Optical insignificance of the nose and the Pinocchio effect in free-scan visual straight-ahead judgments

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We tested whether the retinal projection of the nose was used to reduce error in free-scan judgments of straight-ahead. Subjects set a luminous target straight ahead with no restrictions on eye position. On half the trials, the nose was visible; on the other half, it was not. Nose visibility did not reduce absolute error. To check response measure sensitivity, an external reference condition was added. The two nose conditions were run with no external surrogate reference, or with a reference on the nose, 3/8 of the way between the target and the observer, or directly in front of the target, which was 183 cm from the observer. There was no advantage of a reference on the nose as compared to no reference, and nose visibility did not interact with the surrogate reference condition. However, the external reference became much more effective in reducing absolute error as it approached the target. We called this the Pinocchio effect. It is consistent with the adjacency principle, but its cause is not certain. Most importantly, the Pinocchio effect showed that the null nose result was not simply a matter of an insensitive response measure.

Localizing objects with respect to the self is an overdetermined ability. Absolute retinal location can be processed in combination with extraretinal eye-position information to specify visual direction: the relationship between elements in the ambient array can also specify visual direction (cf. Shebilske, in press). Although relational or higher-order retinal information has many potential sources, few have actually been tested for static judgments of visual direction. The present experiment attempts to test the effectiveness of one possible source of higher-order retinal information, the nose. Specifically, the experiment tests whether the retinal projection of the nose is used in free-scan judgments of straight-ahead.

Bower (1974) prompted the present experiment by suggesting that "all objects that are straight ahead are symmetrically projected onto the retinas with respect to the projection of the nose and regardless of eye position. All objects that are not straight ahead are asymmetrically projected with respect to the nose. The relative symmetry of the projection of an object could thus serve as the stimulus to specify straight ahead" (p. 54). This optically significant nose hypothesis is intriguing for several reasons. First, it suggests that optically degraded contours,

such as those provided by the nose, can be perceptually effective. Second, it implicates a unique form of binocular interaction. The image of a straight-ahead object is to the left of the nose image in the right eye and to the right of the nose image by the same amount in the left eye. This symmetry is not in either retinal pattern alone; therefore, a novel kind of binocular interaction would be required for the nose to be a useful straight-ahead reference. Third, if the nose provides effective relational information, it would represent an interesting deviation from a generalization that holds over a broad range of perceptual phenomena. It is generally the case that the effectiveness of relational information between objects is maximal when objects are in the same plane and reduced when they are separated in depth. Gogel (1970) called this generalization the "adjacency principle." It holds for stereoscopic induction (Gogel, 1972), brightness contrast (e.g. Gogel & Mershon, 1969), and many illusions, including induced movement (Gogel & Koslow, 1972; cf. Gogel, in press, for general discussion). The nose as straight-ahead reference would represent an exception to the adjacency principle, since there is usually a large separation in depth between the nose and objects that are judged.

One can think of reasons why the nose might be an exception to a principle that applies to external objects. Unlike external objects, the nose is almost always present in the ambient array. Furthermore, whenever it is present, it has a simple invariant relationship to straight-ahead, whereas external objects do not. However, evidence is lacking.

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Therefore, the present experiment was designed to determine if the nose was an exception to the adjacency principle. This was done by the factorial combination of two manipulations, one to test the influence of depth separation between an external reference and target and one to test the importance of nose visibility in free-scan straight-ahead judgments.

The procedure was simple. In all conditions, subjects were asked to move a luminous target in the frontal plane until it looked straight ahead of them. The judgments were free-scan, since no restrictions were placed on eye position during the settings. The influence of depth separation was tested with a luminous dowel which served as an external reference. When the dowel was present, it was always straight ahead. The separation in depth between the target and reference was varied by placing the dowel on the nose, 3/8 of the way between the target and the observer, or directly in front of the target plane. Trials without a reference were included as a base-line condition. To test the importance of nose visibility, the nose was visible on half of the trials and not visible on the other half.

METHOD

Subjects

The subjects were 16 undergraduates enrolled in an introductory psychology course at the University of Virginia. None of them wore glasses or contact lenses. They did not know the hypothesis being tested.

Apparatus

A round luminous target with a 2-cm diameter was mounted on a lens holder which slid freely along an optical bench rail. A continuous loop of cord ran through pulleys and allowed the subjects to move the target horizontally in the frontal plane over a range of 1 m. The target was at eye level and viewed at a distance of 183 cm. The position of the target could be read accurately in millimeters which gave units of about 0.04 deg. The head was held by a bite plate containing dental impressions. The plate was attached to a sturdy holder that allowed vernier adjustments of rotation around the mid-body axis and displacements in the X, Y, and Z axis. Thus, the surfaces of the eyes could be put on a line parallel to the target track and at the exact distance, left-right position, and height.

