DOI: 10.7763/IPEDR. 2012. V53. 11

Gaze-evoked Attention Orienting is affected by the Position of Face Stimuli

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Abstract. An uninformative cue by a centrally-presented face gazing to one-location can trigger reflexive shifts of attention toward the location gazed at. In this gaze-cueing paradigm, the variation of face stimuli providing the gaze cue can influence the amount of cueing effect. Therefore, present study is concerned with the influence of position of face stimuli on gaze-cueing effect. The face position was shifted away from the fixation point along the central horizontal or vertical axis. The results showed that the gaze-cueing effect was impaired when the direction of the position shift of the face stimulus matched the gaze direction (e.g., a left face with a left gaze or a right face with a right gaze). The results presented here support the hypothesis that face positions affect gaze-evoked attention orienting.

Keywords: Gaze Perception, Attention, Gaze Cueing, Gaze-Cueing Effect, Attention Orienting.

1. Introduction

The eyes and the surrounding facial region can communicate complex information about people's mental states, such as emotions, intentions, and desires. People tend to automatically orient their attention to the same object that other people are looking at. In behavior studies, the gaze-cueing paradigm, a modification of the traditional spatial cueing paradigm [1] has been used to investigate the precise cognitive mechanisms underlying attention shifts in response to observed gaze direction [2][3]. In these studies, observers were presented with a centrally-presented face cue looking left or right, and after a certain cue-target stimulus onset asynchrony (SOA) were instructed to respond to the appearance of a target to the left or right of the face. Although observers were told that the gaze direction of the face stimulus did not predict where the target would occur, reaction time (RT) was reliably faster when the face's gaze was toward (i.e., cued), rather than away from (i.e., uncued), the target. This facilitation of RT is referred to as gaze-cueing effect, which is considered to be the evidence of attention orienting.

Gaze cueing is considered to be a reflexive and automatic processing for the following reasons. First, gaze-evoked cueing effects emerge rapidly even with short cue-target SOAs [2][4]. Second, those cueing effects arise with short cue-target SOAs even if the subject knows the target will more likely appear in the location opposite the location gazed at [5][6]. It means gaze-evoked attention shift is obligatory and cannot be suppressed. Third, the gaze-cueing effect disappears with long SOAs and even exhibits an inhibition effect with longer SOAs in which reaction time is delayed, rather than facilitated, in the location gazed at [7][8].

Gaze cueing is a robust phenomenon in social cognition, and is modulated by many social signals [9][10]. The studies dealing with attention orienting by social cues like gaze have enriched our knowledge about human behavior. However, it is worth noticing that in most previous studies, the cueing face was presented exactly at the center of the screen. To the best of our knowledge, the influence of face position has not been investigated. In real world situations, we are not limited to perceive a face or a gaze only when it is located exactly at the position of our focal attention. An investigation to the influence of face position on gaze cueing will enrich our knowledge about the interaction between gaze perception and attention orienting in the real world.

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In order to investigate the influence of face position on gaze cueing, face position was shifted horizontally or vertically away from the central fixation point in the present study. Cueing effects induced by one face, located in different positions, were compared to show whether face stimuli presented away from the fixation point could reduce or abolish gaze cueing.

2. Experiment

2.1. Subjects

A total of 18 students (with a mean age of 25 years, range 20 to 34 years, 3 females) consented to participate in two experiments. All subjects reported normal or corrected-to-normal vision and were naive as to the purpose of the experiment.

2.2. Apparatus

The stimuli were presented on a LCD display that was controlled by a video board (Cambridge Research Systems, VSG2/5) using a Dell Pentium computer. An IR CB6 Response Box was used to collect responses from subjects. The subjects were seated approximately 100 cm away from the screen.

2.3. Stimuli

A cross, subtending 0.3◦, was placed at the center of the screen as a fixation point. The target stimulus was a black capital letter ’T’ measuring 0.5◦ wide, 1◦ high, and was presented 10◦ away from the fixation point on the left or right side. The face stimulus, which was similar to the stimulus in the study of Friesen & Kingstone [2], consisted of a light gray background with a black line drawing of a round face subtending 3◦. The face contained two circles representing the eyes, a smaller circle representing the nose and a straight line representing the mouth. The center of the face’s eye region was located at the fixation point for centered faces, and presented 2.5◦ away from the fixation point along central horizontal or vertical axis for all non-centered faces.

2.4. Design

The cue-target SOAs were 100, 300, and 700 ms. On each trial, gaze direction, target location, and SOA duration were selected randomly and equally. Five cue conditions (i.e., face positions) were tested: one face at center; above center; below center; left of center; right of center. The stimuli illustration of these cue conditions can be seen in Fig. 1. The five cue conditions were divided into five blocks. Including 20 training trials, there were total 320 trials for each subject.

