PERSUASIVENESS OF SOCIAL ROBOT ´NAO´ BASED ON GAZE AND PROXIMITY

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List of Abbreviations

- HRI = Human-Robot Interaction
- ANOVA= Analysis of Variation
- HCI= Human Computer Interaction
- HHI= Human-Human Interaction
- AI= Artificial Intelligence
- GPS= Global Positioning System
- LED= Light Emitting Diodes
- GUI= Graphical User Interface
- HD= High Definition
- PC= Perceived Competence
- C-CODE= Communication, Computing and Digital System

Statement of Original Authorship

The work contained in this thesis has not been previously submitted to meet requirements for an award at this or any other higher education institution. To the best of my knowledge and belief, the thesis contains no material previously published or written by another person except where due reference is made.

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Abstract

Social Robots have widely infiltrated the retail and public space. Mainly, social robots are being utilized across a wide range of scenarios to influence decision making, disseminate information, and act as a signage mechanism, under the umbrella of Persuasive Robots or Persuasive Technology. While there have been several studies in the afore-mentioned area, the effect of non-verbal behaviour on persuasive abilities is generally unexplored. Therefore, in this research, we report whether two key non-verbal attributes, namely proximity and gaze, can elicit persuasively, compliance, and specific personality appeals. For this, we conducted a 2 (eye gaze) x 2 (proximity) between-subjects experiment where participants viewed a video-based scenario of the Nao robot. Our initial results did not reveal any significant results based on the non-verbal attributes. However, perceived compliance and persuasion were significantly correlated with knowledge, responsiveness, and trustworthiness. In conclusion, we discuss how the design of a robot could make it more convincing as extensive marketing and brand promotion companies could use robots to enhance their advertisement operations.

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Chapter 1: Introduction

Social robots are becoming very popular nowadays due to their versatile applicability nature. They are being used in varying places, from private use to public spaces (Shiomi et al., 2009). Social robots help assist in regular duties, but they also influence decision-making through verbal and non-verbal gestures.

As the application of social robots is at its peak, researchers from Human-Computer Interaction (HCI) and Human-Robot Interaction (HRI) are focusing on how to make a social robot more user friendly (Han, Jo, Park, & Kim, 2005). Usage of natural human-like attributes and characters makes the robot more familiar to the human being. This includes different body languages, verbal communication cues and techniques, and many more. Although verbal usage of a social robot as a persuasive nature is quite common (Mavridis, 2015), it is fascinating to see how a social robot such as Nao can be made effective based on using non-verbal gestures and proximity factors.

This chapter outlines the background (section 1.1) and context (section 1.2) of the research and its purposes (section 1.3). Section 1.4 describes the significance and scope of this research and provides definitions of the terms used. Finally, section 1.5 includes an outline of the remaining chapters of the thesis.

1.1 BACKGROUND

In persuasive technology using social robots, the use of verbal gestures as a communication tool is quite common. We can witness quite much research done (Mavridis, 2015) and still being made in social robotics based on verbal gestures (Dautenhahn, 2003). One practical and most widespread persuasion mechanism is verbal media; non-verbal communication and gesture´s use was often neglected. That the study on the effectiveness of proximity between the robot and communicating party in conjunction with non-verbal gesture is quite a rare sight.

1.2 CONTEXT

As we are aware of the fact that the verbal and non-verbal communication is equally important in the field of persuasion (Ham, Cuijpers, & Cabibihan, 2015), we must admit the prominence of physical distance i.e. proximity between two/more communicating parties. A lot

of studies (André et al., 2011; Mavridis, 2015) have already stated that non-verbal gestures techniques in robotics are very crucial in persuasion process through compliance and various personality appeals. Similarly, how the varying proximities have different effects in the field of robotics specially in the field of robotic persuasive technology.

Discrete studies on persuasion primarily either based on verbal/non-verbal gestures or varying proximities are equally important on its own. We have a big void of studies in the field where earlier two techniques and combined as an integral part of study (Chidambaram, Chiang, & Mutlu, 2012). The area of concern is the need of studies based on social robotic persuasion using most common non-verbal communication gesture i.e., gaze with varying proximity factor i.e., distance between communicating objects.

1.3 PURPOSES

Social intelligence is a phenomenon long defined and known to human being and animals specifically (Whiten & Van Schaik, 2007). With the rise of robots and their applicability in our daily life, a need of such phenomenon deemed essential in robotics as well. There are various way of showing such a characteristics by a robot but most easily understood and effective would be to mimic human nature of showing social intelligence (Kozima & Yano, 2001). Persuasion is a technique not only used to put the idea of one into other´s perception as a viable idea but also has been used to achieve compliance and reach on the final agreement easily (Fogg & Eckles, 2007). Exhibiting such psychological traits is certainly a sign of positive social intelligence. If a social robot can effectively show such a feature of mimicking psychological attributes then not only will it aid in Human Robot Interaction and design and production of commercial robot that is capable of Artificial Intelligence in a certain limit(Kaptein, Markopoulos, Ruyter, & Aarts, 2011).

It all comes to the natural interaction a robot presents while interacting with a human-being to be more persuasive and effective(Michalowski, Sabanovic, & Michel, 2006). Various use of verbal and non-verbal technique for the persuasion has been used in natural interactions. Verbal interactions techniques such as speech, pitch, loudness, flow, etc and non-verbal communication techniques based on emotions, postures, gestures, etc (Lee & Liang, 2019) has been studied and used in the field of HCI and HRI for the purpose of effective communication and interactions. The strategy of using verbal phenomenon is quite common in human history and so it is in

robotics as well. There are a lot of advancement being done and a lot still in progress to use natural speech pattern in robotics. The more human-like speech a robot can exhibit, better the perception of speech to the other interacting entity and thus more effective the communication is (Siegel, Breazeal, & Norton, 2009). Having said so, we can see that must had been a lot of scenarios where verbal communication were not possible if we see the history. In fact, non-verbal communication was more popular if we look at the past when standardized language were not well-established. So, we intend to see how a robot persuasion works using strategy where verbal techniques are avoided. Specifically, using gazing technique where robot make eye contact and maintain the eye contact throughout the conversation to the other entities.

Chapter 2: Literature Review

2.1 BACKGROUND ON SOCIAL ROBOT AND PERSUASION

Persuasion is an essential component of where and how user interacts. Now a days robots are growing rapidly in different sector of industry where they have gaining aptitude to persuade will be essential to interact with human effectively(Li, Cabibihan, & Tan, 2010). Social robots are gaining their space in mainly in information technology, mechanical engineering, healthcare, education, manufacturing business etc (Heerink, Vanderborght, Broekens, & Albó-Canals, 2016; Leite, Martinho, & Paiva, 2013). Social robots are referring to interaction with human through the human behaviour in society. Scientists are extremely careful during implementing the different type of persuasion to robots and they are concern about the senseful moral response toward the human.

The most significant distinction among industrial robots and robots that operate in everyday life is one of engagement with human and their behaviours (Bartneck & Forlizzi, 2004). The robotics technology is booming and in daily schedule of different task, first a robots need to consult or programmed by human, but the stage of self-starter robots is developing. As we discussed above that the study of social robot are increasing rapidly and way of interacting with human are changing, there are few measurable symbolic persuasions for robots which make the human-interaction more efficient which comes under the Gaze, gesture, Gaze, Proximity, and a Vocal Expression, moving head while talking with human, Gesture when listening to human, looking at eye / face while interacting, Use a different symbolic or oral gesture, etc.

The engagement of the human with the robot depend on the sexuality of participant and the robot .The people are more engaging when the robot is of opposite sex (Tay, Jung, & Park, 2014). To make the robot persuasive, trusting beliefs should be component that will convince the interactivity. Robots are more effective when it comes to assisting human with the true facts rather than with false information. Robots has been used as a museum guides, providing information etc., as they are not only good with providing information but also can hold rhetorical ability. The robots which are designed to pass the rhetoric information , has capacity take information like metaphors (Andrist, Spannan, & Mutlu, 2013). As the Robot are mostly used for assistance purpose (Heerink, Krose, Evers, & Wielinga, 2009) , it is vital to give out the correct information to users. In order to make Robot trustworthy and persuasive they are

designed to process the complex, twisted metaphors, good fluency and be social. It is still in progress to make the robot interaction as experts working on the number of cues. Persuasion depends on the factor like good non-verbal communication that the expert human use to convince another human. If all the factors such as eye contacting, when necessary, proper guidance not only intending to provide right information, rather using rhetorical ability. Establishing a feature of persuasion in Robot completely exert then a simple malfunction can be dangerous.

Gender and the facial expression of the robot plays a crucial role persuading human (Cameron et al., 2018). It was found that the interaction between the opposite sexes was more active. The facial expression of trustworthy robot was found to persuade participant quickly and completed while the one with less worthy face was repelling its participant. Cultural difference also contrasts the persuasion of different background country. If the robot appearance is like their background, then participant is more likely to interact with that robot.

2.1.1 Social robot

In a simple term social robot is an Artificial intelligence (AI) that is design to interact between the human and robots to complete the potential jobs. Form the past history social robots has been made an immense growth and drawn the increasing attention in the field in Computer vision, communication between human and technological artifacts (Bishop, van Maris, Dogramadzi, & Zook, 2019). Social robotics has drawn the increasing attention in the field in Computer vision, communication between human and technological artifacts. It is assuming that the interaction between the robot and human will be different in future because of technological advancement.

The idle idea of social robot is associated with belief that robot will adopt and display the human and social behaviour. It is also belief that, robot can be develop equally to human brain through the cognitive behaviour and able to understand the context of the situation (De Graaf & Allouch, 2013). In order to interact with people like human-manner, the social robots need to understand the complexity of social behaviour, speech, facial expression, language, and emotion to display the person identification, recognition, and emotive expression. In addition, human awareness is not limited to cultural, historical, and situational context (Solomon, Greenberg, Schimel, Arndt, & Pyszczynski, 2003). It comes with individual understanding of person behaviours, emotive state, and ability to deal with human being. Let us take an example of human cognition robot, the cog is an invention of robot which helps to understand the human cognition. This robot can easily manipulate the objects, focus on its goals, and easily adopt in

face detection and object segmentation. Similarly, in public places or domestic environments, there are some socially assistive robots that serve people. They are closely related to human life; these robots possess enhanced recognition abilities and social cues. Additionally, due to the distinction between public and private environments, the perception tasks are distinct (Kusumowidagdo, Sachari, & Widodo, 2015). Human can easily develop and guess the event that is happening near to their environment, but robot sensor provides some limitation so it cannot be able to make strategy and decision, same method as human in wider environment. However, the advancement of technology has developed the sensor distributes networks which covers the high level of functionality which are currently using in society.

2.1.2 Human Robot Interaction (HRI)

Robot requires an information of environment, people daily life to behave intelligently. Basically, the human-robot interaction starts with human-like body movements such as: - shaking hands, greeting, gestures, and holding hands. Such natural interaction is useful for improving the friendly behaviours towards the people. Robots' behaviours are decided by the periodical rules that are stored data in database that direct through the sensors (Jalal, Nadeem, & Bobasu, 2019). If database store the behaviour with Child interaction than robot follows the data accordingly such as: - Engaging the child with child-like behaviour by hugging, playing games, smiling, and handshaking.

While demonstrating that robots may provide social indications to human communication, where a machine learning is a new dimension in HRI. Similarly, self-learning for social robots is a critical component of cognition factor, which has a very minimal impacts towards machine learning. Navigation and manipulation are the very first area of the robotics, they have been in using form long time in the different industry which is rapidly impactful on the manufacturing and production line. Still there is a vast gap between a human like robot and the simply working robot in recent era, whereas many scientists from different county are working to fill that gap which helps them to find out the key unit to develop a human-like robot which is called a social robot with human-matching persuasion (Ghazali, Ham, Barakova, & Markopoulos, 2018).

We can find a different domestic type of robot which has been developed in Japan such as: The technology company Sony developed AIBO (Veloso, Rybski, Lenser, Chernova, & Vail, 2006), Honda developed ASIMO (Sakagami et al., 2002) which is categorised as a child-like robots.

2.1.3 Potential threat in Human-Robot Interaction

The topic of social robot is becoming the emerging debate topic in both academic and non-academic environment. It is becoming a cutting-edge research field in various environment such as computer science, military application, research project, hospitals, commercial and so on. Due to the advancement technology, robots have contribution its impact to serving, enhancing and facilitating human life. However, there have been many incidents, which have caused serious injuries and devastating consequences such as unnecessary loss of life, malicious deportation and control of robots and serious financial and economic losses (Giger, Piçarra, Alves-Oliveira, Oliveira, & Arriaga, 2019).

2.1.4 How social robot are being used in public space.

Military and law enforcement fields

As an artificial intelligence, a concept called autonomous power has been introduce in robotics, which is represented as morally active and responsible while learning and making an effective action (Taipale, De Luca, Sarrica, & Fortunati, 2015). Exceptionally on military robots, which are hugely presented by countless militaries all over the world. The robot called SWORDS (Special Weapons Observation Remote Direct-Action System) developed by Foster-Miller which can carry a different type of guns and required equipment (Singer, 2009). Whereas the SWORDS can be used as a location tracking device (GPS) to find a secure place or a measurable distance in war zone. Similarly, the Phalanx is a missile ship device which has been in operation by the U.S Navy in last 80's. we can identify a security guard robots develop by Samsung which has an auto enable to fire a gun in required situations (Roff, 2014), the era of using robots in war are majorly developed as autonomous, mobile robot with gun with the ability of scanning the danger zone.

Agriculture

In the field of agriculture, the robots are emerging gradually with a significant progress in cluttered environments, autonomous navigation, and dexterous handling. The further application of robots is emerging progressively as an extension to precision agriculture, food processing, packaging, and high-rise storage of food before rolled out in table-vegetables crops and orchards. Robots is coming up with its remarkable impacts and implications by increasing the performance when comes in dealing with a large farming area (Bogue, 2016). Robots has brought numerous advantages but in other side, still majority of farmers are no able to adopt

the concept of advance technology. The vast majority of consumers possess robot as a threat which eliminate the significant need of agriculture labour and eliminate the jobs in rural areas (King, 2017). In addition, the robots may exacerbate inequalities of wealth in rural areas, might possess thread in lifestyle, flexibility of work, and reduce the labour intensity.

Robots in industrial sectors

While we talk about the industrial sector there are multiple field such as banking, education, manufacturing, farming, production line etc. AI and auto farming have been in fast phase on the production of different Corp with the special care of their quality. The introduction of advanced robotics technology has made it easier to apply such approaches to farming procedures. Robotics in farming is more focusing on replacing the iterative, process-oriented and the time-consuming task (R Shamshiri et al., 2018). Different banks are using robotic system to solve a customer-based issue and providing the information regarding bank balance, last transaction, interest rate for different type of loans, bank statement etc, which is a cost-cutting method and an IT oriented service for the customers.

The value of social robots in assisting children's education, it has a significant contribution to a variety of human-centered tasks in education for instance preparing a manual for teaching, supporting to record video on specific book as a tutorial for children as well as adults. Checking a computer-based exam and providing a result. In other parts the social robot on education has an impactable issue as well (Belpaeme, Kennedy, Ramachandran, Scassellati, & Tanaka, 2018), robots need to be a smart to provide or teach a smart type of children and as robots has no emotional sense, so it has been taken a risk to provide an education for disabled child with different gender (Diep, Cabibihan, & Wolbring, 2015). Some of them can provide a flow of information which cannot be acquire by children so they must be aware about the limitations of information to flow.

Production line is a joint task operation which has a multiple sites and multiple robots working on it with different programming (Singh, Sellappan, & Kumaradhas, 2013). In this area robots can be used from simple assembling task to complex re-engineering process such as binding an engine of an aeroplane.

Medical Field

Robots' technologies are taking a paradigm shift in therapy. The reprogrammable multifunction manipulator robots are design to transfer the materials, tools and many other specialised medical devices to perform different task such as surgical task, biopsy, brain

stimulation, and radiosurgery. Moreover, In Medical fields robots are designed to perform a virtual care, remote treatment concepts, helps in delivery the medical supplies to nursing stations in timely manner (Lane et al., 2016). Robots are not only used in operating room but also has played a remarkable role to support health workers and enhance the patient care. Now a days robots are quite popular in handling, updating customer information, inventory management and distributing medications. The use of robots in healthcare is in increasing trends. In 2000 the first surgical robots were introducing name the da Vinci Surgical System to perform surgical procedures (DiMaio, Hanuschik, & Kreaden, 2011). Due to the advancement of robots, todays many healthcare assistants can walk, and able to do their normal day-to day activities.

Counter-pandemic field

With ongoing pandemic COVID-19, the extensive use of robots cannot be denied. The adoption of Artificial intelligence and Machine learning are used in faster detection of infected rates and helps to reduce the impact of those viruses (Javaid, Haleem, Vaish, Vaishya, & Iyengar, 2020). In 2020 May, the "Anti-COVID-19 volunteer Drone Task Force" robot was established in New York urge people to maintain social distance, and general guidance of the COVID-19 (Agarwal et al., 2020). Similarly, different other countries such as UK, France, Hongkong, Korea, japan adopt the different robotic technology to make people awareness, spray, and disinfection, and supply medical testing. Different medical emergencies were carried out by robots to reduce the direct contact of medical staff. In china the "Xiao Bao" and "Companion robots" robots are introduced to come over the loneliness of the people (Bao et al., 2013). These robots in china were introduced to minimise the exposure areas and deliver the medicines and helps in detecting the early sign (Zeng, Chen, & Lew, 2020).

