ADULTS’ PERCEPTION OF EMPATHY WHEN INTERACTING WITH A NURSING ROBOT OR A PHYSICALLY PRESENT NURSE: A RANDOMIZED NON-INFERIORITY COMPARISON

by

Dennis Raymond Crain

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A Dissertation Submitted to the Faculty of the

COLLEGE OF NURSING

In Partial Fulfillment of the Requirements
For the Degree of

DOCTOR OF PHILOSOPHY

In the Graduate College

THE UNIVERSITY OF ARIZONA

2015
THE UNIVERSITY OF ARIZONA
GRADUATE COLLEGE

As members of the Dissertation Committee, we certify that we have read the dissertation prepared by Dennis Raymond Crain entitled “Adults’ Perception of Empathy when Interacting with a Nursing Robot or a Physically Present Nurse: A Randomized Non-inferiority Comparison” and recommend that it be accepted as fulfilling the dissertation requirement for the Degree of Doctor of Philosophy.

______________________________ Date: November 3, 2015
Kimberly D. Shea, PhD, RN

______________________________ Date: November 3, 2015
Kathleen C. Insel, PhD, RN

______________________________ Date: November 3, 2015
Pamela G. Reed, PhD, RN, FAAN

Final approval and acceptance of this dissertation is contingent upon the candidate’s submission of the final copies of the dissertation to the Graduate College.

I hereby certify that I have read this dissertation prepared under my direction and recommend that it be accepted as fulfilling the dissertation requirement.

______________________________ Date: November 3, 2015
Dissertation Director: Kimberly D. Shea, PhD, RN
STATEMENT BY AUTHOR

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SIGNED: Dennis Raymond Crain__________________
ACKNOWLEDGMENTS

Thanks to my family and friends for their unflagging support of my efforts to complete my doctoral education. Without that level of commitment and support I simply would have failed to achieve my educational goals. I am most thankful to the Lord\(^1\) who placed Annie, my biggest fan, supporter, and encourager, in my life.

I am grateful to the faculty of the University of Arizona College of Nursing. As a beneficiary of their expertise as educators and researchers I am prepared to tackle the challenges of game changing research. I especially wish to thank my dissertation committee. Dr. Kimberly Shea has supported and encouraged me from the beginning. As I was considering the University of Arizona I called Dr. Shea and she enthusiastically encouraged me to join the PhD program. She has continued to encourage me as my advisor and dissertation chair. Dr. Kathie Insel recognized the importance of my research. She put up with my frustrating eccentricities and continued to encourage and support me. Dr. Pamela Reed opened my eyes to an incredible view of the world through a theoretical lens as opposed to the application lens that dominated my time in the computer industry. Dr. Sheila Gephart pushed me to challenge and stretch my grasp of nursing research. Dr. Joseph Hepworth shared my passion for statistics. He challenged me to consider simplicity as an alternative to my penchant toward esoteric statistical methods. Thanks to them and all of the College of Nursing faculty with whom I have interacted.

\(^1\)And my God will liberally supply your every need according to His riches in glory in Christ Jesus. Philippians 4:19
DEDICATION

This dissertation is dedicated to Annie and our four sons, Timothy, Joel, Andrew and Philip. They are the reason I have taken this journey and they have inspired and amazed me in countless ways.
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ABSTRACT

Background

Nursing presence is an intersubjective connection between the nurse and patient that results in improved patient outcomes. Present day task-oriented healthcare robots possess an evolving capacity to address task-based attributes of nursing care but are far less capable of addressing attributes of nursing presence. The purpose of this study was to explore adults’ perception of nurse-expressed empathy, an attribute of nursing presence, as enacted by a semi-autonomous robot nurse compared to a human nurse following a discussion of the adults’ health concerns or issues.

Methods

The design for this study employed a non-inferiority randomized comparison of two groups. The overall hypothesis was that adults’ perception of nurse-expressed empathy during human-robot interactions was not inferior to the perception of nurse-expressed empathy during human-human interactions. From a broad geographic community 102 adults, age 21 to 80, were recruited and assigned to an active control or reference treatment group using stratified and blocked randomization. In each group, participants discussed the impact of health issues or concerns on their daily life. Participants in the reference treatment group interacted with a semi-autonomous robot. Participants in the control group interacted with the researcher face-to-face. Participants’ perception of nurse-expressed empathy was measured using the Empathic Understanding Scale of the Barrett-Lennard Relationship Inventory. A confidence interval approach using 95%-95% method was used to assess non-inferiority. The first confidence interval was obtained from analysis of seven historical studies that measured empathy using the
Empathic Understanding Scale. The second confidence interval was obtained from analyses of the difference in mean perceived empathy between the two study groups.

Results

Three normalized statistical methods used to evaluate non-inferiority were significant ($p < .025$) and contained confidence intervals less than the non-inferiority margin ($\delta = 3.33$). This resulted in the rejection of the null hypothesis that empathy communicated by a robot was inferior to empathy communicated by a human nurse.

Conclusions

This study provided evidence that nurses operating semi-autonomous robots can communicate empathy to adults. Innovation and collaboration among nurses, computer scientists and engineers will ensure that successive generations of robots maintain a nursing perspective while operating at their optimal capacity.
CHAPTER 1: INTRODUCTION

Healthcare robots are transforming the practice of nursing (Huston, 2013; Metzler & Barnes, 2014; Wood, 2011) yet there are timeless practices in nursing that must endure and translate to robots if they are to acquire more nursing functionality, become integral members of the nursing care team, and be worthy of the title nursing robot. One such timeless practice is the unique relationship formed between nurse and patient often referred to as nursing presence. The focus of this study was the investigation of empathy, an attribute of nursing presence, in the context of a robot, nurse, and patient interaction.

Background

Nursing presence (NP) is a complex concept (Finfgeld-Connett, 2008; Zyblock, 2010) that is understood to be an intersubjective connection between the nurse and patient that is characterized by empathy, caring compassion, sensitivity, holism, intimacy, and vulnerability (Doona, Haggerty, & Chase, 1997; Hessel, 2009). Patient outcomes, reported by patients and nurses, have been shown to improve when NP is enacted between patient and nurse (Finfgeld-Connett, 2008; McCarthy & Aquino-Russell, 2009).

Present day healthcare robots (HRs) possess an evolving capacity to address task oriented attributes of NP including patient monitoring and surveillance, patient education, availability, personalization of care, remote consultation, and companionship (Andrade et al., 2014; Bäck, Kallio, Perälä, & Mäkelä, 2012; Breazeal, 2010; Broadbent et al., 2010; Grant, Rockwood, & Stennes, 2014; Huang, Tanioka, Locsin, Parker, & Masory, 2011; McNelis, Schwall, & Collins, 2012; Sharts-Hopko, 2014; Robinson, MacDonald, & Broadbent, 2014). These HRs are far less effective at perceiving and dispensing other attributes of NP such as empathy, concern,
responsive listening, and reassurance. Substantial research and advancement of the cognitive and affective capabilities of robots is required in order for NP to fully occur between a patient and a HR (Carelli, Gaggioli, Pioggia, & De Rossi Riva, 2009; Chopra, Chandel, Panchal, & Sinha, 2014; Diamant, 2014; Röning, Holappa, Kellokumpu, Tikanmäki, & Pietikäinen, 2014; Scheutz, 2012).

Empathy, a key attribute of NP, was the concept of interest in this study due to its central importance to nursing (American Association of Colleges of Nursing [AACN], 2010; Carper, 1978). Empathy has been investigated by robotics researchers yet little of this research was conducted within the context of nursing (Chen, King, Thomaz, & Kemp, 2014; Coeckelbergh, 2010; Cramer, Goddijn, Wielinga, & Evers, 2010; Glaskin, 2012; Jo, Han, Chung, & Lee, 2013; Kwak, Kim, Shin, & Cho, 2013; Leite, Castellano, Pereira, Martinho, & Paiva, 2014; Meng & Lee, 2009; Riek, Rabinowitch, Chakrabarti, & Robinson, 2009; Rosenthal-von der Putten et al., 2014). Although nurse researchers have studied NP in the context of technologically delivered nursing care none of these studies investigated the use of robotic devices (duMont, 2002; Nagel, Pomerleau, & Penner, 2013; Sävenstedt, Zingmark, & Sandman, 2004). The disjoint nature of these research efforts exploring robotic empathy and NP with technology has resulted in a gap in knowledge that must be bridged.

**Philosophical Perspective**

Intermodernism is a philosophy situated between postmodernism’s anti-realist, anti-objectivist, and somewhat relativistic views that emphasize local and social realities over objective realities and modernism’s notions of essentialism and foundationalism (Martin & Sugarman, 2000; Reed, 2011). The tenets of intermodernism provide a ready philosophical
platform upon which to respect the science and practice of nursing while conceptualizing nursing from a somewhat radical and often unwanted perspective of robotics (DeMoro, 2013; Frederickson, 2014; NYNSA, 2013; Reed, 2011). Intermodernism’s balance or “the middle way” (Reed, 2011, pp. 14-16) between modernism and postmodernism befits the natures of human-robotic interaction (HRI) and nursing discovery. There exists a “dynamic flux” (Martin & Sugarman, 2000, p. 403) in the science of HRI exacerbated by the rapid growth of robotics and evolving theories guiding robotic social interaction and functionality (Shaw-Garlock, 2011). Indeed, confronting the relative nature of large unstructured repositories of data, useful to the support of robotic artificial intelligence, conjures uncanny parallels to postmodernism (Pepi, 2013). Yet, in this context, the needs of patients and the practice of nursing bring focus and purpose to the use of otherwise chaotic and evolving HRI theory and functionality.

**Theoretical Perspective**

The two middle range theories guiding this study were the Theory of Human-Robot Interaction (Scholtz, 2003) and Nurse-Expressed Empathy and Patient Distress (Olson & Hanchett, 1997).

**Theory of Human-Robot Interaction**

Scholtz’s (2003) Theory of Human-Robot Interaction (THRI) provided a framework by which to situate the nurse, patient, and semi-autonomous mobile remote telepresence robot (SMRTR) relative to one another and the roles of each in the context of a nurse-robot-patient interaction. The theory was derived from a seven stage model of human-computer interaction (Norman, 1986) combined with a conceptualization of roles suited to executing and evaluating the interactions. The theory was developed for two purposes to: (a) understand the design of
robotic systems that welcome human input to the robotic workflow, and (b) facilitate understanding of the roles required of humans to interact and intervene with semi-autonomous robots engaged in task oriented behaviors (Scholtz, 2003).

The four main concepts found in THRI are interaction, interaction roles, robot, and human. Each of these concepts are composed of multiple attributes.

Interaction. The interactions found in THRI are based on a heuristic model of human-computer interaction (Norman, 1986). This model incorporates seven stages of interaction including:

1. Goal - The formulation of a broad result to be achieved.
2. Intention - A clear understanding of what is needed to accomplish the goal.
3. Actions - The specification of actions required to achieve the intention.
4. Execution - Perform, to completion, the specified actions.
5. Perception - Have the completed actions produced a result?
6. Interpretation - What do the results mean?
7. Evaluation - Compare the results and their interpretation to the intention. If they match then the goal has been achieved. If they do not match adjust accordingly and iterate until the goal is achieved or modify the goal.

There exist two potential mismatches between these stages that can result in a collapse of the heuristic. A gulf of execution occurs when the intention cannot be met because the actions required to accomplish the intention are not present or permissible. A gulf of evaluation exists when the user’s expectations of the robotic system exceed the system’s capabilities (Norman, 1986; Scholtz, 2003).
**Interaction roles.** Interaction roles represent the relationship and manner by which the robot and human interact with one another. The THRI specifies roles of supervisor, operator, peer, mechanic, and bystander (Sholtz, 2003). The boundaries of the interaction roles are “fuzzy” and often crossed (Scholtz, p. 4). For example, a need may arise where the operator takes on the supervisory role or a peer may need to step into the mechanic role. The functions of the roles occur periodically or simultaneously. Roles are characterized by their highest entry point into the interaction heuristic.

**Supervisor.** The supervisor remotely monitors and controls all stages of the HRI. At any point of interaction the supervisor may add or modify interactions. This role formulates both goals and intentions and has a resolute focus on the perception stage; the perception of satisfactory results that could motivate changes to other interaction stages.

**Operator.** The operator is concerned with the action stage of interaction. The operator monitors actions and determines if the actions are executed in a fashion that supports the goal. If the actions are not appropriate then the operator corrects them in the context of the action not the goal or intention.

**Peer.** The peer role permits a user to issue commands to the robots within the context of the goal and intention interactions. However, the peer role cannot modify the goal and intention. That is reserved for the supervisor role. This role enables interaction at a higher level of abstract behavior than the operator role.

**Mechanic.** The mechanic role focuses on the action role just as the operator does. However, the focus is on those actions that are mechanical or electrical. For example, fixing a broken wheel on the robot or replacing its battery.
**Bystander.** The bystander role focuses on the action level but with a substantially reduced and indirect set of actions. This would permit a robot to stop before running into a bystander who unexpectedly passed in front of the robot.

**Caregiving.** In THRI the patient might best be considered a bystander for which little control of the robot is granted. However, in the context of a social interaction, the patient should have control over many of the same robot capabilities as the nurse operating the SMRTR such as the audio and video features (Breazeal, 2010). For this purpose, this study extends the THRI roles to include a caregiving interaction role. This role can be conceived of as situated between the peer and bystander interaction roles where the role of bystander is elevated to nearly that of the peer interaction role. The role is bidirectional and both participants are aware of the extent of their control over the robot.

**Robot.** The concept of robot found in the THRI is one where mobile semi-autonomous robots carry out tasks independently or in teams as directed by human operators while operating in diverse environments (Scholtz, 2003). Robots such as these are susceptible to physical degradation such as the failure of sensors, electronics, or mechanical systems thus the need for the mechanic role (Scholtz). This conceptualization of a robot may be thought of as an *indirect robot*; a characterization that incorporates a human operator and a unidirectional flow of information from the robot to the human (Thrun, 2004). However, for the purpose of this study, flow of information is bi-directional with the robot and participant interacting with one another.

**Human.** In the THRI humans are teammates with robots. Humans are assigned the interaction roles described earlier. In these roles, humans require certain information from the robot in order to fulfill the purpose of the interaction role. These data provide situational
awareness of the robots and include planned use of robot, current operating status of the robot, timing constraints, which actions are available for a robot, current robot behavior, notification of system failure, and current robot configuration settings. In addition to these data the caregiving role requires additional data such as those received during a typical face-to-face encounter with a patient that provide cues to empathy such as length of encounter and eye contact (Montague, Chen, Xu, Chewning, & Barrett, 2013).

**Nurse-Expressed Empathy and Patient Distress**

The Nurse-Expressed Empathy and Patient Distress (NEEPD) middle range theory was deductively derived from the grand nursing theory of Orlando (Olson & Hanchett, 1997; Orlando, 1961). Olson and Hanchett were led to choose Orlando’s nursing model having perceived an intersection between Orlando’s view of health and their own belief that finding meaning in illness would result in a growth experience. Orlando’s nursing model contains many relational statements three of which Olson and Hanchett focused on and from which the propositions of NEEPD emerged: (a) patient behavior and effective nursing care improve when nurses respond to patients using a disciplined professional manner as opposed to an automatic and personal manner; (b) nursing assessment of a patient’s immediate needs, experiences, and resultant behaviors culminates in nursing care that is more likely to decrease distress; and (c) the perception of patient needs, when accurate and shared verbally with a patient, enriches patient outcomes (Meleis, 2011; Olson & Hanchett, 1997; Orlando, 1961).

**Theory propositions.** According to Olson and Hanchett (1997) three propositions of NEEPD were related to the relational statements noted above. The relationships described in these propositions were described in an earlier correlational study conducted by Olson (1995).
**Proposition 1.** Nurse-expressed empathy is negatively related to the patient’s health distress. When nurse-expressed empathy increases, the patient’s distress decreases. In NEEPD, the patient’s distress infers a patient behavior in accordance with Orlando’s nursing model. Empathy is considered a component of Orlando’s disciplined professional response nursing model because the proper application of empathy requires an accurate perception and validation of the patient’s feelings (Olson & Hanchett, 1997).

**Proposition 2.** Nurse-expressed empathy is positively related to patient-perceived empathy. When the nurse’s perception of the patient is accurate and communicated to the patient, the patient perceives the nurse to be empathetic (Olson & Hanchett, 1997).

**Proposition 3.** The patient’s perception of nurse-expressed empathy is negatively related to their distress. Similar to the first proposition, when the patient feels understood distress and helplessness decrease while comfort increases (Olson & Hanchett, 1997).

**Purpose**

The long-term goal of this research was to improve patient outcomes by supplementing task oriented features of future generation HRs with features that facilitate NP. In pursuit of this goal the purpose of this study was to explore adults’ perception of nurse-expressed empathy, a component of NP, as enacted by a semi-autonomous robot nurse compared to a human nurse following a discussion of the adult’s health concerns or issues. The overall hypothesis of this study was that an adult’s perception of nurse-expressed empathy during a human-robot interaction would not be inferior to their perception of nurse-expressed empathy during a human-human interaction.
This hypothesis was formulated based on the findings of qualitative studies that described various attributes of NP present among subjects receiving care using diverse forms of technology (Nilsson, Ohman, & Soderberg, 2010; Romero, Angelo, & Gonzalez, 2012; Sävenstedt, Zingmark, & Sandman, 2004; Tuxbury, 2013). These studies suggested that attributes of NP are enacted in technically facilitated patient and nurse encounters. The present study supported the conclusions of these previous studies and added new knowledge on the use of robotics by nurses. From the perspective of nursing practice, empirical evidence that nurses can effectively communicate empathy using devices such as the SMRTR supported the notion that the direct use of these devices, by nurses, in practice settings is worthy of consideration.

**Conceptual Framework**

The conceptual framework for this study integrated NEEPD and THRI theories (Figure 1). In the context of THRI the patient shared a caregiving role with the SMRTR or the human nurse. The human nurse had a unidirectional supervisor and peer role with the SMRTR. As a supervisor, the human nurse was responsible for establishing the goals and intentions of the human-robot interaction as well as the proper operation of the SMRTR. In the peer role the human nurse, embodied in the SMRTR, accomplished the goals and intentions established by the supervisor. The SMRTR became an extension of the human nurse’s body and senses during interactions with the patient making the SMRTR, for all practical purposes, similar to the human nurse. From the perspective of NEEPD the patient perceived empathy from the human nurse or SMRTR relative to their level of distress concerning their health.
FIGURE 1. Conceptual Framework Based on Theoretical Frameworks of NEEPD and THRI.

Research Aims

Studies on subjects receiving care using diverse forms of technology suggested that attributes of NP were enacted in technically facilitated patient and nurse encounters. (Nilsson, Ohman, & Soderberg, 2010; Romero, Angelo, & Gonzalez, 2012; Sävenstedt, Zingmark, & Sandman, 2004; Tuxbury, 2013). Additionally, the tenets of the middle range nursing theory of Nurse Expressed Empathy and Patient Distress (Olson & Hanchett, 1997) purported a negative relationship between patient distress and the patient’s perception of nurse-expressed empathy.
Testing the overall study hypothesis and thus achieving the purpose of this study was done by pursuing the following specific aims:

**Aim One**

Examine adults’ perception of nurse-expressed empathy from a semi-autonomous nurse robot as compared to a human nurse.

Adults who interacted with a SMRTR nurse or a human nurse rated their perception of nurse-expressed empathy using the Barrett-Lennard Relationship Inventory Empathic Understanding Scale (EUS; Barrett-Lennard, 2014). The overall hypothesis of this study was that an adult’s perception of nurse-expressed empathy during a human-robot interaction would not be inferior to their perception of nurse-expressed empathy during a human-human interaction.

**Aim Two**

Examine the relationship between adults’ perception of nurse-expressed empathy and level of health distress.

Health distress in the adults was measured using the Health Distress scale (Lorig et al., 1996). According to the middle range theory Nurse-Expressed Empathy and Patient Distress (Olson & Hanchett, 1997; Orlando, 1961) there would be a negative relationship between nurse-expressed empathy and health distress in both SMRTR nurse and human nurse interactions.

**Definition of Key Terms**

**Semi-autonomous Mobile Remote Telepresence Robot**

A semi-autonomous mobile remote telepresence robot (SMRTR) is a system composed of two functional components, a robot and an operator’s console for controlling the robot (Figure 2). The robot, a physical device, is placed in a setting remote to the human operator. The
operator’s console is a computer software interface that permits the human operator to control the SMRTR while freely roaming in the remote location while interacting with those physically present at the remote location (Beer & Takayama, 2011; Tsui & Yanco, 2013). The human operator’s image and voice are captured in real-time from the video and audio components of the computer upon which the operator’s console is running and transmitted to the robot where they are seen and heard by those in the remote location. This aspect of SMRTR provides users of the semi-autonomous robot an opportunity to interact with one another and in which empathy can be studied. For this study, the SMRTR was the Beam+ (Suitable Technologies, 2015).

*FIGURE 2. Components of a SMRTR (BeamPro. Palo Alto, CA: Suitable Technologies, Inc; 2014. Reprinted with permission; Appendix A).*
Empathy

Barrett-Lennard (2014) conceptually defined empathy as:

A personal awareness of the other in the immediate feelings and meaning through actively receptive experiential engagement. It includes taking in the other’s live words and other signs to gain a matching inner sense of their feeling and meaning. This human recognition of the focus and essence of the other’s felt awareness includes a continuity of following, attention, and attunement. A depth of empathic engagement permits an accurate experiential grasp of that which has immediate priority or centrality for the other….the deeply empathizing person sees, at least in glimpses, through the other’s eyes, shares the person’s struggle, pulses with their sensed feeling, knows as from within almost how it is to be the other at some special or critical moment in their journey. This lived knowing, however, proceeds or happens within a frame of clear awareness of which the touchstone is the moving consciousness of the other person (p. 36).

Nurse-Expressed Empathy

Nurse-expressed empathy is the skill of understanding what a patient is saying and feeling. This understanding is then communicated verbally to the patient (Olson, 1995; Olson & Hanchett, 1997).

Patient-Perceived Empathy

Patient perceived empathy is a patient’s report of being understood and accepted by the nurse (Olson, 1995; Olson & Hanchett, 1997).

Health Distress

Health distress is a negative emotional state (Olson, 1995). It is further defined as the
consequence of being discouraged, worried, frustrated, or fearful of one’s health problems and future (Lorig, et al., 1996).

**Significance**

Healthcare robots are transforming the practice of nursing (Huston, 2013; Metzler & Barnes, 2014; Wood, 2011). The core values of nursing (National League for Nursing, 2013) - caring, integrity, diversity and excellence - must be expressed by these robots if they are to best serve the needs of patients and nurses.

**Patients**

A future where HRs lack features and functionality based on concepts central to nursing would be a great loss to patients. Empathic interactions between patient and healthcare provider are known to improve patient outcomes and satisfaction (Hojat, 2009; Ward, Cody, Schaal, & Hojat, 2012). This study provided evidence, to researchers and designers of HRs, that nurse empathy can be communicated while using a semi-autonomous robot in a nursing context.

**Nursing Practice**

Issues related to nursing process, focus, and motivation must be addressed in the context of evolving technology (Androwich, 2013). As robots evolve, they become more capable and acceptable for the delivery of nursing care. Nurses’ confidence in robots’ use for nursing practice becomes essential. Justifiable uncertainty exists about the role of robots in nursing because currently robots cannot reliably analyze complex health issues as can the human nurse (DeMoro, 2013; Frederickson, 2014; Whyatt, 2014). The current generation of HRs are task oriented whereas HRs possessing human-like cognition, problem solving, and decision-making are robots of the future. For now, these future HRs are the subject of research versus mainstream nursing
practice. Rejecting HRs on the basis of this concern serves only to hamper the opportunity for nurses to participate in the evolution and design of HRs (Huston, 2013; Sharts-Hopko, 2014).

**Healthcare System**

Some nurses are concerned that robots threaten to reduce the nursing workforce and depersonalize patient care (Gross, 2013; NYNSA, 2013). Robots can, in fact, assist nurses and streamline the practice of nursing (Chang & Šabanovic, 2013). Such nurse/robot collaborations may result in more quality time for nurses to spend with their patients (Broadbent et al., 2012). Semi-autonomous HRs may also provide a solution for nursing workforce shortages. For examples, robots can be used to perform discharge education and other non-direct patient care activities by nurses who are unable to be physically present in a care setting due to injuries such as back strain (Crain, 2015).

**Summary**

Chapter 1 provided a philosophical and theoretical perspective that guided this study. Using these perspectives a conceptual framework that situated semiautonomous robotics in the context of nursing practice was offered. The purpose of this study was to explore adults’ perception of nurse-expressed empathy, a component of NP, as enacted by a semi-autonomous robot nurse compared to a human nurse following a discussion of the adult’s health concerns or issues. Based on this purpose, the overall hypothesis of this study was that an adult’s perception of nurse-expressed empathy during a human-robot interaction would not be inferior to their perception of nurse-expressed empathy during a human-human interaction.
CHAPTER 2: LITERATURE REVIEW

Introduction

This study investigated empathy, a component of nursing presence, in the context of a robotic nursing intervention with human adults. Nursing presence provided an overarching context from which to explore the literature regarding the concept of empathic understanding among nurses and robots.

Nursing Presence

Doona, Haggerty and Chase (1997) described nursing presence (NP) as a fundamental “experience that changes the nurse as well as the patient” (p. 5). Despite the core nature of the concept, nursing presence is a complex concept that shares many of its antecedents, attributes and outcomes (Figure 3) with other nursing theories and concepts (Benner, 1984; Bishop & Scudder, 1996; Koerner, 2011; Orlando, 1961; Parse, 1981, 1997; Paterson & Zderad, 1976).

![Nursing Presence Diagram]

*FIGURE 3. Selected Antecedents, Attributes, and Outcomes of Nursing Presence.*
Nursing presence encapsulates the relationship that is formed between the nurse and patient. The enactment of NP depends on individual characteristics of the nurse and patient, the interaction environment, and practice decisions of the nurse (McMahon & Christopher, 2011). The phenomenon is one during which the patient and nurse enter into a reciprocal interpersonal relationship that may result in positive outcomes for both patient and nurse (Finfgeld-Connett, 2006; Kostovich, 2012). The sum of many attributes, NP augments a patient’s physical and mental well-being (Hickman, 2013, Finfgeld-Connett, 2006; McCarthy & Aquino-Russell, 2009). Antecedents of NP include patient attributes such as openness, need, and willingness, and nurse attributes including professional maturity, moral foundation, and opportunity (Finfgeld-Connett, 2006). The phenomenon of NP is most often enacted during physical face-to-face encounters and is characterized as a sensitive, holistic, intimate, vulnerable and unique interaction between patient and nurse (Finfgeld-Connett).

Foundations of Nursing Presence

Presence was introduced to the literature of nursing by Sister Madeline Clemence Vaillot (1962, 1966). Influenced by theistic existentialism Sister Vaillot drew from Buber’s (Buber & Smith, 1937) I-Thou relationship of self to others and Marcel’s (1949) use of the term “presences.” Sister Vaillot suggested that Marcel’s “presences,” the discovered affirmation of being, guided the commitment of the nurse to a full and sacrificial engagement of oneself with patients. Ferlic (1968) postulated that existentialism was a relevant philosophical foundation for nursing. The philosophies of Marcel and Buber clearly influenced Ferlic’s view of presence relative to nursing practice as she stated:
For the nurse, it [presence] is a free act which encompasses listening, giving and receiving, and nonverbal communication that she is available … Presence implies closeness, perception, awareness, and involvement - not refusal to see or really be with the patient (p. 31).

