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# Visual Search of Interactive Gaze in a Virtual Environment: Detecting Eye Contact is Faster than Gaze Averting

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**Abstract**

*We often gaze at each other when we communicate with others intimately. A previous study with static stimuli has revealed that perception of others' gaze is asymmetric only when the head is deviated; gazing face target is found faster than averting gaze target. However, the gaze research has been limited to static eye's stimuli, and the perceptual processing of dynamic gaze has not yet been investigated. Therefore, we created dynamic and interactive gaze stimuli of frontal heads in a virtual environment using a head mounted display that can measure eye movements, and conducted visual search experiments. We found that the gaze contacting target presented among gaze averting distractors was detected faster than the gaze averting target among gaze directing distractors. Thus, the detecting eye contact is faster than gaze averting even with frontal faces in dynamic environments, suggesting that dynamic eye contact has a special value for human perception.*

**CCS Concepts**

• ***Human-centered computing*** → ***Virtual reality;***

## 1. Introduction

Eye contact and gaze aversion have special values as social behaviors, and they are important for social communications [Kle86] [BCCKS*95]. Sensitivity to gaze contact appears very early even in newborns [FCSJ02]. Autistic children rarely engage in eye contact, and show gaze aversion [RC76]. Detection of other's gaze is important for us to escape from predators and to communicate with others.

Search asymmetry is reported in detection of human gaze stimuli. A straight gaze target among averted gaze distractors is detected faster than an averted gaze target among straight gaze distractors [vGA95]. In a following study. perception of others' gaze is asymmetric only when the head is deviated; gazing face target is found faster than averting gaze target [CTH*06].

However, these gaze studies have been limited to static eye's stimuli, and the perceptual processing of dynamic gaze has not yet been investigated. Either in real or virtual environments, gaze behaviours including eye contact and gaze averting are dynamic and interactive. Therefore, we created dynamic gaze stimuli in a virtual environment using a head mounted display that can measure eye movements, and conducted visual search experiments. We aimed to investigate human gaze detection behavior for eye contact and gaze aversion using visual search paradigm.

## 2. Methods

### 2.1. Participants

Twenty volunteers participated in the experiment. They had healthy binocular vision. All participants gave written informed consent before the experiment. All the experiments were approved by the Ethical Committee for Human-Subject Research at Toyohashi University of Technology, and all experiments were performed in accordance with the committee's guidelines and regulations.

### 2.2. Apparatus

Visual stimuli were generated and controlled by a computer (Intel Core i7-8700, 3.20GHz, RAM 32.0GB, NVIDIA GeForce GTX 1070 Ti, MS-Windows10, Unity) and presented on a head-mounted display with eye tracking (HTC Vive-based Tobii VR integration: 1080 x 1200 pixel, 90Hz refresh; eye tracking at 120Hz). Participants' head was stabilized with a chinrest, and they observed stimuli with binocular vision.

### 2.3. Stimuli and conditions

Either 4, 8, or 12 faces (male heads of an Asian avatar) were presented at random positions on the display (Figure 1). Their eyes were contingent with participants' gaze. The eye contacting avatar initially looked straight, then made eye contact when the participant looked at him. The gaze aversion avatar initially looked straight,



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then averted the eyes when the participant looked at him. The target was either the eye contacting avatar or the gaze averting avatar, and the distractors were either the gaze aversion or the eye contact, respectively. In the half trials, there was no target. All faces were upright or inverted to test inversion effect. All combination of the conditions (2 type of gaze, 3 levels of the number of faces, 2 orientation, 2 with/without target) were repeated 20 times in a random order (total 480 trials). The trials were blocked by the type of the target.

**Figure 1:** *Example of stimulus (12 upright faces)*

### 2.4. Procedure

Participants were informed of the target type (eye contact or gaze aversion) before each session. They were asked to judge whether the target existed or not by looking at faces as accurately and quickly as possible.

## 3. Results

We conducted three-way repeated measures ANOVA for correct rates. We found a main effect of the orientation ($F(1,19)=10.40$, $p=.0045$), and an interaction of the number of faces x the orientation ($F(2,38)=3.47$, $p=.041$). The upright faces were detected more accurately than the inverted faces, and it was clearer in the case of 8 faces than 12 faces.

We conducted four-way repeated measures ANOVA for reaction times of the correct trials. We found main effects of the existence of target ($F(1,19)=134.29$, $p<.0001$), the type of gaze ($F(1,19)=16.94$, $p=.0006$), the orientation ($F(1,19)=17.97$, $p=.0004$), the number of faces ($F(1,19)=330.56$, $p<.0001$), and interactions of the existence of the target x the type of target ($F(1,19)=6.43$, $p=.020$), the type of the target x the number of faces ($F(2,38)=3.30$, $p=.0475$), the existence of target x the number of faces ($F(2,38)= 113.41$, $p<.0001$), and the orientation x the number of faces ($F(2,38)=3.36$, $p=.0454$).

Thus, both the eye contact and the gaze averting targets were searched serially. The judgment was faster with target than without target, with the eye contact target than the gaze averting target, and with the upright than the inverted faces (Figure 2).

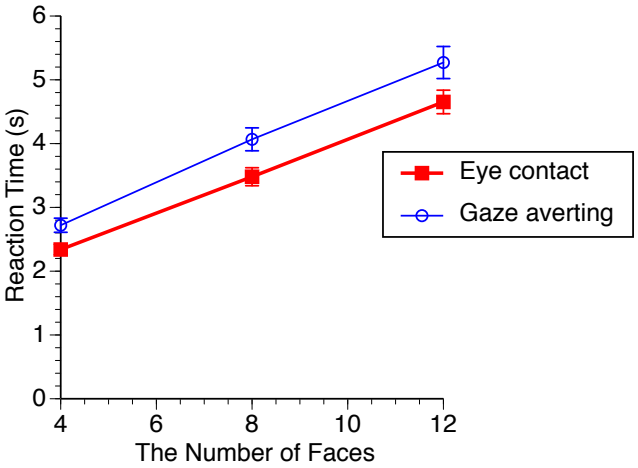


**Figure 2:** *Results of reaction time of the type of target x the number of faces.*

## 4. Discussion and conclusions

We found that the gaze contacting target presented among gaze averting distractors was detected faster than the gaze averting target among gaze directing distractors. Thus, the detection of eye contact is faster than that of gaze averting even with frontal faces in the dynamic and interactive environment. We found a typical face-inversion effect that indicated the advantage of upright faces over the inverted faces. These results suggest that the dynamic eye contact of avatars in virtual environment has a special value for human perception. It should be considered in the case of creating virtual-reality communication using human-like avatars.

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