2.5. Procedure

Subjects were instructed to keep fixating on the central fixation point. First, a fixation display appeared at the center of the screen for 1000 ms, followed by a blank face at the central area for 1000 ms, and then the pupils appeared within the eyes, so the faces will be looking left or right. After a certain cue-target SOA (100, 300, or 700 ms), a target letter ’T’ showed either at left or right until subjects had responded or 1500 ms had elapsed. Subjects were instructed to indicate whether a target appeared to the left or the right side of the screen by pressing the left button with their left thumb for a target on the left, and the right button with their right thumb for a target on the right as quickly and accurately as possible. Subjects were also informed that the position, or gaze directions of face stimuli did not predict the location in which target would appear, and should be ignored.

2.6. Results

Anticipations (RT is less than 100 ms), incorrect responses (pressed left button for a right target or right button for a left target), and outliers (RT is over 1000 ms) were classified as errors and were excluded from analysis. After that, responses with RTs exceeding plus or minus two standard deviations of subject’s mean RT were also removed as errors. As a result, about 4.7% of all trials were removed. The error rates did not vary systematically and no signs of any speed-accuracy trade-off were observed.

A three-way ANOVA was conducted with face position (one face at center, above center, below center, left of center, and right of center), SOA (100, 300, and 700 ms), and cue validity (cued and uncued) as within-subjects factors. There was a significant main effect of cue validity, *F(1, 17) = 18.417, p < .0001*, indicating gaze-cueing effect that RTs were shorter at cued than at uncued trials. The main effect for SOA was significant, *F(2, 34) = 80.269, p < .0001*, with RTs becoming shorter as the SOA was increased, reflecting a standard foreperiod effect [11]. The interaction between SOA and cue validity was also significant, *F(2, 34) = 7.936, p < .001*, representing that the amount of cueing effects varied with different SOAs. By inspecting the data, it was found that cueing effect appeared at 100 ms SOA (magnitude of cueing effect (mean RTuncued - RTcued) = 13 ms), reached a maximum at 300 ms SOA (18 ms) and decreased at 700 ms SOA (6 ms).

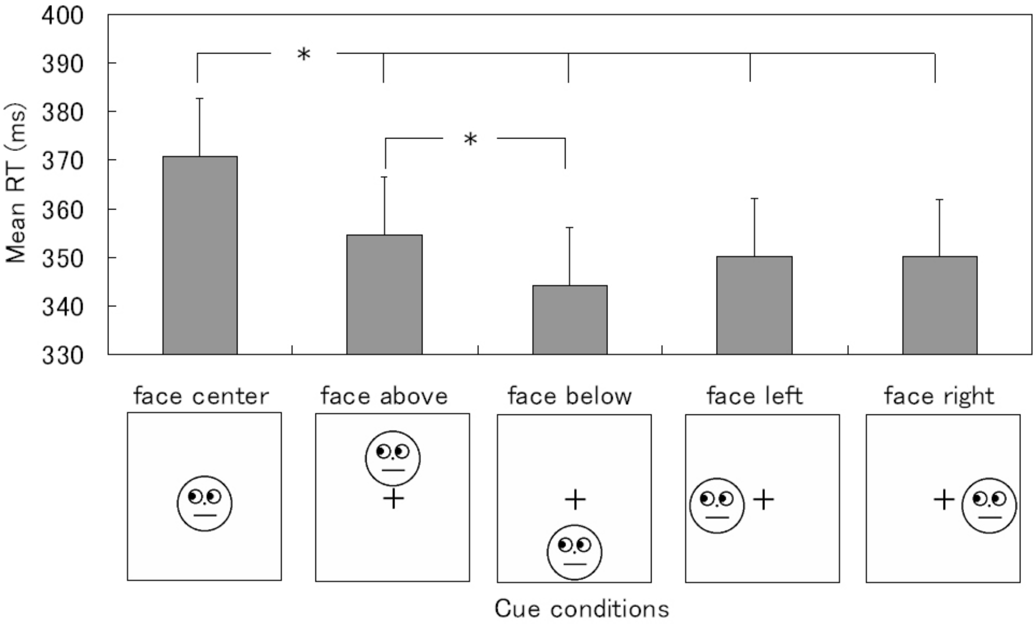

Fig. 1: Mean reaction times (RTs) and stimuli illustration for all cue conditions. Only face stimuli with left gaze were illustrated. The asterisk marks the statistically significant differences (significant level 0.05). Error bars denote standard errors of the mean.

Fig. 2: The magnitude of cueing effects (mean RTuncued - RTcued) as a function of gaze direction (left denoted by black bars and right denoted by gray bars) for all cue conditions. The asterisk marks the statistically significant differences (significant level 0.05). Error bars denote standard errors of the mean.

The face position indicates a main effect on RTs, *F(4, 68) = 6.038, p < .0001*, suggesting that RTs varied as the face positions changed. As can be seen in Fig. 1, the RTs of target detection were significant longer for a central face than that of any other face positions (all *ps < .03*), probably because the central face was presented at the fixation point but other face stimuli were not. In addition, the RTs were significantly longer for face above center than face below center (*p* < *.03*), it is probably due to the fact that we used the center of the face's eye region as the reference point to shift face stimuli, thus causing face above center closer to the fixation point than face below center. These findings about the influence of face position on RTs indicate that subjects need more time to detect target when the face was presented close to or at the observer's fixation point.