The theory of Humanistic Nursing (HN, Paterson & Zderad, 1976), itself borrowing from Marcel’s existentialism, conceptualized nursing as being present to persons in need where the nurse and patient participate with each other.

These conceptualizations of nursing presence were built on a philosophic foundation aligned with existentialism (Doona, Haggerty, & Chase, 1997; Paterson & Zderad, 1979; Vaillot, 1961, 1966). Beginning in the 1980s the discourse on nursing presence branched to accommodate a utilitarian perspective in addition to the philosophical underpinnings of existentialism (Doona, Haggerty, & Chase). During this time, NP was often discussed in terms of nursing actions as well as a philosophy (Benner, 1984; Gardner, 1988; Mohnkern, 1992; Zerwekh, 1997). Benner (1984) blended existentialism and action when she changed the noun presence to the verb presencing, built a nurse competency around it, and offered that presence was enacted when the patient and nurse were in tune with one another despite each one’s uniqueness. Gardner (1988) declared that NP was a core nursing intervention asserting:

Presence is conceived of as the core element of nursing activity. It is the availability of the nurse as helper for the patient. As an intervention, presence is the nurse’s use of self through availability and attention to needs (p. 191).

This ushered in a time of discourse and inquiry among scholars as to what NP really was resulting in a proliferation of types of presence. Healing presence (Koerner, 2011) is an active
receptivity for the patient and unfolding of consciousness for one’s being in the world. Presence goes beyond health problems and touches every aspect of life requiring self-knowledge. Real presence (Marsden, 1990) is a commitment to give oneself to the patient in relationship, availability and spiritual quietness. Caring presence (Bishop & Scudder, 1996) is a “personal presence that assures others of another’s concern for their well-being” (p. 41). Parse’s Human Becoming theory (Parse, 1997) introduced true presence as the nurse’s immersion with the patient permitting each to elucidate the meaning of the patient’s situation while negotiating intricate patterns of the interaction and finally arriving at a reconstructed interpretation of the situation. Wilson’s (1988) mere presencing veered sharply from existential thought positing that the physical presence of the nurse could control psychotic behaviors.

**Definitions of Nursing Presence**

A number of definitions for NP are found in the literature. According to Doona, Haggerty, and Chase (1997) NP is an “intersubjective encounter between a nurse and a patient in which the nurse encounters the patient as a unique human being in a unique situation and chooses to spend herself on the patient’s behalf, while at the same time the patient invites the nurse into his experience” (p. 12). A key antecedent of NP is the reciprocal commitment of the nurse and patient to one another and the situation at hand. Hessel (2009) highlights the reciprocal commitment and defined NP as:

A holistic and reciprocal exchange between the nurse and patient that involves a sincere connection and sharing of the human experience through active listening, attentiveness, intimacy and therapeutic touch, spiritual exploration, empathy, caring and compassion,
and recognition of the patient’s psychological, psychosocial, and physiological needs (p. 281).

Finfgeld-Connett (2006) offered a definition based on a metasynthesis of the nursing literature: “presence is an interpersonal process that is characterized by sensitivity, holism, intimacy, vulnerability and adaptation to unique circumstances. It results in enhanced mental wellbeing for nurses and patients and improved physical wellbeing for patients” (p. 710).

**Empathy and Nursing Presence**

In the context of NP, empathy has been considered both a related yet distinct concept and an integral component of the phenomenon (Curley, 1997; Gilje, 1992; Gardner, 1988; Godkin, 2001; Kostovich, 2012; Mohnkern, 1992). This seeming contradiction echoes scholars’ concern that the widening of the concept to include other concepts has hampered the clear delineation of the concept (Finfgeld-Connett, 2006; Smith, 2001). While, unlike the existential roots of NP, the relativistic and phenomenological foundations of empathy would seem to distinguish empathy from NP. Despite this scholars increasingly embraced empathy as an attribute of NP (Burhans & Alligood, 2010; Curley, 1997; Gardner, 1988; Gilje, 1992; Kostovich, 2012, 2014; Mohnkern; Stueber, 2014). Gardner (1988), one of the first to discuss empathy relative to NP, offered that NP was enacted “in the cognitive domain by verbal communication of empathy or understanding of the patient’s experience” (pp. 320-321). Mohnkern (1992) concluded, “empathy must be a part of the nurse’s experience for presence to occur” (p. 168) but cautioned that empathy does not fully embody the concept of NP. Empathy is conceived of as a nursing activity to be accomplished to achieve presence as a nursing intervention (Bulechek, Butcher, Dochterman, & Wagner, 2013). Curley (1997) identified mutuality as an attribute of presence. Mutuality
describes the quality of the nurse-patient relationship that stimulates the process of personal becoming (Archbold, Stewart, Greenlick, & Harvath, 1990; Curley, 1997). Olsen (1991) further described mutuality to be dependent on empathy.

**Nursing Presence with Technology**

In the context of technologically facilitated, and often remote, nurse-patient encounters, nursing presence is not fully understood. O’Keefe-McCarthy (2009) suggested that technology may compete for the nurse’s attention causing the nurse to focus more on the technology than on the patient (O’Keefe-McCarthy, 2009). In the early 2000s nurses grappled with the physical separation of nurse and patient as a consequence of evolving technologies. Later, studies exploring these technologies began to identify attributes of nursing presence.

**Knowing the patient.** Technology imposes a new reality in which the nurse’s perception and interaction with patients is fundamentally changed often resulting in an illusion of presence as opposed to a physical face-to-face presence. Ideally, that illusion melts away leaving a perception of true and shared presence (Sandelowski, 2002). Sandelowski postulated that nurses must reconceptualize presence, place, and body in the context of technologies that impose virtual environments in which nurses and patients interact.

The mode of technology further complicates matters because of the difference in channels of communication among the varied forms of technology in healthcare. Understanding the issues and channels of communication is essential to a more complete understanding of nursing presence in technically facilitated environments (duMont, 2002). duMont offered that the “preservation of the caring moral imperative of nursing” (p. 16) is essential as new technologies are broadly adopted.
Presence enacted. Studies using technologies such as telephones, videophones, and text messaging, have demonstrated that attributes of nursing presence are enacted in the context of technology. Video enabled communication technology provided a sense of familiarity and transparency that resulted in attributes of nursing presence as well as a sense of physical presence in the remote location (Sävenstedt et al., 2004). Text messaging served as a secure communication channel that engendered trustworthy accessiblity and availablity (Nilsson, Ohman, & Soderberg, 2006). In a study using standard telephones, nurses found themselves engaging in an imagining processes that permitted them to abstract and incorporate the patient into the call scenario. As they imagined, the nurse began to identify with the patient’s reality and establish an interaction in the context of psychological versus physical space where they become present for the patient (Romero, Angelo, & Gonzalez, 2012). In a study also using the telephone Tuxbury (2013) concluded that nurses and patients interacting with one another using the telephone experience nursing presence in the fullest sense.

Empathy

Empathy is a concept with a complex history and an evolving future (Hojat, 2007). Bisagni (2013) advanced that empathy “is a goal more than a tool and empathic words are extremely sophisticated elements that give shape to the multi-determined levels of cognition” (p. 627). This notion of empathy seems distant from its historical and complex philosophical pedigree.

Einfühlung and Empathy

In the late 18th century, the German philosopher Johann Gottfried Herder, an adherent of relativism, encouraged scholars to experience hineinfühlung [feel yourself into] as an approach
to expressing knowledge and knowing (Edwards, 2013). Herder believed that there was little difference between cognition and sensation and that both informed all mental constructs. This belief was expressed by Herder’s (1778/2002) statements: “the sensing human being feels his way into everything, feels everything from out of himself and imprints it with his image … Hence, Newton in his system of the world became a poet contrary to his wishes” (p. 178).

Nearly one hundred years later Robert Vischer, a German aesthetic philosopher, unknowingly likened aesthetics to Herder’s hineinfühlung (Edwards, 2013). He coined the term Einfühlung to express the psychology of one’s immersion into a work of art (Bullock, 2014). Einfühlung, a noun as opposed to the verbal form hineinfühlung, was a process that permitted a viewer to elicit emotional reactions to artistic objects (Edwards, 2013). As a process, Einfühlung was positioned for expanded philosophical analysis (Stueber, 2014).

In the early 20th century the German psychologist Theodor Lipps (1903) adapted Einfühlung transmuting it from philosophical aesthetics to the philosophy of social and human sciences. Lipp’s Einfühlung was fundamental to “recognizing each other as minded creatures” (Steuber, 2014). In later writings Lipps (1907) described the “instinct of empathy” (p. 713). Imitating the observed yet unknown gestures of others was an instinctual drive to know and own the feelings associated with the gesture in an effort to understand the other (Zahavi, 2010).

The English translation of Lipp’s notion of Einfühlung, empathy, was offered by the British psychologist Edward B. Titchener in 1909 (Lanzoni, 2012; Steuber, 2014). Titchener’s empathy, envisioned the “mind’s image or inner representation of bodily movement” (Lanzoni, p. 304). Put differently, empathy was “an imaginative entry into one’s experience of objects” (Lanzoni, p. 309-310). Ironically, this concept of kinesthetic image was so bound to the
observer’s own mind that understanding another person was not a consideration (Lanzoni).

Phenomenologists objected to the assertion that imitation formed the basis of empathy arguing that while imitation explains how an expression is understood by oneself it fails to explain understanding of another person (Husserl, 1929/2012; Scheler, 1954; Zahavi, 2010).

Philosophical debates, such as this, were largely ignored by psychologists who approached empathy as a psychological process and phenomenon to be studied (Steuber, 2014).

Despite this, in the U.S. the study of empathy fell silent between 1909 and 1948 because of, ironically, a philosophical debate among psychologists (Edwards, 2013). Relativistic and introspective psychological methods such as empathy were denounced as unscientific owing to behavioral psychology’s absolutist position that the mind was unobservable (Edwards, 2013; Watson, 1913). Despite efforts encouraging psychologists to retain empathy as a concept worthy of investigation it was not until Dymond’s (1948) study of empathy that there was a renewed interest in the study of empathy (Cottrell, 1950; Cottrell & Dymond, 1949). In Dymond’s study, empathy was operationalized as a personal quality as opposed to a method. This restored interest in experimentation on empathy as a personal quality resulted in 40 reported studies on empathy just in the period from 1950 to 1959 (Edwards). Carl R. Rogers was among the psychologists with deep interest in empathy (Barrett-Lennard, 2014).

Definitions of Empathy

A psychotherapist, Rogers proposed that empathy was one of six definable and measurable conditions necessary to bring about constructive personality change in a person (Rogers, 1957). Roger’s (1959) definition of empathy was:
The state of empathy, or being empathic, is to perceive the internal frame of reference of another with accuracy and with the emotional components and meanings which pertain thereto as if one were the person, but without ever losing the 'as if' condition. Thus it means to sense the hurt or the pleasure of another as he senses it and to perceive the causes thereof as he perceives them, but without ever losing the recognition that it is as if I were hurt or pleased and so forth. If this 'as if' quality is lost, then the state is one of identification (pp. 210-211).

While restating and clarifying this definition in 1975, Rogers offered a similar yet alternative conceptual and operationalized definition from one of his students, Godfrey Barrett-Lennard (Barrett-Lennard, 1962; Rogers, 1975). Barrett-Lennard (2014) has recently updated his conceptual definition as follows:

Empathic understanding is a personal awareness of the other in the immediate feelings and meaning through actively receptive experiential engagement. It includes taking in the other’s live words and other signs to gain a matching inner sense of their feeling and meaning. This human recognition of the focus and essence of the other’s felt awareness includes a continuity of following, attention, and attunement. A depth of empathic engagement permits an accurate experiential grasp of that which has immediate priority or centrality for the other … the deeply empathizing person sees, at least in glimpses, through the other’s eyes, shares the person’s struggle, pulses with their sensed feeling, knows as from within almost how it is to be the other at some special or critical moment in their journey. This lived knowing, however, proceeds or happens within a frame of
clear awareness of which the touchstone is the moving consciousness of the other person (p. 36).

The operationalized definition of Barrett-Lennard’s client received empathy is found in the Empathic Understanding Scale form of the Barrett-Lennard Relationship Inventory (BLRI) (Barrett-Lennard, 2014) found in Appendix B.

**Phases of Empathy**

Empathy is a bidirectional concept that initially requires two parties, one of which is expressing themselves and the other listening (Barrett-Lennard, 1981, 2014). The three phases of the empathy cycle are shown in Figure 4 (Barrett-Lennard). In the first phase the listening party constructs an empathetic response to information communicated by the expressing party. In the second phase the listening party communicates their constructed empathetic response to the expressing party. In the third phase of the empathy cycle the expressing party receives and evaluates the listening party’s degree of expressed empathy based, in part, on the qualities of phases one and two. From the perspective of the listener, the first phase is always about the listener’s response to the individual in the expressing role. Barrett-Lennard describes this as my response to the other (MO; Barrett-Lennard). Phase three focuses on the received empathy by the person in the expressing role. From perspective of the listener this may be thought of as the other’s response to self (OS; Barrett-Lennard).
Empathy and Robots

Empathy between human and robot has been a subject of interdisciplinary study over the last decade. The vast majority of these studies have come from the computer sciences, engineering, and psychology (Cramer, Goddijn, Wielinga, & Evers, 2010; Doori, Jooyun, Kyungmi, & Sukhan, 2013; Hofree, Ruvolo, Bartlett, & Winkielman, 2014; Kim, Kwak, & Kwak, 2009; Kwak, Kim, Kim, Shin, & Cho, 2013; Marti, Iacono, Tittarelli, & Stienstra, 2013; Mazzei et al., 2011; Miura et al., 2008; Riek, Rabinowitch, Chakrabarti, & Robinson, 2009; Rosenthal-von der Putten et al., 2013; Urgen, Plank, Ishiguro, Poizner, & Saygin, 2013). There exists no tangible evidence that those in the nursing sciences have investigated empathy and robots.
Much of the research focuses on human-like attributes of autonomous robots that are thought to enhance a human’s empathy toward a robot. These attributes, among others, are the extent to which a robot appears humanoid (Riek, Rabinowitch, Chakrabarti, & Robinson, 2009), the use of non-verbal cues (Breazeal, 2003), and imitation of human movement and expressions (Gonsior, 2011; Haffey, Press, O’Connell, & Chakrabarti, 2013). While there has been research conducted that evaluates semi-autonomous robots in the listening role this has not been in the context of empathy but of other relationship conditions such as presence (Lee & Takayama, 2011; Sakamoto, Kanda, Ono, Ishiguro, & Hagita, 2007).

**Related studies.** In order to assess the extent to which empathy and robots has been studied the literature was searched in February of 2015 using the CINAHL, IEEE Xplore, and PUBMED databases. The inclusion criteria for the selection of studies for review were: (a) written in the English language; (b) published between the years 1980 and 2015; (c) title, abstract, keywords, or metadata included the word base “empathy” and the word base “robot” or the acronym HRI (human-robot interaction). Studies were excluded if they failed to meet the inclusion criteria or were duplicates of studies found in other query results. Finally, an in-depth reading of selected studies was conducted to determine the suitability for inclusion based on the context and usage of empathy and robot. For example, one article included empathy in its title and keywords but was not found as a variable in the study or mentioned in the manuscript. Based on these inclusion and exclusion criteria 13 studies were selected from among the results of the database queries found in Table 1. No studies were found in the nursing literature archived in the CINAHL database. The selected studies are described in Appendix C (Table C1).
### TABLE 1. Bibliographic Database Queries for Robots and Empathy Studies.

<table>
<thead>
<tr>
<th>Database</th>
<th>Query String</th>
<th>Scope</th>
<th>Results</th>
<th>Selected</th>
</tr>
</thead>
<tbody>
<tr>
<td>CINAHL</td>
<td>((TI robot OR AB robot) OR (TI HRI OR AB HRI)) AND (TI empathy OR AB empathy)</td>
<td>Title and abstract</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>IEEE Xplore</td>
<td>(&quot;Abstract&quot;:robot OR &quot;Author Keywords&quot;:robot OR &quot;Document Title&quot;:robot) OR (&quot;Abstract&quot;:HRI OR &quot;Author Keywords&quot;:HRI OR &quot;Document Title&quot;:HRI) AND (&quot;Abstract&quot;:empathy OR &quot;Author Keywords&quot;:empathy OR &quot;Document Title&quot;:empathy)</td>
<td>Abstract, title and keywords</td>
<td>29</td>
<td>10</td>
</tr>
<tr>
<td>PUBMED</td>
<td>(HRI[Title/Abstract] OR robot[Title/Abstract]) AND empathy[Title/Abstract]</td>
<td>Title and abstract</td>
<td>6</td>
<td>3</td>
</tr>
</tbody>
</table>

**Synthesis of robot and empathy related studies.** The most significant characteristic of the related studies is the phase of empathy in which they are situated. All of the studies measured phase one of the empathy cycle in order to examine the empathic response formed by human subjects relative to the robot. This observation is visually represented by modifying Figure 4 to highlight phase one of empathy (Figure 5). This is an important distinction between the related studies and this present study which sought to investigate phase three.
FIGURE 5. Phases of Empathy Where Listening Role = Human and Expressing Role = Robot.

With the exception of one study (Kwak, Kim, Kim, Shin, & Cho, 2013) the robot platforms investigated in these related studies were autonomous or simulated to operate as autonomous robots. The study by Kwak et al. (2013) had particular relevance to the present study because of the conclusion that humans empathize more toward a physically embodied robot mediated by a remote operator. This conclusion informed the present study’s hypothesis that a person’s perception of nurse-expressed empathy is similar whether the nurse is interacting with a patient while embodied in and remotely operating a robot or physically face-to-face.

Measures of empathy were either absent (Mazzei et al., 2011), based on fMRI results (Miura et al., 2008; Rosenthal-von der Putten et al., 2013), electroencephalography (Urgen et al., 2013), or one of an array of self-report instruments. Many of the instruments were unknown as they were not cited or they were created specifically for the study (Cramer, Goddijn, Wielinga, &
Evers, 2010; Gonsior et al., 2011; Hayes et al., 2014; Riek, Rabinowitch, Chakrabarti, & Robinson, 2009). Some estimates of empathy were based on the measurement of emotion as opposed to empathy (Doori, Jooyun, Kyungmi, & Sukhan, 2013; Kwak et al., 2013). In one study, coding of empathy was conducted yet there were no references or justification given for such coding (Kim, Kwak, & Kwak, 2009). In only one study was a well-documented and psychometrically analyzed instrument used (Marti, Iacono, Tittarelli, & Stienstra, 2013). This study used the Interpersonal Reactivity Index created by Davis (1983).

Many of the related studies utilized an experimental factorial design (Cramer, Goddijn, Wielinga, & Evers, 2010; Doori, Jooyun, Kyungmi, & Sukhan, 2013; Kim, Kwak & Kwak, 2009; Miura et al., 2008; Rosenthal-von der Putten et al., 2013;). One study employed a true experimental design with random assignment of subjects to groups (Doori, Jooyun, Kyungmi, & Sukhan, 2013). The remainder of the related studies were either quasi-experimental, descriptive, or exploratory.

**Research Framework**

Based on the synthesis of the related studies relative to Barrett-Lennard’s phases of empathy a framework emerged by which the concept of empathy was investigated in this study. The phases of empathy described in the synthesis of related studies (Figure 5) situated the relationship between the roles of a listening human and an expressing robot. For the purpose of this study the listening and expressing roles were reassigned. The robot was assigned the listener role. Participants were assigned the expressing role. The perception of the listener’s empathy, phase three, by the participant was the measurement of interest (Figure 6). The framework, as
specified, permitted a full cycle of empathy phases to transpire before the measurement of perceived empathy was taken.

**FIGURE 6.** Phases of Empathy Where Listening Role = Robot and Expressing Role = Human.

**Summary**

In this chapter the foundations, definitions, and the state of technology as applied to NP, empathy, and robotics were reviewed. Studies related to robots and empathy were retrieved from the literature. All of the retrieved studies were from the scientific domains of computer science, engineering and psychology. No studies were found in the nursing literature. All of the related studies investigated the first phase of the empathy cycle (Barrett-Lennard, 1981, 2014) with the robot assigned to the expressing role. Modifying this approach the present study investigated the third phase of the empathy cycle with the robot assigned to the listening role. The study reported by Kwak et al. (2013) concluded that humans empathize more toward a physically embodied
robot that is operated by a remote human operator, such as the SMRTR, than a simulated autonomous robot. This result supported the hypotheses of the present study suggesting that participants might experience empathy while interacting with the researcher embodied in the SMRTR.
CHAPTER 3: METHODS

Research Design

The design for this study was a non-inferiority randomized comparison using parallel groups receiving a reference treatment or active control (Table 2). The purpose of a non-inferiority study is to demonstrate that a new treatment is no worse than that of a standard and effective treatment by a predetermined margin of difference (Allen & Seaman, 2007; Ng, 2008; Snapinn 2000). The choice of a non-inferiority design for this study was based on the expectation that nurse-expressed empathy could be communicated using remote telepresence devices, such as the SMRTR, in a manner that was no worse than during a face-to-face encounter between a nurse and patient. Comparative studies, such as this, are needed to begin closing the gap in knowledge about nursing presence when nurses use remote technology as opposed to traditional face-to-face interactions (du Mont, 2002; Nagel, Pomerleau, & Penner, 2013).

TABLE 2. Design Notation for Randomized Non-inferiority Trial with Parallel Groups.

<table>
<thead>
<tr>
<th>Group</th>
<th>Assignment</th>
<th>Treatment</th>
<th>Observation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reference Treatment</td>
<td>R</td>
<td>$X_R$</td>
<td>O</td>
</tr>
<tr>
<td>Active Control</td>
<td>R</td>
<td>$X_A$</td>
<td>O</td>
</tr>
</tbody>
</table>

Abbreviations: R, random; $X_A$, active control; $X_R$, reference treatment; O, observation

Empathic Engagement Intervention

The intervention applied to each study group was an empathic engagement enacted between the researcher and participant during a 15 minute conversation. The empathic engagement was modelled (Figures 4 & 6) after the cycle of empathy (Barrett-Lennard, 1981, 2014). During the intervention the researcher, trained in empathetic listening, was assigned the
role of listener and the participant was assigned the expressing role. In phase one of the empathy cycle, a conversation began with the researcher inviting the participant to discuss their health concerns. As the conversation unfolded, phase two of the empathy cycle was entered. In this phase the researcher formed empathic responses to the participant’s expression of their health concerns and verbally communicated those responses to the participant. In phase three, the participant, having received empathic responses from the researcher, formed an opinion of the degree to which they believed the researcher was conscious of their immediate and felt situational awareness. The cycle of empathy continued until the intervention was complete.

**Randomization and Assignment to Groups**

As shown in Table 2 this study utilized two groups, a reference treatment group and an active control group. The assignment of participants to these groups was achieved using a fixed allocation scheme of stratification and permuted block randomization also known as stratified block randomization. Stratified block randomization (SBR) offered a number of advantages over other forms of randomization including safeguards against Type I and II errors, heightened efficiency, and facilitation of subgroup and interim analyses (Kernan, Viscoli, Makuch, Brass, & Horwitz, 1999). Most importantly, this process of randomization assured that compared groups were similar relative to the covariates gender and health distress which are suggested to influence adult’s perception of empathy (Christov-Moore et al., 2014, Kernan et al., 1999; Olson & Hanchett, 1997). The Nurse-Expressed Empathy and Patient Distress middle range theory, described earlier, posits that a patient’s perception of nurse-expressed empathy is negatively related to the patient’s level of health distress ( Olson & Hanchett, 1997). Measurement of health distress was obtained using the Health Distress scale (HD; Appendix D) originally developed for
the Medical Outcome Study and later modified by the Stanford Patient Education Research Center (MOS; Stewart et al., 1992; Stanford, n.d). Gender differences related to sociocultural and neurobiological considerations have also been shown to account for variances in empathy among males and females (Christov-Moore et al., 2014).

These two factors resulted in four strata: (a) male with HD score greater than or equal to the mean HD score as reported in psychometric studies ($M = 2.04$), (b) male with HD score less than the mean HD score, (c) female with HD score greater than or equal to the mean HD score, and (d) female with HD score less than the mean HD score. Using the R data analysis software (R, 2015) blockrand package (Snow, 2013) these four strata were each block randomized using block sizes of two and four the result of which were stratified and blocked randomization schedules for each stratum (Appendices E, F, G, H, & I). Participants were sequentially assigned to the treatment group from the stratum schedule associated with their gender and mean HD score measured immediately after informed consent was obtained.

**Application of Intervention**

The empathic engagement treatment was applied to each study group. In the reference treatment group, the intervention took place during a human-robot interaction. The researcher, while not physically present in the room, was present as a robot—embodied in and operating a SMRTR (Figure 2). In the active control group the intervention took place, face-to-face, during a human-human interaction between the researcher and participant.

**Observation**

One observation was taken immediately after the intervention was applied. Participants were asked to complete a scale measuring their perception of empathy expressed by the
researcher. If the intervention took place more than one day after the HD scale was first completed, for the purpose of assigning the participant to a study group, the participant was asked to retake the HD scale.

Sample and Setting

The study targeted adults in a community setting. Participants were recruited from communities north of Seattle, WA including Mukilteo, Edmonds, Lynnwood, and Everett WA. These communities were composed of predominantly white adults aged 18 to 65 with females slightly outnumbering males (Table 3; U.S. Census Bureau, 2010). The setting in which the study was conducted was the office of a mental health counselor located in a professional office building in Mukilteo, WA where various social and psychological services are offered (Appendix J). The office was easily accessible from all of the communities from which participants were recruited.

Selection of Participants

Potential participants were required to meet all inclusion criteria for enrollment in the study including: (a) age between 21 and 80 years, (b) male or female, (c) English reader and speaker, (d) self-reported a health related chronic condition or illness (e) able to hear and correctly answer the question “What is today’s date?” asked by a recorded SMRTR voice from a distance of ten feet, and (f) able to correctly identify the subject of three images, similar in size to the video monitor on the SMRTR, from distance of ten feet.

Recruitment and enrollment of participants. The researcher was the sole recruiter of participants for the study. After obtaining permission to recruit from event organizers and property managers (Appendix K) potential participants (PPs) were recruited at community events
TABLE 3. Demographic Profiles of Recruited Communities.

<table>
<thead>
<tr>
<th>Metric</th>
<th>Edmonds</th>
<th>Everett</th>
<th>Lynnwood</th>
<th>Mukilteo</th>
<th>M</th>
<th>WA state</th>
</tr>
</thead>
<tbody>
<tr>
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</tr>
<tr>
<td>Females</td>
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<td>51</td>
<td>49.8</td>
<td>50.7</td>
<td>50.2</td>
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<tr>
<td>Males</td>
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<td>50.9</td>
<td>49</td>
<td>50.2</td>
<td>49.4</td>
<td>49.8</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Under 18</td>
<td>18.6</td>
<td>22.7</td>
<td>21.7</td>
<td>23.3</td>
<td>21.6</td>
<td>23.5</td>
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<td>18-65</td>
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<td>66.1</td>
<td>65.1</td>
<td>64.2</td>
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<tr>
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<td>13.4</td>
<td>12.3</td>
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<tr>
<td>White</td>
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<td>5.5</td>
<td>1.7</td>
<td>3.5</td>
<td>3.6</td>
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<tr>
<td>Native American</td>
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<td>0.6</td>
<td>1.0</td>
<td>1.5</td>
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<tr>
<td>Other</td>
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<td>4.2</td>
<td>3.9</td>
<td>4</td>
<td>4</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HS or greater</td>
<td>95.2</td>
<td>86.7</td>
<td>88</td>
<td>97.5</td>
<td>91.9</td>
<td>90.5</td>
</tr>
<tr>
<td>Bachelors and up</td>
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<td>20.5</td>
<td>27.9</td>
<td>47.5</td>
<td>35.7</td>
<td>31.9</td>
</tr>
</tbody>
</table>

and locations in the designated communities including neighborhood and community social gatherings and local churches. At these events and locations PPs approached a table where the researcher was seated. Adjacent to the table was a poster highlighting elements of the study (Appendix L). Study brochures were placed on the table in a location such that PPs and passersby could pick them up (Appendix M).