The external straight-ahead reference was a luminous dowel which was 5.13 cm long and .64 cm in diameter. When it was present, it was always at the same height and always straight ahead. The height was set by aligning the top of the dowel with the top of the nose. It was placed either on the nose with transparent tape or at 68.25 or 182 cm in front of the subject. In the latter positions, the top of the dowel was slanted 55° toward the subject to stimulate the angle of the nose.

The nose was illuminated by a 6-V positive-lens bulb. Brightness was adjustable. The light was focused on the nose from 60 cm above and 10 cm in front of the center of the cornea. Black cloth was draped over the subject's shoulders and everything else that might have otherwise reflected light. When the nose was illuminated in this fashion, the subjects reported that they could see their noses, the luminous stimuli, and nothing else. The luminous stimuli were made from luminescent dark-room tape. Overhead room lights recharged the stimuli after each setting while subjects kept their eyes closed. The stimuli were seen clearly by all subjects.

Design and Procedure

Each subject made 32 straight-ahead settings in a within-subject factorial design. One factor was the position of the external reference, which was absent, on the nose, or at 68.25 or 182 cm in front of the subject. The other factor was the visibility of the nose, which was visible on half the trials and not visible on the rest. The factorial combination of external reference and nose variables produced eight conditions. The order of these conditions was balanced across subjects by means of two randomly selected 8 x 8 Latin squares. A subject's score for each condition was based on the average of four consecutive settings. Starting position was controlled in a left, right, right, left order for half the subjects and a right, left, left, right order for the other half. Starting positions were evenly distributed within a range from 20° to 25° from straight-ahead. Minimal light was used during bite plate preparation and instructions in order to help control dark adaptation at the beginning of experimental trials.

On each trial, the task was to set the target so that it looked straight ahead. We told subjects that there were no right or wrong answers; we simply wanted to know how the stimulus looked to them. They were told that the external reference was always straight ahead, but they were neither encouraged nor discouraged from using it. Subjects were free to move the target until they were satisfied that it looked straight ahead. Viewing was binocular, and no restrictions were placed on where subjects looked. They sat back and closed their eyes between each trial, and received no feedback about the accuracy of their responses. The overhead room lights not only recharged the stimuli during trials, but also helped control dark adaptation so that sensitivity was comparable throughout the experiment. Every third or fourth trial, the subjects were asked what they saw. When the nose was not illuminated, the subjects saw only the luminous stimuli; when the nose was illuminated, the subjects saw their noses and the luminous stimuli. If a subject saw anything else, his data were discarded. Some pilot subjects were excluded on these grounds; however, after improvements were made, none of the last 16 subjects had to be excluded. In other words, the experimental subjects were 16 consecutive subjects who saw only what we intended them to see.

RESULTS

The results are given in Figure 1, which shows absolute error in degrees as a function of external reference condition for nose visible and not visible. The overall effect of external reference conditions was highly significant, $F(3,24) = 28.77$, $p < .001$, coming chiefly from the effect of separating the target and reference in depth. The external reference became much more effective in reducing absolute error as the reference approached the target plane. There was a nonsignificant difference [$F(1,45) < 1$] in favor of no reference in comparison to an external reference on the nose. This suggests that an external reference on the nose provides no useful straight-ahead information.

The nose itself showed no advantage over external references. The overall effect of whether or not subjects saw their own noses was not significant [$F(1,195) = 1.66$, $p > .05$], and nose visibility did not interact with external reference conditions [$F(3,45) < 1$]. Apparently, the retinal projection of the nose did not aid the present free-scan judgments of visual straight-ahead.

Figure 1. Absolute error in straight-ahead settings is shown as a function of nose visibility and state of the external reference. The base-line condition of no external reference is shown to the left of the dotted vertical line. To the right of that line is shown the Pinocchio effect, which is created by moving the external reference away from the nose toward the target.

DISCUSSION

One purpose of the present experiment was to test the influence of depth separation between a target and external straight-ahead reference. The results were clear. When an external reference is placed at the same height and direction as the nose, it becomes much more effective in reducing absolute error in free-scan judgments of visual straight-ahead as the reference approaches the target. We call this the Pinocchio effect because our manipulation brought to mind Collodi's famous character who would have been a natural for this experiment. We could have fastened the external reference to his nose and had the reference approach the target by increasing the lies that he told.

Although the depth manipulation was suggested by the adjacency principle, the effect should have a separate identity, because it might not have the same explanation as the other phenomena that are consistent with the adjacency principle. There are many factors correlated with differing depths in the present study. For example, contours were less blurred, the angular separation of binocular images decreased, and the subjects may have been more likely to adopt an aligning strategy when the reference approached the target. Gogel (in press) argues that *perceived* separation is important in explaining the adjacency principle. That may or may not be true in explaining the Pinocchio effect.

