fusiform gyrus. This relatively posterior locus of injury buttresses the view of acquired prosopagnosia as a disorder of visual processing. Although people with developmental prosopagnosia have no obvious lesion in the fusiform gyrus, recent work suggests that there is a subtle alteration of the white matter connections in this region of the brain. Neurons in this area have been shown to respond vigorously, and selectively, to the visual image of faces.

Aren't faces just harder to recognize? Or the subject of greater experience? In fact, several such alternative explanations have been proposed. Many are variants on the 'individuation' account, which holds that special processing for faces is not specific to this visual stimulus category. Proponents of this view note that faces are a special category of object for which we constantly identify individual exemplars, whereas such 'subordinate-level' processing is seldom necessary for recognition of other classes of object. In line with this view, some prosopagnosics demonstrate impairments in individuation of other object classes, such as specific animals. But this within-category impairment may reflect damage to adjacent but separate cortical areas. Furthermore, some experiments have still found specific impairment for faces versus other object classes in prosopagnosic subjects when the difficulty of individuation for these stimulus sets is matched. The issue of the specificity of the deficit in prosopagnosia remains an active area of debate.

Where can I find out more?

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Mediaeval artists: Masters in directing the observers' gaze

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The gold leaf in early Renaissance paintings such as Duccio's "*The Annunciation*" (1311) appears to glow when lit by candles as the artist would have expected. Subjectively, the candle-lit painting appears drastically different from the same painting illuminated with diffuse daylight typical of modern art galleries. By analysing the density of observers' eye fixations when looking at this painting under these two lighting conditions, we found objective differences in where in the painting observers attended: specifically, the glow of the gold induced shifts in fixations to symbolically important regions of the painting.

To investigate the effects of illumination on the perception of mediaeval paintings, we first constructed an area of gold leaf, using the techniques of the Italian Renaissance painters, and measured its reflectance properties. We also measured the spectral characteristics of beeswax candle light and daylight illumination. This allowed us to mimic the effects of such light sources on gold. On the basis of these data, we then used photorealistic computer graphics to render a high resolution digital scan of the original painting under both beeswax candle illuminant and daylight illuminant (see Supplemental experimental procedures in the Supplemental data available on-line with this issue). In the behavioural experiment, we had two groups of human participants view one of the two rendered pictures while we measured their eye movements. Figure 1 shows how the nature of the illuminant affected where in the picture the participants fixated in the picture.

The gold leaf, which is used so extensively in paintings of this era, creates a dramatic glow effect when lit by candles, which would have been the contemporary illuminant for these paintings. This glow effect leads the eye to fixate in a different part of the image than when ordinary diffuse daylight illumination is used. In the case of Duccio's *Annunciation*, observers look less at the faces of the Angel and the Virgin and more towards the Virgin's hand. One might speculate that this is the eyes being directed away from the faces (looking at them directly might have been considered irreverent). Alternatively, the eyes could have been directed towards the Virgin's hand, which she uses to grasp her veil and to gather her mantle around herself protectively. Her gesture has been claimed to reflect a state of mind somewhere between disquiet and reflection, consistent with the early stages of the Angelic Colloquy or the interaction between the Angel and the Virgin [1]. The methods used by this great Italian painter appear to exploit the effect of 'glowing' gold to direct the viewer's eyes.

Our results raise two important scientific issues. First, why does the subtle induction of 'glow' have such a significant effect on eye movements? Sources of illumination are often the most perceptually visible regions in a visual scene. Traditional low-level salience models of eye movement control [2] would predict a high fixation probability of these regions. In the current experiment, however, eye movements were not directed toward the brightest parts of the image, such as the gold-covered garments or windows under candle-light conditions, as predicted if fixations were driven by either brightness or the *global effect* in which saccades are directed to the centre of gravity

