Human-Telepresence Robot
Proxemics Interaction

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Abstract

This research aims to find distinct and crucial factors needed in order to design a better robot through exploring the meaning of movement. The researcher conducted six-weeks of iterative work to collect data via an ethnographic method. The researcher examined the interactions between a telepresence robot and human beings in an authentic environment through the collected data and analyzed it based on proxemics theory. The research observed that the robot was given social space when it approached the participants with pauses in between movements. Furthermore, the research introduces proxemics pivot and its notion. Proxemics pivot refers to the part of the robot that people perceive as a standard point when they adjust the proximity between the robot and themselves. The proxemics pivot was considered “a face” and was attributed social properties; the other parts of the robot did not receive the same consideration.

Keywords: Human-Robot Interaction, Telepresence Robot, Social Robotics, Proxemics, Proxemics Interaction, Embodied Interaction, Perception Design
1. Introduction

Is a telepresence robot, a robot? This might sound like a superfluous question since it has “robot” in the name already. However, a telepresence robots identity is ambiguous. If a person were to simply type “What is a robot?” into an internet browser’s search bar and click the search button, the top result is “A machine capable of carrying out a complex series of actions automatically, especially one programmable by a computer”. This can be dismal news for the telepresence robot industry because, unlike other robots with artificial intelligence, a telepresence robot is remote controlled and serves as a representative of the controller. The controller interacts with other non-digital creatures through the telepresence robot in real time. The controller is the one who is interacting; the machine is not capable of carrying out any complex series of actions automatically. In this sense, a telepresence robot is a computerized artifact which works as a medium.

Here is an example from a user’s perspective: John is a controller of a telepresence robot. John sends the robot to a conference room for his business meeting. In the conference room, the telepresence robot’s identity would be John, but only as long as John is connected. John’s co-workers would think they are interacting with him during the meeting. When they repeat John’s words to a third person later, they would say “We heard about it from John today.” instead of “Hey, we heard about it from a telepresence robot.”. If a person were to write a post on their Facebook, it is considered “their post” and not Facebook’s. A telepresence robot works the same way; it is the controller’s conversation, not the robot’s. Even though other people were physically present and interacting with the robot, it is recognized as an interaction with the controller. This is the aspect of telepresence robots that make them a mobile medium. Furthermore, there are many devices that allow an individual to interact with other people. Mobile phones, tablet PC’s, laptops, etc. all allow an individual to interact with others. An individual can easily contact others with these devices. Many devices, such as those previously listed, also support group and video calls and appear to provide the same functionality as a telepresence robot. However, these devices are not perceived as robots even though they have more functions and display a certain level of intelligence. They are even smaller and more portable for convenience than the telepresence robot. How dare this giant phone which has no function except for video calls be called a robot? Should telepresence robots be disqualified as being a type of robot because they do not have the “proper” function of a robot? The argument doesn’t seem to be convincing.

Even if a telepresence robot does not meet the definition of a robot on Google, it has significant differences from mobile phones or tablets. One such difference is shown in the robot’s name; it differs by its autonomous presence. Beyond being a medium that works as a communication channel between people, a telepresence robot allows the controller to stay in a specific location while allowing a second body representing the controller to be in another location. This is possible because the robot can move. A telepresence robot does not communicate through the recipient’s mobile phone or laptop; it exists in a physical location as a second body of the controller. The controller can interact with the interaction target directly. This is what makes a telepresence robot distinct from other communication devices. This is the reason why a robot’s movement is an extremely important component to
designing a telepresence robot. Movement is the basis of its identity as a telepresence robot. Movement is not only a function. It is more than just a telepresence robot being able to change its location on its own. Movement influences a human being's cognition. When a Google-owned robotics company called Boston Dynamics released a video of a four-legged robot named Spot on YouTube, many people became a part of a totally unexpected phenomenon. A discussion about cruelty and inhumanity took place in the comments section due to a scene in which a staff member was seen kicking the robot to test the robot’s ability to balance. This reaction is not the only occurrence of this phenomenon; another testing video of a humanoid robot named Atlas had a similar comments section. These videos were edited by many people and spread on social networks with different titles such as “Stop robot abuse!”, “Robot lives matter”, “Spot Cruelty!”, and etc. One of these videos received over one million views and the comments section included many profane remarks towards the tester who kicked the robot.

![Image of a telepresence robot](https://via.placeholder.com/150)

**Picture 1. Boston Dynamics’ Robot Balance Test (YouTube)**

It is a funny as well as the interesting phenomenon that people recognize a robot as an entity that can earn sympathy instead of being viewed as a piece of furniture or a tool. It was not difficult to figure out the reason why. As is evident from the comments section of the video, the anthropomorphic responses were mainly induced by the movement of the robot balancing itself during the test. The robot’s movements were merely a set of programmed responses in order for the robot to rebalance itself from any external forces acting upon it.
However, many of the viewers recognized the movements as the robot having a hard time recovering from being kicked by a human being and thus felt empathy for it. The movement of the robot actually influenced people’s recognition.

Feeling empathy towards humanoid robots has also been observed in research. According to a recent neurophysiological study, humans can have an empathetic reaction to robots. Suzuki, et al.(2015) at Kyoto University showed different images of humans and robots under painful and nonpainful situations to test participants. It was observed that humans feel empathy towards robots by monitoring electrical activity in the participants’ brains via electroencephalography, or EEG. It proved that people can perceive a robot as more than an ordinary machine. Furthermore, the movement of a robot can influence human perception. The discussion about the relationship between robot movement and human perception was first initiated by a well-known hypothesis named The Uncanny Valley, by Japanese roboticist Masahiro Mori(1970). He claimed that the human-like appearance of a robot made people enjoy a sense of familiarity, but the familiarity turns into displeasure rapidly at some point. Masahiro Mori called it the uncanny valley.

