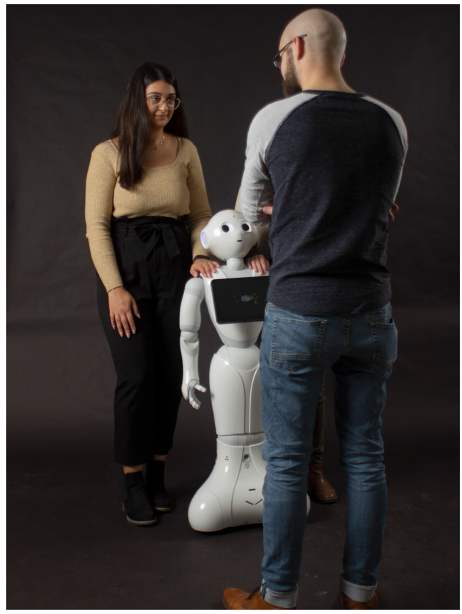

Fig. 1. An Arab and a German participant interacting with the Pepper robot.

robots" has shaped the perception of robots as a whole: from tools to social entities [39]. This has influenced both the roles these robots play and the social practices associated with that use. Indeed, the fascination built up in countless science-fiction stories still fuels public views and expectations: Whenever robots are shown in public, they are points of attraction—frequently attributed with more cognitive and emotional capabilities than they actually have or demonstrate [12]. In line with the increasing emergence of social robots, research has repeatedly pointed to the complexity of the social practices associated with robot acceptance [22]. Important design decisions have to be made when social robots are reaching global markets: How should they greet people, how should they interact, and to what extent should they follow cultural norms, for example when it comes to showing emotions, or better, simulating them?

These questions call for a deeper understanding of cultural variability in robot acceptance. What people expect from robots is shaped by their specific cultural values, beliefs, and customs. For example, subjects from collectivistic cultures consider social cues employed by robots more important than persons from individualistic cultures [11, 18]. In Japan, which is classified as a relationship-oriented culture, most users have a positive image of robots and accept them in everyday life (e.g., References [13, 20, 21]), whereas in the United States, which is considered a task-oriented culture, most users are skeptical toward robots, due to fears of job losses through automation and the negative presentation of robots in media [3]. Further research has identified the effect of cultural factors—such as media, religion, and social beliefs (e.g., References [9, 40]), on both the positive and the negative perceptions of robots across different cultures. Despite these findings, robots are generally designed without giving much consideration to cultural adaptation. They are typically designed and programmed to behave consistently rather than to adapt to cultural differences with regard to greetings, emotional behavior, or physical contact. As a result, users' willingness to engage with robots and the resulting perceptions may not align with the expectations of the designers.

In line with existing research, we believe that the development of robotic technologies for the global markets requires a deeper understanding of the cultural factors that affect robot acceptance and use (e.g., References [3, 24]). Robots have started to enter our lives. While, at present, robotic toys and robot vacuum cleaners are the most common domestic robotic applications, the common interest in these early-stage "robots" but also their unembodied counterparts like Alexa or Siri indicates a willingness to try more refined assistive technology, such as future social robots. To facilitate their acceptance, these robots should allow adjustments for different cultural values and norms. Hence, cross-cultural adjustments to social robots are necessary with regard to both design choices and smooth integration into society. Clearly, cultural nuances are important to ensure comfortable human-robot interaction in the future.

In this article, we present a cross-cultural study investigating the impact of cultural background on the perception of social robots within two different frames: intercultural (German and Arab) as well as intracultural (three Arab countries: Egypt, Jordan, and Saudi Arabia). We asked 794 participants what social robots should look like and how they should behave. The aim was to deepen our understanding of the impact of cultural values on the preferences regarding social robots. In general, we took an explorative approach, which manifests in five research questions, as well as hypotheses 1 and 2: [H1]Cultural background has an impact on the preferences regarding social robots. [H2] Arab participants have a more positive attitude toward task-automation (through the use of robots) than German participants.

We first provide an overview of the main theoretical approaches investigating the impact of culture on interactions with robots in Section 2. We then introduce the method of our study, including research questions in Section 3. Data are analyzed and results are presented in Section 4. We discuss these results in line with the participants' religious beliefs, traditions, and cultural norms, and we present our conclusion in Section 5.

2 RELATED WORK

Research on human-robot interaction has consistently found that cultural factors affect people's attitudes toward robotic technology, shaping "visions of future possibilities for robots in society" [24]. Driven by a theoretical concern, the goal of these studies has been to assess how cultural backgrounds account for different attitudes, and preferences concerning how robots should look and behave.

Several of these studies indicate that robots are understood as social actors and are expected to comply with the social norms of specific cultures [15], both in non-verbal [43] and verbal behaviors [4]. Already in 2007, Bartneck et al. [3] asked 467 participants from seven countries about their attitudes toward robots. Their study highlighted cultural differences, which were explained by the different levels of exposure to robots through media or personal experience. Cultures with a longer history regarding the abilities and shortcomings of robots, such as the Japanese, showed positive attitudes, as well as great concern about the impact of robots on society. Two years later, Reference [28] found similarities in the attitudes of Japanese and U.S. participants toward robots, suggesting that factors such as religion and history may affect differences in attitudes toward robot adoption. However, an online survey with 218 participants from Korea, Turkey, and the United States [24] additionally highlighted the importance of social norms and dynamics when assessing robot acceptance across nationalities: While factors such as media exposure are indeed related to acceptance, they do not fully account for the cultural variances.

While early studies primarily adopted a non-experiential approach, investigating how cultural background impacts the vision of future interactions with robots, more recent studies have observed users' interactions with social robots. The goal of such studies is to assess the effect of culture in real-life scenarios and explore how robots could adapt to the cultural background. In

2010, Li et al. [26] defined a culturally adaptive robot as a type of social robot that can detect users' cultural cues in communicative behaviors and respond to them appropriately. Rau et al. [35] found that different communication styles indeed shape people's perceptions of the likeability and trustworthiness of robots: Chinese participants considered robots more likable and trustworthy when they used implicit communication styles (as opposed to explicit styles), while Germans were less likely to accept a robot's recommendations, irrespective of the adopted communication style. In a similar approach, Wang et al. [45] investigated the extent to which people changed previously adopted decisions based on the recommendations of a robot collaborator. Chinese participants were more likely to reverse their decision when collaborating with robots that communicated implicitly, while participants from the U.S. favored robots using an explicit communication style. Salem et al. [38] also examined the effect of different communication styles (i.e., polite versus direct communication). They found that Arab participants were friendlier toward more direct robots and perceived them as more human-like than robots that employed polite communication strategies, such as apologizing for not being able to answer a question. This corresponds with the findings of Riek et al. [36], who found more favorable views toward human-like robots within Arab nations in the Gulf region (e.g., Saudi Arabia, Iraq) than in African regions (e.g., Egypt, Morocco, Tunisia).

