Presence is considered to be the perceptual illusion of nonmediation that occurs when technology users lose awareness of their physical surroundings during media-use. Experienced presence is commonly measured with subjective self-report questionnaires. However, this operationalization is problematic, because presence is an involuntary perceptual change and self-report questionnaires are most appropriate when evaluating conscious and voluntary experiences. In an effort to find a more objective, valid, and reliable measure of presence, this thesis compares physiological responses, specifically heart rate and electrodermal activity, between participants who viewed Robosapien V2, a programmed robot, in small-screen television, large-screen television, and nonmediated environment groups. The large-screen group participants experienced significantly greater subjective presence than did the participants in the small-screen group, which significantly supported Hypothesis 1. The manipulation of presence by screen-size allowed for comparison of physiological responses between high- and low-presence groups. Heart rate measured in change in beats per minute during the stimulus presentation was greater for participants in the large-screen group than for those in the small-screen group, but only marginally so. Therefore, Hypothesis 2 was not supported. Hypothesis 3 predicted that participants who viewed the large-screen display would have
skin conductance response greater than the skin conductance responses of the participants who viewed the small-screen display, and the participants in the nonmediated environment would have skin conductance responses greater than those of the two mediated conditions. The data significantly supported Hypothesis 3 when analyzing skin conductance response frequency, but not when analyzing maximum skin conductance response magnitude. The results of this thesis suggest that skin conductance response, an indicator of electrodermal activity, may serve as a valid and objective measure of presence to compliment or supplement the use of self-report questionnaires in future presence research.
Dedicated to my parents, Jeffrey and Sara Laubacher.
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CHAPTER 1
INTRODUCTION

As technologies improve the quality of such media as television, virtual reality, radio, and computer-mediated communication, one primary goal is to make the mediated experience seem more realistic to the users. This sense of “being there” in some environment created by a communications medium is often called presence, “the perceptual illusion of nonmediation” (Lombard & Ditton, 1997, Concept Explication section). To date, the majority of presence studies have utilized subjective self-report questionnaires to measure the construct. However, self-report questionnaires have limitations. When a person experiences presence in some virtual technology-mediated environment, the person is not apt to be consciously thinking about his or her relationship to the environment and is unlikely to be able to reliably answer questions about this relationship. In an attempt to develop a more objective measure of presence, researchers have begun to examine how psychophysiological responses to mediated messages are related to presence (Heeter, 1992; Dillon, Keogh, Freeman, & Davidoff, 2000b; Slater, 2004a; Lee, 2004b; Meehan, Razzaque, Insko, Whitton, & Brooks Jr., 2005). According to Meehan et al.: “We hypothesized that to the degree that a VE [virtual environment] seems real, it will evoke physiological responses similar to those evoked by the corresponding real environment, and that greater presence will evoke a
greater response. If this hypothesis holds, these responses can serve as objective surrogate measures of subjective presence” (p. 240-241). Through this thesis, differences in media users’ heart rate and skin conductance between a virtual environment and its corresponding real environment are examined. Through the real environment, participants will view the stimuli in the room with them, whereas the virtual environment will be viewed on a large or small screen. Television screen-size is manipulated allowing for participants to experience relatively high and low levels of presence, measured with a questionnaire (Appendix A) derived from the Slater-Usoh-Steed Questionnaire (IJsselsteijn, 2005) and the Basdogan, Ho, Srinivasan, and Slater (2000) questionnaire. As presence experienced during television viewing increases, it is anticipated that the difference in the physiological responses between this mediated environment and the real environment will decrease.
CHAPTER 2
LITERATURE REVIEW

Conceptualization of Presence

The study of presence is relatively young, with its roots in the 1976 text by Short, Williams, and Christie, *The Social Psychology of Telecommunications*, and Minskey’s 1980 article, “Telepresence.” The concept of presence itself exists under various names. Lee (2004a) explains, “Scholars from different fields use different terms (e.g., telepresence, mediated presence, virtual presence) to refer to the same concept, sometimes in noninterchangable ways” (p. 28). Although it is true that there is no single agreed upon conceptual definition for presence, scholars in the field have published similar explanations for the concept. Freeman, Avons, Pearson, and Ijsselsteijn (1999) define presence as “the observer’s subjective sensation of ‘being there’ in a remote environment” (p. 1). This definition clearly implies a sense of transportation into an environment physically separated from where the observer exists. Lombard and Ditton (1997) define presence as “the perceptual illusion of nonmediation” (Presence Explicated section). Similar to the definition by Freeman et al. – which involves subjective sensation experienced by a media user – Lombard and Ditton claim that, “because it is a perceptual illusion, presence is a property of a person” (Presence
Explicated section, para. 1). Most recently, Lee has attempted to define presence using words without negative connotations, such as “illusion.” According to Lee, “Presence is newly defined as ‘a psychological state in which virtual objects are experienced as actual objects in either sensory or nonsensory ways’” (p. 27). Regardless of which conceptual definition a presence researcher feels is most accurate, Biocca (1997) argues that presence can be summarized as the illusion of “being there.”

