The Global Precedence in Gaze Direction Perception

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Abstract

Gaze direction can be represented in terms of not only local feature information, i.e., the location of the pupil in the eye socket, but also of the global property determined by the configural relation between the eye region and head context. The present study examined whether global property is preferentially accessed when searching for an oddly-directed gaze. Specifically, we measured the search efficiency for the oddly directed gaze under follwing conditions. In one condition, the gaze direction indicated by the global property contradicts with that indicated by the local feature information. In the other condition, the gaze directions indicated by these types of information are the same. The results demonstrated that the search efficiency was determined by the gaze direction indicated by the global property regardless of that indicated by the local feature information. Moreover, the participants' response was significantly delayed when the global property contradicted with the local feature information.These results indicate the precedence of the global proprty in gaze direction perception, but the elucidation of the underlying perceptual mechanism awaits future research.

Of various social information, the gaze direction is of particular importance for human beings, and the high sensitivity of human visual system to other's gaze direction is clarly illustrated in the fascinating results by von Grunau and Anston(1996) that the straight gaze embedded within the ditractors with averted gaze was searched significantly more efficiently than the target with averted gaze embedded within the distractors with straight gaze.Then, what perceptual mechanism underlies this so-called "a stare in the crowd effect"?

It is well established that the perceived gaze direction changes according to the configurational relation between the eye region and the head context, the facial regions other than the eye region. Thus, what induces a stare in the crowd effect could be either the local feature information extracted from the eye region, i.e. the concentricity of the pupil in the sclera, or the global property, which is determined by the configural relation between the eye region and the head conetxt.

Regarding this issue, Doi and Ueda(2007) recently suggested that the primaty cue that induces the stare in the crowd effect is the global property. However, they did not directly investigate the relative superiority of the global proprty and the local feature information in gaze direction perception.

Therefore, the present study examined whether the perception of local feature information is preceded by that of the global property in judging others' gaze directions. To this end, we measured the search efficiency for the oddly directed gaze under the follwing conditions. In one condition, the gaze direction indicated by the emergent property contradicts with that indicated by the local feature information. In the other condition, the gaze directions indicated by these types of information are the same. If the global property preceds the local feature infromation in gaze direction perception, the search rate should be determined by the
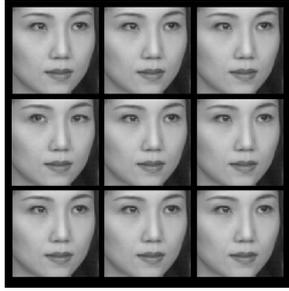
Fig. 1. Example of the stimulus display.

gaze direction indiecated by the global property in both conditions regardless of the gaze direction indicated by the local feature information.

Method

Two males and five females participated in the study. All participants had normal or corrected-to-normal vision, and were naive as to the purpose of this experiment.

Each stimulus consisted of nine gray scale pictures of an identical person. In half of trials in each condition, the model of the face pictures was male, while in the other half of the trials female. Thus, the face pictures of two models were shown in the experiment. The pictures, which subtended a visual angle of approximately 4.3 deg in height and 4.3 deg in width, were arranged in a 3 × 3 matrix. The matrix was centered in the participants' visual field and was displayed against a black background. An example of the stimulus display is shown in Fig. 1.

Each trial began with a 1500 ms fixation cross, which was immediately replaced by a stimulus display. The stimulus display remained on the screen until a response was made. The participants were asked to answer whether there was a discrepant face in the matrix as quickly and accurately as possible by pressing the "L" key when there was a discrepant face and the "S" key when there was not. The response triggered the next trial, and then the whole cycle was repeated. A short break was taken between the two blocks, and eight practice trials were given at the beginning of each block.

On any given trial, the target and the distractors were taken from four pictures of the same individual as shown in Fig. 2. The Type A Eye Region is the eye region with the gaze directed straight toward the viewer, and the Type B Eye Region is the eye region with the gaze slightly averted to the right. Of the two head contexts, the 0 deg head context is the picture of the whole face without the eye region, which is directed straight toward the viewer, while the 15 deg head context is the picture with the face slightly averted to the right. As can be seen from the 2 × 2 matrix in Fig. 2., the gaze direction of the Type A eye region was perceived to be averted when pasted onto 15 deg head context, while it was perceived to be straight when combined with 0 deg head context. Likewise, the gaze direction of the Type B eye region was perceived to be straight when pasted onto the 15 deg head context, while it was perceived to be averted when combined with 0 deg head context.