![Figure 1. Valley of familiarity (Masahiro Mori, 1970)](image)

According to Mori’s graph, moving makes the uncanny valley more clear and steep. A number of researchers have sought to determine the uncanny valley. MacDorman and Ishiguro(2006) analyzed it as a defense mechanism of human beings. Brenton, Gillies, Ballin, and Chatting(2005) considered it as a form of cognitive dissonance. However, the common conclusion is that a robot’s movement influences human perception and that movement is becoming increasingly important in human-robot interaction. Paradoxically speaking, proper movements can increase the familiarity. AIBO, a robot dog created by Sony, triggered similar responses. AIBO was designed to be a
pet. It is composed of different moving parts (a mouth, head, four legs, two ears, and a tail) and sensors so it can make various movements. This allows the robotic dog to mimic expressions and emotion. When Sony stopped technical support for their pet robot product, funerals were held for these robotic dogs because the owners felt a strong bond with their robotic dogs. This was not a one-time event; to this day, there are still funerals being held for these robotic dogs as they cease to function.

In this way, a robot’s movement becomes an important factor in interaction not only from a functional perspective but also a social perspective. Essentially, the movement of a robot is a crucial component when designing a socially competent robot.

The question that is now being posed is if it is currently possible to design telepresence robots in a way that considers these facts. What should be considered when designing the movement pattern of a robot? Human beings do not perform an action solely based on the ability and efficiency to finish a task. An individual does not run into the middle of a conference room going full speed to talk to another person, even if they have the ability to do so. One person’s motions and actions will influence the people surrounding them. People try to take in their surrounding environment in order to forestall evoking a socially awkward atmosphere or from making an inappropriate action. Humans generally have the empirical ability to steer the level of attention directed towards themselves in a crowd, based on their own needs and purpose. Humans also know how to get attention and avoid attention through experience and sensory feedback. This ability helps to prevent committing inappropriate actions and knowing what the appropriate action is to take. We can talk about this ability as a form of social competence that is related to their physical and social presence. The same can
be applied to a robot; a robot that is able to receive or avoid attention through appropriate movements can be seen as more socially competent. The owners of a telepresence robot would not want the robot to aimlessly run around in a conference room, get unwanted attention, and distract everyone or possibly even intimidate other people in the room. So beyond the questions of “How stable can the robot stand?” or “How fast can the robot move?”, the question of “How socially competent can the robot be?” is an important question to answer in the design of a telepresence robot’s movements. This research question is not primarily technological; it emphasizes the needs of an approach that considers the social aspects.

The main goal of this research is to provide relevant and adequate information as a pre-study towards the endeavor to create socially competent telepresence robots. The approach presented in this thesis is rooted in proxemics theory, which is looking at how humans arrange themselves spatially in different forms of social interaction. Through observation, this research seeks to answer the question of how proxemics affect social interaction with, and around, a telepresence robot located in an environment where many people are present. More specifically, the thesis aims to provide design recommendations on how proxemics can be used to design and facilitate central social interactions. Ergo, this research endeavors to figure out:

1. Whether or not the traditional proxemics theory is applicable to interactions between humans and telepresence robots.

2. The difference in the proxemics between human-human interaction and human-robot interaction.

3. The predominant factor that influences physical human-robot interaction.
2. Theory

Proxemics is an important concept related to communication between human beings. While there are a variety of definitions for the term proxemics, this research uses the definition that was first suggested by anthropologist Edward Hall(1963). Hall focused on the relation between physical distance and interpersonal distance. Hall observed that human beings control physical distance during interactions with others according to their social distance. In Hall’s study, he organized the interpersonal distance into four zones; intimate distance, personal distance, social distance, and public distance, according to the physical distance from the entity(Hall, 1966). One can assume from the names that the physical distance is shorter in the intimate zone and grows increasingly longer towards the public zone. In short, humans control the distance between two persons through social distance.

![Diagram of Proxemics Zones](image)

**Figure 2. Delineation of Proxemics Zone (Hall, 1966)**

Additional research was derived from Hall’s study that studied proxemics with HCI (human-computer interaction) in depth. The research concluded that proxemics can be a key component to designing interaction in ubiquitous computing environments(Greenberg, Marquardt, Ballendat, Diaz-Marino, & Wang 2011). The criteria of each zone can vary between cultures and individuals. Cultural differences and/or environment can change the size of the zone or can influence the test participants into adjusting their zone. However, adjusting physical distance according to one’s purpose, cognition, and interpersonal distance is an integral ability of a human being as a socially competent entity.