*Operationalization of Presence*

As a result of the ongoing struggle to develop an agreed upon conceptual definition of presence, researchers must currently determine what measure of presence best suits their purposes. Sheridan (1996) states, “there is no accepted theory or operational measurement of presence” (p. 241). Until now, the majority of studies on presence have utilized self-report questionnaires, administered during or after the presence-invoking experience (IJsselsteijn, Ridder, Freeman, Avons, & Bouwhuis, 2001). Meehan et al. (2005) explain that the practice of using subjective questionnaires is directly related to presence being a subjective condition. Certain presence questionnaires focus on specific dimensions of presence. De Greef and IJsselsteijn (2001) developed the IPO Social Presence Questionnaire, which is used to measure social presence, a subconceptualization of presence. The IPO Social Presence Questionnaire is comprised of 12 seven-point semantic differential items and five subjective attitude statements. Lessiter, Freeman, Keogh, and Davidoff (2001) created the ITC Sense of Presence Inventory, which includes 44 items measuring physical space, engagement, naturalness, and negative effects (Dillon, Keogh, Freeman, & Davidoff, 2000a). In an article relevant to this thesis, Meehan et al. (2005) used the University
College London (UCL) questionnaire, which was developed by Slater, Usoh, and Steed (1994). After reading across the presence literature, one begins to notice that few researchers have attempted to measure presence without subjective self-response questionnaires.

Although most studies of presence utilize subjective questionnaires, the use of questionnaires and rating scales has limitations, including “potentially poor reliability” (IJsselsteijn et al., 2001, p. 299). Slater (2004a) describes questionnaire-based presence measures as inherently instable. Slater (2002) elaborates on this stance by stating, “Questionnaire responses can provide an integration over time of only conscious, voluntary, and supported responses” (p. 437). Dillon et al. (2000a) concludes that the error in using questionnaires to measure presence is that they are post-test measures which rely on the memory of an event. It is reasonable to say that questioning a participant about an experience in which his or her consciousness was split between a real spatial environment and a virtual environment would yield unreliable results. Ijsselsteijn, Freeman, and De Ridder (2001) elaborate: “We are seldomly aware of our sense of presence, or feeling of ‘being there,’ in the world. It is not an experience we are used to reflecting upon” (p. 180). Slater (2004a) speculates that questionnaire measurement of presence cannot measure the concept and cannot actually prove the existence of presence. Based on the limitations of subjective questionnaires of presence, it is believed that progress in presence research must be made with another form of measurement.

Physiological research offers a promising path toward objective measures of presence. Dillon et al. (2000a) suggests the use of physiological recordings of arousal as
an objective measure of presence. According to IJsselsteijn et al. (2001), “An alternative approach is to measure user responses that are produced automatically and without conscious deliberation, but that are still sensibly correlated with measurable properties of the medium and/or the content” (p. 299). Compared to still images, moving images invoke higher levels of electrodermal activity and larger heart rate decelerations. Research also supports the ability of motion to increase subjective ratings of presence (Ijsselsteijn, 2001). If there is indeed a relationship between presence and physiological responses, then perhaps certain physiological responses can serve as objective measures of presence. Held and Durlach (1992) expressed an interest in presence being measured objectively with psychological and physiological tests, but until very recently, such studies were not conducted. Slater (2002) expresses confidence in this new direction: “Physiological measures appear to offer a promising way forward” (p. 437).

Linking Presence and Physiological Responses

It seems very possible, based on the literature mentioned above, that physiological responses may be somehow related to presence, and Dillon et al. (2000b) attempt to explain this relationship: “As presence within a displayed environment increases, physiological reactions will tend towards those that would be observed in a real environment” (Introduction section, para. 1). Meehan et al. (2005) supports this explanation with a nearly identical hypothesis: “We hypothesized that to the degree that a VE [virtual environment] seems real, it will evoke physiological responses similar to those evoked by the corresponding real environment, and that greater presence will evoke a greater response. If this hypothesis holds, these responses can serve as objective surrogate measures of subjective presence” (p. 240-241). When Meehan et al. write
about presence evoking a “greater response,” it logically follows that they mean that a physiological response that is more like the physiological response that would be experienced in the corresponding real environment. However, Meehan et al. tested no participants in a real environment for comparison of physiological responses to mediated conditions. The key to investigating physiological responses’ abilities to act as measures of presence is to test individuals who experience high presence and low presence and compare the results to physiological responses of individuals who see and hear the same stimuli as the high and low presence mediated groups. This possible link between physiological responses and presence was the inspiration for this thesis. Slater (2004b) lends further support to the existence of this relationship: “If presence is the extent to which behaviors in virtual reality reflect behaviors in similar real life circumstances, then of course one would expect high presence to be associated with the set of emotions that would have been observed in similar real life circumstances” (p. 121).