2.2 GAZE: -

Any social interaction requires certain amount of verbal or non-verbal communication between the interacting parties. Whether it is a verbal exclusive communication or non-verbal based communication, some sort of signal and gestures can be often found if the communication is held on natural social interaction scenario. Like we´ve just mentioned, signalling and gesturing are some crucial aspects in non-verbal communication (Phutela, 2015). Gaze could be used not only to perceive information from the other interacting entity but also relay information via signalling. Although signalling has its own area of application in Human Computer Interaction and Human Robot Interaction, our focus is on gesture and more precisely

gaze. Gaze is a phenomenon often occurred in natural human interaction from which it is inspired and adopted to HRI as well, it requires eye contact between the interacting entity for a certain period of time (Foulsham, Walker, & Kingstone, 2011). The timing and duration of eye contact to exhibit gaze depends upon the purpose of the communication and situational variation of the environment (Willemsen-Swinkels, Buitelaar, Weijnen, & van Engeland, 1998). If the communication initiator is trying to persuade user to achieve some compliance through trust, then the gaze is expected to be continuous and usually longer. Alternatively, if it is a casual interaction to fulfill common social interaction without any predefined purpose then there might be discreet gaze action usually for brief period.

Now, social robotics is come very close to the human behaviour and communication strategies that have been in used in persuasive interaction. As most of the ideas in robotics are originally mimicked from natural social interaction it is always interesting to see what Persuasive strategies may include in robotics and how many strategies for robots are good enough. The focus on social robots where the robots can be used effectively are evident. There are variety of persuasive strategy which can be implemented on robots but to make effective we are using Gazing and Gestures. Here we are investigating the basic ideology that binding more than two persuasive strategy is resultant or not. (Ham et al., 2015)

Multiple separate experiments found evidence that direct gazing and touching may raise compliance with obvious request of co-ordination with human being. It was determined that behavioural responses of social robot with human are based on the attention and arousal caused which can be measured of different persuasive strategy. According to the hypothesis, the functional significance of both gaze and touch is to increase the level of subject compliance. (Kleinke, 1977)

Robots are increasingly utilized in various areas, including the needs of the different social sector. The findings did not represent the numerous familiar impacts of eye contact. As with signals, gaze cues such as eye contact happen simultaneously with the spoken communication. Robots, being physically incarnated entities, can roam around in congested situations with the opportunity to gives the information everywhere. If a robot has a humanistic structure, it can use semi life form signals to improve its communication much easier and suitable, that will allow a human being to understand and see the robots without any negativity. Throughout a discussion, gaze could be used to convey familiarity, distinctions in social standing, or emotion. (Van Dijk, Torta, & Cuijpers, 2013)

Robots can express emotional responses, which facilitates social robot intercommunication. In this domain, the NAO robot is a commonly utilized technology. They display sentiments mostly through gestures and coloured LED eyes, while being unable to portray body language because of its different joint in body structure but the capacity for emotion detection as well as expression is a critical component of human–robot interaction. Facial expression in establishing social bonds via face and body gestures is seen as being very important. In contrast to the gentle and attractive movement of human and animals, certain social robots can demonstrate a specific set of facial gestures or act unexpectedly and strangely. A current approach in social robotics emphasizes on system deployment is the factor coding of robot behaviours. Furthermore, one robot's activities can be easily transmitted to other robotic system without modifying the programming. (De Beir et al., 2016)

As developing technologies such as social robots grow more intimate and convincing, concerns need to be answered about how individuals interact socially, what elements enhance the interaction, and what defines the positive influence of the robotic interaction. The last several years have seen growing numbers of mainstream media representations including human encounters involving social robots. A lab experiment was done to evaluate connections among individual variation, verbal, and kinematic signs of robotic systems. Television programs like Westworld and Humans have raised significant debate regarding distinguishing people from machines. (Xu, 2019)

In Knowledge model defines essential frames for specific program, robots, stances, gestures, and robot behaviours. Those system uses the own face approach to identify the person. Hand and face positions can be segregated from the camera frame buffer using the skin tone data of the subject and categorized by a subdomain approach. Because of Increased demand for social services for the elderly and the disabled in the circumstance of declining modern generation, the robotic system in social welfare are extensively researched. It is essential to build realistic communication between social-robot and human to achieve a sustainable relationship. (Hasanuzzaman et al., 2007)

A particular emphasis on how it can be used to characterize social behaviour and the results that result from certain behaviour. Nonverbal immediacy metrics are offered to characterize behaviour of robot social in human interactions. Numerous academics has started to explore specific forms of social behaviour in human–robot interaction in education sector. The human–human interaction (HHI) literature indicates that as awareness grows, so

does intelligence, but this conclusion has not been confirmed with robots. (Kennedy, Baxter, & Belpaeme, 2017)

During communication, individuals utilize imitation to inspire one another. The robot could be controlled in one of three ways: by copying full head gestures, by replicating portion head gestures (nodding), or by not replicating at all (blinking). We also conducted gesture analysis to check whether there were variations across genders, and found that when human interact with robot, male produced considerably higher movements than female. (Riek, Paul, & Robinson, 2010)

2.3 PROXIMITY

Proximity is an intelligence of robots, it can tell and identify the object take a required action, judge the situation accordingly (Malm et al., 2010). Proximity can be able to fill the gap of safety measuring, object-oriented act in industry and performing various activities in different geo-location. Safety application can be implemented while working with power tools such as Ceramic tile cutter, when working cutter makes job easier but it may harm and create collisions, to avoid that we can use the capacitive sensor, which help to detect the object and auto shut-down the tool (Maurtua, Ibarguren, Kildal, Susperregi, & Sierra, 2017). In a finding of different article (Haddadin et al., 2011), the avoidance of physical injury is major aspect in robotics, so that robot science is extremely careful in the case of safety sensor. When objects are movable, the processing becomes even more hazardous.

2.3.1 Robotics and its proximity with human interaction.

Robots can operate through the different sensor of proximity; some proximity sensors are briefly pointed out as follows: -

Proximity in Sensing:

This a one type of proximity sensor which is helpful for the robots to understand the surrounding situation in working area. It has a different type such as hearing outer interface sound, detecting touch object, and observing the scenario through vision (Cheung & Lumelsky, 1989). To maintain the safe distance while communicating, some system needs to be setup within robots, which helps to identify how close it needs to be with human. Motion detect system is a vital to maintain distance. The activity needs to be smooth with different gesture and robots need to be programmed with required direction about the using of gesture while it is

too close with human or too far with any kind of communicating object. Those gesture may be like pointing for short period of time, moving a hand, or moving robots itself. This provide a confidence and assure to human that the robots are safe to communicate and working together.

Proximity in Distance:

This proximity comes under safety measurement for both human and the robots. It mostly includes the physical safety, such distance measuring while working in certain place by robots. There is no regular human interaction with fixed robots or with mobile robots, especially those who are not in the robotics sector they never faced with robots, which can be categorized as expert and non-expert. The height of the robot and the positioning of the operator is a factor of communication with human and it make sure that a human is comfortable while communicating (Rae, Takayama, & Mutlu, 2013). Because of non-experts the scenario may create an anxiety, awkwardness, and fear with human. The position of robots such close interaction, long distance interaction, communicating while sitting, communicating while standing with different posture is an approaching element with human. Close proximity has a higher ability to make a promising improvement in human-robot communication (Chidambaram et al., 2012).

It has been always challenging part to share and collaborate the work, study place with robots, so there is different aspect which leads to be a good and safety collaboration between human and robots. The maintaining distance between robots and human may help to:

- *Safety Plan:* Identifying the potential danger is a process to avoid it, operation failure in human and social robot environment interaction should be analysed with proper specific procedure. Operative risk analysis and human activity are the approach that are being used to identify the risk. There is a HRI strategy to measure a safety with the environment, which are the impulsive factor to make an effective decision while working with robots in shared space.
- *System control design:* The development of inclusive control design for the prevention of danger can be take in following outline can be reviewed. Such as proximity detection, collision avoidance, docking and compliance control. Recent control in robot's technology has an improved and guarantee safety.

2.3.2 HRI in Risk-based methods and policy:

As technology is booming and the robots are taking a place of human working space, and this must be concerned with different factor of safety. The common strategy to avoid the collision is control strategy as it helps to manage the movements of robots which surely helps

to decrease the impact of danger. Apart from that the robotics proximity sensors are in use to avoid different type of danger in workspace, such sensor is like a laser beam to identify the detect of any existence (Rezazadegan et al., 2015). A real time object identifier setting in the robots helps to reduce risk. Real time object detection can be robotics environment where a human interaction can work safely. Velocity obstacle setup, which is used to find and observe upcoming collision. Docking is also a helpful method to avoid a risk while performing the highly risk task. The HRI risk-based task can be avoid with other different methods like position control, movement control, object scanning methodology, sound-based control to make safe work environment with human.

2.3.3 Proximity in private space and public space

Proximity can be detecting by using the control design system where it might be a task for individual or supervision. Robot used in public space and private space can be identify as a train station, airports and public spots can be taken as a private while organization rest room, hotel service, robotics car can be taken as a private spot. We can take an example of Covid-19 pandemic and lot of airports are closed and few are in operation with the help of auto printing or a contact less self-service kiosk machine. AI, which is an emerging technology, is used to implement a certain strategy to identify the covid interaction people, tracing it and maintaining the contact less communication. In this case we can use different proximity to avoid the danger while communicating and working with the people in workplace (Yang et al., 2020). Users should be allowed to set their own proximity detection thresholds, rather than having a universal level that is set for everyone. The reason for this is that normal optimal performance is not operating properly.

2.3.4 Nonverbal Communication and persuasion

Certain non-linguistic actions, for instance voice quality, body gestures, touch, and usage of individual space proxemics, tend to play a significant role in communication, according to recent research (Steels, 2005). Relations are regulated by nonverbal communication, which may be used to supplement or sometimes even eliminate verbal conversation in a variety of contexts. Gender and cultural variations in nonverbal communication can have an influence on the nature of human interaction because they can alter the way people interact with one another. Nonverbal communication has the potential to either create or dismantle the obstacle to create successful collaboration. According to different article found (Schuller, Eyben, & Rigoll, 2008), it is possible that nonverbal system changes depending on the context, and that each scenario defines its own set of terms and condition. Non-verbal communication is a process of silent way to

communicate with a person or group of people that does not include the use of any other vocal language in order to interact and convey their message. The hand gesture can be use while communicating non-verbally to assist the speaker in order to provide a shape to their words, where a specific gesture can be used to transmit non semantic information.

The study of speech and gestures combines with the study of personal perception and processes of attribution (Bavelas, 1994). As physical motions and lexical movements, several forms of conversational gestures may be identified. The importance of these gestures is unclear and affects the meanings and effects of the movements seen. As physical motions and lexical movements, several forms of linguistic gestures may be identified the importance of these movements is unclear and affects the implications and effects of the movements seen. Scientists have shown that non-verbal communication is an essential role in cooperative task by team members for collaboration. Where it has examined the influence of social and economic factors and types of different habit activity with robots which are in work with human.

Social robots are growing so rapidly, researchers have identified and look on how people are interacting with robots in order to share and gathering information. A study (Breazeal, Kidd, Thomaz, Hoffman, & Berlin, 2005) explores the role of nonverbal communication in social interaction between robots and humans and discovered that it is crucial to investigate how robots' nonverbal actions affect people.

Kinesics, proxemics, haptics, and chronemics these four can be identified as a nonverbal communication for robots and use of combine among these also helps to interact more intensely with human being (Saunderson & Nejat, 2019). They affect people in four different ways: shifted cognitive frame, emotional reaction, particular affective response, and task performance improvement. The condition of the robotics technology does not have any feelings so any specific systematic nonverbal communication can be it nonverbal data source. However, an extra para-emotional structure to promote the uniqueness of the robot's interpersonal connection with people and the robot itself is being created to present this information naturally and in a realistic manner. We can find a good verbal persuasions are being underestimated while there are very few words has taken a place, Non-verbal persuasion can be used in robotics system in a very distinguished manner. We human tends to believe that persuasion should appear with confidence, trust wise and the non-threating so social robots can be used accordingly (Friestad & Wright, 1999). This involves the resolution of work restrictions or other variables with regarding social awareness. Because of this factors many robots in social has faced the problem like human is behaving inappropriate manner on different persuasion.

Non-verbal communication can be used to detect and gather a feedback and find the human emotion on the specific topic. Non-verbal conduct may affect and be more acceptable to ideas, emotions. This impact takes place both inside the complete awareness of interactors and outside perception. This gesture is co-related between the spoken words and the body language. It can be used in learning phase for children or newly self-learner social- robots, for example learning new words with the picture of words like A for Apple. Further classification of gestures are as follows (Feyereisen, Van de Wiele, & Dubois, 1988) :

Semiotic Gesture:

In most of the cases this gesture is used in mathematics teaching learning, it helps to concentrate on the different aspect of gesture in relation with other semiotic sources on combine model. For instance, traffic sign and emojis are basic example of this gesture.

Ergotic Gesture:

This gesture is use in virtual places and it has been a system for the improvement of musical instrument sound quality, virtual reality etc.

Epistemic Gesture:

Diverse gesture and a combination of gesture are in use to make communication easy. Such as tilting or shaking of the head, shrugging, or furrowing of the eyebrow and it is a gesture which can change a work environment like opening a water tap.

Linguisticity:

This section is described as a different way of communicating using symbol, verbal, non-verbal and a combination of multisemiotic. McNeill (McNeill, 2012) writes "As we move from left to right: the obligatory presence of speech declines; the presence of language properties increases; and idiosyncratic gestures are replaced by socially regulated signs". Thumbs up can be used in emblematic gesture and other simple type of gesture comes in emblematic.

Iconic gesture:

This gesture is co-related between the spoken words and the body language. It can be used in learning phase for children or newly self-learner social- robots, for example learning new words with the picture of words like A for Apple. To make people aware about some information or some knowledge, the shape and animation are used and some of them are like pointing an object or action to describe some co-related tasks.

Metaphoric Gesture:

This gesture is different than Iconic gesture, metaphoric gesture can reflect the meaning with the symbol by using different action. For example, winking an eye may represent some affection toward other.

Deictic Gesture:

This is mostly used gesture in human life which can be very usable for social robots, it represents a scenario, providing an information. Such as pointing, Nodding, waving, moving palm to show how fish swim etc.

Beat Gesture:

Beat gesture has no meaning or context, this can be use while giving a speech, this gesture is a rhythmic flow of hand movement with the words and sentence which is deliver to the listener.

Translating and verifying is one of the mostly observed effect in nonverbal marketing communication and application. Basically. Artificial intelligent are introducing a cognitive in robotics which can be used in solving problems, finding solution for business needs, and using in marketing to expand the use of robots or an application which helps people for cognitive type problems. The cognitive robots are found to be very encouraging in the factor of neural computing and different abstract type of intelligence (Wang, 2010). This type of robots is helpful in decision making process without putting any emotions such as while buy clothes, creating different strategy to approach the ideas for businesspeople, reacting on an accurate manner depend on the situation but the main issue with this kind of cognitive robots does not have any moral values and any emotion so something it may create a problem while finding a strategy in marketing sectors.

Loyalty and satisfaction should be on main factor when convincing the humankind and now a days in most of the place we find a robot to deal with human. Research shows that, robots are finding difficulty to convince a human (Wu et al., 2016). Similarly, nonverbal communication is bit difficult to convince a people because, there may be a lot of gesture need to be used, those are some gestures which needs to be implement in robotics system to make nonverbal communication effective.

2.4 RESULT FROM THE LITERATURE TABLE

We have generalized some of the result we´ve found from table of literature. The list of literature was carefully selected based on keywords and study focus areas. After careful analysis of the all the literature we found the result as following based on gesture types.

2.4.1 Gestures and their uses throughout the literature: -

As we can see from the Figure 1 below, our extensive analysis from the research on literature shows which gestures are prominent and which are least researched. We have categorized six gesture types broadly which contains gestures not only exclusive to one feature but may contain generalized gestures. They were categorized as Head, Face, Proxemics, Gaze, Hand, and Combined. We have one extra category names as ´na´ which represents the excluded paper which were had gone through. The papers were excluded because they were not talking about any of the gestures despite their focus on social robotics. The bubbles in Figure 1 below represents the number of times the literature papers that we´ve included in Appendix A above talked about the specific gesture type. The size of the bubble is proportional to the number of times the gesture type was mentioned. The bigger the size of the bubble labelled with gesture type is, higher the focus of the literature through the time is. As we can depict from the Figure 1 that the combined gesture type is the most talked about gesture. In this category of gesture, we´ve included all the other types of gestures used in robotics other than five major categories we´ve mentioned earlier. As there were various gesture types which if we mentioned as major category would create more confusing analysis, we aggregated the less researched and mentioned gesture types into one single category labelled as combined.

It came as a no surprise that the Combined type of gesture is the most prominent gestures in our research literature but after that we can see that Face is the most prevalent type of gesture in most of the research. Gesture type head follows in the most used gesture type after the Face. Proxemics, Hand and Gaze were some of the least researched ones. Although we need to acknowledge the fact that early analysis on types of most researched gestures and least researched gesture which were based on only 48 papers is not sufficient to make any type of conclusion, our selection process for the inclusion of these papers certainly was extensive and

filtered and was very cautiously and carefully conducted. Thus, these analyses do have some meaning specifically in persuasive social robotics and use of gesture and their various types. Based on the Figure below we can conclude that we have a large void in research typically related to Gaze gestures and proximity used in public places.