Some attempts have been made to adapt this theory to HCI. One of these attempts by Ballendat, Marquardt and, Greenberg(2010) resulted in the development of the proxemics interaction theory. They devised proxemics interaction based on the assumption that people’s natural ability and recognition of proxemics can be used to mediate an interaction between
humans and digital devices. They found that proxemics interaction can be useful to design interactions, especially when users are in a space with more than one digital and non-digital device (what they call ubiquitous computing ecologies). The core idea is somewhat similar to Embodied Interaction, as developed by John Dourish (2001). Users can interact naturally with digital devices by controlling proxemics, just as humans control their proxemics to engage and initiate interaction. Marquardt and Greenberg (2015) described this aspect of proxemics in their book as follows:

“Overall, proxemics mediate many aspects of social interaction. For example, it influences casual and serendipitous encounters (Kraut et al., 1988), is a nuance in how people greet one another (Kendon, 1990), and is a major factor in how people arrange themselves for optimal small group collaboration via spatial-orientational maneuvering (Kendon, 2010; Sommer, 1969).”-Proxemics Interaction: Theory and Practice (2015)-

Proxemics is a form of non-verbal interaction and a social aspect in and of itself. If an individual detects a person approaching them, the individual would prepare to interact with a said person. An individual can also trigger an interaction with another person by approaching without any verbal communication. Then, one could pose the question of how proxemics is different from the notion of “distance”. Distance is about physical distance between two points.

![Image 1](image1.png) ![Image 2](image2.png)

Figure 3. Distance and Proxemics

When we see the two images in figure 3 in the notion of distance, B is closer to A than to C in both images. Therefore, there’s no difference in the relationship among A, B, and C in the two images. However, proxemics is more semantic. It considers the location, orientation, identity, and attributes of the entities. Namely, in the notion of proxemics, it considers the semi-fixed feature of location, which is often called a group or arrangement. So unlike image 1, it seems B is in a same group with C in image 2. It implies that the relationship of A and B might be different from what is seen in image 1 even though there is no difference in terms of distance. That is the difference between proxemics and distance.

Then, can proxemics be adapted to telepresence robots? If it is possible, can it also be a key to designing a socially competent telepresence robot?
This research focuses on the dimensions of movement and distance. The meaning of the two dimensions in this study was converted from existing research to make them appropriate for this telepresence robot experiment based on the ability of the robot.
3. Method

Applied-ethnomethodology is a neologism that originates from research based on ethnomethodology but adds an embodied interaction perspective. It is well known that ethnomethodology was coined by Harold Garfinkel. According to Garfinkel’s notes, ethnomethodology focuses on how social actors create and understand the basis of their actions (Garfinkel, 1984). Ethnomethodology has been broadly applied in HCI studies (Dourish and Button, 1998). An ethnographic approach helps in the understanding of cultures and the meaning of technology in people’s everyday lives. We can use the understanding to design computer systems (Button, Crabtree, Rouncefield, and Tolmie, 2015). Applied-ethnomethodology still has the general attributes of ethnomethodology but has two major distinctions.

Applied-ethnomethodology relies more on inter conversation through interaction analysis. Unlike the conversation analysis of ethnomethodology, interaction analysis analyzes both verbal and non-verbal interactions of participants, and includes both conscious and unconscious interaction to understand the phenomenon in depth. The observation of non-verbal interaction allows the researcher to observe less mediated interaction that happens among the participants in an authentic context without intervention. Hence, the research can capture and analyze the phenomenon that can be missing in a conversation analysis.

Like all qualitative research, one of the main concerns of ethnomethodology is external influences to the natural context and adverse effects on the authenticity. Because of this, the researcher put in an effort to minimize them. However, in this research, the robot must be inserted as a participant into an existing group; it makes a change to the environment on purpose. In traditional ethnomethodology, this could be considered harmful to the authenticity and the collected data can be seen as interventionist data since the study inserts a robot into an authentic context and it is a form of experimentation. However, as mentioned in the earlier chapter, the telepresence robot is identified as a second body of the controller and the controller is selected from the test group. One of the original members participated in the group as they normally would through the telepresence robot. There is no change in the identity of the participant nor the test group. The other participants of the test group perceive the telepresence robot as the same person.

This brings some merits of applied-ethnomethodology. First, it allows the research to have an insider’s view as a participant and also from an outsider’s view as an observer. It helps the researcher to observe and analyze more phenomena in depth and from different angles.

Secondly, it allows the collection of ethnographic data by inserting the robot as a second body into the existing group. In this case, the researcher did not need to be concerned about the establishment of rapport and could collect ethnographic data that still excluded the possible artificial setups that could induce specific behaviour by inserting a new participant.

Data is also collected through filming iterative work. Data collection is made through six times over the course of two months. A group interview was conducted at the very end of the last session. The reason why the observation was conducted iteratively over a period of time is to exclude any exceptional phenomenon to prevent the hazard that the research would generalize any abnormal case precipitously; also to observe repetition and holistic contexts.
3.1 Test Group

