Cultural Differences in how an Engagement-Seeking Robot should Approach a Group of People

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ABSTRACT

In our daily life everything and everyone occupies an amount of space, simply by "being there". Edward Hall coined the term proxemics for the studies of man's use of this space. This paper presents a study on proxemics in Human-Robot Interaction and particularly on robot's approaching groups of people. As social psychology research found proxemics to be culturally dependent, we focus on the question of the appropriateness of the robot's approach behavior in different cultures. We present an online survey (N=181) that was distributed in three countries; China, the U.S. and Argentina. Our results show that participants prefer a robot that stays out of people's intimate space zone just like a human would be expected to do. With respect to cultural differences, Chinese participants showed high-contact responses and believed closer approaches were appropriate compared to their U.S. counterparts. Argentinian participants more closely resembled the ratings of the U.S. participants.

Author Keywords

human-robot interaction, cross-cultural survey, proximity, social robotics, social interaction, online survey.

ACM Classification Keywords

J.4 [**Computer Applications**]: Social and Behavioral Sciences

INTRODUCTION

In our daily life everything and everyone occupies an amount of space, simply by "being there". When moving through around, people keep a certain distance between each other, and this distance depends on factors like culture, familiarity and personality, as well as the context of the situation.

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In 1966 Hall coined the term proxemics to describe this phenomenon. According to Hall [5], one's body is surrounded by ellipse-shaped bubbles. Each of these bubbles is appropriate for different social interactions. One of these zones, the personal space zone, acts as a virtual buffer zone around our body. Hall describes it as *"a small protective sphere or bubble that an organism maintains between itself and others"*. When this buffer zone is invaded, people compensate for this intimate contact, by non-verbal or verbal compensation behaviors such as stepping away, or limiting eye contact [14]. While every human adheres to others' personal space, what individuals regard as appropriate distances in certain social situations depends on culture [e.g., [19], [7], [17]).

Individual people keep certain distances towards each other, but small groups of people also organize themselves spatially in patterns; such as circles or lines. When such a pattern is stable, it is called a formation. Kendon [10] introduced the term *F*-formation to refer to a specific formation which occurs "*whenever two or more people sustain a spatial and orientational relationship in which the space between them is one to which they have equal, direct and exclusive access"*.

Our work focuses on the spatial organization of small groups in Human-Robot Interaction (HRI). Previous research has provided support for the Media Equation theory, which holds that people treat computers and other media as if they were either real people or real places [15]. A most relevant example is a study by Hüttenrauch et al. [8], which found that most people place themselves in Hall's personal zone (between 0.45 and 1.2 meters distance) when interacting with a robot.

While research in HRI has focused to some extent on the concept of proxemics, this research has been limited in that it has mostly studied robots approaching single persons – usually from Western countries - in controlled lab settings. We intend to extend this state of the art by looking at small groups of people from different cultures. Specifically, we try to identify optimal approach and placement position for a robot which is seeking to gain the attention of a small group of people. As social robots are envisioned to operate in contexts in which they have to interact with people having different cultural backgrounds (such as airports and fairs), we are particularly interested in finding out if a robot requires different spatial behavior depending upon the cultural background of its users. To do so, we have conducted an online survey which we distributed to three different cultural regions in the world through a crowdsourcing platform. In this paper we report on the methodology we used and we provide first results.

RELATED WORK

This section reviews the two major themes of our work: cross-cultural proxemics and group formations. We will conclude this section with our hypotheses, which provide the basis for the experimental method.

Proxemics and culture

In his book, *The Hidden Dimension*, Hall [5] defined four interpersonal distance zones. These zones are called the *intimate, personal, social* and *public* space zones (Table 1).

As stated in the introduction, research has found that the proxemics zones depend on multiple factors, among which culture. Based upon observations, Hall noted that people from low-contact cultures maintain a larger personal space compared with their counterparts from high-contact cultures. Northern European cultures are considered being low-contact, whereas Southern European, Southern American and Arab [4, 5, 19] cultures on the other hand are considered high-contact cultures.

Little [12] used the placement of dolls to infer at which distance people from either the U.S., Sweden, Scotland, Italy and Greece would place people in 19 different social situations. He found that people from North European cultures placed dolls significantly further apart compared with their Mediterranean counterparts. This could be explained by Hall's explanation of high contact- and low contact cultures.

Sussman & Rosenfeld [19] conducted a study in which 105 students from three different countries (Japan, U.S. and Venezuela) had a five-minute conversation with a same sex, same-nationality confederate. They found that, when they were speaking English, participants from the low-contact culture (Japan) sat further apart from each other compared to participants from a high-contact culture (Venezuelan). Within their respective cultural groups, male participants sat further apart than female participants.