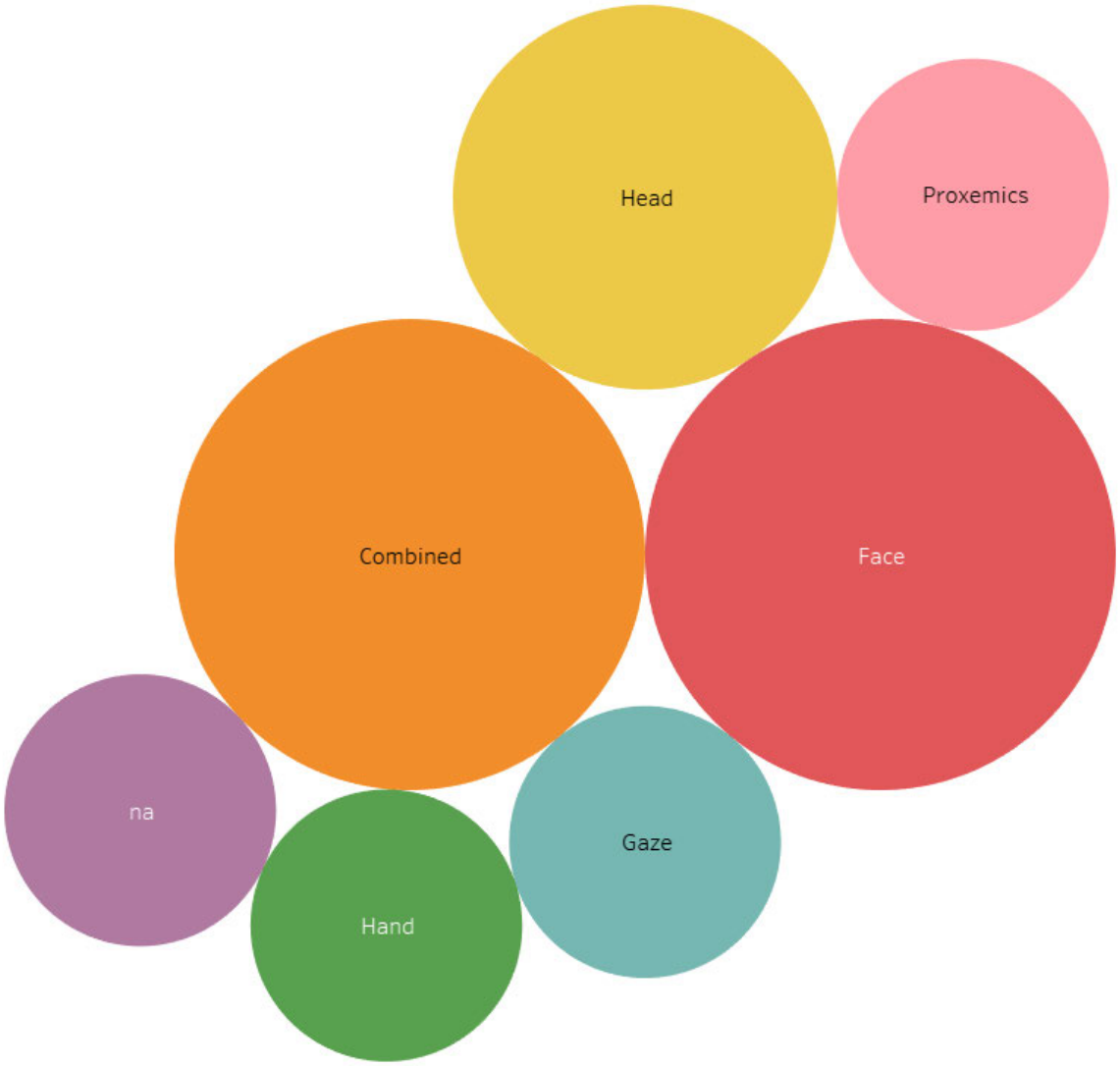


Figure 1 Gestures and their prominence throughout the literature

2.4.2 Use of face as a gesture throughout the literature

In Human-Robot-Interaction (HRI), we can witness the use of face for persuasion and compliance is generally extensive. Due to the reason that face encompasses a lot of attributes such as lips, eyes, cheek, chin, forehead, ears, etc which generates extensive list of gestures based on their allocation, movement and timing, it is quite obvious that they are the most researched gestures types throughout the history in HRI and Human-Computer-Interaction

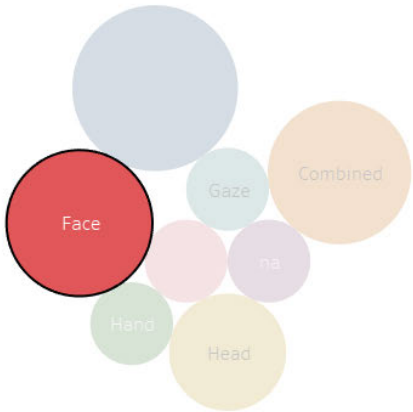
(HCI) (Triesch & Von Der Malsburg, 1997). Movement of mouth and eyebrows in robotics plays a vital role in persuasion. The colour of eyebrows, size and its action speech and timing, etc are some examples of possible gesture outcome of one typical part of face such as eyebrows. Other possibilities include use of eyelashes, eyes, lips and the list are endless. We can even see some research where these facial attributes are achieved through external attachment which are based on plug-ins. Dynamic characteristics of the same robot can be found through these plug-ins for e.g., to achieve eyebrows movement variations to express anger or sadness, pluggable eyebrows can be connected to the robots.

As face is used to express not only gestures but also emotions such as anger, happiness, sadness, surprise, etc, it is up to us how we use the same human phenomena of face in robotics to achieve such emotional state. A robot can be designed to move its face in different directions easily and these varying directional movement mimics human nature of facial expression. For example, robot can be designed to look straight down when it is angry or sad, to look straight up when it is surprised or happy, and to look down and to its right when it is afraid. These are just some examples of how robot can mimic simple face allocation in different directions to achieve human emotional state. We can see research that go beyond these and combined vocal realism such an eye scale-out, pupil motions and body movements aligned with changes in facial expression. Simple Light Emitting Diodes (LED) lights can also make huge impact in robot mimicking power of human emotions. As our face turn into red when angry or embarrassed, a simple led lights inclusion in robot can produce red lights around cheek which represent its state of emotion as either angry or embarrassed. Hence, face gesture is the gesture with unlimited possibilities in research to mimic human behaviour through varying expressions and emotions (Ham & Midden, 2014).

We can see from the Figure 2 below representing our literature, various robots including Nao used face as a gesture type mostly based on Experimental research. A research papers published in 2013 and two research papers published in 2016 used iChat robot, IGUS-Robolink and Volt Servo Robot System and NAO robot respectively all of which were based on experimental research style. But most of the research studies based on Face gestures can be found in recent years, typically in our literature walkthrough 2018. This year the research based on face gestures were not only based on experimental style but also were survey based and review system based. The extended use of virtual agent and robot based on animation and virtual reality could be found during these years of research in face gestures. Overall, we could clearly see the lack of humanoid robots such as NAO that are implemented in research based

on face gestures even though NAO robot is competitively equipped with features and specifications suitable for research as such.

Robot Gesture



Year of publication	Name of the Social Robot	Research style
2013	iCat robot	Experimental
2016	IGUS-Robolink and Volt Servo Robot System	Experimental
	Nao	Experimental
2018	EmIR (Emotional Intelligent Robot)	Null
	image of robot animation instead of actual robnot	internet survey
	na	Review
	virtual agent	Experimental

Figure 2 Gesture type Face and its use throughout the literature

2.4.3 Combined gestures use throughout the literatures

This is the special category of gaze where we made this category to combine rest of the gesture types other than listed categorize above. It is intended to represent various gesture types that we found throughout the literature and acknowledge other categories beyond our analysis. This category included various gestures in action together such as gestures expressed while sitting close or far from user, relaxed body expression or tensed body posture, smiling, touching users, gesture types: deictic gesture while referring to itself, deictic gesture while referring to the participant, metaphoric gesture using both hands to form a gesture space containing an idea, beat gesture, moving its arms rhythmically, and iconic gesture depicting “higher.” These mentioning of gestures ignite the importance of pointing and act of showing direction to express various emotions and share information. Although we had a different category for gestures

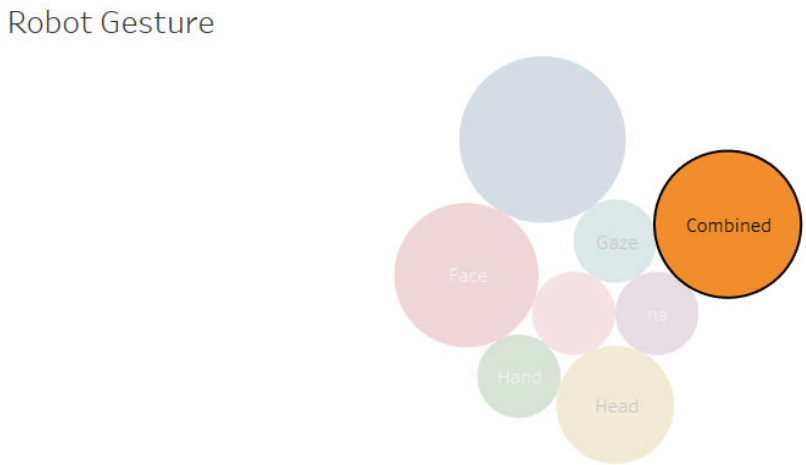
related to face such as nodding and blinking, the combination of both were nowhere to be found as a single category. So, this category includes these hybrid gestures into one and mention is as combined one.

Use of various body parts and movement of these parts in different direction generates individual gestures. Same directional movement with different body parts could have different meaning and hence have its own importance in the field of Human Robot Interaction (HRI). We can take an example of most visible body parts arms which could show different etiquette by placing it in different directions. One could clearly present its own characteristics and emotions through these arms' movement. For example, open arms mean being open to the others' ideas and being friendly while closing and crossing arms would represent the idea of repentant and shy nature. Also, if someone is putting their both hand in front of their chest then it could be understood that the person or entity is trying to introduce itself. Like this, same movement of typical body part could have different meaning based on number of body parts used. One example of such case is waving; if someone is waving one hand to other then it generates the meaning that the person is trying to either greet someone or simply saying goodbye to others, on the other hand, if the same person is waving hand to others specially in events such as sports, then it means the person is trying to celebrate of cheer the team up.

These body parts and their directional movements are also based on cultural and religious factors (Geertz, 2010). Generally, people from Asian countries especially Hindu and Buddhist, raise their hand in front their chest and close their palm to represent greeting which is sometimes called ´Namaste`. The same gesture is sometimes perceived as welcoming someone while it might have meaning of saying goodbye as well. There are not really any differences in hand movement and direction change in body parts. Thus, these identical gestures which have varying meaning without any visible change are very hard to analyse because of which they are very difficult to mimic and incorporate in robotics. As human strategies of visual expressions such as threat, criticize, fondness, mutual understanding, authority, etc depends upon not only hands but also head, other body parts and external factors, it can be very hard to achieve compliance through single gestures in robotics. This raises the necessity of combined gestures to express varying emotions and expressions in robotics.

We can witness a lot of research paper talking about combined gestures which is very natural as they consist of lot of gestures that we put in the category containing rest of the gestures. Most of the research performed were experimental and uses of varying robot such as Honda, Alpha, Aqua, etc can be seen. Latest experiment based research published in 2019 (Xu,

2019)has only used NAO as a humanoid robot. So, it can be inferred that humanoid robot such as NAO´s use in recent years to study combined gestures has started taking place but still need to prevalent throughout.



Year of publication	Name of the Social Robot	Research style
2004	Embodied social agent (ESA)	Experimental
2007	Robovie	Experimental
2009	Mobile Dexterous Social Robot	Experimental
2012	Others	Experimental
2013	Honda Humanoid Robot	Experimental
2015	Nao	Experimental
2016	na	literature review
2018	Visual-Intraction Robot (OpenROV, Aqua)	Experimental
2019	Alpha (UBTECH, 2017)	Experimental
	Nao	Expertimental

Figure 3 Combined gesture types and its use throughout the literature

2.4.4 Uses of Gaze gesture throughout the literature

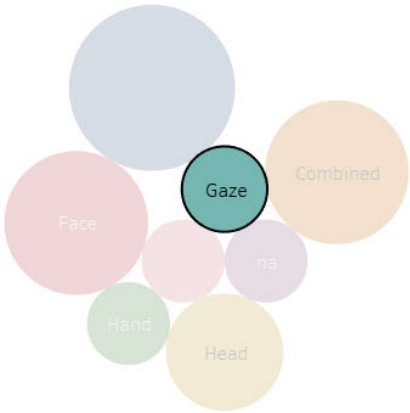
Gazing is a common form of human expression to establish trust and achieve compliance. This gesture is generally achieved by looking at someone´s eye for a certain period. Prolonged stare could haemorrhage the true intension of gazing which is why timing and duration of staring moment is very crucial in gazing. Gazing gestures can be achieved through various body parts specially head. Basically, gazing uses combination of body parts such as face, head, eyes, eyebrows, etc. Coordination of these body parts make the gazing gesture possible. For example, to establish a gaze while interacting with another entity, one should raise its head, open eyes and make eye contact to other entity, eyebrows should be generally neutral, etc. Similarly,

movement of individual body part could entirely alter the meaning of the communication. Nodding head up and down slowly while gazing at someone would have different meaning than sliding head left and right slowly while gazing. It depends upon demographics and culture as well to how other entity in the communication perceive such gestures.

Use of other verbal gestures such as persuasive speech can be combined with the gaze for enhancement in communication and persuasion, it is interesting to see the combination of distinct non-verbal communication strategy such as gaze and proximity. One example of combined non-verbal gestures could be gaze and use of hands and fingers in different directions. While making an eye contact (i.e., exhibiting gaze behaviour) pointing at some direction or at an object would certainly enhance the interaction purpose.

The Figure 4 below represent the use of gaze throughout the literature we have adopted in our case. As we can see gaze is one of the least mentioned and used gestures types out of all the literature throughout the year 1976 to recent years. Various robots such as Virgil (WowWee Alive Chimpanzee Robot), Robovie-R ver. 2, Honda, and NAO were used to study the gaze behaviour throughout the years (Iio et al., 2011; Riek et al., 2010). Most of these studies were experimental based and conducted in laboratory environment. We will not be wrong if we assume that although humanoid robot such as NAO and Honda have been in use to study gaze behaviour, they clearly lack the advancement to recent years. The last study based on gaze was published in 2015 which is a clear indication that we need more studies on them now than ever.

Robot Gesture



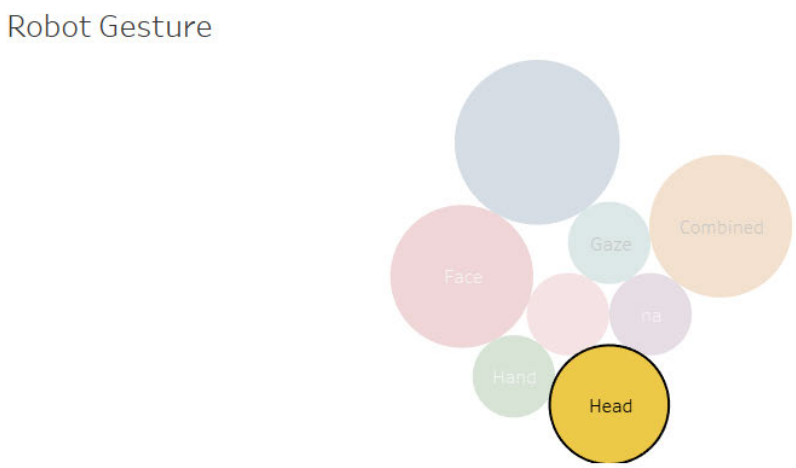
Year of publication	Name of the Social Robot	Research style
1976	Others	Null
2009	Virgil (WowWee Alive Chimpanzee Robot)	Experimental
2011	Robovie-R ver.2	Experimental
2012	Honda humanoid robot	Experimental
2013	Nao	Experimental
2015	Nao	Experimental

Figure 4 Gaze and its use in Human Computer Interaction (HCI) and Human Robot Interaction (HRI) research as mentioned in this paper.

2.4.5 Uses of Head only gesture throughout the literature

Head is the most important part of the body in any living things when exhibiting the emotions and expressions. Expressions could be generated throughout or with combination of other body parts but generating emotions is only possible through the head and constituting parts of head such face, eyes, ear, etc. To express the state of various emotions such as being angry, sad, happy, surprised, feared, etc, use of head and movements associated with is very crucial. Despite the fact that head gestures might include facial expression specially to express emotions as we have mentioned earlier, head gestures impact largely on the perception of these emotions to the other entity in the interaction environment (Johnson & Cuijpers, 2019). Nodding head in different direction causes different meaning in communication like the examples we mentioned earlier in the gaze gestures section above.

The Figure 5 below represents the major studies that specifically talk about the head gestures through the table and mentioning and use of head as a gesture in those studies represented by bubble. We can see that there were only three major literatures published from year 2014 to year 2019 that included the Head gestures as their major focus of research. Although one of them was based on feasibility study, rest were experimental based. This lower number of studies is an evidence that there are not a lot of studies that use Head gesture as their primary focus of gestures. Instead, the large size of bubble labelled Head despite lower number of papers from the figure below it shows the importance of head gestures in various research studies. We can report that large number of studies mentioned Head gestures in their research, but only three of them focus primarily on such type of gesture. Uses of SocioBot and NAO in these research studies is quite low although this research was published in recent years which is a promising energy and motivation for further studies based on Head gestures.



Year of publication	Name of the Social Robot	Research style
2014	Nao	Experimental
2016	na	feasibility study
2019	SocioBot	Experimental

Figure 5 Head only gestures throughout the literature

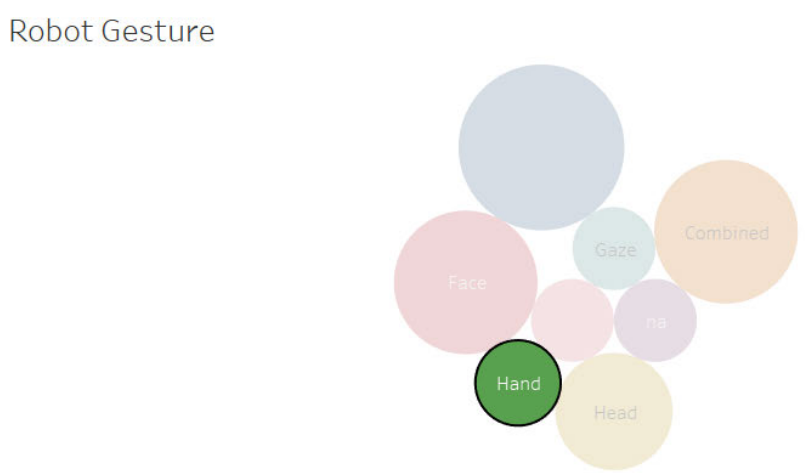
2.4.6 Uses of Hand only gestures throughout the literature

Hand is an integral part of human body, and we can see a lot of robotic design are based on inclusion of hand embodiment in the field of Human Robot Interaction (HRI). While a single hand can generate various gestures on its own, combining two hands generate various gestures meaning in human communication. Mimicking such hand gestures is quite common in robotics as well. Although it was hard to mimic the motion of hand gestures like human before, recent advancements in hardware structure and sensors in robotics have enhanced such experience through various animation and features. Hand gesture alone can express various gestures which if combined with other gestures would result in more clarification on the intention of the interactions. We often witness human using hands in verbal communications. Sometimes they do not carry any specific meaning on its own but help verbal speech be expressive and clear. While there are conditions where these hand gestures would entirely alter the meaning in that communication scenario.

