



## Chapter 89

# The Bogart Effect

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A key aspect of human face perception is our ability to accurately estimate the direction of a gaze (Hinde & Rowell, 1962; Kleinke, 1986). Studies have shown that other besides using the overall orientation of the head, the visual system relies on cues from the eyes (Baron-Cohen, 1995; Perrett et al. 1985; Todorović, 2006; von Grunau & Anston, 1995). Even under highly degraded conditions, the eyes seem to provide a wealth of information for determining gaze direction. Cline (1967) showed that observers can detect gaze deviations as small as  $1.4^\circ$  at a distance of a meter. This ability is not surprising given the key role that gaze direction plays in mediating social interactions and enabling joint attention (e.g., see Driver, Davis, & Ricciardelli, 1999; Emery, 2000; Hietanen, 1999, for review). For instance, direct gaze, even from an image, can be very persuasive (e.g., posters of Uncle Sam calling people to join the army during World War II).

So how do we decide where someone is looking? Many researchers have suggested that the unique morphology of the human eye means that useful information can be recovered using simple structure-based cues (Langton, 2000, p. 52). That is, compared to other animals, the human eye has a relatively small dark region (including the pupil and iris) and a large white sclera on either side of the iris (Kobayashi & Kohshima, 1997). The high contrast between the white sclera and the dark iris make the discrimination of gaze direction much easier in humans than in other animals and implies that simple geometric features can be used to determine eye-gaze direction. One geometry-based strategy that many researchers have suggested plays a predominant role in the determination of gaze direction is iris eccentricity, or the relative position of the circular iris within the visible part of the sclera (Anstis, Mayhew, & Morley, 1969, p. 489; Baron-Cohen, 1994, p. 519; Symons, Lee, Cedrone, & Nishimura, 2004, p. 452). According to this idea, the position and curvature direction of the high contrast between the sclera and the iris facilitates the extraction of geometric cues considered essential for estimating gaze direction.

While a geometry-based eye-gaze estimation strategy has been the basis of many theories, such a strategy would rely on relatively detailed curvature information and would therefore function suboptimally under low-resolution viewing conditions. Partly in response to this concern, the past

decade has seen the rise of luminance-based theories of eye-gaze estimation. The idea of luminance-based estimation of gaze direction arose from the observation that contrast negation affects eye-gaze perception, and an early demonstration and possible explanation for this phenomenon was offered by Sinha (2000) and named the “Bogart effect.”

The Bogart effect received its name after being first demonstrated using an image of Humphrey Bogart (Sinha, 2000). In the untouched version of the image, Humphrey Bogart is seen looking to his left. However, when the same image is contrast negated (like in negatives of a photographic film), Bogart’s gaze appears to reverse direction and look to the right (Fig. V.89-1). As can be seen from Figure V.89-1a, the effect of contrast negation on the estimation of gaze direction is not unique to Bogart’s face.

To test the robustness of this effect, subjects were shown the images from Figure V.89-1 and asked to indicate whether the individuals depicted in the image appeared to be looking to the (subject’s) left or right. As Figure V.89-2 shows, contrast negation of the entire face led to a reversal of the perceived gaze direction in most subjects. For the few cases in which contrast negation did not lead to a reversal in the estimation of gaze direction, postexperiment debriefing suggested that subjects might have been deliberately compensating for the contrast negation and estimating the “real” gaze direction by reversing the perceived one. Overall, the strong correlation of perceived gaze direction with contrast polarity in these images suggests that the visual system uses a gaze-estimation strategy that may be based on a simple luminance-based heuristic: Which side is darker?

