Mere Exposure Effect on Uncanny Feelings toward Virtual Characters and Robots

by

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ABSTRACT

As technology increases, so does the concern that the humanlike virtual characters and android robots being created today will fall into the uncanny valley. The current study aims to determine whether uncanny feelings from modern virtual characters and robots can be significantly affected by the mere exposure effect. Previous research shows that mere exposure can increase positive feelings toward novel stimuli (Zajonc, 1968). It is predicted that the repeated exposure to virtual characters and robots can cause a significant decrease in uncanny feelings. The current study aimed to show that modern virtual characters and robots possessing uncanny traits will be rated significantly less uncanny after being viewed multiple times.

DEDICATION

To my Mother and Father who gave me every advantage they could so that I may succeed.

ACKNOWLEDGMENTS

This thesis would not have been possible without the constant feedback and support from committee members: Hyunjin Song, Bing Wu, and Mike Kuzel; to whom the author is forever grateful.

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As technology gets more advanced, so do our methods of entertainment. Video games are one example of a technology that has been around for decades but continue to advance with each passing day. Once exclusive only to a target wealthy audience, they are now at the forefront of digital entertainment. Their desirability comes from the technology within the games themselves, such as high fidelity graphics and multiplayer capabilities, and their extreme diversification of games in several different genres. With each passing year, virtual worlds become more detailed and more complex.

One noticeable aspect of gaming that is ever advancing is the visual fidelity of the virtual characters themselves; as the technology used to create virtual characters advances, so does the technology used to display them. Graphical technology is constantly reaching new heights as to what level of realism can be achieved. However, with such high levels of realism, there is a growing concern about modern virtual characters falling into the uncanny valley; which can be defined as a point where a stimulus reaches near perfect human likeness and causes negative affect as a result (Burleigh, Schoenherr & Lacroix, 2013).

High fidelity virtual characters are not the only humanlike technology that has advanced over the past couple of decades; humanlike robots, or androids, have slowly started to become more widely developed. Thanks to advances in computing power and hardware development, high performance GPUs no longer need a large amount of space to perform the day to day operations of an autonomous robot (Yamazaki et al., 2012). It is now possible to give almost any type of robot at least some basic function. Low fidelity robots (for the remainder of this paper the fidelity of the robots will refer to the amount of human characteristics in the design) are already working in factories across the world, doing jobs either too dangerous for humans or jobs that would take humans too long to do by hand. But working in factories is not the only focus of robotic development.

Personalized robotic assistants on a large scale are one of the many other long term goals that the future holds for robots. Humanlike robots designed for in home use for a variety of tasks will one day become a reality for consumers. While not yet available for mass production, prototypes of humanlike robots have begun making their way into the spotlight. But like their virtual counterpart, android robots also have a growing concern of falling into the uncanny valley. However, due to the greater popularity of virtual characters, it is possible that robots will be affected more than virtual characters.

The current study investigates whether manipulating the amount of exposure a person has to a virtual character or robot can significantly reduce uncanny feelings. Utilizing research on the mere exposure effect, the current study will focus on how the relationship between virtual characters, robots, and the uncanny valley can be manipulated by exposure. For the current study, uncanny will be operationally defined as any feeling of eeriness or discomfort brought on by the presentation of the virtual characters or robots. In order to provide support for hypotheses of the study, a review of the literature will be presented.

The Uncanny Valley

The uncanny valley is a phenomena that states when stimuli reach near-perfect resemblance to humans, a feeling of uncanniness occurs from the presentation of the stimuli (Burleigh, Schoenherr & Lacroix, 2013). The term uncanny (uncanniness) is also synonymous with eerie, creepy, unnatural, and weird; therefore, such terms are considered interchangeable and will be used to represent uncanny throughout the remainder of this paper. The term Uncanny Valley was first coined by robotics professor Masashiro Mori (1970); it is known as a 'Valley' because there is an area roughly between 70%-90% of total human likeness where, when expressed graphically, there is a radical shift from positive to negative affect (see figure 1). This shift symbolizes a valley when plotted against familiarity, affinity, social acceptance or some other measure of approval.

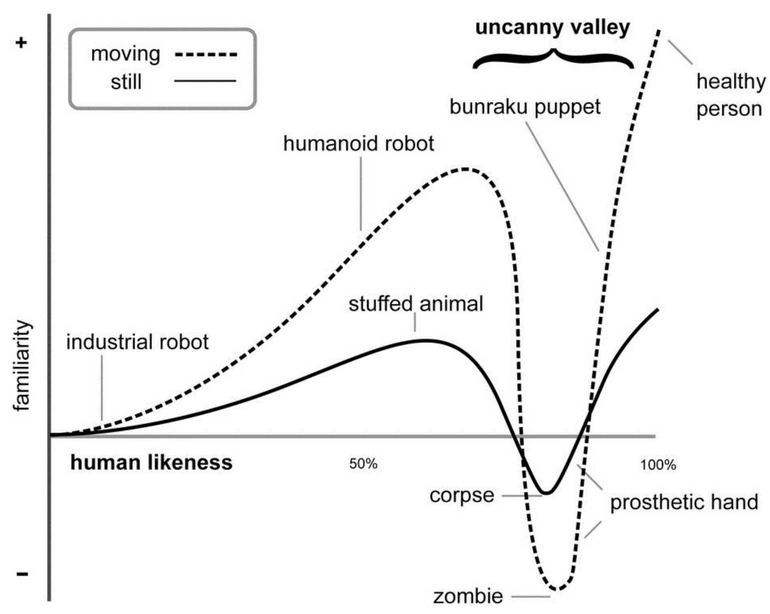

Figure 1. Uncanny Valley Plot: Familiarity vs. Human likeness

Even though the phenomenon was coined in the 70s, research on an uncanny effect dates back to the early 1900s. Since that time, recent research has focused on providing explanations for the Uncanny Valley Phenomenon with regards to more modern technology such as computer generated characters, advanced robotics, artificial limbs, and even zombies (Tinwell, Nabi & Charlton, 2013; Gray & Wegner, 2012). While this phenomenon has been believed to be true for a long time, there has not been very much systematic scientific research on the uncanny valley. Since present research focuses on uncanny feelings toward virtual characters and robots, the literature in these domains is reviewed below.

