The Less You Look the More You Get: Designing Gaze Avoidance in Human-Robot Interaction

Jung Ju Choi[1], Yunkyung Kim[2], Sonya S. Kwak[3*]

[1] Department of Industrial Design, Ewha Womans University, Seoul, Korea
[2] Department of Industrial Design, KAIST, Daejeon, Korea
[3] Department of Industrial Design, Ewha Womans University, Seoul, Korea

Background Gaze avoidance is usually perceived as having the intention to escape from an embarrassing situation in a human-human interaction. This study explores whether gaze avoidance by a robot can deliver an intention, and whether this intention can make a robot be perceived as sociable and intelligent.

Methods We executed a 2 (question type: normal vs. embarrassing) x 2 (gaze type: gaze vs. gaze avoidance) within-participants experiment (N=24).

Results Participants perceived a robot with gaze avoidance as more sociable and intelligent and having intention than a robot that holds its gaze in an embarrassing situation, while in a normal situation, the opposite result was revealed.

Conclusion We investigated the effect of gaze avoidance on a robot's levels of sociability, intelligence, and intentionality. This study provides evidence that gaze avoidance can be used to express social attitudes as well as communicational intentions. Implications for the design of human-robot interactions are discussed.

Keywords Embarrassing Situation, Gaze, Gaze Avoidance, Human-Robot Interaction, Intelligence, Intention, Sociability

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Corresponding author: Sonya S. Kwak (sonakwak@ewha.ac.kr)

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1. Introduction

Because gaze cues play an important role in social communication (Goodwin, 1981), gaze is effectively applied to increase engagement with social robots in the field of Human-Robot Interaction (HRI) design. There are many studies on the topic of social robots with gaze. Mutlu et al. (2006; 2009) proposed effective gaze cues that demonstrate robots' mental states and communicating attention. Moreover, in the study of Ekman and Friesen (1969; 1974), they used glancing as a social cue to increase interaction between human and robot in a guessing-game situation. While various studies have been performed on people's perceptions of robots using gaze, limited work has been done on people's perception of robots in terms of gaze avoidance in an embarrassing situation.

In human-human interaction, gaze avoidance is used as a nonverbal cue to express one's feelings or intentions. Gaze avoidance is effectively applied to increase the engagement of intentionality (Costa et al., 2001). Specifically, gaze avoidance is powerful and distinct in its ability to express people's embarrassment (Keltner & Buswell, 1997). However, gaze avoidance does not always have a positive meaning (Kelly et al., 2009). In a study of Argyle and Dean (1965), they argued that gaze avoidance could cause people to engage less in a communication. Depending on the situations, gaze avoidance could be understood as having intention or having disinterest. Likewise, gaze avoidance can be applied to a robot to express the intentions of a robot in an embarrassing situation.

2. Gaze Cues

Most human communication research on gaze is concerned with the orientation of the eye (Emery, 2000). Eye orientation can convey different social messages, including those interpreted as polite and impolite. Hietanen (2002) argues that facing away can be interpreted as social disinterest. However, in an embarrassing situation, gaze avoidance can be used as a channel to express one's intention to escape from that moment.

2.1. Gaze Cues in Human–Robot Interaction

Gaze is usually recognized as an essential component of human-robot communication. As communicating with a social partner with gaze can make positive impressions, many studies have been conducted on the topic of gaze with robots in the field of HRI (Imai et al., 2002; Sidner et al., 2004). For example, Imai et al. (2002) found that people can precisely interpret a robot's attention using cues from its gaze. Sidner et al. (2004) proposed that a robot's use of gaze and gestures increased people's engagement with them. Although these studies provide some evidence that robot gaze affects people's perception, a study on the effect of the gaze avoidance is lacking.