*Physiological Response*

When researchers speak of psychophysiological or physiological responses to media, they are referring to the autonomic nervous system and its control of the heart, skin, and eyes. Lang (1994) explains the power of measuring heart rate in cognitive research: “The beating of the heart can tell us something about attention, arousal, effort, and emotion. It can tell us details about a person’s physiological and cognitive state before that person is aware of them” (p. 99). If heart can indicate a sense of presence, researchers would be able to use heart rate as a compliment to or substitute for subjective questionnaires. The autonomic nervous system is composed of two systems, the sympathetic and the parasympathetic divisions (Lang, 1994; Bradley, 2000). The
sympathetic division is related to emotional arousal and when activated, the heart rate increases. The parasympathetic division is related to attention and when activated, the heart rate decreases. A popular way to measure heart rate is through the use of an electrocardiogram (EKG), which measures the electrical impulses that direct the heart. Because the heart is dually innervated, a change in heart rate cannot be strictly attributed to either the sympathetic or parasympathetic nervous systems. For example, an increase in heart rate could be the result of an activation of the sympathetic division, a deactivation of the parasympathetic division, or a combination of the two.

Another physiological response, related to heart rate, is electrodermal activity. Stern, Ray, and Quigley (2000) state that, “Electrodermal activity (EDA) has been recorded in thousands of psycho-physiological studies” (p. 206). A significant linear relationship exists between rated arousal and electrodermal activity (Bradley, 2000). Electrodermal activity can be measured either exosomatically (i.e., on the surface of the skin) or endosomatically (i.e., embedded within the skin), but the exosomatic method is most commonly used by researchers. This exosomatic method involves the passage of a current through skin and the measurement of the resistance to that externally generated current. Skin conductance, the reciprocal of skin resistance, can be measured through the exosomatic method. Reeves, Lang, Kim, and Tatar (1999) state that physiological arousal, or activation of the sympathetic nervous system, can be measured with skin conductance.

Meehan et al. (2005) find heart rate to be the response most highly correlated with presence, after measuring heart rate, skin conductance, and skin temperature. The authors’ experimental methods seem faulty because of the lack of corresponding reality
environment, but regardless of this, it is dangerous to say that heart rate is the best measure of presence. It is possible that heart rate may be a better indicator of presence compared to skin conductance or skin temperature, but heart rate itself is the result of the two divisions of the autonomic nervous system. Simply knowing the extent to which a heart rate increased or decreased does not tell researchers which division, the sympathetic or parasympathetic, is most responsible for heart rate change. This is why skin conductance is an important physiological response. By measuring skin conductance, researchers are able to better understand the causes for changes in heart rate. Electrodermal activity is innervated solely by the sympathetic nervous system, so measuring skin conductance can show whether or not the sympathetic division is activated and therefore which of the two nervous systems is most responsible for heart rate changes.

The Meehan et al. (2005) study chose to use change in heart rate, change in skin conductance, and change in skin temperature as physiological measures to correlate with presence, because they are commonly used. This study focuses on heart rate and skin conductance, based on the impression from the literature summarized above that these two responses are the most relevant to emotion and arousal, and therefore relevant to this study. It is possible to quantify several aspects of electrodermal activity, which is strongly correlated with activity in the sympathetic nervous system (Hopkins & Fletcher, 1994). During a period of stimulus exposure, one can quantify both the frequency of spontaneous skin conductance responses and the size of individual skin conductance responses. In the present study, skin conductance response frequency and maximum magnitude are used as quantification procedures for electrodermal activity (Dawson,
Schell, & Filion, 2000). Dawson et al. (2000) explains the importance of utilizing both frequency and magnitude when measuring skin conductance: “A magnitude measure can create the impression that response size is changing when in fact it is the response frequency that is changing” (p. 207-208). Dawson et al. also claims that frequency is the least distorted component of skin conductance response.

Television and Presence

Meehan et al. (2005) study Virtual Reality as a medium, with participants each wearing a head-mounted display. Virtual Reality enables users to interact with a computer-simulated environment, and the head-mounted display keeps a Virtual Reality user’s eyes trained on the virtual environment rather than viewing any of the current physical environment. Although Virtual Reality provides the ability to evoke a greater amount of presence than most other communications media, it may be most beneficial to conduct the proposed study with television rather than Virtual Reality. Because more people have access to television than Virtual Reality, results pertaining to television would be relevant to a greater percentage of society. Although not as immersion-inducing as Virtual Reality, studies have supported television’s ability to induce a sense of presence (Kim & Biocca, 1997; Lombard, Reich, Grabe, Bracken, & Ditton, 2000).

For the purposes of this thesis, both high and low feelings of presence must be evoked, and one way to manipulate presence is through television screen size. In 1992, Held and Durlach speculated that large field of view should affect presence. Studies (Lombard et al., 2000; IJsselsteijn, Ridder, Freeman, Avons, & Bouwhuis, 2001) lend support to the notion that screen size has a significant effect on presence. Lombard et al. explain: “The results suggest that television may be able to evoke presence in viewers”
(p. 81) and "that larger television images may evoke greater presence" (p. 81). For this experiment, having a wide range of levels of presence evoked would be ideal, so by using both relatively large and small screen television screens, we are more likely to achieve this range than if we were to only use one size screen.