Uncanny feelings toward virtual characters

When animating virtual characters, their form, dynamics, and interactivity can be manipulated in order to obtain the desired level of human likeness (MacDorman, Green, Ho & Koch, 2009). Facial animation, specifically upper face animation, is one of the largest contributing factors to whether or not an animated virtual character appears uncanny, and can be manipulated by either removing upper face animation or hindering it to a degree (Tinwell, Grimshaw, Nabi & Williams, 2011; Tinwell, Nabi & Charlton, 2013). Tinwell et al. (2011) conducted a study that examined the effect of varying upper lip animation and found that the feelings of uncanny greatly relied on the emotion being displayed by the virtual character, with negative emotions creating the greatest feelings of uncanniness. The study was later revisited by Tinwell et al. (2013) using female virtual characters, instead of male virtual characters, and found that virtual character gender differences are generalizable.

When it comes to negative emotions portrayed by virtual characters that produce feelings of uncanniness: fear, sadness, and disgust are the emotions most commonly cited (Tinwell et al. (2011); Tinwell et al. (2013); Burleigh, Schoenherr & Lacroix, 2013). However, since the virtual characters used as stimuli in the present studies will not be animated, only neutral facial expressions will be used.

Uncanny feelings toward robots

Robots are similar to virtual characters in that they too have the potential to fall into the uncanny valley. Like their virtual counterparts, recent research has focused on how the design (physical appearance as well as mechanical features such as movement) of the robot impacts the feelings of uncanny as rated by the participants (Rosenthal-von der Putten & Kramer, 2014; Walters, Syrdal, Dautenhahn, Boekhorst, & Koay, 2008).

Just as there are high fidelity and low fidelity virtual characters, there are also different variations of robots; with each version reacting differently to the uncanny valley. The different variations are based on the amount of humanlike characteristics that are placed in the appearance. There are three main robot appearance variations: mechanoid – machinelike appearance showing no overtly human characteristics; humanoid – appearance has some simplified human characteristics such as outer extremities or facial features; and android – appearance is as close to human as technically possible (Walters et al., 2008). The definition of the previous terms were adopted from the Walter et al. (2008) study on avoiding the uncanny valley by manipulating robot appearance. In the Walter et al. (2008) study, the research team assessed the personality and appearance of different types of robots by having the robot complete an attention getting task. The personality was manipulated by the voice of the robot and by the way in which the robot moved. The high fidelity robots used a recorded human voice, while the lower fidelity robots used a synthesized voice or a beep. The results found that overall participants preferred the more humanlike robot in terms of appearance and personality.

When it comes to human-robot interactions, the simple appearance of a robot is enough to significantly affect the mood of the interaction. Robots with a more human-like appearance tend to be viewed more favorably in terms of treatment and are viewed as being more competent than mechanical looking robots (Walters et al., 2008). High fidelity androids may also be somewhat immune to the uncanny valley phenomenon. A Rosenthal-von der Putten et al. (2014) study on unscripted human-robot interactions found that only a small percentage (4%) of participants reported any uncanny feelings. The authors proposed two theories as to why this occurred: 1) the authors did not explicitly ask the participants questions regarding their feelings in the post experiment interview and, 2) participants did not experience any negative feelings or, if they did, they were only short term. It is possible that the constant exposure to the android during the experiment was sufficient to significantly enhance the participants' feelings towards the android. The present studies examine this possibility by using research on the mere exposure effect to determine whether or not repeated exposure to an android can significantly reduce uncanny feelings.

Mere Exposure Effect

Previous research has shown that an individual's positive feelings toward a stimulus are enhanced through repeated exposure, which is referred to as the mere exposure effect (Zajonc, 1968). In a seminal study, Robert Zajonc (1968) evaluated ratings of foreign words using a good-bad scale based on the frequency of exposure to the words. In the first experiment, Turkish adjectives were presented to the participant who were then tasked with pronouncing the words as well as rating them on a good-bad scale. The results indicated that words presented more often were rated more positively on the good-bad scale, suggesting that even though participants didn't know the meaning of the word, they could still make an assumption based on the frequency of the word.

To show that the results weren't due to the ease of pronunciation of certain words with a higher frequency, a second experiment was conducted (Zajonc, 1968), during which Turkish adjectives were changed to Chinese characters and there was no pronunciation of the words. The results of study were similar to that of the first experiment; participants viewed words shown more frequently more favorably, thus providing further support for the mere exposure effect hypothesis. More relevant to the present studies, a third experiment examined male faces and manipulated the frequency that they were presented to the participant. The results of the third experiment demonstrated similar favorable ratings based on frequency, although not as prevalent as the previous two experiments (Zajonc, 1968).

Subsequent research has shown that subliminal stimuli produce stronger mere exposure effects than stimuli that are clearly recognized (Bornstein & D'Agostino, 1992). The implications of this research suggest that unknown or unrecognized stimuli presented for longer than just fractions of a second, are able to produce mere exposure effects stronger than if the stimuli were presented for minimal amounts of time. When choosing the duration of exposure, it is important to note that effect size is seen as a function of exposure time (Bornstein, 1989). According to Bornstein (1989) exposure durations of less than one second produced the strongest effects, while anything over one second produced small effects. This effect can also be seen in familiar objects as well; as shown in the Hekkert, Thurgood & Whitfield (2013) study where familiarity was manipulated and mere exposure was controlled. The results of their study demonstrate that even if the objects presented were all familiar, a mere exposure effect can still be seen.

