The Negative Attitudes towards Robots Scale and Reactions to Robot Behaviour in a Live Human-Robot Interaction Study

Dag Sverre Syrdal, Kerstin Dautenhahn, Kheng Lee Koay, Michael L. Walters,[1]

ABSTRACT

This paper describes the use of the Negative Attitudes Towards Robots Scale (NARS) to explain participants' evaluations of robot behaviour styles in a Human-Robot Interaction (HRI) study. Twenty-eight participants interacted with a robot in two experimental conditions in which the robot's behaviour was varied. Reliability analysis and a PCA was performed on the NARS items, creating three new subscales. Correlations between the subscales and other evaluations of the robot's behaviour found meaningful results, supporting the use of the NARS in English speaking samples.

1 INTRODUCTION

The LIREC (LIving with Robots and intEractive Companions) project aims to investigate theoretical aspects of artificial companions and test these across a wide range of embodiments in different contexts and environments [1].

While research in the LIREC project has a strong technological component, the development of tools for standardised measurements of the quality of interactions, perceptions of robots and agents and pre-existing attitudes towards such agents, is very important in order to establish a means of objectively comparing the success of agent and robot behaviour across a wide range of interactions and embodiments.

Dautenhahn [2] suggests that current work in human-robot interaction(HRI) is characterised by heterogeneity, both in terms of methodologies and measurements used to study technologies and their impact. This allows the field of HRI to accumulate a wide range of information regarding the use and perceptions of different robots in different contexts, but also limits the replicability of results across the field as a whole. It is understood that the technology driven nature of the field, and as such, the need to evaluate specific technologies in specific contexts, is a motivating factor for conducting such research. It is, however, important to note that this may become a problem for the HRI community in the long-term as the lack of common benchmarks and measures may hamper communication and application of results across different research groups and projects, and thus the advancement of the field as a whole.

The multidisciplinary nature of the LIREC consortium ,as well as the qualitative differences between agent embodiments and use-contexts across the project, suggests that this issue is not only of particular interest, but also provides a unique opportunity to study the efficacy of measures intended to measure attitudes to robots and their behaviours across diverse situations.

2 THE NEGATIVE ATTITUDES TOWARDS ROBOTS SCALE

In order to establish an understanding of how the behaviour and embodiment factors of a robot are perceived and responded to by potential users, such tools will also be needed to establish an understanding of the idiosyncratic factors in the individual user that may impact on behaviour, as well as subsequent evaluations of a given interaction. We have previously [2-5] suggested that individual differences in terms of underlying personality, gender and demographics may play an important role. However, these effects may not necessarily translate into analogous behaviour across different interactions. Also, measures regarding experience with computers and robots have been used [3, 6]. The results from Walters et al. [6] in particular, suggests that the relationship between individual differences and evaluation of robots and their behaviours can be quite complex. While these measures may provide possible answers to explain participant responses to robots, sometimes they are heavily influenced by the context of use, as suggested by Mutlu & Forlizzi [7]. They found that while overall computer use was not relevant, using computers for playing games did have an impact. As such, pre-existing biases and attitudes towards robots are difficult to extrapolate purely from demographics, personality and a history of technology usage.

One such scale is the Negative Attitudes towards Robots Scale (NARS). The NARS was developed using a lexical method, in which its developers created a scale based on free-form responses from participants regarding anxieties towards robots (Nomura and Kanda 2003). This later formed the NARS

[1]Adaptive Systems Research Group, School of Computer Science, AL10 9AB Email: (d.s.syrdal, k.dautenhahn, k.l.koay, m.l. walters, }@herts.ac.uk.

Table 1 NARS Items with Subscales

Item No.	Questionnaire Item	Sub-Scale
1	I would feel uneasy if robots really had emotions.	S2
2	Something bad might happen if robots developed into living beings.	S2
3	I would feel relaxed talking with robots*	S3
4	I would feel uneasy if I was given a job where I had to use robots.	S1
5	If robots had emotions I would be able to make friends with them.*	S3
6	I feel comforted being with robots that have emotions.*	S3
7	The word “robot” means nothing to me.	S1
8	I would feel nervous operating a robot in front of other people.	S1
9	I would hate the idea that robots or artificial intelligences were making judgements about things.	S1
10	I would feel very nervous just standing in front of a robot.	S1
11	I feel that if I depend on robots too much, something bad might happen.	S2
12	I would feel paranoid talking with a robot.	S1
13	I am concerned that robots would be a bad influence on children.	S2
14	I feel that int the future society will be dominated by robots.	S2