Therefore, the perceived gaze direction extracted from the global property contradicts with that extracted from the local feature information in 15 deg head context condition, but not in 0 deg head context condition. This means that the global property is consistent with the local feature information in 0 deg head conetxt condition, while these types of information contradict with each other in 15 deg head context condition. The original face pictures were taken from an ATR DB99 database.
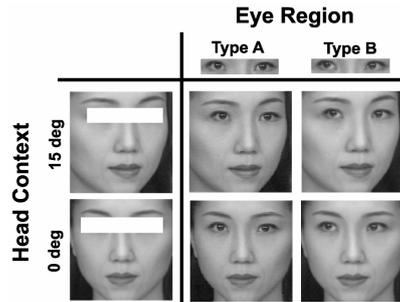
Fig. 2. The exapmles of the stimulus face in each condition.

The visual search task consisted of an equal number of target-present and target-absent trials. In the target-present trials, a discrepant picture was inserted in the 3 × 3 matrix as the target. The target and the eight distractors differed only in the eye region, and the head contexts were the same. For example, if the Type A + 15 deg picture served as the target, then the distractors were the Type B + 15 deg pictures. In the target absent trials, the stimulus display consisted of the same face pictures. Thus, one of the four pictures appeared in every 3 × 3 matrix position in the target-absent trials. The face pictures of the stimulus array were presented either in the original orientation or in the left-right reversed orientation. The orientation was determined randomly at each trial.

The experiment consisted of two blocks, and there were a total of 224 experimental trials to ensure that every condition (Present-Absent (2) × Eye Region (2) × Head Context (2) = 8) was administered 28 times, which were presented pseudo-randomly.

Each trial began with a 1500 ms fixation cross, which was immediately replaced by a stimulus display. The stimulus display remained on the screen until a response was made. The participants were asked to answer whether there was a discrepant face in the matrix as quickly and accurately as possible by pressing the "L" key when there was a discrepant face and the "S" key when there was not. The response triggered the next trial, and then the whole cycle was repeated. A short break was taken between the two blocks, and eight practice trials were given at the beginning of each block.

Results

The averaged RTs in target present condition were derived for each of the four conditions (Eye Region × Head Context) for every participant. The inter-participant means for these median RTs are shown in Fig. 3 together with the standard errors.

Two-way, within-subject analyses of variance were conducted on the RT data for the target-present separately, with the factors of Head Context (2) × Eye Region (2).
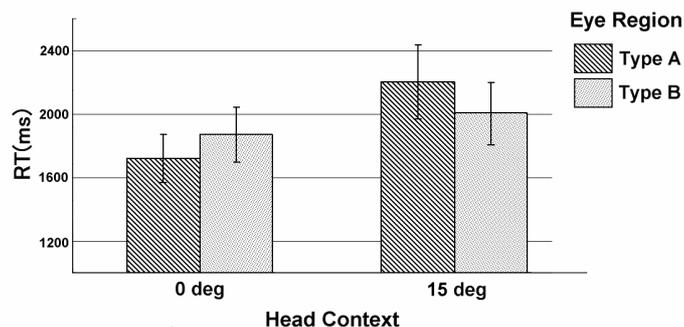

Fig. 3. The averages RTs in each condition. The error bars indicate ±1SE.

ANOVA revealed a significant main effect of Head Context with RTs in 15 deg head context condition being longer than that in 0 deg Head Context condition, $F(1,6) = 14.84$, $p <.05$. This main effect was qualified by a significant interaction between Eye Region and Head Context, $F(1,6) = 7.86$, $p <.05$.

The analysis of simple main effect showed that the search for the target with Type B Eye Region was significantly fater than that for target with Type A Eye Region in 15 deg Head Context condition, $F(1,12) = 4.11$, $p <.05$. Moreover, the simple main effect of Eye Region was marginally significant in 0 deg Head Context: the search for the target with Type A eye region tended to be longer than that for the target with Type B Eye Region, $F(1,12) = 2.34$, $.05 < p < .10$.

Discussion

The present study revealed two important findings. First, in the critical condition where the local feature information and the global property were in conflict with each other, the effect of local feature information was overridden by the global property. More specifically, the search efficiency for target face was faster when the gaze direction was perceived to be straight than when averted regardless of the gaze direction indicated by the local feature information. Second, the participants' response was significantly delayed when the global property contradicted with the local feature information.

There are several tentative hypothetical models of gaze direction perception, which can explain the present results. One possibility is that both local feature information and the global property are accessed simultaneously, and the gaze direction is represented through the competition between them. This model further suggests that the global property dominates the local feature information in the processing stage where the competition between these two types of information takes place. Another possibility is that the local feature information is not accessed at all, and the visual system utilizes only the emergent property of the visual stimuli.

We favor the former explanation on the basis of the finding that the search was significantly slowed when the global property and local feature information were incongruent than when they were congruent. At the same time, the previous study(Busch & Müller, 2004), whcih investigated the search for Müller-Lyer stimuli, showed that the emergent property was accessed quite efficiently with little if ever interference from the context information.Apparently, futher research is required in order to elucidate the underlying mechanism of gaze driection judgment.

Acknowledgements

References

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