Since the mere exposure effect refers to the increase in positive affect resulting the repeated exposure of otherwise neutral stimuli (Wang & Chang, 2004), in order to bridge the gap between the uncanny valley and the mere exposure effect, it is important to keep the stimuli neutral. The uncanny valley phenomenon is a decrease in positive affect resulting from the presentation of stimuli with a certain level of human likeness, but in order to minimize these effects (and allow more room for mere exposure to take effect), the stimuli must remove the most common amplifiers of the uncanny valley phenomenon; emotion and animation. In 1976, Grush conducted a study that found that positive words were rated as more positive and negative words were rated as more negative after exposure. In the study, participant were presented with five positive words and five negative words of varying exposure. The results indicate that if a negative association with the word is formed, the resulting exposure will lead to increased negative feelings, while the opposite is true with positive words (Grush, 1976). It is believed that this effect can transfer to faces as well, particularly faces showing emotion. In attempt to keep the association with the stimuli neutral for the present study, only neutral expression faces will be used.

The present studies aim to utilize the knowledge from the mere exposure effect to help explain the uncanny valley phenomenon by manipulating the number of times a person is exposed to both robots and virtual characters. Since mere exposure increases positive feeling toward novel stimuli, it is predicted that repeated exposure to virtual characters and robots would decrease uncanny feelings toward them. The studies in the current paper aim to investigate this effect.

Study 1

Study 1 examined the mere exposure effect on virtual characters, robots, and humans by manipulating the number of times participants were exposed to each character. Each test condition within the study had a total of three characters that the participants will be asked to evaluate. Participants were assigned to either two virtual characters and one human or two robots and one human. The human character in each condition was used as a filler in the middle to separate the two other (either virtual or robot) characters. Therefore, the human character was always be the second character displayed, with the order of the other characters counterbalanced (see appendix B for visual representation).

Hypotheses

Based upon the past research on the mere exposure effect, there are three hypotheses for the current study. Previous research involving the mere exposure effect has indicated that a stimuli shown multiple times, enhances an individual's positive feelings towards that stimuli (Zajonc, 1968). The first hypothesis for Study 1 (H1) is that there will be a difference in uncanny ratings between robots and virtual characters presented multiple times, and robots and virtual characters presented only once. Utilizing research on the mere exposure effect, the current study predicts that robots and virtual characters presented multiple times will be rated as significantly less uncanny than robots and virtual characters presented only once.

Hypothesis 2 (H2) for the present study is that there will be a difference in uncanny ratings between virtual characters in both conditions, and robots in both conditions. It is predicted that modern virtual characters will be viewed as significantly less uncanny due in part, to the growing popularity of video games, and as a result, increased exposure to virtual characters. Because of this familiarity and repeated exposure in real life, it is predicted that virtual characters will be rated as significantly less uncanny than robots across all test conditions.

Although a human character will be used as a filler in all test conditions, hypothesis 3 (H3) predicts that there is no difference between the human characters in any condition. Since the uncanny valley phenomenon usually doesn't respond to human faces, uncanny feelings would not exist in the first place for human faces even when participants saw it only once leading to a floor effect. Therefore, it is predicted that repeated exposure will not make any difference for the human face.

While not a factor in the current study, a measure of video game experience will be given at the end of the study. It is predicted that participants with high levels of video game exposure will rate both virtual characters and robots as less uncanny than those with lower levels of video game exposure. To serve as a reminder, uncanny will be operationally defined as any feeling of eeriness or discomfort brought on by the presentation of the virtual characters.

Method

Participants. Fifty seven (*N* = 57) participants were recruited to participate in Study 1 using the psychology subject pool at Arizona State University. All participants were 18 or older and gave informed consent before they were eligible for participation.

Figures 2-7. Stimuli for Study 1 and 2. Left to right, top to bottom: Figure 1: Virtual Character 1, Figure 2: Human Character (Conditions 1 and 3), Figure 3: Virtual Character 2, Figure 4: Android Jules (Robot 1), Figure 5: Human Character (Conditions 2 and 4), Figure 6: Android Geminoid Hi-4 (Robot 2).

Materials. A total of five different images were used to create the four test conditions in the study (see figures 2-7). The images of virtual characters were taken from the concept art of the 2001 film *Final Fantasy: The Spirits Within*, the image of the human was taken from free use stock photos, and the images of the robots were taken from the androids Jules and Geminoid Hi-4 created by David Hanson of Hanson Robotics and Hiroshi Ishiguro of Hiroshi Ishiguro Laboratories respectively. The images used are referred to as faces or characters interchangeably. The images are all headshots taken of the characters showing minimal clothing below the neck.

Procedure. The study was conducted entirely online using the online survey tool Qualtrics (www.qualtrics.com). Participants were able to access the study through the Arizona State University SONA Systems website, which is the main hub for the Psychology 101 participant subject pool. No prerequisites were required for participants to sign up for the study, and they were given class credit for their participation.

After signing up for the study, participants were given immediate access to the study and were asked to complete it in one sitting as the study was not expected to take longer than 20 minutes. The participants were randomly assigned to one of four test conditions in a 2 (Stimuli: Virtual character vs. Robots) X2 (number of presentations: once vs. three times) design: (1) exposure to virtual characters one time (Virtual Characters 1), (2) exposure to virtual characters three times (Virtual Characters 3), (3) exposure to robots one time (Robots 1), and (4) exposure to robots three times (Robots 3). The presentation of the characters in the four test conditions was counterbalanced with the human image serving as a filler to separate the other images. In an attempt to prevent participants from guessing the true purpose of the study, a cover story was employed.