(*inverse item)

Scale, and was used successfully to explain differences in participants' behaviour in live Human-Robot Interaction (HRI) studies [8, 9]. Nomura et al. [10] also examined the relationship between the NARS scale and the Robot Anxiety Scale (RAS) with participants' behaviour in a HRI trial. The NARS has also been proposed as a means of gauging changes in attitudes towards robots over time as a result of prolonged interactions [11]. These possible applications make the use of such a scale interesting for both general HRI research across different robot types, as well as studying how prolonged relationships with robot companions may influence potential users' attitudes towards robots.

The items in the NARS are presented in Table 1, along with the sub-scales they are assigned to. The sub-scales are as follows:

Sub-scale 1: Negative Attitudes toward Situations and Interactions with Robots
Sub-scale 2: Negative Attitudes toward Social Influence of Robots,
Sub-scale 3: Negative Attitudes toward Emotions in Interaction with Robots

An English translation of the items in the scale has been created using appropriate methods of translation and backwards translation to achieve a linguistically valid scale. However, this translation has primarily been used for the purpose of evaluating cultural differences in attitudes towards robots [12]. Findings from these studies have been counter-intuitive, and suggest that Western participants are more well-disposed towards robots than Japanese. Studies using other means of measuring such as Implicit Association Tests and non-standardised Likert-scale questionnaires have provided conflicting results suggesting that Western participants find robots more threatening than their Japanese counterparts [13].

While this issue could be seen as a threat to the overall validity of using the NARS with a non-Japanese population, researchers should also consider some of the inherent dangers of using standardised questionnaires for such cross-cultural evaluations. In the field of individual differences, there exists a body of research that suggests that comparing culturally different samples using only participants' scores on such a scale is problematic. It appears more appropriate to investigate how differences in behaviour or related attitudes within the samples can be explained by such scores [13]. Secondly, while the NARS translation into English is valid from a linguistic perspective, cross-cultural differences not related to language may alter the internal reliability of both the scale as a whole as well as its sub-scales [15]. As such, reliability analysis of both the scale and its sub-scales would be useful when applied to a non-Japanese sample.

This paper describes the use of the NARS in a live HRI study, in order to examine the internal validity of the scale and its sub-scales, and to ascertain if it can account for differences in reactions to a robot's behaviour amongst participants.

Table 2 Robot Behaviour Styles:

Behaviour	Robot A	Robot B
Path	Straight	Circuitous Route with respect to participant’s pose
Speed	Fast	Slow when close to participant
Camera	Static and Forward-facing	Moving and Tracking
Negotiation of Space	“Excuse me”, and continuing as soon as possible	“After you”, continues after participant has moved away
Initiative in Bringing Pen	Does not wait for participant	Waits for participant to look for /ask for pen
Initiative in Delivering Pen	Bringing basket with pen to side of table, close to participant putting it down	Waiting in front of table facing participant, waiting for the participant’s notice, then putting basket down.

3 METHOD

Twenty eight (14 male, 14 female; aged between 18-55) participants were recruited for the study from students and staff at the University of Hertfordshire from a variety of disciplines. These participants took part in two interaction sessions with a robot. The sessions took part in a seminar room that was transformed into a simulated 'living room' for the purpose of this study (Fig. 1). In both interaction sessions, the participants were asked to perform a task which involved moving in a shared space with the robot as well as requiring a pen which was brought to the seated participant by the robot.

The robot's behaviour would differ between the two sessions. These behaviours were labelled Socially Ignorant (A) and Socially Interactive (B). The main differences between these behaviours can be found in table 2, both in terms of shared spaces as well as other interactional differences. The two behaviour styles were defined by the research team in terms of how much the robot adjusted its behaviour to the participant, rather than treating her as any other obstacle in the environment.

Participants were invited to evaluate the robot's behaviour after each interaction session, as well as rate the robot on a personality scale.

The whole experimental session, including the questionnaires took about 45 minutes per participant.