We can see various hand gestures categorized based on their functionality and purpose such as directional, orientational, manipulation, and feedback based. Directional movements of hand have been in use from very early time in human history to specify intention and direction. Pointing gestures is also based on directional movement of hands. Like this, hand orientation plays a vital role too. From cultural perspective to learning aspects, hand orientation has various meanings. As the hand gestures can be expressed in various ways, it is quite common to use the same phenomenon as a technique of persuasion. Expression of interest as well as discomfort can easily be achieved through activities involving hand such as waving hand, raising in different orientation, joining hands, clapping, etc. Thus, design of hand gestures in robotics is equally important. As it has been common in HRI, the focus of research in robotics specially in public scenario is increasing and application of humanoid robot such as NAO, Pepper, Honda, etc is directly aiding those researches. (Sheikholeslami, Moon, & Croft, 2017)

The Figure 6 below represents the two figures combined as one essentially representing number of times gestures are used robotics which can be seen from bubble size and the table figure depicting further details. As we can witness from the Figure 6, hand gesture is also one of the often-neglected gesture in HRI. It is evidential that not only does hand gestures-based paper research are relatively low with only 5 papers directly relating to them, but also the number of times the typical gestures are mentioned throughout other paper is also minimal. Relatively small bubble size labelled Hand is a proof how ignored this field of research is. Similarly, humanoid robot such as NAO has been used primarily using Hand gestures is

included in just one paper (Verhagen, Berghe, Oudgenoeg-Paz, Küntay, & Leseman, 2019) published in 2019. Although the research mentioned in the literature were based experiments, we must admit that the humanoid robots use not quite popular in terms of hand gestures-based research according to the Figure 6 below.



Year of publication	Name of the Social Robot	Research style
2000	AMELIA (RWI B21 robot)	Experimental
2012	(use of telepresence robot)	Experimental
2016	Zeno	Experimental
2017	Others	Experimental
2019	Nao	Experimental

Figure 6 Hand gestures throughout the literature

2.4.7 Use of proximity as a gesture in the literature

Proximity plays a crucial role in human communication. The factor of proximity that determines the quality and purpose of the communication is always there in the effective human communication. How close a person can be in terms of distance to other communicating person is an example of effect of proximity factor. Generally, close the person is the intimate the communication and interaction are. So, in the field of persuasion proximity is considered as one of the effective ways of method of persuasion. But it might not be true in all the scenarios regarding the persuasion. Proximity sometimes inverts the purpose and deter the interaction. And most importantly, the proximity factor is always there in most of the interactions that uses

other gestures involving human bodily parts. It is just a matter of whether this gesture type is mentioned or kept as an integral factor in that experiment or not. Otherwise, in every gesture type, the distance between interacting party if considered plays a significant role.

We can clearly see the extent of papers that mention the proximity as a primary source of gesture type as the proximity in the research. It is almost non-existential with only exception of paper published in 2006 (Brooks & Arkin, 2007) that use Sony QRIO robot studying the effect of proxemics in the field of robotics. Although there is not much research done that are based on proximity, the relatively average sized bubbled labelled Proxemics represents the mentioning of proximity effect in other literature as well. This indicates the importance of proximity and the relation it to other gestures. Despite its significance, we could hardly find any mainstreams research based and focused primarily on proximity and its effects.

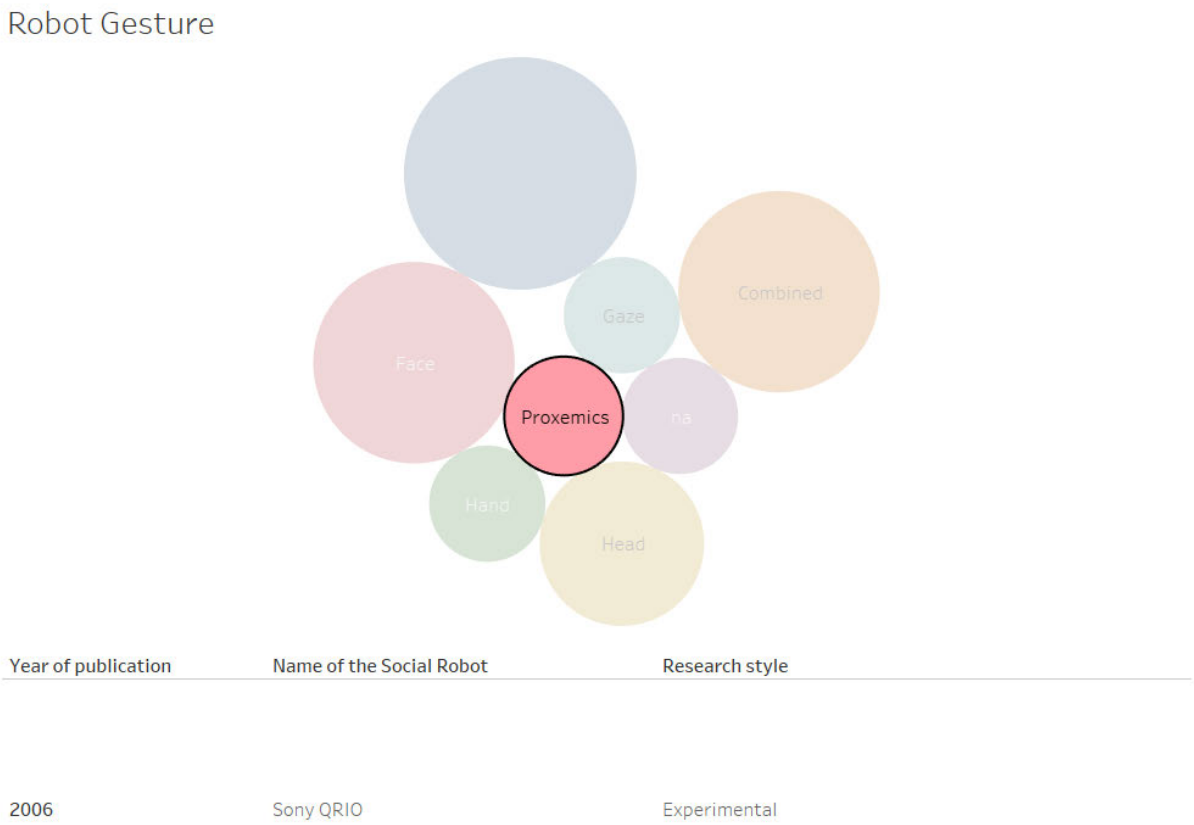


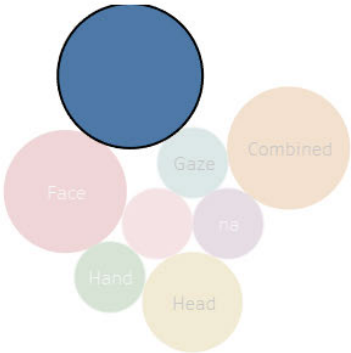
Figure 7 Gestures based on proximity throughout the literature

2.4.8 Other literature

The blue bubble which is the largest in size with comparison to other represents literature which we´ve excluded in our review for various reasons. Some of the reasons are as follows: -

- Uses of gestures in the research but no robots were mentioned or used throughout the literature. (Kleinke, 1977)
- Some of them are deeply focused on verbal gestures and verbal communication style only ignoring the non-verbal aspects of gestures completely. (Maricchiolo, Gnisci, Bonaiuto, & Ficca, 2009)
- Paper described the perception of robot where robot senses the gestures generated by human instead of robot exhibiting gestures and human receiving and analysing it. (Zhang, Ampornaramveth, & Ueno, 2006)
- Detailed mechanical aspects of humanoid robot is the primary focus and thus more suitable for robotic engineering. (Oh, Bailenson, Krämer, & Li, 2016)
- Development process of gesture and deeply focused pantomimic based papers are also irrelevant to our literature review. (Van de Perre et al., 2016)

Robot Gesture



Name of the paper	Include / Exclude
Development of a Framework for Human–Robot interactions with Indian Sign Language Using Possibility Th..	out
Effects of different types of hand gestures in persuasive speech on receivers' evaluations	out (focus on verbal gestur..
Gesture-based human-robot interaction using a knowledge-based software platform	out (focus is on robot recog..
Give me a sign: decoding four complex hand gestures based on high-density ECoG	out (no robots were used)
Human–Robot Interaction by Understanding Upper Body Gestures	out (robot is responsible fo..
iSocioBot: A Multimodal Interactive Social Robot	out (dialogue based interac..
Let the Avatar Brighten Your Smile: Effects of Enhancing Facial Expressions in Virtual Environments	out (no use of robots)
Pantomimic Gestures for Human–Robot Interaction	out (focus is on pantomimic..
Persuasive Robots Acceptance Model (PRAM): Roles of Social Responses Within the Acceptance Model of Pe..	out (verbal persuasive dial..
Reaching and pointing gestures calculated by a generic gesture system for social robots	out (deeply focused on gen..
The influence of social cues in persuasive social robots on psychological T reactance and compliance	Out(focushed on human so..
The NAO robot as a Persuasive Educational and Entertainment Robot (PEER)..	in
Visual recognition of pointing gestures for human–robot interaction	Out(focushed on detection ..
When Artificial Social Agents Try to Persuade People:..	Out(focused on Psychologi..

Figure 8 List of literature that are were excluded from our review for various reasons

2.5 SUMMARY AND IMPLICATIONS

We realized throughout the literature the importance of non-verbal communication strategy evolving into the persuasive techniques. Such techniques have been in focus in different types of studies from literature review to the experimental one. Major body parts such as face, head, hand, eyes were the primary sources of the different gestures. Gazing was also a similar phenomenon composed from using some of the body parts we have mentioned earlier. The importance of gazing behaviour to persuade someone to achieve compliance was very crucial as we can see from the literature review, we have performed earlier. We must have to admit how the use of proximity as a persuasive technique have evolved and impacted other non-verbal gestures in HRI. From the literature review we´ve performed earlier, we came to realize that although there are some studies that focused on combining various non-verbal persuasive strategies (Ijuin, Jokinen, Kato, & Yamamoto, 2019; Zaraki, Mazzei, Giuliani, & De Rossi,

2014), we could hardly find any focusing on joint persuasion technique by using gaze and proximity at the same time. Also, which setting of varying proximity in effect with gaze are significant is also unknown. Since, altering the distance while changing the gaze behaviour in any human interaction and communication reserve special interest we came up with a research question for our study based on previous literature and studies (Burgoon, Coker, & Coker, 1986; Miklósi et al., 2003; Mumm & Mutlu, 2011) as follows

2.5.1 Research Question: -

What level of proximity and gaze jointly increases the persuasion through compliance?

The aim of our research question is to find out which conditional scenario that reflects the gaze and proximity behaviour as a combined one is preferable, and which one are less preferred. As we have categorized the four conditional statement that represents the varying but joint scenario of these two non-verbal persuasive strategies, various test results based on participant opinion are expected to point out some significant findings to answer our research question.

Chapter 3: Research Design

The objective of this research is to find out whether the eye gaze and proximity make the social robot more persuasive in public space or not. Based on user opinions and review we analysed the result to see whether the persuasive strategies used by Nao makes any difference in public space or if there is not much of differences. We want to see how mobile technology such as social robot use in public space varies with our proposed eye gazing technique with varying proximity.

3.1 METHODOLOGY AND RESEARCH DESIGN

We conducted 2 (gaze, no gaze) x 2 (high proximity, low proximity) between participants experiment where robot Nao exhibit its persuasive nature using gazing technique specifically eye gaze to persuade user. As we know persuasion depends upon a lot of factors among which familiarity with the communicating or interacting subject make a substantial impact. Comfort, open-minded characteristics, fluency, etc. like factors automatically make their presence in an environment of familiar technology or subject and retain their importance. So, keeping in mind the previous experience with not only robots but also other indirectly impacting factors such as electronic toys, sensors and actuators, we consider that they certainly have some effects in our entire experiments.

We designed the robot Nao to exhibit two specific natural humans like mimicking characteristics; express persuasive speech while making an eye contact (gazing) and express the same persuasive speech while nodding its head down (without using gaze). The idea here is to simulate the natural communication phenomenon of persuasion. Furthermore, presence and absence of gaze were also tested against two specific setting; low proximity (robot and communicating person have 1 meter distance between them) and high proximity (there is a distance of 3 meters between the participating communicating objects Nao and Research Team Member) (Graepel, Herbrich, Bollmann-Sdorra, & Obermayer, 1999). The lab setting is to simulate the real-life public scenario where persuasive robot tries to persuade user mimicking salesperson in the supermarket or similar scenario with the low proximity setting. And the second scenario is trying to have a similar environment where the persuading person such as salesperson is at comfortable distance from the shopper. The interaction between shopper and

cashier is an example of scenario of high proximity and user of persuasive techniques such as gaze. The idea explained above can be listed in points as: -

Low Proximity No Gaze:

In the very first condition where the humanoid social robot Nao try to persuade shopper (volunteer Research Team Member) to opt for another energy drink named Hyped-up. In this setting, the robot is close to the Research Team Member i.e., 1 meter. This is to mimic the setting where humanoid robot acting as a salesperson is trying to sell some specific product to the customer it is programmed to. As the salesperson might use some form of convincing technique, the appropriate use of direct gaze is equally important in a scenario as such. While saying so, avoiding the direct eye gaze is also crucial in some scenarios which is why we are having this setup to mimic the similar condition. So, while having the pre-defined persuasive dialogue delivery, robot Nao will look down avoiding the direct gaze to Research Team Member.

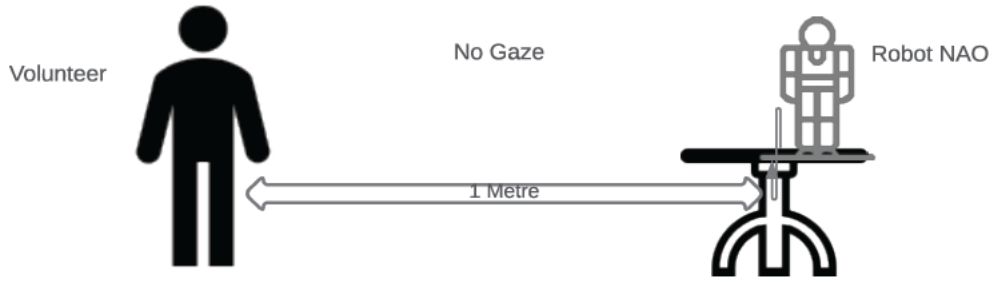


Figure 9 Illustrating robot NAO interacting with volunteer without gaze in 1 metre proximity

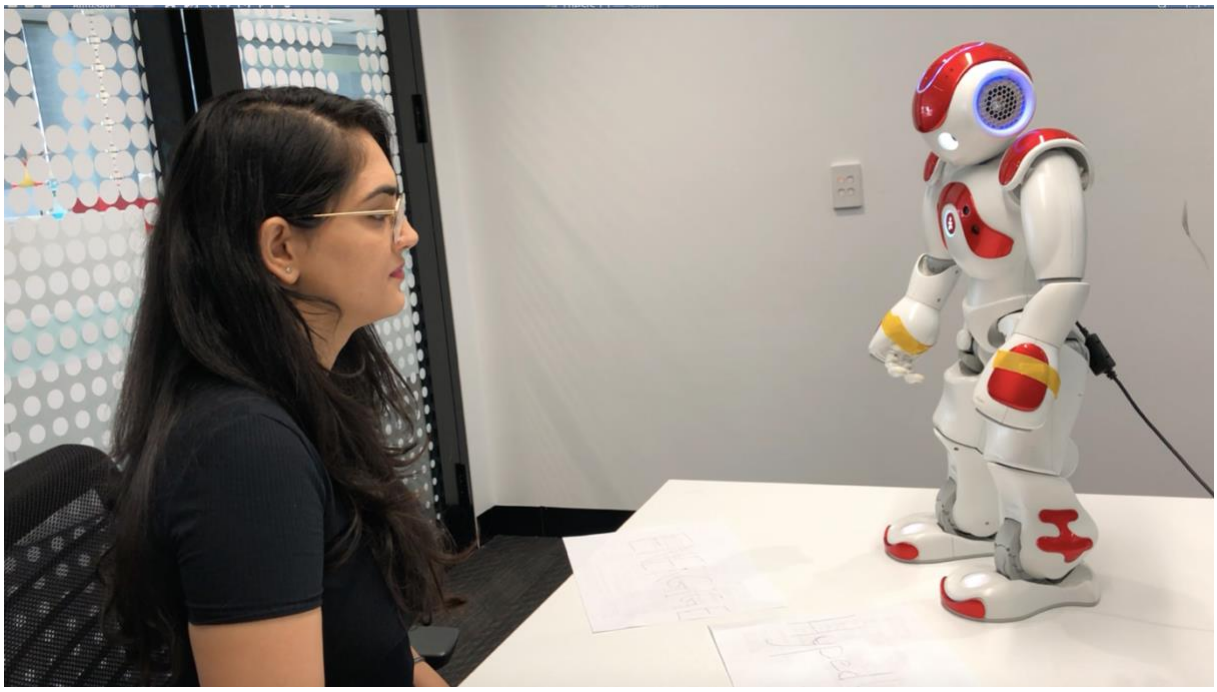


Figure 10 Nao and Research Team Member in a laboratory setting with low proximity and no gaze

Low Proximity Yes Gaze

This is quite similar scenario to the first Low Proximity No Gaze condition only with the exception that Nao will use another persuasive strategy Gaze to persuade Research Team Member for the change in her decision making. Although, Research Team Member is participating in this scenario, she will be choosing her pre-defined drink as her final choice of energy drink. It is up to the survey participant who will decide how they feel about the persuasive power of the robot Nao. In this condition as well, it will be the robot Nao who will be the only one to initiate a dialogue and end it, that means there will be a monologue conversation between Nao and Research Team Member. Only Nao will be doing the persuasive talking and expressing gestures i.e., Gaze. The inclusion of dialogue delivery that is already a persuasive speech from Nao with the combination of direct eye contact (gaze) with Research Team Member. This kind of emotionally neutral gestures has been found effective in a lot of scenarios. Although in real human conversation, gazing continuously like our robot Nao is doing might not be common, but there are certainly many scenarios specially the ones that consist of convincing scenario. We know that robot gaze behaviour has positive influences in human's acceptance and various compliance attributes such as trust, affections towards robot. The perceptions of human towards robot seems to be highly impacted by the gaze factor as the

human compares the gaze initiated by robot with another human staring and gazing at them while having the conversation.