When a PP indicated their interest in participating in the study a screening checklist (Appendix N) was prepared in order to track their progress through the screening process. The screening checklist included the PP’s first name and last name initial for identification purposes. The screening checklist was placed in an unmarked 11” x 14” envelope that remained in the possession of the PP during the screening process in order to protect their privacy. After the completion of each screening activity, the researcher removed the screening checklist from the
envelope, marked the screening activity accordingly, placed the checklist in the envelope, and returned the envelope to the PP.

**Screening for inclusion.** Figure 7 illustrates the process used for screening PPs for inclusion in the study. After verifying that the PP was the appropriate age and could speak and read the English language they were asked if they had a health related concern or issue that they would be willing to discuss. If they reported such an issue or concern two additional screening activities were performed to further determine their suitability for the study.

![FIGURE 7. Recruiting Workflow Diagram.](image)

Participants were required to have the ability to adequately see and hear the study treatments. To determine if the PP possessed an adequate level of hearing the researcher moved 10 feet away from the PP. The researcher then played an audio recording at a volume similar to that of the SMRTR. The audio recording instructed the PP to tell the researcher the current date. The PP was given two opportunities to correctly state the current date. If the PP was unable to hear the recorded voice or their final response was not appropriate they were thanked and excluded from further consideration as a study participant. Having determined that the PP’s hearing was sufficient for participation in the study, the PP was screened for sufficient visual acuity to visualize images on the SMRTR video screen. Located 10 feet from the researcher the
PP was shown three printed images similar in size to the video monitor on the SMRTR. The researcher asked the PP to identify each image. The images were those of a circle, square, and triangle (Appendix O). The PP was given two opportunities to correctly identify all three images. If the PP was unable to identify all three images they were thanked and excluded from the study.

If PPs passed these screening activities they were invited to participate in the study.

**Enrolling the participant.** After the PP accepted the invitation to participate in the study, three final activities concluded the study enrollment process.

*Informed consent.* The PP was provided a copy of the approved University of Arizona consent to participate in research and instructed to review its content. The PP was encouraged to ask questions regarding details of the informed consent should any content be unclear. After questions and concerns were addressed satisfactorily the PP was asked to date and sign the informed consent. A copy of the informed consent was given to the PP.

*Assignment to study group.* Once informed consent was obtained the participant was asked to complete the health distress scale (HD) and demographic survey (Appendices D & P). Using the mean score of the participant’s responses on the HD scale and their gender, assignment to a treatment group was done by selecting the next available participant ID - descending from the top - on the appropriate randomization schedule.

*Scheduling the intervention.* The researcher and participant agreed on a date and time for completing the study intervention. In most instances, the intervention was applied the same day that recruitment and enrollment took place. If the intervention could not be conducted on the same day, the researcher scheduled a date and time for the PP to receive the intervention. The
date and time were written on a study appointment card (Appendix Q) and given to the participant.

**Sample**

A sample of empathic understanding was obtained from the reference treatment and active control groups. The sampling ratio was 1:1. The primary objective of the study was to demonstrate that the difference in perceived empathy between the active control and reference treatment groups was less than a pre-determined margin (δ). The pre-determined margin is commonly referred to as the non-inferiority margin. The non-inferiority margin represents the acceptable loss of the active control’s effect in the reference treatment (Rothmann, Weins, & Chan, 2012). Stated differently, the non-inferiority margin describes how close the efficacy of the reference treatment must be to the efficacy of the active control in order to be called non-inferior (Allen & Seaman, 2007; Chan, 2002; D’Agostino, Massaro, & Sullivan, 2003). The selection of the non-inferiority margin is critical to non-inferiority studies. The sample size and data analysis depend on the value of the non-inferiority margin (Julious, 2004; Rothmann, Weins, & Chan).

**Selection of non-inferiority margin (δ).** Using an approach to non-inferiority testing called the generalized historical control (GHC), confidence interval approach, or δ-margin approach the non-inferiority margin δ was derived from parameters found in historical studies that used the BLRI Empathic Understanding Scale (EUS) (Barrett-Lennard, 1962, 2014; Tsong, Zhang, & Levenson, 2007, p. 281). Meta-analysis of the historical studies was used to establish the non-inferiority margin as a fixed value.
**Historical control studies.** For the purpose of establishing the non-inferiority margin for this study the literature was searched for historical studies using the EUS. The search, conducted in March of 2015, applied the queries found in Table 4 to the CINAHL, PsycINFO and PUBMED databases.

<table>
<thead>
<tr>
<th>Database</th>
<th>Query</th>
<th>Scope</th>
<th>Results</th>
<th>Selected</th>
</tr>
</thead>
<tbody>
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<td>CIHAHL</td>
<td>“blri” OR “barrett-lennard relationship inventor”</td>
<td>All fields</td>
<td>10</td>
<td>2</td>
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<tr>
<td>PsycINFO</td>
<td>“blri” OR “barrett-lennard relationship inventory”</td>
<td>All fields</td>
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<tr>
<td></td>
<td>Limiters: English, Adults, Humans</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PUBMED</td>
<td>“blri” OR “barrett-lennard relationship inventory”</td>
<td>All fields</td>
<td>24</td>
<td>1</td>
</tr>
</tbody>
</table>

The inclusion criteria for selecting a study for use in the calculation of the non-inferiority margin were: (a) written in English language, (b) study population of non-critically ill adults, (c) empathy subscale means and standard deviations were reported, and (d) study examined therapist (or nurse) and client (or patient) dyad. Studies were excluded if they did not fully meet the inclusion criteria.

**Selected studies.** Seven studies were selected for the calculation of the non-inferiority margin (Table 5). Five studies were identified using database queries and two studies were added based on Barrett-Lennard’s (2014) recent review of the literature of studies using the EUS. All of the included studies used an earlier and longer version of the EUS composed of 16 items. The range of scores for the 16 item scale was -48 to 48. The revised scale, used in this study, was composed of 12 items with a range of -36 to 36. In order to calibrate the 16 item scale to the 12
item scale the reported means and standard deviations were scaled using a conversion ratio of 36 items to 48 items (3:4).

**TABLE 5. Studies Using BLRI Empathic Understanding Scale.**

<table>
<thead>
<tr>
<th>Author</th>
<th>N</th>
<th>M adjusted (original)</th>
<th>SD adjusted (original)</th>
<th>Design</th>
<th>Population</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dawson, 1985</td>
<td>216</td>
<td>15.91(^1) (21.21)</td>
<td>10.95(^1) (14.66)</td>
<td>Quasi-Exp</td>
<td>Outpatient HTN</td>
</tr>
<tr>
<td>Fuertes et al., 2007</td>
<td>59</td>
<td>24(^2) (80)</td>
<td>8.54(^1) (11.39)</td>
<td>Descriptive</td>
<td>Counseling</td>
</tr>
<tr>
<td>Madrid, 1993</td>
<td>80</td>
<td>19.58(^1) (26.1)</td>
<td>9.5(^1) (12.2)</td>
<td>Correlational</td>
<td>Inpatient med/surg</td>
</tr>
<tr>
<td>Marci et al., 2007</td>
<td>20</td>
<td>18.83(^1) (25.1)</td>
<td>5.63(^1) (7.5)</td>
<td>Correlational</td>
<td>Outpatient psychiatric</td>
</tr>
<tr>
<td>Olson, 1995</td>
<td>140</td>
<td>20.4(^1) (26.72)</td>
<td>5.38(^1) (7.1)</td>
<td>Experimental</td>
<td>Inpatient med/surg</td>
</tr>
<tr>
<td>Osborn, 2000</td>
<td>61</td>
<td>14.0(^1) (18.67)</td>
<td>8.46(^1) (11.28)</td>
<td>Experimental</td>
<td>College students</td>
</tr>
<tr>
<td>Turan et al., 2000</td>
<td>20</td>
<td>19.25(^1) (25.67)</td>
<td>4.39(^1) (5.85)</td>
<td>Experimental</td>
<td>Community adults</td>
</tr>
</tbody>
</table>

Note. \(^1\)Adjusted for 12 item EUS; \(^2\)Adjusted for 12 item EUS and response adjusted -48

**Summary effect.** Meta-analysis was used to compute a summary effect from which the non-inferiority margin could be established. A random effects model was selected for the meta-analysis based on two considerations: (a) degree of functional equivalence of the studies, and (b) desire to extrapolate to broader populations (Borenstein, Hedges, Higgins, & Rothstein, 2009).

**Functional equivalence.** None of the selected studies were functionally equivalent.

Several characteristics distinguished the non-equivalent nature of the studies. The investigators, while limited to nurses and psychologists, conducted the studies independently of one another. Sample sizes ranged from 20 to 216. Study participants, all drawn from different populations, were most often male and female although the study conducted by Osborn (2000) limited participants to female. Study designs were varied including randomized experimental, quasi-experimental, descriptive, and correlational. There was little similarity among study interventions; some were carefully structured and others were casual with little structure or boundaries.
Extrapolation to broader populations. The selected studies drew subjects from a broad range of populations including medical-surgical inpatients, outpatient psychiatric patients, psycho-therapy clients, college students and community members. The diverse populations found in these studies supported the notion that the summary effects of a random effects meta-analysis could be applied to a broad and diverse community based population such as found in this study.

Homogeneity of effects found in studies. The decision to use a random-effects model was supported by the inconclusive nature of testing the null hypothesis that all studies shared a common effect size. In the case of a fixed-effect model the null hypothesis was rejected indicating that the studies did not share a common effect size ($Q = 68.34, df = 6, p < 0.001$). In the case of a random-effects model the null hypothesis was supported indicating that the studies shared a common effect size ($Q = 7.03, df = 6, p = 0.319$). In both models the between-studies variance was large ($\tau^2_{fixed} = 4050.05$, $\tau^2_{random} = 293.22$) indicating that a fixed-effect model was inappropriate for use with the selected studies (Borenstein, Hedges, Higgins, & Rothstein, 2009). The inconclusive nature of the hypothesis testing, large between-studies variance, lack of functional equivalence among historical studies, and the desire to extrapolate to broader populations all suggested that a random effects-model was preferable to a fixed-effect model (Borenstein, Hedges, Higgins, & Rothstein).

Random-effects meta-analysis model. A random-effects meta-analysis model was constructed using the computer application Comprehensive Meta-Analysis (Table 6; http://www.meta-analysis.com/). The model was configured to estimate the means and weights of the seven studies using each study’s EUS mean and standard deviation. The model weighted
the summary effects of the seven studies assuming that the true mean value of the EUS varied from study to study due to the variance and model selection criteria described earlier.

**TABLE 6. Random-effects Model for Studies Using BLRI Empathic Understanding Scale.**

<table>
<thead>
<tr>
<th>Study</th>
<th>$M$</th>
<th>$SE$</th>
<th>$s^2$</th>
<th>95% CI</th>
<th>Relative Weight</th>
<th>Group $T^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dawson</td>
<td>15.91</td>
<td>0.745</td>
<td>0.555</td>
<td>14.449-17.370</td>
<td>14.98</td>
<td>32.58</td>
</tr>
<tr>
<td>Fuertes</td>
<td>24.00</td>
<td>1.112</td>
<td>1.236</td>
<td>21.820-26.179</td>
<td>13.84</td>
<td>32.58</td>
</tr>
<tr>
<td>Madrid</td>
<td>19.58</td>
<td>1.062</td>
<td>1.128</td>
<td>17.498-21.661</td>
<td>14.01</td>
<td>32.58</td>
</tr>
<tr>
<td>Olson</td>
<td>20.40</td>
<td>0.455</td>
<td>0.207</td>
<td>19.508-21.291</td>
<td>15.64</td>
<td>32.58</td>
</tr>
<tr>
<td>Osborn</td>
<td>14.00</td>
<td>1.083</td>
<td>1.173</td>
<td>11.876-16.123</td>
<td>13.94</td>
<td>32.58</td>
</tr>
<tr>
<td>Turan</td>
<td>19.25</td>
<td>0.982</td>
<td>0.964</td>
<td>17.326-21.173</td>
<td>14.27</td>
<td>32.58</td>
</tr>
</tbody>
</table>

**Assay sensitivity.** The International Conference on Harmonization E10 guideline (U.S. Food & Drug Administration, 2001, 2010) defined assay sensitivity as the capacity of an experiment to distinguish between effective and ineffective treatments. Non-inferiority studies generally do not have a placebo arm so it is essential that the effectiveness of the active control be established using some other means (Rothmann, Weins, & Chan, 2012; U.S. Food & Drug Administration, Yue, 2001). Assay sensitivity establishes the efficacy of the treatment such that if a placebo had been used in this study both the active control and reference treatment would have been superior to the placebo (D’Agostino, Massaro, & Sullivan, 2003). Grounded in clinical drug trials, assay sensitivity applies equally to other forms of treatment such as medical devices and behavioral interventions (Ng, 2008, Yue, 2001). Two criteria guided the conclusion of assay sensitivity including: (a) historical evidence of sensitivity to the treatment and (b) appropriate conduct of the experiment. The meta-analysis of historical studies measuring empathy using the Barrett-Lennard Relationship Inventory provided clear evidence that empathic
understanding by the therapist was effective in increasing a subject’s perception of therapist-expressed empathy. The appropriate conduct of this present study, described in Chapter 4, was supported by the full compliance of participants with no losses to follow-up and no missing data. These two guidelines provided assurance that assay sensitivity was achieved in this study (U.S. Food & Drug Administration).

**Non-inferiority margin.** The non-inferiority margin was calculated using a confidence interval approach. In this approach, the first step was to estimate an effectiveness margin (M1). This margin encompassed the entire treatment effect assumed to be present in this study based on the historical evidence of perceived empathy as summarized in the previous random-effects meta-analysis model. It is common to specify M1 as the lower bound of a $100(1 - \lambda)\%$ confidence interval found in the random-effects model (Rothmann, Wiens, & Chan, 2012; U.S. Food & Drug Administration, 2010). In this study the lower bound of the 95% confidence interval, of the summary effect found in the random-effects model, was chosen resulting in $M1 = 16.662$ (Table 7).

The next step was to establish a non-inferiority margin (M2) The non-inferiority margin, M2, is the largest clinically acceptable difference of the study’s treatment, is a fraction of M1, is always less than the value of M1, and is chosen such that a suitable portion of the active control effect is retained in the reference treatment (Rothmann, Wiens, & Chan, 2012; U.S. Food & Drug Administration, 2010). It is often suggested to be 10 to 20% of the measured outcome (Allen & Seaman, 2007; Ng, 2008). Allen and Seaman summarize this as “in clinical trials, with patient and treatment variability, a new treatment that performs within 10 to 20% of an old treatment is often the margin used to be called non-inferior” (p. 53). For the purpose of this study
preserving 80% of the treatment effect found in the random-effects model was selected as a clinically acceptable level of perceived empathy. The non-inferiority margin was calculated to be 
\[ \delta = M2 = (1 - .80) \times 16.662 = 3.33 \] (Table 8).

**TABLE 7. Effectiveness (M1) and Non-inferiority Margins (M2).**

<table>
<thead>
<tr>
<th>Margin</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>M1 lower bound of 95% CI</td>
<td>16.662</td>
</tr>
<tr>
<td>M2 ((1 - \lambda) \times M1)</td>
<td>3.33</td>
</tr>
</tbody>
</table>

**Sample size calculation.** Using the following sample size formula for non-inferiority

\[ n_a = \frac{(r + 1)\sigma^2(Z_{1-\beta} + Z_{1-\alpha})^2}{r(\mu_A - \mu_B - \delta)^2} \]

trails (Julious, 2004) the total sample size for significance \( \alpha = 0.5 \) and power \( 1 - \beta = 0.9 \) was evaluated resulting in 51 participants assigned to each arm of the study for a total sample size of 102.

**Measures**

**Barrett-Lennard Relationship Index Empathic Understanding Scale**

The Barrett-Lennard Relationship Index (BLRI) Empathic Understanding Scale (EUS; Appendix B) measures one’s (the expresser) perception of a listener’s empathy toward them. This perception is formed by the expresser as the listener attempts to communicate empathy to the expresser during the second phase of the empathy cycle (Figure 4; Barrett-Lennard, 2014).

The EUS scale commonly used for measuring the subject’s perception of the listener’s expressed empathy is the OS-EMP+ where OS refers to the direction of empathy, in this case the other (the listener) to self (the expresser). Barrett-Lennard has made the EUS available freely to all researchers without need for permission (Barrett-Lennard, 2014).
The EUS is composed of 24 items. Of the 24 items, 12 measure empathy and the remaining 12 items are fillers composed of a mix of items that measure other relationship constructs. The fillers are interspersed throughout the scale in order to maximize item independence and avoid consistency bias relative to previous item responses. When an item response is suggested or encouraged by previous item responses, especially when all items are presented consecutively, the response may suffer consistency response bias (Barrett-Lennard, 2014). Each item is structured as a multiple choice question. There are six possible responses, indicating agreement, in two broad categories the: (a) false category, and (b) true category. Each category has three grades of response: (a) “I strongly feel that it is not true” (or true), (b) “I feel it is not true” (or true), and (c) “I feel that it is probably untrue” (or true). Respondents indicate their choice by indicating the value assigned to the category grades. False responses are assigned -3, -2, and -1 and true responses are assigned +3, +2, and +1 respectively. Six of the empathy items are worded in a positive manner and six are worded negatively.

**Scoring.** Before scoring, the negatively worded item value signs are reversed (e.g., -3 would become +3). Once completed the values are then summed producing the total empathy score. The range of total score is -36 to +36. The score may be offset by adding +36 thus producing a range of 0 to 72. The higher the score the greater the degree of the subject’s perceived empathy from the listener.

**Validity.** Content validity was assessed on two occasions. The first was during the creation of the BLRI (Barrett-Lennard, 1962). Using a five judge panel mean item ratings were later used for split half reliability assessment. The five judges were in near perfect agreement on the classification of items as positive or negative. Three items were eliminated because of
inconsistent judges’ ratings and three were eliminated because contained duplicate content. During a subsequent revision of the scale (Barrett-Lennard, 1978) three judges reviewed and refined items.

**Reliability.** The internal consistency reliability of the EUS was assessed using the alpha coefficient and split half method. The Spearman-Brown reliability coefficient, \( r = .86 \), was reported using client data from early psychometric assessments of the EUS (Barrett-Lennard, 1962, 2014). Over a decade later, Gurman (1977) reported similar split half reliability findings, \( r = .84 \), based on data from the work of 11 researchers using the EUS. The alpha coefficient ranged from \( r = .64 \) to \( r = .92 \) with a mean of \( r = .83 \) among four studies. Test-retest reliability was assessed in nine studies. The mean test-retest for the EUS was \( r = .83 \). Gurman accumulated over 50 reports of Cronbach’s alpha coefficient. Over 60% of the reported alpha coefficients were over \( \alpha = .87 \).

**Time burden.** Barrett-Lennard (2014) did not estimate the burden for the revised 24 item EUS. The time burden for the 16 item EUS was reported to be five minutes (Olson, 1995). It was estimated that the burden for the 24 item EUS would not exceed 10 minutes.

**Health Distress Scale**

The Health Distress (HD; Appendix D) scale was originally developed for the Medical Outcome Study (MOS; Stewart et al., 1992). A modified version of the HD is available from the Stanford Patient Education Research Center and is free to use without permission (Stanford, n.d.). The scale is composed of four Likert items that probe subject’s frustration and distress related to their health. Each Likert item is composed of six responses ranging from: (a) “None of the time,” (b) “A little of the time,” (c) “Some of the time,” (d) “A good bit of the time,” (e)
“Most of the time,” and (f) “All of the time.” The subject circles their response numbered 0 through 5.

**Scoring.** The score for each item is the number circled. If two consecutive numbers are circled the highest number is used for scoring. If the two numbers are not consecutive the item is not scored. The HD score is the mean score of all items scored. If more than one item is missing then the HD score is indicated as “missing.” The mean score of the HD ranges from 0 to 5. Higher scores indicate that the subject has more distress about their health.

**Validity.** Construct validity was conducted during the construction of scales for use in the MOS study. Discriminant and convergent validity were part of the HD scale construction and were assessed during a multi-trait analysis of the MOS scales. Convergent validity of the modified HD scale was demonstrated with a range of item-scale correlations between .67 and .75 (Lorig et al., 1996).

**Reliability.** Internal consistency reliability of .87 was reported with a sample size of N = 1,130. Test-retest reliability of .87 was assessed using a sample size of N = 51 (Lorig et al., 1996).

**Time burden.** The burden for the HD was not reported. It was estimated that it would take approximately one minute to complete the scale.

**Procedures**

**Training the Researcher**

Before data collection began the researcher received training for the purpose of achieving, as closely as possible, a standardized approach to the delivery of the reference
treatment and active control. Two activities were central to this training: (a) operation of the SMRTR, and (b) empathetic understanding and responses by the researcher.

**SMRTR operation.** The SMRTR used in this study was the Beam+ from Suitable Technologies (Suitable Technologies, 2015). The goal of the SMRTR operation was to successfully and consistently navigate the SMRTR from the “docked” charging station location to the participant’s location. This required connecting to the SMRTR while seated at a remote operator’s console, navigating the SMRTR to the participant’s location, announcing the SMRTR’s presence to the participant, and positioning the SMRTR at an appropriate distance and angle relative to the participant for optimal communication. Two activities were completed in order to achieve this level of operational mastery.

First, the researcher reviewed a SMRTR safety video and operator’s documentation on the SMRTR manufacturer’s web site (Suitable Technologies, n.d.). After this review of safety information and user documentation the researcher conducted six hours of hands-on operation of the SMRTR over the course of three days. During this navigation obstacles were avoided and stopping five and ten feet from a target was practiced (Figure 8). There were no incidents involving collision or incorrect navigation (e.g., turning left when a right turn was indicated).
**FIGURE 8.** Navigating the SMRTR Around Obstacles.

**Empathetic understanding and responses.** This was the critical component of phase two of the empathy cycle (Figure 4) where, after listening to the participant, an empathetic response was formed and then communicated to the participant. The goal of this training component was for the researcher to acquire a sufficient understanding of empathy and to apply it in a consistent manner.

While it may take years to develop and hone empathy skills and techniques there are some principles that can be applied immediately in order to achieve a basic and effective level of empathic understanding. Barrett-Lennard (2014) offered the following guidance:

(a) Listen as receptively and acutely as possible

(b) Follow the other becoming absorbed in their sharing and try not to lead the conversation
(c) Respond to concerns the participant wishes to share

(d) Let go of any desire to produce change in the participant’s feelings or thinking

(e) Ask questions sparingly and only to become more in touch with the participants felt experience and meanings

(f) If you lose track of what the participant is expressing acknowledge this as your difficulty and express your desire to understand the participant’s feeling or meaning

(g) Engage in sensitive reflection by expressing your present sense of the participant’s felt meaning

Using these guidelines, three structured activities were identified for three one hour training sessions. Each session was conducted with a license mental health counselor (LMHC).

**Session one.** Prior to meeting with the LMHC the researcher viewed two educational videos by psychotherapist Carl Rogers, a proponent of patient centered counseling (Rogers, 1957, 1959). The first video was a counseling session that Dr. Rogers conducted with a real patient by the name of Gloria (Duncan, 2015). During the course of this counseling Dr. Rogers utilized followed many of the guidelines described above. In the second video Dr. Rogers lectured students on the concept of empathy (MetaRealLizard, 2015). Having watched these videos the researcher met with the LMHC and discussed the concept of empathy and the principles of empathetic understanding.

**Session two.** The researcher met with the LMHC during which face-to-face role playing took place. The LMHC and researcher alternated the listening and expressing roles. At the completion of each role-play the LMHC and researcher completed the EUS OS or MO form as
appropriate to the role played (Appendices B & R). The EUS scores were reviewed and the LMHC and researcher discussed the results in the context of the role-play.

**Session three.** During this session the researcher met with the LMHC while embodied in the SMRTR. Skills and techniques for communicating with participants while using a SMRTR were discussed and practiced. At the conclusion of each role-play, the LMCH and researcher discussed the quality and effectiveness of the communication. The remainder of the activities for the session were the same as those in session 2.

**Results of empathy training.** Three observations emerged from the training on empathetic understanding. First, with time and practice the researcher’s empathic skills improved. Second, perceived empathy on the part of the expressing role was nearly equal in both human-human and human-robot interactions. Finally, the perception of empathy was well established within the first 10 minutes of the conversation. As the length of the discussion approached 30 minutes the conversation became redundant with long awkward gaps. For these reasons, the researcher elected to limit the empathic engagement intervention to 15 minutes. This decision was supported by a number of studies that found 10 to 20 minutes of empathic engagement or nursing presence to be suitable for study (Demiris, Edison, & Vijaykumar, 2005; Jo, Han, Chung, & Lee, 2013; Liu et al., 2007; Penque & Kearney, 2015; Riek, Rabinowitch, Chakrabarti, & Robinson, 2009).

**Procedure for Applying the Intervention to Study Groups**

The study intervention was applied equally to the reference treatment and active control groups. The intervention communicated empathy to the participant during a discussion with the researcher while the participant reflected on their current health concerns and its impact on their
day-to-day activities. In the reference treatment, the intervention was applied during a human-robot interaction. In the active control the intervention was applied during a human-human interaction.

**Initial participant processing.** When the participant arrived at the study setting on the appointed date and time they were greeted by the researcher. The researcher verified the participant’s appointment and oriented them to the study setting. The researcher then accompanied the participant to the office where the intervention would be applied. The participant was asked to sit on the couch opposite of the researcher’s location as shown in Figure 9. The participant was reminded that they would discuss, with the researcher, concerns that they might have regarding their health during a 15 minute conversation. The participant was then asked if they had questions about the research.

*FIGURE 9. Study Setting Layout with Researcher, SMRTR, and Participant Locations.*
**Introduction of intervention.** Depending on the participant’s group assignment the researcher would engage the participant in a human-human interaction or a human-robot interaction.

*Active control: Human-human interaction.* In the active control the researcher remained in the office after the participant had been seated. The researcher then asked the participant to describe their health concern. This initiated phase one of the cycle of empathy (Figure 4).

*Reference treatment: Human-robot interaction.* After the initial processing of the participant, the researcher left the office in which the initial participant processing took place. The research moved to a conference room remotely located to the office in which the participant was seated. The researcher then connected with the SMRTR which was located in the office with the participant. Once connected to the SMRTR, the researcher’s image and voice were streamed to the SMRTR and available in real-time to the participant as they viewed the SMRTR (Figure 10). In a similar manner, the researcher was able to see the participant on the computer from which the researcher was operating the SMRTR (Figure 2). The researcher greeted the participant and instructed them to remain seated as the robot approached them while moving to position two (Figure 9). Once in position two the researcher invited the participant to describe their health concern or issue. This initiated phase one of the cycle of empathy (Figure 4).
FIGURE 10. Streaming of SMRTR Operator’s Image and Voice.