Zone	Range	Situation
Intimate	0-0.45m	Lover or close friend
Personal	0.45-1.2m	Conversation between friends
Social	1.2-3.6m	Conversation
Public	3.6m+	Public speech

Table 1: Proxemics zones as defined by Hall [5].

Furthermore, when speaking in their native language, participants from high-contact culture sat closer together than when speaking English. This research implies that human personal spaces zones are dependent on peoples' cultural background.

Also in the field of Human-Robot Interaction (HRI) some studies have been conducted in the area of proxemic zones. Research on proxemics found that people appear to "respect" a robot's personal space zone [8, 23] and maintain a distance from a robot that would be considered respectful when approaching a fellow human. When a robot approaches a person, the comfortable approach distance has been found to be roughly 57 cm [22], which is comparable with distances between people when they have a conversation (see Table 1). Furthermore, similar to human encounters behaviors such as a robot's gaze can influence the distance people chose [21]. If the robot is gazing at people, they tend to stay further away. Work on proxemics in HRI also found that people show similar compensating behavior as they would do when a person invades their personal space [18]. While these findings provide important insights for robot behavior design, HRI research has not yet taken the impact of users' culture into account for proxemics research. As culture is an important factor in human spatial interaction, our work centers around this factor.

F-formations

People organize themselves spatially not only by interpersonal distance, but also in terms of their spatial arrangement when being part of small groups. Kendon [10] introduced the concept of *F*-Formations to capture this phenomenon. According to Kendon, activity is always located in a space. This space can be called the 'transaction segment'.

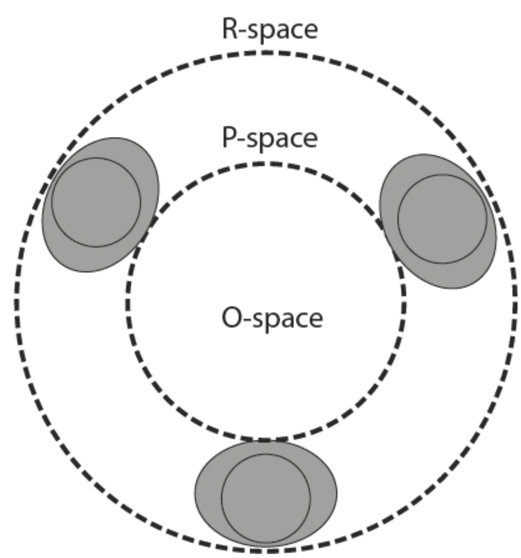


Figure 1 circular *F*-formation around an O-space.

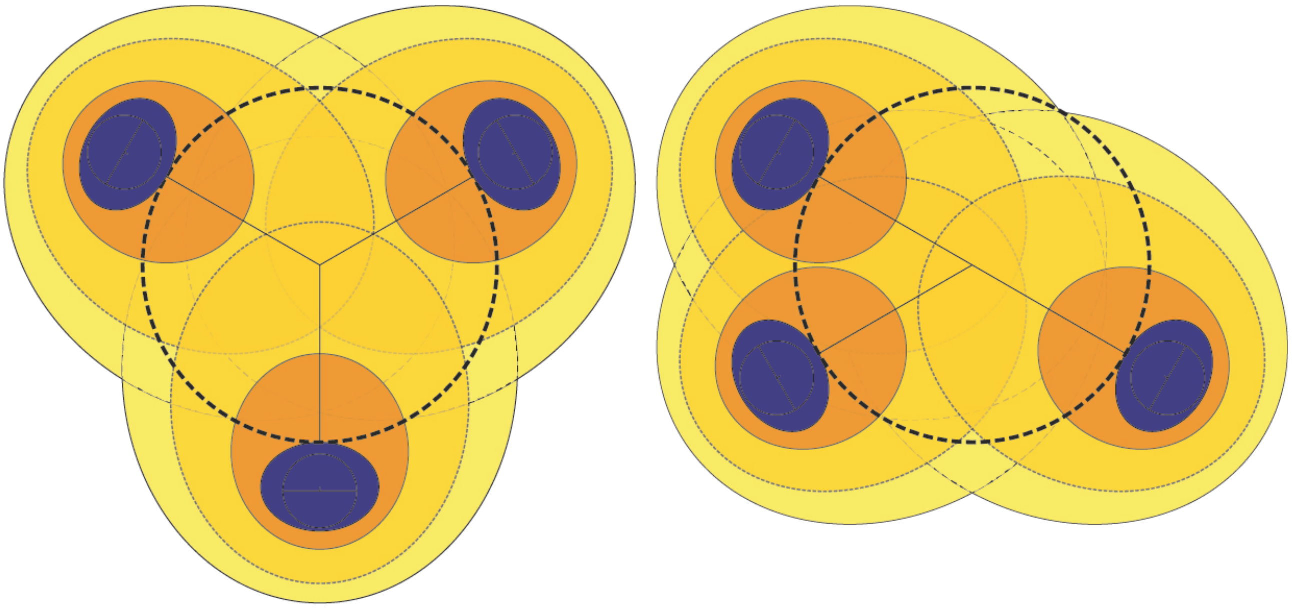


Figure 2: Circular *F*-Formation with congruent (left) and incongruent (right) angles.