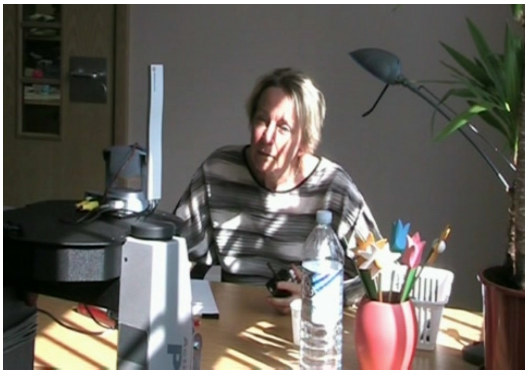

Fig. 1: A participant interacting with a robot, a Peoplebot robot (ActivMedia Robotics).

4 RESULTS

Results from these trials not related to the NARS scale can be found in [16], which discusses the relationship between participant personality traits and those attributed to the robot.

NARS Analysis

After administering the NARS scale to the participants, a reliability analysis using Cronbach's Alpha was performed on the participant's responses, and three items were removed from the analysis. These items were:

- The word 'robot' means nothing to me (S2)
- I would feel nervous operating a robot in front of others (S1)
- I feel that in the future, society will be dominated by robots (S2)

After these items were removed, the revised NARS scale had a Cronbach's Alpha of .80, supporting the notion of the scale as measuring a uni-dimensional construct.

However, [15] suggests that there were some cultural differences in how the scale functioned for a Western European sample. This would make an exploratory Factor Analysis using the Principal Components Analysis (PCA) method appropriate for investigating how attitudes towards robots would load within this sample.

The results from the PCA using the Varimax rotation method are in Table 3.

- **Future/Social influence -** had clear similarities with the Sub-scale 2 reported by Nomura et al.[9]
- **Relational attitudes** - which included items from all of the original Japanese sub-scales.
- **Actual interactions and situations -** shared characteristics with Sub-scale 1 in the original Japanese version (as opposed to the largely hypothetical aspects of the two other sub-scales highlighted by the double loading on one of the items).

Table 3: Subscale loadings

Item	Subscale		
	1	2	3
I feel that if I depend on robots too much, something bad might happen	0.86		
I am concerned that robots would be a bad influence on children	0.65		
I would hate the idea that robots or artificial intelligences were making judgements about things	0.54		
I would feel uneasy if robots really had emotions		0.81	
I feel comforted being with robots that have emotion*		0.79	
I would feel relaxed talking with robots*		0.75	
If robots had emotions I would be able to make friends with them*		0.64	
I would feel paranoid talking with a robot		0.44	
I would feel very nervous just standing in front of a robot			0.79
I would feel uneasy if I was given a job where I had to use robots			0.67
Something bad might happen if robots developed into living beings	0.48		-0.51

*inverse item

While there were similarities between these sub-scales and the original sub-scales reported by Nomura et al. [9], the differences between the two versions were considered large enough to merit the use of these sub-scales in this study.

This use should be considered tentative and was primarily done in order to understand the relationship between responses on the NARS and responses to robot behaviour styles within this sample of participants. It should be considered a response to the results from the Reliability Analysis which suggested differences in how the scale performed when compared to the results from Nomura et al. [9].

The revised NARS, as well as it sub-scales, was then used in a series of correlations in order to examine how they impacted evaluations of the robot's behaviour in each condition across the different types of interactions that took place in the experiment.

Participant Evaluation of Robot Behaviour Style
The evaluations the participants were asked to make were reported ratings on 5-point Likert scales when:

- Comfort for approaching or being approached by the robot.
- Comfort when physically close to the robot.
- Comfort moving in the same room as the robot.
- Comfort interacting with the robot whilst seated at the table.
- Reported overall enjoyment of the interaction.

A series of paired t-tests found that overall there were no significant differences between the two robot behaviour styles in how they were viewed by the sample.

Also, participants were invited to rate the robot according to 12 different traits suggested by Eysenck [17], anxiety, tension, shyness, emotional vulnerability, sociability, general activity level, assertiveness, excitement-seeking, dominance), and aggressiveness, impulsiveness, creativity. Note that some traits were removed from those originally suggested as they were considered unsuitable for describing robot behaviour. In addition, autonomy, controllability, predictability and considerateness were additional traits added. This was based on research that suggested that mental models of robots, while incorporating aspects of how we view humans, also include aspects that are defined by the robots' mechanical nature [18].