Application of empathy cycle. Once the participant began discussing their health concern the researcher applied the cycle of empathy as shown in Figure 4. As the researcher listened to the participant, the researcher formed empathic responses and then communicated the responses back to the participant as indicated in phases one and two of Figure 4. During phase three the participant progressively formed a perception of the empathy expressed by the researcher. The cycle continued until the allotted time limit of 15 minutes was reached or the participant indicated that there was nothing further to discuss.

Data collection. Once the discussion was concluded the researcher asked the participant to complete the EUS. If the intervention took place more than one day after the HD scale was first completed, for the purpose of assigning the participant to a study group, the participant was asked to retake the HD scale. The researcher provided paper-based versions of the EUS and HD to the participant. The forms were identified by participant’s study ID only. Before leaving the room the researcher and participant reviewed the instructions for completing the EUS. The
researcher then exited the room leaving the participant to complete the EUS (see section 3.4 of Appendix S).

**Securing Data**

All completed paper-based EUS and HD scales were placed in a locked filing cabinet during each day of data collection. At the end of the day, the completed scales were scored by the researcher. The scores were written to a digital file for each participant, encrypted, and stored in secure cloud storage. The researcher then returned all of the completed paper-based scales to the locked filing cabinet for storage. At the completion of the study all forms and scales were sent to the University of Arizona College of Nursing for storage in a secure locked facility.

**Monitoring Fidelity**

Consistency of the researcher’s empathetic responses was crucial to this study. For the purpose of reviewing the level of consistency, the audio portion of the conversation during each observation was recorded. The use of audio recording was disclosed to participants during informed consent and just before the intervention took place. The researcher complied with participants’ requests not to be recorded should they have asked. Such a request did not impact enrollment in the study. In the active control group the researcher used a small digital recorder to capture the audio interaction. In the reference treatment group the audio stream of the SMRTR was captured digitally.

A licensed mental health counselor (LMHC), not familiar with or associated with this study, randomly selected and reviewed the audio recordings. The LMHC assessed the randomly selected recordings for consistency of the researcher’s empathetic responses during the recorded discussions. Participant information and group assignment was blinded so that the LMHC had no
knowledge of these data or conditions. The following questions guided the evaluation of the recordings (Barrett-Lennard, 2014): Did the researcher:

(a) Listen as receptively and acutely as possible?
(b) Ignore reactions to the participant’s reaction to the situation of sitting with the researcher discussing their health in the context of a research study?
(c) Respond to the felt concerns of the participant that they wished to share?
(d) Let go of any desire to produce change in the participant’s feelings or thinking?
(e) Ask questions sparingly and only to become more in touch with the participant’s felt experience and meanings?
(f) Offer an explanation of why the researcher may have lost track of what the participant was expressing?
(g) Engage in sensitive reflection by expressing the researcher’s present sense of the participant’s felt meaning

**Participant Compensation**

Completion of the EUS scale signaled the end of the participant’s study for the participant. The participant was thanked for their participation in the study and given a Starbucks coffee card with a value of ten dollars ($10 USD).

**Data Analysis**

The strategy for data analysis focused on statistical methods for assessing the assumptions of parametric data, addressing data abnormalities, dealing with missing data, and examining the two research aims guiding this study:
Aim One: Examine adults' perception of nurse-expressed empathy from a semi-autonomous nurse robot as compared to a human nurse.

Aim Two: Examine the relationship between adults’ perception of nurse-expressed empathy and their level of health distress.

Description of Key Study Variables

Four study variables were key to the analyses employed to test the hypotheses of this study. These variables included the categorical variable Gender, the categorical variable Groupnum, the ordinal, yet treated as continuous, variable for the second instance of health distress score, HD#2score, and the continuous variable for the empathy scale score EUS.

Gender. This categorical variable was assigned 0 for male and 1 for female.

Groupnum. This categorical variable was used to track the study group to which the participant was assigned. Groupnum was assigned 0 if the participant was assigned to the active control group and 1 if the participant was assigned to the reference treatment group.

EUS. This continuous variable recorded the result of the Empathic Understanding Scale; a scale that was used to score the participant’s perception of nurse-expressed empathy.

HD #2 score. This variable was considered interval even though the HD #2 score data were based on a Likert scale ranging from 0 to 5 making it appear to be ordinal. The original study from which the scale was developed treated the variable as if it were a continuous measurement. Norman (2010) concluded that parametric statistics can be used on data from Likert scales. These parametric statistics are robust with respect to violations of the assumption of sample size, normality, and the ordinal nature of the data. Norman pointed out that the assumption of normality applies to the distribution of means and not the data itself. This
observation strengthens the use of HD #2 score as interval data because it is the mean of the responses to Likert scales as opposed to the raw response data. The HD #2 score was obtained on the same day that the Empathic Understanding Scale was administered as opposed to the first HD score which was obtained for the purpose of randomizing a participant into a study group.

**Assumptions of Parametric Data**

Parametric data are those interval data that are distributed normally, demonstrate homogeneity of variance, and are independent (Field, 2009). The assumptions of normality and homogeneity of variance are often ignored in non-inferiority studies due to larger sample sizes and equal group assignments (Mandansky, 1988; Rothmann, Wiens, & Chan, 2012). Despite the tendency to ignore normality and homogeneity of variance the variables of this study were evaluated in the context of these assumptions. The use of non-parametric and statistical methods that assumed both equal and unequal variances were employed in the analyses to further mitigate the potential consequences of ignoring parametric assumptions (Rothman, Wiens, & Chan).

**Normality.** Normality was assessed visually and statistically. Visually, the data were assessed for normality using histograms and Q-Q plots. Statistically, the Shapiro-Wilk test was used to evaluate normality (Shapiro & Wilk, 1965). Although there are many statistical tests for evaluating normality the Shapiro-Wilk test is considered to be one of the best omnibus tests of normality (Mandansky, 1988).

**Homogeneity of variance.** The Brown-Forsythe test evaluated the null hypothesis of homogeneity of variance. The Brown-Forsythe test is similar to Levene’s test but uses the residual median for each group as opposed to the residual mean (Brown & Forsythe, 1974). The Bruesch-Pagan test evaluated the null hypothesis of homoscedasticity (Breusch & Pagan, 1979).
**Interval data.** The EUS and HD #2 score data were continuous meeting the requirement of interval data.

**Independence.** The study design ensured independence of participant data. All outcome data came from participants assigned to one and only one study group.

**Addressing Violations of Parametric Data**

Data that violated or appeared to violate assumptions of parametric data were analyzed and transformed to restore the necessary assumptions required for the use of parametric statistics.

**Data transformation.** If data violated parametric assumptions the data were transformed using the Box-Cox power transformation (Box & Cox, 1964; Sakia, 1992). The Box-Cox power transformation is given by the monotonic function:

\[
y_t^{(\lambda)} = \begin{cases} 
(y_i + \lambda_2)^{\lambda_1} - 1)/\lambda_1; & \lambda_1 \neq 0 \\
\log(y_i + \lambda_2); & \lambda_1 = 0
\end{cases}
\]

The transformation required values greater than zero. If a study variable contain zero values all values of the variable were incremented by one in order to meet the requirement. The function boxcox in the R package MASS (Venables & Ripley, 2002) was used to compute the log-likelihoods for the lambda parameter of the Box-Cox transformation. The optimal lambda (\(\lambda\)) value chosen for the power transformation was the right most intersection of the lambda-by-log-likelihood curve with 95% of log-likelihood as shown in Figure 15.
Using this value of $\lambda$ a new study variable was computed given by:

$$y_i^\lambda = (y_{\text{untransformed}})_i^\lambda$$

Transformed data were assessed for normality and homogeneity of variance and then used in the appropriate statistical evaluation. If the results of the statistical evaluation using the transformed data were the same as the results using the untransformed data then the results using the untransformed data were reported.

**Outliers.** Data that appeared to be outliers were identified using the outlier labeling rule (OLR). Using OLR, outliers were identified by establishing limits to which data observations could be compared (Hoaglin & Iglewicz, 1987; Hoaglin, Iglewicz, & Tukey 1986). The OLR established upper and lower resistant rules based on the 25th and 75th percentiles of the observed data. Observations less than lower limit or greater than the upper limit were considered outliers. The main resistant rule, $k$, has routinely been considered to be $k = 1.5$. Hoaglin and Iglewicz,
through simulation, concluded that a more reasonable estimate for \( k \) when the sample size \( 20 \leq n \leq 100 \) was \( k = 2.28 \). Using this value for \( k \), the calculation of the upper and lower limits was given by:

\[
Upper = F_U + 2.28(F_U - F_L) \\
Lower = F_L + 2.28(F_U - F_L)
\]

The value \( F_L \) is assigned the value found in the 25th percentile. The value \( F_U \) is assigned the value found in the 75th percentile. To identify outliers the upper and lower limits were compared to the extreme values found in the observed data.

**Missing Data**

There were no missing data in this study. This was accomplished using a strategy to prevent missing data through a comprehensive effort of study design, participant education, and administrative oversight. The design of the study mitigated many issues related to missing data in clinical trials. If a participant withdrew their consent and went off-study there were no data for analysis as there was only one observation. While no participants withdrew if a participant had chosen to withdraw a new participant would have been recruited to replace the withdrawing participant. Participants were told about the importance of completing all scale items on two occasions, during informed consent and before the participant completed the EUS and HD scales (see section 3.4.2.1.1 of the Intervention Manual in Appendix S). After participants completed the EUS and HD scales and before the participant left the study setting the researcher reviewed the scales to ensure that the participant had responded to all items. If items were found with no response the participant was asked to complete the items.
Had data been missing in this study it would have been at the item response level and characterized as missing at random (MAR) or missing not at random (MNAR) depending on the reason the participant gave for not completing an item. Because single imputation is inappropriate for non-inferiority studies multiple imputation would have been utilized to address MAR and MNAR conditions (Wiens & Rosenkranz, 2013).

Examining Research Aims

Analyzing adults’ perception of nurse-expressed empathy. The analysis goal for the first aim was to demonstrate that the difference between the reference treatment and the active control was small enough to support the conclusion that a semi-autonomous robot nurse was just as effective in communicating empathy as was the human nurse. The outcome measure used for this research aim was the EUS. The EUS provided a continuous measure of an adult’s perception of the researcher’s empathy toward them. The mean of the EUS scores established a summary of central tendency from which to evaluate the difference between the reference treatment and active control groups.

Hypotheses of non-inferiority. The one-sided null and alternate hypotheses for this research aim were:

\[ H_0 : \mu_{AC} - \mu_{RT} \geq \delta \]
\[ H_1 : \mu_{AC} - \mu_{RT} < \delta \]

The null hypothesis implied that the active control (\(\mu_{AC}\)) exceeded the reference treatment (\(\mu_{RT}\)) by at least the non-inferiority margin (\(\delta\)) inferring that the reference treatment was inferior to the active control. The alternative hypothesis implied that the active control exceeded the reference treatment by no more than the non-inferiority margin inferring that the reference treatment was
not inferior to the active control (D’Agostino, Massaro, & Sullivan, 2003). Rejection of the null hypothesis was required to conclude non-inferiority ((Rothmann, Wiens, & Chan, 2012; Wellek, 2010).

**Statistical approach.** A two confidence interval approach using the fixed margin method, also known as the 95%-95% method, and an analyses of covariance (ANCOVA) were used for the non-inferiority analyses of the outcome measure EUS (U.S. Food & Drug Administration, 2010; Rothmann, Wiens, & Chan, 2012).

*95%-95% method.* In the 95%-95% method, the first confidence interval, described earlier, was used to establish the non-inferiority margin. This 95% confidence interval was obtained from a meta-analysis of historical studies that measured empathy using the EUS (Table 7). The second 95% confidence interval was used to evaluate the difference in mean EUS scores of the active control and reference treatment groups in this study. This confidence interval was obtained from an ANCOVA or normalized methods that evaluated the mean EUS scores and the distribution of the EUS data.

**Analysis of covariance.** In non-inferiority trials it is a common practice to include stratification factors as covariates in an ANCOVA model (Rothmann, Weins, & Chan, 2012) in order to refine the confidence interval by which to evaluate non-inferiority. The factors gender and health distress, identified earlier as factors used in the stratified block randomization strategy, were evaluated as covariates in the ANCOVA (Christov-Moore et al., 2014, Kernan et al., 1999; Olson & Hanchett, 1997). If these covariates were found to significantly contribute to the variability of the outcome measure then the standard error in estimating the difference of means would be reduced resulting in a shorter confidence interval than the confidence intervals
calculated using the normalized methods described below. In such a case, the confidence interval obtained from the ANCOVA would be used to evaluate non-inferiority as opposed to the confidence intervals obtained using the normalized methods (Rothmann, Wein, & Chan). If the assumptions for ANCOVA were fully met a standard parametric ANCOVA was conducted. Should any assumptions for ANCOVA be violated a robust alternative to standard ANCOVA, the Wilcox method, was used (Wilcox, 1997, 2013). The Wilcox method is robust to all violations of the assumptions of data used in ANCOVA especially normality, heteroscedasticity, and homogeneity of variance.

If the results of the ANCOVA were not significant it was concluded that the covariates of HD #2 score and Gender had no effect on EUS. In this case, the confidence intervals obtained from the normalized methods, described below, were used to assess non-inferiority. If the results of the ANCOVA were significant the confidence interval obtained from the ANCOVA was used to evaluate non-inferiority.

**Normalized methods.** Rothmann, Wiens and Chan (2012) described a strategy for analyzing the difference in means between the active control and the reference treatment using normalized methods. Their strategy incorporated three methods for comparing means with underlying distributions having unknown and unequal variance, the Behrens-Fisher problem (Scheffe, 1943, 1970), and unknown and equal variance. Each method constructed a test statistic from which a confidence interval and one-sided $p$-value were calculated. If, and only if, all three methods demonstrated that the confidence interval contained only values less than the non-inferiority margin, the test statistic was less than the critical value, and the $p$-value was less than the one-sided $\alpha = 0.025$ then non-inferiority was concluded (Rothmann, Wiens, & Chan).
**Method one.** This method assumed unknown and unequal variance. The method evaluated the difference of means assuming a standard normal distribution. The test statistic was given as:

\[ Z = \frac{\bar{X} - \bar{Y} - \delta}{\sqrt{S_c^2 / n_c + S_e^2 / n_e}} \]

The means \( \bar{X} \) and \( \bar{Y} \) were the EUS means of the active control and reference treatment groups respectively. The variances for the active control and reference groups’ EUS score was \( S_c^2 \) and \( S_e^2 \) respectively. The \( 100(1 - \alpha)\% \) confidence interval was calculated using:

\[ \bar{x} - \bar{y} \pm z_{\alpha/2} \sqrt{S_c^2 / n_c + S_e^2 / n_e} \]

The critical value of \( z_{\alpha/2} \) reflected the assumption that the data shared a standard normal distribution.

**Method two.** This method assumed unknown and unequal variance. The method utilized the same \( Z \) test statistic as in method one. This statistic was compared with a critical value derived from the \( t \) distribution as opposed to the standard normal distribution. The critical value \( t_{\alpha/2,\nu} \) was based on the observed sample variances representing the upper \( \alpha/2 \) percentile of a \( t \) distribution where \( \nu = \) Satterthwaite degrees of freedom. Satterthwaite degrees of freedom are derived from a linear combination of the variances found in the active control and reference treatment groups. The use of Satterthwaite degrees of freedom resulted in a critical value larger than \( z_{\alpha/2} \). This, in turn, produced a wider confidence interval that promoted a more conservative analysis of the difference of means (Rothmann, Wiens, & Chan, 2012; Satterthwaite, 1946).
Satterthwaite degrees of freedom are the greatest integer less than or equal to the estimate obtained using the following equation (Rothmann, Weins & Chan; Satterthwaite):

\[
df = \frac{\left( \frac{s_C^2}{n_C} + \frac{s_E^2}{n_E} \right)^2}{\frac{s_C^4}{n_C(n_C - 1)} + \frac{s_E^4}{n_E(n_E - 1)}}
\]

The 100(1 – \(\alpha\))% confidence interval was given by:

\[
\bar{x} - \bar{y} \pm t_{\alpha/2, v} \sqrt{\frac{s_C^2}{n_C} + \frac{s_E^2}{n_E}}
\]

**Method three.** This method assumed unknown and equal variance. The test statistic was a T statistic given by:

\[
T = \frac{\bar{X} - \bar{Y} - \delta}{\sqrt{S^2(1/n_C + 1/n_E)}}
\]

The standard error of the difference in means utilized a pooled estimation of the variance \(S^2\) given by:

\[
S^2 = [((n_C - 1)s_C^2 + (n_E - 1)s_E^2)/(n_C + n_E - 2)]
\]

The critical value \(t_{\alpha/2, n_C + n_E - 2}\) was based on a t-distribution where degrees of freedom equaled \(n_C + n_E - 2\). The 100(1 – \(\alpha\))% confidence interval was given by:

\[
\bar{x} - \bar{y} \pm t_{\alpha/2, n_C + n_E - 2} \sqrt{S^2(1/n_C + 1/n_E)}
\]

**Analyzing adults’ perception of empathy related to health distress.** In accordance with the second aim NEEPD predicted that there would be a negative relationship between an adult’s health distress and their perception of nurse-expressed empathy. As health distress
increased, the perception of empathy would decrease and as health distress decreased the
perception of empathy would increase.

**Hypotheses of association.** The hypotheses for the relationship between health distress
and perceived empathy were:

\[ H_0 : \tau = 0 \]
\[ H_0 : \tau < 0 \]

The null hypothesis implied that there was no relationship between a participant’s health distress
and their perception of empathy. The one-sided alternative hypothesis implied that a negative
monotonic relationship existed between the participant’s health distress and their perception of
nurse-expressed empathy. As the participant’s perception of nurse-expressed empathy increased
their health distress would decrease (Olson, 1995; Olson & Hanchett, 1997). Rejection of the
null hypothesis was required to conclude that a negative relationship, as predicted by NEEP, was found among participants in this study.

**Statistical approach.** A non-parametric Kendall rank correlation (Kendall, 1974) and z-
statistic were used to evaluate the strength and significance of the relationship between the EUS
score and the second HD #2 score respectively. The Kendall rank correlation coefficient, also
known as Kendall’s tau-b (\( \tau \)), was given by:

\[ \tau = \frac{n_c - n_d}{\frac{1}{2} n(n - 1)} \]

where \( n_c \) is the number of concordant pairs of the EUS and HD mean observations and \( n_d \) is the
number of discordant pairs of the EUS and HD mean observations. Concordant pairs are any pair
of observations \((x_i, y_i)\) and \((x_j, y_j)\) where both \( x_i > x_j \) and \( y_i > y_j \) or both \( x_i < x_j \) and \( y_i < y_j \).
Discordant pairs are any pair of observations \((x_i, y_i)\) and \((x_j, y_j)\) that do not meet these criteria (Kendall, 1974). The Kendall rank correlation provided an indication of the strength of the association between the participant’s health distress and the EUS score. The significance of the correlation coefficient was tested using a \(z\)-statistic for Kendall’s tau-b given by:

\[
z = \frac{n_c - n_d}{\sqrt{v}}
\]

The conditions for rejecting the null hypothesis, indicating an association between EUS and perceived empathy, measured by the HD mean, included a \(p\)-value less than or equal to \(\alpha = .025\) and the \(z\) statistic less than the critical value of -1.96 where \(\alpha = .0.25\).

**Analysis Tools**

The statistical analyses of non-inferiority and correlation were conducted using the R data analysis application (R, 2015). Graphical inspection of the study data was conducted using both R and IBM Statistical Package for the Social Sciences (SPSS, Version 23). Analyses using R were coded using R packages including car, gdata, HH, Kendall, lmtest, MASS, plotrix, and WRS2 (Fox & Weisberg, 2011; Heiberger, 2015; Lemon, 2006; Mair, Schoenbrodts, & Wilcox, 2015; McLeod, 2011; Venables & Ripley, 2002; Warnes et al., 2015; Zeileis & Hothorn, 2002 ). The R code for the non-inferiority analysis following the strategy described by Rothmann, Weins and Chan (2012) is found in Appendix T.

**Human Subjects Protection Plan**

Approval for the study was obtained from the University of Arizona Institutional Review Board (Appendix U). Participants reviewed and signed the approved University of Arizona consent to participate in research (Appendix V). The signed consent forms have been filed with
University of Arizona College of Nursing where they will remain under lock-and-key for six years after which they will be properly disposed of.

Privacy of Subjects and Confidentiality of Data

Data privacy during recruitment. During the recruiting and screening phase of the study a screening checklist was prepared for each potential participant (Appendix N). The participant’s first name and last name initial were used for identification purposes. The screening checklist was placed in an unmarked 11” x 14” envelope that remained in the possession of the participant during the screening process in order to protect their privacy. After the completion of each screening activity, the researcher removed the screening checklist from the envelope, marked the screening activity accordingly, returned the checklist to the envelope, and passed the envelope back to the potential participant.

Data privacy after enrollment. Once eligibility for participation in the study was established and informed consent was obtained the participant was asked to complete the Health Distress scale (Appendix D) and the demographic survey (Appendix P) for purpose of randomization to a study group. The participant ID associated with the assignment was written on the completed forms. The forms were then added to the participant’s unmarked envelop. At this point, the researcher took possession of the unmarked envelop. The participant’s ID was written on the outside of the envelope. The envelope and its contents were placed in a locking file box that remained in the possession of the researcher at all times. At the completion of recruiting and enrollment of participants the data were transcribed to the digital master list and participant data files.
**Master list.** The master list was created as a text file with each row representing a unique fixed length participant contact record. The participant contract record format is shown in Table 8. At a minimum, the participant record included the participant ID (PID), last name, first name, city and state. If the participant wished to be reminded of their scheduled intervention appointment additional contact information was included in the row including phone number, email address, home address and zip code. Newly added participant records were appended to the end of the file. This list was used to coordinate PIDs with the EUS and HD forms and to manage the study appointment schedule. The master list file was digitally encrypted using an encryption plugin for the text editor Notepad++ called NppCrypt (http://docs.notepad-plus-plus.org/index.php?title=Plugin_Central#N). This encryption plugin implemented the symmetric Advanced Encryption Standard (AES; NIST, 2002) using a single encryption key with a length of 256 bits. The file was stored in secured cloud storage. The researcher maintained the AES key on paper in a locked filing cabinet.

**TABLE 8. Text File Format for Participant Contact Record.**

<table>
<thead>
<tr>
<th>Field</th>
<th>Type</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>ParticipantID</td>
<td>String</td>
<td>12</td>
</tr>
<tr>
<td>LastName</td>
<td>String</td>
<td>15</td>
</tr>
<tr>
<td>FirstName</td>
<td>String</td>
<td>15</td>
</tr>
<tr>
<td>Phone</td>
<td>String</td>
<td>10</td>
</tr>
<tr>
<td>Email</td>
<td>String</td>
<td>50</td>
</tr>
<tr>
<td>HomeAddress</td>
<td>String</td>
<td>50</td>
</tr>
<tr>
<td>City</td>
<td>String</td>
<td>25</td>
</tr>
<tr>
<td>State</td>
<td>String</td>
<td>2</td>
</tr>
<tr>
<td>ZipCode</td>
<td>String</td>
<td>5</td>
</tr>
</tbody>
</table>

**Participant data.** The participant data file was created as a text file with each row representing a unique fixed length participant data record. The participant data record format is
shown in Table 8. All fields of the participant data record contained data. No fields were optional and no data was missing. Fields were populated with the mean value of the health distress scales, EUS scores and demographic data. The participant data file was digitally encrypted using the AES algorithm. The file was stored in secured cloud storage.

**TABLE 9. Text File Format for Participant Data Record.**

<table>
<thead>
<tr>
<th>Field</th>
<th>Type</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>ParticipantID</td>
<td>String</td>
<td>12</td>
</tr>
<tr>
<td>Groupnum</td>
<td>String</td>
<td>1</td>
</tr>
<tr>
<td>EUS</td>
<td>String</td>
<td>5</td>
</tr>
<tr>
<td>HDscore</td>
<td>String</td>
<td>5</td>
</tr>
<tr>
<td>HD#2score</td>
<td>String</td>
<td>5</td>
</tr>
<tr>
<td>Gender (coded)</td>
<td>String</td>
<td>1</td>
</tr>
<tr>
<td>Age</td>
<td>String</td>
<td>2</td>
</tr>
<tr>
<td>MaritalStatus (coded)</td>
<td>String</td>
<td>1</td>
</tr>
<tr>
<td>Education (coded)</td>
<td>String</td>
<td>1</td>
</tr>
<tr>
<td>Race/Ethnicity (coded)</td>
<td>String</td>
<td>1</td>
</tr>
<tr>
<td>HealthRating (coded)</td>
<td>String</td>
<td>1</td>
</tr>
</tbody>
</table>

*Audio recordings.* The audio recordings used for monitoring the fidelity of participant interventions were digitally encrypted using the AES 128 algorithm and stored in cloud storage.

*Access to files.* Only the researcher had access to the encrypted files using a single AES key as described above. The files are stored on secured servers at the University of Arizona College of Nursing for a period of six years after which time they will be properly disposed of.

**Benefit to Participant**

This study afforded no direct physical benefit to the participant. During the course of the intervention, participants had an opportunity to discuss their health concerns and the impact of those concerns on their day-to-day activity. Other than anecdotally, it is unknown if empathy, communicated during the intervention, provided a benefit to participants.
Adverse Event Monitoring

The potential for adverse effects during the human-robot interaction, while low, was present. While the researcher was able to see and hear the participant at all times while using the SMRTR the participant was the only person physically in the study setting. Should the participant have required immediate assistance during the course of the study the researcher was always nearby. The researcher operated the SMRTR from an office adjacent to the study setting in which the participant was located thus permitting rapid access to the participant. The door lock to the study setting was disabled to ensure such rapid access.

In order to prevent adverse events related to the electro-mechanical components of the device the SMRTR was inspected daily including system diagnostics and operational assessment. Should there have been mechanical, electrical or diagnostic issues with the SMRTR the robot would have been taken offline and queued for support. Participants impacted by taking the SMRTR offline would have been contacted and rescheduled for the human-robot interaction. However, during the course of this study there were no electro-mechanical issue with the SMRTR and no adverse effects related to the use of the SMRTR were reported during the course of the study.

Summary

This chapter described details of the design, enrollment of participants, conduct of the study, and strategy for data analysis and potential for adverse effects. The experimental design chosen for this study was the non-inferiority randomized trial. In this non-inferiority study the margin was established using historical studies. The observed effect of the present study should not be less than the historical mean minus the margin in order to make the claim that empathy
perceived by participants interacting with a robot was not inferior to participants interacting with a human. Potential participants for the study were screened for health concerns and their ability to interact with the SMRTR. After informed consent participants were assigned to one of two groups, the reference treatment or the active control using stratified randomization composed of two strata, gender and health distress. The measures used in the study, the EUS and HD were described relative to their psychometric properties. The procedures for conduct of the study were described in detail including procedures to prepare the researcher for delivering the treatment consistently and procedures for the conduct of observations with participants. The strategy for data analysis of each research aim was presented in detail. The data analysis for the first research aim included a two confidence interval approach and ANCOVA. The analysis for the second research aim was correlational testing the strength and significance of the association between perceived empathy and health distress. Human subject’s protection was described with emphasis on the privacy of data and the monitoring of adverse events.
CHAPTER 4: RESULTS

The investigation of robots in the context of nursing is in its infancy. The lack of robotics research by nursing scientists has resulted in large gaps of knowledge about the use of robots in nursing practice. This study sought to begin bridging that gap by investigating adult’s perception of empathy from a robotic nurse compared to a human nurse. The research aims of the study were:

Aim One: Examine adults’ perception of nurse-expressed empathy from a SMRTR nurse as compared to a human nurse.