When two or more people form a group, they arrange the spatial formation of the group in such a way that the individual transaction segments overlap; thus creating a joint transactional space, also called the o-space (Figure 1). Whenever two or more people establish an o-space, an *F*-formation exists. The o-space is enclosed by the p-space, in which the persons making up the formation are located. The r-space is the space located beyond the p-space. Kendon [10] describes this latter space as *"under the influence of the F-formation [...]"*, and provides as example that when multiple *F*-formations occur in a space without physical barriers, these formations tend to be spread out over the space.

F-formations can assume different spatial arrangements. For instance, a circle such as in Figure 2 but also other formations such as a side-by-side or vis-à-vis arrangement. The type of arrangement depends on a number of factors, for instance the number of participants and the context in which the arrangement occurs [10].

Rehm et al. [16] report the "six most occurring formations", and divide these six in open and closed formations. People in open formations are said to allow others to join the conversation; while this is not the case with closed formations. In an experiment with virtual characters, Rehm et al. [16] found that participants were more likely to join an open formation (84% of the trials) than a closed formation. All participants positioned themselves at a social distance, half in the close-social, and half in the far-social distance. However, the authors found that two Arabic participants positioned themselves in the close-social space, which is consistent with findings in cross-cultural research in that Arabic people generally stand closer to each other.

The role different people take on in the *F*-formation could be related to their spatial position. For instance, Kendon [9] observed that speaking rights are reflected in the formation. In a circular formation, rights tend to be equal, in other formations such as a rectangular formation the one in the spatially differentiated position (i.e. the one person sitting opposite others) has the right to speak more compared with others [9].

The arrangement of an *F*-formation can change depending on numerous factors. According to Kendon [10, pg. 221] an L-shape arrangement can for instance become a side-by-side arrangement when the participants focus their attention at an event in the vicinity instead of each other. A participant joining or leaving the specific *F*-formation can also result in a change as the group maneuvers' to maintain the *F*-formation. Thus: *F*-formations can be highly dynamic.

In the field of HRI, research has been conducted investigating the use of *F*-formations in modelling a robot's position. Yamaoka et al. [25] developed a model in which the o-space was established between a robot, listener and an object. The position based upon the developed model was preferred over positions in which the robot was placed either close to the object or to the listener. Kuzuoka et al. [11] investigated the capability of an information-providing robot to change the *F*-formation of a group of listeners. The underlying premise is that a robot which can change the *F*-formation can thereby direct the attention of its listeners. It was found that a robot could achieve this most effectively by rotating it's whole body. While these results are really important for robot design, in HRI, the role of culture with respect to a robot's most optimal position within the *F*-formation has not yet been taken into account.

Personal space and *F*-formations in HRI - Hypotheses

Work on personal space zones has mostly focused on the personal space of single people, and while numerous works call these zones "elliptical", only one distance is reported, which is the distance to the front of the participant. The diameter of the different zones can be estimated, but has not been researched extensively up till now.

Figure 2 contains two different *F*-formations: a circular formation with congruent angles between participants, and a more open formation with incongruent angles. There are three figures along a circle with a diameter of 122 cm (or 4 feet). The circles around the participants represent our hypothesized proxemics zones, these being the intimate zone, close personal and far personal space zone, respectively. The initial position where an actor places him-/herself to join a group can be found more appropriate or inappropriate. We would like to introduce this optimal approach position as a combination of the position an actor chooses with respect to the group members in between which he/she approaches, and the distance he/she takes from those actors.

Based upon the proxemics theory, we hypothesize that participants will find the approach of a robot which stays out of their intimate zone more appropriate. Our first hypothesis is therefore:

> H1: Participants will rate an approach by a robot as more appropriate when the robot stays out of every group member's intimate space zone.

We often have preferences to join a group at a particular position where there is a person we know, or that seems otherwise appropriate. We are interested in small groups such as families (father, mother and child). It may for instance, be seen as more appropriate to approach a group in between the mother and father as compared to in between the child and one of the parents, essentially cutting off a child from one of the parents. This leads us to the second hypothesis.