The perceptual power of this rule of thumb is evident in the observation that, for most subjects, gaze-direction reversal was obtained even though the subjects could tell that they were looking at contrast-negative images and thus “knew” that the irises were the light regions in the eyes. That is, the gaze-estimation process appears to be largely “cognitively impenetrable” (Pylyshyn, 1999), with the rule of thumb taking precedence over cognitive classifications of eye regions as the iris and sclera. Importantly, gaze-direction reversal was obtained despite the fact that the geometric cues obtained from the negated image did not coincide with the new perceived direction. That is, the putative iris in the negated image is of an abnormal size



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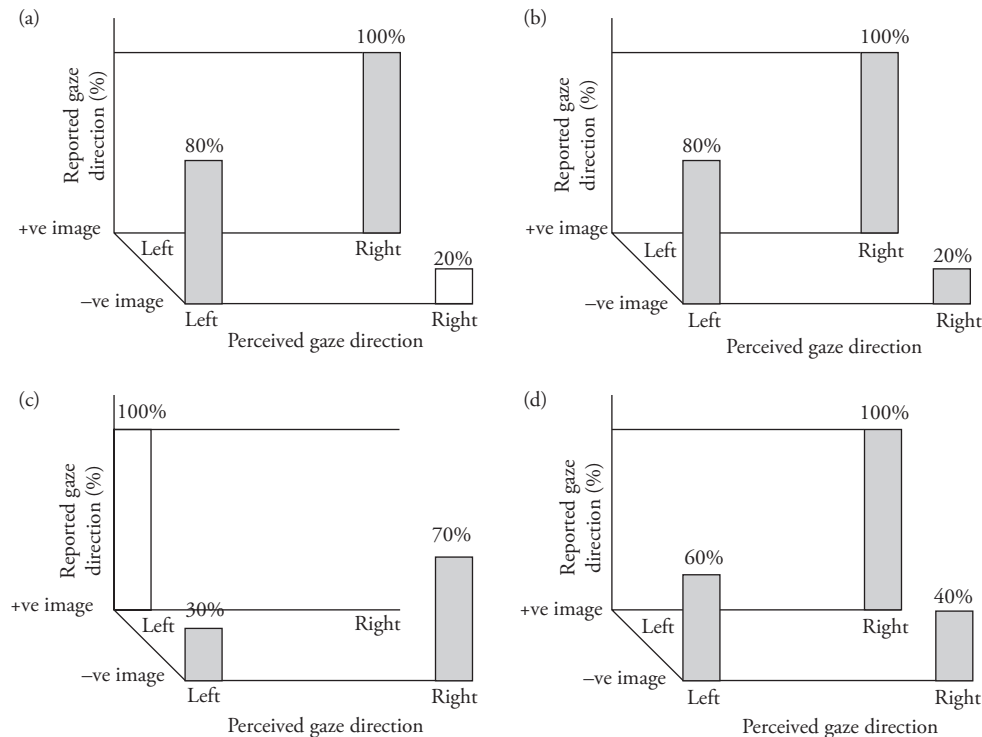


**Figure V.89-1** The influence of contrast negation on perceived gaze direction. (Adapted from Sinha, 2000.)

relative to the rest of the eye and/or is bounded by arcs that curve in the wrong direction. Thus it seems that an eye region can be treated as an iris by the gaze-estimation process, so long as it satisfies the darkness heuristic, even though its other structural attributes may be abnormal. In other words, the Bogart effect suggests that rather than using the position or curvature of high contrast between the sclera and the iris to judge gaze direction, the visual system may use the polarity of high contrast to accurately perform this task.

A luminance-based heuristic, as proposed by Sinha (2000), provides the missing link for similar findings regarding the effect of contrast negation on the estimation

of gaze direction. For instance, Ricciardelli, Baylis, and Driver (2000) showed that subjects were very poor at correctly judging the gaze direction of images with contrast-reversed eyes. They noted that a system based only on the position of the contrast boundary cannot explain why the reversal of contrast around the eyes should affect gaze perception and proposed that their finding can be explained by an “expert” system, whereby the darker region of the eye is the part that does the looking. The Bogart effect, in essence, demonstrates the validity of this heuristic for highly eccentric gaze directions by showing that contrast negation actually reverses the direction of the estimated gaze by this “expert” system.