Aim Two: Examine the relationship between adults’ perception of SMRTR or human nurse-expressed empathy and level of health distress.

This chapter presents the results of the data analysis strategy described in chapter three. The chapter begins with a description of the sample and the results of the study variables of interest. Assumptions of parametric data are evaluated relative to the study variables. Concluding the chapter are the results of hypotheses testing.

Description of the Sample

Four potential participants were excluded from among 106 assessed for eligibility. The exclusions were due to a potential participant’s failure to meet the inclusion criteria, declining to participate, or not keeping a scheduled intervention appointment. Among the remaining one hundred and two ($N = 102$) participants fifty ($n = 50$) were randomly assigned to the reference treatment group and fifty-two ($n = 52$) to the active control group. The data from all of the participants ($N = 102$) were analyzed having lost none to follow up or exclusion for other reasons. The flow of participants through the enrollment, allocation, follow up and analysis
The characteristic study participant was 56.45 years of age ($SD = 11.3$), currently married (85.3%), and white (94.1%) with at least some post-secondary education (89.2%, $M = 15.62$, $SD = 2.4$). Summaries of the continuous and categorical demographic data are given in Tables 10 and 11.

**FIGURE 12.** Flow of Participants Through Phases of Non-inferiority Randomized Trial.
TABLE 10. Summary of Continuous Participant Demographic Data.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Range</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Variance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>56</td>
<td>21</td>
<td>77</td>
<td>56.45</td>
<td>11.284</td>
<td>127.319</td>
</tr>
<tr>
<td>Education (years)</td>
<td>11</td>
<td>12</td>
<td>23</td>
<td>15.62</td>
<td>2.421</td>
<td>5.862</td>
</tr>
</tbody>
</table>

TABLE 11. Summary of Categorical Demographic Data.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Frequency</th>
<th>Percent</th>
<th>Cumulative Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>43</td>
<td>42.2</td>
<td>42.2</td>
</tr>
<tr>
<td>Female</td>
<td>59</td>
<td>57.8</td>
<td>100.0</td>
</tr>
<tr>
<td>Marital status</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Married</td>
<td>87</td>
<td>85.3</td>
<td>85.3</td>
</tr>
<tr>
<td>Widowed</td>
<td>3</td>
<td>2.9</td>
<td>88.2</td>
</tr>
<tr>
<td>Divorced</td>
<td>4</td>
<td>3.9</td>
<td>92.2</td>
</tr>
<tr>
<td>Never married</td>
<td>8</td>
<td>7.8</td>
<td>100.0</td>
</tr>
<tr>
<td>Race/Ethnicity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Native American</td>
<td>5</td>
<td>4.9</td>
<td>4.9</td>
</tr>
<tr>
<td>Asian</td>
<td>1</td>
<td>1.0</td>
<td>5.9</td>
</tr>
<tr>
<td>White</td>
<td>96</td>
<td>94.1</td>
<td>100.0</td>
</tr>
<tr>
<td>Health Rating</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Very good</td>
<td>30</td>
<td>29.4</td>
<td>29.4</td>
</tr>
<tr>
<td>Good</td>
<td>52</td>
<td>51.0</td>
<td>80.4</td>
</tr>
<tr>
<td>Moderate</td>
<td>17</td>
<td>16.7</td>
<td>97.1</td>
</tr>
<tr>
<td>Bad</td>
<td>2</td>
<td>2.0</td>
<td>99.0</td>
</tr>
<tr>
<td>Very bad</td>
<td>1</td>
<td>1.0</td>
<td>100.0</td>
</tr>
</tbody>
</table>

Summary of Key Study Variables

Four study variables were key to the analyses employed to test the hypotheses of this study including the categorical variables gender and groupnum, and the continuous variables EUS and HD #2 score.
Gender

There were 43 males among the participants (42.2%) and 59 females (57.8%).

Contingency relationships of gender with marital status, race, and health rating are presented in Tables 12, 13, and 14.

**TABLE 12. Contingency Table for Gender * Marital Status.**

<table>
<thead>
<tr>
<th>Marital Status</th>
<th>Married</th>
<th>Widowed</th>
<th>Divorced</th>
<th>Never Married</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td>Male</td>
<td>38</td>
<td>0</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>49</td>
<td>3</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Total</td>
<td>87</td>
<td>3</td>
<td>4</td>
<td>8</td>
<td>102</td>
</tr>
</tbody>
</table>

**TABLE 13. Contingency Table for Gender * Race/Ethnicity.**

<table>
<thead>
<tr>
<th>Race/Ethnicity</th>
<th>Asian</th>
<th>Hispanic or Latino</th>
<th>White</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td>Male</td>
<td>2</td>
<td>0</td>
<td>41</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>3</td>
<td>1</td>
<td>55</td>
</tr>
<tr>
<td>Total</td>
<td>5</td>
<td>1</td>
<td>96</td>
<td>102</td>
</tr>
</tbody>
</table>

**TABLE 14. Contingency Table for Gender * Health Rating.**

<table>
<thead>
<tr>
<th>Health Rating</th>
<th>Very good</th>
<th>Good</th>
<th>Moderate</th>
<th>Bad</th>
<th>Very bad</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td>Male</td>
<td>14</td>
<td>23</td>
<td>6</td>
<td>0</td>
<td>43</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>16</td>
<td>29</td>
<td>11</td>
<td>2</td>
<td>59</td>
</tr>
<tr>
<td>Total</td>
<td>30</td>
<td>52</td>
<td>17</td>
<td>2</td>
<td>1</td>
<td>102</td>
</tr>
</tbody>
</table>

**Groupnum**

Fifty-two (51%) participants were assigned to the active control group (groupnum = 0).

Fifty participants (49%) were assigned to the reference treatment group (groupnum = 1).
EUS

The analysis of the EUS data evaluated the difference of means between each experimental group having received the study intervention. Factored by groupnum the mean EUS for the active control group (groupnum = 0, $M = 26.85$, $SD = 4.804$) was greater than the mean EUS for the reference treatment group ($M = 26.12$, $SD = 6.426$). A complete summary of the descriptive statistics for EUS, factored by groupnum, is presented in Table 15.

HD #2 Score

The HD #2 score data were evaluated in the context of the relationship between it and the EUS. For that analysis the data were not factored by the experimental group to which the participant was assigned. The average health distress score ($M = 1.53$, $SD = 1.00$) was less than the average score reported in the psychometric evaluation ($M = 2.04$, $SD = 1.16$) reported by the authors of the health distress measurement scale (Lorig et al., 1996). A complete summary of the descriptive statistics for HD #2 score is presented in Table 16.

Assumptions of Parametric Data

Assumption of normality. A key assumption when using parametric statistics (Madansky, 1988), normality was assessed for the key study variables.

Gender. Gender was a categorical variable with a categorical distribution as opposed to a normal distribution. No assessment of normality was required for this variable.

Groupnum. This variable was a categorical variable that, like gender, was distributed categorically. No assessment of normality was required for this variable.

HD #2 score. The visual and statistical assessment of the data associated with HD #2 score indicated that the data deviated from a normal distribution.
**Visual inspection.** Visually, the HD #2 Score data were assessed using a frequency histogram of HD #2 Score and a normal Q-Q plot. The histogram (Figure 13) appeared to be positively skewed with floor and ceiling effects due to the minimum allowable response of zero and the maximum allowable response of five. On the Q-Q plot (Figure 14) two isolated values in the right tail suggested a moderately skewed distribution with positive kurtosis.

**TABLE 15. Descriptive Statistics of EUS by Groupnum.**

<table>
<thead>
<tr>
<th>Groupnum</th>
<th>EUS</th>
<th>Statistic</th>
<th>Std. Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Mean</td>
<td>26.85</td>
<td>.666</td>
</tr>
<tr>
<td></td>
<td>95% Confidence Interval for Mean</td>
<td>Lower bound</td>
<td>Upper bound</td>
</tr>
<tr>
<td></td>
<td>Median</td>
<td>27.00</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Variance</td>
<td>23.074</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Std. Deviation</td>
<td>4.804</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Minimum</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Maximum</td>
<td>36</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Range</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Interquartile Range</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Skewness</td>
<td>-.310</td>
<td>.330</td>
</tr>
<tr>
<td></td>
<td>Kurtosis</td>
<td>-.569</td>
<td>.650</td>
</tr>
<tr>
<td>1</td>
<td>Mean</td>
<td>26.12</td>
<td>.909</td>
</tr>
<tr>
<td></td>
<td>95% Confidence Interval for Mean</td>
<td>Lower bound</td>
<td>Upper bound</td>
</tr>
<tr>
<td></td>
<td>Median</td>
<td>27.00</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Variance</td>
<td>41.291</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Std. Deviation</td>
<td>6.426</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Minimum</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Maximum</td>
<td>36</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Range</td>
<td>25</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Interquartile Range</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Skewness</td>
<td>-.399</td>
<td>.337</td>
</tr>
<tr>
<td></td>
<td>Kurtosis</td>
<td>-.449</td>
<td>.662</td>
</tr>
</tbody>
</table>

*Note.* a active control group = 0, reference treatment group = 1

<table>
<thead>
<tr>
<th>Statistic</th>
<th>Statistic</th>
<th>Std. Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>HD #2 score</td>
<td>Mean</td>
<td>1.5245</td>
</tr>
<tr>
<td></td>
<td>Std. Error</td>
<td>.09923</td>
</tr>
<tr>
<td>95% Confidence Interval for Mean</td>
<td>Lower Bound</td>
<td>1.3277</td>
</tr>
<tr>
<td>Mean</td>
<td>Upper Bound</td>
<td>1.7214</td>
</tr>
<tr>
<td>Median</td>
<td>1.5000</td>
<td></td>
</tr>
<tr>
<td>Variance</td>
<td>1.004</td>
<td></td>
</tr>
<tr>
<td>Std. Deviation</td>
<td>1.00217</td>
<td></td>
</tr>
<tr>
<td>Minimum</td>
<td>.00</td>
<td></td>
</tr>
<tr>
<td>Maximum</td>
<td>5.00</td>
<td></td>
</tr>
<tr>
<td>Range</td>
<td>5.00</td>
<td></td>
</tr>
<tr>
<td>Interquartile Range</td>
<td>1.50</td>
<td></td>
</tr>
<tr>
<td>Skewness</td>
<td>.691</td>
<td></td>
</tr>
<tr>
<td>Kurtosis</td>
<td>.621</td>
<td></td>
</tr>
</tbody>
</table>

FIGURE 13. Histogram of HD #2 Score Frequency with Normal Distribution Overlay.
Statistical inspection. Statistically the skewness for HD #2 score (Table 15) revealed a moderate skew (skewness = .691, $SE = .239$) of the data in the positive direction. The $z$-score ($Z = -2.891, p = .002$) was significantly greater than the critical value of 1.96 indicating that the null hypothesis of no skewness was rejected. Kurtosis of .621 ($SE = .474$) supported the visual assessment of kurtosis. The kurtosis $z$-score ($Z = -1.310, ns$), less than the critical value of 1.96, indicated that the null hypothesis of no kurtosis failed to reject. The significant finding of the Shapiro-Wilk test of normality for HD #2 score $W(102) = .954, p = .001$ rejected the null hypothesis that the data were normally distributed and therefore deviated from normal (Table 17).
### TABLE 1. Test of Normality for HD #2 Score.

<table>
<thead>
<tr>
<th>Statistic</th>
<th>Shapiro-Wilk Statistic</th>
<th>Df</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>HD #2 score</td>
<td>.954</td>
<td>102</td>
<td>.001</td>
</tr>
</tbody>
</table>

**Outliers.** No outliers among the HD #2 score were identified. The Q-Q plot and boxplot graph of HD #2 score (Figures 14 & 15) suggested that outliers may have contributed to the HD #2 score deviation from normal. Using the outlier labeling rule (OLR) limits were established for HD #2 score observations by which outliers could be identified. From the 25th and 75th percentiles (Table 18) the values of the upper and lower limits were calculated (upper = 5.67 and lower = -2.67). When the OLR limits were compared to the extreme values found in the observed HD #2 score data (Table 19) no outliers were identified.

*FIGURE 15.* Boxplot of HD #2 Score.
TABLE 18. *HD #2 Score Percentiles.*

<table>
<thead>
<tr>
<th>Variable</th>
<th>5</th>
<th>10</th>
<th>25</th>
<th>50</th>
<th>75</th>
<th>90</th>
<th>95</th>
</tr>
</thead>
<tbody>
<tr>
<td>HD #2 score</td>
<td>.0000</td>
<td>.2500</td>
<td>.7500</td>
<td>1.5000</td>
<td>2.2500</td>
<td>2.7500</td>
<td>3.0000</td>
</tr>
</tbody>
</table>

TABLE 19. *Extreme Values for HD #2 Score.*

<table>
<thead>
<tr>
<th>Case Number</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Highest</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>54</td>
</tr>
<tr>
<td>2</td>
<td>84</td>
</tr>
<tr>
<td>3</td>
<td>94</td>
</tr>
<tr>
<td>4</td>
<td>14</td>
</tr>
<tr>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>Lowest</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>97</td>
</tr>
<tr>
<td>2</td>
<td>76</td>
</tr>
<tr>
<td>3</td>
<td>74</td>
</tr>
<tr>
<td>4</td>
<td>67</td>
</tr>
<tr>
<td>5</td>
<td>34</td>
</tr>
</tbody>
</table>

Note. ¹ Only a partial list of cases with the value 3.00 are shown in the table of upper extremes; ² Only a partial list of cases with the value .00 are shown in the table of lower extremes.

**EUS.** The EUS variable was composed of continuous data with a potential range of -36 to 36 and an observed range of 11 to 36. The parametric analysis of these data evaluated the difference of means between each experimental group that received the study intervention. Because of this, the EUS variable, factored on the variable groupnum (EUS₀ = active control; EUS₁ = reference treatment), was assessed for normality according to study group (Table 15). The data for EUS₀ and EUS₁ were visually and statistically assessed for normality. The results of those assessments, described below, indicated that the data were normally distributed.

*Visual inspection.* Visually, the EUS₀ and EUS₁ data were assessed using frequency histograms and Q-Q plots. The histograms (Figure 16 & 17) illustrated ceiling effects due to the maximum allowable response of 36. A negative skew was present in both histograms. The
normal Q-Q plots (Figures 18 & 19) suggested normal distribution with light negative tail for EUS\textsubscript{0} and a more pronounced negative tail for EUS\textsubscript{1}.

*Statistical inspection.* Statistically the skewness for EUS\textsubscript{0} (Table 15) indicated a small skew (skewness = -.310, SE = .330) of the data in the negative direction. The \( z \)-score (\( Z = -.939, ns \)), less than the critical value of 1.96, failed to reject the null hypothesis of no skewness. Kurtosis for EUS\textsubscript{0} of -.569 (SE = .650) supported the visual assessment of kurtosis. The kurtosis \( z \)-score for EUS\textsubscript{0} (\( Z = -.875, ns \)), less than the critical value of 1.96, failed to reject the null hypothesis of no kurtosis. The non-significant finding of the Shapiro-Wilk test of normality for EUS\textsubscript{0} \( W(52) = .974, ns \) failed to reject the null hypothesis that the data were normally distributed (Table 20).

The skewness for EUS\textsubscript{1} (Table 15) indicated a small to moderate skew (skewness = -.399, SE = .337) of the data in the negative direction. The \( z \)-score (\( Z = -1.184, ns \)), less than the critical value of 1.96, failed to reject the null hypothesis of no skewness. Kurtosis for EUS\textsubscript{1} of -.449 (SE = .662) supported the visual assessment of kurtosis. The kurtosis \( z \)-score for EUS\textsubscript{1} (\( Z = -.678, ns \)), less than the critical value of 1.96, failed to reject the null hypothesis of no kurtosis. The non-significant finding of the Shapiro-Wilk test of normality for EUS\textsubscript{1} \( W(50) = .968, ns \) failed to reject the null hypothesis that the data were normally distributed (Table 20).

<table>
<thead>
<tr>
<th>Groupnum</th>
<th>Statistic</th>
<th>Shapiro-Wilk df</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>EUS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>.974</td>
<td>52</td>
<td>.308</td>
</tr>
<tr>
<td>1</td>
<td>.968</td>
<td>50</td>
<td>.188</td>
</tr>
</tbody>
</table>
FIGURE 16. Histogram of EUS$_0$ with Normal Distribution Overlay.

FIGURE 17. Histogram of EUS$_1$ with Normal Distribution Overlay.
FIGURE 18. Normal Q-Q Plot of EUS$_0$.

FIGURE 19. Normal Q-Q Plot of EUS$_1$. 
Assumption of homogeneity of variance. Homogeneity of variance was tested using the Brown-Forsythe test.

**HD #2 score.** The variances for HD #2 score factored by Groupnum were equal $F(1, 100) = .347$, *ns* (Table 21).

**EUS.** The variances for EUS, factored by Groupnum, were not equal $F(1,100) = 4.297$, *p* = .041 (Table 21).

<table>
<thead>
<tr>
<th>Factor</th>
<th>Brown-Forsythe Statistic</th>
<th>df1</th>
<th>df2</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Groupnum HD #2 score</td>
<td>0.347</td>
<td>1</td>
<td>100</td>
<td>.558</td>
</tr>
<tr>
<td>EUS</td>
<td>4.297</td>
<td>1</td>
<td>100</td>
<td>.041</td>
</tr>
</tbody>
</table>

**Summary of assumptions of parametric data.** The scorecard of the assumptions of parametric data are presented in Table 22. The HD #2 score was found to deviate from a normal distribution and the variance of the EUS data was found to be heterogeneous. The data were transformed before applying parametric statistical tests.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Normality</th>
<th>Homogeneity of Variance</th>
<th>Interval</th>
<th>Independence</th>
</tr>
</thead>
<tbody>
<tr>
<td>HD #2 score</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>EUS</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>+</td>
</tr>
</tbody>
</table>

*Note.* + = null hypothesis not rejected or data meets criteria; - = null hypothesis rejected or data does not meet criteria

**Data Transformations**

The HD #2 score and EUS data were transformed in order to correct the normality and heterogeneity of variance deficiencies respectively.
**HD #2 score.** The HD #2 score data were transformed using the Box-Cox power transformation (Box & Cox, 1964; Sakia, 1992). The optimal lambda ($\lambda = 0.62626263$) value was found at the right most intersection of the lambda-by-log-likelihood curve with 95% of log-likelihood shown in Figure 20. Using this value of $\lambda$ a new variable, HDScoreTransformed, was computed given:

$$y_i^\lambda = (HD#2\, score)_i^{0.62626263}.$$ 

**FIGURE 20.** Log-likelihood by $\lambda$ for Box-Cox Power Transformation of HDScoreTransformed.

**EUS.** Due to the rejection of the null hypothesis of equal variance, $F(1,100) = 4.297, p = .041$, the data for EUS were transformed using the Box-Cox power transformation (Box & Cox, 1964). The optimal lambda ($\lambda = 2.45454545$) value was found at the right most intersection of the lambda-by-log-likelihood curve with 95% of log-likelihood shown in Figure 21. Using this value of $\lambda$ a new variable, EUSTransformed, was computed given:

$$y_i^\lambda = (HD#2\, score)_i^{2.45454545}.$$
FIGURE 21. Log-likelihood by $\lambda$ for Box-Cox Power Transformation of EUS.

**Parametric assumptions of transformed data.** The newly computed transformed variables HDScoreTransformed and EUSTransformed were assessed for normality and homogeneity of variance.

**HDScoreTransformed.** Descriptive statistics are summarized for HDScoreTransformed in Table 23.

TABLE 23. *Descriptive Summary of HDScoreTransformed Data.*

<table>
<thead>
<tr>
<th></th>
<th>Range</th>
<th>Min</th>
<th>Max</th>
<th>M</th>
<th>SD</th>
<th>Var</th>
<th>Skewness Stat</th>
<th>Kurtosis Stat</th>
</tr>
</thead>
<tbody>
<tr>
<td>HDScoreTransformed</td>
<td>2.74</td>
<td>0</td>
<td>2.74</td>
<td>1.2195</td>
<td>.57471</td>
<td>.330</td>
<td>-.136</td>
<td>-.126</td>
</tr>
</tbody>
</table>

*Normality.* The data for the newly computed variable HDScoreTransformed were visually and statistically assessed for normality. The results of those assessments, described below, revealed that the HDScoreTransformed data did not deviate from a normal distribution.

Visually, the HDScoreTransformed were assessed using a frequency histogram of HDScoreTransformed and a normal Q-Q plot. The histogram (Figure 22) illustrated a floor effect
due to the minimum allowable response of zero with a small negative skew and kurtosis. The normal Q-Q plot (Figure 23) suggested a slightly skewed distribution with a small negative kurtosis.

**FIGURE 22.** Histogram of HDScoreTransformed Frequency with Normal Distribution Overlay.

**FIGURE 23.** Normal Q-Q Plot HDScoreTransformed.
Statistically the skewness for HDScoreTransformed (Table 23) demonstrated a small negative skewness of -.136 ($SE = .239$). The $z$-score ($Z = -.569$, $ns$), less than the critical value of 1.96, indicated that the null hypothesis of no skewness was not rejected. The negative kurtosis -.126 ($SE = .474$) supported the visual assessment of kurtosis. The kurtosis $z$-score ($Z = -.266$, $ns$), less than the critical value of 1.96, indicated that the null hypothesis of no kurtosis was not rejected. The non-significant finding of the Shapiro-Wilk test of normality for HDScoreTransformed $W(102) = .979$, $ns$ failed to reject the null hypothesis that the data were normally distributed (Table 24).

**TABLE 24. Test of Normality HDScoreTransformed.**

<table>
<thead>
<tr>
<th>Statistic</th>
<th>Shapiro-Wilk Statistic</th>
<th>Df</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>HDScoreTransformed</td>
<td>.979</td>
<td>102</td>
<td>.104</td>
</tr>
</tbody>
</table>

*Homogeneity of variance.* The HDScoreTransformed data demonstrated homogeneity of variance. A Brown-Forsythe test was run to assess homogeneity of variance among the HDScoreTransformed data factored by Groupnum $F(1,100) = .285$, $ns$ (Table 25). The non-significant result failed to reject the null hypothesis of equal variance.

**TABLE 25. Brown-Forsythe Test for Homogeneity of Variance of HDScoreTransformed.**

<table>
<thead>
<tr>
<th>Factor</th>
<th>Brown-Forsythe Statistic</th>
<th>df1</th>
<th>df2</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Groupnum</td>
<td>HDScoreTransformed</td>
<td>.285</td>
<td>1</td>
<td>100</td>
</tr>
</tbody>
</table>

*EUSTransformed.* Descriptive statistics are summarized for EUSTransformed in Table 26.
TABLE 26. Descriptive Summary of EUSTransformed Data.

<table>
<thead>
<tr>
<th>Groupnum</th>
<th>Min</th>
<th>Max</th>
<th>M</th>
<th>SD</th>
<th>Var</th>
<th>Skewness Stat</th>
<th>SE</th>
<th>Kurtosis Stat</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>902.75</td>
<td>6607.17</td>
<td>3394.04</td>
<td>1384.15</td>
<td>1915868.24</td>
<td>.188</td>
<td>.330</td>
<td>-.719</td>
<td>.650</td>
</tr>
<tr>
<td>1</td>
<td>359.87</td>
<td>6607.17</td>
<td>3318.92</td>
<td>1757.88</td>
<td>3090142.54</td>
<td>-.266</td>
<td>.337</td>
<td>-.906</td>
<td>.662</td>
</tr>
</tbody>
</table>

Normality. The data for the newly computed variable EUSTransformed were visually and statistically assessed for normality. The results of those assessments, described below, indicated that the EUSTransformed data were statistically normal.

Visually, the EUSTransformed data, factored by groupnum (EUSTransformed$_0$ and EUSTransformed$_1$) were assessed using frequency histograms and Q-Q plots. The large grouping of data in the 4500 to 5000 range suggested that the data for EUSTransformed$_0$ may have been skewed in the positive direction (Figure 24). The histogram for EUSTransformed$_1$ (Figure 25) illustrated ceiling effects due to the maximum allowable response of 36 transformed to 7776. A slight negative skew appeared in the histogram for EUSTransformed$_1$. The normal Q-Q plots (Figures 26 & 27) suggested normal distribution with kurtosis in the extreme negative tail for EUSTransformed$_0$ and a more pronounced deflection of the negative tail for EUSTransformed$_1$. 
FIGURE 24. Histogram of EUS by Groupnum = 0 with Normal Distribution Overlay.

FIGURE 25. Histogram of EUS by Groupnum = 1 with Normal Distribution Overlay.
FIGURE 26. Normal Q-Q Plot of EUS by Groupnum = 0.

FIGURE 27. Normal Q-Q Plot of EUS by Groupnum = 1.
Statistically the skewness for EUSTransformed\(_0\) (Table 26) indicated a small positive skew (skewness = .188, \(SE = .330\)). The \(z\)-score (\(Z = .570, ns\)), less than the critical value of 1.96, failed to reject the null hypothesis of no skewness. Kurtosis of the EUSTransformed\(_0\) data, -.719 (\(SE = .650\)), supported the visual assessment of kurtosis in the extreme negative tail. The \(z\)-score (\(Z = -1.106, ns\)), less than the critical value of 1.96, failed to reject the null hypothesis of no kurtosis. The non-significant finding of the Shapiro-Wilk test of normality for EUSTransformed\(_0\) \(W(52) = .975, \ ns\) failed to reject the null hypothesis that the data were normal (Table 27).

The skewness for EUSTransformed\(_1\) (Table 26) indicated a small skew (skewness = -.266, \(SE = .337\)) of the data in the negative direction. The \(z\)-score (\(Z = -.789, ns\)), less than the critical value of 1.96, failed to reject the null hypothesis of no skewness. Kurtosis for EUSTransformed\(_1\) of -.906 (\(SE = .662\)) supported the visual assessment of kurtosis in the extreme negative tail. The \(z\)-score (\(Z = -1.369, ns\)), less than the critical value of 1.96, failed to reject the null hypothesis of no kurtosis. The non-significant finding of the Shapiro-Wilk test of normality for EUSTransformed\(_1\) \(W(50) = .961, \ ns\) failed to reject the null hypothesis that the data were normal (Table 27).

**TABLE 27. Test of Normality for EUSTransformed.**

<table>
<thead>
<tr>
<th>Groupnum</th>
<th>Statistic</th>
<th>df</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>EUSTransformed(_0)</td>
<td>.975</td>
<td>52</td>
<td>.332</td>
</tr>
<tr>
<td>1</td>
<td>.961</td>
<td>50</td>
<td>.101</td>
</tr>
</tbody>
</table>

*Homogeneity of variance.* The EUSTransformed data demonstrated homogeneity of variance. A Brown-Forsythe test was run to assess homogeneity of variance among the
EUSTransformed data factored by Groupnum $F(1,100) = 3.1818$, ns (Table 28). The non-significant result failed to reject the null hypothesis of equal variance.

**TABLE 28. Brown-Forsythe Test for Homogeneity of Variance of HDScoreTransformed.**

<table>
<thead>
<tr>
<th>Factor</th>
<th>Brown-Forsythe Statistic</th>
<th>df1</th>
<th>df2</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Groupnum</td>
<td>HDScoreTransformed</td>
<td>3.1818</td>
<td>1</td>
<td>100</td>
</tr>
</tbody>
</table>

**Research Aims**

Having assessed and corrected assumptions of normality, assumptions of homogeneity of variance, and the impact of covariance the hypotheses for each research aim were assessed according to the data analysis strategy described in Chapter 3.