Some recent studies take these behavioral analyses a step further and employ emotion recognition to analyze the effect of social robots. Trovato et al. [43] conducted a simulated video conference, in which participants from Japan and from Egypt had to engage with the KOBIAN robot, which is capable of expressing emotions. While all communication happened in English, in some conditions the robot was using a Japanese or Arabic accent and greetings. Also, typical Arab or Japanese gestures were used. The participants' willingness to engage varied according to these communication facilitators.

Overall, these studies highlight the importance of incorporating cultural factors when designing robots. Our study aims to deepen the understanding of cultural differences. While earlier research typically investigated cultural differences in a binary frame (Western versus Eastern [2, 25]), we paid particular attention to three Arab groups (Egypt, Jordan, Saudi Arabia) and a European group (Germany). Thus, we examined the similarities and differences both within Arab cultures and in respect to the European culture. The explorative study sheds light on design preferences, the acceptance of affective computing (should robots detect or simulate emotions at all?). We especially looked at delicate areas such as health. Furthermore, we were interested in the influence of long-term orientation, i.e., the respect for tradition and fulfilling social obligations, which correlates with cultures but is also a personal trait. Thus, this study differs from others in its effort to look into specific aspects of Islamic culture, a largely unexplored area in social robotics.

3 STUDY

We present a large-scale empirical study on the cultural differences in the perceptions of social robots. The study had 794 participants from Germany and the three Arab countries of Egypt, Jordan, and Saudi Arabia, was part of a project funded by the Arab-German Young Academy of Sciences and Humanities (AGYA) [1]. One of the reasons for selecting these three Arab countries was that they had established agencies for conducting the surveys. The cultural domains differ on several levels: Germany is considered an individualistic, task-oriented culture, while the Arab world is considered collectivistic and relationship-oriented [9, 11]. Furthermore, the documented use of and exposure to robots differs within these cultures. Germany represents the largest market for industrial robots in Europe, with robots widely used in the automotive, machinery, metal, and food industries [14]. In comparison, most countries in the Arab world have a low density of robots in industry. Selecting multiple Arab countries allowed us to explore not only the similarities and differences across cultures but also within the Arab countries sharing a similar cultural background, for example with respect to the role of family and traditions. While previous cross-cultural research on social robotics has mostly focused on Western samples versus Eastern samples, this study considers intracultural and intercultural analyses.

3.1 Study Design

We recruited participants at universities either by direct contact or through consultancies. The participants received a paper-based questionnaire in their native language (i.e., German, English, French, or Arab). Each participant received 10 USD as compensation for their participation.

Conducting this study as a survey rather than an experimental study allowed us to collect the opinions of hundreds of people. Collecting the same amount of data with a physical robot would require a vastly extended period of time and financial effort. Furthermore, a specific robot always sets a frame for interpretation, while this study aims to explore the general preferences with respect to future social robots.

As robots are on the rise in our lives, with different roles and capabilities, it is important that these robots can interact in different cultural settings. The growth in technology brings a need for social robots to fit into a larger ecosystem and provide a flexible solution for everyone. We believe that understanding the target users is the first step in the deployment of social robots that can adapt to society.

3.2 Research Questions

This study attempts to investigate the impact of cultural background on individuals' preferences regarding social robots. Specifically, we investigate the following questions:

(1) Does cultural background impact the acceptance of social robots within different contexts?
(2) Does cultural background affect the preferences for social roles assigned to social robots?
(3) Does cultural background affect the perception of emotion awareness and interactivity of social robots?
(4) Does cultural background affect the users' acceptance/preference for the level of automation (i.e., the robot's independence from human control)?
(5) Do cultural values (traditions) affect preferences regarding social robots?

Through the administered questionnaires, in the presented study, we tried to answer the questions above by testing our main hypotheses:

Hypothesis 1 [H1] Cultural background has an impact on the preferences regarding social robots.

Hypothesis 2 [H2] Arab participants have a more positive attitude toward task-automation (through the use of robots) than German participants.

3.3 Participants

A total of 794 persons completed our survey (381 females, 413 males, $\mu = 22.4$, $\sigma = 4.2$). Of these, 185 participants were German (23%), 209 were Egyptian (27%), 200 were Saudi Arabian (25%), and 200 were Jordanian (25%). All participants were native-born citizens and residents in their respective countries. Most participants from Egypt (N = 134, 64%) and Germany (N = 97, 53%) had a yearly income of less than $5,000, while most participants from Jordan (N = 129, 65%) and Saudi Arabia (N = 124, 62%) had a yearly income of between $5,000 and $15,000 (see Table 1).

Table 1. Summary of Participant Information

Device		Egypt (N = 209)	Germany (N = 185)	Jordan (N = 200)	Saudi Arabia (N = 200)
Age (IQR)		20 (19–21)	23 (22–25)	21 (19–26)	24 (20–27)
Gender (%)	Female	107 (51.20%)	71 (38.38%)	105 (52.50%)	94 (47.00%)
	Male	102 (48.80%)	110 (59.46%)	95 (47.50%)	106 (53.00%)
	<$5,000	134 (64.11%)	97 (52.43%)	1 (0.50%)	20 (10.00%)
	5,000–$15,000	48 (22.97%)	35 (18.92%)	129 (64.50%)	124 (62.00%)
Yearly Income (%)	15,000–$25,000	10 (4.78%)	6 (3.24%)	51 (25.50%)	56 (28.00%)
	25,000–$50,000	1 (0.48%)	9 (4.86%)	18 (9.00%)	0 (0.00%)
	>$50,000	7 (3.35%)	5 (2.70%)	1 (0.50%)	0 (0.00%)

Table 2. General Attitudes toward Robots

Social robots should generally be used at work.
Using social robots in health care should be promoted by society.
Social robots should be used in health care.
Social robots should be used in the manufacturing industry.
Social robots should be used in service industries.
Social robots should be used in the handicraft business.

3.4 Questionnaires

In this section, we explain the questionnaire in detail. It consisted of three parts: (1) a definition of the term "social robot," (2) ratings of various attributes of social robots, and (3) demographic information.

