Robot Gaze Does Not Reflexively Cue Human Attention

Henny Admoni, Caroline Bank, Joshua Tan, Mariya Toneva, Brian Scassellati
Yale University

Background

- People are susceptible to low-level attentional influence from directional cues, especially social cues such as human faces and eyes
  - When viewing an image of a person directing their gaze to one side, people reflexively shift their attention in the direction of that gaze, even when following the gaze is explicitly counter to their task (Driver et al., 1999; Friesen, Ristic and Kingstone, 2004; Downing, Dodds and Bray, 2004)
  - Non-social directional symbols, like arrows, elicit weaker attention shifts that may be overcome by top-down motivation (Friesen, Ristic and Kingstone, 2004; Ristic and Kingstone, 2005; but see Tipples, 2008)
- Behavioral evidence suggests people are responsive to robot gaze
  - Infants follow the gaze of "social" robots (Meltzoff, Brooks, Shon and Rao, 2010)
  - Subtle gaze shifts subconsciously influence behavior (Mutlu, Shiwa, Kanda, Ishiguro, Hagita, 2009; Mutlu, Yamaoka, Kanda, Ishiguro, Hagita, 2009)
- We would like to understand what kind of low-level influence robot gaze has on human attention
- We measure reflexive attention shifts using the counterpredictive cueing test to establish an answer to this question:

Problem Statement

Does robot gaze influence low-level reflexive attention, on par with human gaze? Or are robot faces perceived differently from other directional symbols?

Methods

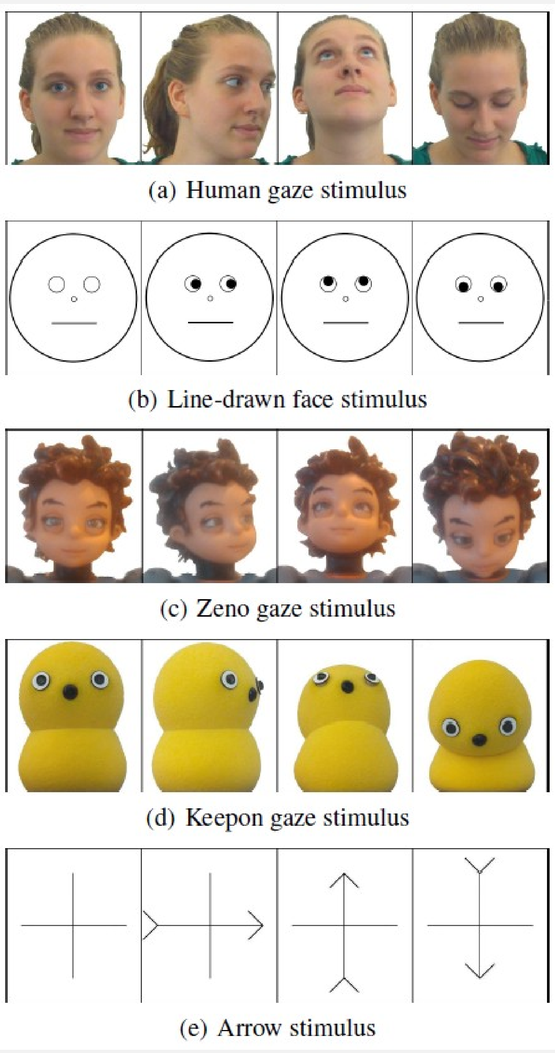

Figure 1: Stimuli

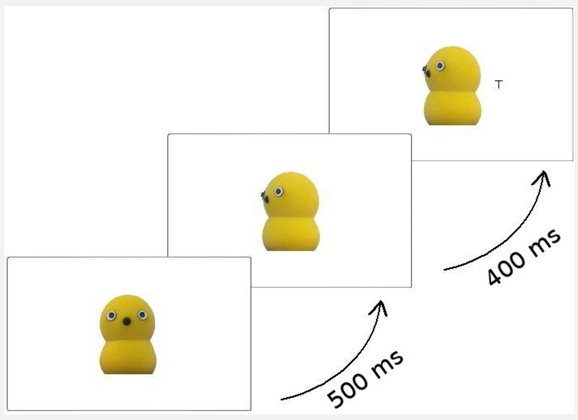

Figure 2: Time course for a single (predicted) trial of the Keepon gaze condition. Setup is similar for other stimuli and gaze directions.