Because the purpose of this study is to examine whether or not physiological responses can serve as objective measures of presence, it is worth noting that much like the relationship between television screen size and presence, a relationship exists between screen size and physiological responses. Research lends support to a larger screen or image invoking greater arousal (Reeves & Nass, 1996; Lee, 2004b). Reeves et al. (1999) state that, "The results of this experiment suggest that screen size, regardless of content, can increase attention and arousal for media messages" (p. 62).

**Hypotheses**

Given the research suggesting that screen-size significantly influences feelings of presence, it is predicted that:

H1: Participants who view the stimulus on the large-screen display will experience greater subjective presence than will participants who view the stimulus on the small-screen display.

Based on the fact that the body's reaction to a high presence environment should more closely mimic a reaction to a nonmediated environment than would the body's reaction to a low presence environment, the following is predicted:

H2: Participants who view the large-screen display will have heart rates significantly greater than the heart rates of the participants who view the small-screen display. An external stimulus is likely to induce attention and innervate
the parasympathetic nervous system, but the stimulus is entertaining and therefore likely arousal-inducing, activating the sympathetic nervous system. Because there is no attention-intensive task involved in this experiment and no manipulated difference in attention between conditions, it is predicted that the participants in the nonmediated environment will have heart rates greater than those of the two mediated conditions.

Because the stimulus is entertaining and therefore likely arousal-inducing, and based on the logic that the body’s reaction to a high presence environment should more closely mimic a reaction to a nonmediated environment than would the body’s reaction to a low presence environment, the following is predicted:

**H3:** Participants who view the large-screen display will have skin conductance responses significantly greater than the skin conductance responses of the participants who view the small-screen display, and the participants in the nonmediated environment will have skin conductance responses greater than those of the two mediated conditions.

**Research Question:** Will heart rate or skin conductance better differentiate the high and low presence groups?
CHAPTER 3

METHOD

Participants

The participants were recruited from communication classes at a large Midwestern university. The sample consisted of 109 students. Each student received extra course credit for participation. Of the total sample, 40 participants were male, and 69 were female. The ages of the participants ranged from 19 to 30, with a mean of 21.45 years-old.

Apparatus

Two of the three experimental conditions involved the viewing of the stimulus on screens. The screen size was manipulated to evoke feelings of high and low presence, depending on large and small screen-size. Lombard et al. (2000) set a precedent for such screen-size manipulation using a large 46-inch projection and a small 12-inch television screen. Participants for this experiment viewed the stimulus video on either a 45-inch projected display or a Dell 15-inch LCD flat-panel monitor, depending on random group assignment. Both the large and small-screen displays were viewed from a distance of four feet. The large-screen display spanned 63 degrees of the participant’s horizontal viewing field and 49 degrees of the vertical viewing field, whereas the small-screen display spanned 22 degrees horizontally and 17 degrees vertically. The stimulus video
was played from a Dell computer with an Intel Pentium 4 processor. Skin conductance was measured using In Vivo Metric silver/silver chloride electrodes, a Coulbourn Instruments LabLinc V-series isolated skin conductance coupler, and a Scientific Solutions Labmaster A/D D/A board. A three-electrode electrocardiogram sensor was used to measure heart rate, with one electrode being placed on each of the participant’s forearms and the third electrode placed on the non-dominant arm’s wrist. The two electrodes used to collect skin conductance data were placed on the palm of the non-dominant hand.

Design

This experiment utilized between-subjects design. Heart rate and skin conductance could be measured simultaneously, so there was no need to run separate experiments to test hypotheses two and three. The participants were randomly assigned to one of three groups; nonmediated, small-screen display, or large-screen display. The two television display groups were for the purpose of evoking high and low presence scores on the post-test subjective questionnaire. The physiological responses of participants who were in the television groups are being compared to each other, as well as to the physiological responses for the participants in the nonmediated group. In this respect, the experiment is between-subjects.

Stimuli

It was difficult to select stimuli that would both be appropriate for the laboratory setting and that could be assured to be constant in both mediated and nonmediated settings. Most presence experiments utilize very visually engaging stimuli, such as a colorful rainforest or a fast moving car (IJsselsteijn et al., 2001). This is not necessarily
feasible for the purposes of this study, however, because a corresponding real environment also needed to exist in which participants could be tested. It would have been impractical to transport physiological-measuring equipment and 50 participants to a zoo or a race track. To compensate for the lack of movement or exotic location, a feasible stimulus needed to be emotionally involving. The stimulus also needed to be consistent through all trials.

Ultimately, the decision was made to utilize Robosapien V2, a robot produced by Wow Wee Robotics (Appendix B, Figure 1). This anthropomorphic robot stands 61 centimeters tall and can be operated by infrared remote control. For the purposes of the current study, Robosapien V2 was programmed with a routine of 14 functions, such as laughing, dancing, and walking a short distance toward the participant. The entire routine spanned 120 seconds. To eliminate any differences in content between the nonmediated and television groups, the video stimulus for the television groups was a digital video recording of Robosapien V2 performing the same routine that was performed for the nonmediated group. The participants in the television groups were told that the robot was performing live in a room nearby and that they were to see this live performance on the screen.