An existing theatre group is selected as the test group. This theatre group is a club of the Snerikes Nation (a student society). It is an exuberant group of people who like to practice theatre. Members are gregarious and often create vigorous, non-verbal interactions in their practice sessions. This group has two different sessions; one on Monday and another on Thursday. Each session goes for an hour to two hours. They are held in different locations (rooms). The observation test was conducted at two different locations to deduce a general and common conclusion in which the results would not be influenced by location or arrangement. The test was conducted in the main hall and uppermost room of the Snerikes Nation building, which is located in Uppsala, Sweden. The main hall is rectangular shaped, and the uppermost room is a circular shape. On average, ten participants join for each session. The Monday session is for regular members, while the Thursday session is an open session which allows non-members to participate. This presents the opportunity for the controller to meet various people. Since it is a theatre group, many different physical activities are carried out during the theatre sessions so interactions are made vigorously. It is considered a good environment to explore interactions using a holistic approach. This test was composed of both male and female participants that have different majors and occupations and are of different nationalities and ages. One male member of the theatre group was selected to be the controller of the robot. He joined the group meetings as a participant as well as a group leader.
The main activity for the theatre group during the meetings is practicing different acting techniques used in theatre, which includes some physical activities such as running around, grouping with partners, etc. This meant that the test environment was often very noisy and crowded. The group leader would normally talk very loud or clap to get people’s attention and to control the meeting. During the session, many different types of activities were taken on besides acting practice. Participants often play games using their body, such as ‘Red Light/Green Light’ (One person is chosen to call out either red light or green light. When “green light” is spoken, people can move. When “red light” is spoken, people need to stop moving immediately.) and also perform improvisatory acting with undecided roles. Participants not only act as live creatures but also act as inanimate objects, such as trees or popcorn. Some of these activities proceed in turns since they include performing in front of others. The controller was asked to join the activity and perform in the same way as the other participants. In this case, the controller’s goal is to join as many activities as possible with the telepresence robot.

Picture 3. Test group during a session
3.2 Test Setup

![Experiment setup 1](image1)

Figure 4. Experiment setup 1

![Experiment setup 2](image2)

Figure 5. Experiment setup 2

Participants were informed in advance that the meeting was being recorded for research purposes, but the footage would not be published in any form of media. The research purpose was explained as “a robot’s performance test” to all the participants except the controller. This was to prevent any influence on the participants’ actions. The meeting was recorded by one camera which was set up in different locations, depending on the situation. Video quality was taken in 1080p at 30fps with a 170° angle lens. The controller was located in the same building but was in a separate room during both setups so the other participants could not see the controller. In setup 1, the moderator stayed with the controller in room 2 to instruct the controller and observe the status of the robot through the door. In setup 2, the researcher stayed in room 1 with the other participants to check the robot’s status because room 2 is not connected to room 1.
3.3 Post Interview

Post interview is a semi-structured post-session interview. It is an intervention for the controller that helps the controller to create movements. The controller is not asked to do a specific task. Instead, the moderator poses some open questions after the session to motivate and inspire the controller, eg. “How was the session?” “What were the difficult parts?”. The controller can answer freely about the experience and suggest what to do in the next session. The moderator does not suggest any specific idea or give feedback about the controller's opinions. The moderator solely helps the controller to share his experience and ideas. Also, the moderator gives information about what the controller couldn’t observe, eg. “There was a collision with one participant when you did this”. Through this process, the controller can do a self-evaluation to evolve their own interaction skills through the telepresence robot rapidly and naturally.

3.4 Ethics

The ethical issues of qualitative research have been a topic in academia for a long time and I believe there is a need to address the ethical issues for this research. Ethical issues in qualitative research are often more subtle, especially when the research has qualitative methodologies such as long-term and close personal involvement, interview, and/or participant observation like in this research. (Lipson, 1994). Before proceeding with the research, the researcher must express concern about these issues. Ethical research not only leaves participants unscathed, but also avoids infringing upon their rights. The ethnographic approach has a responsibility to protect research participants from harm and to hold a high regard for their rights. (Murphy and Dingwall, 2001)

As mentioned earlier, the participants were informed that the research purpose was “a robot’s performance test”. The participants were given this explanation to prevent them from being overly aware of their behaviour. By suggesting to the participants that it was a robot’s performance test, the authentic context could be observed and accurate ethnographic data collected. It is not so that the researcher allows the ethical issues to be compromised for a better result and the value of the study to be heightened.

The decision to provide this explanation to the theatre group participants was made after conversing with an instructor of the theatre group. A condition to the terms of the agreement was that the research did not collect or publish any unnecessary personal information on the participants and that a group interview would be administered at the end of the last session. Another condition was that the collected data would not be used for any other reason except for its intended academic purpose. This is made under the concerns about how the collected data would influence the participants and the consideration of the general ethical issues of the qualitative research method. I emphasize again that all researchers have a duty to contemplate this matter and make it a priority in their mind when proceeding with a qualitative research.
3.5 A Telepresence Robot

One distinct design of the selected robot is that the motions of the display and the body are separate.

Picture 4. Telepresence robot model used in the experiment (Padbot U1)

1. Distance can imply a physical distance from an entity or it can imply a discrete zone. The difference is that an entity can be plural, such as a group of people. The meaning indicates that the study can explore any differentiation of interaction with one or more than one entity.

2. Movement is divided into two categories; head movement and body movement. These can be further subdivided into active movement and passive movement.

- Head movement involves the display part's movement on the telepresence robot. It moves only vertically. The range of motion (angle) is approximately 15°. Head movement is only used when the robot is stopped. Eg. nodding its head, or looking up or down.

- Body movement is the movement of the robot which includes speed and orientation. The robot that is used for the experiment has four different speed levels. Each level is measured before the experiment to consider the delay time (signal from the controller to the robot) and the result is shown below.

- Active movement is an action that a controller makes to initiate, trigger, and involve interaction or vice versa. A specific targeted entity to interact with exists. Eg. approaching others, leaving from others.
Passive movement is a movement to react to a human being’s approach or a movement which is irrelevant with interaction. It can be made during interaction but also when the robot is not involved in any interaction. Eg. turning to answer a question or changing orientation slightly or repeatedly.

Both active and passive movements can be applied to either head movement or body movement.

Based on the change of these parameters, the research aims to explore specific effects of proxemics and its movements to build a framework for designing a socially competent robot.