**Aim One**

Examine adults' perception of nurse-expressed empathy from a SMRTR nurse as compared to a human nurse. The hypotheses for this research aim were:

$$H_0 : \mu_{AC} - \mu_{RT} \geq \delta$$

$$H_1 : \mu_{AC} - \mu_{RT} < \delta$$

An analysis of covariance (ANCOVA) was initially conducted to determine if covariates had an influence on the dependent variable EUS. Normalized methods were then employed to further estimate the confidence intervals used to evaluate non-inferiority of the reference treatment group to the active control group. Each method was applied to the transformed data EUSTransformed and the untransformed data EUS. The results of those analyses were similar. Because the untransformed data were more readily interpreted relative to the response range of
the EUS scale and the meta-analysis of the historical studies using the EUS scale the results of the analyses of the untransformed data were reported.

**Analysis of covariance.** An ANCOVA was run to determine the effect of the empathic understanding during a human-human or a human-robot interaction on participant’s perception of empathy after controlling for health distress and gender.

**Assumptions of ANCOVA.** A visual inspection of the regression lines on the scatterplot of the dependent variable EUS by HD #2 score suggested heterogeneity of regression slopes (Figure 28). The linear interpolation of the graph of EUS means by treatment (active control or reference treatment) suggested an interaction between gender and the mean EUS (Figure 29). Although the appearance of interactions in these graphs suggested a violation of the assumption of homogeneity of regression slopes statistical assessment of the interactions were not statistically significant. These results indicated that the assumption of homogeneity of regression slopes were not rejected. The interaction between treatment group and Gender was non-significant, $F(1, 97) = 3.245, p = .075$ (Table 29) and the interaction between treatment group and HD #2 score was non-significant, $F(1,97) = 1.025, p = .314$ (Table 30). Standardized residuals for the interventions within-group were normally distributed as assessed by Shapiro-Wilk's test ($p > .05$; Table 31). There was homoscedasticity and homogeneity of variances, as assessed by visual inspection of a scatterplot and a non-parametric Levene's test of homogeneity of variance ($p = .337$; Table 32), respectively. There were no outliers in the data; no cases with standardized residuals greater than ±3 standard deviations were present (1.76: -2.68).
FIGURE 28. Scatterplot of EUS by HD #2 Means Factored by Assigned Study Group.
FIGURE 29. Scatterplot of Mean EUS by Assigned Study Group Factored by Gender.

TABLE 29. GroupNum * Gender Interaction.

<table>
<thead>
<tr>
<th>Source</th>
<th>Type III Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corrected Model</td>
<td>125.778(^a)</td>
<td>4</td>
<td>31.445</td>
<td>.988</td>
<td>.418</td>
</tr>
<tr>
<td>Intercept</td>
<td>16921.872</td>
<td>1</td>
<td>16921.872</td>
<td>531.598</td>
<td>.000</td>
</tr>
<tr>
<td>GroupNum</td>
<td>104.760</td>
<td>1</td>
<td>104.760</td>
<td>3.291</td>
<td>.073</td>
</tr>
<tr>
<td>Gender</td>
<td>3.604</td>
<td>1</td>
<td>3.604</td>
<td>.113</td>
<td>.737</td>
</tr>
<tr>
<td>HD#2score</td>
<td>2.438</td>
<td>1</td>
<td>2.438</td>
<td>.077</td>
<td>.783</td>
</tr>
<tr>
<td>GroupNum * Gender</td>
<td>103.285</td>
<td>1</td>
<td>103.285</td>
<td>3.245</td>
<td>.075</td>
</tr>
<tr>
<td>Error</td>
<td>3087.712</td>
<td>97</td>
<td>31.832</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>74790.000</td>
<td>102</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corrected Total</td>
<td>3213.490</td>
<td>101</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\(^{a}\) R Squared = .039 (Adjusted R Squared = .000)
TABLE 30. *GroupNum * HD #2 Score Interaction.*

<table>
<thead>
<tr>
<th>Source</th>
<th>Type III Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corrected Model</td>
<td>55.856a</td>
<td>4</td>
<td>13.964</td>
<td>.429</td>
<td>.787</td>
</tr>
<tr>
<td>Intercept</td>
<td>16478.008</td>
<td>1</td>
<td>16478.008</td>
<td>506.191</td>
<td>.000</td>
</tr>
<tr>
<td>GroupNum</td>
<td>7.578</td>
<td>1</td>
<td>7.578</td>
<td>.233</td>
<td>.631</td>
</tr>
<tr>
<td>Gender</td>
<td>2.276</td>
<td>1</td>
<td>2.276</td>
<td>.070</td>
<td>.792</td>
</tr>
<tr>
<td>HD#2mean</td>
<td>10.692</td>
<td>1</td>
<td>10.692</td>
<td>.328</td>
<td>.568</td>
</tr>
<tr>
<td>GroupNum * HD#2score</td>
<td>33.363</td>
<td>1</td>
<td>33.363</td>
<td>1.025</td>
<td>.314</td>
</tr>
<tr>
<td>Error</td>
<td>3157.634</td>
<td>97</td>
<td>32.553</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>74790.000</td>
<td>102</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corrected Total</td>
<td>3213.490</td>
<td>101</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a. R Squared = .017 (Adjusted R Squared = -.023)

TABLE 31. *Normality of Standardized Residuals Within Groups.*

<table>
<thead>
<tr>
<th>GroupNum</th>
<th>Statistic</th>
<th>Shapiro-Wilk df</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Standardized Residual for EUS</td>
<td>0</td>
<td>.978</td>
<td>52</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>.969</td>
<td>50</td>
</tr>
</tbody>
</table>
FIGURE 30. Scatterplot Demonstrating Homoscedasticity of Standardized Residual for EUS by Predicted Value for EUS.

TABLE 32. Homogeneity of Variance of Ranked EUS.

<table>
<thead>
<tr>
<th>Levene Statistic</th>
<th>df1</th>
<th>df2</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>.931</td>
<td>1</td>
<td>100</td>
<td>.337</td>
</tr>
</tbody>
</table>

Results of ANCOVA. After adjustment for HD #2 score and gender, there was no statistically significant difference in EUS between the active control and reference treatment groups, $F(1,98) = .457, p = .501$, partial $\eta^2 = .005$ (Table 33).
Because the covariates of HD #2 score and Gender had no influence on the dependent variable EUS difference the normalized methods were used to establish the confidence intervals for assessing the non-inferiority of the reference treatment group to the active control group.

**Normalized methods.** Three methods were used to evaluate the non-inferiority of the reference treatment. The methods compared EUS means with underlying normal distributions and t-distributions. A summary of the results from each non-inferiority analysis method is found in Table 34.

**Method one.** The non-inferiority of the reference treatment group’s EUS scores to the active control’s EUS scores was analyzed using a modified two sample z-test using a normal distribution. While the average EUS score of 52 participants receiving the study intervention during a human-human interaction ($M = 26.85, SD = 4.80$) was slightly higher than the 50 participants receiving the study intervention during a human-robot interaction ($M = 26.12, SD = 6.43$) all the values of the 95% confidence interval ($CI_{95} : -1.4822, 2.9345$) were less than the non-inferiority margin of 3.33. The null hypothesis was rejected and non-inferiority was
concluded at the one-sided level of $a/2$ (.025) where the observed value of the $z$ statistic ($z = -2.31, p = 0.010$, one-sided) was less than $-z_{a/2}$ (1.96) and the $p$-value was less than $a/2$.

**Method two.** The non-inferiority of the reference treatment group’s EUS scores to the active control’s EUS scores was analyzed using the same modified two sample $z$-test used in method one but compared to a $t$-distribution using Satterthwaite degrees of freedom ($t_{a/2,v} = 1.99$). The values of the 95% confidence interval (CI$_{95}$: -1.4822, 2.9345) were all less than the non-inferiority margin of 3.33. The null hypothesis was rejected and non-inferiority was concluded at the one-sided level of $a/2$ (.025) where the observed value of the $z$ statistic ($z = -2.31, p = 0.012$, one-sided) was less than $-t_{a/2,v}$ (1.99) and the $p$-value was less than $a/2$.

**Method three.** The non-inferiority of the reference treatment group’s EUS scores to the active control’s EUS scores was analyzed using a modified two sample $t$-test using pooled estimate of variance and compared to a critical value of $-t_{a/2,nc+ne-2}$. The values of the 95% confidence interval (CI$_{95}$: -1.4968, 2.9491) were all less than the non-inferiority margin of 3.33. The null hypothesis was rejected and non-inferiority was concluded at the one-sided level of $a/2$ (.025) where the observed value of $t$ statistic ($t = -2.32, p = 0.011$, one-sided) was less than $-t_{a/2,nc+ne-2}$ (1.98) and the $p$-value was less than $a/2$.

**TABLE 34. Summary of One-sided $p$, 95% CI, Test Statistic and Critical Values.**

<table>
<thead>
<tr>
<th></th>
<th>Large Sample Normal</th>
<th>Satterthwaite ($v$)</th>
<th>Equal Variance</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>p-Value</strong></td>
<td>0.010</td>
<td>0.012</td>
<td>0.011</td>
</tr>
<tr>
<td><strong>95% CI</strong></td>
<td>(-1.4822, 2.9345)</td>
<td>(-1.5123, 2.9646)</td>
<td>(-1.4968, 2.9491)</td>
</tr>
<tr>
<td><strong>Test statistic</strong></td>
<td>$z = -2.311$</td>
<td>$z = -2.311$</td>
<td>$t = -2.324$</td>
</tr>
<tr>
<td><strong>Critical value$^1$</strong></td>
<td>$-z_{a/2} = 1.96$</td>
<td>$-t_{a/2,v} = 1.99$</td>
<td>$-t_{a/2,nc+ne-2} = 1.98$</td>
</tr>
</tbody>
</table>

*Note. $^1 a/2 = 0.025$*

**Aim Two**

Examine the relationship between adults’ perception of nurse-expressed empathy and level of health distress. The hypotheses for this research aim were:

\[ H_0 : \tau = 0 \]

\[ H_1 : \tau < 0 \]

The null hypothesis implied that there was no relationship between a participant’s health distress and their perception of empathy. The alternative hypothesis implied a negative relationship existed between the participant’s health distress and their perception of empathy.

A Kendall’s rank correlation was run to assess the relationship between the participant’s perception of nurse-expressed empathy and their level of health distress. Kendall’s rank correlation is non-parametric so no preliminary analyses of parametric assumptions were
warranted and the data found in the variables EUS and HD#2Score were used for the analysis. There was a small positive correlation between the participant’s perception of nurse-expressed empathy and health distress, \( \tau = .032 \). The correlation was non-significant, \( Z = 0.450, ns \). Having failed to reject the null hypothesis it was concluded that, for these data, there was no relationship between the participant’s perception of nurse-expressed empathy and health distress.

**Summary**

This chapter presented the results of the analyses of the data collected for this study. A description of the sample was followed by a description of the key study variables. Assumptions of parametric data were assessed to ensure that data used for parametric statistics were at least interval data conforming to normality, homogeneity of variance, and independence. The impact of stratified blocked randomization on the control of factors gender and health distress was assessed using ANCOVA. The hypotheses for each research aim were tested. The hypotheses of research aim one were tested using the \( z \) statistic, \( t \) statistic and confidence intervals using normal and \( t \) distributions. The hypotheses of relationship for research aim two were tested using Kendall’s rank correlation and the \( z \) statistic. In the case of research aim one the null hypothesis was rejected and it was concluded that the participant’s perception of nurse-expressed empathy when interacting with a robot nurse was no worse that when interacting with a human nurse. In the case of research aim two the null hypothesis failed to reject concluding that there was no relationship between the participant’s perception of nurse-expressed empathy and the participant’s level of health distress.
CHAPTER 5: DISCUSSION

Major Findings

**Research Aim One**

This research aim, the primary aim of the study, examined adults' perception of nurse-expressed empathy from a robot nurse compared to a human nurse. The one-sided null and alternate hypotheses for this research aim were:

\[
H_0 : \mu_{AC} - \mu_{RT} \geq \delta \\
H_1 : \mu_{AC} - \mu_{RT} < \delta
\]

The data were analyzed using a two confidence interval approach. The first confidence interval was obtained from historical studies using the same empathy measurement as was used in this study. This confidence interval was used to establish a non-inferiority margin to which a set of second confidence intervals, derived from the study data, were compared. The results of the ANCOVA were not significant so use of the confidence interval from the ANCOVA was not used. A set of three confidence intervals were obtained from three normalized methods comprised of Z and T statistics using critical values from normal and T distributions. In all comparisons the confidence intervals contained values less than the non-inferiority margin and the \( p \)-values were less than the one-sided significance level of \( \alpha = .025 \) resulting in the rejection of the null hypothesis. The rejection of the null hypothesis provides strong evidence that, in this rigorous study, nurse-expressed empathy may be communicated to adults by nurses operating semi-autonomous robots such as used in this study.

Although no studies have examined nursing presence from the perspective of adults interacting with semi-autonomous robots the literature suggested that technology, in general, was
not a barrier to the enactment of nursing presence. The findings of this research aim were similar to the findings of previous studies where known elements of nursing presence were observed with the use of technologies such as telephones, video-teleconferencing, and text messaging (Nilsson, Ohman, & Soderberg, 2006; Romero, Angelo, & Gonzalez, 2012; Sävenstedt et al., 2004; Tuxbury, 2013). A consistent theme, found in the literature and the results of this study, suggested that attributes of nursing presence transcended the underlying communication technologies irrespective of the simplicity or complexity of the technology. This apparent transcendence may be the result of the use of technology as a tool to facilitate, improve, and optimize the interaction and connection of humans with one another. This line of thought was supported by Kwak et al. (2013) where human subjects were more likely to empathize with a robot that was embodied with and operated by a human than with robots that operated autonomously and independent of a human connection.

Other aspects of human computer interaction, while not measured, were observed during the study. Sandelowski (2002) opined that the the illusion of presence mediated by technology should melt away leaving a perception of true and shared presence. In this study, anecdotal participant remarks such as “Although I did not expect it, I thought that I was interacting directly with Dennis [the researcher]. It was not until I evaluated his empathy that I remebered that he was on the robot instead of face-to-face.” and “[I] shared things that I have not shared with anyone else” suggested that the use of a remotely operated semi-autonomous robot was transparent resulting in a shared presence. Several participants expressed the feeling that they were talking directly to the researcher as opposed to the robot. These participants perceived the experience as transparent and genuine. These anecdotes were congruent with the observations of
studies where patient satisfaction and health outcomes were similar when using telemedicine technologies compared to face-to-face interventions (Flodgren, Rachas, Farmer, Inzitari, & Shepperd, 2015; Currell, 2000).

In summary, the weight of the literature strongly suggested the outcome of this research aim. The intersection of the literature resulted in basic understanding and principles of technology, empathy, and human-robotic interactions that ultimately informed the research design and aims of this study (Figure 32).

**FIGURE 32.** Intersection of Knowledge as it Related to Nurse-expressed Empathy with a Nursing Robot.

**Research Aim Two**

This secondary aim examined the relationship between adults’ perception of SMRTR or human nurse-expressed empathy and level of health distress. The hypotheses for the relationship between health distress and perceived empathy were:
The null hypothesis implied that there was no relationship between a participant’s health distress and their perception of empathy. The one-sided alternative hypothesis implied that a negative monotonic relationship existed between the participant’s health distress and their perception of nurse-expressed empathy. Research aim two hypothesized that as the participant’s perception of nurse-expressed empathy increased their health distress would decrease (Olson, 1995; Olson & Hanchett, 1997). The data were analyzed using a non-parametric Kendall’s rank correlation to assess the relationship between the participant’s perception of nurse-expressed empathy and their level of health distress. A non-significant result suggested that there was no relationship between the participant’s perception of nurse-expressed empathy and health distress. This result was contrary to the propositions of the middle range theory of Nurse-Expressed Empathy and Patient Distress (NEEPD; Olson & Hanchett, 1997). According to those propositions, the participant’s perception of nurse-expressed empathy should have been negatively related to the participant’s health distress. When the participant felt understood their distress and helplessness should have decreased. The findings of this study did not support this expected outcome based on the theory of NEEPD.

**Significance of Findings**

**Research Aim One**

The findings of the first research aim suggested that nurses can communicate empathy to adults while using a semi-autonomous robot. This conclusion was significant in terms of the methodological rigor and the pairing of robotic technology to nursing presence.
**Randomized non-inferiority comparison.** The findings related to this research aim were the result of a randomized non-inferiority experimental design. This research design distinguished this study from the previous qualitative studies investigating nursing presence with technology (Condon, 2013; du Mont, 2002; Eriksson & Salzmann-Erikson, 2013; Nagel, Pomerleau, & Penner, 2013; Nilsson, Ohman, & Soderberg, 2006; Romero, Angelo, & Gonzalez, 2012; Sävenstedt, Zingmark, & Sandman, 2004; Tuxbury, 2013).

Further strengthening the significance of the findings of this research aim was the presence of assay sensitivity in the experiment. The historical studies found empathic understanding to be effective and the appropriate conduct of the study was supported by the full compliance of participants, no losses to follow-up, and no missing data. With such assay sensitivity the conclusion that nurse-expressed empathy may be communicated to adults by nurses operating semi-autonomous robots was significantly strengthened.

It was significant that the sum of the sample sizes of the historical studies used to calculate the non-inferiority margin for this study was 5.8 times larger than the study’s sample size of N = 102. This significant attribute of this study will be useful for future studies that must demonstrate that they are independent of this study. It is difficult to achieve independency when studies derive the non-inferiority margin from the same or similar historical data (Tsong, Zhang, & Levenson, 2007). In order to reduce the correlation between studies to an acceptable level under 15% it has been recommended that the sample size of the historical studies be at least five times that of the non-inferiority study (Tsong, Zhang, & Levenson).

**Robots and nursing presence.** This study was among the first to investigate an attribute of nursing presence during a human-robotic interaction. Previous studies investigating robots in
nursing contexts focused on task-oriented and social behaviors (Bemelmans, Gelderblom, Jonker, & de Witte, 2015; Park, Hong, Kwon, & Chung, 2001; Pineau, Montemerlo, Pollack, Roy, & Thrun, 2003; Pollack et al., 2002; Spenko, Yu, & Dubowsky, 2006). In contrast, this study focused on affective and cognitive qualities of the nurse-patient relationship. This represented an important preliminary step to a deeper understanding of the advancements required for nursing presence to fully occur between a patient and a nursing robot (Carelli, Gaggioli, Pioggia, & De Rossi Riva, 2009; Röning, Holappa, Kellokumpu, Tikanmäki, & Pietikäinen, 2014).

**Research Aim Two**

The findings of the second research aim did not support the negative relationship between the participant’s perception of nurse-expressed empathy and health distress as predicted by NEEPD (Olson & Hanchett, 1997). This was a significant finding that suggested that the middle range theory of NEEPD may not apply to all nurse-patient populations and scenarios.

**Alternative Explanations of Findings**

**Research Aim One**

The participants of this study did not live in a technology vacuum. To varying degrees, each was exposed to other forms of technology including desktop computers, smartphones, computerized appliances, other robotic devices, and applications executing on those devices. Although not measured, participants likely possessed varying degrees of technological self-efficacy. The intersection of technology exposure and self-efficacy could have biased the participants’ perception of nurse-expressed empathy. For example, a participant who used computer video-teleconferencing software on a regular basis with good results might have found
the experience of communicating with a semi-autonomous robot no different than their typical use of video-teleconferencing. Anecdotally, a small number of participants expressed their reluctance to communicate with the SMRTR because of their self-expressed aversion to technology. Ironically, these participants’ BLRI scores were among the highest in the study.

The researcher was the sole recruiter, administrator, and interventionist in this study. Participants assigned to the reference treatment group had interacted with the researcher on two occasions, once during recruitment and then during initial participant processing just before the application of the intervention by the researcher embodied in the semi-autonomous robot. In most instances there was little time for the participant to distance themselves from the effect of the face-to-face encounter with the researcher for administrative reasons before interacting with the researcher embodied in the robot. The average length of time between the participant’s consent and the application of the intervention was less than two days ($M = 1.68, SD = 5.72$). It is possible that the residual effect of the face-to-face interaction before the intervention biased the participant’s perception of the empathy communicated by the researcher during the intervention. In an effort to minimize this effect all interactions with participants before application of the intervention were scripted (Appendix S).

**Research Aim Two**

There were significant differences between this study and the study from which the middle range theory of Nurse-Expressed Empathy and Patient Distress emerged (Olson & Hanchett, 1997). Design and methodological differences could have contributed to the opposing outcomes of the two studies. One difference between the two studies were the participant populations. In the study by Olson and Hanchett study the sample came from the population of
adult, acute medical-surgical in-patients as opposed to this study where the sample was selected from among the population of community dwelling adults with health concerns. Health distress was also measured using different instruments. This study used the Stanford Health Distress scale (Stanford, n.d.) whereas the Olson and Hanchett study inferred patient distress based on data from the Multiple Affect Adjective Check List and Profile of Mood States Inventory (Zukerman, 1969; Zukerman & Lubin, 1965). Given these significant differences it is unlikely that the findings for this research aim are meaningful.

**Implications for Nursing**

The primary research aim of this study has significant implications for nursing practice and research. The findings of this study are an early step in bridging the gap of knowledge about the use of robots in nursing practice. As robotic technology becomes more common in nursing it is imperative that nurses be involved in the feature specification and design process. Robot features and functionality will meet the needs of nurses and their patients only if there is sufficient nursing input to the specification and design of healthcare robots. Nursing scientists must take an active role in conducting innovative research that incorporates the nursing perspective into traditional robotic and artificial intelligence research. Integration and collaboration at this level will ensure that successive generations of autonomous robots will maintain a nursing perspective while operating at their optimal capacity.

**Study Limitations**

**Assay Sensitivity**

None of the historical studies used to establish the non-inferiority margin were placebo controlled. Although it was concluded in Chapter 3 that assay sensitivity was present in this
study it could be argued that the lack of placebo control among the historical studies casted doubt the effectiveness of face-to-face encounters in the communication of nurse-expressed empathy. However, numerous studies have supported the effectiveness of person centered therapy from which the measure used to evaluate nurse-expressed empathy emerged (Barrett-Lennard, 1962, 1981; Rogers, 1957, 1959; Sa’ad, Yusooff, Nen, & Subhi, 2014; Stiles, Barkham, Mellor-Clark, & Connell, 2008).

**Strength of Evidence**

The efficacy of the reference treatment, the delivery of empathy during a human-robot interaction, cannot be confirmed using the results of this study alone. In order to establish if the observed findings of this study were valid the study must be reproduced in similar and different settings (Rothmann, Weins, & Chan, 2012). A second active control study must be conducted and that study must be as independent of this study as possible (Tsong, Zhang, & Levenson, 2007).

**Bias**

“Blinding controls knowledge of allocation, and knowledge of allocation influences beliefs about allocation” (Mathieu, Herbert, McGeechan, Herbert, & Barrat, 2014, p. 671). This study was unblinded. This increased the likelihood of bias (Gluud, 2006). Given the design of this study it was not possible to blind participants to their group assignment due to the presence of the robot in the reference treatment and the human in the active control groups. In the context of this study, beliefs about allocation may have biased the participants’ perception of nurse-expressed empathy, participants’ self-reported outcomes of perceived empathy, and the researcher’s application of the intervention (Rees, Wade, Levy, Colford, & Hilton, 2005). This
may have resulted in performance bias. Anecdotally this was suggested as participants were heard to make unsolicited comments such as “talking with the robot was less judgmental,” “I tried hard to say the right things as if I were sitting with you [face-to-face],” “I hoped to talk to the robot,” and “I knew I wanted to talk to the robot.” The researcher’s own performance bias emerged near the end of data collection when the researcher began to believe that he was more effective in communicating empathy when interacting face-to-face with participants. It is important to note that it was not necessary that the beliefs were correct in order to produce bias (Mathieu, Herbert, McGeechan, Herbert, & Barrat, 2014).

The researcher functioned as data collector and statistician. Because of this these roles were not blinded to hypotheses, group assignment, and study data. As a data collector the researcher risked loss of objectivity while engaging in subtle behaviors that might influence participant responses (Page & Persch, 2013). This was consistent with the earlier observation that the researcher began to believe that he was more effective in communicating empathy during face-to-face interactions. As the study statistician, the researcher had a difficult time with objectivity. Unexpected results caused the researcher to question the data and spend time reviewing and validating the collected data. These role conflicts increased the likelihood of bias in this study (Gluud, 2006; Page & Persch).

**Threats to Internal Validity**

*Experimenter effect and bias.* As discussed above, the researcher began to believe that he was more effective in communicating empathy when interacting face-to-face with participants. This may have influenced his interactions with participants in the active control. During the initial processing of the participants the researcher briefly discussed, with all
participants, the purpose and future of robotics in healthcare. He may have unintentionally communicated his bias toward robotics during these discussions.

**Diffusion.** During the study there were times when two or more participants were in the same waiting room awaiting the intervention with the researcher. On one such occasion the researcher heard one participant say to the other “I hoped to talk to the robot” and “You are so lucky”. Participants in the active control engaged in such discussions may have attempted to outperform those in the reference treatment during the completion of the EUS.

**Subject effects.** Participants who were technologically progressive or conservative may have let their technology orientation influence their perception of nurse-expressed empathy. Those who were technologically progressive may have overstated their perception of nurse-expressed empathy because of their favorable attitude toward technology such as the SMRTR. Similarly, those participants who were technologically conservative may have underrated their perception of nurse-expressed empathy based on their somewhat negative opinion of technology.

**Suggestions for Further Research**

**Follow-up Active Control Trial**

A follow-up active control trial using the same or a similar population is vital to confirming this study’s results. The follow-up is necessary to further validate this study (Rothmann, Weins, & Chan, 2012).

**Examining Other Attributes of Nursing Presence**

Twelve attributes of nursing presence were identified in the review of the literature (Figure 3). Investigating these attributes in the context of a human-robot interaction would further the understanding of nursing presence relative to the use of robots in nursing. For
example, can reassurance be adequately communicated to adults while interacting with a nurse embodied in a semi-autonomous robot?

**Human Operation Relative to Technology Constraints**

During the course of the study’s human-robotic interactions several participants mentioned that the researcher failed to maintain eye contact with them. This was related to the position of the researcher’s computer camera relative to the computer screen. The researcher maintained eye contact with the participant’s image on the screen versus the lens of the camera which was effectively acting as the “eye” of the robot. This technology constraint, due to hardware configuration, illustrated research opportunities relative to configuration of the remote operator workstation, the overall quality of the equipment supporting the operation of the semi-autonomous robot, and even communication style (Briere, Boissy, & Michaud, 2009; Nestel et al., 2007; Sucher et al., 2011). It would be insightful to know if direct eye contact, a characteristic of communication, resulted in the same level of perceived empathy when interacting with a semi-autonomous robot. Future studies could examine the human operator’s use of interpersonal communication skills during the robotic-human interaction (Nestel et al.) to better understand if certain communication styles or attributes resulted in greater empathy than others. Quality of equipment, configuration, and communication style could also be explored in the context of other attributes of nursing presence as described above.

**Autonomous Robot**

Intuitively the outcome of the first research aim was expected. It was reasonable to expect that adults would perceive nurse-expressed empathy from a nurse whose face and voice were seen and heard on a semi-autonomous robot in much the same manner as they would when
talking with the nurse face-to-face. This result would not be nearly as intuitive if the robot were an autonomous robot that functioned independently of human operation. Would adults perceive autonomous robot-expressed empathy to be similar to human nurse-expressed empathy?