Human-robot proximity is very crucial in persuasion through compliance and acceptance in Human Computer Interaction (HCI) and Human Robot Interaction (HRI). We can find some pre-defined proxemic where human react differently with varying location between the communicating partners. Intimacy has been defined differently based on various situation, general distance between two communicating entities revolves around 1 meter for achieving the characteristics of being intimate. And we have come to know so far that the power of persuasiveness is affected by various factors and intimacy and attachment to the communicating entities. So, use of low proximity is to see whether gazing strategy with intimately locating robot seems more effective in establishing and exhibiting persuasiveness through acceptance and compliance.

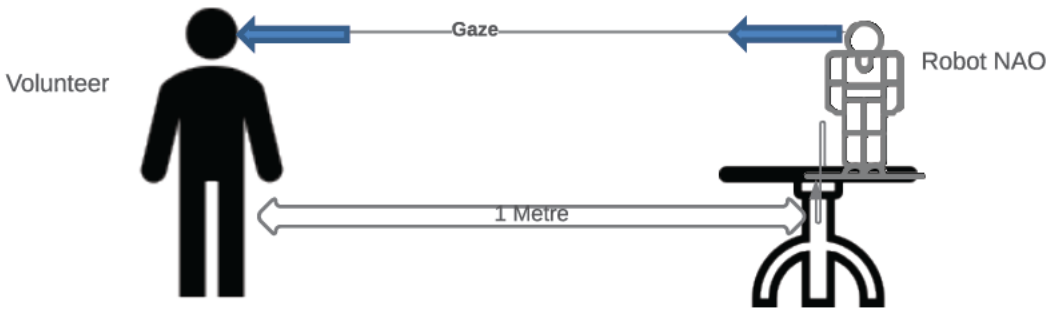


Figure 11 Illustrating robot NAO interacting with volunteer with gaze in 1 metre proximity

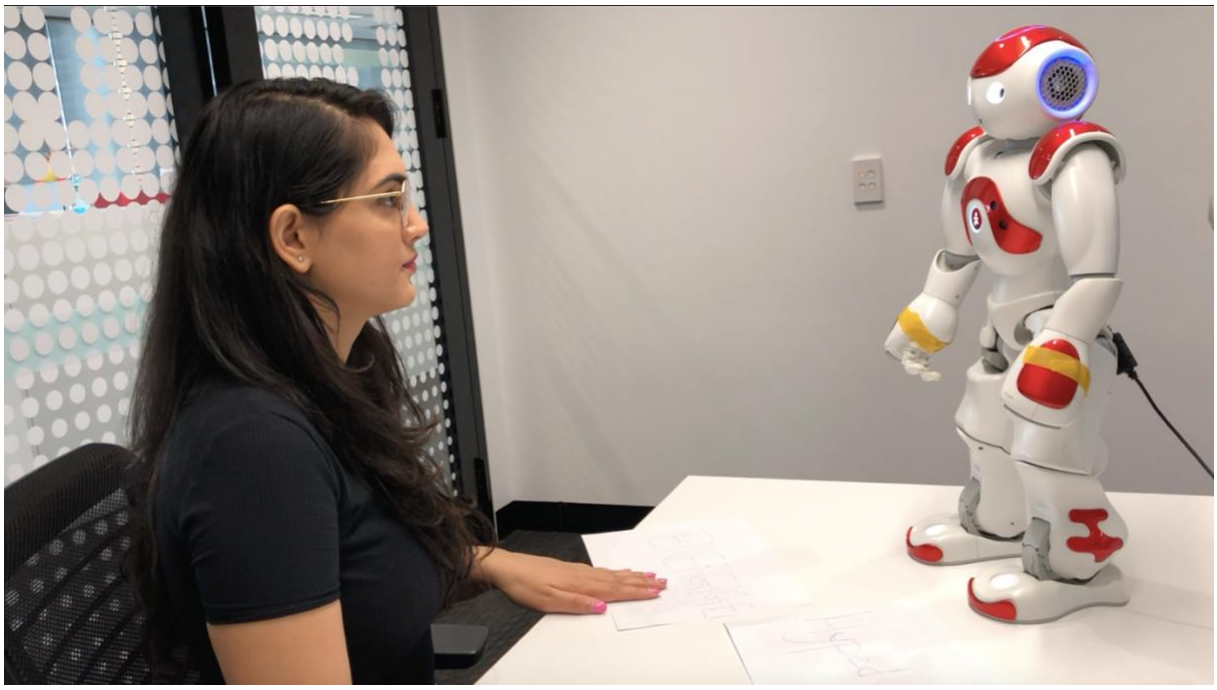


Figure 12 Nao and Research Team Member in a laboratory setting with low proximity and yes gaze

High Proximity No Gaze

Just like human-to-human communication, proximity of robot to the human plays vital role in affecting persuasion. Also, the proximity is dependent on the gaze and other gestures behaviours as well. For e.g., awkward gaze or continuous gaze sometimes create varying proxemics between human-to-human communication. Thus, gazing and gestures are also one of the determinants of the communication distance between not only in human-to-human communication, but also are vital in robot-to-human communication.

Third scenario of Human Robot Interaction in our research is to demonstrate how humanoid robot Nao´s persuasive speech without looking at the human´s eye (gazing) is perceived by the participants. The same pre-defined persuasive speech is delivered to Research Team Member by Nao while keeping its head down to avoid gazing gestures with Research Team Member. But in this scenario, we kept the distance between the social robot Nao and Research Team Member 3 meters. Three-meter distance between robot and human in HRI is often taken as a distance where both can establish and continue a communication without any external disturbance and avoiding the intimacy between them. As Nao´s head will be nodded down while communicating with Research Team Member, the proximity between them is

higher than those earlier condition where we kept the proximity to 1 meter. This is to mimic the scenario in real human-to-human communication where due to the factors of physical objects and barrier intimacy of 1 meter proximity is not possible, yet the job of persuasion is most. The need to convince someone while keeping some distance is what we want to see and achieve through this experimental setting.

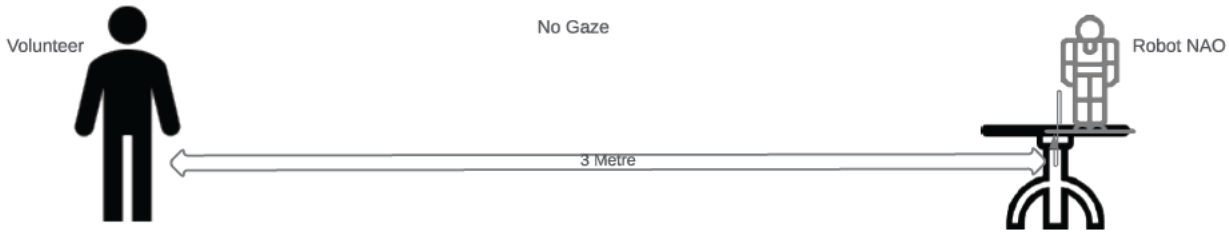


Figure 13 Illustrating robot NAO interacting with volunteer without gaze in 3 metre proximity

Figure 14 Nao and Research Team Member in a laboratory setting with high proximity and no gaze

High Proximity Yes Gaze

As we have discussed earlier in the third scenario above, gazing and the phenomenon of proxemics are directly related to each other. In general communication scenario, direct and

longer gaze will result in increased proximity. In other words, the distance in between human-to-human communication is increased when there is longer and direct gaze with each other. This will help in enhanced trust and hence increase in compliance and trustworthiness between communicating parties. Same case effect can be found in HRI and specifically in our case of robot-to-human communication.

By building this interaction between Nao and Research Team Member, we kept the distance between them 3 meters during the entire interaction and recording. This is to achieve the benchmark of what we established and so-called High Proximity. And Nao will be raising its head up and investigate the Research Team Member directly throughout the persuasive speech delivery to establish gaze gestures. This condition is to ensure that we test and apply both gestures that often has been researched but ignored as a one combined gesture. So, whether keeping 3 meters of distance to avoid intimacy and mimicking the human-to-human gaze gestures has any effect on persuasive degree of humanoid robot Nao perceived by human through various adjective factors such as trust, attractiveness, responsiveness, fluency, etc. as included in the survey.

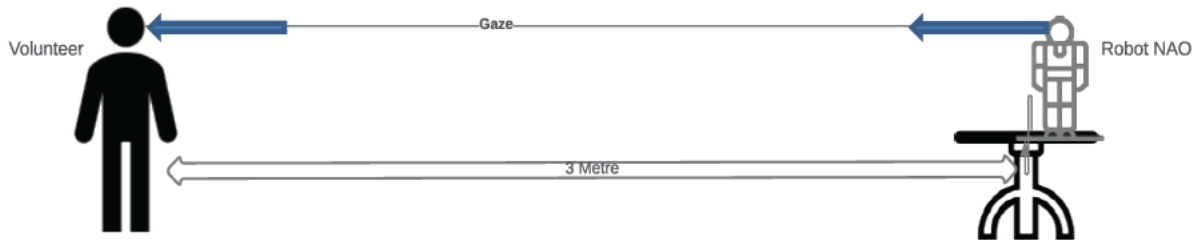


Figure 15 Illustrating robot NAO interacting with volunteer with gaze in 3 metre proximity

Figure 16 Nao and Research Team Member in a laboratory setting with high proximity and yes gaze

3.1.1 Research Design

Our study is focused on a laboratory setup of 2x2 between-subjects factors (proximity and gaze). This arrangement yields four conditional scenarios which were explained in the chapter above. We have used humanoid robot Nao as a persuasive agent in our research. Nao is a persuasive robot which is a commercial product of Softbank Robotics. Being very popular choice around various companies as a robotic assistant and equally in demand among healthcare centres and public spaces, Nao has become a standard robotic tool for various research and educational purposes.

Now lets talk about robot Nao itself and some of the general specifications of it most of which are relevant and applicable in our research. It has height of 58 cm, 25 degrees of freedom for physical movements, speakers arrangement to interact with human, dialogues available in 20 languages including English, support for open platform programming, etc. (Jokinen & Wilcock, 2014)

Programming in Nao:

The coding in Nao is based on python programming language. Although Choregraphe (Pot, Monceaux, Gelin, & Maisonnier, 2009) programming tool based on visual drag and drop

option was available, we completely rely on python program. A simple python based Graphical User Interface (GUI) was made for this purpose which was controlled by the Wizard of Oz when the video was made. NAOqi operating system in Nao robot allow this python-based programming to create animations based behavioural gestures and dialogues. Our animation of raising and lowering Nao´s head, showing gaze behaviour and delivering the speech was programmed using this very programming method python. We also want to clarify that there is not much of manipulation in robot´s design. Only manipulation made was the voice (common throughout) which consist of same persuasive pre-defined dialogue. After designing gestures and coding the gestures behaviour through this tool we came to the phase of testing. We first tested the functioning of our code virtually and later tested in Nao itself physically at the time when the Nao was placed on Western Sydney University, Parramatta campus. In case of another gesture i.e., proximity, we manipulated this variable manually. This process includes lifting the robot Nao from one place to another. In our study, as we have placed robot on top the table, we move Nao to and from the initial position based on our conditional scenario. Overall, out of two gestures gaze and proximity, we programmed the gaze behaviour through python programming

only by moving the robots head down and proximity was achieved through manual alternation of distance.

Figure 17 Humanoid robot NAO

3.2 INSTRUMENTS

Nao is placed at one end of the table facing the human volunteer Research Team Member directly. The placement of Nao on the table is to simulate the equal positioning of face between robot and human. We used the Western Sydney University, Paramatta City Campus study room for this experimentation where Nao was powered through the electricity outlet

provided in the room. We used a mobile phone (Apple iphone X) as our recording camera which had 12-megapixel dual sensor camera capable of recording High Definition (HD) quality videos. This camera was put on a side to the robot and human volunteer Research Team Member, where the desired field-of-view can be captured. Field-of-view in our arrangement consist of Nao robot at the one end and Research Team Member at the other end. Recorded video quality on the camera was of 1280X720 pixel resolution at the time of recording which was later compressed to 480p resolution. This shrinking of video resolution was necessary to avoid upload limit issues in the survey platform later. The length of the video was kept between 33 seconds long. The video consisted of descriptive scenario script at the beginning and actual recording footage of Nao and Research Team Member interaction later. Nao´s persuasive speech was only 10 seconds long after which the video was ended.

As we have four conditional scenarios, we recorded the four videos that fulfill the conditions of gaze and proximity which we have mentioned earlier in the above sections. Each recording was unique by the differentiating factor of proximity between Nao and human volunteer Research Team Member, and gaze behaviours from Nao. Everything else were kept constant such as persuasive speech, human volunteer Research Team Member´s selection of drinks, Research Team Member´s reactions to robot Nao, other physical movements from Nao. These external variables were carefully kept intact.

All our four conditions are robot-initiative i.e., we only have persuasive monologue from Nao. As same dialogue script is repeated throughout the differing conditions, human volunteer Research Team Member always opt for pre-defined energy drink called **Energise**. The use of paper label was necessary to avoid branding and copyright issues. So used papers labelled as ´**Energise**´ and ´**HypedUp**´ to represent the two options of energy drinks offered to Research Team Member. These two labelled papers were placed Infront of Research Team Member. This is to mimic the dilemma in real life scenario Research Team Member might face when she is offered two energy drinks options. To make a real-life scenario, we have made a script which was played in beginning part of the video playback as background text. The same script runs in each of the four videos at the start. The script was as follows:

It´s a hot day of the summer. After a long day at the university, Research Team Member needs to pick me up a drink before the next class. She remembers about an energy drink sample testing happening on campus. Via a pamphlet Research Team Member is introduced to two energy drinks ENERGISE AND HypedUp.

- *ENERGISE contains 10g of sugar and 50g of caffeine.*

- HypedUp contains over 50g of sugar and 10g of caffeine.

Research Team Member is then told that she needs to register her choice with a robot in a room nearby who is facilitating the delivery of the drink. Research Team Member chooses ENERGISE as her choice of drink and the robot is informed accordingly.

Nao´s gaze was designed in such a way that the head will be either nod down or raised up based on the condition of the scripted scenario. The persuasive speech of the robot was pre-defined dialogue script and monologue which as kept same during the four conditional scenarios. The dialogue script is as follows:

´Hi there, do you know that another energy drink HypedUp has only ten grams of caffeine and fifty grams of sugar. ´

We used Wizard-of-Oz scenario (WoZ) (Riek, 2012) for the timing and control of the Nao´s reaction during the interactions. The reaction first consisted of its head raised up in two conditions where gaze was established namely Low Proximity Yes Gaze and High Proximity Yes Gaze. After this, the persuasive speech as we have mentioned above has to be delivered to the Research Team Member. Although, both actions of gaze and speech were designed in one click event based, a human operator was needed for this. Human operator was responsible for correct timing of robot initialization while the recording is initiated. As we have a monologue interaction from robot to human only, we used wizard of oz method of controlling robot behaviours instead of automating it.

3.3 PARTICIPANTS:

We recruited 130 participants who were mostly university student studying either bachelor's course or master's course in Western Sydney University. The reason to choose university student was first it was easier to distribute survey to varieties of faculty around Western Sydney University through the help of helping tutors, and second reason is that we assume the familiarity with such robots and technology would be somewhat more frequent among students rather than common populations. We had many of the survey participants who either did not completed the survey or withdraw from it. Some of the participants withdraw from the study rejecting the consent form and many of them left the survey unfinished. This

was beyond our control, and we could not possibly do anything about it, so we had to reject many unfinished and incomplete data

The survey was distributed randomly among these students. Even though the allocation of each video out of four videos consisting of each conditional scenario was completely random, the number of times video distributed to these survey participants was equal. There were four groups of videos and each video had almost equal number of participants compared to the rest. This gave us the opportunity to evaluate the opinion of user fairly and evenly on all conditional scenarios. Further breakdown of exact number of video distribution to the participant were as follows: -

a. Low Proximity, No Gaze = 32 respondents
b. High Proximity, No Gaze = 30 respondents
c. High Proximity, Yes Gaze = 35 respondents
d. Low Proximity, Yes Gaze = 33 respondents

3.4 PROCEDURE AND TIMELINE

We want to collect user opinion about the interaction between Nao and Research Team Member. To be more specific, we want to know how robot is perceived as a persuasive agent while delivering persuasive speech with varying proximity. For this we needed relatively large amount of user and their opinion. And most importantly, due to the COVID19 and restrictions at the time of the data collection, we could not do face to face data collection. Hence, we decided to conduct an online survey where participant will be prompted to complete a survey form after watching the interaction video between Nao and Research Team Member which we previously recorded.