The proximity sensor on the robot that prevents collisions was turned off during the experiment.
4. Result

Over a span of six weeks, the experiment was conducted six times and the result of each experiment is shown below.

4.1 Arrangement (Semi-Fixed Location)

According to the proxemics interaction theory, an environment can be a fixed feature location such as a room or space, which is divided by a wall or a door. It can also be an array, which is a semi-fixed feature location. During the sessions, many different arrays of participants (groups) were created. Participants organized various forms by themselves according to the different activities. There were many arrays, but the six arrays shown below were the most common. It is delineated by figure 6 to help in understanding.

![Figure 6. Common Arrays (Semi-Fixed Location)](image)

In figure 6, the orange colored hexagons represent the robot and the green colored lines and circles are the groups of participants. Big circle arrays are generally used for starting and ending the sessions. According to the activity type, participants group into different arrays. If the participants line up like in arrays 5 or 6, participants are facing the robot. The robot will often stay out of sight in groups oriented like in arrays 3 and 4. The purpose of the movements is to get attention from the participants in order to lead the theatre group.
Weeks 1 and 2 were conducted at open sessions in setup 1. In the initial weeks of the iterative work, the main focus was the controller’s experience with the robot. The controller needed time to acquire fundamental knowledge and basic control skills to manipulate the robot. The controller had some time to learn how to control the robot and think about its movements before joining the session. Because there was no prior experience with any other type of telepresence robot, the controller needed some time to get used to the robot and set the appropriate moving speed, speaker volume, and microphone volume. Since the other participants in the theatre group session had no experience with interacting with the robot, it gained a lot of attention. The controller joined the activity, both with the robot and without the robot, for the first two weeks. The robot wandered through groups of people and around the room. As explained earlier, there are many activities that include the movement of different body parts, so the controller had some limitations when it came to mimicking others in the group. This challenged the controller to create different movements in order to join the activities. The controller observed others as well as themselves in order to build ideas on how to lead the group and join activities through the robot. The controller shared their newly developed ideas with the moderator.
By conducting the post interviews, the controller could improve different movements and implement them in the next session. The controller had no previous experience. Figure 7 shows the movements devised by the controller during the first two weeks. Movements were mainly devised to initiate attention. The images on top (colored orange) indicate that the movement is made in the robot’s intimate zone. The robot makes movements at the standing point. The images on the bottom (colored blue) indicate the movement is made out of the robot’s intimate zone; the robot leaves its standing point to do the movement. The speed level was fixed at 4.

<table>
<thead>
<tr>
<th>Speed Level</th>
<th>Time (sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Speed Lv.4</td>
<td>2.97–3.03</td>
</tr>
<tr>
<td>Speed Lv.3</td>
<td>3.61–3.87</td>
</tr>
<tr>
<td>Speed Lv.2</td>
<td>5.21–5.37</td>
</tr>
<tr>
<td>Speed Lv.1</td>
<td>6.57–6.69</td>
</tr>
<tr>
<td>Walking Speed</td>
<td>1.0–1.4</td>
</tr>
</tbody>
</table>

Table1. Padbot Robot’s Speed
4.3 Week 3

Week 3 observations were made during an open session in a setup 1 configuration. In week 3, the aim was to test if the robot could participate in group activities solely based on proxemics relationships. After the first two weeks, curiosity toward the robot had gradually abated. While the participants’ curiosity was not completely gone, they did not give any unusual attention to the robot like in the previous weeks. However, people excluded the robot so that it could not join any activities and consequently, it was not considered as an equal entity. While in the robot’s blind spot, some participants even stepped on or jumped over the robot’s bottom part when it stood in a queue. The controller could not find a way to show his intention to join a group through the robot. The robot also had difficulties when the arrangement of people changed and needed to stand in a newly formed group. When participants were sitting in a circle, the robot approached the other participants to indicate that the controller wanted to join. The controller moved the telepresence robot into the personal space of another person. However, the person did not show any reaction nor attempted to adjust their distance from the robot. None of the participants gave the robot space to join even though they realized the robot was standing behind them. The participant in front of the robot only looked back at the robot once. The robot stayed next to the participants but could not join the group. The session resulted in the exclusion of the robot from the ongoing activities. From this session, we concluded that human proxemics does not transfer easily to the interaction with a telepresence robot.
4.4 Week 4

Picture 7. The robot is standing in line to wait its turn

Week 4 observations were made during an open session in a setup 2 configuration. This week, the main goal continued to be for the controller to join as a participant. The controller was instructed to move the robot more actively and aggressively. The controller focused on controlling the robot’s distance from other participants. For example, when people organized themselves in the arrangement of standing in a line to take a turn, the robot also stood in the line and moved closer to the person in front of it to show that the controller had the intent to join.

Figure 8. Change of approaching movement

When the participants were sitting in a circle, the controller approached the participants to join in the same fashion as in week 3. However, the controller made a breakthrough in the robot’s motion. The difference was that the controller divided the movement into two. The controller approached the group a little bit, stopped, and then approached again. The controller did not modulate the speed level nor direction; there was just a pause between
movements. Surprisingly, this made people scoot over to make space for the robot. The strategy worked in several situations; the controller learned he could use this movement to show an intention to join a group.