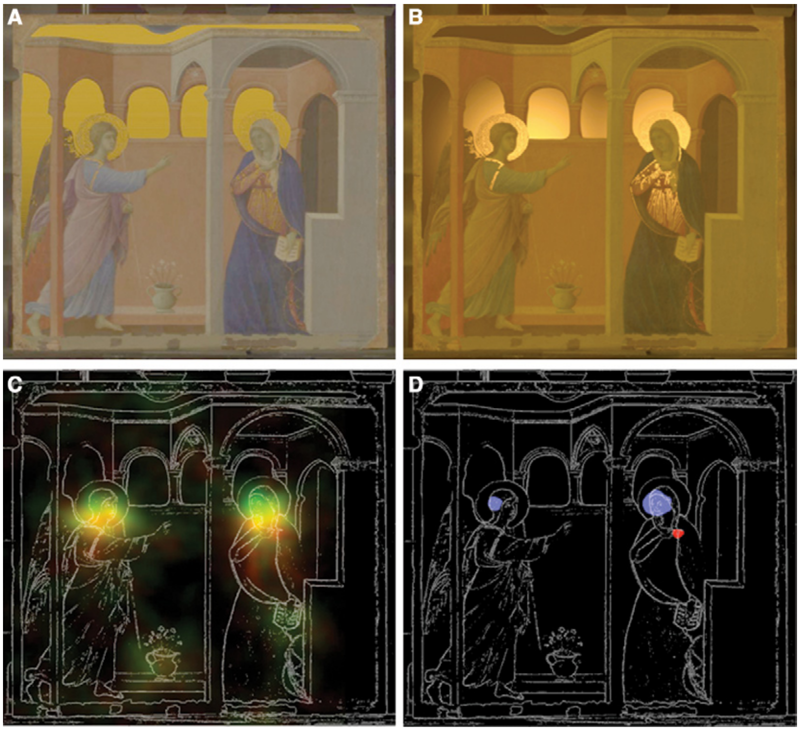

Figure 1. Lighting conditions can affect the significance of parts of a painting as revealed by the pattern of observers' fixations.

The top two panels show Duccio's "*The Annunciation*" rendered either using synthetic diffuse illumination (A), or synthetic candle light (B). When observers view such paintings, they make about three eye movements a second, and where they choose to fixate will be determined by both the visual characteristics of the picture and their interest. (C) The density of eye fixations from observers, estimated using a new kernel density estimator specifically designed to estimate the density of eye movements (see Supplemental data). The density of fixations to the diffuse illumination is shown in green; the fixations to the candle light are shown in red, and hence regions fixated in both conditions are shown as yellow. As can be seen, the vast majority of eye movements were concentrated around the faces of the angel and Virgin. (D) The differences in fixation patterns between candle lit and diffusely lit paintings, analysed using a spatial permutation test [7], where regions coloured red show areas significantly more fixated when viewed using synthetic candle light, and regions coloured blue show locations viewed under synthetic diffuse light. As can be seen, simply changing the lighting changes the pattern of emphasis from the faces to the Virgin's hand.

of a number of discrete objects [3]. Instead, fixations were more likely on the less visible hands. The apparent avoidance of the illuminant fits with recent computational studies showing that extremes of low-frequency brightness predict low fixation probability [4] and neuroimaging studies demonstrating that the visual system shows differential activation of light-emitting and light-reflecting objects in the occipito-temporal cortex [5]. Moreover, light sources are mostly behaviourally unimportant.

Second, by measuring fixation density across different conditions for the same visual scene and using rigorous statistical methods developed for the analysis of brain images, we are now in a position to objectively identify the factors that determine what is fixated. As we have shown here with Duccio's painting, the nature of the lighting has the effect of significantly altering the way in which observers look at paintings. The current practice in the exhibition of mediaeval paintings is to use lighting that maximises visibility and discriminability [6]. However, these criteria might disrupt the sophisticated techniques available to the artist to direct the observer's gaze.

Supplemental data

Supplemental data including experimental procedures are available at http://www.current-biology.com/cgi/content/full/17/1/R8/DC1

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