Measurement

The dependent measures were presence, heart rate, and skin conductance. Presence was measured with a questionnaire (Appendix A) adapted from the Slater-Usoh-Steed questionnaire and the Basdogan et al. (2000) questionnaire. The Slater-Usoh-Steed questionnaire was first proposed by Slater, Usoh, and Steed in 1994 but more recently revised to include six seven-point Likert scale items (Ijsselsteijn, 2000).
This presence index is useful because it is not as content specific as other presence questionnaires. Many validated questionnaires of presence involve task completions and virtual reality, which this experiment does not involve. The questionnaire developed for the purposes of this study was comprised of five seven-point Likert scale items, four derived from the Slater-Usoh-Steed questionnaire and one derived from the Basdogan et al. questionnaire. The participants circled one of seven bullet points between two descriptions such as “Always the reality” and “Never the reality” to represent their opinions. These seven points represent values “1” through “7,” but the participants only viewed and circled bullet points. The responses to these five items were then used to create a presence index for each participant. The presence index is the average across the five items. However, because “7” represented the lowest feelings of presence and “1” represented the greatest feelings of presence on the questionnaire, the responses to these items were then subtracted from eight to reverse the scoring. The generated presence index score for each participant would have a minimum possible presence value of “1” and a maximum presence value of “7.” An alpha of .935 was obtained for this five-item presence scale in the current study.

Although Meehan et al. (2005) calculated the difference between mean heart rate in one virtual room compared to another virtual room and the difference between mean skin conductances in one virtual room compared to another, this experiment does not allow for the same measurement procedure. Instead of examining skin conductance level, we were more concerned with skin conductance response. A skin conductance response will be the height or amplitude of an electrodermal activity peak evoked, in μS (Stern et al., 2000). The change in heart rate will be the difference between the heart
rate monitored and the baseline heart rate at zero seconds into the experimental stimulus. Heart rate will be expressed in beats per minute.

Procedure

When the participants arrived at the designated meeting room, they were notified of their experimental condition; either that they would be viewing a robot performing tasks in front of them or that the robot would be performing in a room nearby and they would be viewing these actions on a large or small monitor. Halves of days were randomly assigned to these three conditions, and the participants were not aware of the conditions for their day until arrival. The participants were reminded that five electrodes would be safely placed on their palm and both arms to monitor body signals. After a participant signed the consent form, he or she was then escorted into a room where the physiological response electrodes were applied.

For the nonmediated group, Robosapien V2 was placed on the ground approximately four feet in front of the participant’s chair. A baseline heart rate was then collected prior to the start of the robot’s routine, to give a place from which to access change in heart rate. A lab worker then used a remote control to signal the commencement of the robot’s routine from just outside the doorway. For the television groups, the actual robot used in the nonmediated condition was shown to the participants and the participants were told that the robot would be placed in another room and its actions would then be displayed on the screen in front of them. The baseline heart rate was then collected prior to the start of the robot’s routine. The lab then started the playback of the previously recorded robot routine from a computer in the neighboring room inside the lab.
Following the viewing of the stimulus, the electrodes were removed from the participant, and the participant was handed a questionnaire comprised of five presence items and demographic questions. At the completion of this questionnaire, the participant was thanked for his or her time and shown to the exit.
CHAPTER 4

RESULTS

Hypothesis 1 predicted that participants who viewed the stimulus on the large-screen display would experience greater subjective presence than would participants who viewed the stimulus on the small-screen display. This hypothesis was a manipulation check for the purpose of finding whether or not the screen size difference evoked feelings of high and low presence. Each participant's responses to five seven-point Likert scale items were reverse-scored and averaged to create a presence index score. (See Appendix C, Table 1) The presence index score for a participant could range from one to seven. The mean presence index score for participants who viewed the large-screen display is 3.491 ($SD = 1.227$), which is greater than the mean presence index score for those who viewed the small-screen display ($M = 2.985, SD = 1.294$). (See Appendix C, Figure 2) The mean difference between the presence index scores of the large-screen and small-screen display groups, 0.506, is significant, t(69.065) = 1.701, $p < .05$, one-tailed, Welch-Satterthwaite adjusted. Therefore, a person who viewed the large-screen display would be expected to have experienced greater presence than would a person who viewed the small-screen display. Hypothesis 1 is supported by the data. The manipulation of screen-size induced significantly different subjective presence index scores.
Hypothesis 2 predicted that participants who viewed the large-screen display would have heart rates significantly greater than the heart rates of the participants who viewed the small-screen display, and participants in the nonmediated environment would have heart rates greater than those of the two mediated conditions. The mean change in beats per minute over the entire 120-second stimulus presentation for the participants who viewed the large-screen display is .409 (SD = 0.932), which is greater than that of the small-screen display group (M = -.146; SD = 0.870). (See Appendix C, Figure 3) However, the mean difference, .555, is not significant, F(106) = 0.95, p = .332, one-tailed. The data does not significantly support Hypothesis 2, but the data did point in the hypothesized direction. The mean change in beats per minute for the nonmediated condition group (M = 3.633, SD = 0.906) is significantly greater than the mean change in beats per minute for the large-screen display group (M = 0.409, SD = 0.932), t(106) = 2.70, p < .01, one-tailed. However, it is not important that the mean change in beats per minute for the nonmediated condition is significantly greater than the mean change in beats per minute for the large-screen group. The key is that the mean change in beats per minute for the nonmediated condition is greater than that of the large-screen condition, whereas the mean change in beats per minute for the small-screen condition is less than that of the large-screen condition.