![Picture 8. Succeeded in joining the group](image)

However, people still did not adjust their proximity in relation to the robot except for adjusting for the intent. The robot was still standing too close to the participant who had made the space; it was even touching the participant’s leg. The participant did not show any attempt to adjust the distance from the robot. This participant had never met the controller and had no experience with other telepresence robots. When asked if the robot making body contact was noticeable, the participant confirmed that this was indeed noticeable. The participant was also asked if the robot’s proximity was uncomfortable and would the previous answer change if it had been an actual human. The participant answered that it was not uncomfortable, but that it would have been quite startling if a human had stood that close. When asked to think about why they had not adjusted the proximity from the robot, the participant answered that the robot appeared to be a machine and that having body contact with the robot did not create any sense of unease. However, it would be different if it had been the head part (the tablet display) having body contact. This very interesting statement was explored further in week 5, in the same setup but with a different group of participants.
4.5 Week 5

Picture 9. Performing with a participant in front of others

Week 5 observations were made during a closed session in a setup 2 configuration. Week 5 differs from week 4 in that the session was not open to newcomers. All of the participants were regular members of the theatre group and had interacted with the robot before. Their former experience with the robot helped participants to interact more comfortably with and through the robot. In this session, the participants started to develop a role for the robot. The controller could join activities with ease. Since the robot was playing a role in an acting activity, people had to interact with the robot more closely and more often. However, there was no difference in proxemic interaction. Participants adjusted their proximity from the display only. This is in line with week 4’s discussion where it was stated that if the display was in close proximity, participants would adjust accordingly.

Figure 9. When a participant is NOT facing the robot’s display

Like week 4, the robot was often in other participants’ personal zones or intimate zones and people did not make any attempt to adjust their proximity. There were many instances of physical contact between the robot and the participants, but the participants did not adjust
the proximity between the robot and themselves. In figure 9, we can see that one participant’s foot is touching the robot but it did not bother the participant.

However, when the same participant was facing the robot’s display, the participant adjusted the proximity to an appropriate distance in the same way that would be normally done with other participants.
4.6 Week 6 (Leading Group)

Week 6 observations were made during an open session in a setup 2 configuration. In week 6, unlike in other weeks, the controller lead the whole session through the telepresence robot. When the controller leads the session, the main goal of the controller is to lead the group for two hours through the telepresence robot. There are many tasks to carry out in this role but in the grand scheme of things, the leadership role can generally be divided into two tasks. One task is getting attention so the controller can lead the meeting. The controller must have the ability to get attention from the other participants in order to instruct them. Eg. when the small activity time is finished, the controller will notify people that the time is over and instruct them to move on to the next activity. The second task is avoiding attention. During activities, the group leader needs to avoid attention from the participants. Eg. when participants group up with others and practice acting, the group leader wants to observe the activity to give feedback later but does not want to distract the participants at that moment in time so they can focus on the activity.

Since the robot was leading the group, the controller could decide more suitable activities that could be confidently instructed through the robot. The robot’s volume was a minor problem as the participants had a hard time listening to instructions. The controller successfully leads the entire session with the robot by using a combination of movements(Figure 7, 8). No distinct differences were observed.
The tendency to adjust the proximity from only the display was observed many times. When the robot was interacting with two participants, one part of a participant’s body was touching the robot. In congruence with past weeks, the participant did not attempt to adjust their proximity to the robot.

4.7 Group Interview

Following the session in week 6, a group interview was conducted. Thirteen people joined as participants. Before asking questions, the purpose of the recording and the research was once again briefly stated as well as a short message to encourage the participants to be honest since there was no notion of right or wrong in their answer. The participants’ answers were to be about the robot and not about other participants or their behaviour. Some coffee and snacks were provided to express gratitude to the participants. Two general questions were asked first to trigger a talkative atmosphere. These questions were “What is your
comprehensive experience with the robot?” and “What activities did you like to play with the robot?” More detailed questions about the specific phenomenon that were observed during the previous 6 weeks of sessions were then asked, such as “What was the reason that you considered the distance from the display part of the robot, but not from other parts of the robot?” with follow up questions according to the answers received.

The first two questions were asked to generate discussion and this method worked quite well. The first opinion given was about having negative feelings towards the noise of the robot. This produced a complaints session about some of the bad features of the robot which hindered people’s ability to concentrate on the activities. Even though the topic was focused on discussing the negative aspects of the robot, it made the atmosphere to where people could talk freely and everyone was able to actively join the group interview. When the actual questions about the observation results were brought up (“Did you realize that you adjusted your proximity only from the display and not from other parts of the robot?”), an interesting phenomenon was observed. One of the participants said it happened because they were concerned about the touchscreen. This statement caused many other participants to express their disagreement with the opinion. It was explained that they felt uncomfortable in keeping their heads too close to the robot’s face. Although the researcher asked the question using the term “display” and without using any words that could imply human body parts, people started calling the display part of the robot a “head” in their answers. One participant even made a metaphor between a human face and the display of the robot to explain why attempts were made to keep a certain distance from the display and not from other parts. One of the participants pointed to the camera on the display as the reason. It was mentioned that, regardless if the screen is on or off, it made the participant think that it was the part that the controller could see through. Seeing is a sense and that caused the participant to be more careful with the face, unlike the other parts. Other participants nodded their heads in agreement and added comments that the display is more like a human than the other parts.

To the follow-up question “Did you actually feel that the display was a face?”, many of the participants answered, “Yes.”, “Somehow...”, and that “The rest of the parts (except for the display) are things.”. These answers highlighted how they have perceived the display part as different from other parts of the robot.
5. Analysis

Ethnographic data collected through six-weeks of iterative work and its analysis deduced the following conclusion.