2.2. Gaze Avoidance in Human–Human Interaction

Gaze avoidance can be used differently depending on the situation. While gaze avoidance is recognized as an impolite and inadequate attitude during a normal conversation, it is perceived as a communicational intention during an embarrassing situation (Keltner & Buswell, 1997). One of the embarrassing situations people experience is when asked to a question that invades their privacy (Keltner & Buswell, 1997). Consistent with this study, nonverbal cue, such as gaze avoidance could be used as a cue to reveal intention and information to others about the mental and emotional states of an individual (Ekman & Friesen, 1969; Zuckerman et al., 1981). Therefore, we assume that if a robot is asked an embarrassing question, gaze avoidance of the robot can be used as a channel to express the robot's

intention to escape from that moment. According to a study by Sohn et al. (2011), a robot with intention can be perceived as more sociable and intelligent.

These analyses led to the following hypotheses:

H1. A robot with gaze avoidance is perceived as more sociable than a robot with gaze in an embarrassing situation while a robot with gaze is perceived as more sociable than a robot with gaze avoidance in a normal situation.

H2. A robot with gaze avoidance is perceived as more intelligent than a robot with gaze in an embarrassing situation while a robot with gaze is perceived as more intelligent than a robot with gaze avoidance in a normal situation.

H3. A robot with gaze avoidance is perceived as having intention than a robot with gaze in an embarrassing situation while a robot with gaze is perceived as having intention than a robot with gaze avoidance in a normal situation.

3. Study Design

We used a 2 (question type: normal vs. embarrassing) x 2 (gaze type: gaze vs. gaze avoidance) within-participants experiment design. The participants were exposed to four robots and answered questions on a survey.

3.1. Participants

As most of university students are familiar with high technology, we recruited twenty-four undergraduate students as participants. Participants' ages are ranged from 22 to 27, and gender was balanced across conditions (Male:11, Female:13). They were fairly well educated on average with the college level. Participants were given a $1 gift certificate.

3.2. Materials

The robot we used in the experiment was the Eye-robot shown in Fig. 1. We constructed four different scenarios. A woman asked the robot either a normal question, "Have you ever had a pet?" or an embarrassing question, "Have you ever lied?" At the end of each question, the robot answered using gaze or gaze avoidance.

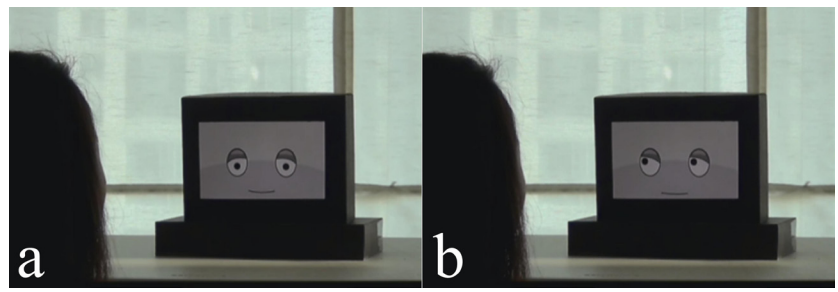


Figure 1 Conditions by the Gaze Type (a: gaze, b: gaze avoidance)

3.3. Procedure

Participants were welcomed to the lab and watched a short introductory video about the function of the robot and about the experiment. They were then shown four videos with different robots in a random order. After the participants saw each video, a questionnaire regarding each stimulus was administered.

3.4. Measures

The post-experimental survey was composed of ten seven-point Likert type items, which were combined into two scales.

(1) Sociability Measures

Sociability was an index of five items (Cronbach's α= .95) which were drawn from Parise et al.'s (1998) research. The five items were "cheerful, friendly, optimistic, warm, and happy."

(2) Intelligence Measures

Intelligence was an index of four items (Cronbach's α= .94), which were drawn from Parise et al.'s (1998) research. The four items were

"knowledgeable, responsible, intelligent, and sensible."

(3) Intentionality Measures

Intentionality was an index of one item (Short et al., 2010). Participants were asked whether gaze or gaze avoidance was interpreted as having intention to escape from a normal or an embarrassing situation.