The cover story for the present study stated that the characters being presented have been selected to appear in an advertising campaign, and that the designers would like some initial feedback on the design of the characters. As part of the cover story, participants were asked to rate the skin tone (1 = extremely unrealistic; 7 = extremely realistic), the facial proportions (1 = extremely inaccurate, 7 = extremely accurate), and the eye color (1 = extremely unrealistic; 7 = extremely realistic). To manipulate the number of times a participant was exposed to the images, questions from the cover story were either presented all at once or separated by the same image shown three different times depending on the condition that the participant is assigned to (see appendix B for a visual representation).

Participants assigned to conditions Virtual Characters 1 (condition 1) and Robots 1 (condition 3) were exposed to each stimuli one time; after which they were given all three cover story questions on the same page. Finally, immediately following the cover story questions, participants were asked to rate the eeriness of the image on a separate page as a main DV using a 1-7 Likert Scale (1 = extremely uneerie; 7 = extremely eerie). This process was identical for the three different images used in each of these two test conditions.

Participants assigned to conditions Virtual Characters 3 (condition 2) and Robots 3 (condition 4) were exposed to each stimuli three different times. For these two test conditions, the cover story questions were used to separate the images allowing them to be presented three different times. Participants in these two conditions viewed an image, were asked a cover story question, viewed the same image again, were asked another cover story question, viewed the image a final time, and then asked the last question pertaining to the cover story. Finally, participants were asked to rate the eeriness of the image on a separate page as a main DV using a 1-7 Likert Scale. This process was also identical for the three different images used in each test condition.

At the end of the study standard demographic information was collected including: age, gender, ethnicity, and whether or not the participant is a native English speaker. The participants were also asked to indicate the number of hours they spent each week playing video games: less than 3 hours per week, between 3-7 hours per week, greater than 7 hours per week.

Results

Descriptive Statistics

Eerie

Exposure	Character	Mean	Std. Deviation	N
Once	Robots	4.7143	1.97790	14
	Virtual Characters	4.8667	1.55226	15
	Total	4.7931	1.73985	29
Thrice	Robots	4.9333	1.43759	15
	Virtual Characters	4.6154	1.50214	13
	Total	4.7857	1.44932	28
Total	Robots	4.8276	1.69177	29
	Virtual Characters	4.7500	1.50616	28
	Total	4.7895	1.58944	57

Figure 8. Study 1 Descriptive Statistics for H1 and H2

A 2 (Stimuli: Virtual character vs. Robots) X 2 (once vs. three times) ANOVA was conducted to test H1 and H2 (see figure 10). Levene's test was non-significant indicating homogeneity of variance F (3, 53) = 0.68, p = 0.57. The results of the analysis revealed no significant effect of eeriness ratings on condition between characters presented once (*M* = 4.79, *SD* = 1.74) and characters presented three times (*M* = 4.79, *SD* = 1.45), F (1, 53) = 0.01, p = 0.97, η^2= 0.0001; resulting in a failure to reject the null hypothesis for H1 (see figure 8). The results also revealed no significant difference of eeriness ratings between characters (Robots: *M* = 4.83, *SD* = 1.69; Virtual Characters: *M*

= 4.75, *SD* = 1.51) F (1, 53) = 0.04, p = 0.85, η^2= 0.001; resulting in a failure to reject the null hypothesis for H2. The results yielded a non-significant interaction effect F (1, 53) = 0.30, p = 0.59, η^2= 0.006.

Descriptive Statistics

Eerie

Character	Exposure	Mean	Std. Deviation	N
Robot Human	Once	3.2857	1.20439	14
	Thrice	3.9333	2.28244	15
	Total	3.6207	1.84030	29
Virtual Character Human	Once	4.4000	1.80476	15
	Thrice	4.6923	1.49358	13
	Total	4.5357	1.64389	28
Total	Once	3.8621	1.61961	29
	Thrice	4.2857	1.95992	28
	Total	4.0702	1.79144	57

Figure 9. Study 1 Human Character Descriptive Statistics for H3

Since the uncanny valley phenomenon traditionally doesn't apply to human faces, a 2 X 2 ANOVA was conducted to analyze any differences in the human character across all test conditions in order to test H3 (see figure 10). Levene's test was significant indicating the assumption of homogeneity of variance was violated, F (3, 53) = 3.72, p = 0.03. In partial support of H3, the results of the analysis revealed no significant difference of eeriness ratings between human characters presented once (*M* = 3.86, *SD* = 1.62) and human characters presented three times (*M* = 4.29, *SD* = 1.96), F (1, 53) = 1.01, p = 0.32, η^2= 0.02. In further support of H3, the results also revealed a non-significant interaction effect F (1, 53) = 0.15, p = 0.71, η^2= 0.003. However, the results revealed an unexpected significant difference of eeriness ratings on condition between human characters in conditions 3 and 4 (conditions with robots as stimuli: *M* = 3.62, *SD*

= 1.84) and human characters in conditions 1 and 2 (conditions with virtual characters as stimuli: *M* = 4.50, *SD* = 1.64), F (1, 53) = 4.02, p = 0.05, η^2= 0.07, r = 0.3.