5.1 Proxemics Theory

![Proxemics Zone Comparison](image)

As it was explained in an earlier chapter, adjusting proximity from other humans is a prevalent cultural and natural behaviour. The size of the zone can vary depending on the individual and culture, but generally, if a stranger comes into an individual's personal space or intimate space, they adjust their proximity from the entity. On the contrary, an individual would go into another interactive entity's personal space if they were in a friendly relationship with them. However, proxemics interaction applies to telepresence robots differently than traditional proxemics theory. Participants did not attempt to adjust their proximity from the robot nor deter the robot when it came into their personal space or intimate space. When the telepresence robot moved from point A to point B to initiate conversation or join another group (array), it often failed at initiating interaction because people did not react to the robot being in their proxemics zone. However, when the controller divided the distance between point A and point B (hesitant moving), people reacted to the robot's movement and the telepresence robot could easily join the group. The hesitant movement did not make a difference in terms of getting attention, but dividing the movement showed that it is an efficient way to convey intention to other people. Even when the robot touched one participant inadvertently, the person did not move to adjust their proximity. It seems that proxemics theory applies to interactions between a telepresence robot and humans when the robot has a ‘face’. In this case, the ability to see the other participants seems just as important as to be seen on the screen.
5.2 Proxemics Pivot

People adjust proximity differently depending on which robot part is nearest to them. All the participants tended to adjust their proximity from the display but not from other parts. All the participants who had physical contact with the robot had it occur to them equally, regardless of their gender, age, and the relationship with the controller. This phenomenon was observed for the first time at the beginning of week 4 and was consistently observed for three weeks after the first observation. Since it was observed in week 4 for the first time, one might speculate that it emerged as a result of a fortified affinity that gradually grew between the participants and the robot over the repeated tests. However, the participant who was observed in week 4 was a newcomer to the session and had no experience with either the robot nor the controller of the robot. Hence, it is more likely that the behaviour emerged this late because it required the controller to be accustomed to controlling the robot’s movement.

Participants perceived the robot as an object; almost like it was a piece of furniture. On the other hand, many participants perceived and recognized the display as an entity when they interacted with the robot. Many participants delineated the display as a “face” in the group interview. Some of them even used the term “respect” to explain why they tried to keep a certain distance from the display. This means that traditional proxemic interaction cannot be applied to a telepresence robot when the pivot (standing point) is a standard of measurement for distance. However, it can be partially applied depending on which component of the robot is being observed, even though the component is a part of a single entity (a telepresence robot). In this research, the display was the only part that people adjusted their distance from. Other parts, including the speaker and the body, were not influenced by proxemics. The researcher defined this zone that proxemics interaction is applied to as the proxemics pivot. The proxemics pivot is the part that people perceive as a standard point when they adjust the proximity between the robot and themselves. It also can induce people to adjust the proximity between the robot and themselves.
6. Conclusion

Overall, the results indicate that social distance or interpersonal distance does not influence proxemics in human-telepresence robot interaction as much as it influences proxemics in human-human interaction. In this research, people perceived the display part of the telepresence robot as a proxemics pivot and they adjust their proximity accordingly. It also implies there is a way to control the proxemics of a telepresence robot by adjusting the proxemics pivot.

6.1 Suggestion

In the area of robotics, there has been a recent surge in interest and research in the human-computer interaction perspective. This research set a telepresence robot in a real user environment to observe proxemics between humans and a telepresence robot through long-term ethnographic data collection. This allowed the researcher to observe how humans act and react to a telepresence robot differently from when they interact with other humans. In particular, by applying proxemics theory, this research could examine how human beings perceive a telepresence robot. However, due to practical constraints, there are some aspects that could not be provided through this research that the researcher originally intended to have. The researcher would like to organize these aspects to foster future research and projects.

6.1.1 Reflection of cultural difference

The research did consider the influence of cultural differences. As previously stated, there are limitations made by cultural differences in defining the size of the proxemics zones. The distance of the zone can vary from culture to culture. Ergo, it was difficult to generate an appropriate method to observe proxemics between human beings and a robot. However, controlling physical distance according to the social distance is a prevalent action of human beings. Therefore, the influence of cultural differences was not a problem in this research since this research discusses the applicability of proxemics theory to a telepresence robot and the data collection focused on observing the participants’ perception of the robot. In the detailed design of telepresence robots, it is still recommended to review data about the relation between different cultures and social distance to reflect the cultural difference.

6.1.2 Decide on an appropriate model of a telepresence robot

What the researcher wants to say through this research is, solely copying or mimicking humans may not be the only solution to designing a better robot. It can be different from the humanoid robots and could have a different role with its own character and potential. A telepresence robot can be used in the medical industry, such as for the treatment of patients who suffer from mental disorders or those who are afraid to interact with other human beings. In short, “Let’s expand the applicability of a telepresence robot in the HCI perspective.” is the message that is being conveyed. This feeble telepresence robot was enough to conduct the research even though there were problems with noise, speed,
connectivity, speaker, and size. However, there are many different types of telepresence robots. Their size, ways to move, and shape are all different. It is desirable to replicate these results with a more robust robot. Most of all, it will create less stress by dealing with a less clumsy robot.