> H2: Participants will rate a robot approach as less appropriate when a robot approaches in between a child and parent, as compared with approaching in between both parents.

Given that different cultures exist, and that research by Rehm et al. [16] found that participants from high-contact cultures stand closer to a group of people compared with people from low-contact cultures, we hypothesize a similar cultural dependent preference will exist when a robot approaches.

> H3: Participants from a high-contact culture (China, Argentina) are more comfortable with a closer approach by a robot than participants from a low-contact culture (U.S.).

METHODOLOGY

We conducted a 3 (nationality) x 3 (position in the group) x 6 (distance from the group) online study. A survey-based questionnaire was distributed through a crowdsourcing platform (crowdflower.com) to a targeted population. Participants were shown images of small families of 3D people and a robot (see Figure 3). These groups were composed of three people: a man, a woman and a child. The survey consisted of an introduction that contained detailed instructions as well as a picture of the family (Figure 4). Participants were asked to indicate how appropriate they believed the position of the robot was, imagining that the position was the position after the robot had completed its approach. The position of the robot was manipulated two-fold within-subjects (see next section), the nationality of the participants was a between-subjects variable. A questionnaire was used to measure the dependent variables.

For the groups, a circular formation with congruent angles was chosen. We are aware of the fact that people will often stand in non-congruent angle formations, however, if we were to introduce a formation with non-congruent angles and/or people spaced differently we would introduce a multitude of factors that would be hard to control for and that would make the study overly complex.

The diameter of the o-space was set to 122 cm, which corresponds to Hall's social space. The height of the participants was based upon average international height[1]. The male was scaled to 178 cm, the female to 152 cm, and the child to 140 cm. The height of the robot was scaled to 140 cm, as can been seen in Figure 4.

Figure 3 Example top-down still as shown to participants

Figure 4 The fictional family was scaled to average international dimensions based on [1]

[1] http://dined.nl//ergonomics/

Independent variables

Two variables were manipulated within-subjects: approach position (the position between which family members the robot approached, Figure 5), and the approach distance of the robot. We refer to the combinations of position and angle as scenes.

For each of the three different approach positions, the robot was placed at six different distances, measured from the center of the circle. These distances were 20, 40, 60, 80, 100 and 120 centimeter. As a control method, participants were exposed to each scene **twice**. Thus: participants were asked to rate (2 (ratings) *3 (approach directions) *6 (distances)) = **36 scenes**.

Circles 1 and 2 (20 and 40 cm) are within participants' intimate zone, circles 3 and 4 (60 and 80 cm) in the personal zone, and circles 5 and 6 (100 and 120 cm) lie in the social zone.

Dependent variables

The dependent variables were measured using a 112-item online questionnaire, measuring a total of 6 constructs. The questionnaire was divided into three consecutive blocks: appropriateness rating of the robot-group scenes, questions regarding participants' cultural background and personality, and general demographic questions.

In the first block, participants were asked to rate the 36 'robot approaches a family' scenes that have been described in the previous section. To avoid order-effects, the order of all scenes was randomized. Participants were provided with the instruction: "*The robot approached the family and has come to a halt between particular family members at a particular distance. Now it will interact with them*", and asked to indicate on a 7-point Likert scale how appropriate the position of the robot was. Another four items were included in this block to measure how participants themselves would approach the family. Two items were included to check the approach position- and distance manipulation. Here participants were provided with statements such as *"the robot generally approached from the same direction"* and *"the robot generally approached from different directions"*. Participants were forced to choose which of the statements was true. A final item was included in which we asked participants if they could indicate where they thought the family they had seen in the situations originated from.

The second block of the questionnaire consisted of a series of validated scales measuring four dependent variables. An indication of whether participants were members of a high-contact or low-contact culture was assessed by measuring *closeness* as people from a high-contact culture have been found to sit significantly closer to each other compared with members from a low-contact culture [19]. Five items from the IPROX (iconic proximity) questionnaire were used [7]. Participants' general attitude towards robots was measured by the *Negative Attitude Towards Robots* scale, a 14-item 7-point Likert scale. Hofstede [6] identified five dimensions of culture, one of these being Individualism-Collectivism. One way to explain cultural differences is by measuring *individual* and *group self-representations*. Individual self-representations refer to whether the self is represented as "a separate, unique individual" [1] whereas group-self representation refers to one who is "an interchangeable part of a larger social entity" [1]. This was operationalized using 7 items, by Brewer & Chen [1].

The final construct in this block was personality as we figured this could influence people's preference for a robot position (e.g., more extrovert people preferring the robot to come closer or to approach at their side of the group). We measured the Big Five personality traits using the 20-item Mini-IPIP scale [2].