3.4.1 Definition of Social Robot. Drawing insights from the work of Duffy [5], social robots were described to participants. The following definition was given at the beginning of questionnaire: "Social robots are robots that support us in social situations like work, care, or even leisure. While common robots usually only have an awareness of space, social robots ideally have some awareness of human behavior and can communicate accordingly."

3.4.2 Ratings of Various Attributes of Social Robots. This part included different sections where participants were asked to rank their preferences regarding five areas: (1) general attitudes toward robots (i.e., willingness to have robots in different contexts, such as at work or in hospitals, see Table 2), (2) social roles (i.e., social roles that robots should have, see Table 3), (3) abilities and appearance (i.e., how robots should look and act, see Table 4), (4) emotional awareness and interactivity (i.e., how robots should interact with humans, see Table 5), and (5) preferences for level of automation (i.e., degree of automation of specific tasks, see Table 6). The questions were answered using a five-point Likert scale ranging from "1 = completely disagree" to "5 = completely agree" except for the question on accepted automation. The options for accepted automation were "1 = Human only," "2 = Predominantly human," "3 = Human-robot cooperation," "4 = Predominantly robot," and "5 = Robot only." The items were derived from previous literature on social robotics [42] and robot acceptance [27, 30] as well as factors related to users' perception of robots [23, 33]. Terrence et al. [42] summarize the state-of-the-art of social robots in different applications and provide a framework for how to design such interactive robots. The application areas differ based on how intimate the interaction is between individuals and robots.

Table 3. Potential Social Roles of Robots

Robotic pet
Cleaning robot
Robotic cook
Robotic masseur
Robotic nanny
Robotic teacher
Robotic companion for lonely persons
Robot as emotional replacement for absent partner
Robotic pilot
Robotic surgeon

Table 4. Abilities and Appearance - Desire for Anthropomorphism

Social robots should be able to move.
Social robots should be able to climb stairs.
Social robots should be able to talk.
Social robots should be able to understand us when we talk.
Social robots should recognize emotions.
Social robots should look similar to humans.
Social robots should have a face resembling the human face.
Social robots should behave as if they had emotions.

Table 5. Emotional Awareness and Interactivity

Robots should recognize and respond to the emotions of everyone—no matter if these persons are healthy, impaired, or ill.
Robots should recognize and respond to the emotions of persons with cognitive impairments (e.g., Alzheimer's).
Robots should recognize and respond to the emotions of persons with psychological illnesses (e.g., depression).
Social robots may analyze the movements and gestures.
Social robots may analyze the voice.
Social robots may measure my pulse from a distance.
Social robots may inspect the eyes, e.g., pupil width.
Social robots may measure arousal via skin (only when touched).

This part of the questionnaire ended with time predictions about social robots becoming widespread (i.e., comparable to the current use of car navigation systems) in the following categories:

- care robots (robots that support caregivers with physical work);
- emotion-aware robots (social robots that can recognize a person's emotional state);
- emotional robots (social robots that can adequately respond to a person's emotional state);
- sensors implanted into the human body for health control;
- human-like robots (robots that act like a human, so one could not tell if they are robots or not).

Using a similar approach, Enz et al. [8] presents a questionnaire with 328 participants reporting on their fears and hopes concerning social robots in the future. They asked about the time frame, i.e.,

Table 6. Level of Automation in Care Activities

Imagine you were in need of care: Which activities would you prefer to be conducted by humans and which activities would you prefer to be conducted by social robots?
Detect emergency situations (e.g., a fall)
Support when walking
Being put into another bed
Washing
Changing clothes
Support when eating
Going to the toilet
Giving medicine
Blood test
Everyday talk

Table 7. Personal Attitudes toward Traditions

I appreciate and uphold traditions.
I appreciate innovations.
I have a close connection with my parents.
I have to obey my parents.

whether a scenario would come true in 5 years, 10 years, 25 years, or never. To keep the answers more open-minded regarding the time-frame, We asked the participants to suggest the year when they thought one of the scenarios would become real.

3.4.3 Demographic Information. This part included demographic information on the participants, such as age, gender, occupation, personal cultural background, questions about personal attitudes toward traditions (see Table 7), and approximate yearly income.

4 RESULTS

To test our research hypotheses and to investigate the effects of culture on participants' preferences toward certain attributes of social robots, we used one-way between-subjects analysis of variance (ANOVA). Norman [31] provided compelling evidence that parametric statistics can be used with Likert scales without "fear of coming to the wrong conclusion." In addition, post hoc comparisons based on the Tukey HSD (honestly significant difference) test were used to further investigate the source of significant differences between groups. With Pearson's r test, we examined correlations between participants' preferences, and further independent variables (i.e., age, gender).

We first describe the participants' general attitudes toward robots as well as their preferences regarding various attributes of robots, including abilities and appearance, emotional awareness, sociality, and interactivity. Then, we discuss participants' expressions of religious belief and their agreement with various traditions and cultural norms, and explore the correlations between these and preferences for robot design and use. We also analyze participants' predictions regarding the future societal spread of robots.

4.1 General Attitudes

Participants were asked to rank the extent to which they would like to see robots used in the following areas: handcraft business (i.e., activities involving manual labor such as the work

Table 8. Mean Effect (and Standard Deviation) of Cultural Background on Robot Preferences within Different Contexts

Context	ANOVA (sig)	η_p^2	Egypt (N = 208)	Germany (N = 185)	Jordan (N = 200)	Saudi Arabia (N = 200)	Post hoc (Tukey)
Handcraft business	F(3,790) = 14.7 ($p < .01$)	.05	3.3 (1.4)	3.2 (1.2)	3.3 (1.1)	3.9 (1.1)	Jo, Sa > Eg, Ge
Health care	F(3,790) = 46.1 ($p < .01$)	.15	3.3 (1.2)	3.4 (1.2)	4.3 (0.7)	4.1 (1.0)	Jo > Sa > Eg, Ge
Manufacturing industry	F(3,790) = 8.1 ($p < .01$)	.03	4.1 (1.0)	3.8 (1.2)	4.2 (0.9)	4.2 (0.9)	Eg, Jo, Sa > Ge
Service industry	F(3,790) = 45.7 ($p < .01$)	.15	3.9 (1.0)	3.4 (1.0)	2.9 (1.3)	4.1 (0.9)	Eg, Sa > Ge > Jo

of carpenters or tailors), health care, manufacturing, and service industries. Our goal was to understand the participants' overall preferences for robots within these areas of use (see Table 2). Participants evaluated their preferences (i.e., do you think social robots should be used in) on a five-point Likert scale, ranking them from "completely disagree" to "completely agree" (which we refer to as the "five-point opposition scale," as used in Reference [24]).