**Conclusion**

Empathy is a key attribute of nursing presence and of central importance to nursing (American Association of Colleges of Nursing [AACN], 2010; Carper, 1978). Nurse-expressed empathy is an effective nursing intervention. Empathy stimulates a nurse’s understanding of the patient experience (Gardner, 1988; Mohnkern, 1992). The perception of the patient’s experience, when accurate and shared verbally with the patient, enriches patient outcomes (Meleis, 2011; Olson & Hanchett, 1997; Orlando, 1961). Using a rigorous non-inferiority comparison, this study demonstrated that the perception of nurse-expressed empathy communicated to adults while using a semi-autonomous robot was not inferior to empathy communicated during face-to-face interactions. It is useful to reflect on this finding from the perspective of the preservation of the nursing perspective in robots as opposed to the mimicry of nursing by robots. Mimicry is an exercise in engineering. Preservation of nursing in robots requires insight, visionary innovation, collaboration, and perseverance on the part of nurse scientists and clinicians.
APPENDIX A:

PERMISSION TO REPRODUCE IMAGE
Erin Rapacki <erin@suitabletech.com>

Hi Dennis,

I'm happy to learn about your articles, please feel free to use the image!

Thanks,

Erin Rapacki
Director of Marketing

beam™

mobile: (650) 687-7193
erin@suitabletech.com
Join Mailing List

On Fri, Mar 14, 2014 at 1:33 PM, Dennis R. Crain <denniscr@email.arizona.edu> wrote:
Hello,

I would like your permission to use an image of your Beam Pro remote presence system in scholarly papers. I plan on using an image from your press kit. I would also like to add labels to image to identify the components of a MRPS. I have included an image demonstrating what I am hoping to do.

Are you willing to provide permission to use the image with modifications? Or do you have another image that meets my needs?

thanks much...Dennis

Dennis R. Crain
APPENDIX B:

BLRI EMPATHIC UNDERSTANDING SCALED – OTHER TO SELF
Barrett-Lennard Relationship Inventory: Form OS-Emp+

Developed by Godfrey T. Barrett-Lennard, PhD

Below are listed a variety of ways that one person may feel or behave in relation to another person.

Please consider each statement with reference to your present relationship with __________. Think of him or her ('seeing' their name in the blank spaces) as you answer each numbered statement.

Mark each statement with a number, out in the left margin, according to how strongly you feel that it is true, or not true, in this relationship. Answer each item as though it was by itself, not to agree with another answer. Please be sure to mark every one. Write in a minus number (−3, −2, or −1) when your answer is on the ‘no’ side, and a plus number (+1, +2, or +3) when your answer is a grade of ‘yes’. Here is the meaning of each answer number:

−3: I strongly feel that it is not true.
−2: No, I feel it is not true.
−1: (No) I feel that it is probably untrue, or more untrue than true.
+1: (Yes) I feel that it is probably true, or more true than untrue.
+2: Yes, I feel it is true.
+3: YES, I strongly feel that it is true.

1. ______ respects me.
2. ______ usually senses or realizes what I am feeling.
3. ______'s interest in me depends on how I present myself or perform.
4. ______ reacts to my words but does not see the way I feel.
5. I feel that _______ puts on a role or front with me.
6. ______ nearly always sees exactly what I mean.
7. ______ is friendly and warm toward me.
8. ______ appreciates just how the things I experience feel to me.
9. ______ finds me rather dull and uninteresting.
10. ______ does not understand me.
11. I feel that _______ is genuine with me.
12. ______',s own attitude toward things I do or say gets in the way of understanding me.
13. No matter what I say about myself, _______ likes (or dislikes) me just the same.
14. ______ realizes what I mean even when I have difficulty in saying it.
15. ______ expresses his/her true inner impressions and feelings with me.
16. ______ doesn't listen and pick up on what I think and feel.
17. ______ wants me to be a particular kind of person.
18. ______ usually understands the whole of what I mean.
19. Whether I express 'good' thoughts or 'bad' feelings/wishes (or would make) no difference to his/her attitude toward me. (Answer 'no' if this does make a difference to his/her attitude.)
20. ______ doesn't realize how sensitive I am about some of the things we discuss. (Answer with one of the 'no' ratings if you feel she is aware of your sensitivity.)
21. I feel that _______ does not like me.
22. _______'s response to me is so fixed and automatic that I don't get through to him/her.
23. I believe that ________ has feelings she doesn't tell me about that affect our relationship.
24. When I am hurting or upset ________, recognizes my painful feelings without becoming upset him/herself.

Please check that you answered every item. Thank you.

(Form adapted by Godfrey T. Barrett-Lennard, 2012)
APPENDIX C:

RELATED EMPATHY AND ROBOT STUDIES
### C1. RELATED EMPATHY AND ROBOT STUDIES

<table>
<thead>
<tr>
<th>Authors</th>
<th>Purpose</th>
<th>Design</th>
<th>Sample</th>
<th>Robot</th>
<th>Empathy</th>
<th>Conclusions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cramer, Goddijn, Wielinga &amp; Evers, (2010)</td>
<td>Examine the effects of emphatic robot behaviors on subjects’ attitudes toward a robot gaming teammate</td>
<td>Experimental factorial</td>
<td>N = 155 mean age 30.5, 53% male</td>
<td>Autonomous, non-anthropomorphic</td>
<td>Interaction effect between empathic accuracy and emotional valence</td>
<td>Inaccurate robot empathic behavior can negatively influence user attitudes toward and trust in robot. Reconsider introduction of empathic behaviors when likelihood of inappropriate inferences on user affect is high</td>
</tr>
<tr>
<td>Doori, Jooyun, Kyungmi &amp; Sukhan, (2013)</td>
<td>Examine the effect of the presence of robots in a social context</td>
<td>Experimental factorial</td>
<td>N = 37 College students 14 females, mean age 25.37, range 21-32 years</td>
<td>Autonomous, humanoid</td>
<td>Presence of robot companion is similar to human companion.</td>
<td>Subjects accepted the presence of the robot companion Subjects felt empathy with the laughing robot when they felt pleasant emotions.</td>
</tr>
<tr>
<td>Gonsior, Sosnowski, Mayer, Blume, Radig, Wollherr &amp; Kuhnlenz, (2011)</td>
<td>Explore subjects’ perception of empathy for robot based in its facial expressions and perceived subjective performance</td>
<td>Experimental factorial</td>
<td>N = 55 15 female, age range 21 to 60. Mean age 28.8</td>
<td>Simulated autonomous anthropomorphic and zoomorphic</td>
<td>Robot behavior during interaction influences empathy and perception of task performance by humans.</td>
<td>Approach for mirroring facial expressions should be influenced and refined by social factors. Mean ratings of empathy higher, in order, for SMM, mirror, and neutral. Empathy measure Cronbach's alpha = .82</td>
</tr>
<tr>
<td>Authors</td>
<td>Purpose</td>
<td>Design</td>
<td>Sample</td>
<td>Robot</td>
<td>Empathy</td>
<td>Conclusions</td>
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</tr>
<tr>
<td>Hayes, Ullman, Alexander, Bank &amp; Scassellati, (2014)</td>
<td>Examine the effect of empathy-generated robot dialogue on subject’s performance</td>
<td>Experimental factorial</td>
<td>N = 53 college students, 29 female</td>
<td>Autonomous non-anthropomorphic</td>
<td>Empathetic or antipathetic applied as classification based on survey</td>
<td>Effect of petitions from robots on human perceptions and actions can be used to build tools that allow for increased precision in human-robot interaction</td>
</tr>
<tr>
<td>Hofree, Ruvolo, Bartlett &amp; Winkielman, (2014)</td>
<td>Demonstrate subjects spontaneous mimicry of physically present humanlike android robot</td>
<td>Quasi experimental</td>
<td>N = 23 college students, 9 female</td>
<td>Simulated autonomous humanoid</td>
<td>Nearly all subjects demonstrated mimicry, a predictor of empathy (Morgan, Harrison &amp; Critchley, 2010)</td>
<td>Rudimentary connection between humans and robots is conceivable. Mimicry should be used to create more meaningful HRI</td>
</tr>
<tr>
<td>Kim, Kwak &amp; Kwak, (2009)</td>
<td>Examine how methods for emotional expression influence the degree of empathy with a robot.</td>
<td>Experimental factorial</td>
<td>N = 16 college students, 10 females, Age = 10 years</td>
<td>Autonomous non-anthropomorphic</td>
<td>Humans can empathize with a robot when the robot expresses emotions through the use of bruise colors and speech</td>
<td>Humans empathize a robot when it expresses its emotional state by means of bruised color and/or speech Males and females empathize equally with an emotional expressing robot</td>
</tr>
<tr>
<td>Kwak, Kim, Kim, Shin &amp; Cho, (2013)</td>
<td>Examine the effect of robot agency and physical embodiment on human empathy toward robot</td>
<td>Quasi experimental</td>
<td>N = 30 children, age range 10 to 12 years</td>
<td>Non anthropomorphic Autonomous and semi-autonomous</td>
<td>Humans empathized more toward a physically embodied robot mediated by a remote operator than the reverse</td>
<td>The effect of mediation and physical embodiment on human empathy toward robots should inform the design of emotional robots</td>
</tr>
<tr>
<td>Marti, Iacono, Tittarelli &amp; Stienstra, (2013)</td>
<td>Evaluate a dynamic expressive mask to control an assistive robot</td>
<td>Descriptive</td>
<td>N = 60 college students, 27 female, age range 18 to 70</td>
<td>Simulated non anthropomorphic autonomous</td>
<td>Use of an empathic mask had a positive impact on the subject’s empathic concern for robot and facilitated the comprehension of different scenarios</td>
<td>When robot’s behavior conforms to human social expectations, human-robot interactions are more likely to be found enjoyable and meaningful</td>
</tr>
<tr>
<td>Authors</td>
<td>Purpose</td>
<td>Design</td>
<td>Sample</td>
<td>Robot</td>
<td>Empathy</td>
<td>Conclusions</td>
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<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Mazzei et al., (2011)</td>
<td>Evaluate the capability of android guided therapy to convey emotions and empathy to ASD subjects</td>
<td>Exploratory</td>
<td>N = 6 males, 4 with ASD. Age 15-22 years</td>
<td>Autonomous humanoid</td>
<td>No analysis conducted.</td>
<td>The HRI assessment platform may well serve therapeutic approaches to ASD in the future</td>
</tr>
<tr>
<td>Miura et al., (2008)</td>
<td>Evaluate the effect of robotic embodiment on human-robot interaction</td>
<td>Experimental factorial</td>
<td>N = 39 12 female, age range 19 to 54 years, mean age 24, right handed (due to focus on left orbitofrontal gyrus)</td>
<td>Simulated autonomous anthropomorphic (bipedal and wheeled)</td>
<td>Bipedal anthropomorphic robot, performing emotionally positive actions, induced the activation of the brain's left orbitofrontal gyrus which is associated with emotional empathy</td>
<td>Humans empathize with a bipedal anthropomorphic robot based on the simulation of human-like body movements.</td>
</tr>
<tr>
<td>Riek, Rabinowitch, Chakrabarti &amp; Robinson, (2009)</td>
<td>Examine how people empathize with robots along the anthropomorphic spectrum</td>
<td>Quasi experiment</td>
<td>N = 120 80 female, age range 18 to 76 years, mean age 29.4</td>
<td>Simulated autonomous mechanical, android, and humanoid</td>
<td>The more human looking a robot the stronger subjects will empathize with it. A person’s ability to empathize (EQ) has no predictive value for expressing empathy toward robots</td>
<td>Findings inform the human likeness debate among robot designers Potential biases that users have in terms of their empathetic outlook toward the robot should inform design of social robots</td>
</tr>
<tr>
<td>Authors</td>
<td>Purpose</td>
<td>Design</td>
<td>Sample</td>
<td>Robot</td>
<td>Empathy</td>
<td>Conclusions</td>
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<td>-------------------------------------------------------------------------------------------------</td>
<td>-----------------------------------------------------------------------------------------------</td>
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</tr>
<tr>
<td>Urgen, Plank, Ishiguro, Poizner, &amp; Saygin (2013)</td>
<td>Explored human brain activity evoked by humans and robots</td>
<td>Descriptive</td>
<td>N = 12 right-handed college students (3 female) mean age 23.4. All college students</td>
<td>Autonomous anthropomorphic and humanoid</td>
<td>Similar mu oscillations in all three conditions</td>
<td>Actions taken by a humanoid robot evoke the MNS in a manner similar to actions taken by humans.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Significant increase in power of theta oscillations associated with observation of robot compared to human agent</td>
<td>Processing of the robot agent resulted in greater demands on memory system compared to human agent</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Sufficiently humanlike robots facilitate access to semantic representations pertaining to the seen stimuli</td>
</tr>
</tbody>
</table>
APPENDIX D:

HEALTH DISTRESS SCALE
Health Distress

These questions are about how you feel and how things have been with you during the past month. For each question, please circle the one number that comes closest to the way you have been feeling.

How much time during the past month...

<table>
<thead>
<tr>
<th></th>
<th>None of the time</th>
<th>A little of the time</th>
<th>Some of the time</th>
<th>A good bit of the time</th>
<th>Most of the time</th>
<th>All of the time</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Were you discouraged by your health problems?</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>2. Were you fearful about your future health?</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>3. Was your health a worry in your life?</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>4. Were you frustrated by your health problems?</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

Scoring

Score each item as the number circled. If two consecutive numbers are circled, score the higher (more distress) number. If the numbers are not consecutive, do not score the item. The scale score is the mean of the four items. If more than 1 item missing, set the value of the scale to missing. Scores range from 0-5; higher score indicating more distress about health.

Characteristics

Tested on 1,130 subjects with chronic disease. N=51 for test-retest.

<table>
<thead>
<tr>
<th>No. of items</th>
<th>Observed Range</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Internal Consistency Reliability</th>
<th>Test-Retest Reliability</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>0-5</td>
<td>2.04</td>
<td>1.16</td>
<td>.87</td>
<td>.87</td>
</tr>
</tbody>
</table>
Source of Psychometric Data


Comments

This is a modified version of the MOS health distress scale. We use 4 of the original 6 items, and changed the wording slightly. If possible items should be scrambled among other items using the same response categories, if possible (e.g., Energy/Fatigue scale). Because of the problems we have had using scales to measure negative emotion (e.g., depression) across cultures, we have substituted this scale. While it is not a depression or an anxiety scale, it does give us a good idea of distress caused by illness. It correlates .61 with the MOS depressive symptoms scale and .63 with the CES-D scale. Reprinted with permission, Duke University Press. This scale available in Spanish.

References


This scale is free to use without permission

Stanford Patient Education Research Center
1000 Welch Road, Suite 204
Palo Alto CA 94304
(650) 723-7935
(650) 725-9422 Fax
self-management@stanford.edu
http://patienteducation.stanford.edu

Funded by the National Institute of Nursing Research (NIHR)
APPENDIX E:

R SCRIPT FOR CREATING STRATIFIED AND BLOCKED RANDOMIZATION SCHEDULE
R script for stratified randomization schedule of the study

## NON-INFERIORITY RANDOMIZED TRIAL OF ADULT’S PERCEPTION OF EMPATHY
## WHEN INTERACTING WITH A NURSING ROBOT COMPARED TO A PHYSICALLY
## PRESENT NURSE
##
## Dennis Crain, March 2015
##
## stratified by gender & health distress, n = 100 in each stratum, 2 treatments, minimum block
## size = 2, maximum block size = 4

#stratum for male with HD score >= population HD mean
male.HDGTE <- blockrand(n=100, id.prefix='M-HDGTE-', block.size = 1:2, block.prefix='M.HD >= 2.04', levels = LETTERS[1:2], stratum='Male-HD >= 2.04')

#stratum for male with HD score < population HD mean
male.HDLT <- blockrand(n=100, id.prefix='M-HDLT-', block.size = 1:2, block.prefix='M.HD < 2.04', levels = LETTERS[1:2], stratum='Male-HD < 2.04')

#stratum for female with HD score >= population HD mean
female.HDGTE <- blockrand(n=100, id.prefix='F-HDGTE-', block.size = 1:2, block.prefix='F. >= 2.04', levels = LETTERS[1:2], stratum='Female-HD >= 2.04')

#stratum for male with HD score < population HD mean
female.HDLT <- blockrand(n=100, id.prefix='F-HDLT-', block.size = 1:2, block.prefix='F.HD < 2.04', levels = LETTERS[1:2], stratum='Female-HD < 2.04')

#bind all stratum into strata
my.study <- rbind(male.HDGTE, male.HDLT, female.HDGTE, female.HDLT)

##write to pdf file as cards to be given participants
plotblockrand(my.study,'mystudy.pdf',
    top=list(text=c('Empathy & Robots: CRAIN-NI-RCT','Patient: %ID%','Treatment: %TREAT%'),
        col=c('black','black','red'),font=c(1,1,4)),
    middle=list(text=c("Empathy & Robots Study","Strata: %STRAT%","Patient: %ID%"),
        col=c('black','blue','green'),font=c(1,2,3)),
    bottom="Email denniscr@email.arizona.edu if you have questions",cut.marks=TRUE)
APPENDIX F:

RANDOMIZATION SCHEDULE FOR MALES WITH HEALTH DISTRESS SCORE
GREATER THAN OR EQUAL TO MEAN
<table>
<thead>
<tr>
<th>Participant ID</th>
<th>Stratum</th>
<th>Block ID</th>
<th>Block Size</th>
<th>Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>M-HDGTE-001</td>
<td>Male-HD &gt;= M</td>
<td>M.HD &gt;= M-01</td>
<td>2</td>
<td>A</td>
</tr>
<tr>
<td>M-HDGTE-002</td>
<td>Male-HD &gt;= M</td>
<td>M.HD &gt;= M-01</td>
<td>2</td>
<td>B</td>
</tr>
<tr>
<td>M-HDGTE-003</td>
<td>Male-HD &gt;= M</td>
<td>M.HD &gt;= M-02</td>
<td>2</td>
<td>A</td>
</tr>
<tr>
<td>M-HDGTE-004</td>
<td>Male-HD &gt;= M</td>
<td>M.HD &gt;= M-02</td>
<td>2</td>
<td>B</td>
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APPENDIX G:
RANDOMIZATION SCHEDULE FOR MALES WITH HEALTH DISTRESS SCORE LESS THAN MEAN
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APPENDIX H:

RANDOMIZATION SCHEDULE FOR FEMALES WITH HEALTH DISTRESS SCORE
GREATER THAN OR EQUAL TO MEAN
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APPENDIX I:

RANDOMIZATION SCHEDULE FOR FEMALES WITH HEALTH DISTRESS SCORE LESS THAN MEAN
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APPENDIX J:

PERMISSION TO USE OFFICE SPACE
Hi Jim,
I have a good friend, Dennis Crain, working on his dissertation and research project for his Ph.D. in Nursing. Part of his research includes interviewing subjects (1/2 face to face and 1/2 using a robotic system (similar to skype). I'm willing to let him use my office on the days I am not in it and he will schedule subjects to be interviewed for 1/2 hour or so at a time. I'm wondering, though, first of all if you are okay with him doing it here. I want your clearance first, of course. And secondly, he would like to have an assistant meet the subjects down on the first floor and bring them upstairs. Would you be okay if she sat at the desk to greet the subjects? He has a fairly small number of subjects he will be interviewing over the course of 1-2 months. He will also be approved to do this research through the University of Arizona.

Would you be okay with this? If you want to talk more about it or have more questions, please feel free to call me.

--

Shellee xxxxxx MA LMHCA
Licensed Mental Health Counselor Associate

Re:

Shellee
Good to hear. Yes, he can use your office.
Using the front desk is ok for short periods, as we have others that are thinking to use it also.
I don't know how long this is planned. For use or how often, ok till we see a conflict.
Have a Great Day
Jim J xxxxxxxx via Windows8 ph
APPENDIX K:

TEMPLATE FOR REQUESTING PERMISSION TO RECRUIT AT COMMUNITY EVENT
Dear Insert contact name,

I am a PhD candidate at the University of Arizona, College of Nursing. I am conducting my PhD dissertation research here in the Pacific Northwest. My study investigates people's perception of healthcare provider's empathy when technology comes between a person and their healthcare provider. My target population is people in the community as opposed to acutely ill folks in the hospital. I am beginning to recruit participants. I would like to recruit at community events that are well attended by a broad cross section of community members. The **insert community event name** is one such event for which I am hoping that I might be permitted to recruit participants.

The recruitment process would involve setting up a table in a location designated by your event planners. Ideally, this would be a location with potential for a large number of attendees passing by. At that table I would have brochures describing the research. Next to the table there would be a 24” x 36” poster also describing the research. The poster is branded "University of Arizona College of Nursing". If potential participants agree to participate in the study I will seek their informed consent and then screen their visual and hearing ability and have them take a short four question scale where they would indicate their level of health distress (e.g. Are you frustrated by your health problems?). I would then schedule the participant for a one hour interview during June 1 to August 14, 2014.

This study is approved by the University of Arizona's Institutional Review Board which requires very strict protection of human subjects by taking steps to ensure confidentiality and privacy. Just to clarify, I am only telling people about the study and seeing if they wish to participate. The actual study happens at a later scheduled time.

If you are interested in this please let me know. I am happy to provide you with more information.

Best regards,
Dennis

---

*Dennis R. Crain*

**College of Nursing**

1305 N. Martin Avenue
PO Box 210203
Tucson, AZ 85721-0203
TEL: [520.626.6152](tel:5206266152)
FAX: [520.626.2569](tel:5206262569)
APPENDIX L:

STUDY RECRUITMENT POSTER
RESEARCH STUDY OPPORTUNITY

ROBOT EMPATHY—DOES IT EXIST?

WHEN
June 1st to August 14th, 2015
60 minute appointment

WHERE
8490 Mukilteo Speedway
Suite 202
Mukilteo, WA 98275

HTTP://NURSING.ARIZONA.EDU

ADULTS
AGE 21 TO 80
MALE/FEMALE

STUDY COMPENSATION
WILL BE PROVIDED

TIME COMMITMENT
No more than 60 minutes

SAFE & CONFIDENTIAL
- Approved by University of Arizona IRB
- All personal data secured and confidential
APPENDIX M:

STUDY BROCHURE - FRONT AND BACK
Join Our Research Study

Have you ever wondered what the future of healthcare will look like as the use of healthcare technology increases?

As a participant in this study you will have an opportunity to help define that future.

University of Arizona, College of Nursing

Study Location
SWM Health Sciences Building 657
Minneapolis, W 55405

Investigator — Denise Cruse, PhD Candidate
Phone: 612-289-5115
E-mail: dcruse@umn.edu

Healthcare, Empathy, & Technology Research Study

Empathy — the ability to understand and share the feelings of another

Research exploring robots in healthcare
The Research

The patient-nurse relationship is an important one. It has been demonstrated that when patients and nurses have a professional, positive, and useful relationship that your health outcomes improve. As technology begins to play an increasing role in healthcare, nurses need to understand how the patient-nurse relationship can be established and maintained in those situations where technology separates the nurse from the patient.

The purpose of this research study is to compare your perception of the nurse’s empathy toward you when discussing your health with a nurse face-to-face or when using technology.

Eligibility

- There is something about your health and wellness that concerns you or you wish to improve.
- You are aged 21 to 80.
- You speak and read the English language.
- Your hearing and vision are adequate for participating in the study.
- You are willing to discuss your health and how it impacts your daily life.

Benefits

- You will receive compensation for participating in the study.
- You will help provide insight to the relationship between people and technology that will influence the design of future healthcare technologies.

Time Commitment

If you choose to participate you will be scheduled for a one hour appointment between June 1 and August 14. During this time you will spend 15 minutes talking with the study investigator and up to 45 minutes completing two short surveys that assess your perception of the nurse’s empathy toward you and any distress that you may have regarding your health.

Confidentiality

Information that identifies you will not be reported in this study. If you agree to participate you will be assigned a participant identification number (PID).

This study is approved by the Institutional Review Board of the University of Arizona.
APPENDIX N:

SCREENING CHECKLIST
Screening Checklist (Circle response)

Participant
First name ______________________
Last name initial ______________________

Age appropriate?
1. Yes
2. No

Reported health concern or issue?
1. Yes
2. No

Responded correctly to recorded voice from 10 feet?
1. Yes
2. No

Correctly identified content of three photos from 10 feet?
1. Yes
2. No
APPENDIX O:

IMAGES USED FOR SCREENING POTENTIAL PARTICIPANT’S VISUAL ABILITY
APPENDIX P:

DEMOGRAPHIC SURVEY
Demographic Survey

Participant ID _________________________________

Instructions: Fill in the blank or check the box that applies to you

Q. Gender
What is your sex?

☐ Male
☐ Female

Q. Age
What is your age? _____ (in years)

Q. Marital Status
What is your marital status?

☐ Now married
☐ Widowed
☐ Divorced
☐ Separated
☐ Never married

Q. Education
Please circle the highest year of school completed

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23+

(primary) (high school) (college/university) (graduate school)
Q. Race
*Please specify your race.*

☐ American Indian or Alaska Native
☐ Asian
☐ Black or African American
☐ Hispanic or Latino
☐ Native Hawaiian or Other Pacific Islander
☐ White

Q. Health Rating
*In general how would you rate your health today?*

☐ Very good
☐ Good
☐ Moderate
☐ Bad
☐ Very bad
APPENDIX Q:

STUDY APPOINTMENT CARD
Dennis Crain, MN
Phone: 425-239-3115
E-mail: denniscr@email.arizona.edu

APPOINTMENT

ROBOT EMPATHY RESEARCH STUDY

Date:

Time:

Location: 8490 Mukilteo Speedway, Suite 202
Mukilteo, WA 98275
APPENDIX R:

BLRI EMPATHIC UNDERSTANDING SCALED – MYSELF TO OTHER
Barrett-Lennard Relationship Inventory: Form MO-Emp+
Developed by Godfrey T. Barrett-Lennard, PhD

Below are listed a variety of ways that one person may feel or behave in relation to another person. Please consider each statement with reference to your present relationship with [add first name]. Think of him or her ("seeing" their name in the blank spaces) as you answer each numbered statement.

Mark each statement in the left margin, according to how strongly you feel that it is true, or not true, in this relationship. Answer each item as though it was by itself, not to agree with another answer. Be sure to mark every one. Write in a negative number (-3, -2, or -1) when your answer is on the "no" side, and a positive number (+1, +2, or +3) when your answer is a grade of "yes." Here is the meaning of each answer number:

-3: NO, I strongly feel that it is not true.
-2: No, I feel it is not true.
-1: (No) I feel that it is probably untrue, or more untrue than true.
+1: (Yes) I feel that it is probably true, or more true than untrue.
+2: Yes, I feel it is true.
+3: YES, I strongly feel that it is true.