For the online survey platform, we used Qualtrics which is a cloud based online survey platform. As this online surveying is quite popular with research based on employee experiences throughout various organization, we find this tool fits best in our research as well. We distributed the survey through the anonymous survey link which can be pasted to any web browser and fill out the survey. After getting the consent the survey form will take the participant to the video playback page where the pre-recorded video will can be played at participants will. There were four different videos with unique conditional scenario as we have explained earlier. Each participant will be shown just one video per survey. This has been controlled by survey flow option in the Qualtrics menu. We used Randomizer feature to

randomly distribute video to the participant. Additionally, we used options to Evenly Present Elements so that each of the video are distributed equally among the participants. After watching thirty-three seconds long as an activity, participants will be taken to the actual survey.

Survey Form 1:

The very first survey question is intended to find out the familiarity of the participants with the robotics technology and exposure to similar technologies. As we knew that previous experience and familiarity to something have impacts on choice and decision making, we want to collect data on participants earlier experience. For this, we divided three major similar technological experiencing items, familiarity with Robots, Electronics toys, and Sensor's actuators. Participants were allowed to rate their experience based on 7-scale Likert, first option of having almost no experience to the specified technology to the last option of being very familiar with the technology.

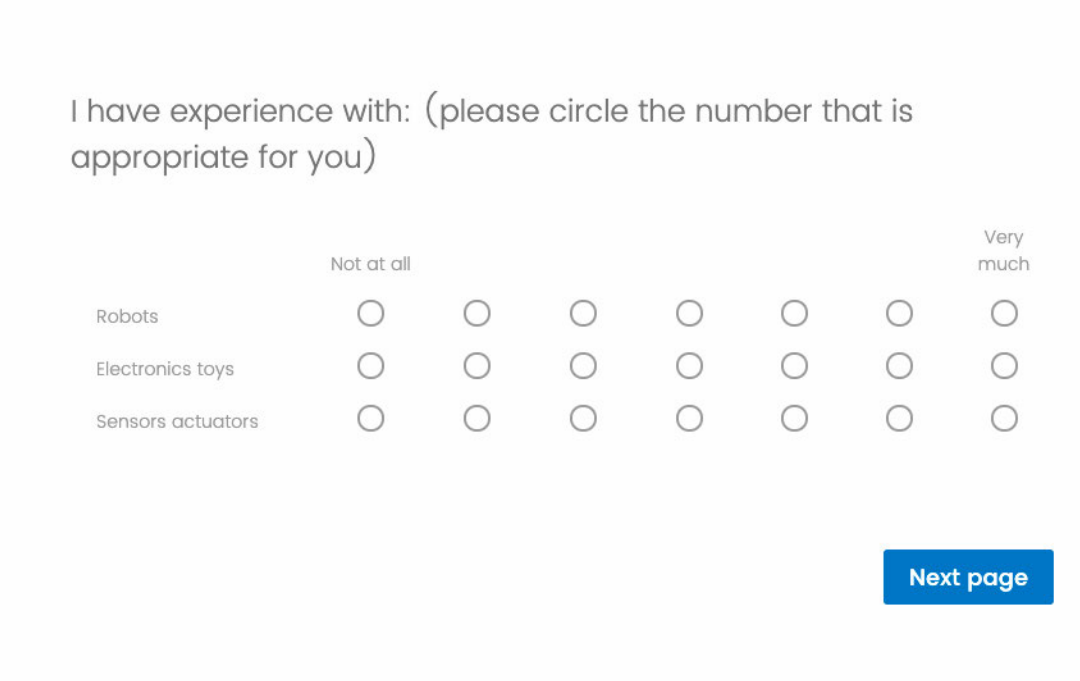


Figure 18 First survey form asking participant demographic details

Survey Form 2:

This page of our survey is designed to capture the user opinion based on eight adjective attributes about the humanoid robot Nao. These subjective features of Nao that we put in the test were attractiveness, responsiveness, fluency, friendliness, knowledge, responsibility, natural, and reliability or trustworthiness. Although these characteristics are independent on their own, they contribute highly when they are combined to judge persuasiveness and

compliance. Participants must choose scale from 1 to 7, 1 being featured with least of the characteristics listed and 7 being highly carrying characteristics. We have made this form to be filled mandatorily to advance into the next survey question. So, user must rate the Nao based on its impression from video from 1 to 7 based on each individual characteristic.

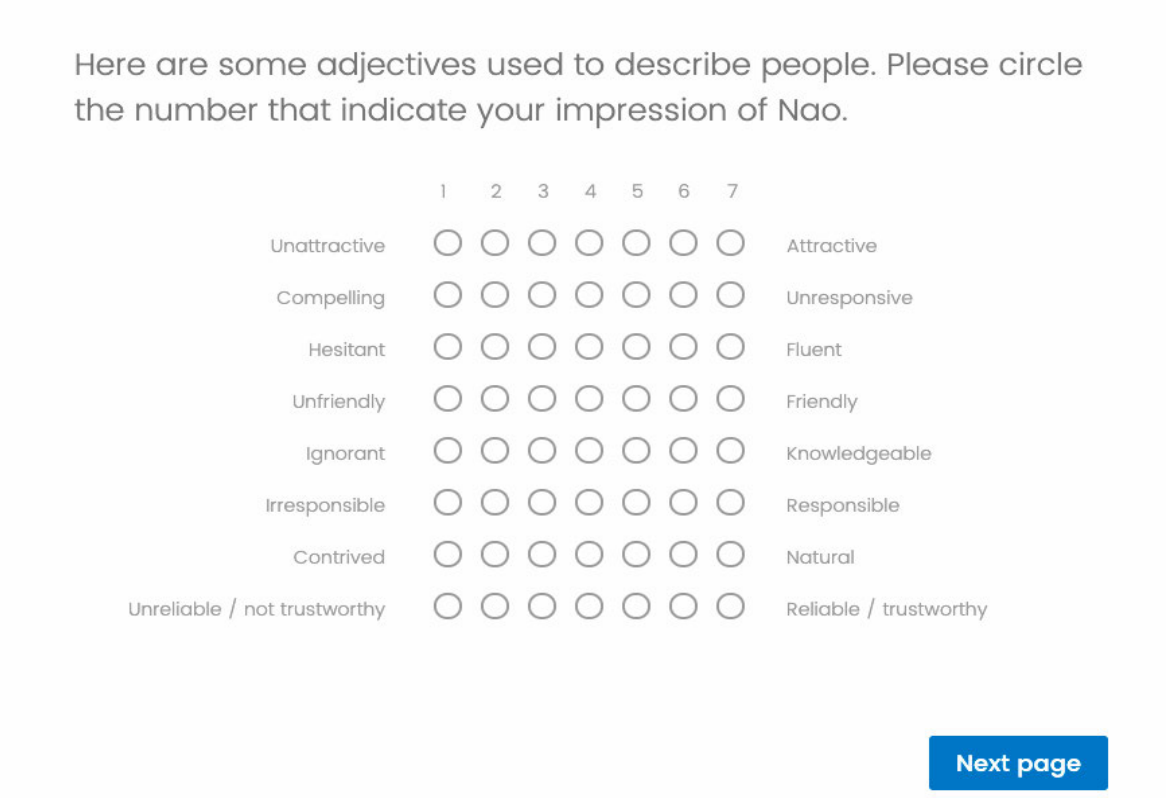


Figure 19 Second survey form capturing participants opinion on Nao´s characteristics

Survey Form 3:

Due to the COVID19 and restrictions the federal and state government placed on different sector, we couldn't invite participant to the lab and place them Infront of robot Nao for the interaction. Instead, we rely on survey based on their opinion and feeling which is totally subjective. This section of survey form is to see whether the participant agree or not with the three-statement made by us. These statements where Nao was persuasive, The video was clear, I will comply with having advice from Nao. The first statement is seeing if the participants of the survey find the persuasive strategy used by robot Nao working or not. The second statement was to collect the participants view on quality of the video. And last statement will virtually let the user to think and place them in front of the robot Nao instead of Research Team Member and check whether they will follow the advice from the Nao or not. We use 7-likert scale where circle on the very left represents user opinion based on their strong disbelief, whereas the circle

option on the right-most side represents their strong credibility. 7-likert scale option are increasing from left side to right side based on approval. Each statement has the option for user to rate their strong disagreement on the statement up to strong agreement.

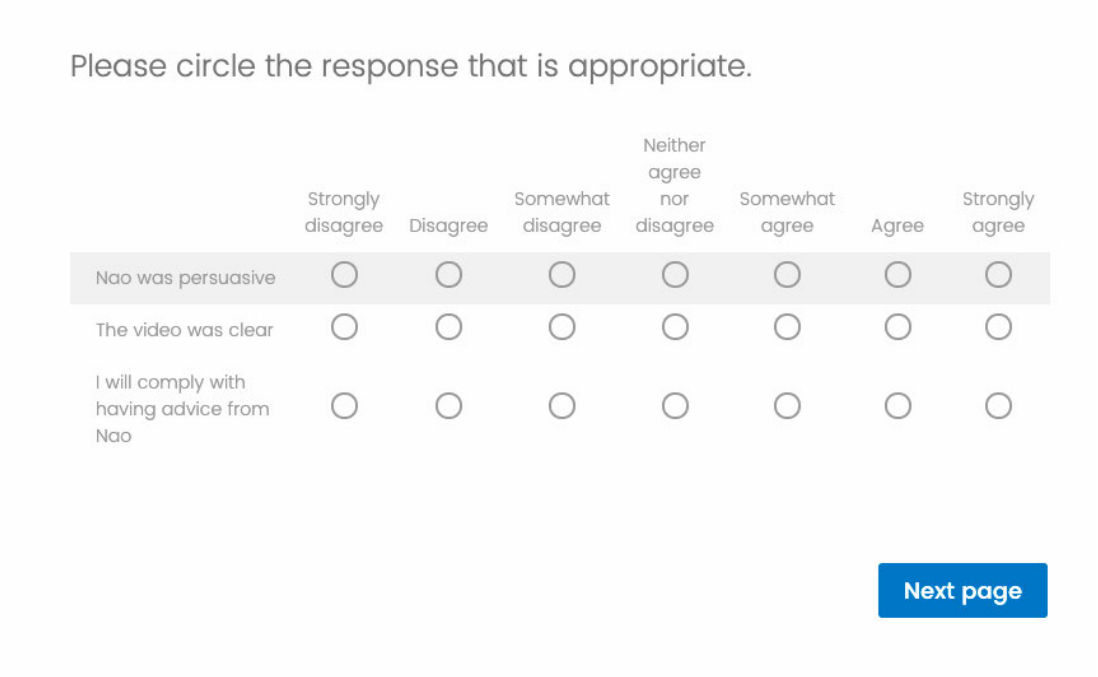


Figure 20 Third survey form to capture participant´s perception on Nao´s persuasiveness, video quality and compliance with Nao

Survey 4:

This is the part of the survey where we want to collect some subjective data. Although participants can leave this part blank without any of their opinion and progress further, we want to see the user´s perspective on the video. We expected the answers based on their attractions on the video. These attractions they found about the video could by anything from the video quality itself to the actors in our experiments such as Nao and Research Team Member. Even though we have given eight different options for survey participants to express their view on the subjective characteristics of robot Nao already, we expect that some participants will have other perspective than the listed ones. This is where this form which ask what the participants liked about the video come into play.

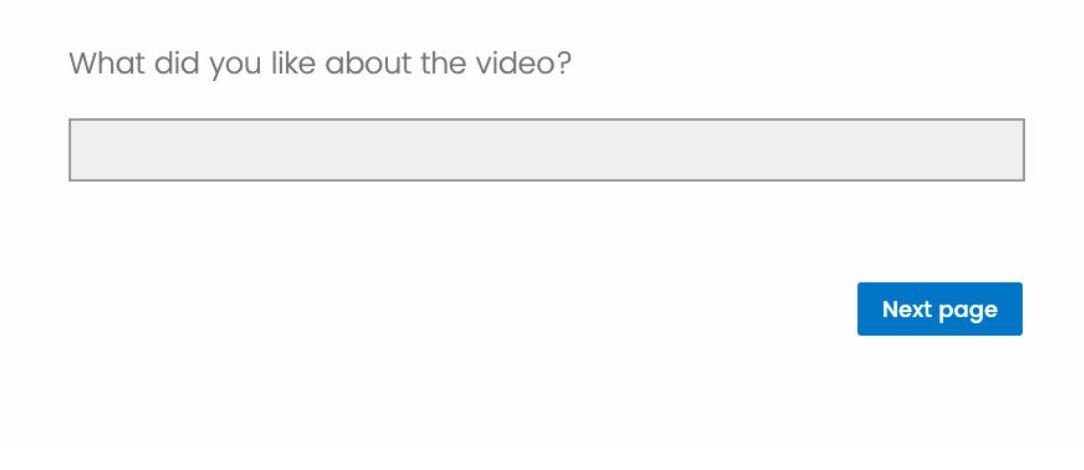


Figure 21 Fourth survey form asking about positive aspects of survey

Survey 5

This is quite like the survey form 4 in terms of design and option it provides to the survey participants with the only exception that we expect the user to express their negative perception about the video they have watched. Participants are allowed to express their opinion about the video and contents itself. There is no specific rule about what they can express and what they can´t, it is our assumption that they will write what they did not like about the video through this form. We gave these textbox options to the participants so that they can express something else that we have been missing and that that information might be useful in future research. Additionally, there could be some data that might have some meaningful outcome if combined with such qualitative expressions which is also why the text box is there in the survey form for the participants.

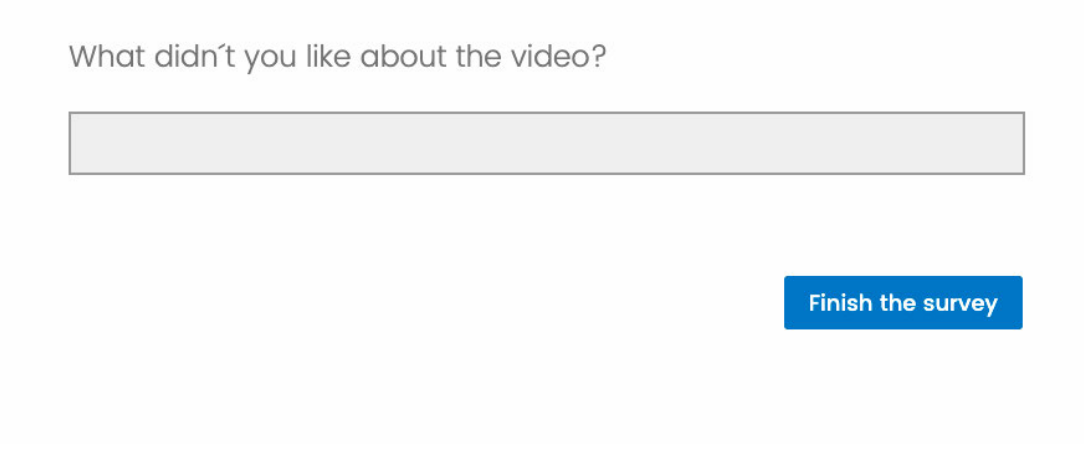


Figure 22 Final survey form asking the participant´s negative experience with survey

3.5 MEASUREMENTS

Participants were driven to three forms throughout the survey. After finishing watching video, they were encountered with the first form which was to capture. We targeted this form to collect demographic data from the participants so that we can analyse participant´s level of previous knowledge and previous experience with similar technologies such as robots, electronic toys, and sensors and actuators. The second and third form in the survey is the primary focus of our study. In total, we have 12 measurements based on various characteristics of robot and the user opinion on descriptive analytical questionnaires. 11 out of them were mentioned in the survey for the participants to fill out and we calculated the remaining 1 measurement manually by ourselves. We calculated the Perceived Competence (PC) which was the average of three characteristics Knowledgeable, Trustworthy and Responsible. The measurements are further listed as follows: -

- Attractive
- Fluent
- Friendly
- Knowledgeable
- Responsible
- Natural
- Trustworthy
- Nao_was Persuasive
- Video_clarity
- I_will_comply_Nao
- Compelling (calculated by deduction by 7 i.e., compelling = 7 minus unresponsive)
- Perceived Competence (PC) which was the average of Knowledgeable, Trustworthy and Responsible from the list above.

We have 7-point Likert scale (Joshi, Kale, Chandel, & Pal, 2015) for each of the above mentioned measurements 7 being user strongly agreed upon. For the former 8 measuring characteristics we used numeric rating from 1 to 7 where each participant expresses their opinion on the video and robot Nao. The lower number represents the participant opinion on the specific measuring factor as weaker perception and ascending numbers represent

the vice-versa. Each of these measuring factors were described and differentiated based on 4 videos. As participant were allowed to watch only one video, each descriptive data is different. But we have gathered and categorized them based on different blocks. These 4 blocks essentially represent four conditional scenario which were captured in the 4 different videos accordingly.

Additionally, we had two sections presented as textbox where respondents can write what did they like about the video and what they did not like about the video. This is where respondents were allowed to write beyond the pre-selected options.

3.6 ETHICS AND LIMITATIONS

While taking consent of participants before involving them in any research is very important, it is equally crucial that the participants were told beforehand any risk involved in the research to them or others. Keeping in mind the very fact that any research that involves human should be conducted cautiously, we followed all the ethics standards on research containing human involvement. As we conducted online survey for collecting user data instead of face-to-face interaction, we had some liability and responsibility specifically related to ethical aspects on data and privacy. The survey experience included in the survey were consent form, introduction to the content and survey, viewing video and filling survey all of which were made possible to be done through a single link.

This research is a part of project titled `The social robot as a medium of communication´, HREC approval number H13082 with Dr. Aila Khan as a principal researcher. The recruitment email sent to the school admin was as follows be referred from the Appendix B. Similarly, consent form we have used to take consent from the respondents could be referenced from Appendix C.