The final block of questions included demographic questions like gender, age, nationality, and level of education. Social-demographic questions like nationality of ancestors, marital status and number of children were also included.

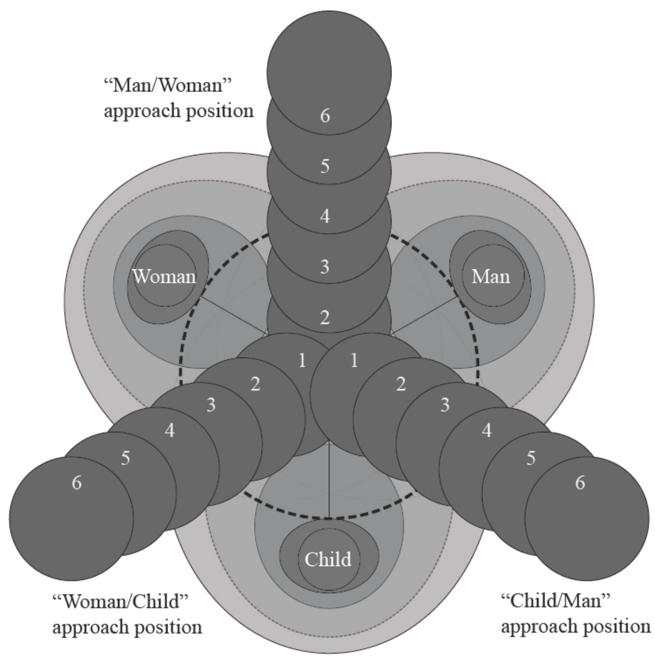


Figure 5: Participants standing in a circular F-Formation with a diameter of 122 cm. Dark grey indicates possible location of the robot. Grey: intimate zone, light grey: personal space zone.

	N	Mean age (sd)	Male / Female
U.S.	86	43.27 (12.25)	26 / 60
China	29	30.48 (8.93)	19 / 10
Argentina	66	33.06 (10.90)	48 / 18
Total	181	37.50 (12.54)	93 / 88

Table 2 Number, nationality, mean age, and gender of the participants

Participants

Participants were recruited from three different countries: China, Argentina and the United States. People from these three countries are generally considered culturally different; not only because they are geographically on different continents, but also because various studies have shown cultural differences [3, 4, 17] in for instance societal values.

For each country, participants were recruited through the Crowdflower platform, which allows for specification of the target country. 244 participants completed the questionnaire; each being paid $1 for completion of the survey. Responses were limited to one per IP address. Participants who failed to correctly answer the two manipulation checks were excluded from the sample. A second control method was the analysis of the robot-scene questions, which were 18 situations rated twice by each participant on a 7-point Likert scale. Participants who rated four or more situations with a difference of 3 or more points were also excluded from the survey. In total 63 participants (26%) were excluded. After applying the exclusion criteria, the total sample contained 181 participants, as specified in Table 2.

Data analysis

The results presented in this paper focus on the ratings of the scenes and on the closeness scale (five items from the IPROX questionnaire, see Dependent variables). Internal reliability of all scales was assessed by calculating Chronbach's α, and deemed acceptable for all scales.

As stated in the previous section, the participants rated all scenes twice as form of control method. After having excluded participants these ratings were averaged per participant and scene.

Approach in between	Mean	SD
Man-Woman	4.11	0.095
Woman-Child	4.16	0.100
Man-Child	3.93	0.093

Table 3 Mean appropriateness scores and standard deviation grouped by approach direction

To determine whether the participants found an approach more appropriate if the robot stayed out of every group member's personal space zone (H1), we conducted a repeated-measures ANOVA with one within-subjects variable (being intimate- or personal space zone), and two between-subject factors (nationality and gender). For the purpose of analysis of this hypothesis, ratings for circles 1 and 2 (intimate space zone) were averaged as well as the ratings of circles 3, 4, 5 and 6 (outside intimate space zone).

To analyze whether an approach between the child and one of the parents was rated as being less appropriate (H2) and whether participants from higher contact cultures were more comfortable with a closer approach (H3), we conducted factorial repeated-measures ANOVAs with two factors as within-subjects variables; these being the average ratings of the position in the group (3) and distance from the group (6). Nationality and gender were used as between-subject factors.

RESULTS

In this section we present the results of the survey that we acquired from the analysis of the ratings of the scenes and the closeness scale

Participants prefer a robot that stays out of our intimate space zone

In H1 we hypothesized that participants would rate it as more appropriate if the robot was positioned out of every group member's intimate space zone. A repeated mixed-model ANOVA revealed that participants rated the robot positions in the intimate space zone as significantly less appropriate (M=3.14, sd=1.25) compared with those positions where the robot was positioned outside the intimate space zone (M=4.61, sd=.99), $F(1, 100.658) = 109.567$, $p<0.01$. We therefore **accept H1**: a robot which stays out of the intimate space zone of each of the group members is considered to be more appropriate. These ratings were neither affected by gender (p=.87) nor by nationality (p=.60).