The main effect of face position × cue validity interaction was not significant, *F(4, 68) = 0.336, p > .8*, meaning that gaze-cueing effect was not significantly influenced by the variation of face position. However, it is worth noting that the face stimuli had two kinds of gaze directions in this experiment, i.e., left and right gaze directions. In the above analysis, the RTs of two gaze directions in a certain cue condition were combined, thus the influence of gaze direction could not be investigated. It is possible that the interaction of gaze direction and face position had influenced gaze cueing. For example, a left face with a left gaze may induce different gaze-cueing effect from the same face with a right gaze. Therefore, we analyzed each cue condition separately by ANOVAs with gaze direction (left and right) and cue validity as within-subjects factors. As shown in Fig. 2, we found that gaze direction × cue validity interactions were significant for the face left or right of center, *F(1, 17) = 5.134, p < .04*, and *F(1, 17) = 5.853, p < .03*, respectively, reflecting that in these two cue conditions, face stimuli with different gaze directions induced different gaze-cueing effect. Additional analysis revealed that gaze-cueing effect failed to reach significance in the conditions of a left face with a left gaze and a right face with a right gaze (both *ps* > *.6*). These results suggest that gaze-cueing effect was impaired when the direction of face position shift matched the gaze direction.

3. Discussion

There were three key findings. First, the basic gaze cueing pattern was replicated: uninformative gaze direction triggered a rapid shift of attention to the location gazed at. Gaze-evoked cueing effect emerged rapidly at 100 ms SOA, was strong at 300 ms SOA, and decreased at 700 ms SOA.

Second, RTs of target detection were prolonged when the face was presented close to or at the observer's fixation point. This result is consistent with the finding of a previous study [12], which suggests that attention is particularly difficult to disengage from faces. In that study, the presence of an upright face significantly delayed target response times, in comparison with other stimulus categories. The present results give evidence to support Bindemann et al.'s hypothesis [12] and, further, suggest that the distance between the face and the fixation point might strongly influence the time latencies of attention disengagement from faces.

Third, when the face stimulus was shifted perpendicular to the gaze-axis, i.e., face above center and face below center, gaze-cueing effect was not significantly influenced by gaze direction and not significant different from the cueing effect of a central face. On the other hand, gaze-cueing effect was impaired when the direction of face position shift matched the gaze direction. For example, when the gaze cue located left of the fixation point was looking right, the cueing effect was almost the same as that of a gaze cue located at the fixation point. However, if this gaze cue was looking left, contrary to expectation no significant gaze-cueing effect was observed. This is a new finding in the study of gaze cueing. It suggests that when an observer perceives another's averted gaze, the magnitude of gaze-evoked attention orienting is not only correlated with the face per se (e.g., the orientation or emotional expression of the face [4][9]), but also correlated with the face's position within the observer's visual field.

When the face stimulus was shifted along the face's gaze direction (e.g., a left face with a left gaze), the gaze-cueing effect was impaired. This is probably due to the fact that face stimuli have strong influence on observer's attention. Previous studies suggest that attention could be automatically captured [13][14] and held [12] by faces. When a central face with left or right gaze was presented, the face stimuli did not influence the magnitude of cueing effect, because the face's attentional influences were identical for both cued and uncued trials, i.e., they canceled each other. However, when the direction of the face position shift matched the gaze direction, in cued trials, the face stimuli was located between the target and the fixation point, but in uncued trials, there was nothing between the target and the fixation point. As a result, the face stimuli captured and held attention for a while in cued trials, but had no influence on uncued trials. This disparity in influence disrupts the facilitation effect of gaze cue, resulting in the impairment of gaze-cueing effect.

It is still possible that aside from the attentional influence of face stimuli, other factors also contributed to the above observation about the impairment of cueing effect. For example, for a left face stimulus, the distance from the pupils of the face to the central fixation point is relatively longer (though only 0.4◦) when the face is left gazing than when it is right gazing. This difference in the spatial configuration may have made the left gaze of the left face difficult to perceive clearly, resulting in the impairment of cueing effect under these conditions.

In conclusion, the present study investigated the influence of position of face stimuli on gaze-cueing effect. It was found that face position affected gaze cueing. It is clearly important for future studies to take the influence of face position into account in the evaluation of their results. Furthermore, considering that previous studies usually put the face stimuli at the fixation point, which is not always the case in real social interactions, the present study enriches knowledge about the interaction between gaze perception and attention orienting in the real world.

4. Acknowledgements

This research is supported by NSFC (61063027), Applied Basic Research Foundation of Yunnan Province (KKSY201203026), and 2012 Grant-in-Aid of KUT.

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