The Impact of the NARS
The focus of the subsequent analysis was to investigate if the NARS could be used to differentiate participant evaluation of the robot, both in terms of how participants evaluated the robot's behaviours and how participants attributed personality to the robot.

Evaluating Robot Behaviour Styles
In order to investigate the relationship between NARS scores and post-experimental evaluations of robot behaviour, a series of correlations were run between the NARS and its sub-scales with participant evaluations of the robot's behaviour styles.

The most important trait for evaluating robot behaviour styles within the interaction was the third tentative sub-scale: **Actual Interactions**. In terms of Robot A (Socially Ignorant) it impacted on both Comfort when being physically close to the robot (r*(28)=.448, p=.02*) as well as comfort when approaching or being approached by the robot (*r(28)=.464, p=.01*). For Robot B (Socially Interactive), the **Actual Interactions** sub-scale also impacted Comfort when being physically close to the robot (r*(28)=.442, p=.02*) as well as comfort when approaching or being approached by the robot (*r(28)=.466, p=.01*). It also impacted Comfort when moving in the same room as the robot (*r(28)=.462, p=.01*) and the Overall enjoyment of the interaction (*r(28)=.393, p=.04*)

The Overall NARS scores had no significant relationships with evaluations of Robot A's behaviour. There were however significant relationships between the NARS and Comfort when interacting with the robot while seated at the table (*r=(28)=.425, p=..02*) and Overall enjoyment of the interaction (*r(28)=.383,p=.04)*.
Note that for all these significant correlations a higher score on the NARS or its sub-scale, suggests a less favourable evaluation of the interaction.

Table 4 Correlation between trait attributions and NARS scores for Robot A (Socially Ignorant)

Trait	Overall Nars	Social/Future Implications	Emotional Attitudes	Actual Interac.
Anxiety	r=-.476, p=.010		r=-.436, p=.02	
Tension				
Shyness	r=-.441, p=.02			
Emotional Vulnerability				
Sociability				
General Activity Level				
Assertiveness				
Excitement Seeking	r=-.430, p=.022		r=-.394, p=.04	
Dominance				
Aggressiveness				
Impulsiveness				
Creativity			r=-.377, p=.05	
Autonomy		r=.389, p=.04		
Controllability				
Predictability				
Considerateness				

These results suggest that the NARS differentiated between participant responses to the two different robot behaviour styles. Participants with a higher score on the NARS scale found Robot B's behaviour less comfortable across a wider range of interaction sequences.

Attributing Traits to the Robot

In order to investigate the relationship between participants' NARS scores and how traits were attributed to the robot, a series of tests were run, correlating the NARS and its sub-scales with the different traits. The results from these correlations are shown in tables 4 and 5.

Table 5 Correlations between trait attributions and NARS scores for Robot B (Socially Interactive)

Trait	Overall NARS	Social/Future Implications	Emotional Attitudes	Actual Interac.
Anxiety		r= -.491, p=.01		
Tension				
Shyness		r= -.434, p=.02		
Emotional Vulnerability				
Sociability				
General Activity Level				
Assertiveness				
Excitement Seeking	r= -.446, p=.02			
Dominance				
Aggressiveness				
Impulsiveness				
Creativity				
Autonomy				r=.407, p=.03
Controllability	r= -.402, p=.03		r= -395, p=.04	
Predictability				r= -.384, p=.04
Considerateness				r= -.457, p=.01

Summarising these results presented in table 4 and 5, the NARS and it sub-scales correlate significantly with the traits attributed to both Robot A and Robot B. However, the overall picture emerging from these correlations is less clear than that for the evaluation of the interactions.

In general, it seems that Negative Attitudes Towards Robots Scale and its sub-scales are associated for both robots in terms of seeing the robot as the less anxious, less shy and less excitement seeking. What is more interesting for this particular investigation are the correlations between NARS scores and the robot specific traits. For these traits, the NARS sub-scale of **Actual Interactions** serves to differentiate between how participants attribute traits to the two different robots. Participants having higher scores on the **Actual Interaction** sub-scale tend to rate Robot B as more autonomous, less predictable and less considerate. Also higher **Overall NARS** and **Emotional Attitudes** were associated with seeing Robot B as less Controllable. This relationship is not seen for Robot A.

