Eclipse, shape-from-shadow, and perceiving astronomic size—Earth’s

Two geometries applied widely by vision are perspective and shape-from-shadow. We have to observe from somewhere, and perspective is the geometry describing directions from somewhere to something at some distance. Objects are illuminated nonuniformly generally, and cast shadows. The scale on which vision applies the geometries runs from the minute to the astronomic. This is obvious for perspective, since we often peer close-up from various directions at tiny novel objects, and all we have to do is turn to the left, say, and even the stars change their direction 90°. Also, because of motion parallax, we can walk a kilometre without changing the directions of hills on the horizon noticeably. The perspective parallax effect can help tell us about the distance of the hills, and their size. Of interest here is that shape-from-shadow may work as widely, and be capable of stretching up to an astronomic size we can see in a vivid fashion. One story about an eclipse may make the point.

I was looking at an eclipse at a time when the Moon was a third covered by Earth’s shadow. Under these conditions it is apparent that the circle implied by the arc of the shadow subtended an angle (about 2 degrees) much larger than the Moon’s (about half a degree). Since it lay beyond the horizon, at the Moon’s distance, and totally enclosed some distant buildings and hills, the implied circle was huge in linear size. Indeed, I will suggest here the circle was an implied object in the sky much larger in linear terms than the terrain from horizon to horizon. It certainly implied the largest object I had ever seen. My argument here is that I was looking at indications of an object the size of the Earth, and I gained a remarkable impression of that astronomic size via shape-from-shadow perception.

The impression was not simply due to explicit calculation of the relative size of the Moon and the Earth’s shadow, in the manner proposed by Aristotle, involving measures of their relative angles, taken during eclipses (Casati 2000). Rather, I will suggest here, it was a visual impression based on standard principles of perception. In particular, it required good continuation, projection, and shape-from-shadow principles. Certainly it seemed like a visual impression at the time. With hindsight I will try to outline here how that could be so.

The extent of the shadow was given by taking the visible contour and extending it, envisaging good continuation of the visible curve. This is much like appreciating the form given by an incomplete figure if its contours are extended. In the eclipse, only one shadow arc needed to be extended. But, of course, that is normal with contours of shadows. They are often individual items, one-offs like a shadow on a cheek of the bridge of a nose. This is a sample of one, but it is not hard to discern how the bridge’s shadow might continue and what projects it.

In the case of the eclipse I had a distinct impression of the continuation of the shadow’s arc, but with no modal contour. One black region of sky was grouped inside the shadow’s circle; the equally-black remainder was outside.

The apparent disc thus defined by extensions of the visible shadow contours covered a large area of the sky and swept down to the horizon. As a disc, located at the distance of the Moon, but subtending a much larger angle than the Moon, it gave a strong impression of its linear size (to an approximation of course). Described as a visual impression, rather than a calculation, likely one should give ordinal measures.
If so, I would say it was clearly and unmistakably the largest object I had ever seen. It was larger than any terrestrial building, and larger than any mountain, for example. Indeed, for reasons that will become plain, it was larger than any lake or sea I had viewed.

I took the terminator and the disc it suggested as projected. They were not simply a luminance contour and its continuation, as in an incomplete figure. Rather, they were indicators of the object casting the shadow, much as a cast shadow on a wall indicates the shadow caster.

The shadow was straight ahead. Its top I envisaged as projected by the horizontal ground where I was standing. Of interest, its left and right borders were seen as projected by parts of the ground to my left and right. But for some reason these parts were seemingly well beyond the horizon of the visible terrain. That is, the horizon to left and right was just a fraction of what was projecting the shadow—I had the impression. The shadow was evidently larger than the visible terrain, several times over. I have seen large glows in the sky, from terrestrial events and objects beyond the horizon, or over the top of faraway hills, but they always indicated the events were on a restricted terrain, albeit one beyond the visible limits.

The vast cast circle in the sky—I had the impression—was projected by limits to left, centre, and right beyond any I could readily encounter. I suggest it may be that what contributed heavily to this sense of size was that the ground was relatively flat, and yet the shadow was curved. Reconciling the two, the projection of the flat ground was fitted onto a small section of the arc of the Earth’s shadow. That is, what was on the left and right horizon and the ground in-between projected into the sky to fit onto a small section of the arc of the great shadow. By comparison to the shadow, the projection implied, the limits of the ground I could see shrank almost to insignificance.

The terrain stretching to the horizon was slight in comparison to the huge shadow, and the distance involved in the projection to the shadow was required to be enormous. The ground shrank in the projection in the fashion of railroad tracks narrowing their visual angle with distance. But railroad tracks a metre or more apart shrink to a very small visual angle over kilometers, and for a ground spanning several kilometers to shrink to insignificance requires proportionately a much larger distance.

In short, for reasons to do with visual features, the circle tokening Earth’s shadow in the sky appeared to be an object of incomparable extent in the sense that no Earth-bound building or mountain was of its ilk. The flat ground from which I was observing fitted within it as a fraction of its arc. It offered astonishing astronomical size, at an astronomical distance, as a visual impression. The object casting the shadow was the object on which I stood, and its linear size was on a par with the shadow, the features implied. Unlikely as it may seem at first, information for Earth’s size and distance was there to be used, in the optic array, via continuation, projection, and shape-from-shadow.

Shape-from-shadow is not activated holus-bolus in the first year of life. Some shape-from-shadow figures (Mooney 1954) are easily recognized as faces by children, and others are only deciphered with difficulty by adults. Also, in drawing development, skill in depicting shadows is not suddenly acquired as one unit. Advanced skill in portraying shadows is shown by Caravaggio, de la Tour, and Kienker (Cavanagh and Kennedy 2000). Shape-from-shadow perception and related skills in drawing likely develop a long way from primitive simple versions. The use to which I put shadows in viewing an eclipse may be one that requires some such sophistication. That use of the array, like the use of some features in incomplete figures, may be greatly favoured by relevant suggestions. But I think that use is one to which most observers can turn once hints are given. Once sought, the relevant impressions may be gained fairly readily.
If I am correct, information to support the percept is available in the sky and the terrain in a fashion that fits vision's principles. Once attained the impression is, well, both out of this world and very much of this world.

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References
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