Using a one-way ANOVA, we found a significant effect of cultural background on participants' preferences for robots within different areas of use (see Table 8). Jordanian and Saudi Arabian participants were more willing to use robots in all contexts in comparison to German and Egyptian participants, except for industrial services (as revealed by multiple post hoc Tukey tests, all significant at a level of $p < .01$). Jordanian participants showed the lowest acceptance of robots within industrial services. German participants were generally unwilling to use robots in everyday spaces but considered factories a more appropriate use context for robots.

We found participants' gender to account for some variance in these results. A two-way ANOVA revealed a significant interaction effect between participants' gender and cultural background for the preferences for the handcraft industry ($F(3, 786) = 5.69$, $p < .01$) and health care ($F(3, 786) = 4.6$, $p < .05$). Male participants from Germany were found to have higher acceptance of robots within the handcraft business and healthcare, as compared to German females (both significant at a level of $p < .05$). We found these variations to be independent of participants' levels of income, as revealed by non-significant interaction effects between participants' levels of income and their cultural background—indicating that income did not drive the reported cultural differences.

4.2 Social Roles

Participants chose their preferences among various roles social robots could have, such as pets, teachers, and companions (see Table 9 for all categories) on the five-point opposition scale. A one-way ANOVA (with follow-up post hoc Tukey tests) revealed a significant effect of cultural background on participants' preferences. Participants from Jordan and Saudi Arabia were found to assign social roles to robots significantly more often than participants from Egypt and Germany—over a range of duties and responsibilities, from teaching to medical (i.e., surgeon, masseur) roles. Although German and Egyptian participants showed an overall lower acceptance of robots within social roles, their acceptance increased significantly of robots in housekeeping roles (i.e., cleaning, cooking, and servants). All countries showed low acceptance of using robots as companions and as an emotional replacement for partners. These preferences were independent of participants' levels of income (as indicated by multiple two-way ANOVAs, with non-significant interaction with participants' cultural background), but not of their gender. Interestingly, female participants were found to have lower acceptance for companion ($F(3, 786) = 4.58$, $p < .05$) and emotional replacement robots ($F(3, 786) = 4.47$, $p < .05$) as compared to male participants, for all cultural backgrounds (see Figure 3).

Table 9. Mean Effect (and Standard Deviation) of Cultural Background on Robot Acceptance within Different Contexts

Social roles	ANOVA (sig)	η_p^2	Egypt	Germany	Jordan	Saudi Arabia	Post hoc (Tukey)
Pet	F(3, 790) = 56.8 ($p < .01$)	.18	2.4 (1.5)	2.5 (1.5)	3.6 (1.2)	3.7 (1.1)	Jo, Sa > Eg, Ge
Janitor	F(3, 790) = 7.4 ($p = .37$)	.01	4.5 (0.9)	4.5 (0.9)	4.3 (0.8)	4.4 (0.7)	-
Servant	F(3, 790) = 23.7 ($p < .01$)	.08	4.3 (0.9)	3.4 (1.3)	3.9 (1.1)	4.1 (0.8)	Eg, Jo, Sa > Ge
Cook	F(3, 790) = 2.3 ($p = .07$)	.01	3.8 (1.3)	3.5 (1.3)	3.7 (1.2)	3.6 (1.1)	-
Masseur	F(3, 790) = 15.2 ($p < .01$)	.05	3.8 (1.3)	3.2 (1.5)	4.0 (0.9)	3.9 (1.1)	Eg, Jo, Sa > Ge
Nanny	F(3, 790) = 125.4 ($p < .01$)	.33	2.3 (1.5)	1.9 (1.2)	3.8 (1.1)	3.7 (1.1)	Jo, Sa > Eg > Ge
Teacher	F(3, 790) = 125.5 ($p < .01$)	.32	2.8 (1.5)	2.2 (1.3)	4.1 (0.8)	4.1 (1.0)	Jo, Sa > Eg > Ge
Companion for the lonely	F(3, 790) = 2.3 ($p = .08$)	.01	2.9 (1.2)	2.6 (1.3)	2.8 (1.2)	2.9 (1.2)	-
Emotional replacement for partners	F(3, 790) = 2.0 ($p = .10$)	.01	2.0 (1.3)	2.1 (1.2)	2.3 (1.0)	2.2 (1.2)	-
Pilot	F(3, 790) = 61.5 ($p < .01$)	.20	3.3 (1.4)	2.9 (1.4)	4.2 (0.7)	4.2 (0.9)	Jo, Sa > Eg > Ge
Surgeon	F(3, 790) = 87.5 ($p < .01$)	.25	2.8 (1.6)	2.7 (1.5)	4.3 (0.8)	4.0 (1.0)	Jo, Sa > Eg, Ge

Table 10. Mean Effects (and Standard Deviation) of Nationality on Different Abilities and Appearance of Social Robots

Abilities and Appearance	ANOVA (sig)	η_p^2	Egypt	Germany	Jordan	Saudi Arabia	Post hoc (Tukey)
Move	F(3, 790) = 1.6 (p = .18)	.01	4.2 (1.0)	4.2(1.0)	4.4 (0.7)	4.2 (0.8)	-
Climb stairs	F(3, 790) = 1.8 (p = .15)	.01	3.9 (1.1)	3.8(1.2)	3.7 (0.9)	4.0 (1.0)	-
Talk	F(3, 790) = 8.5 (p < .01)	.03	3.8 (1.2)	4.0 (1.1)	3.6 (1.3)	3.4 (1.1)	Eg, Ge > Jo, Sa
Understand speech	F(3, 790) = 18.9 (p < .01)	.07	4.1 (1.1)	4.3 (1.0)	3.8(1.1)	3.5 (1.2)	Eg, Ge > Jo > Sa
Recognize emotions	F(3, 790) = 1.70 (p = .17)	.01	3.1 (1.4)	3.3 (1.2)	3.1 (1.4)	3.2 (1.3)	-
Face resembling humans	F(3, 790) = 31.2 (p < .01)	.10	2.3 (1.3)	2.6 (1.1)	3.3 (1.4)	3.3 (1.3)	Jo, Sa > Eg, Ge
Behave as if having emotions	F(3, 790) = 1.6 (p = .18)	.01	2.6 (1.3)	2.6 (1.2)	2.5 (1.2)	2.4 (1.2)	-

4.3 Abilities and Appearance

We asked participants to evaluate on the five-point opposition scale how much they would like to interact with robots that understood emotions and speech, moved autonomously, or had human-like faces. A one-way ANOVA and subsequent post hoc Tukey tests revealed similar preferences among all countries regarding robots' ability to move and climb stairs, as well as recognize and express emotions (see Table 10 and Figure 2). Participants from Egypt and Germany showed a significantly more positive attitude toward robots that understood and expressed themselves through speech, compared to Jordanian and Saudi Arabian participants. This was not the case, however, in terms of robots' human-like faces: Egyptians and Germans were significantly less willing to accept robots with human-like faces, compared to Jordanian and Saudi Arabian participants. These preferences were independent of participants' levels of income and gender, as indicated by multiple two-way ANOVAs, with non-significant interaction effects with participants' cultural background.