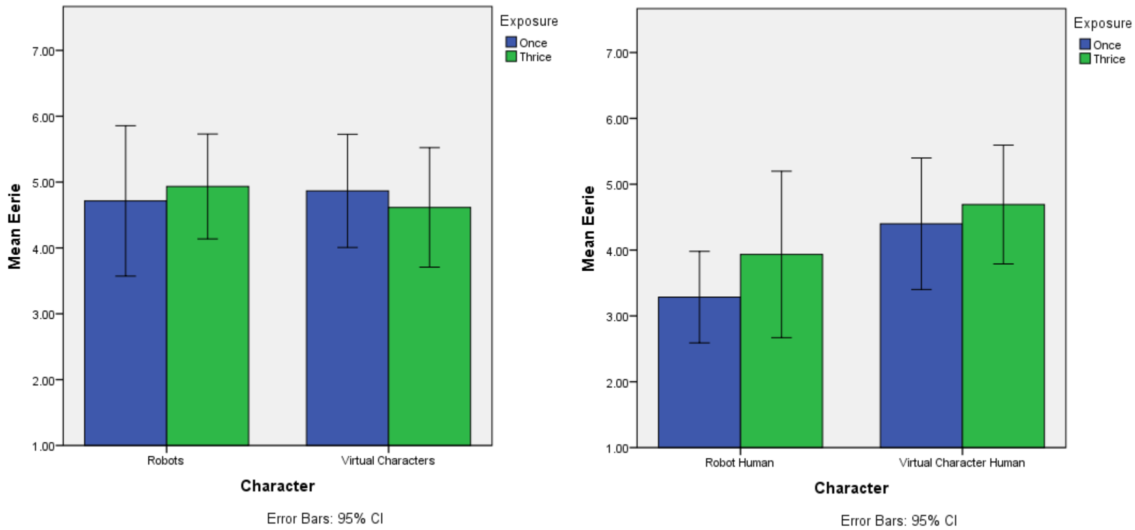

Figure 10. Study 1 Graph of the Means. 1 = Extremely Uneerie, 7 = Extremely Eerie

Discussion

Study 1 examined high fidelity virtual characters and robots in order to assess the relationship between the uncanny valley phenomenon and exposure. Analysis of the results revealed no significant differences between eeriness ratings across all test conditions. While small differences can be seen between test conditions (see figure 8), the data does not indicate any specific trend. The cause of the non-significant data is believed to be due to the narrow focus of Study 1. Since there is little systematic research examining the relationship between the mere exposure effect and the uncanny valley phenomenon, Study 1 only focused on one specific test condition; Robots vs. Virtual characters using a human character to separate the other images. Confounding effects within the design may have reduced the ability to see any significant differences caused by the manipulation as revealed by the analysis. Confounding effects may have also caused the unexpected significant difference between characters (robot human and virtual human) across exposure conditions (1 vs. 3 times exposure). In order to reexamine the relationship between the mere exposure effect and the uncanny valley phenomenon, Study 2 was conducted taking a broader approach to examining the relationship and using a more refined methodology.

Study 2

To further explore the relationship between the uncanny valley phenomenon and mere exposure, Study 2 was conducted using refined methodology from Study 1. While study one looked at a specific instance of the possible relationship between these two phenomena, Study 2 takes a broader approach with the use of a Latin Square design. While Study 1 always had the human character in the middle of the other two images (position 2), the Latin Square design will allow Study 2 to have the human character evenly represented in positions one, two, and three (see Appendix C for visual representation). This will allow Study 2 to study the relationship between the mere exposure effect and the uncanny valley in a broader sense--by eliminating some of the confounding effects found in Study 1, and allowing the human character to be freely randomized. Identical to Study 1, participants were randomly assigned to a condition with either two virtual characters and one human, or two robots and one human. Unlike Study 1, the presentation order of the characters in each condition for Study 2 is completely randomized according to the Latin Square design.

Hypotheses

The hypotheses for Study 2 are identical to study 1. Since the study takes a broader approach to examining the relationship between mere exposure and the uncanny valley phenomenon, the same hypotheses will be used as predictions of the outcome of Study 2:

H1: there will be a difference in uncanny ratings between robots and virtual characters presented multiple times, and robots and virtual characters presented only once.

H2: that there will be a difference in uncanny ratings between virtual characters in both conditions, and robots in both conditions.

H3: there will be no difference between the human characters in any condition.

It has been well documented that mere exposure can result in an increase in positive affect towards neutral stimuli; therefore H1 predicts that there will be a significant difference in uncanny ratings between characters shown three times and characters shown only once (Wang & Chang, 2004).

Due to the rising popularity of video games and virtual media, and as a result increased exposure, H2 predicts that there will be a significant difference between virtual characters in both conditions and robots in both conditions.

The human character used for Study 2 is an unaltered human face expressing a neutral expression. Since the uncanny valley phenomenon traditionally doesn’t apply to human faces, in support of H3, it is predicted that there will be no significant difference between the human characters across all test conditions.

Method

Participants. One hundred (N = 100) participants were recruited to participate in Study 1 using the psychology subject pool at Arizona State University. All participants were 18 or older and gave informed consent before they were eligible for participation. Participants were not eligible to participate if they had taken part in Study 1. Participants were given class credit for their time.

Materials. Identical to Study 1, a total of five different images were used to create the four test conditions in the study (see figures 2-7). The images of virtual characters were taken from the concept art of the 2001 film *Final Fantasy: The Spirits Within*, the image of the human was taken from free use stock photos, and the images of the robots were taken from the androids Jules and Geminoid Hi-4 created by David Hanson of Hanson Robotics and Hiroshi Ishiguro of Hiroshi Ishiguro Laboratories respectively. The images used will be referred to as faces or characters interchangeably. The images are all headshots taken of the characters showing minimal clothing below the neck.

Procedure. The procedure is identical to that of Study 1, whereas the study will be conducted entirely online using the online survey tool Qualtrics (www.qualtrics.com). Participants for this study were able to access it through the Arizona State University SONA Systems website (SONA). Students enrolled in Psychology 101 are able to access SONA and participate in experiments for class credit. Participants from the psychology subject pool were not eligible to take part in Study 2 if they had previously participated in Study 1.

