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## Reply to Critique of Leonardo Strabismus Analysis

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478 words

Dr. Marmor's points are well-taken, but they were mostly fully recognized in the analyses for the paper. The form of 'evidence' of my title is not specified, but I would certainly agree that the evidence is circumstantial in legalistic terms, in the sense that no one item constitutes proof, but each adds an increment of probability to the case. In the absence of specifics, Dr Marmor's claim that the analyses could have "just as convincingly led to the opposite conclusion" is unsupported. If these are not portraits of Leonardo, they lead to no conclusion about his ocular alignment, not the opposite conclusion.

It is important to recognize both that faces are viewed differently by different artists (since these are not photographic images) and that the facial physiognomy changes with age. Thus the variation in the height of the brows, in particular, seems consistent with the age progression expected from the mid-teens to the mid-sixties, and similarly for the length of the nose. So, I would suggest that, when age is considered, these variations tend to support rather than dispute their identification as his portraits.

As recognized in Dr Marmor's critique, the iris position relative to the Hirschberg 'reflex' provides a more accurate measure of eye alignment than its position relative to the eyelid aperture, but this measure was not available in the other identified portraits. I am planning to apply the gold-standard Hirschberg analysis to published claims of strabismus in other artists, as I myself am skeptical of the ones I cited in the introductory review (although it did not seem prudent to mention this before assessing the evidence in this manner).

Dr. Marmor illustrates an apparent artifact in the alignment in eyes viewing to the side, although Figure 1 illustrates that my geometric quantification method is not subject to such an artifact. Nonetheless, my analysis focused on straight-ahead facial views that are not subject to this criticism (with the exception of the best-established self-portrait by Leonardo in his sixties, which was included for its authenticatory value).



**Figure 1.** Application of my geometric analysis method to the example provided by Marmor's figure. Although the lacrimal caruncles tend to extend the visual impression of the eye width nasally (see his Fig. 1), they are fully discounted in the fitting of the lenticular arcs I used to fit the curvature of the lid aperture, such that the fiducial positions of the pupil/iris circle fits are exactly identical in this example, despite the apparent illusion. (Note that this image lacked a Hirschberg reflex.)

I would question the statement, "The esodeviation, anisocoria, hypertropia and eccentric pupil (in del Verrocchio's *David*) in these works are in fact proof that these artists took liberties with reality." Whether such deviations in these depictions is "proof" of such "liberties" depends on the underlying state of the reality (which is necessarily a probabilistic endeavor in such a case of undocumented history). However, an informal survey of other Renaissance paintings makes it clear that such deviations are extremely rare in Renaissance art, so their confluence in these attributed portraits of Leonardo himself provides some form of evidence of a deviant binocular condition.

Finally, Leonardo's noted facility in depicting three-dimensional form is well-recognized by art historians as having been highly influential on subsequent artistic developments, which had become standard practice by the C17th period of Guercino, independently of his own strabismic condition.