- Stimuli (figure 1) were a human face, a stylized line drawing of a human face (from Friesen et al., 2004), a humanoid robot (Zeno), a less anthropomorphic robot (Keepon), and an arrow
- Robot stimuli were chosen to represent different levels of anthropomorphism
- Human face, line drawing of a face, and an arrow have been used in previous experiments, and were used here as controls

- Counterpredictive cueing experiment, figure 2 (after Friesen et al., 2004):
  - Participants view a frontal image of stimulus followed by an image of that stimulus turned left, right, up or down
  - A probe appears beside the turned stimulus image, either to the left, right, above or below the stimulus
  - Participants identify the probe by pressing a key
  - Key press response times are recorded
- Gaze direction is counterpredictive to probe location: probes appear three times as often in the direction opposite gaze, and equally often in the three other locations; hence, the direction opposite gaze is *predicted*, the direction of the gaze is *cued*, and the other directions are *not-predicted-not-cued* (NPNC)
- Response times (RTs) to probes on the counterpredictive cueing task correlate with attention: shorter RT suggests that attention was directed at the probe's location, whereas longer RT suggests that attention had to be shifted from elsewhere

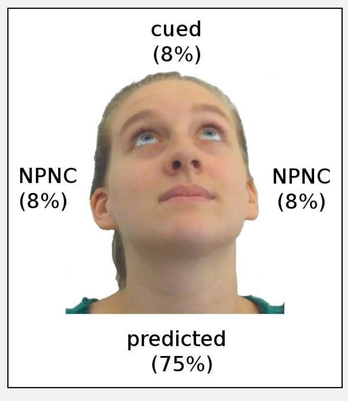

Figure 3: Three types of trials were presented: cued, in which probe and gaze are congruent; predicted, in which probe location is opposite to gaze direction; and not-predicted-not-cued or NPNC, in which probe is on a different axis than gaze. Percentages indicate probability of occurrence.

Results and Discussion

Stimulus	Trial type	Avg. RT (ms)	SD	N
Human	cued	444	46	
	predicted	428	54	15
	NPNC	462	61	
Line	cued	458	73	
	predicted	449	73	16
	NPNC	474	70	
Zeno	cued	473	147	
	predicted	452	108	13
	NPNC	473	116	
Keepon	cued	464	65	
	predicted	428	52	14
	NPNC	469	55	
Arrow	cued	453	66	
	predicted	433	44	12
	NPNC	461	53	

Table 1: Average response times and standard deviations, in milliseconds, for all participants (rounded to the nearest millisecond). Each row represents a stimulus condition separated into trial types. The last column indicates the number of participants in each condition.

- Participants recognized the directional significance of all stimuli, but only responded to the cueing significance of non-robot stimuli
  - For human face, line-drawn face, and arrow stimuli, RTs were statistically faster for predicted trials than for NPNC trials only, indicating that direction of gaze was informative but that the (counterpredictive) cued location attracted some attention
  - For both robot stimuli, response times were statistically faster for predicted than NPNC trials and for predicted than cued trials, indicating an absence of gaze cueing effects
- Participants seem to ignore social content of robot gaze in order to focus on the counterpredictive task, though they do not do so for faces, line drawn faces, or arrows.
- Cueing effect is absent from both robot stimuli, regardless of level of anthropomorphism
- More research is needed to tease apart visual and contextual effects of robot stimuli
- Analyzing cognitive effects of robots on human attention helps cognitive scientists interested in which features cue attention, as well as robot designers interested in creating robots that engage in natural social interactions