Appropriateness of a robot's approach is not always affected by its position relative to the family members.

A factorial repeated-measures ANOVA with two independent variables (distance and position) and two between-subjects factors (gender and nationality) was conducted. Mauchly's test indicated that the assumption of sphericity had been violated for the main effects of distance, $\chi^2(14) = 613.9$, $p<0.001$, and angle, $\chi^2(2) = 76.37$, $p<0.001$. Sphericity had also been violated for the interaction effect (distance*direction), $\chi^2(54)=183.55$, $p<0.001$. The degrees of freedom were corrected using Greenhouse-Geisser estimates of sphericity (ε=.42 and ε=.74 for the main effects, and ε=.81 for the interaction effect).There was a significant main effect of the approach distance ($F(2.09,365.19)=54.37$, $p<0.001$), and a non-significant effect of approach angle on the appropriateness of the robot's position ($F(1.47, 258.25)=2.857$, $p=0.075$).

Post-hoc contrasts revealed a significant difference of appropriateness between the "Woman/Child" and "Man/Child" approaches: the appropriateness of the "Woman/Child" approach was significantly higher compared with the "Man/Child" approaches, $F(1, 175) = 11.71$, $p<0.001$ (See Table 3). The appropriateness of the "Man/Woman" approaches was equally appropriate as the "Woman/Child" approach, We therefore only **partially accept H2**, in which we hypothesized that participants would rate a robot approach as less appropriate if a robot approached in between a child and parent, as compared with approaching in between both parents. Instead, participants indeed found an approach between parent and child less appropriate but only for the position between father and child. The most appropriate approach position was generally thought to be in between the mother and the child (see Table 4).

Influence of cultural background on appropriateness

To check whether the countries that we chose actually differed in the low-high contact dimension, we analyzed the items from the closeness questionnaire. There was a significant difference between the ratings, $F(2) = 15.528$, $p<0.001$. As can be seen in Figure 6, participants from the United States gave significantly higher ratings on the closeness measure (M=4.96, sd=1.05), which indicates they put more distance between themselves and other people. This effect was vice-versa for Chinese people, as expected (M=3.88, sd=1.20). The Argentinian participants rated in between (M=4.11, sd=1.19).Therefore, we can assume that

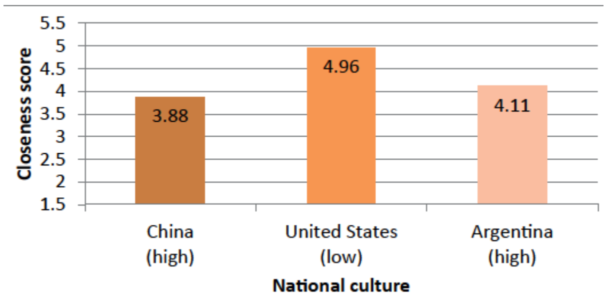


Figure 6 Participants from what are considered low-contact cultures scored indeed significantly higher on the "closeness" construct (scale: 1: high contact, 6: low contact. Mean scores provided in bars).

the national groups included in this sample can indeed be considered to have different cultural backgrounds concerning the low-high contact dimension.

Our third hypothesis was that participants from high-contact cultures (such as China and Argentina) would rate a close approach as more comfortable than participants from a low-contact culture (United States). There was a significant three-way interaction effect between the nationality of the participant, distance, and position of the robot on appropriateness of the scene, $F(16.20, 1417.24)=1.912$, $p<0.05$. This effect can be seen in Table 4 and Figure 7.

The Table and Figure show that the U.S. and Argentinian participants gave similar appropriateness ratings for the

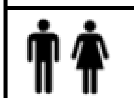
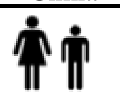
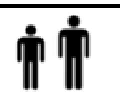
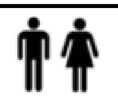
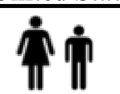
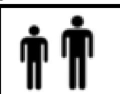
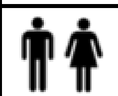
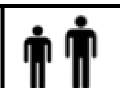
distance	China			United States			Argentina		
									