Results and discussion

The tables depict the list of measurements capturing respondent's opinion and their perception of Nao. Table 2 represents the mean value and standard deviation in each of the first eight characteristic measurement factors based on four different conditional scenarios. The characteristics column represents the eighth measuring factor of robot Nao, and the video Watched section represents the type of video out of 4 videos we made representing four different gazes and proximity common scenarios. Mean and Std. Deviation represents the average mean and standard deviation value we calculated. Row named total shows the mean and standard deviation value average for the single characteristics of robot Nao perceived through user opinion. From Table, 2we can see that out of four videos respondents watched, video with the condition ´Low Proximity, Yes Gaze´ exhibit the maximum mean value in all eight measuring characteristics of the Nao robot, i.e. Attractive (μ=5.09, σ=1.646), Fluent (μ=5.24, σ=1.226), Friendly (μ=5.27, σ=1.281), Knowledgeable (μ=5.15, σ=1.603), Responsible (μ=4.97, σ=1.571), Natural (μ=4.18, σ=1.722), Trustworthy (4.73, σ=1.663), Nao_was_Persuasive (μ=4.42, σ=1.437).

Similarly, Table 3 represents three questionnaires asked respondents with additional measurements. Perceived Competence (PC) we derived based on earlier three characteristics. Like the earlier Table 2, the mean value and standard deviation were calculated based on each participant's video. These four conditional scenarios representing video were then grouped into four more categories. The first category measures the respondent's opinion on the quality of the video, and the second measuring factor is whether the respondents show compliance with robot Nao or not, then respondent´s perception of the compelling power of robot, and finally the perceived competence (PC) which was measured using the average value of Nao´s three characteristics Knowledgeable, Trustworthy, and Responsible. The average mean and data dispersion from the central value can be found as follows; clarity of video was highest in Low Proximity, Yes Gaze (μ=5.18, σ=1.424), compliance to robot Nao´s instruction (if have any) is highest in the scenario with Low Proximity, No Gaze (μ=4.53, σ=1.741), respondents found out the setting with Low Proximity, No Gaze was more compelling (μ=3.53, σ=1.665), and Perceived Competence (PC) was significant in Low Proximity, Yes Gaze (μ=4.95, σ=1.339).

Characteristics	Video Watched	Mean	Std. Deviation
Attractive	Low proximity, No Gaze	4.81	1.635
	High Proximity, Yes Gaze	4.20	1.795
	Low Proximity, Yes Gaze	5.09	1.646
	High Proximity, No Gaze	4.37	1.159
	Total	4.62	1.611
Fluent	Low proximity, No Gaze	4.38	1.699
	High Proximity, Yes Gaze	4.20	1.623
	Low Proximity, Yes Gaze	5.24	1.226
	High Proximity, No Gaze	4.70	1.264
	Total	4.62	1.511
Friendly	Low proximity, No Gaze	4.81	1.731
	High Proximity, Yes Gaze	4.94	1.514
	Low Proximity, Yes Gaze	5.27	1.281
	High Proximity, No Gaze	5.00	1.438
	Total	5.01	1.492
Knowledgeable	Low proximity, No Gaze	4.78	1.773
	High Proximity, Yes Gaze	4.97	1.543
	Low Proximity, Yes Gaze	5.15	1.603
	High Proximity, No Gaze	4.70	1.535
	Total	4.91	1.606
Responsible	Low proximity, No Gaze	4.75	1.796
	High Proximity, Yes Gaze	4.37	1.767
	Low Proximity, Yes Gaze	4.97	1.571
	High Proximity, No Gaze	4.50	1.432
	Total	4.65	1.651
Natural	Low proximity, No Gaze	4.13	1.601
	High Proximity, Yes Gaze	3.54	1.559
	Low Proximity, Yes Gaze	4.18	1.722
	High Proximity, No Gaze	3.97	1.474
	Total	3.95	1.596
Trustworthy	Low proximity, No Gaze	4.25	1.832
	High Proximity, Yes Gaze	4.37	1.734
	Low Proximity, Yes Gaze	4.73	1.663
	High Proximity, No Gaze	4.33	1.269
	Total	4.42	1.637
Nao_was_Persuasive	Low proximity, No Gaze	4.28	1.550
	High Proximity, Yes Gaze	4.26	1.704
	Low Proximity, Yes Gaze	4.42	1.437
	High Proximity, No Gaze	4.27	1.285
	Total	4.31	1.493

Table 1 Table showing the results based on mean and standard deviation of 8 characteristic measurements

Characteristics	Video Watched	Mean	Std. Deviation
Video_clarity	Low proximity, No Gaze	4.66	1.658
	High Proximity, Yes Gaze	4.69	1.659
	Low Proximity, Yes Gaze	5.18	1.424
	High Proximity, No Gaze	4.50	1.676
	Total	4.76	1.608
I_will_comply_Nao	Low proximity, No Gaze	4.53	1.741
	High Proximity, Yes Gaze	4.20	1.677
	Low Proximity, Yes Gaze	4.39	1.619
	High Proximity, No Gaze	4.20	1.375
	Total	4.33	1.601
Compelling	Low proximity, No Gaze	3.53	1.665
	High Proximity, Yes Gaze	3.46	1.615
	Low Proximity, Yes Gaze	3.18	1.758
	High Proximity, No Gaze	3.07	1.230
	Total	3.32	1.580
PC	Low proximity, No Gaze	4.59	1.608
	High Proximity, Yes Gaze	4.57	1.447
	Low Proximity, Yes Gaze	4.95	1.339
	High Proximity, No Gaze	4.51	1.206
	Total	4.66	1.405

Table 2 Table representing three questionnaires asked to participants with additional measurements Perceived Competence (PC)

Table 4 below is the further extension on the three measuring factors we gathered from the respondents. Table 4 represents whether the respondents found Nao compelling, persuasive, and the quality of the video itself based on a 7-point Likert scale where seven being strongly agreed and descending value being less agreed upon. Table 4 represents respondents opinions based on all four videos, and the percentage value out of 100 was to show how many of the respondents have which level agreement based on a 7-point Likert scale. We can see from Table 4 that 33.1% of respondents expressed their neutral opinion on compliance with the Nao robot. Similarly, only 6.2% of people strongly disagree with complying with Nao. It was quite significant that most people have some level of agreed response on compliance to Nao.

On the other hand, only 3.8% of total respondents found the Nao non-persuasive. The majority of the 30% respondents find the Nao robot to be somewhat persuasive. Similarly, not many people show their strong support for Nao's persuasiveness, only 7.7% of total respondents showing strongly agreed. And now, when it comes to the overall video quality, we could see most of them have some level of agreement, saying the video was clear. Only 3.8% of total

respondents found the video to be not clear Similarly, and Table 3 represents three questionnaires that asked respondents with additional measurements. Perceived Competence (PC) we derived based on earlier three characteristics. Like the earlier Table 2, the mean value and standard deviation were calculated based on each participant's video. These four conditional scenarios representing video were then grouped into four more categories. The first category measures the respondent's opinion on the quality of the video, and the second measuring factor is whether the respondents show compliance with robot Nao or not, then respondent's perception of the compelling power of robot, and finally the perceived competence (PC) which was measured using the average value of Nao's three characteristics Knowledgeable, Trustworthy, and Responsible. The average mean and data dispersion from the central value can be found as follows; clarity of video was highest in Low Proximity, Yes Gaze (μ=5.18, σ=1.424), compliance to robot Nao's instruction (if have any) is highest in the scenario with Low Proximity, No Gaze (μ=4.53, σ=1.741), respondents found out the setting with Low Proximity, No Gaze was more compelling (μ=3.53, σ=1.665), and Perceived Competence (PC) was significant in Low Proximity, Yes Gaze (μ=4.95, σ=1.339).

#	Question	Strongly disagree	Disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Agree	Strongly agree
1	Nao was persuasive	3.85%	10.77%	10.77%	26.15%	30.00%	10.77%	7.69%
2	The video was clear	3.85%	5.38%	13.08%	18.46%	21.54%	23.08%	14.62%
3	I will comply with having advice from Nao	6.15%	9.23%	7.69%	33.08%	20.00%	13.85%	10.00%

Table 3 Table representing three questionnaires asked to participants based on 7-point Likert scale

The bar graph below exhibits the respondents' demographic data based on their previous experience with familiar technology. The three coloured straight standing bar represents the respondents previous encounter with either technologies related to robots, electronics toys or sensors actuators. The read tower standing vertically shows the respondents demographic data based on experience with robots similar to the one they will be facing in the survey. The violet colour represents the previous knowledge and association with electronics toys. Those electronics toys could be anything from children´s toys based on electronics devices to small dolls operated electronically. And the light blue colour is for the user opinion on their previous

familiarity with sensors actuators based devices. The left side vertical line aligned with horizontal axis represents the number of respondents in each of the familiar devices. And horizontal line below the bars aligned with vertical axis represents the 7-scale Likert rating 1 being not at all and 7 being very much. The Table 5 below the graph is to clarify the same data through the table presentation.

As our participants were mostly university students, we expected the higher level of familiarity of the respondents with all the three devices. But, the result was quite opposite to the expectation as we can clearly see from the graph below. Majority of 42% respondents have no previous experience at all regarding the robots and associated technologies. The figure following 19.46%, 12.08%, 12.75%, 5.37%, 2.68% and 4.70% in ascending order of familiarity around robots is very fascinating. It is a clear indication that most of the respondents in our research study have very less familiarity with robots and technologies very closely tied with robotics. We can witness somehow similar result in terms of respondents familiarity with sensors actuators. 32.89% of total respondents were completely unfamiliar with sensors and actuators and similar closely tied technologies. And only 8.72% of the entire respondents were fully experienced with the sensors and actuators. We can see the similar trend to previous experience with robots in case of sensors actuators experience i.e., most of our respondents have either no or little previous familiarity with those technologies. Contrary to this result associated with robots and sensors actuators familiarity, our respondents have a very different opinion in terms of previous experience with electronics toys. Only 11.41% and 6.71% of total respondents had either zero or little familiarity to the electronic toys. 16.11% out of total respondents were very familiar with electronics toys and large number of respondents seems to have a good knowledge and experience with such technology. Overall, the data from bar graph and Table 5 clearly says that although very large number of respondents have minimal familiarity and previous experience with robots and sensors actuators, it was quite opposite when it comes to electronics toys. Large number of respondents seems to have good amount of understanding on the use, functionality, purpose and usability of electronics toys and very closely tied technologies associated with it.

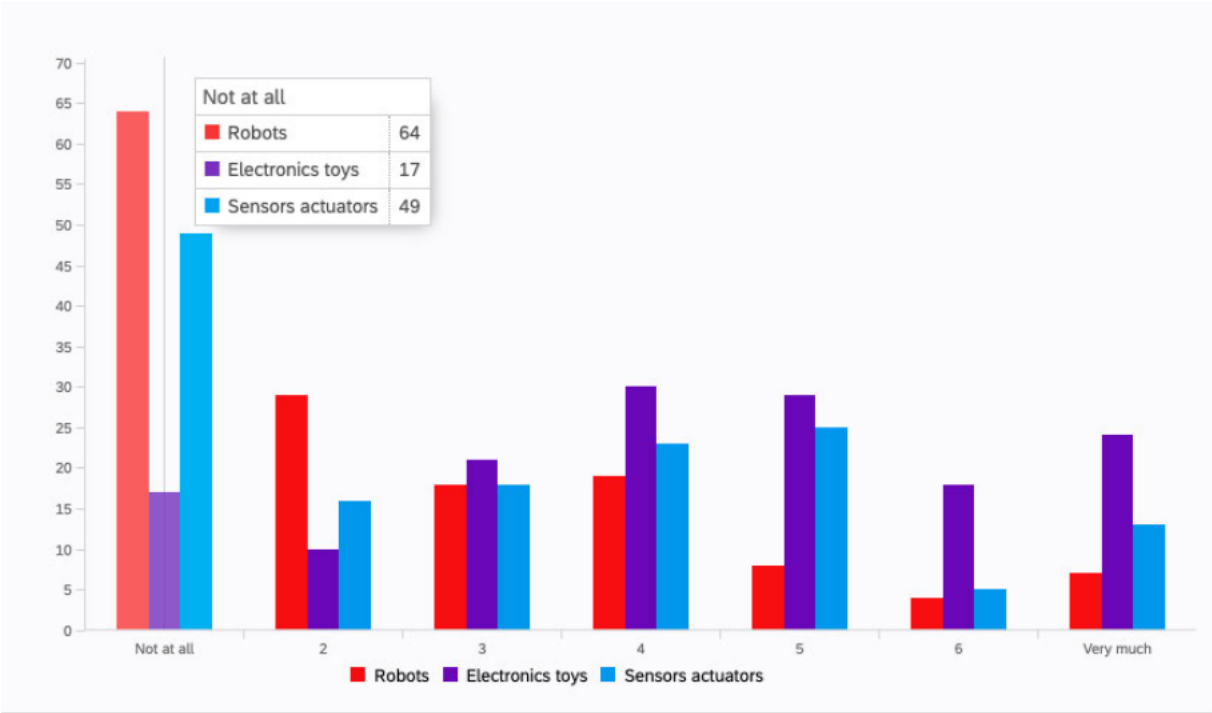


Figure 23 Bar graph exhibiting the respondents' demographic data based on their previous experience with familiar technology

	Question	Not at all 1	2	3	4	5	6	Very much 7
1	Robots	42.95%	19.46%	12.08%	12.75%	5.37%	2.68%	4.70%
2	Electronics toys	11.41%	6.71%	14.09%	20.13%	19.46%	12.08%	16.11%
3	Sensors actuators	32.89%	10.74%	12.08%	15.44%	16.78%	3.36%	8.72%

Table 4 Supplementary table for the bar graph exhibiting the respondents' demographic data based on their previous experience with familiar technology

3.7 PARTICIPANT´S COMMENTS

We recorded the respondents´ opinion on what they liked and what they did not where the participants express their opinion beyond the pre-set choices. Although we did not go to semantic aspects (Landauer, Foltz, & Laham, 1998) of those comments made by respondents, we focused on the frequency of those text form of participants opinion. More than half of the total respondents left this field blank and did not bother to convey anything, we still have many thoughtful comments and purely natural opinion of the respondents as listed below.

- “Audio is somewhat unclear”
- “Short”
- “The setting for the video could have been better”
- “Felt like one way communication”
- “It was boring”
- “The muteness of the video”
- “Robots struggle to replicate human emotions – cannot replace”
- “I didn’t like that Nao was small and somewhat unresponsive at the end”
- “Unresponsive and didn’t show what we wanted to see”
- “The filming quality was low and made the video unclear”
- “I could not really hear what Nao said, and was not sure what Nao was trying to accomplish.”
- “The robot”
- “No sense of engagement”
- “The instruction was very fast.”
- “Too short, not informative”
- “Not on board with robots replacing human jobs”
- “It was poorly made”
- “I had to listen to the video twice to understand what the robot said”
- “No question, just the answer”
- “It went too fast. I read quickly and had trouble keeping up and had to go back to read the whole screen. It could have also been more detailed or had multiple examples to help me formulate a more solid opinion.”

As with the comments made from the participants we came to various conclusion. Although our focus was not purely on semantics of these comments, we briefly analysed these comments. Most of the commentators were talking about audio quality, quality of feedback, time, information about the video and the scenario, graphics and video quality, and some of them express the fear of robot capturing the human jobs. From brief semantic analysis we realized

that participants were talking about the quality of survey, video itself. So, the root reason for all of this is the effect of online survey instead of physical face to face interview. Most of those participant´s comments indirectly remind us of the cons of online survey and at the same time significance of physical interview.

3.8 REFLECTION ON ONLINE STUDY

Our original intention and plan were to conduct and experimental research where participant was supposed to be recruited physically and participate in the interaction with the robot Nao. It assumed that it would have been much more realistic and efficient for us to collect data from the use through the direct interaction with the user instead of watching videos of our research team member interacting with Nao. Instead of our research team member it would have been the actual participant who sees how the robot Nao presents its persuasive techniques. The interaction would have been much more intuitive and the feedback from the participant could be considered highly accurate and trustworthy (Wright, 2005). Despite all these pros of physical and face to face interview, we had to rely on online survey due to the COVID-19 and its effects.

At the time when we were at the phase of experiment and data collection, the federal government and state government of Australia imposed a lot of restrictions including the physical distancing and limit on the capacity. Due to this reason, our primarily associated university for the research Western Sydney University had to follow the government guidelines and set the protocol for the university´s physical room and lab access accordingly. Thus, we could possibly conduct the interview, but it would have taken us more than the allocated time we had for the data collection stage. Also, we had to focus more on the COVID-19 guidelines and protocols for conducting physical interview in such pandemic scenario rather than actual focus on the interview, quality of interaction, data, etc. And most importantly, to keep the safety measures we decided to adopt proactive approach so that the spread of COVID-19 virus is limited. Thus, we opt to use online approach and confirmed our data collection method as online survey and restructured our plan accordingly.

There were some limited pros of this online approach of data collection as well as overall research journey but mostly it limits our overall plan and immersive passion to the research. First, let´s go quickly through some of the pros we´ve witnessed due to this online survey and the platform service it provided. It was quite cost effective for us to conduct the survey as otherwise we might have been bounded to provide some sort of incentive to the participant in

the face-to-face interview we planned to conduct. Distribution process was instantaneous with the help of faculty co-ordinator and tutors which is why we were able to collect large amount of data at the first phase of distribution. Similarly, this online based survey must have put the convenience to all the respondents as it was possible to go through the survey on their own time. They had this freedom of choosing time and place to participate on their own convenience.