4.4 Emotional Awareness and Interactivity

To understand how participants expected to engage with robots, we asked them to rate which mode of interaction they would like to have with robots, using the five-point opposition scale (see Table 11 for all modes of interaction). Egyptian, German, and Jordanian participants preferred movement and voice over other modalities of interaction, with arousal measuring (via touch)

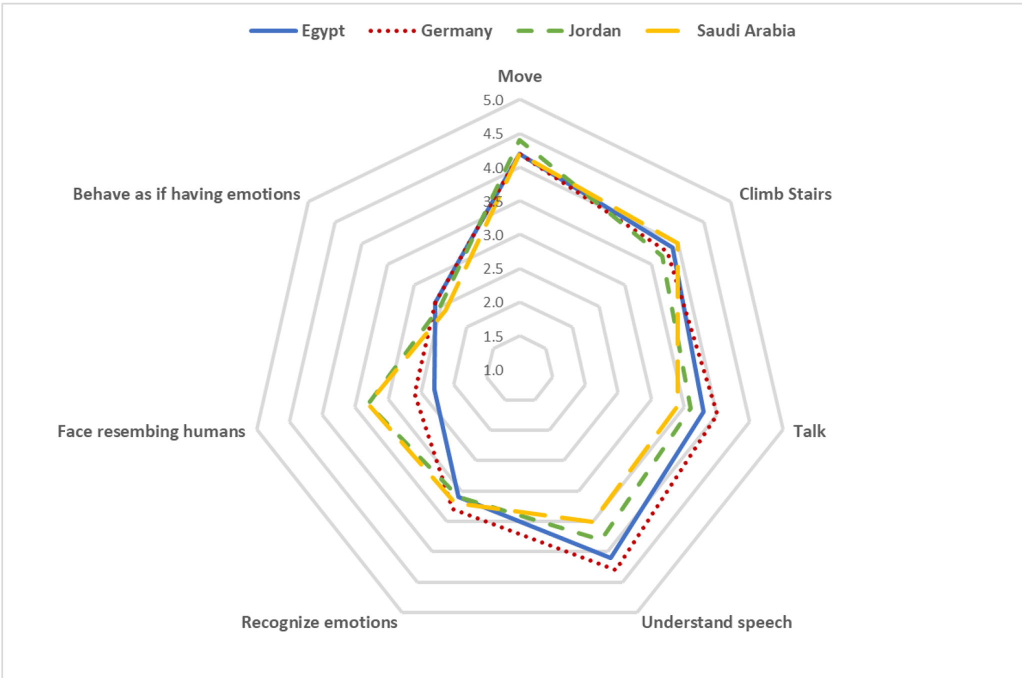

Fig. 2. Spider diagram of the national preferences for social robots' abilities and appearance, i.e., the level of desired anthropomorphism.

Table 11. Mean Effects (and Standard Deviation) of Nationality on Different Modes of Interaction with Robots

Modalities	ANOVA (sig)	η_p^2	Egypt	Germany	Jordan	Saudi Arabia	Post hoc (Tukey)
Movements and gestures	F(3, 790) = 1.2 (p = .31)	.01	3.8 (1.2)	3.7(1.1)	3.9 (1.1)	3.8 (1.0)	-
Voice	F(3, 790) = 13.6 (p < .01)	.05	4.0 (1.1)	3.6 (1.2)	4.2 (0.9)	3.9 (1.2)	Eg, Jo, Sa > Ge
Pulse (without touch)	F(3, 790) = 29.4 (p < .01)	.08	3.7 (1.2)	3.0 (1.2)	3.8 (1.1)	3.8 (1.1)	Eg, Jo, Sa > Ge
Eye-tracking	F(3, 790) = 22.2 (p < .01)	.06	3.5 (1.3)	3.1 (1.3)	3.5 (1.3)	3.9 (0.9)	Sa > Eg, Jo > Ge
Arousal (via touch)	F(3, 790) = 57.4 (p < .01)	.13	3.3 (1.3)	2.8 (1.3)	3.2 (1.3)	4.1 (0.9)	Sa > Eg, Jo > Ge

ranking as the least preferred modality. Conversely, participants from Saudi Arabia showed an equal level of preference among all modalities of interaction. Post hoc Tukey tests showed they were more willing to accept robotic eye-tracking and touch (i.e., measuring arousal via skin conductivity) in comparison to participants from other cultural backgrounds. German participants showed the lowest overall acceptance among all countries for any type of interaction with robots.

These preferences were not independent of participants' gender: compared to male participants, females were less welcoming of interactions involving touch (see Figure 4). This was the case for participants from all cultural backgrounds (as indicated by two-way ANOVAs with significance levels of $p < .05$). Furthermore, participants' preferences were independent of their levels of income (as indicated by multiple two-way ANOVAs, with non-significant interaction effects with participants' cultural background).