5 DISCUSSION

The results suggest that using the English translation of the NARS is an appropriate method of investigation prior attitudes towards robots that may impact participant evaluations of robot behaviour styles. After assessing the NARS using the Cronbach's Alpha as a measure of internal consistency, and removing three items, it had a high degree of internal consistency in a sample recruited at a British University. As suggested by Auer et al.[15], when using standardised measures across cultures, certain artefacts that originate in particulars of a given culture may impact both internal consistency as well as the validity of such a measure when applied to other cultures. It is possible that the three items removed may originate in such artefacts, specific to Japanese culture. This can also may serve as a possible explanation as to the differences in how the PCA performed in the responses from this sample described the sub-scales and those suggested by Nomura et al. [9]. We propose that such artefacts, rather than actual differences in cultural attitudes towards robots, may be the cause for the divergence of results from this study with those performed on Japanese samples. MacDorman et al. [13] suggests that these differences are not as pronounced as they are often believed to be.

More importantly however, is the utility of the NARS to explain, and possibly predict, other aspects of how people view and evaluate robot behaviour styles. In terms of differentiating between the two types of robot behaviours in this study, use of the NARS and its sub-scales differentiated between robot behaviour styles, which over the sample as a whole were not evaluated differently. Of particular interest is that higher scores on the NARS and the Actual Interactions sub-scale were associated with a more negative evaluation of the behaviour of Robot B, which was actually intended to act in a more socially appropriate manner.

There may be several reasons for this. One reason may be that this robot was seen as more socially sophisticated and that participants scoring high on the NARS as well as the sub-scale may be more wary of robots displaying a higher degree of sophistication.

Another explanation can be found in relating the trait attributions to these evaluations. It appears that participants with higher scores in the Actual Interactions sub-scale were more likely to rate Robot B as more autonomous, and less predictable. This may have been caused by the robot's behaviour. The behaviours by the socially interactive robot, could by some participants be considered more intrusive. Some of the behaviours of the robot, such as the movement of the camera, responding to the participants presence in terms of movement, waiting for participants to respond before leaving the pen, could have drawn attention to the robot as an autonomous agent within the scenario to a larger extent than Robot B's behaviour. This effect may be analogous as to that reported by Rickenberg & Reeves [19] when examining the impact of the behaviour of an animated character, in which participant evaluation of two differend behavioural styles varied dramatically depending on the participants' locus of control.

6 CONCLUSIONS

These results suggest that the Negative Attitudes towards Robots Scale may be susceptible to cultural differences. This may necessitate that research using this scale on a population outside of Japan may need to re-validate the scale and its sub-scales. However, our research also validates the value of the NARS as a means of explaining variance within a given sample in terms of evaluations of robot behaviour styles in a live HRI trial. Both the NARS and its sub-scales had an impact, not only on how participants evaluated their interactions with the robot, but also had some power to explain how participants differentiated between the two different robot behaviour styles. Negative Attitudes towards robots tended be associated with more negative evaluations of the behaviour of robot B (Socially Interactive behaviour style).

Of particular interest here, is that the sub-scale that had the strongest relationship with evaluations, **Actual Interactions**, might be considered to be related to the notion of robot anxiety as described in [11] as these items do refer to anxieties in actual interactions.

We would however, like to qualify the results from the PCA, as the number of participants was quite low due to resource constraints when running a live HRI experiments (the current study already took 2 months with daily HRI trials). However, this does not invalidate the meaningful relationships between at least one of the sub-scales and participant evaluations of the robots behaviour that were found.

7 ACKNOWLEDGEMENTS

We would like to thank our colleague Christina Kaouri for her help in setting up and running the experiments. The work described in this paper was conducted within the EU Integrated Projects, COGNIRON ("The Cognitive Robot Companion") and LIREC (LIving with Robots and integrated Companions). Funded by the European Commission under FP6-IST and FP7-ICT under contracts FP6-002020 and FP7-215554.

8 REFERENCES

[1] LIREC, http://www.lirec.org, 2008.

[2] K. Dautenhahn, "Methodologies and Themes of Human-Robot Interaction - A Growing Research Field," *International Journal of Advanced Robotics Systems*, vol. 4, pp. 103-108, 2007.

[3] D. S. Syrdal, K. Dautenhahn, S. Woods, M. Walters, and K. L. Koay, "Looking Good? Appearance Preferences and Robot Personality Inferences at Zero Acquaintance," *Multidisciplinary Collaboration for Socially Assistive Robotics: Papers from the AAAI Spring Symposium -Technical Report SS-07-07*, pp. 86-92, 2007.