Once a participant signed up for the study they were given immediate access and asked to complete the study in one sitting. Analysis from Study 1 indicated an average completion time of about five minutes (*M* = 5 minutes 18 seconds). Participants were randomly assigned to one of four test conditions in a 2 (Stimuli: Virtual Character vs. Robot) X 2 (number of presentations: once vs. three times) design: (1) exposure to virtual characters one time (Virtual Characters 1), (2) exposure to virtual characters three times (Virtual Characters 3), (3) exposure to robots one time (Robots 1), and (4) exposure to robots three times (Robots 3). The presentation of the characters in the four test conditions was counterbalanced in accordance with a Latin Square design. In an attempt to prevent participants from guessing the true purpose of the study, a cover story was employed.

The cover story stated that the following faces have been selected to appear in an advertising campaign and the designers would like some initial feedback, your task is to evaluate each of the faces along the following criteria: skin tone, facial proportions, and eye color. All participant ratings pertaining to the cover story were done using 1-7 Likert Scales: skin tone (1 = extremely unrealistic; 7 = extremely realistic), facial proportions (1 = extremely inaccurate, 7 = extremely accurate), and eye color (1 = extremely unrealistic; 7 = extremely realistic). In order to manipulate the number of times a participant is exposed to the images used in Study 2, questions from the cover story were either presented all at once following an image, or used to separate the images by asking one question at a time following an image, thus requiring the image to be shown three different times in order to answer all questions pertaining to the cover story (see appendix B).

Participants assigned to conditions Virtual Characters 1 (condition 1) and Robots 1 (condition 3) were only exposed to each stimuli one time; after which they were given all three cover story questions on the same page. Finally, immediately following all cover story questions, participants were asked to rate the eeriness of the image on a separate page as a main DV using a 1-7 Likert Scale. This process was identical for the three different images used in each of these two test conditions. Due to confounding effects found in Study 1, the direction of the Likert Scale for the eeriness rating was reversed for Study 2; going from 1 = extremely uneerie; 7 = extremely eerie in Study 1, to 1 = extremely eerie; 7 = extremely uneerie in Study 2.

Participants assigned to conditions Virtual Characters 3 (condition 2) and Robots 3 (condition 4) were exposed to each stimuli three different times. For these two test conditions, the cover story questions were used to separate the images allowing them to be presented three different times. Participants in these two conditions viewed an image, were asked a cover story question, viewed the same image again, were asked another cover story question, viewed the image a final time, and then asked the last question pertaining to the cover story. Finally, participants were asked to rate the eeriness of the image on a separate page as a main DV using a 1-7 Likert Scale; the direction of which was also reversed due to confounding effects. This process was also identical for the three different images used in each test condition.

Identical to Study 1, standard demographic information was collected, including: age, gender, ethnicity, and an indication as to whether or not the participant was a native

English speaker. The participants were also asked to indicate the number of hours per week they spent playing video games: less than 3 hours per week, between 3-7 hours per week, greater than 7 hours per week.

Results

Descriptive Statistics

Eerie

Exposure	Character	Mean	Std. Deviation	N
Once	Robots	3.7115	1.29748	26
	Virtual Characters	4.3929	1.23496	28
	Total	4.0648	1.29966	54
Thrice	Robots	3.4091	1.42792	22
	Virtual Characters	4.5625	1.22752	24
	Total	4.0109	1.43561	46
Total	Robots	3.5729	1.35266	48
	Virtual Characters	4.4712	1.22240	52
	Total	4.0400	1.35714	100

Figure 11. Study 2 Descriptive Statistics for H1 and H2

A 2 (Stimuli: Virtual character vs. Robots) X 2 (once vs. three times) ANOVA was conducted to test H1 and H2 (see figure 13). Levene's test was non-significant indicating homogeneity of variance $F(3, 96) = 0.05$, $p = 0.97$. The results of the analysis revealed no significant effect of eeriness ratings on condition between characters presented once ($M = 4.06$, $SD = 1.30$) and characters presented three times ($M = 4.01$, $SD = 1.44$), $F(1, 96) = 0.07$, $p = 0.80$, $\eta^2 = 0.001$; resulting in a failure to reject the null hypothesis for H1. The results also revealed no significant interaction effect $F(1, 96) = 0.83$, $p = 0.37$, $\eta^2 = 0.009$. In support of H2, analysis of the results revealed a significant difference between robots and virtual characters $F(1, 96) = 12.46$, $p = 0.001$, $\eta^2 = 0.115$

(Robots: *M* = 3.57, *SD* = 1.35; Virtual Characters: *M* = 4.50, *SD* = 1.22), with a medium effect size r = 0.34; resulting in a rejection of the null hypothesis (see figure 9).

Descriptive Statistics

Eerie

Exposure	Character	Mean	Std. Deviation	N
Once	Robot Human	3.9231	1.91673	26
	Virtual Character Human	4.3214	1.94467	28
	Total	4.1296	1.92350	54
Thrice	Robot Human	4.0455	1.98752	22
	Virtual Character Human	4.0417	1.39811	24
	Total	4.0435	1.68598	46
Total	Robot Human	3.9792	1.92950	48
	Virtual Character Human	4.1923	1.70396	52
	Total	4.0900	1.80960	100

Figure 12. Study 2 Human Character Descriptive Statistics for H3

A 2 X 2 ANOVA was conducted to analyze any differences in the human character across all test conditions in order to test H3 (see figure 13). Levene's test was non-significant indicating homogeneity of variance F (3, 96) = 2.24, p = 0.09. In support of H3, the results of the analysis revealed no significant difference of eeriness ratings between human characters presented once (*M* = 4.13, *SD* = 1.92) and human characters presented three times (*M* = 4.04, *SD* = 1.69), F (1, 96) = 0.05, p = 0.83, η^2= 0.0001. In further support of H3, the results also revealed no significant difference of eeriness ratings on character between human characters in conditions 3 and 4 (conditions with robots as stimuli: *M* = 3.98, *SD* = 1.93) and human characters in conditions 1 and 2 (conditions with virtual characters as stimuli: *M* = 4.19, *SD* = 1.70), F (1, 96) = 0.29, p = 0.59, η^2= 0.003. The results also revealed no significant interaction effect F (1, 96) = 0.30, p = 0.59, η^2= 0.003.