The Pinocchio effect refers to the influence of depth separation on an external straight-ahead

reference which is placed at the same height and direction as the nose. It does not refer to the effect of a human nose. However, the Pinocchio effect is relevant in testing the optically significant nose hypothesis. At the very least, the surrogate nose manipulation provides a check on the sensitivity of the response measure used to test the influence of nose visibility. If and when nose effects are found, it will provide versatility in the kinds of manipulations that can be done to test the relevant optical parameters.

In the present experiment, the Pinocchio effect showed that the response measure was sensitive to changes in a straight-ahead reference, yet the visibility of the nose was not important. Bower (1974) argued that "the location of objects relative to the observer is possible only if the observer can see himself and the object to be located . . . the retinal projection of the nose and orbit specify the observer's position to himself. If this information is available, position perception will be accurate. If it is not available, position perception will be inaccurate" (p. 51). The present results, although limited in scope, suggest that Bower's proposition must be qualified.

The present results are restricted to specific conditions, while Bower (1974) musters a surprising number of phenomena that are consistent with the optically significant nose hypothesis. This might create the impression that the weight of empirical evidence favors the nose hypothesis. In fact, more direct tests are required before the balance of evidence can be properly evaluated, because the indirect evidence cited by Bower is open to other interpretations, as follows:

(1) The autokinetic effect vanishes when a black spot is viewed in homogeneous light by an observer who can see himself. This could happen because the observer sees his nose, as Bower claims, or it could happen because some surface texture is present in the homogeneous field. Gibson (1954) notes that even the slightest visibility of room surfaces will destroy the autokinetic effect. It could also be that visible nose and orbits do not provide direction information *per se*, but they reduce the autokinetic effect by reducing eye movements that are associated with the autokinetic effect (e.g., Matin & MacKinnon, 1964).

(2) In reduced cue situations where the nose is not visible, there is no position constancy for tracking eye movements (Stoper, 1967). Although this is consistent with the nose hypothesis, it is misleading to single out this one reduced cue experiment. Stoper's procedure was a modified version of a method developed by Matin and his co-workers (cf. Matin, 1972), which showed that there is a high degree of visual direction constancy for saccadic eye movements in reduced cue fields. In addition, Matin (1972) showed that Stoper's failure to find constancy

may be owing to an insufficient interval between the standard and comparison stimuli.

(3) In the case of squint, patients sometimes see the same objects in the same place even though the foveas of the two eyes are pointed in different directions. Bower claims that this could only be possible if "the information specifying distal position is site of stimulation on the retina relative to site of the retinal stimulation produced by the self" (p. 56). The double vision that often accompanies squint can be eliminated in other ways besides using the nose as a reference. For example, sometimes suppression occurs; the brain suppresses the visual stimulation received by one eye to eliminate double vision. The development of anomalous correspondence is another possibility. This can be thought of as a shifting of retinal local signs in one eye or as a reevaluation of extraretinal information (cf. Duke-Elder, 1973, for a general discussion). Since the mechanisms of these phenomena is not well understood, it would be interesting to study the role of structural overlap in the ambient array. However, the present results suggest that the retinal projection of the nose may be less important than structural contours from adjacent objects.

(4) When a small object or its frame moves, the movement will be attributed to the small object. When an observer moves his head or body, there is a change in the retinal projection of every object except the projection of the observer. Bower (1974) notes that if the projection of the observer's nose were processed like a small object and the background were processed as a frame, then the relative movement would be attributed to the self. This seems unlikely, however. As noted above, Gogel and Koslow (1972) showed that depth adjacency is important in induced movement. In addition, Wallach and Kravitz (1965) showed that self-produced optical motion can be accurately attributed to the self without the nose visible.

(5) Finally, as one last attempt to defend the optical significance of the nose, Bower notes that "among those species with chambered eyes, there is not one whose eyes do not pick up a projection of the nose or some other part . . . this cannot be a biological accident. The projection of body parts on to the eye must be of functional importance to have been preserved in so many differently evolved forms. Indeed, the hypothesis about position perception presented here has the merit of making sense of what would otherwise be a continuing biological error . . ." (p. 57). There are other reasons why the protrusion of the nose may be adaptive. One of them became especially clear to the senior author when his daughter came into the house with a kite-string burn across her nose, eyebrow, and forehead. If it were not for the nose, the string would have surely damaged her eye. This protective function of the protruding nose would seem adaptive in reducing

damage from brush and grass in the natural environment.

In summary, although a surprising number of phenomena are consistent with the idea that the nose is an important reference in judgments of visual direction, each of these phenomena has a reasonable alternative explanation. Rejection of the optically significant nose hypothesis would be premature. However, the present direct test suggests that Bower's (1974) strong claims in favor of the optical utility of the nose must be qualified. Perhaps the nose plays some role in the early development of a sense of visual direction and becomes unimportant later, or perhaps it is important for adults under different conditions. But the nose seems to be an ineffective straight-ahead reference for the kind of free-scan straight-ahead judgments made in the present experiment. The null nose result was not simply a matter of an insensitive response measure, because the same measure was used to show a highly significant Pinocchio effect.

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