Hypothesis 3 predicted that participants who viewed the large-screen display would have skin conductance responses significantly greater than the skin conductance responses of the participants who viewed the small-screen display, and the participants in the nonmediated environment would have skin conductance responses greater than those of the two mediated conditions. This hypothesis was tested in two ways; using
frequency of skin conductance responses, with a magnitude of response greater than 0.096 μSiemens qualifying as a valid response, and using maximum magnitude of skin conductance response.

The mean frequency of skin conductance responses for participants who viewed the large-screen display is 8.229 (SD = 1.315), which is greater than 4.432 (SD = 1.279), the mean frequency of skin conductance responses for those who viewed the small-screen display. The mean difference in skin conductance response frequencies between the large-screen and small-screen display groups, 3.796, is significant, F(103) = 5.49, p < .05, one-tailed. Also, the mean frequency of skin conductance responses for participants who viewed the nonmediated stimulus, 10.941 (SD = 1.335), is greater than the mean frequency of skin conductance responses for each of the television display conditions. (Appendix C, Figure 4) Although the mean difference, 2.713, between the mean frequency of skin conductance responses for the participants who viewed the nonmediated condition (M = 10.941, SD = 1.335) is not significantly greater than the mean frequency of skin conductance responses for participants who viewed the large-screen display (M = 8.229, SD = 1.315), t(103) = 1.79, p = 0.076, one-tailed, this is inconsequential. Because the high presence large-screen skin conductance responses should mimic those of the nonmediated condition, these groups need not necessarily be significantly different, but the nonmediated condition's mean frequency should be greater. This is the case, and Hypothesis 3 is therefore supported by the data when tested using total frequency of skin conductance responses.

The mean maximum skin conductance response magnitude for participants who viewed the large-screen display is 0.651 (SD = 0.100), which is greater than the mean.
maximum skin conductance magnitude for participants who viewed the small-screen display ($M = 0.501, SD = 0.097$). The mean difference in maximum skin conductance response magnitude, 0.151, is not significant, $t(103) = 1.48, p = 0.142$, one-tailed.

Although the mean maximum skin conductance response magnitude of the large-screen display group is not significantly greater than that of the small-screen display group, it is in the correct direction. The nonmediated group's mean maximum skin conductance response magnitude, 0.768 ($SD = 0.102$), is greater than the mean maximum skin conductance response magnitude for participants who viewed the large-screen display ($M = 0.651, SD = .100$), but not significantly greater, $t(103) = 1.26, p = .209$, one-tailed.

(See Appendix C, Figure 5) This testing method based on maximum skin conductance response magnitude does not support Hypothesis 3.

Taken together, Hypothesis 3 is partially supported. The frequency of skin conductance responses supports H3, however the magnitude of skin conductance responses is not significantly different, although it is in the predicted direction.
CHAPTER 5
DISCUSSION

Implications of Results

The results suggest that screen-size does influence presence as reported by the television-viewing participants. This supports the results of previous studies by Lombard et al. (2000) and Ijsselsteijn et al. (2001). The focus of the current study was to test physiological responses, heart rate and skin conductance, as potential measures of presence; and the screen-size manipulation successfully created a group whose participants reported feeling of high presence and a group whose members reported feelings of low presence. This allowed physiological responses to be compared between participants in these two groups, as well as comparisons with the nonmediated group.

Hypotheses 2 and 3 were based on the idea that as presence increases, participants’ bodies should respond more like their bodies would if the same stimulus was experienced in a nonmediated reality. The physiological data did not support Hypothesis 2, but Hypothesis 3 was significantly supported when tested using frequency of skin conductance responses. The data’s support for a relationship between presence and skin conductance response frequency, rather than magnitude, is not unexpected. Schneider, Lang, Shin, & Bradley (2004) reported a link between sense of presence and
physiological arousal through the measure of skin conductance response frequency in a study involving first-person shooter video games. The lack of support for Hypothesis 2 may indicate that heart rate is not a reliable measure of presence. This contradicts the results of a study conducted by Meehan et al. (2005), through which heart rate was determined to be the greatest correlate of presence, compared to skin conductance and skin temperature.