[4] D. S. Syrdal, K. Dautenhahn, S. Woods, M. L. Walters, and K. L. Koay, "'Doing the right thing wrong' – Personality and tolerance to uncomfortable robot approaches," *Proc. 15th IEEE International Workshop on Robot and Human Interactive Communication(RO-MAN 2006)*, pp. 183-188, 2006.

[5] D. S. Syrdal, K.-L. Koay, M. L. Walters, and K. Dautenhahn, "A personalised robot companion? The role of individual differences on spatial preferences in HRI scenarios.," *IEEE International Symposium on Robot and Human Interactive Communication(Ro-man), Jeju Island, Korea*, 2007.

[6] M. Walters, D. S. Syrdal, K. Dautenhahn, R. T. Boekhorst, K. L. Koay, and S. Woods, "Avoiding the Uncanny Valley – Robot Appearance, Personality and Consistency of Behavior in an Attention-Seeking Home Scenario for a Robot Companion," *Autonomous Robots*, vol. 24, pp. 159-178, 2008.

[7] B. Mutlu, J. Forlizzi, and J. Hodgins, "A Storytelling Robot: Modeling and Evaluation of Human-like Gaze Behavior," presented at Humanoid Robots, 2006 6th IEEE-RAS International Conference on, 2006.

[8] T. Nomura, T. Kanda, T. Suzuki, and K. Kato, "Psychology in Human-Robot Communication: An Attempt through Investigation of Negative Attitudes and Anxiety toward Robots," *Proc. 2004 IEEE International Workshop on Robot and Human Interactive Interactive Communication, Kurashiki, Okayama Japan, September 20-22, 2004*, pp. 35-40, 2004.

[9] T. Nomura, T. Kanda, and Y. Suzuki, "Experimental Investigation into Influence of Negative Attitudes toward Robots on Human-Robot Interaction," *AI&Society*, vol. 20, 2006.

[10] T. Nomura, T. Suzuki, T. Kanda, and K. Kato, "Altered attitudes of people toward robots: Investigation through the Negative Attitudes toward Robots Scale," *Proc. AAAI-06 Workshop on Human Implications of Human-Robot Interaction*, pp. 29-35, 2006.

[11] T. Nomura, T. Kanda, T. Suzuki, and K. Kato, "Prediction of Human Behavior in Human--Robot Interaction Using Psychological Scales for Anxiety and Negative Attitudes Toward Robots," *Robotics, IEEE Transactions on*, vol. 24, pp. 442, 2008.

[12] C. Bartneck, T. Nomura, T. Kanda, T. Suzuki, and K. Kennsuke, "A cross-cultural study on attitudes towards robots.," *Proceedings of the HCI International 2005, Las Vegas.*, 2005.

[13] K. F. MacDorman, S. K. Vasudevan, and C.-C. Ho, "Does Japan really have robot mania? Comparing attitudes by implicit and explicit measures," *AI & Society*, vol. 23, pp. 485-510, 2009.

[14] G. Matthews, I. J. Deary, and M. C. Whiteman, *Personality Traits*. Cambridge, UK: Cambridge University Press, 2003.

[15] S. Auer, H. Hampel, H.-J. Möller, and B. Reisberg, "Translations of Measurements and Scales: Opportunities and Diversities," *International Psychogeriatrics*, vol. 12, pp. 391-394, 2000.

[16] S. Woods, K. Dautenhahn, C. Kaouri, R. te Boekhorst, K. L. Koay, and M. Walters, "Are Robots Like People? - The Role of Subject and Robot Personality Traits in Human-Robot Interaction Trials," *Interaction Studies.*, vol. 8, pp. 281-305, 2007.

[17] Eysenck, H. J., & Eysenck, M. W. (1985). *Personality and individual differences: A natural science approach*. New York, USA: Plenum.

[18] S. Kiesler and J. Goetz, "Mental Models and Cooperation with Robotic Assistants," *Proceedings of the ACM CHI'02 Conference on Human Factors in Computing Systems*, pp. 576–577., 2002

[19] R. Rickenberg and B. Reeves, "The Effects of Animated Characters on Anxiety, Task Performance, and Evaluations of User Interfaces.," *Proceedings of the ACM CHI 2000 Human Factors in Computing Systems Conference.*, pp. 49-56., 2000.