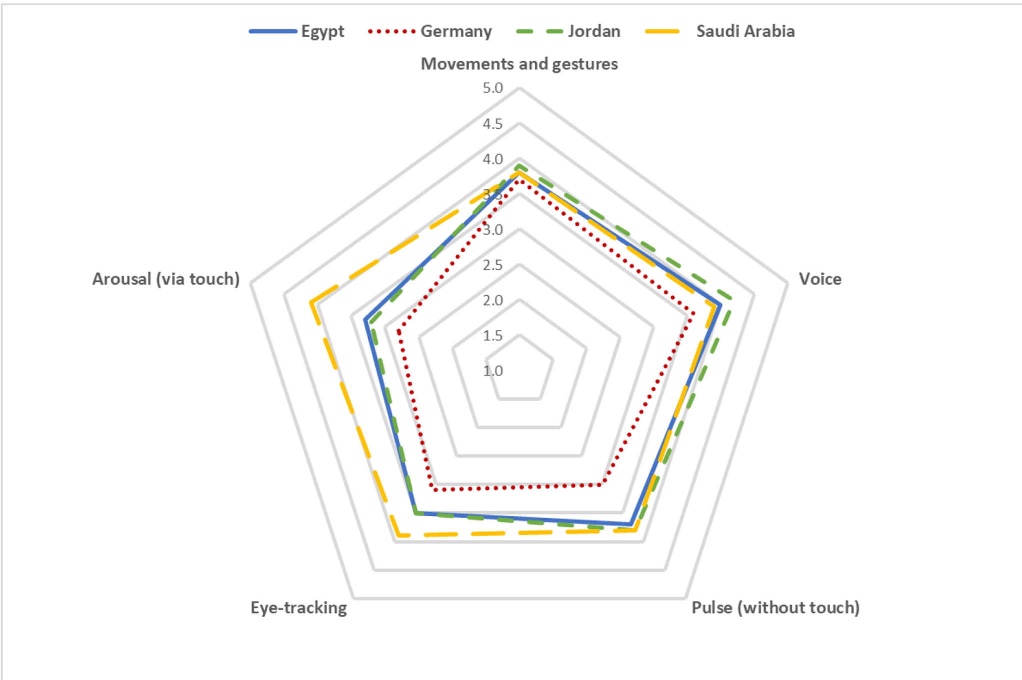

Fig. 3. Spider diagram of the national preferences for social robots' interaction modes.

4.5 Automation Preferences

To understand the preferred level of automation, participants were asked to denote the extent to which they wanted certain activities to be conducted by a robot or by a human on a scale, for example: "Imagine you were in need of care: Which activities would you prefer to be conducted by humans and which activities would you prefer to be conducted by social robots?: 1: Human only; 2: Predominantly Human; 3: Human-robot cooperation; 4: Predominantly robot; 5: Robot only" (see Table 6).

A one-way ANOVA revealed significant effects of cultural background on preferences (significant at a level of $p < .01$). Participants from Jordan and Saudi Arabia showed a higher preference for automation compared to participants from Egypt and Germany (see Figure 5). In particular, participants from these countries preferred robots to conduct the following activities: being put into a clinical bed (60% of Jordanian, and 82% Saudi Arabian participants preferred this activity to be exclusively conducted by robots), giving support when walking (Jordanian: 81%, Saudi Arabian: 67%), washing (Jordanian and Saudi Arabian: 74%), and detecting emergency situations (Jordanian: 73%, Saudi Arabian: 80%). German and Egyptian participants, in contrast, showed a greater preference for activities to be conducted by humans, or with human-robot cooperation. This was particularly emphasized in the case of everyday talking (61% of Egyptian, and 84% of German participants, respectively, preferred to talk to humans, as opposed to robots). Contrasts were found in the participants' preferences for: (a) detecting emergency situations, (b) going to the toilet, and (c) washing. While participants from Jordan and Saudi Arabia showed a preference for the detection of emergency situations by robots, only 20% of Egyptian and 16% of German participants showed the same preference. Interestingly, in contrast, German participants showed the highest preference for robotic support when going to the toilet. Approximately half (48%) of

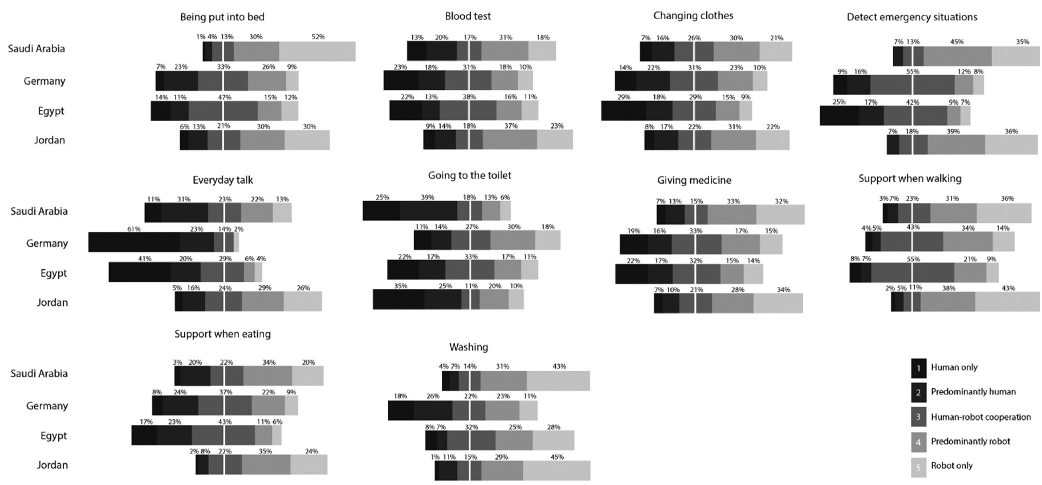

Fig. 4. Preference for human and robot-led activities among Saudi Arabian, German, Egyptian, and Jordanian participants.

the German participants preferred robots to perform this activity, while Jordanian (64%) and Saudi Arabians (60%) preferred human support. With respect to washing, German participants showed a preference for human-robot cooperation, contrasting with a preference for automation shown by participants from Egypt (73%), Jordan (74%), and Saudi Arabia (74%). A two-way ANOVA with gender, income, and cultural background as fixed factors revealed no main effects of gender and income on participants' preferences for automation (all at a significance level of $p > .05$). Furthermore, no interaction effects were found, indicating that gender and income had little impact on the reported cultural differences.

4.6 Time Predictions

Participants were asked to forecast robot dissemination, within five different contexts: (a) care robots, supporting caregivers at work; (b) emotion-aware robots, which recognize one's emotional state; (c) emotion-aware robots, which respond to one's emotion state; (d) human-like robots, with similarities to the extent that no distinctions can be made between humans and robots, and (e) digital humans, in which sensors are implemented into the human body for health control. Participants were asked about the expected year by widespread dissemination for each of these contexts where "widespread" was defined as "comparable to the current use of car navigation systems." A one-way ANOVA revealed no significant effect of cultural background on the expected year of dissemination of care robots and human-like robots. Participants expected, on median, care robots to be widespread around 2030 to 2040—irrespective of the participants' background (see Table 12). A more distant prediction was given for robot-human resemblance. Participants expected, on median, robots to be unrecognized among humans by around 2,060 to 2,095. However, a significant effect of cultural background was found in participants' perceptions of the dissemination of digital humans and emotion-aware robots, both in terms of recognizing and responding to one's emotional state. Egyptians and Germans expected sensors to be implemented in the human body, on median, 50 years earlier (2,030) than Jordanian and Saudi Arabian participants. Similarly, robots were expected to recognize, and respond to one's emotional state 25, and 50 years earlier, respectively.