3.5. Experimental Manipulations

The independent variable question type had two levels: normal question and embarrassing question. Participants watched either the video a woman asked the robot a normal question, "Have you ever had a pet?" or an embarrassing question, "Have you ever lied?" In the questionnaire, participants were asked to indicate whether the question type was either a normal or an embarrassing question using seven-point Likert scale. The differences by the question type were significant (t=-32.95, df=94, p=0.000, one-tailed). Participants who were in a normal situation (M=1.65) rated the question type as a normal question and those who were in an embarrassing situation (M=6.27) rated the question type as an embarrassing question.

The independent variable gaze type had two levels: gaze and gaze avoidance. Participants watched either a robot with gaze or gaze avoidance. In the questionnaire, participants were asked to indicate whether the robot gazed or not using seven-point Likert scale. The differences by gaze conditions were significant (t=-51.29, df=94, p=0.000, one-tailed). About the degree of gaze, participants who were shown a robot with gaze rated higher (M=6.54) than a robot with gaze avoidance (M=1.13).

4. Results

We investigated the effect of the question type and the gaze type on the perception of a robot. Statistical analyses were conducted using analysis of

variance (ANOVA).

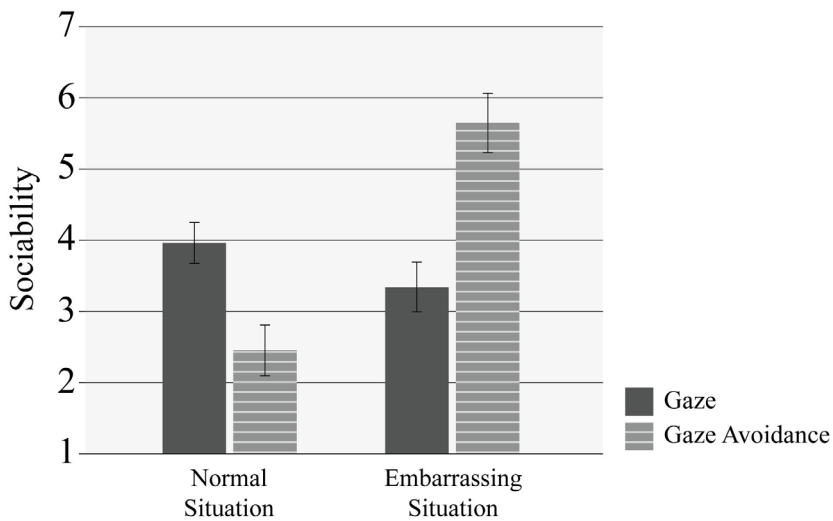
4.1. Sociability

In the case of sociability, as predicted by H1, there was a significant difference depending on the question type and the gaze type ($F(1,23)=124.19$, $p<.001$). Participants evaluated a robot with gaze avoidance in an embarrassing situation (M=5.66, SD=0.83) as the most sociable compared to a robot with gaze in a normal situation (M=3.98, SD=0.58) and a robot with gaze in an embarrassing situation (M=3.32, SD=0.70). The robot with gaze avoidance in a normal situation was evaluated as least sociable (M=2.48, SD=0.72). Table 1 and Fig. 2 show the effect of the question type and the gaze type on the perceived sociability of a robot.