20	3.052 (1.555)	3.862 (1.870)	3.741 (1.751)	2.721 (1.560)	3.023 (1.627)	2.721 (1.516)	2.697 (1.544)	2.909 (1.446)	2.530 (1.364)
40	3.345 (1.748)	4.017 (1.740)	3.310 (1.785)	3.552 (1.690)	3.843 (1.676)	3.407 (1.474)	3.477 (1.515)	3.614 (1.230)	3.038 (1.178)
60	3.862 (1.737)	4.155 (1.895)	3.759 (1.740)	4.308 (1.478)	4.552 (1.596)	4.128 (1.468)	4.083 (1.583)	4.439 (1.383)	3.689 (1.202)
80	4.259 (1.766)	4.466 (1.732)	4.414 (1.547)	5.047 (1.490)	4.988 (1.538)	4.709 (1.523)	4.795 (1.48)	5.000 (1.547)	4.220 (1.356)
100	4.517 (1.825)	3.672 (1.649)	4.414 (1.753)	5.337 (1.428)	4.977 (1.439)	4.994 (1.610)	5.136 (1.423)	5.220 (1.465)	4.644 (1.315)
120	3.724 (1.893)	3.103 (1.749)	3.603 (1.655)	4.913 (1.722)	4.692 (1.736)	4.837 (1.591)	4.917 (1.690)	4.841 (1.813)	4.689 (1.583)

Table 4 Mean appropriateness ratings for the Chinese, U.S. and Argentinian sample. Distance indicates distance between the center of the circle and the robot (in cm). Mean appropriateness ratings on a scale from 1 to 7, standard deviations between brackets.

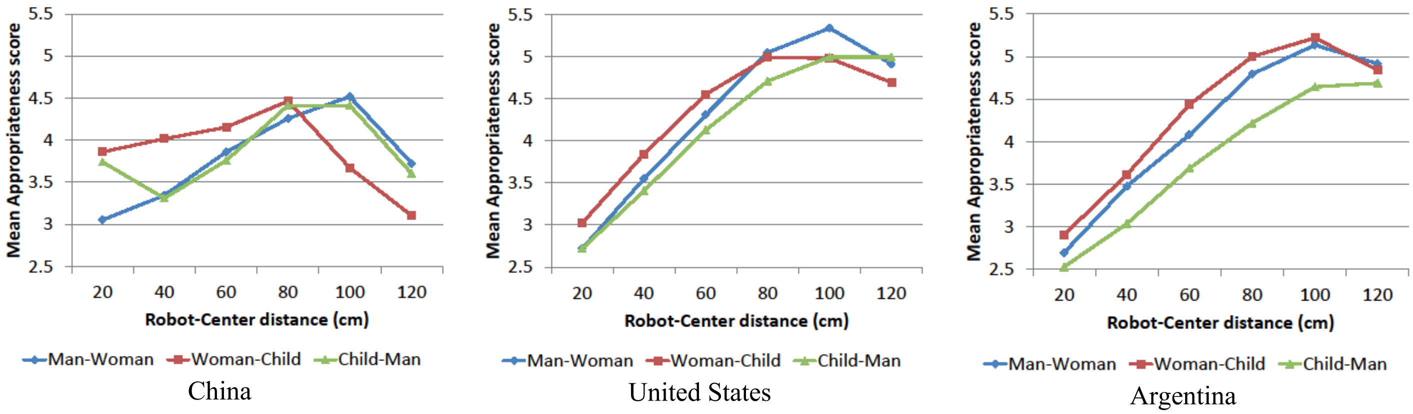


Figure 7 Mean appropriateness ratings for the Chinese, U.S. and Argentinian sample. Appropriateness on a scale from 1 to 7.

approach distances, but that one particular approach in between the "Man/Woman" was considered most appropriate by the U.S. participants, whereas the Argentinian believed the "Woman/Child" position was more appropriate.

The Chinese participants' ratings were generally lower and a notable difference was that the closer approaches (within the intimate zone) were actually considered to be quite appropriate. Like the U.S. and Argentinian participants, the Chinese also had a preference for a further stop distance (80-100 cm), though this difference was much less pronounced.

We therefore **partially accept H3**. We hypothesized that participants from high-contact cultures (such as China and Argentina) would rate a close approach as more comfortable than participants from low-contact cultures. Chinese participants saw a closer approach as more appropriate. However, we expected similar results for Argentinians, which we did not find. Interestingly enough the ratings the Argentinians provided were quite similar to those provided by the U.S. participants. We will reflect on this in the discussion.

DISCUSSION

In this paper we presented the methodology and first results of a survey investigating cross-cultural HRI proxemics preferences. This paper shows that there are indeed cultural differences in spatial behaviors in HRI. Thus, taking culture into account is an important next step for HRI if social robots are designed to operate all over the world in various cultural contexts or in environments where people from different cultures are around (such as airports, fairs and museums). We will now discuss both the methodology and the results to retrieve directions for future research.