Table 12. Median (and IQR) Year of Predicted Robot Dissemination, among Nationalities

Context of robot dissemination	ANOVA (sig)	η_p^2	Egypt	Germany	Jordan	Saudi Arabia	Post hoc (Tukey)
Caregiver support	F(3, 790) = 1.2 (p = .31)	.01	2,040 (2,030-48)	2,030 (2,025-40)	2,035 (2,030-45)	2,040 (2,030-48)	-
Emotion-aware (recognize state)	F(3, 781) = 11.0 (p < .01)	.04	2,030 (2,025-40)	2,035 (2,028-50)	2,055 (2,056-75)	2,065 (2,056-80)	Jo, Sa > Eg, Ge
Emotion-aware (respond to state)	F(3, 778) = 10.6 (p < .01)	.04	2,035 (2,025-50)	2,045 (2,030-50)	2,080 (2,070-90)	2,085 (2,070-90)	Jo, Sa > Eg, Ge
Human resemblance	F(3, 750) = 0.7 (p = .53)	.01	2,060 (2,055-90)	2,070 (2,050-100)	2,095 (2,090-100)	2,095 (2,095-100)	-
Digital humans	F(3, 777) = 40.4 (p < .01)	.03	2,030 (2,023-50)	2,030 (2,025-48)	2,085 (2,075-95)	2,088 (2,075-99)	Jo, Sa > Eg, Ge

These cultural variations were independent of participants' gender and level of income. A two-way ANOVA indicated no interaction effect between participants' gender and cultural background regarding predictions for care robots ($F(3, 775) = 1.14$, $p = .33$), emotion-aware robots—either in terms of recognizing ($F(3, 777) = 1.72$, $p = .16$) and responding ($F(3, 774) = 1.15$, $p = .33$) to emotions, human-like robots ($F(3, 773) = 0.21$, $p = .89$) and digital humans ($F(3, 746) = 1.31$, $p = .27$).

4.7 Tradition and Innovation

One of the aims of this survey was to understand how the acceptance of social robots is shaped by the participants' attitude toward family traditions and innovation—and how this varied among different cultural backgrounds. In the AGYA community, we conducted interviews with Arab researchers on how to ask for personal preferences that are common in the Arab and especially within the Islamic tradition without explicitly mentioning religious rules or disrespecting societal norms. At the same time, we wanted the questions to also work for European participants. As a result, we inquired into these factors with the following four assertions:

- I appreciate and uphold family traditions.
- I appreciate innovations.
- I have a close connection to my parents.
- I have to obey my parents.

Overall, a stronger appreciation of family traditions was found among Jordanian and Saudi Arabian participants, as compared to participants from Egypt and Germany. Regarding family traditions, 63% of the Jordanian participants (N = 126) and 56% of the Saudi Arabians (N = 111) identified themselves as strong appreciators. These levels contrast with only 15% from Egyptians (N = 31) and 10% from Germans (N = 18). Regarding participants' attitude toward innovation, the majority appreciated it, irrespective of their nationality. 92% of the participants with a background from Egypt (N = 191), 88% of those with a German background (N = 162), 87% of those with a Jordanian background (N = 173), and 91% of those with a Saudi Arabian background (N = 181) appreciated innovation. A Pearson's r test revealed a positive correlation between participants' appreciation for family traditions and their appreciation for innovation—namely, for those with an Egyptian background ($r = .20$, $p < .01$) and a Jordanian background ($r = .17$, $p < .05$). Contrastingly, a negative correlation was found between the same factors for participants with a Saudi Arabian background ($r = -.17$, $p < .05$). While cultural background was found to impact the participants' perspective toward family traditions and innovations, these factors did not fully explain the variations in their perceptions of social robots. Regarding participants' appreciation for family traditions, no significant correlation was found with any of the various robot criteria (i.e., social roles, abilities and appearance, emotional awareness, accepted closeness, and general attitudes)—irrespective of their background. Participants' appreciation for innovation, however, accounted for some of the cultural variations in the perceptions of social robots. Regarding participants with a background from Egypt and Germany, a range of positive correlations was found between their appreciation for innovation and most robot criteria. Agreement with the statement "I appreciate innovation" was strongly correlated with the willingness to have robots in different contexts, such as at work (GE: $r = .41$, $p < .01$; EG: $r = .27$, $p < .01$) or in hospitals (GE: $r = .37$, $p < .01$; EG: $r =.23$, $p < .01$), as well as the willingness to interact with robots using different modes of interaction (i.e., voice, touch). This was not the case, however, regarding participants' perspectives on the abilities and roles of robots. No correlations were found between Egyptian and German participants' appreciation for innovation, and the emotional abilities of robots, i.e., their ability to recognize emotions (GE: $r = .10$, $p = .19$; EG: $r = .11$, $p = .12$), and behaving as if they had emotions (GE: $r = -.03$, $p = .74$; EG: $r = .86$, $p = .22$). Similarly, robots were accepted in most social roles except for robotic pets (GE: $r = .08$, $p = .29$; EG: $r = .09$, $p = .19$), replacements for absent partners (GE: $r = .03$, $p = .70$; EG: $r = .01$, $p = .95$), and teachers (GE: $r = .10$, $p = .19$; EG: $r = .01$, $p = .85$). These results were not replicated for participants with a background from Jordan and Saudi Arabia, where no significant correlations were found between participants' appreciation for innovation and any of the robot criteria.

In the next section, we discuss the implications and limitations of our results, including the possible reasons for the differences between Egyptians and the two other Arab countries.

5 DISCUSSION

This article investigated the differences in acceptance and design preferences of social robots, based on a study with 794 participants with backgrounds from Germany and from the Arab world (Egypt, Jordan, and Saudi Arabia). Our study revealed some intracultural and intercultural similarities and differences. We selected three Arab countries since the Middle East and Islamic culture in general is quite unexplored in terms of the preferences for social robots. The study was guided by our research questions (RQ) (see Section 3.2). We wanted to explore the impact of culture on the preferences for the uses and roles of social robots (RQ1–RQ4) and explore how participants' cultural values accounted for such preferences (RQ5). There was support for the hypothesis H2, that Arab participants are more inclined toward automation than German participants. We also found that preferences varied significantly across cultures, with cultural factors (e.g., traditions) accounting for limited variance in participants' preferences (H1).