This thesis does not show heart rate to be a strong indicator of presence because the high and low presence participants did not differ greatly in their changes in heart rate from baseline measured heart rates. Figure 6 (Appendix C) displays the estimated marginal means of change in beats per minute over the course of the 120-second robot performance. An estimated marginal mean of 0.00 would indicate a heart rate that is equal to the baseline heart rate measured prior to the stimulus presentation. Each single unit of time on the X-axis represents 10 seconds. One can see that at 10 seconds into the stimulus presentation, the nonmediated condition in which the robot was actually in the room with the participants induced heart rates that were on average approximately 4 beats per minute faster than the baseline measurement. The large-screen condition had an estimated marginal mean heart-rate change of approximately 1 beat per minute at 10 seconds, whereas the small-screen condition’s estimated marginal mean heart-rate was nearly -1 at 10 seconds. This would suggest that at that point in time, 10 seconds into the stimulus presentation, the activation of the sympathetic nervous system was more dominant than the activation of the parasympathetic nervous system for the nonmediated and large-screen groups, because they are greater than zero. For the nonmediated and large-screen groups, the sympathetic division was activated, as evidenced by the skin
conductance response frequencies being significantly greater than those of the small-screen group. Conversely, the small-screen group displays an activation of the parasympathetic nervous system that is more dominant than the activation of the sympathetic nervous system. This seems to indicate that physiological arousal is relatively more prevalent for the nonmediated and large-screen groups, whereas the small-screen group shows indication of attention to an external stimulus.

Figure 6 (Appendix C) shows that at 70 seconds into the stimulus presentation, the large-screen and small-screen display groups had essentially equal estimated marginal means of change in beats per minute. The two television conditions remain nearly even in this measure until approximately 110 seconds, when the large-screen estimated marginal mean of change in beats per minute becomes greater than that of the small-screen group again. This collapsing of the difference in estimated marginal means of change in heart rate occurs while the robot is performing a dance, from 65 to 95 seconds into the routine. Although this can be interpreted in many ways, it is important to note that during this dance, the robot also plays music in the audio channel. The same audio music plays for all three conditions. It might be possible that the constant audio music during the dance decreases the manipulation or polarizing power of the screen-size difference. When the robot simply talks, the audio is not constant, because there are moments of silence between words. However, when the music plays and the robot dances, the audio cues received by the participants are constant. The visual differences, the screen-size difference, may become relatively less polarizing when audio cues are constant. During this time span, the small-screen change in beats per minute increases to greater than zero. This increase is indicative of the sympathetic division of the
autonomic nervous system becoming more activated than the parasympathetic division. This may indicate an increase in arousal when participants view the dancing robot and listen to music.

Electrodermal activity, which was measured as skin conductance response, is a direct indicator of arousal and activation of the sympathetic division of the autonomic nervous system. Hypothesis 3 predicted that participants who viewed the large-screen display would have skin conductance responses significantly greater than the skin conductance responses of the participants who viewed the small-screen display, and the participants in the nonmediated environment would have skin conductance responses greater than those of the two mediated conditions. This hypothesis was significantly supported when tested using frequency of skin conductance responses rather than maximum skin conductance response amplitude. On average, a member of the large-screen display group had a higher frequency of skin conductance responses during the 120-second stimulus presentation compared to the small-screen group. The members of the nonmediated group experienced a higher mean frequency of skin conductance responses than either television display group. This is encouraging, because it seems that measuring electrodermal activity with skin conductance frequency is sensitive and differentiable between high and low presence environments. An increase in presence, from small-screen to large-screen, correlates with a significant change in skin conductance response frequency. As presence increased, the participants’ sympathetic nervous systems appear to have responded increasingly as if to a real environment, the nonmediated condition.
That skin conductance response frequency may serve as an operationalization of presence fits a conceptual explication of presence as explained by Lombard and Ditton (1997). The authors described presence as a feeling that does not exist in degrees, but instead either occurs or does not occur at any media-use moment. According to this conceptualization of presence, relatively high or low presence is dependent on the number of moments in which the illusion of nonmediation takes place. It stands to reason that measuring the number of moments that the body is aroused by the mediated environment during the time of viewing would be a valid measure of presence. This is what is achieved through measuring skin conductance response frequency. Utilizing maximum skin conductance response as a measure of presence would contradict Lombard and Ditton’s conceptualization, because a high maximum skin conductance response for a participant would then imply high presence at a single moment. Lombard and Ditton do not believe that presence is high or low at a moment, but either existent or non-existent over a period of time. These data support this logic. Skin conductance response frequency is the best physiological measure of presence, compared to heart rate or maximum skin conductance response.

Limitations

One of the greatest challenges in conducting this study was to develop stimuli that could be presented in a nonmediated environment while the participants were attached to physiological data-collection equipment. Meehan et al. (2004) utilized mobile equipment allowing heart and skin data to be collected as the participants walked in a room. With access to extremely mobile equipment, research could conceivably be
conducted in a very arousing environment, such as in a zoo. Along these lines, this thesis was limited by the physiological data-collection equipments physical nature.