Table 1 The Effect of the Question Type and the Gaze Type on the Perceived Sociability of a Robot

Dependent Measure		Gaze	Gaze Avoidance
Sociability	Normal Situation	3.98*** [.58]	2.48*** [.72]
	Embarrassing Situation	3.32*** [.70]	5.66*** [.83]

Note. The numbers in brackets indicate the standard deviation. ***p<.001



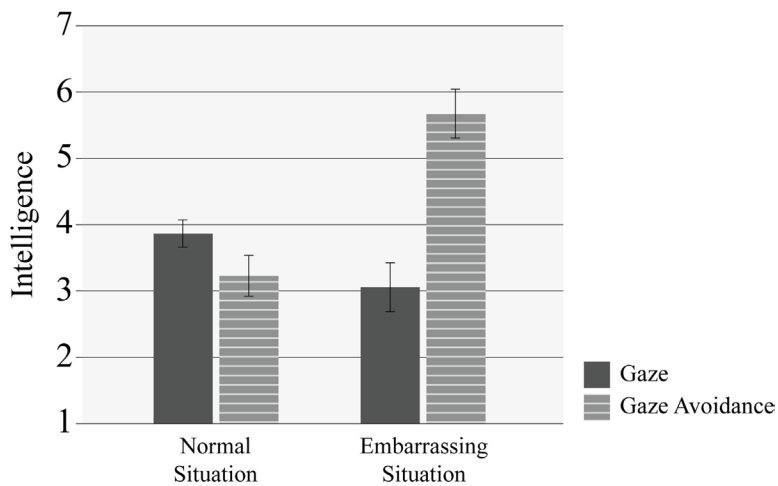
4.2. Intelligence

In the case of intelligence, as predicted by H2, there was a significant difference according to the question type and the gaze type ($F(1,23)=131.23$, $p<.001$). A robot with gaze avoidance in an embarrassing situation ($M=5.68$, $SD=0.74$) was evaluated as more intelligent than a robot with gaze in a normal situation ($M=3.89$, $SD=0.41$) and a robot with gaze avoidance in a normal situation ($M=3.22$, $SD=0.61$). Participants evaluated a robot with gaze in an embarrassing situation as least intelligent ($M=3.06$, $SD=0.74$). Table 2 and Fig. 3 show the effect of the question type and the gaze type on the perceived intelligence of a robot.

Table 2 The Effect of the Question Type and the Gaze Type on the Perceived Intelligence of a Robot

Dependent Measure		Gaze	Gaze Avoidance
Intelligence	Normal Situation	3.89*** [.41]	3.22*** [.61]
	Embarrassing Situation	3.06*** [.74]	5.68*** [.74]

Note. The numbers in brackets indicate the standard deviation. ***p<.001



4.3. Intentionality

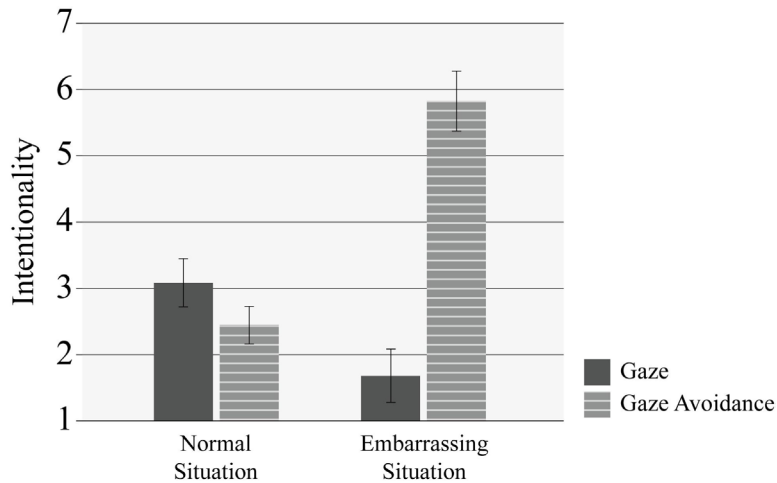
In the case of intentionality, as predicted by H3, there was a significant difference according to the question type and the gaze type ($F(1,23)=279.88$, $p<.001$). A robot with gaze avoidance in an embarrassing situation ($M=5.83$, $SD=0.92$) was evaluated as having more intention than

a robot with gaze in a normal situation (M=3.08, SD=0.78) and a robot with gaze avoidance in a normal situation (M=2.46, SD=0.59). Participants evaluated a robot with gaze in an embarrassing situation as having least intention (M=1.71, SD=0.86). Table 3 and Fig. 4 show the effect of the question type and the gaze type on the perceived intentionality of a robot.