**Figure V.89-2** Gaze-estimation results from 10 subjects tested with the face images shown in Figure V.89-1. Panels (a) through (d) display results for the positive and negative images of Figures V.89-1a through V.89-1d, respectively. Contrast-negation reverses perceived gaze direction for the majority of the subjects. The gaze direction reversal effect is weaker in (d), perhaps because the gaze direction is close to frontal. (Adapted from Sinha, 2000.)

The use of this simple polarity-based strategy may also account for the bloodshot illusion, first demonstrated by Ando and Osaka (1998). Gaze direction of forward-looking eyes seems to be skewed to the side if one scleral region is darkened (as if bloodshot). One possible explanation for this phenomenon is that the visual system is grouping both the iris and the darkened scleral region together into one “composite” iris (since both of them now satisfy the darkness heuristic). The inclusion of the “bloodshot” sclera makes the center of this composite iris shift to a side, thus leading to a change in the perceived gaze direction (see also Ando, 2002). Data from a follow-up study led Ando (2004) to propose a similar luminance-based strategy based on the ratio between the sclera and its surrounding region rather than the polarity within the eye. Rather than darkening the sclera within the eye, Ando artificially placed a dark square in the area surrounding one corner of the eye. He found that eye gaze seemed to be directed toward the side for which the luminance ratio between the sclera and its surrounding skin region was smaller. One important advantage of the strategy proposed by Ando is that it promotes correct estimates of gaze direction under different lighting conditions (e.g., a shadow cast on one side of the eye would not cause errors in perceived gaze direction).

In the discussion so far we have emphasized a luminance-based approach to estimating eye gaze. However, it is clear that the role of geometry-based cues cannot be completely discounted. After all, an eye represented only by the outlines of an oval and a circle, with no luminance contrast across the iris and scleral regions, can still provide sufficient cues to determine gaze direction. It is possible that

luminance and geometry are both important and are combined in ways that are yet to be fully understood to enhance the accuracy of gaze estimates. Indications of such cue interactions come from studies that have used a cue-conflict paradigm. For instance, measuring how subjects judge the direction of eye gaze shown at different eccentricities in positive and negative polarity images, Olk, Symons, and Kingstone (2008) found that the highest number of errors were incorrect “straight” judgments at low eccentricities, suggesting that gaze judgments were based on the outcome of a competition between the luminance cues that indicate that the gaze is directed from the dark part of the eye and geometric cues that indicate the opposite. Indeed, they found a reduced error rate and fewer incorrect “straight” responses for more extreme gaze directions. In addition to the use of geometric- and/or luminance-based information from the eyes, it is clear that the orientation of the head also influences the perception of general gaze direction (Todorović, 2006). However, in the absence of head-orientation cues (such as nearly frontal gaze), further experiments are needed in order to fully resolve the conditions under which a competition between different cues from the eyes might ensue, as well as how the final decision for which strategy to use is ultimately made.

Although both geometric and luminance cues are likely to contribute to gaze estimates, the latter probably dominate over long viewing distances. An informal study we conducted illustrates this point. Participants were shown line drawings of faces that fell into two categories: those with a darkened iris (providing cues for “which side is darker?”) and those with an empty iris (providing only structural





cues). Gaze directions were approximately 30° to the left or right. Starting from a distance at which gaze could not be estimated in either of the two stimulus conditions (filled or unfilled irises), 10 participants were instructed to walk slowly toward the face and indicate when they were able to determine the direction of the eye gaze. This very simple procedure yielded a clear difference between the threshold distance for the two conditions: with filled irises, observers were able to reliably estimate gaze direction from a viewing distance 50% longer than that corresponding to the unfilled iris condition. Thus luminance-based cues likely play a key role in gaze estimation under conditions in which the contours of the eyes are blurred, such as when viewing a face from a distance. By not being overly reliant on structural cues alone, the visual system is able to estimate gaze direction even under degraded viewing conditions caused by refractive errors or large viewing distances. The rule of thumb for gaze estimation based on ordinal brightness relationships (“the darker side is gazing”) allows for a simple and robust implementation of this important perceptual ability.

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