1. I respect ________ as a person.
2. I usually sense and realize how ________ is feeling.
3. My interest in ________ depends on his/her actions and performance.
4. I can hear or react to ________'s words without sensing the way s/he feels inside.
5. I tend to put on a role or front with ________.
6. I nearly always can see exactly what ________ means.
7. I feel friendly and warm toward ________.
8. I appreciate just how ________'s experiences feel to her/him.
9. I find ________ rather dull and uninteresting.
10. I really don't understand ________.
11. I feel genuinely myself with ________.
12. My own feelings or attitude get in the way of understanding ________.
13. My liking or disliking of ________ isn't changed by anything s/he says about her/himself. (Answer on the 'no' side if your feeling does change.)
14. I can tell what ________ means even when he/she has difficulty saying it.
15. I can express my true inner impressions and feeling with ________.
16. I don't (or can't) listen well to ________, and pick up on what s/he feels and thinks.
17. I would prefer ________, to be a different or particular kind of person.
18. I usually catch and understand the whole of what ________ means.
19. Whether ________ is expressing "good" thoughts or "bad" feelings or desires makes no difference to my attitude toward him/her.
20. I don't realize how sensitive or touchy ________ is about some of the things we discuss.
21. I don't like ________.
22. I often respond to ________ rather automatically, not taking in what s/he is thinking or feeling.
23. I feel there are things I/we don't talk about that are affecting our relationship.
24. When ________ is hurting or upset I can recognize his/her pain without it becoming my pain so that I feel hurt and upset. [Answer "no" if his/her pain triggers your own upsetting pain.]

Please check that you answered every item. Thank you.

(Form adapted by Godfrey T. Barrett-Lennard, November 2012.)
APPENDIX S:

INTERVENTION MANUAL
1. Overview

1.1. Name of intervention: Empathic engagement between nurse and patient delivered in human-human interaction or human-robot interaction.

1.2. Definition of terms

1.2.1. Semi-autonomous mobile remote telepresence robot (SMRTR): a mobile telecommunications robot that is placed in a setting that is remote to the human operator. The human operator controls the robot through the use of a computer software interface that permits the SMRTR to freely roam, virtually, in a remote location while interacting with those physically present at the remote location.

1.2.2. Human-human interaction (HHI): the researcher discusses a participant’s health issues and concerns physically face-to-face.

1.2.3. Human-robot interaction (HRI): the researcher discusses a participant’s health issues and concerns while embodied in and operating the SMRTR.

1.2.4. Empathic engagement: a conversation between the researcher and the participant during which time the participant’s health issues, and concerns are discussed. The researcher, trained in empathic techniques, responds to the participant’s conversation with empathic understanding.

1.3. Goals

1.3.1. Overall goal
1.3.1.1. Demonstrate that a participant’s perception of the nurse’s empathy toward them, when the nurse is embodied in a SMRTR, is no worse than when the nurse is interacting with the participant face-to-face.

1.3.2. **Immediate goals**

1.3.2.1. Empathetically respond to participant during a conversation of their health issues, and concerns.

**1.4. Components and Activities**

1.4.1. Component 1: SMRTR orientation

1.4.1.1. Goal: Participants receiving empathic engagement using HRI will become acquainted with and oriented to the nurse embodied in SMRTR.

1.4.1.2. Activities: At the beginning of the discussion session, using the SMRTR, the researcher will introduce himself and establish guidelines for the interaction e.g. communication and visualization, and engage in a short conversation designed to demonstrate the communication style to the patient.

1.4.2. Component 2: Discussion of health issues and concerns

1.4.2.1. Goal: Engage in a discussion where the participant is permitted to discuss their current health and its impact on their daily activities.

1.4.2.2. Activities: As the participant discusses their health issues and impact on their lives the researcher will respond empathically being sure to put himself in the patient’s position and engage in sensitive reflection of what is communicated by the participant.

**1.5. Mode of Delivery**
1.5.1. One-on-one interaction between researcher and participant

1.5.1.1.1. HHI: Researcher and participant physically situated in room face-to-face

1.5.1.1.2. HRI: Researcher is embodied in SMRTR. SMRTR is physically situated in room with participant.

1.5.2. Discussion format

1.5.2.1. First, the researcher assures participant of confidentiality of conversation. After this the researcher introduces the topic of discussion, the participant’s health status, health concerns, and health goals. The researcher tunes into the participant and follows their discussion while attempting to become absorbed in whatever the participant is expressing and exploring. Ideally, all responses by the researcher are empathic responses.

1.6. Dose

1.6.1. One observation

1.6.1.1. 10 minutes for introduction

1.6.1.2. 15 minutes for empathic engagement

1.6.1.3. 20 minutes for completion of EUS & HD

2. Human and Material Resources

2.1. Environment

2.1.1. Location
2.1.1.1. The study requires a professional office setting that is configured with a central receptionist area. Participants enter the building and are immediately engaged by the researcher in the receptionist role.

2.1.2. Receptionist role

2.1.2.1. The receptionist role is filled by the researcher. The receptionist will greet participant and take them to the office where the intervention takes place.

2.1.3. Private office

2.1.3.1. A medium sized private office in a professional setting with two opposing chairs and space for the SMRTR. The chairs (or chair and couch) should be at least four feet apart. For privacy there must be a closeable door.

2.2. Equipment

2.2.1. The SMRTR with charging station is required for HRI.

3. Procedure

3.1. Introduction

3.1.1. Script

“Introduction: Hi, [participant name] I am Dennis Crain. Thanks for agreeing to take part in this study. As I mentioned when I enrolled you in the study, I am a doctoral student at the University of Arizona College of Nursing. Tell me a bit about yourself.”

[pause and listen]

“Today I would like to talk with you about your health.”

3.1.2. Introduce the treatment by reading the following script
3.1.2.1.1. Script

“Before we begin our discussion I want to let you know that what we will discuss today is strictly confidential. It stays between you and me. I will not discuss what we talked about to anyone but you. Are you comfortable with that? Do you have any questions?”

[Pause for questions]

3.1.2.1.2. Script

“This study is intended to explore your perception of my empathy toward you as you tell me about your health concerns. While you and I are having this conversation [face-to-face/using this robot] there are others in the study who will have a similar conversation [using a robot/face-to-face]. The reason I am investigating this is to try to understand how technology impacts the human to human connection that usually occurs when two people are sitting face-to-face having a conversation such as this. My only expectation of you today is that you will feel free to openly discuss your health. Please note that I will not be able to advise you on your health. For that advice you will need to find some time to talk to your healthcare provider. We will talk for 15 minutes. Once we have concluded our conversation I will ask you to complete two surveys composed of 24 and 4 multiple choice questions respectively. That should take no more than 15 minutes to complete. After you are done return the surveys to me.”
3.2. Main part

3.2.1. Script

“Let’s begin. When I enrolled you in the study you indicated to me that you had a health issue or concern. I would like you to tell me about that health issue and how it impacts your daily life. As we discuss that issue feel free to explore other areas of your health that may come up during the conversation. You may discuss any aspect of your health that you would like.”

3.2.2. Practice Cycle of Empathy

3.2.2.1. Once the participant has begun discussing their health the researcher should follow the cycle of empathy as shown below. As the researcher listens to the participant, empathic response are to be formed and then communicated back to the participant as indicated in phases 1 and 2 in the above figure. Phase 3 consists of the participant forming a perception of the empathy expressed by the researcher. The cycle continues until the end of the conversation time limit
of 15 minutes.

3.3. Conclusion

3.3.1. Instruct participant to complete measurement scale and return to researcher

3.3.1.1. Script

“It has been a pleasure speaking to you about your health. I want to remind you that everything we have discussed is confidential. Now I would like you to complete the two surveys. Read section 3.4.2.1 and 3.4.2.1.1 to participant. Once you have completed the surveys please return them to me. I will be at the reception desk. Thank you for your participation in this study.”

3.3.2. Researcher exits room

3.4. Data Collection
3.4.1. Before the researcher leaves the room they give paper based versions of the EUS and HD to the participant.

3.4.2. The researcher briefly provides the participant with instructions for completing each of the scales

3.4.2.1. Script

“For the Empathic Understanding scale you will see a variety of statements that suggest ways that you may feel or behave in relation to me as the researcher. Please consider each statement with reference to the discussion that you just had with me (Dennis). Think of Dennis as you read each numbered statement. Mark each statement with a number in the left margin, according to how strongly you feel that it is true, or not true, in this relationship. Write in a minus number (–3, –2, or –1) when you disagree with the statement A -3 indicates strong disagreement, -2 means you disagree, and -1 indicates that you are not certain but believe that the statement is probably false. If you agree with the statement answer with a plus number (+1, +2, or +3) when your answer is a grade of ‘yes’. A +3 indicates strong agreement with the statement, -2 means you agree, and -1 indicates that you are not certain but believe the statement to be true.

For the Health Distress scale there are questions are about how you feel about your health during the 30 days. For each question, please circle the one number that comes closest to the way you have been feeling.”
3.4.2.1.1 “It is important that you answer each item of the scale in order for the proper statistical analysis of the scales. Please be sure to mark every item to the best of your ability.”

3.4.3. After answering questions or concerns the researcher instructs the participant to return the completed scales to the researcher at the reception desk and then leaves the room permitting the participant to complete the scales.

3.4.4. If the participant returns the completed scales to the researcher within the allotted time of 60 minutes for the entire observation they take the forms and place them in a locking box for security and safekeeping. If the participant has not returned at conclusion of 60 minute scheduled time the researcher will go to room, interrupt, and remind the participant to return the scale to them. If the participant has not yet completed the scale the researcher will take them to a conference room where they may complete the scale.

3.4.5. Final Review of Scales

3.4.5.1. The researcher, having received the EUS and HD forms, will review each for completeness. If an item has not been answered the researcher will ask the participant to respond to the item. If the participant refuses to respond to the item the researcher will make note of the reason the participant chose not to respond.

3.4.5.2.
APPENDIX T:

R CODE FOR ANALYSIS OF NON-INFERIORITY
## Dennis Crain
## August, 2015
##
## Research aim #1 Non-interiority testing - Strategy found in Rothmann, Weins & Chan, 2012
## Research aim #2 Peason’s R and t-test
##
## Libraries required
##   gdata
##   plotrix
##
library(gdata)
library(plotrix)

## Retrieve data
##
xlsfile <- "C:/Users/Dennis/OneDrive/UA/Dissertation/DataCollection/MasterList/MasterList-FINAL.xlsx"
DisData <- read.xls(xlsfile, sheet="Data")

## subset of EUS data relative to Active Control
##
ControlSubset = subset(DisData, GroupNum == 0)
AC <- ControlSubset["EUS"]

## subset of EUS data relative to Reference Treatment
##
TreatmentSubset <- subset(DisData, GroupNum == 1)
RT <- TreatmentSubset["EUS"]

## function
##
## Method of Moments estimator
##
MoM <- function(datavector, mean, n)
{
  result <- 0
  sumofmeandiff <- 0
  for (i in seq(datavector)) {
    sumofmeandiff <- sumofmeandiff + (datavector[i] - mean)^2
  }
  result <- sumofmeandiff * (1/n)
  return(result)
}
## function
##
## Z distribution
##
ZScore <- function(alpha)
{
    result = qnorm(alpha, mean=0, sd=1)
    return(result)
}

## function
##
## T distribution
##
TScore <- function(alpha, df)
{
    result = qt(alpha, df)
    return(result)
}

## function
##
## Satterthwaite DF
##
Satterthwaite <- function(sdC, sdE, nc, ne)
{
    num <- (sdC^2/nc + sdE^2/ne)^2
    denom <- (sdC^4/(nc^2 * (nc - 1))) + (sdE^4/(ne^2 * (ne - 1)))
    result <- num/denom
    return(floor(result))
}

## function
##
## Standard CI
##
CI <- function(Xmean, Ymean, critval, varX, varY, nX, nY, lower = TRUE, pooled = FALSE)
{
    result <- 0
    df = nX + nY - 2
    if (pooled == FALSE)
    {
        criticalSE <- critval * sqrt(varX/nX + varY/nY)
    } else
    {
        criticalSE <- critval * sqrt(PooledVar(nX, nY, varX, varY) * (1/nX + 1/nY))
    }
if (lower == TRUE)
{
    result <- (Xmean - Ymean) - criticalSE
} else
{
    result <- (Xmean - Ymean) + criticalSE
}
return(result)

## function
##
## ZStatistic - Rothmann p. 324
##
ZStatistic <- function(Xmean, Ymean, margin = 0, varX, varY, nX, nY)
{
    Z <- (Xmean - Ymean - margin)/(sqrt(varX/nX + varY/nY))
    return(Z)
}

## function
##
## TDistPVal
##
PooledVar <- function(nX, nY, varX, varY)
{
    result <- (((nX - 1) * varX) + ((nY - 1) * varY))/(nX + nY - 2)
    return(result)
}

## function
##
## TStatDiffMeans
##
TStatDiffMeans <- function(Xmean, Ymean, margin = 0, varX, varY, nX, nY)
{
    pooledvar <- PooledVar(nX, nY, varX, varY)

    # T for difference of means in NI
    result <- (Xmean - Ymean - margin)/ sqrt((pooledvar *((1/nX) + (1/nY))))
    return(result)
}

## function
##
## NormalPVal
## NormalPVal

```r
NormalPVal <- function(z, sided = 1)
{
  result <- pnorm(abs(z))
  if (sided != 1) {
    result <- 2 * result
  }
  return(result)
}
```

## TDistPVal

```r
TDistPVal <- function(t, df, sided = 1)
{
  result <- pt(abs(t), df)
  if (sided != 1) {
    result <- 2 * result
  }
  return(result)
}
```

## AnalyzeNI

```r
AnalyzeNI <- function()
{
  ## essential values
  ## calculate means
  meanRT <- mean(RT, na.rm = TRUE)
  meanAC <- mean(AC, na.rm = TRUE)
  
  ## non-inferiority margin
  NiMargin <- 3.33

  ## sample sizes
  nc <- sum(!is.na(AC))
  ne <- sum(!is.na(RT))

  ## variances and SD
  varC <- var(AC, na.rm = TRUE)
  sdC <- sqrt(varC)
  varE <- var(RT, na.rm = TRUE)
  sdE <- sqrt(varE)
  pooledvar <- PooledVar(nc, ne, varC, varE)

  ## calculate all degrees of freedom
```
## calculate all critical values - alpha = 0.025
##
## critical value for alpha = 0.025 in normal distribution
ZCritVal = ZScore(0.025)
## critical value t alpha/2 & satterthwaite df
tCritValSdf = TScore(0.025, sdf)
tCritValDf = TScore(0.025, standardDf)
##
## Method of Moments variance estimators
##
ACMoM <- MoM(AC, meanAC, nc)
RTMoM <- MoM(RT, meanRT, ne)
##
## Standard Error of difference: meanAC - meanRT
##
SEofMeanDiff <- sqrt((ACMoM/nc) + (RTMoM/ne))

StandardCIUpper = CI(meanAC, meanRT, TScore(0.025, 100), ACMoM, RTMoM, nc, ne)
StandardCLower = CI(meanAC, meanRT, TScore(0.025, 100), ACMoM, RTMoM, nc, ne, lower = FALSE)

## alternative Rothmann p. 323

testalt = (meanAC - meanRT - NiMargin)/SEofMeanDiff

if (testalt < -ZCritVal) {
    print("Alternative test: NI Concluded")
}

## Large Sample Normal Inference = first case in Rothmann p.323
##
## test statistic: z
FirstCase = ZStatistic(meanAC, meanRT, NiMargin, varC, varE, nc, ne)
##
## p-value
normp <- NormalPVal(FirstCase)
##
## CI
FirstCaseCIUpper <- CI(meanAC, meanRT, ZCritVal, varC, varE, nc, ne)
FirstCaseCLower <- CI(meanAC, meanRT, ZCritVal, varC, varE, nc, ne, lower = FALSE)

print(sprintf("First case - z: %1.5f p: %1.5f CI: upper bound = %1.4f lower bound = %1.4f critical value = %1.4f", FirstCase, normp, FirstCaseCIUpper, FirstCaseCLower, ZCritVal))

# conclusion
if (FirstCase < -ZCritVal) {
    print("First case: NI Concluded")
}

## Satterthwaite df using Z statistic found in first case - second case in Rothmann p.324
## test statistic is same z used in first case above
## p-value NOTE: uses z statistic found in normal inference and Satterthwaite df

tpval <- TDistPVal(FirstCase, sdf)

## CI
SecondCaseCIUpper <- CI(meanAC, meanRT, tCritValSdf, varC, varE, nc, ne)
SecondCaseCILower <- CI(meanAC, meanRT, tCritValSdf, varC, varE, nc, ne, lower = FALSE)

print(sprintf("Second case - t: %1.5f p: %1.5f CI: upper bound = %1.4f lower bound = %1.4f critical
    value = %1.4f", FirstCase, tpval, SecondCaseCIUpper, SecondCaseCILower, tCritValSdf))

# conclusion
if (FirstCase < -tCritValSdf)
    print("Second case: NI Concluded")

## third case Rothmann p.324.
## uses pooled estimator of common variance (Rothmann p. 324)
## test statistic: t for difference of means

ThirdCase <- TStatDiffMeans(meanAC, meanRT, NiMargin, varC, varE, nc, ne)

## p-value
ThirdCasePval <- TDistPVal(ThirdCase, standardDf)

## CI
ThirdCaseCIUpper <- CI(meanAC, meanRT, tCritValDf, varC, varE, nc, ne, pooled = TRUE)
ThirdCaseCILower <- CI(meanAC, meanRT, tCritValDf, varC, varE, nc, ne, lower = FALSE, pooled = TRUE)

print(sprintf("Third case - t: %1.5f p: %1.5f CI: upper bound = %1.4f lower bound = %1.4f critical
    value = %1.4f", ThirdCase, ThirdCasePval, ThirdCaseCIUpper, ThirdCaseCILower, tCritValDf))

if (ThirdCase < -tCritValDf)
    print("Third case: NI Concluded")

## plot CI
a <- (abs(FirstCaseCILower) + abs(FirstCaseCIUpper))/2
b <- (abs(SecondCaseCILower) + abs(SecondCaseCIUpper))/2
c <- (abs(ThirdCaseCILower) + abs(ThirdCaseCIUpper))/2
y <- c(FirstCaseCILower + ((FirstCaseCIUpper - FirstCaseCILower)/2),
    SecondCaseCILower + ((SecondCaseCIUpper - SecondCaseCILower)/2),
    ThirdCaseCILower + ((ThirdCaseCIUpper - ThirdCaseCILower)/2))

liw = c(-FirstCaseCILower, -SecondCaseCILower, -ThirdCaseCILower)
uiw = c(a, b, c)
plotCI(1:3, y, uiw, ylim = c(-4, 4), xlim = c(1,3), axes = FALSE, pch = 16, ylab = "Active Control - Reference Treatment")
  abline(h = 0, v = 0, lty = 1)

abline(h = 3.33, v = 0, col = "gray60", lty = 2)
text(1,3.33, expression(paste("Non-inferiority margin, \( \delta \) = 3.33")), col = "gray60", adj = c(0, .5))
abline(h = -3.33, v = 0, col = "gray60", lty = 2)
text(1,-3.33, expression(paste("Non-inferiority margin, \( \delta \) = -3.33")), col = "gray60", adj = c(0, 1.2))
axis(2)

##
## AnalyzeRelationship
##
AnalyzeRelationship <- function()
{
  ## sample sizes
  alpha = 0.025
  nc <- sum(!is.na(AC))
  ne <- sum(!is.na(RT))

  ## Pearson's R
  r <- cor(EUSAll, HDMean2, method="pearson")

  ## t-test to test hypotheses
  df = nc + ne - 2
  t = (r * sqrt(df))/sqrt(1 - r^2)
  pval <- TDistPVal(t, df)

  ## conclusion
  if (pval <= alpha)
  {
    H0 = "rejected"
  }
  else
  {
    H0 = "failed to reject"
  }
  print(sprintf("%s H0: Pearson's r = %1.4f  t = %1.4f  p-value = %2.4f",  H0, r, t, pval))
}
APPENDIX U:

UNIVERSITY OF ARIZONA INSTITUTIONAL REVIEW BOARD APPROVAL
Date: May 20, 2015
Principal Investigator: Dennis Raymond Crain
Protocol Number: 1505859418
Protocol Title: Noninferiority randomized trial of adult's perception of empathy when interacting with a nursing robot compared to a physically present nurse
Level of Review: Expedited
Determination: Approved
Expiration Date: May 18, 2016

Documents Reviewed Concurrently:

- Data Collection Tools: BLRI-EmpathyScale.docx
- Data Collection Tools: DemographicsSurvey.docx
- Data Collection Tools: HealthDistressScale.docx
- Data Collection Tools: ScreeningChecklist.docx
- Drug/Device info: BeamQuickStartGuide.pdf
- Drug/Device info: BeamRequirements.pdf
- HSPP Forms/Correspondence: F107-DennisCrain.doc
- HSPP Forms/Correspondence: F200-DennisCrain.doc
- HSPP Forms/Correspondence: Signature page.pdf
- Other Approvals and Authorizations: PermissionToUseOfficeSpace.docx
- Participant Material: StudyAppointmentReminderCard.docx
- Protocol: RandomizationScheduleFemaleGreaterthan.docx
- Protocol: RandomizationScheduleFemaleLess than.docx
- Protocol: RandomizationScheduleMaleGreaterthan.docx
- Protocol: RandomizationScheduleMaleLess than.docx
- Recruitment Material: RecruitingPermissionTemplate.docx
- Recruitment Material: RecruitingPoster.docx
- Recruitment Material: StudyBrochure.docx

This submission meets the criteria for approval under 45 CFR 46.110, 45 CFR 46.111 and/or 21 CFR 50 and 21 CFR 56. This project has been reviewed and approved by an IRB Chair or designee.
APPENDIX V:

CONSENT TO PARTICPATE IN RESEARCH
The University of Arizona Consent to Participate in Research

Study Title: Noninferiority randomized trial of adult’s perception of empathy when interacting with a nursing robot compared to a physically present nurse

Principal Investigator:

Dennis R. Crain, BSN, MN
1416 N Lake Stickney Drive
Lynnwood, WA 98037

Phone: 425-239-3115
Email: dennisrc@email.arizona.edu

This is a consent form for research participation. It contains important information about this study and what to expect if you decide to participate. Please consider the information carefully. Feel free to discuss the study with your friends and family and to ask questions before making your decision whether or not to participate.

Why is this study being done?

This study involves research for the purpose of investigating and understanding how you perceive a nurse’s empathy toward you when the nurse is using a robot to communicate with you compared to the usual practice of face-to-face communication. Knowledge of this will encourage designers of future healthcare robots to incorporate empathy in the design and function of healthcare robots as they become more sophisticated.

What will happen if I take part in this study?

If you take part in this study you will complete a short four question questionnaire today asking you to rate your concern about your present health. You will also answer questions about your gender, age, marital status, education level, ethnicity, and overall health rating. Once you complete these questionnaires the researcher will assign you to a study group and schedule a 60 minute appointment with you that suits your schedule during the months of June, July, or August. The location of that appointment will be at a professional business office in Mukilteo, WA. During that appointment you will talk with the researcher for 15 minutes about your health. Depending on the study group you are assigned to you will talk with the researcher face-to-face or with the researcher using a robotic device that permits the researcher to interact with you while not present in the room. The audio portion of the discussion will be recorded. The recording may be reviewed by a licensed mental health counselor in order to help the researcher evaluate his use of empathy during the conversation. The contents of the recording will not be reported and will only be used to review the researcher’s ability to consistently apply empathy. At the conclusion of the 15 minute conversation, you will be asked to complete two questionnaires during the remaining scheduled time. The first is the same four item questionnaire described earlier asking you to rate your concern about your present health. You will complete this questionnaire a second time in order to see if there have been any changes in your health concerns since the first time you completed it. Then you will be asked to complete a 24 item questionnaire that asks you to rate your perception of the researcher’s empathy toward you during the 15 minute conversation. You may finish sooner than the scheduled 60 minutes at which time you are free to leave. At the conclusion of the study you will be given a $10.00 Starbucks coffee card for participating in the study.

Version 05/15/2015
How long will I be in the study?
The study concludes once you have attended the scheduled appointment and completed the two surveys. There is nothing to be done between today and the scheduled appointment.

How many people will take part in this study?
Approximately 100 people will be enrolled in this study. All of these people are residents of Edmonds, Everett, Lynnwood, or Mukilteo Washington.

Can I stop being in the study?
Your participation is voluntary. You may refuse to participate in this study. If you decide to take part in the study, you may leave the study at any time. No matter what decision you make, there will be no penalty to you and you will not lose any of your usual benefits. Your decision will not affect your future relationship with The University of Arizona.

What risks, side effects or discomforts can I expect from being in the study?
There are minimal risks in this study. You will be asked to sit in an office for 15 minutes during the conversation with the researcher. During the conversation you will be asked to discuss your health issues. Such a discussion may be uncomfortable if you have difficulty exploring those issues.

If you are assigned to the group that interacts with the researcher using the robotic device there is a very small risk that you may be injured by the robot should you bump into it or trip over it. During the time that you will be interacting with the researcher using the robot you will be seated and the robot will be approximately ten feet away from you. Note that the researcher has complete control of the robotic device and decides where it will move and when.

What benefits can I expect from being in the study?
You may or may not benefit as a result of participating in this study. It might be helpful to discuss your health issues with the researcher but there is no guarantee of this benefit. The purpose of the conversation is simply to discuss your health issues. It is not intended to discuss remedies for your health issues. For that, you should consult your healthcare provider.

What other choices do I have if I do not take part in the study?
You may choose not to participate in this study without penalty or loss of benefits to which you are otherwise entitled. You are encouraged to discuss your health status with your healthcare provider.

Will my study-related information be kept confidential?
Yes. Your study related information will be kept confidential and safe. During this study you will be identified by your participant ID only. That ID will be assigned to you once you agree to participate in this research study and sign this consent form. A paper-based copy of this consent form will be stored at the University of Arizona College of Nursing in a secure location. The researcher maintains a master list of all participants and their contact information. The master list is digitally encrypted and accessible only by the researcher. It is stored on a secure server. The paper based questionnaires that you completed will not be digitally scanned. The scores calculated from your responses on the questionnaires will be added to an electronic document that is identified only by your participant ID. This file also contains your demographic information including your gender, age, marital status, education level, ethnicity, and overall health rating. That document, stored on a secure server, is encrypted and is accessible only by the researcher. Finally, you will be asked to write your mailing address on an appointment reminder card. This card will be mailed to you. No copy of the card will be made.

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Efforts will be made to keep your study-related information confidential. However, there may be circumstances where this information must be released although it is not anticipated. For example, personal information regarding your participation in this study may be disclosed if required by state law.

Who can answer my questions about the study?

For questions, concerns, or complaints about the study you may contact Dennis R. Crain (contact information above).

If you are injured as a result of participating in this study or for questions about a study-related injury, you may contact Dennis R. Crain (contact information above).

For questions about your rights as a participant in this study or to discuss other study-related concerns or complaints with someone who is not part of the research team, you may contact the Human Subjects Protection Program at 520-626-6721 or online at http://orcr.arizona.edu/hcpp.

An Institutional Review Board responsible for human subjects research at The University of Arizona reviewed this research project and found it to be acceptable, according to applicable state and federal regulations and University policies designed to protect the rights and welfare of participants in research.

What are the costs of taking part in this study?

While there is no cost for participating in this study there are costs associated with transportation to the study site, a professional business office in Mukilteo, WA. If you drive to the study site parking is freely provided. You will also invest your time to get to the study location and participate in the research which may take up to one hour.

Will I be paid for taking part in this study?

Upon completion of the study you will be given a $10 Starbucks Coffee card.

Will my data be stored for future research?

No. Data from this study will not be used for future research. The data will be stored for six years but not used for research or other purposes.

Signing the consent form

I have read (or someone has read to me) this form, and I am aware that I am being asked to participate in a research study. I have had the opportunity to ask questions and have had them answered to my satisfaction. I voluntarily agree to participate in this study.

I am not giving up any legal rights by signing this form. I will be given a copy of this form.

Printed name of subject

Signature of subject

Date and time

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REFERENCES