Table 2 The Effect of the Question Type and the Gaze Type on the Perceived Intentionality of a Robot

Dependent Measure		Gaze	Gaze Avoidance
Intentionality	Normal Situation	3.08*** [.78]	2.46*** [.59]
	Embarrassing Situation	1.71*** [.86]	5.83*** [.92]

Note. The numbers in brackets indicate the standard deviation. ***p<.001



5. Discussion

5.1. Summary and Interpretations of Results

All three hypotheses were supported by the data. As predicted by H1, people perceived the robot with gaze avoidance in an embarrassing situation as sociable unlike the robot with gaze avoidance in a normal situation. Gaze avoidance was interpreted as a positive attitude in an embarrassing question

while as a negative attitude in a normal question. This indicates that gaze avoidance can be used differently as a social attitude depending on the situation.

As predicted by H2, people evaluated the robot with gaze avoidance in an embarrassing situation as most intelligent while the robot with gaze in an embarrassing situation as least intelligent. This implies that gaze avoidance had a positive effect on robot intelligence in an embarrassing situation. In addition, while people perceived the robot with gaze avoidance in a normal situation as less sociable than the robot with gaze in an embarrassing situation, the opposite result was revealed in regards to the perceived intelligence of the robot. This informs that even though gaze avoidance could be interpreted as having less sociability, it could be perceived as having intelligence in a normal situation.

Consistent with H3, the robot with gaze avoidance in an embarrassing situation was interpreted as having intention, while a robot with gaze in an embarrassing situation was interpreted as having no intention. This finding indicates that gaze avoidance could be effectively applied to endow a robot with intention.

5.2. Implications for Design

The results of this study have implications for the interaction design of robots. Designing social cue considering the social context is important as the same social cue, such as gaze avoidance is perceived differently by the social context. Gaze avoidance can positively affect robot's sociability and intelligence in an embarrassing situation. On the other hand, in a normal situation, gaze avoidance can be interpreted as having less sociability. Thus, gaze avoidance is desirable when a robot is in an embarrassing situation while it needs to be avoided in a normal situation. Like gaze avoidance, gaze could be differently interpreted by the social context. In a normal situation, gaze can be effectively used as a social cue to increase a perceived sociability and intelligence of a robot. On the contrary, in an embarrassing situation, gaze could be interpreted as having less intelligence and sociability. These findings inform our understanding of how people perceive and interact differently with a robot depending on the situation with the same social cue.

These results suggest that designers of robots should consider not only the gaze type of a robot but also the social context.

In addition, this study showed that gaze avoidance could express intentionality of a robot. A robot makes mistakes due to the limitation of technology. Alleviating these inconveniences is important to sustain users' acceptance of a robot. When a robot is likely to have mistakes, gaze avoidance could be used as a strategic way to reveal the robot intention by minimizing people's dissatisfaction of a robot.

5.3. Limitations

There are several limitations to this study. First, our participant pool was limited to university students. Replicating this study with people of different ages, backgrounds, and cultures is an important next step. Second, the robot in this study was one type of robots. Future studies need to be done using various types of robots. Third, we examined interactions between humans and robots in an experimental room with short-term study. As interactions in more natural settings featuring different tasks may produce different results, future studies need to examine long-term experience in natural settings. While this study provides evidence that gaze and gaze avoidance could be used as social cues for robots, further work with wider social contexts is required.