6.1.3 Defining the causality in depth
The aim of this research is to help develop a socially competent robot. In this work, the central question relates to how people act and react to a telepresence robot. This research did not attempt to figure out which factors that could influence participants’ perception, eg. exterior design, interactive features, etc. It is an interesting research question that could be answered with further research and the conclusion would be an asset in developing and optimizing a robot.

6.1.4 How and where to optimize a proxemics pivot
This research observed that the proxemics in human-telepresence robot interaction can be changed by focusing on different parts of the robot, even though the interaction is between the same entities under the same environment. The research defined the part of the robot that influenced proxemics in a human-telepresence robot interaction as the proxemics pivot. The part that reinforced people's proxemics in this research was the display of the telepresence robot. Accordingly, there is a high chance that the display is capable of reinforcing or abating people's proxemics under certain conditions. This research did not make a comparison by using different display conditions. Namely, we don’t know how a proxemics pivot can be optimized. There are many questions which are not answered yet. Can there be more than one proxemics pivot? How does increasing/decreasing the size of the proxemics pivot fortify the proxemics interaction? How can removing a proxemics pivot influence the interaction? Further research can explore these questions through adjusting the display part of the telepresence robot by changing the size, angle, visual information, location, and/or number of displays. This will allow us to see how a proxemics pivot can influence proxemics. Furthermore, how it can be optimized to design better robots for different purposes. Proxemics interaction contains many clues on how to interpret non-verbal communications such as action, intention, and social signals; proxemics pivot is a predominant factor of proxemics interaction. It can contribute to psychotherapy by delivering the next generation of robot-enhanced therapy. It can make an advanced multimodal emotion recognition technology which could improve a robot’s ability to understand human behavior and context even better. The applicability is unlimited.

6.2 Reflection
The reason why the introduction chapter started with a question about the identity of a telepresence robot is to explain why this research matters but also to induce a curiosity about a robot’s identity. This is to help reconsider the general concepts and notions about robots and their future. This research shows that a telepresence robot can evolve in a different way; as a single type of media that has a separate existence that is different from a human’s existence. To build an entity to substitute one’s self, or beyond that, to substitute humans is a long time dream and desire of the researcher. But that doesn’t mean to design and build a
robot that simply copies how humans do things. Consider the 20th century drawings of future technology that now exists, such as cleaning robots. The artists had lovely imaginations but the design evolved in a more efficient way than what they had envisioned.

The researcher is not against the development of humanoid robots. However, humanoid robots are very expensive. Most researchers can not afford one to study with and there is a very low chance that people would face a humanoid robot in their daily life as long as they do not visit a humanoid robot convention. Owning a humanoid robot would be too expensive for the average consumer and if someone did own one, they wouldn’t leave it outside without guards due to the danger of it being stolen or vandalized. This means the average person will not even come close to interacting with a humanoid robot.

HCI is a discipline to see technology in a human-central perspective. To make robots capable of entering society smoothly, people need to reconsider what a robot is and review what its future is in multiple dimensions. This is a key to designing a better telepresence robot for the present. Mimicking humans is not a requirement and it is not the only way to develop and evolve robotics. It is the researcher’s hope that this research becomes a legacy to design a better telepresence robot and that further research can be made based on this idea.
Acknowledgement

When I wrote the following page in Sweden, a civil action for impeachment was arised in Korea; where I was born.

There were many obstacles to complete this paper. I am thankful for publishing this paper finally. Many thanks to my supervisor, Annika. She is a person who always motivates and supports me. She makes me agonize over what kind of person I should be. I hope I can be a person like her someday. Mythbuster Friedrich; he gladly participated in my research as the robot controller. I believe I am very lucky to have had him as a participant. My best friend Liz; She stays positive and kept me positive as well during my research. My lovely corridor mates; they are like family to me since I cannot go back to my country and were the source of my happiness during this semester. Thank you my Flogsta family. My sister, SinHye; she is a teacher in Korea. I hope she will continue to be a great teacher who can give not only the knowledge to know what is right, but also the braveness to follow the right path. My mother; you often tell me that you are sorry to have had me in a poor family and cannot support me as much as you had wished. I respect you and admire you. Do not be sorry anymore and let’s live in appreciation. My father; I hope we can live in the same country together in the future. My grandmother; it is hard to be ready to let you go especially when I cannot be next to you. I am so sorry. I love you and I miss you. I appreciate to many more people and promise once again that I, as well as my knowledge, will be used to make a better society; more so than my personal wealth or specific groups/nations.

Even at this moment, I am learning more and awakening myself to truth. I await the day that individual choice and rights are not threatened by the government and authority in Korea. We are not born to be afraid nor punished. We are not a machin which must be efficient and productive for the country. Do not let patriotism obtrude and interrupt your will. Freedome and libery were given to us since the day we breathe.

I sometimes wondered that we can be so frivolous. But now I guaranttee we can expect a better world. I know a man who was born in a tiny ghetto in Korea. He was starving, a victim of a crime, wounded to near death, dropped out from a middle school, having a hopeless life and thinking to suicide. But now he is writing this chapter. Expecting a better society is nothing differ from expecting a better life. Like David H. T. said, “Who shall say waht prospect life offers to another?” Just incessant effort is needed. A great country is the result of moral and inteligent actions.

This paper is written in Uppsala, Tokyo, and Portland.
Reference


Resource

Picture 1: Robot Balance Test (Introducing Spot/ https://youtu.be/M8YjvHYbZ9w?t=28s)

Picture 2: Robot Dogs Funeral (Toshifumi Kitamura / AFP / Getty Images)