

## Is visual angle equal to retinal angle?

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In visual psychophysics and perception research, visual angle is commonly assumed to be the same as retinal angle, based on familiar drawings of chief rays as straight *direction lines* that pass through a single point in the eye. This concept dates back to Volkmann's treatise in 1836 and it has persisted because for small angles it is correct for nodal rays that pass through the 2nd nodal point, and for large angles it is also correct if, following Volkmann's cautionary remark, the lines are thought of as *directions* rather than rays. In practice, actual rays are refracted at the cornea and the lens, and even for paraxial rays it is only the input and output angles that are identical. The simplified drawing allows visual angle to be related to distance along the retinal surface, which can be used to translate anatomical size estimates of the fovea or macula to visual angles. Yet with rays passing through the pupil it is misleading as to the range over which the equality of angles holds; there is extremely high linearity to over 60 deg of visual angle, and a very modest increasing nonlinearity thereafter to beyond 100 deg (and the intuition from the graph might reinforce a common misconception the visual field were limited to 90 deg sideways). The situation is different for patients who have had cataract surgery because far peripheral rays might bypass the intraocular lens, causing the perception of bothersome dark shadows. Here we present an intuitive graph, using ray-trace software, to cover the whole horizontal meridian up to its limits, and results are compared to those from the ophthalmic literature. In sum, visual angles in the visual field map to distance in mm along the retinal surface by a close-to-linear function, with modest non-linearity at very large angles.

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