6. Conclusion

While designers' considerations of emotional and attitudinal cues of robots generally focused on gaze, this study explored the impact of gaze avoidance on people's acceptance of a robot. We compared four different robots with two gaze types and two question types. A robot with gaze avoidance in an embarrassing situation was perceived as sociable and intelligent by delivering an intention to escape from that moment. In addition, gaze

avoidance of a robot was interpreted differently according to the social context: in an embarrassing situation, it was perceived as a sociable and intelligent attitude, while in a normal situation, it was interpreted as an impolite attitude displaying disinterest of a robot. On the contrary, in a normal situation, gaze of a robot was perceived as a sociable and intelligent attitude by showing communicational attention, while in an embarrassing situation, it was perceived as less sociable and intelligent. This study provides evidence that gaze avoidance can be used to express social attitudes as well as communicational intentions.

References

1 Argyle, M., & Dean, J. (1965). Eye-Contact, Distance and Affiliation. *Sociometry 28*(3), 289-304.

2 Costa, M., Dinsbach, W., Manstead, A.S.R., & Bitti, P.E.R. (2001). Social Presence, Embarrassment, and Nonverbal Behavior. *Journal of Nonverbal Behavior, 25*(4), 225-240.

3 Ekman, P., & Friesen, W.V. (1969). Nonverbal Leakage and Clues to Deception. *Psychiatry, 32*, 88-106.

4 Ekman, P., & Friesen, W.V. (1974). Detecting Deception from Body or Face. *Journal of Personality and Social Psychology, 29*, 288-298.

5 Emery, N.J. (2000). The Eyes Have it: The Neuroethology, Function and Evolution of Social Gaze. *Neuroscience and Biobehavioral Reviews, 24*(6), 581-604.

6 Goodwin, C. (1981). *Conversational organization: Interaction between speakers and hearers*. New York: Academic Press.

7 Hietanen, J.K. (2002). Social Attention Orienting Integrates Visual Information from Head and Body Orientation. *Psychological Research, 66*, 174-179.

8 Imai, M., Kanda, T., Ono, T., Ishiguro, H., & Mase, K. (2002). Robot-Mediated Round Table: Analysis of the Effect of Robot's Gaze. *Proceedings of ROMAN* (411-416).

9 Kelly, D., Miellet, S., & Caldara, R. (2009). Cultural Diversity in Eye Movements Extends Across Biological and Artificial Visual Categories. *Journal of Vision, 9*(8), Article 376.

10 Keltner, D., & Buswell, B.N. (1997). Embarrassment: Its Distinct Form and Appeasement Functions. *Psychological Bulletin, 122*(3), 250-270.

11 Mutlu, B., Forlizzi, J., & Hodgins, J. (2006). A Story Telling Robot: Modeling and Evaluation of Human-Like Gaze Behavior. *Proceedings of HRI* (518-523).

12 Mutlu, B., Yamaoka, F., Kanda, T., Ishiguro, H., & Hagita, N. (2009). Nonverbal Leakage in Robots: Communication of Intentions through Seemingly Unintentional Behavior. *Proceedings of HRI* (518-523).

13 Parise, S., Kiesler, S., Sproull, L., & Waters, K. (1998). Cooperating with Lifelike Interface Agents. *IBM WRC Technical Report*.

14 Sidner, C., Lee, C., Kidd, C., Lesh, N., & Rich, C. (2004). Explorations in Engagement for Humans and Robots. *Artificial Intelligence, 166*(1-2), 140-164.

15 Short, E., Hart, J., Vu, M., & Scassellati, B. (2010). No Fair!! An Interaction with a Cheating Robot. *Proceedings of HRI* (518-523).

16 Sohn, B., Yoon, J., Woo, J., Kwak, S.S., & Kim, M.S. (2011). Am I Pretty? : The Intention of a Social Robot by Delayed Nod. *RSS Workshop on HRI*.

17 Zuckerman, M., DePaulo, B.M., & Rosenthal, R. (1981). Verbal and nonverbal communication of deception. In L. Berkowitz (Ed.). *Advances in experimental social psychology, 14*, 1-59. New York: Academic Press.