We hypothesized that participants would find approaches in between the parents more appropriate compared with the approaches where a child is cut off from one of the parents. The reason for the unexpected finding that approaches between mother and child were found quite appropriate could be a pragmatic one, which we had not considered. By approaching in between the mother and child the robot directly faced the father of the family. It could be that a robot's frontal approach to a male is seen as more appropriate. Even though previous work by Walters et al. [24] did not confirm this notion, this warrants further investigation into differences in gender preferences.

Figure 7 shows similarities in the appropriateness ratings of the U.S. and Argentinian samples respectively, despite the fact that Argentinian's closeness scores indicate a higher-contact culture. Therefore, we expected they would find it more appropriate if the robot approached closer. Thus, it could be that the high-low contact culture dimension is too simple and did not completely capture the subtleties of high-low contact cultural backgrounds and that there are more factors at play. One possible explanation can be found in Hofstede's work [6]. On the Individualism dimension, the U.S. scores are high (91 points), and Chines scores are relatively low (20). Argentinians scores are at 46 points. This is still closer to China than the U.S., however, if we look at other Latin American countries, such as Ecuador (8), Venezuela (12), Colombia (13) and Chili (23) it appears to be that Argentina is a rather individualistic country. This might partly explain why Argentinian participants showed a preference for a further positioning of the robot. However, this issue deserves further investigation.

Furthermore, we have not yet analyzed the relation between personality and the appropriateness of robot scenes. Previous work in HRI has shown that a high score on extraversion leads to more tolerance to uncomfortable robot approaches [20]. It could very well be that personality also influences ratings of appropriateness. In a similar way *attitude towards robots* and *individual* and *group self-representations* could influence the results in subtle ways, which we have not yet analyzed.

To analyze cross-cultural differences in proxemics, we used an online questionnaire as this allowed us to distribute the survey to geographically dispersed samples. The survey contained static images, and while the results do support most of our hypotheses, the ecological validity of our research is limited because groups are dynamic entities. The formation of the group changes when a new member joins the group, and our images might very well not have been able to capture these subtle dynamics. In future work, we will conduct a study where actual groups of people are approached by a robot– primarily to see if the results found with this survey are replicable when such an experiment is conducted in a lab or real world setting.

Furthermore, participants viewed the robot-group scenes from above. This may – unintentionally – have caused a limitation as participants were not able to take the height of the actors into account. In retrospect it is possible that participants would provide different ratings had they been provided with different camera angles next to the top-view.

Another limitation of the experimental design concerns the chosen *F*-formation. As we explained in the methodology section, we chose for a closed circular formation with congruent angles (Figure 2). It could very well be that another formation, for instance with incongruent angles, yields different results; either because of the position (and status) of the members within the group, or simply because there is more room for a robot to approach when the angles are not congruent. This issue will also be addressed in future research.

Finally, the context of our stimuli could be debatable. The reason for not providing a specific context in which this group and the robot would interact (for instance a domestic environment, airport or shopping mall) was that we did not want our participants to have a predisposed opinion on for instance the feasibility or acceptability of a robot in a certain context. However, how different real-world contexts influence the ratings is a highly interesting question as future robots will be operating in such contexts.

As stated in the introduction, this is a first study. In order to improve ecological validity and generalizability of our results more research has to be conducted. Our future work will focus on replicating a similar experimental setup in either a physical lab or field setting in order to account for some of the limitations that arose in this experiment, as also pointed out in literature (f.e. [10]).

CONCLUSION

In this paper we have presented the first results of a survey that we distributed to three countries (China, the U.S. and Argentina). We were interested in finding out whether or not people from different nationalities have different proxemics expectations from a robot which approaches a small family.

The most appropriate approach distance appears to be somewhere near 80 cm from the center of the circle. Our results also show that while participants found a robot more appropriate when it stayed out of the intimate space zone, there are cultural differences which surface when comparing China with the other two countries:

- Argentinian and U.S. participants rated approaches in Hall's intimate space zone as clearly inappropriate whereas the Chinese participants rated approaches farther away (100-120 cm) as more inappropriate.
- Argentinian and U.S. participants rated an approach in between the child and man as less appropriate, Chinese participants did not have a clear preference.

Unexpectedly, the Argentinian ratings were closer to the U.S. ratings even though both Argentina and China were considered to be high-contact cultures, and both scored as such on our closeness measure. Hence, there seem to be many factors that contribute to the cultural identity of people that we will look into in the future, among others the interplay between personality and culture, as well as to the limitations caused by the methodological choices.

Overall, the influence of culture on HRI has turned out to be a promising research direction with respect to proxemics. Our first research shows that researchers need to take culture into account when building robots that operate in intercultural environments.

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