While these were some actual and probable benefits of conducting the data collection process through online survey platform ´Qualtrics´, we faced various barrier and backlogged through our research specially in the phase of data collection. We must have to admit the fact that the quality of data through online media and survey is always questionable (Smith, Roster, Golden, & Albaum, 2016). The fear of survey fraud was always roaming around us throughout the data collection. Although our survey was very short and finishes in short period of time from starting the survey, we could never be assured for the quality of data we gathered. As respondents were to participate online in their convenience, the factor of accountability due to which the quality of data remains intact was gone. Although we chose university students as respondents for our survey, we must accept the fact that the respondents might have just clicked and hit the random button to finish the survey instead of expressing their real opinion. Similarly, the distribution process could have been complex for us as well due to the restrictions and closure of campus and classes. But online classes and helping hands of supervisors and their students help us overcome this hurdle. Out of all these, most painful was the transition from planned face-to-face interview to online survey. We would have described the script and scenario to the participant in the research more thoroughly instead of showing text in the video. The informative text on the video could never exceed the comprehensiveness of actual face to face description. As the understanding of the scenario of the video before starting the survey was very crucial, we were not assured of the level of respondent comprehension on the text description we provided. Which could have harshly affected the real opinion of the respondents ultimately affecting the quality of data. Also, many of our participants (or survey respondents), 50 out of 180 either withdraw from the survey or did not complete it. Because of this we had only 130 valid respondents despite our engagements to 180 probable participants. This sort of problem is beyond our control in the scenario of online study and surveys.

3.9 VARIOUS TEST AND RESULTS

3.9.1 Reliability Check

Reliability Check on Perceived Competence was carried out, giving us a *Cronbach Alpha value* of 0.83 which gives us sufficient confidence in the reliability of the questionnaire item perceived competence.

3.9.2 Analysis of Variance (ANOVA) and Post hoc tests (Bonferroni)

We conducted Between Subjects *Analysis of Variance (ANOVA)* where videos type was the main independent variable. The dependent variables were the measurements indicated earlier. Prior to checking for significance, we also checked for covariates analysis on prior experience with robots, where except for the item Natural $F(1,123) = 4.54$, $p = 0.04$, all other items were not significant. This gave us some assurance that any prior biases were in check. Subsequently we observed the primary results of the ANOVA. All items were not significant except Fluent $F(3,126) = 3.24$, $p = 0.03$. Attractive was nearing significance (potentially) $F(3,126) = 2.19$, $p = 0.09$. *Post hoc tests (Bonferroni)* revealed that Low Proximity, Yes Gaze was considered significantly more fluent than High Proximity, Yes Gaze ($p = 0.02$).

3.9.3 Bivariate correlation analysis

We conducted *bivariate correlation analysis* amongst the measurements. Specifically, we focused on the correlation between the items I will comply with the Nao and Nao was persuasive with the 9 survey items. Both had strong correlations with Trustworthy, Attractive, Perceived competence and Natural ($0.41 < r < 0.48$, $p < 0.001$).

3.9.4 Chi Square analysis

We then conducted *Chi Square analysis* to check the associations across the video types and whether participants left any positive or negative comments (a simple Yes or No). A reminder we only checked for the presence of such comments in the relevant fields but at this stage did not analyse the semantics of those comments. The *Chi Square* revealed that there was no significant association between the type of video and the presence of positive comments $\chi 2$ $(3,130) = 1.2$, $p = 0.75$. A subsequent *Chi Square* showed that there was a significant association between the type of video and the presence of negative comments $\chi 2$ $(3,130) = 8.48$, $p = 0.04$. High Proximity Yes Gaze received significantly more negative comments than the other conditions (standardised residual $z = 1.9$).

Our study couldn´t point out significant result other than pointing out the distaste on high proximity with gaze. This is perhaps due to the online nature of the survey and data collection which prevent us to create a face-to-face interaction between participant and humanoid robot Nao. As we´ve mentioned in the reflection on online study (Hyman, Lamb, & Bulmer, 2006), the online nature create some level of distraction, video quality issues, difficulties comprehension of conditional scenarios we´ve tried to simulate, and a lot more unexpressed issues. Many of these issues could have been easily avoided if only we were able to conduct interview with participant directly interacting with humanoid robot Nao.

Based on the participants´ opinion and perceptions on humanoid robot Nao and various comments, we conclude that High Proximity and Yes Gaze was less preferrable. After watching the video where robot and our research team member were put in 3-meter distance and our humanoid robot Nao gazing while delivering persuasive speech, most of the participant in our study pointed that the video with the mentioned conditional scenario is the least preferable one. It could be understood from this result that if robot uses gestures such as gaze, then it is a good idea to avoid the larger gap between the robot and communicating entity. Although it was not very clear from the result that which setting precisely is more effective and desirable, in HRI our results suggest keeping the interacting entities for example robot and human close while robot keeps eye contact (showing gaze behaviour).

Although there were previous studies (Burgoon, Birk, & Pfau, 1990; Burgoon, Buller, Hale, & de Turck, 1984; Chidambaram et al., 2012) based on gaze and proximity suggesting high proximity combined with other gestures are generally more preferrable, our finding opposes the idea. The major factor for this differentiating idea could possibly be the choice of robot and furthermore size of the robot (Ham et al., 2015). As we know the humanoid robot Nao that we used in our study is relatively smaller in terms of size if we compare it other mainstream social robots such as Pepper (Pandey & Gelin, 2018). So, when we increased the distance between our robot and research team member while robot gazed and tried to persuade our research team member, it is hard for the survey participant to watch and analyse the gaze behaviour. Thus, they preferred the same phenomenon only with the exception that the distance should be minimal. We much must admit again that if only the same study was based on face-to-face interview instead of online survey, the shadowing factor to gazing behaviour due to the high proximity could have been minimal. Similarly, we also observed that most of our survey

respondents have very minimal experience with technologies related to robots and electronics. This could have also impacted our result on distaste on gazing behaviour with high proximity.

3.10 STUDY LIMITATIONS

We´ve mentioned the quality of data throughout our thesis as we have less confidence in its purity and actual reflections on the respondent's opinion. Due to the COVID-19 government imposes restrictions on physical contact and social distancing. This impacted our decision of conducting research and compelled us to opt for online survey instead of face-to-face interview. And we know that the quality of such data is always in questions regarding fraud data, original source, intention, etc. So, we could have collected data that we would have more confidents on if only we did not have to rely on online survey. The very impulsive evident of negative effects of the online survey we experience was on the data collection where almost one third of total respondents did not completed or withdraw from the survey. We ended up with empty and incomplete data.

We presented the text box for the survey participant to express their opinion on positive and negative aspects of the survey and the video presented in survey. We were able to collect very random thoughts from the participant which if we did detail semantic result would certainly have pointed out some significant findings. But due to the lack of confidence in the data we have received and very limited comments, we perform the frequency analysis of those comments based on the negative and positive expression of each comment in overall. Our research findings were not very significant overall, and it seems like the size of the robot was one factor for it. If only we had chosen robot larger than Nao, then our only significant result could have been altered.

Chapter 4: Conclusion

In this research paper, we investigate various aspects of Human Robot Interaction (HRI) and Human Computer Interaction (HCI). Due to the evolving technology and demand on the services worldwide that requires assistance from technical perspective, the concept of persuasive robot and related technologies emerges day-by-day. Social robotics is one of the most affected field by the increasing demand of persuasive technologies. From natural social psychology perspective, social robots are the human embodiments (mostly or preferably) primarily intended to assist in human social needs by using persuasive techniques (Deng, Mutlu, & Mataric, 2019). This definition of social robot clearly highlights the importance of persuasive technologies. When we talk about technologies, it could be the combination of various strategies such as gestures and electronics addition to the robots. Our focus of this study is only on the use of gestures in social robots through varying persuasive strategies.

Verbal persuasive techniques such as speech and variation in its tone, speed, stress, etc has been in use throughout the human history to convince someone or to invade the other entities´ perception to achieve the compliance. Often neglected is the use of non-verbal communication strategies which not only has been in use in human history but also many animals consciously and subconsciously perform to survive. Despite having tremendous application on persuasive technologies, non-verbal communication strategies were often underestimated in the field of HRI (Argyle, 1972). Non-verbal communication strategies include variation in different physical body parts, directional movement, orientation, etc. There has been plenty of studies focused on non-verbal persuasive strategies based on face, hand, eyes, gaze, proximity, etc. But effects of combined strategies were minimally researched and even joint strategy such as gaze and proximity are the area in HRI still needs to be discovered more.

We performed 2x2 between experiments where gaze and proximity were the two variables with low and high factors in proximity and yes and no factor in gaze. For this, we created 4 different conditional scenarios that mimic the four different conditions. When the robot Nao was near or distant from the human and when our humanoid robot Nao uses gaze or not is what we primarily created our scenario upon. We created online survey which collects

user opinion on various aspects of Nao robot and some other measurement criteria. The survey was distributed, and 130 participants valid data was collected and analysed.

We created various reports from the data we achieved which shows the demographics of respondents based on their previous exposure to the robot and similar technologies. As most of the respondents had very little familiarity with the technologies, we´ve applied in our survey, we were not surprised by the comments they provide. Most of the comments were made upon the survey quality and robots so it is quite relatable. Although we did not focus on the semantic analysis on the feedback we received from the respondents in the form of comment text, we briefly and individually analysed to see if we could relate them to the persuasion by robot itself.

Addition to those straightforward reports presenting mean and standard deviation values, we performed more analysis to further test various aspects of the parameters we´ve used. We performed Reliability Check on Perceived Competence (PC) to clarify the questionnaire items. Our Between Subjects Analysis of Variance (ANOVA) test reveals that all the measurement items were insignificant except for the Fluent and Attractive characteristics potentially nearing significance. In addition, Bonferroni test we performed shows that out of four conditional scenario, Low Proximity Yes Gaze was fluent than High Proximity Yes Gaze. Furthermore, our bivariate correlation analysis amongst various measurements depicts that compliance with robot Nao and persuasiveness of Nao were strongly correlated with Trustworthy, Attractive, Perceived Competence and Natural aspects of humanoid robot Nao. We adopted Chi Square analysis to see the non-semantic association between type of four videos and the comments made by the participants. We realized that High Proximity Yes Gaze video received was the frequently commented negatively.

Throughout all the test we performed, most of them did not show any significant differences the four-conditional scenario except the Chi Square analysis. So based on the result and analysis we could say that the High Proximity, Yes Gaze was the least preferred scenario. This could have some indirect relation to the size of the robot itself, but this is our assumption based on the brief analysis on the participant's feedback.

Chapter 5: References

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Appendices

Appendix A

List of previous literature in details related to social robotics and gestures

Number	Name of the paper	Publication	Research style	Included/Excluded	Name of the	Participant and	Operation	Robot Gestu	Gesture details	Operation
1.	A Gesture Based	2000	Experimental	in (despite it is a service robot)	AMELIA (RWI		Teleoperated	Hand		Lab
2.	A new emotional	2018		in	EmIR (Emotio		Autonomous	Face	(mouth and eyebrows	Health care and
3.	A Persuasive Robot to	2013	Experimental	in	iCat robot	33 students	Simulated	Face	(eyebrows, eyelashes,	Lab
4.	Assessing the effect of	2019	Experimental	in	SocioBot	22 participan	WizOfOz	Head	random head movementa	lab
5.	Behavioral overlays for	2006	Experimental	in	Sony QRIO		Autonomous	Proxemics	Personal space	
6.	Child's Perception of	2014	Experimental	in	Nao	8 participan	WizOfOz	Head	Body posture to express	lab
7.	Children's reliance on	2019	Experimental	in	Nao	60 and 42 monolingu		Hand	Pointing with hands and	student´s school
8.	Combining Robotic	2015	Experimental	in	Nao	64 participan	WizOfOz	Gaze	Gazing (looking at	Lab
9.	Compliance to Requests	1976		out (no use of any sort of				Gaze		
10	Cooperative gestures for	2017	Experimental	in		17 participan		Hand	directional, orientational,	Lab consistin
11	Designing Persuasive	2012	Experimental	in		32 native english		Combined	sitting close or far from	lab
12	Development of a	2017		out	Nao					
13	Differences in effect of robot	2004	Experimental	in	Embodied social		Teleoperated	Combined	included pointing to a	Lab
14	Effects of different	2009	Experimental	out (focus on verbal		50 university				
15	Effects of Eye Contact and	2013	Experimental	in	Nao	23 native dutch	WizOfOz	Gaze	making eye contact by	lab
16	Enhancing Emotional	2016	Experimental	in	Nao	70, 40 , 40 and 40	wizOfOz	Face	eyebrows movement	lab
17	First encounter	2019	Experimental	in	Alpha (UBTEC	110 uni students		Combined	opening arms (i.e. to show	lab
18	Generation and	2012	Experimental	in	Honda humano	60 german speaking	WizOfOz	Gaze	Deictic gestures, e.g.,	kitchen environ
19	Gesture-based	2006		out (focus is on robot						
20	Persuasive Robots	2019	Experimental	out (verbal persuasive	SociBot	78 university	WizOfOz			
21	Give me a sign:	2014	Experimental	out (no robots were used)						
22	Human–Robot	2016	Experimental	in	Zeno	54 adults from	Teleoperated	Hand	1 Wave with right arm	Lab
23	Human–Robot	2014	Experimental	out (robot is responsible for						
24	Interaction of robot with	2016	Experimental	in	IGUS-Robolin	18 participan	Teleoprated	Face	1. Point-point motion	lab
25	Investigating Entrainment	2011	Experimental	in	Robovie-R ver.2	18 native-Japanese-	WizOfOz	Gaze	looking at participant	lab
26	Investigating the Effect of a	2018	internet survey	in	image of robot	44 participan	online	Face	robot to look straight down	online
27	iSocioBot: A Multimodal	2017		out (dialogue based						
28	It Would Make Me	2019	Experimental	in	Nao	200 participan	teleoperated	Combined	movement of hands and	lab
29	Let the Avatar Brighten Your	2016		out (no use of robots)						
30	Mechatronic design of	2009	Explanatory	in (detailed mechainical	Nao	none	na	na	NAO has a total of 25	na
31	Mood contagion of	2015	Experimental	in	Nao	36 student from Delft	WizOfOz	Combined	body movement is	lab

32	Natural Deictic	2007	Experimental	in	Robovie	30 university	Teleoperated	Combined	using hand and fingers to	lab
33	Nonverbal Immediacy as	2016	literature review	in	na	na	na	Combined	Guidline G1 In general,	na
34	Nudging for good: robots	2016	feasibility study	in	na	na	na	Head	na	na
35	Pantomimic Gestures for	2015		out (focus is on pantomimic						
36	Persuasive Robotics: The	2009	Experimental	in	Mobile Dextero	134 museum	teleoperated	Combined		lab
37	Reaching and pointing	2016		out (deeply focused on						
38	Telerobotic Pointing	2012	Experimental	in	(use of telepres	32 and 26 male	teleoperated	Hand	pointing	lab
39	The NAO robot as a	2015	case study	in	Nao					
40	The Effects of Humanlike	2018	Review	in	na		na	Face	Different color of LED	
41	The influence of social cues	2018	Explanatory	Out(focushed on human		60 (41M, 19F), 6	WizOfOz			
42	To Err is Human(-	2013	Experimental	In	Honda Humano	NA	WizOfOz	Combined	unimodal (speech-	Simulated
43	Towards an intelligent	2015	Experimental	In	Nao		WizOfOz	Combined	Multimodal combined	Lab
44	Uncanny...But Convincing?	2018	Experimental	In	virtual agent	107 out of 128	Autonomous	Face	changes in the facial	Lab
45	Understanding human	2018	Experimental	In	Visual-Intractio	10 participan	Autonomous	Combined	Executes tactical	closed(p
46	Visual recognition of	2007	Review	Out(focushed on detection of		15 test persons				
47	When Artificial	2011		Out(focused on Psychological		138 participan				
48	When my robot smiles	2009	Experimental	In	Virgil (WowW	12 participan	WizOfOz	Gaze	Full head gesture	Lab

Appendix B

Email sent for recruitment of participants

As we were strictly following the protocols under the project, we conducted a permission to approve our ethics application through Amendment Request From. There were discussion on any potential ethical issues amongst team of the project and there was no anticipation that any major ethical constraints as the new study design is in line with the prior conducted rounds of data collection. Data collection will be online and the only issue is if participants run into some logistical issue (with their internet connection for example) they may need to abandon their study and report back to us via email or phone. We anticipate student recruitment to be handled by school admin wherever applicable to avoid issue with coercion. This was the same protocol followed in the original approval (hence no change).

Recruitment Email (to be sent by School Admin to Student Body)

Dear Students
As part of a research project at the University, you are invited to participate in an online survey, which will take approximately 10 -15 minutes to complete. This aim of this survey is to get your opinion about robots and some business organisations. Your participation is entirely voluntary. If you would like your opinion to be heard, please follow the link to the survey: (give qualtrics link here)
If you wish to get further information on this research project, please contact Aila Khan on: a.khan@westernsydney.edu.au or Omar Mubin on omar.mubin@westernsydney.edu.au

Regards

School Manager

Research Team Members:
Dr Aila Khan
Dr Omar Mubin

Appendix C

Consent form

The consent form was as follows:-

Project Title: Social robots as a medium of communication

This study has been approved by the Human Research Ethics Committee at Western Sydney University. The ethics reference number is: H13082. If you have any complaints or reservations about the ethical conduct of this research, you may contact the Ethics Committee through Research Engagement, Development and Innovation (REDI) on Tel +61 2 4736 0229 or email humanethics@westernsydney.edu.au.

Any issues you raise will be treated in confidence and investigated fully, and you will be informed of the outcome.
I hereby consent to participate in the above-named research project.

I acknowledge that:
I have read the participant information sheet (or where appropriate, have had it read to me) and have been given the opportunity to discuss the information and my involvement in the project with the researcher/s The procedures required for the project and the time involved has been explained to me, and any questions I have about the project have been answered to my satisfaction. I consent for my data and information provided to be used for this project. I understand that my involvement is confidential and that the information gained during the study may be published but no information about me will be used in any way that reveals my identity. I understand that I can withdraw from the study at any time without affecting my relationship with the researcher/s, and any organizations involved, now or in the future.

Please select the box to provide your consent to complete an online activity (i.e. watching a video showcasing a robot) and to fill out the survey at the end of the activity

- ○ **Yes**
- ○ **No**

If you wish to get further information on this research project, please contact Aila Khan on: a.khan@westernsydney.edu.au or Omar Mubin on omar.mubin@westernsydney.edu.au