An explanation for the elusive quality of the Mona Lisa's smile is advanced: "her smile is...more apparent to peripheral vision than to central vision....you can't catch her smile by looking at her mouth." Claims that inclusion of rats, mice, and birds in the Animal Welfare Act will increase animal-care costs—a cause of panic in some sectors of the biomedical community—are countered. A call is made for more research into the global warming potential of U.S. food production systems "to determine where the greatest reductions [in GWP] are to be found." And the importance of understanding U.S. sediment movement and redistribution is discussed.

Is It Warm? Is It Real? Or Just Low Spatial Frequency?

Leonardo da Vinci's portrait of the Mona Lisa is famous for her smile (Fig. 1). Perhaps it is the difference in her expression carried by high and low spatial frequency ranges (gradual versus sharp luminance gradations) that helps produce her smile's elusive quality.

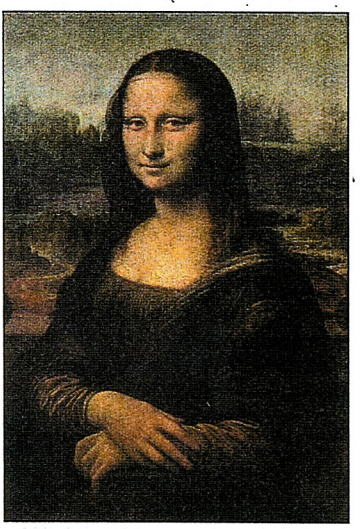

Fig. 1. Mona Lisa. Leonardo da Vinci. c. 1502. Oil on wood, 77 x 53 cm, Museé du Louvre, Paris.

The spatial resolution of the human visual system changes dramatically with distance from the center of gaze (*1*), due to the fact that both the retina and the visual cortex devote disproportionately more neuronal machinery to the fovea. Acuity 6 to 7° eccentric of the center of gaze is about one-tenth the acuity at the center of gaze. This means that our central vision is dominated by significantly higher spatial frequencies than is our peripheral vision. Conversely, vision only a few degrees from the center of gaze is much blurrier than in the fovea.

To see how Mona Lisa's smile would look at different eccentricities, the image has been filtered to exaggerate selectively low or high spatial frequencies (Fig. 2). A clear smile is much more apparent in the low spatial frequency images than in the high spatial frequency image. Thus, if you look at the painting so that your gaze falls on the background or on Mona Lisa's hands, your perception of her mouth would be dominated by low spatial frequencies, so it would appear much more cheerful than when you look directly at her mouth.

This explanation goes beyond the popular idea that da Vinci blurred her mouth (*sfumato*) to make her expression ambiguous (*2*). It seems that her smile is more apparent in the low spatial frequency range, and therefore more apparent to peripheral vision than to central vision. Hence the elusive quality—you can't catch her smile by looking at her mouth. She smiles *until* you look at her mouth, and then it fades, like a dim star that disappears when you look directly at it.

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2. E. H. Gombrich, *The Story of Art* (Phaidon, London, 1999), p. 300.

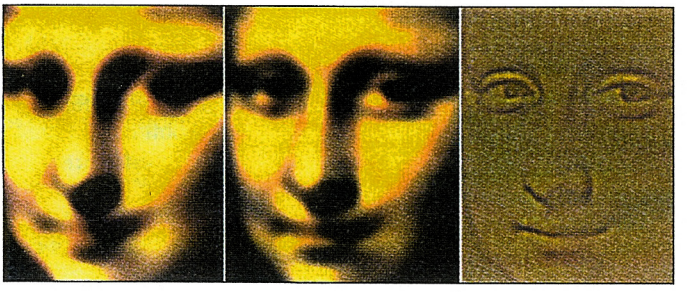

Fig. 2. Face of Mona Lisa, filtered to reveal very low spatial frequencies (left), low spatial frequencies (center), and high spatial frequencies (right). The two low spatial frequency images were generated by applying a Gaussian blur to the image and then enhancing the contrast; the high spatial frequency image was generated by applying a high-pass filter and then blurring slightly (Adobe Photoshop).

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