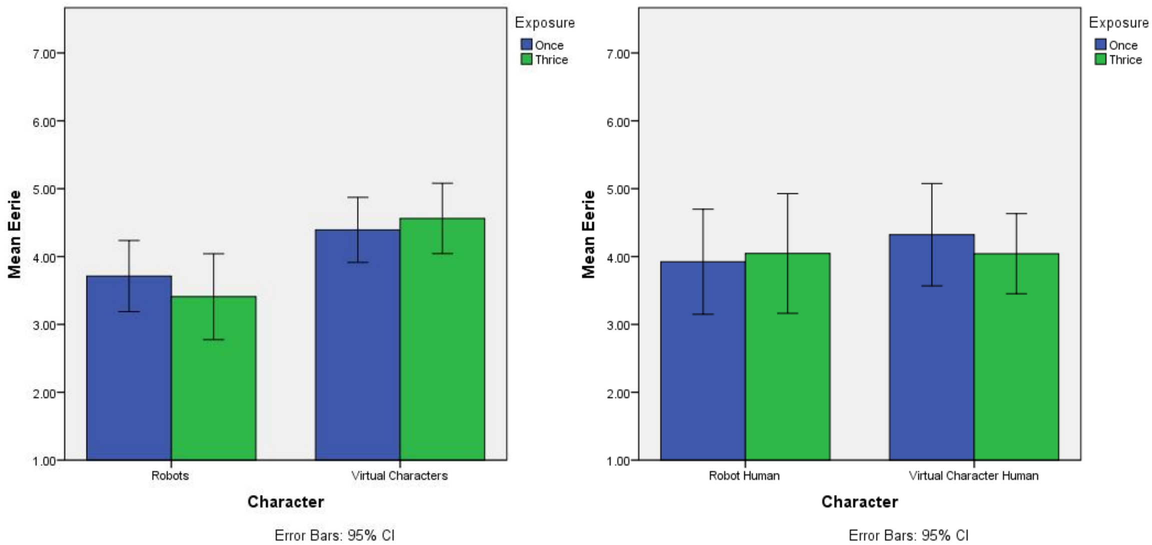

Figure 13. Study 2 Graph of the Means. 1 = Extremely Eerie, 7 = Extremely Uneerie.

Discussion

Using a more refined methodology based on data from Study 1, as well as utilizing a broader approach, Study 2 reexamined the relationship between mere exposure and the uncanny valley. Although a more visible difference can be see between exposure times (see figure 9), analysis of the data revealed no significant main effect of condition. This could be caused by the number of exposures in the study; while three exposures are enough to produce the mere exposure effect, according to Bornstein's 1989 meta-analysis, four exposures is optimal (Bornstein, 1989). Similar to Study 1, the results did not indicate a uniform trend of exposure. Participants who were exposed to the robot characters three times rated their appearance as eerier than participants who were only exposed to the robot characters once. However, participants who were exposed to the virtual characters three times rated their appearance as less eerie than participants who were only exposed to them once.

In support of H2, analysis of the results revealed a significant difference between virtual characters and robots, with robots being rated as significantly eerier than virtual characters across all test conditions. The stimuli chosen for Study 1 and Study 2 were some of the most high fidelity characters availably today in their respective fields, suggesting that virtual characters are able to achieve a significantly higher level of realism than robots; however, this difference could be due to differing technologies used to create high fidelity android robots and high fidelity virtual characters.

In support of H3, data analysis revealed no significant difference between human characters across all test conditions, however, some participants rated the human character as highly uncanny; this is believed to be due to a carryover effect caused by the virtual characters and robots. In order to determine the cause of these differences, future studies must be conducted that remove the human character from the test conditions and test it against virtual characters and robots separately.

General Discussion

Past research shows that stimuli presented multiple times is viewed more favorably than stimuli presented only once, which is evident in conditions involving virtual characters (Zajonc, 1968); however, in the case of robots, it is theorized that mere exposure allowed participants more time to identify potential flaws in the features of the character—resulting in them appearing more eerie. It would seem that eerie or uncanny features in the design of a high fidelity robot or virtual character, are amplified by mere exposure; the significant difference in eeriness ratings between virtual characters and robots provides support for this observation. It's also possible that this effect could be due to the reception of the character itself; Grush (1976) states that if associations are positive in evaluation, then increased exposure should lead to a more positive evaluation, while negative associations should lead to a more negative evaluation with increased exposure. A poor reception of the robot characters could explain why they were rated as eerier with exposure.

Highly advanced virtual characters are created using a game engine, which is software designed to assist in the creation of virtual characters or world (Jacobson & Lewis, 2005). These game engines allow high fidelity virtual characters to be created much faster than their robotic counterparts. This is because the game engine takes on the bulk of the design work and uses previously established graphics and simulation modeling to create these characters within a virtual environment. Android robots however, require physical components and manual labor in order to be created, resulting in a longer creation time; this process could take even longer when having to fix a design flaw. Fixing a design flaw in a virtual character may be as simple as rendering the face a different color, while it may require the replacement of certain parts in robots. This quick turnaround time for virtual characters allows them to keep progressing towards total human likeness at a faster pace than android robots.