5.1 Preferences across and among Cultures

We found significant differences in the preferences of participants with a German and an Arab background regarding how robots should be interacted with, their anthropomorphism, and the contexts in which they should be used. Participants with a German background had a predominantly functional view of robots, preferring machine-like robots without facial expressions that communicated verbally and had emotional awareness, but they were less receptive to interactions through touch. Participants with an Arab background showed a greater preference for robots that were social, with a human-like appearance, and they were more willing to accept highly specialized roles for robots (e.g., surgeons, pilots). Furthermore, participants with an Arab background showed a greater preference for automation, and higher acceptance of robots in everyday spaces (e.g., the home) and in health care contexts—while participants with a German background considered industrial contexts more appropriate for robots.

Interestingly, our results showed that Egyptian participants differed from other Arab countries and showed considerable similarities with German participants' preferences. One possible reason for this might be the government initiative for free internet in Egypt in 2001 [32], which resulted in Egyptians having better and less restricted access to the internet. At the same time, Egypt was also one of the first countries to use the internet in the Arab world [7]. We think that technology acceptance is correlated with free access to the internet. The participants' predictions on the dissemination of digital humans and emotion-aware robots also showed similarities between Egyptians and Germans, who predicted the widespread use of these technologies would occur much earlier compared to the Jordanian and Saudi Arabian participants.

Our work extends previous work showing that Germans and Arabs not only have different expectations on the interpersonal distance between themselves and robots [9], but also of the modes of interaction and social roles that robots are expected to engage in. Participants from Germany seemed less acknowledging of robots as social actors, typically preferring them to remain in industrial contexts and stay out of their intimate space, while participants from Arab countries expected robots to behave as socially competent actors. These results align with Hall's cultural dichotomy [6] that characterizes the Arab culture as high-contact, preferring interactions that tend to be physically close, involving continuous eye-gaze and bodily contact. Germany belongs to the medium-contact group, preferring greater interpersonal space.

These results can be further be explained by the different levels of exposure to robots across the Arab world and Germany, as well as their specific labor economies. According to the World Robotics survey 2016 [17], Germany has consistently been the largest market for industrial robots in Europe—as its industry is one of the most automated in the world with robots being widely used in the automotive, machinery, metal, and food sectors. Even though most persons in Germany have never come close to an industrial robot, their extensive coverage in the media creates a mindset where robots are strongly linked to the industry. In contrast, most Arab countries have a relatively low density of industrial robots. Emergent economies, however, such as Jordan or Egypt in the Arab world, seem to be more open toward robots both for health care and general services. A recent report from Price Waterhouse Coopers (PWC) [34] concluded that 66% of Arab participants were willing to engage with robots for healthcare needs—namely, for consultation and minor surgery, contrasting with only 41% of German participants. It is clear that Germany has a high exposure to industrial robots, and people seem to prefer it to stay that way, while Arab countries have an affinity toward service and healthcare robots. Another interesting result is the accepted activities for robots: While Arab participants preferred activities such as putting people to bed and detecting emergency situations, they did not show a preference for getting help with taking a shower or going to the toilet. This may be explained by the strong notion of shame in Islamic teaching. We found these results to be impacted by participants' gender, but not by their economic status. Female participants were less welcoming of closer contact with robots (e.g., touch) and assigned robots a lower number of social roles than male participants, specifically when the interactions involved emotions (e.g., companion robots). These results are not surprising: Previous research has already found that men are more welcoming toward robots than women [41]. However, our study indicates that this gender-specific difference seems to be independent of culture, as the results were consistent in all four countries.

Preferences were found to differ not only across cultures, but also within countries with similar cultural backgrounds. Among the Arabic participants, those from Jordan and Saudi Arabia showed a wider diversity of opinions about the social roles, abilities and appearance, and modes of interaction of social robots, than those from Egypt. These results accord with the findings of Riek et al. [36], who also found more favorable views toward human robots within Arab nations in Gulf regions (e.g., Saudi Arabia, Iraq) than in African regions (e.g., Egypt, Morocco, Tunisia). These results may be partially explained by the future vision, governing politics, and investments in robots across these countries. For example, Saudi Arabia has unveiled plans to invest up to $500 billion in fully automated cities [29], where social robots are expected to cover a range of general services (e.g., home deliveries, security) and even healthcare (e.g., caretakers).

5.2 Influence of Traditions and Perspectives on Innovation

Hofstede et al. defined culture as "the collective programming of the mind that distinguishes the members of one group or category of people from others" [16, p. 6]. They developed a model consisting of several dimensions. "A dimension is an aspect of a culture that can be measured relative to other cultures" [16, p. 31]. One of the dimensions of this model was individualism versus collectivism. In our study, we have one individualist culture (German) and a collectivist culture (Arab). Islam has become blended in Arabic countries as both religion and culture and has a strong influence on Arabs, which ties individuals to each other and their traditions tightly with loyalty.

Our survey showed that the participants' perspectives toward traditions and innovations varied. Nevertheless, these factors did not fully account for the cultural variations in the perceptions of social robots. One reason for this might be that we had young participants who were certainly being influenced by globalization through the use of both the internet and TV. As seen in previous research [24], individuals' broader cultural values (e.g., religion and traditions) account only partially for the variance in their perspectives toward robots: Accordingly, no correlations were found among participants' appreciation for traditions and preferences for any of the robot criteria. We did, however, find that participants' appreciation for innovation correlated with the majority of their preferences. Appreciation for innovation was especially relevant for Egyptian and German participants: They preferred to deploy socially interactive robots within a range of different contexts, and they were willing to interact with robots more freely.

5.3 Limitations and Future Work

This study can only be an incremental step in the investigation of cross-cultural preferences. Although there were a considerable number of participants, our sample was not representative of a broader population: Most participants were students, with similar age and levels of income. While fitting the profile of early adopters [24], preferences are expected to differ across age, gender, and exposure to robotic technology [44]. Thus, broader samples will be required in future work. Another challenge that is somewhat unique to this method is the limited insights provided into the factors causing cultural differences in robot preference. Here additional qualitative work is required.

In line with previous research, we believe that more real-life practices emerging from the situated use of robots should be investigated. Besides focusing on the impact of broader cultural values related, for example, to religion and traditions, future studies should examine how users interact, or avoid interaction, with robots within specific contexts of use. The obvious demand and the upcoming market for social robots make defining this design space even more important. We believe that our findings might help robot designers when considering the appearance and behavior of social robots. Cultural nuances should not only influence design choices, they should also be taken into consideration when it comes to organizing and legislating on the integration of social robots in our society. We hope our study can provide guidance for robot designers and help both fellow researchers and the general public in adapting social robots for different cultural backgrounds.

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