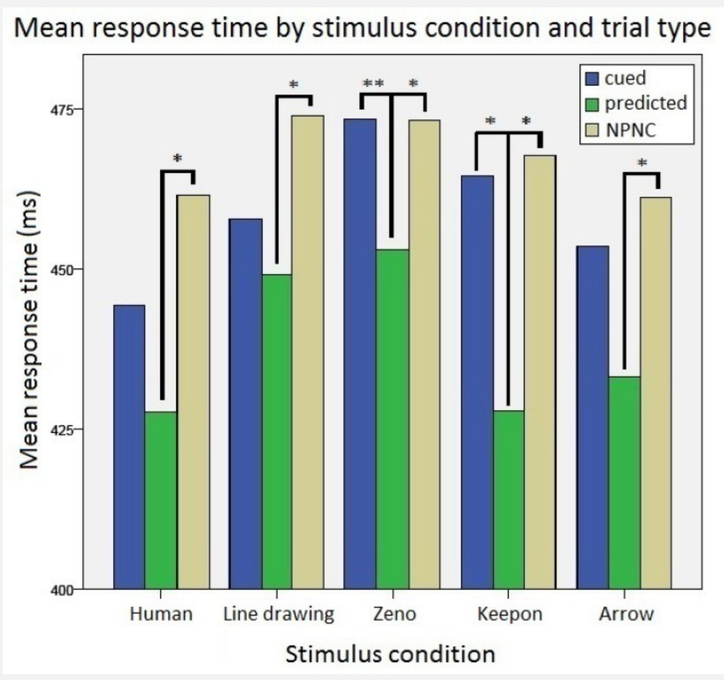

Figure 4: Mean response times in milliseconds for each trial type and stimulus condition. A single asterisk indicates significant differences ($p < 0.05$), a double asterisk indicates borderline significant differences ($p < 0.10$).

Conclusion

- Images of human eyes, faces, and arrows elicit reflexive attentional shifts in viewers, even when this shift is detrimental to viewers' goals
- Robot gaze has been shown to influence high-level behavior, but low-level effects of robot gaze have not previously been examined
- We investigated whether robot gaze would elicit reflexive attention shifts under similar conditions via a counterpredictive cueing experiment
- Stimuli were photo and line drawing schematic of a human face, the faces of two robots at varying levels of anthropomorphism, and an arrow
- Results indicate that robot stimuli failed to evoke low-level attentional cueing present with face and arrow stimuli
- This work examines low-level perceptual effects of robots, and is relevant to the fields of cognitive psychology and human-robot interaction

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References

- Downing, P. E., Dodds, C. M., & Bray, D. (2004). Why does the gaze of others direct visual attention. Visual Cognition, 11(1), 71–79.
- Driver, J., Davis, G., Ricciardelli, P., Kidd, P., Maxwell, E., & Baron-Cohen, S. (1999). Gaze perception triggers reflexive visuospatial orienting. Visual Cognition, 6(5), 509–540.
- Friesen, C. K., Ristic, J., & Kingstone, A. (2004). Attentional effects of counterpredictive gaze and arrow cues. Journal of Experimental Psychology: Human Perception and Performance, 30(2), 319–329.
- Meltzoff, A. N., Brooks, R., Shon, A. P., & Rao, R. P. N. (2010). "Social" robots are psychological agents for infants: A test of gaze following. Neural Networks 23, 966-972.
- Mutlu, B., Shiwa, T., Kanda, T., Ishiguro, H., & Hagita, N. (2009, March). Footing in human-robot conversations: How robots might shape participant roles using gaze cues. In Human robot interactions (HRI'09) (pp. 61–68). La Jolla, California, USA: ACM.
- Mutlu, B., Yamaoka, F., Kanda, T., Ishiguro, H., & Hagita, N. (2009, March). Nonverbal leakage in robots: Communication of intentions through seemingly unintentional behavior. In Human robot interactions (HRI'09). La Jolla, California, USA: ACM.
- Ristic, J., & Kingstone, A. (2005). Taking control of reflexive social attention. Cognition, 94, B55–B65.
- Tipples, J. (2008). Orienting to counterpredictive gaze and arrow cues. Perception and Psychophysics, 70(1), 77–87.