The laboratory should be at or greater than a temperature of 74 degrees Fahrenheit to collect skin conductance data. The thermostat in the laboratory was malfunctioning for many weeks, so a space heater and thermometer were used to regulate room temperature. Low temperatures contributed to some unusable skin data.

Future Research

By examining heart and skin physiological data, this thesis provides a step toward a more objective operationalization of presence. The results of this study have implications on directions of future presence research. In order to have greater confidence in skin conductance response as a measure of presence, research should use other manipulations of presence, rather than screen size, to better understand if skin conductance response is a valid measure of presence or simply a measure of screen size. Screen size is a variable of technological form. Similarly, screen resolution is a form variable that could be utilized to test skin conductance response as a presence measure. Also, this study could be replicated using an interactive stimulus. Task completion and conversational stimuli are interactive and examining physiological measures of presence in these environments would expand the scope of such measures. Future studies examining physiological measures of presence should not only focus on form variables, but also on content and media user variables.

The stimuli for this thesis, a laughing and dancing robot, can be considered humorous and arousing. However, presence research is important in less entertaining contexts, as well. This study's design could be replicated while manipulating presence
with content. Different levels of arousing and non-arousing stimuli should be utilized. For example, an educational environment such as an online lecture could provide a low-arousal, high-attention stimulus. Media user variables should also be examined in future studies involving physiological measures of presence. However, media user variables such as prior experience with the medium, gender, or age cannot be used to validate skin conductance response as a measure of presence, because adequate research findings do not exist to show how presence is affected by these factors. Previous studies have suggested that screen size directly affects presence experienced, so physiological measures could be tested for high and low presence groups.

If further research lends support to the ability of skin conductance response or other physiological data’s ability to serve as a measure of presence, then existing studies of presence should be replicated using physiological measures to compliment the questionnaire-based results. Once a more objective measure of presence exists, potentially through physiological data such as skin conductance response, new insights may be gained through exploring studies from the past. The results from this thesis suggest that skin conductance response frequency is a significant direct correlate of presence and therefore a valid measure of presence.
APPENDIX A

PRESENCE QUESTIONNAIRE
Thank you for agreeing to participate in this study. It is very important that you read the following instructions carefully.

We want to ask you some questions about your experience with the robot.

For each of the following questions, please circle one point to represent your opinion between the two descriptions.

1. Please rate your sense of being in an environment with the robot.
   - Actually with the robot
   - Not at all with the robot

2. To what extent were there times during the experience when the environment with the robot was the reality for you?
   - Always the reality
   - Never the reality

3. During the time you were watching the robot, which was strongest on the whole, your sense of being with the robot or of being elsewhere?
   - Being with the robot
   - Being elsewhere

4. During the time you were watching the robot, did you often think to yourself that you were actually with the robot?
   - Always with the robot
   - Never with the robot

5. To what extent, if at all, did you have a sense of being with the robot?
   - Greatest
   - Least
Now we ask that you please answer the following demographic questions by filling in the blank or circling the correct answer. This will help us make sense of the differences we find among respondents.

6. How old are you? __________

7. You are: Male Female Choose Not to Answer

8. Are you Hispanic or Latino/Latina? Yes No Choose Not to Answer

9. Would you mind telling us your race?
   ______ American Indian or Alaskan Native
   ______ Asian
   ______ Native Hawaiian or Pacific Islander
   ______ Black or African American
   ______ White
   ______ More than one race
   ______ Choose not to answer

Thank you for participating!
APPENDIX B

IMAGES
Figure 1

Robosapien V2
APPENDIX C

RESULTS CHARTS
Table 1

*Mean Questionnaire and Physiological Results by Experimental Condition*

<table>
<thead>
<tr>
<th>Condition</th>
<th>Small screen</th>
<th>Large screen</th>
<th>Nonmediated</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean (SD)</td>
<td>Mean (SD)</td>
<td>Mean (SD)</td>
</tr>
<tr>
<td>Presence index</td>
<td>2.985 (1.294)</td>
<td>3.491 (1.227)</td>
<td>5.533 (1.237)</td>
</tr>
<tr>
<td>Change in BPM</td>
<td>-.146 (.870)</td>
<td>.409 (.932)</td>
<td>3.633 (.906)</td>
</tr>
<tr>
<td>SCR frequency</td>
<td>4.432 (1.279)</td>
<td>8.229 (1.315)</td>
<td>10.941 (1.335)</td>
</tr>
<tr>
<td>SCR magnitude</td>
<td>.501 (.097)</td>
<td>.651 (.100)</td>
<td>.768 (.102)</td>
</tr>
</tbody>
</table>

BPM = Beats per minute

SCR = Skin conductance response
Figure 2

Mean Presence Index Scores by Condition

Figure 3

Estimated Marginal Means of Change in Beats Per Minute
Figure 4

*Estimated Marginal Means of Skin Conductance Response Frequency*

Figure 5

*Estimated Marginal Means of Maximum Skin Conductance Response*
Figure 6

Estimated Marginal Means of Change in Beats Per Minute Over Time
LIST OF REFERENCES