While more research needs to be conducted in this particular area, moving forward it can be theorized that high fidelity virtual characters will not fall victim to the uncanny valley, as long as they have no major design flaws. The results of Study 2 suggest that high fidelity humanlike robots are not at a realism level high enough to completely avoid the uncanny valley phenomenon completely.

Future Directions

One of the possible limitations for Study 2 was the number of participants. The Arizona State University subject pool on the polytechnic campus only has around 200 students that are available to participate. Students who participated in Study 1 were not eligible to participate in Study 2 due to the similar nature of the two studies, resulting in a lower number of available participants for Study 2. Future studies in this area will look at larger sample sizes for each study to determine if any other significant effects can be found.

Another limitation may lie within the stimuli themselves. High fidelity virtual characters and robots were used in this study to test the mere exposure effect, but they may have been too real to serve as a starting point for this research topic. In order to continue testing the relationship between the uncanny valley and the mere exposure effect, future studies will use lower fidelity stimuli, opposed to high fidelity stimuli, to examine the relationship.

Analysis of data from both studies indicated that only a small percentage of participants had high exposure to video games (more than 7 hours playing time per week); too small to conduct a sufficient analysis. Given the significant difference between virtual characters and robots, it is believed that video game experience may have played a role in how eerie or uncanny the characters were rated. Future research will look at video game exposure as a main factor in order to determine what that role might be.

Conclusion

Study 2 found a significant difference between virtual characters and robots, and no significant difference between any of the human characters across test conditions as predicted by the hypotheses. While limitations may have masked the true effects of exposure, simple changes to the design process may allow greater visibility of these effects. Moving forward a new baseline should be established for each character that will be used in the study. Using a pilot study to select characters within a range of varying fidelities, would allow for optimum stimulus selection by selecting characters that are rated as highly uncanny.

Choosing the proper human character is vital to establishing a well-defined baseline as well. The human character in the Studies 1 and 2 had a mean eeriness rating of about 4 on a 1-7 Likert Scale (1 = extremely eerie, 7 = extremely uneerie). In order to truly compare the humanlike qualities and levels of realism in robots or virtual characters against a human character, the human character must be on the higher end of the scale (preferably 6 or 7), while the robots and virtual characters must be on the lower end of the scale (preferably 1 or 2). The greater the difference in uncanny ratings between the human character and the robots or virtual characters, the greater the opportunity for mere exposure differences to be seen.

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APPENDIX A

INSTITUIONAL REVIEW BOARD APPROVAL

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EXEMPTION GRANTED

Hyunjin Song
CTI - Cognitive Science Engineering
480/727-1589
Hyunjin.Song@asu.edu

Dear Hyunjin Song:

On 8/28/2014 the ASU IRB reviewed the following protocol:

Type of Review:	Initial Study
Title:	Mere Exposure Effect for Uncanny Feelings in Virtual
Investigator:	Hyunjin Song
IRB ID:	STUDY00001414
Funding:	None
Grant Title:	None
Grant ID:	None
Documents Reviewed:	• Consent Form, Category: Consent Form; • IRB_Uncanny (3).docx, Category: IRB Protocol; • Survey, Category: Measures (Survey questions/Interview questions /interview guides/focus group questions); • Debriefing, Category: Other (to reflect anything not captured above); • Recruitment Statement, Category: Recruitment Materials;

The IRB determined that the protocol is considered exempt pursuant to Federal Regulations 45CFR46 (2) Tests, surveys, interviews, or observation on 8/28/2014.

In conducting this protocol you are required to follow the requirements listed in the INVESTIGATOR MANUAL (HRP-103).

Sincerely,

IRB Administrator
cc:
Christopher Corral

APPENDIX B

STUDY 1 EXAMPLE SURVEY FLOW

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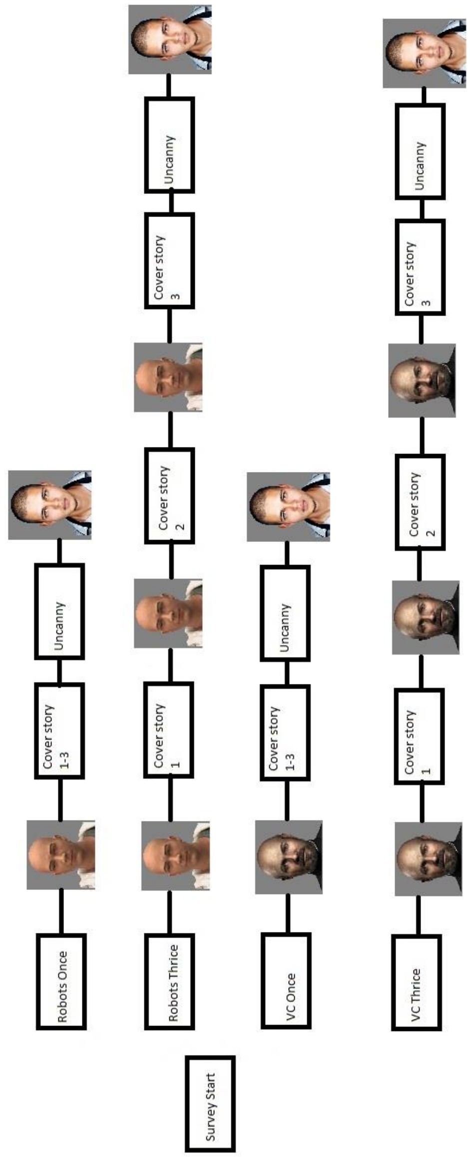

APPENDIX C

STUDY 2 EXAMPLE SURVEY FLOW

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