The Gloss of Glossy Things

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by

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Abstract

This paper discusses the visual phenomenon of gloss. It is shown that the perception of this phenomenon derives from two effects (1) that the image reflected by a glossy surface lies in a different plane from the surface, and (2) that the highlights in a glossy scene are abnormally bright. The perception of gloss seems to arise as a side effect of depth perception and lightness judgment.

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In this brief paper, I discuss some of the issues relating to the phenomenon of gloss. As with other perceptual phenomena such as brightness, color, and texture, it is possible to deduce the physical basis for gloss. nevertheless, as with these other phenomena, gloss has a singular and startling "affective strength" which seems somehow divorced from the physical basis. I shall discuss the physical bases (explanations?) of gloss; later I will deal with the affective phenomena relating to it, with suggestions of an explanation for these phenomena. These explanations, in turn, lead to possible methods whereby a vision system, biological or artificial, could perceive and respond to gloss.

My first acquaintance with the phenomenor came as a child when I was informed that "gold" and "silver" were not colors but lightnesses (whatever that means). In contrast to this, I was subsequently informed that gold (or brass, bronze , etc.) was "yellow" while silver (or chrome, aluminum, etc.) was "white." This seemed reasonably sensible, but what was it that so strongly set off "gold" from "yellow" (as in a lemon) and "silver" from "white" (as in a piece of paper)? It is, of course, the phenomenon of gloss. Later I learned that non-metallic objects (such as a dazzingly metallic "gray" sportcoat that I coveted) were possessed of gloss. More recently, in studying color vision, I learned of some of the physical bases

of gloss. To quote Judd (1962, pp. 368-369):

> A layer of material has a top, a bottom, and an interior whose thickness is small compared with its length and width. Some of the light incident on the top is reflected without penetrating into the body of the film. The various angular distributions of this reflected light flux determine whether the layer appears glossy or mat... a perfect mirror is said to have maximum gloss.

Thus, gloss is a "surface effect," as opposed to "body effects" such as colors, lightness, and texture. This is the clue we may need to come to an understanding of the phenomenon.

Let me now discuss two suggestions relating to gloss. When a scene is viewed through eyeglasses with one red lens and one green lens (such as are used in "3D" movies), many objects take on a distinctly "metallic" appearance. I noticed much the same phenomenon when looking through glasses with two perpendicularly polarized lenses: objects viewed at a shallow angle (such as would yield reflected light that was strongly plane-polarized) appeared scintillating and metallic. The converse phenomenon occurs when one views a surface covered with "silver" paint from one eye and then the other; the surface has a plainly different brightness in the two views. All the observations support the claim that glossiness is inherently due to binocular rivalry—different objective "pictures" falling on the two retinas. This observation seems remarkably cogent, except that when one shuts one eye, the affect of gloss remains (although the subjective impression alters in a rather

indescribable way).

I believe that there is an underlying explanation for the sufficiency but non-necessity of binocular rivalry to produce gloss: Judd all but gives away the answer in the following (p. 369):

> The ideally perfect mirror surface is a plane surface reflecting all the incident light flux in a perfect image-forming state, whence we see that the surface itself must be invisible. No light leaves a perfect mirror surface in such a way as to permit us to focus upon the surface...

To the extent that a surface is less than a "perfect mirror" the light will reflected in less than "a perfect image forming state."

Part of the light coming to us from a glossy surface constitutes an image of the environment, particularly the illuminant. More important, this image comes into focus not in the plane of the glossy surface, but in some more distant "virtual" surface. The effect on the observer is clear: Suppose we are gazing on a glossy surface. If we are focussed on the surface itself, so that our gaze converges (in the stereoscopic sense) on elements on that surface, then the image of the environment (illuminant) will be "out of register" or unconverged. But this is a sort of binocular rivalry. It would appear from this that the phenomenon of gloss is just an

artifact of the process of stereoscopic depth perception.

However, this does not explain how the sensation of gloss persists under monocular vison; in fact, until I got my first pair of glasses at 16 I had virtually no stereoscopic depth perception—yet was clearly aware of gloss. Again, it we view the image of the environment as occuring in a different "depth plane" than that of the surface, then the monocular phenomenon can be explained by the same means as monocular depth perception: accomodation. If we focus on the glossy surface, then the image is out of focus, and vice-versa. Thus, we can come to view gloss as an artifact of depth perception in general. As further evidence, another depth cue—motion parallax—seems to play a part in perceiving gloss. Consider that when you walk past a mirror or puddle of water the reflected image moves at a different rate from the reflector itself. Winston suggests that this fact, coupled with the constant saccadic movements of the eye, may yield another monocular gloss cue.

These arguments have a pleasant ring to them, and more important, suggest that a vision system with capabilities of depth perception (via stereopsis, accomodation, or parallax) will have a derivative capability of perceiving gloss. Yet there seems to be something lacking. Generally gloss suggests

cther terms like "sheen," "dazzle" and "highlight." We think of glossy surfaces as having loci of high brightness. Jerry Lerma mentioned that he and Marvin Minsky had postulated this "highlight" phenomenon as being the criterial feature of glossy surfaces. As with binocular rivalry, thi~ seems indisputable; can we extend the notion by relating it to the underlying physical phenomena?

Consider the following thought experimert: Gaze at a glossy surface, fixating on a spot having a "highlight." Now, place on that spot a patch of maximum reflectance but total "matte-ness," e.g., a small tile coated with magresium oxide (a traditional colorimetric standard). Although the patch is a near per'ect reflector—in the sense that the 'otal luminous flux leaving it nearly equals the incident flux—I would bet that the patch will not look nearly as bright as the glossy highlight. The reason is simple: While the total reflected flux leaving the matte patch may actually exceed that for the glossy patch, the flux is uniformly distributed through a hemispherical surface. The light from the highlight could represent the concentratiion of the reflected light into a "beam" aimed directly at our eye.

Here we have an interesting phenomeron. Land (1971) points out that subjective "lightness" is a function of the

reflectance of the object, with 100% reflectance yielding maximal "lightness." The glossy area yields an amount of reflected light (for at least a critical viewing angle) exceeding that of a 100% reflecting non-glossy surface; that is, highlights are "super-maximally bright" areas. Perhaps our visual system (and that of a hypothetical gloss-seeing robot) takes some sort of average brightness measure over the scene and estimates a "maximum" value that would obtain for a 100% reflecting matte surface. Glossy surfaces would then exceed this threshold and trigger a highlight signal. Although I have not carefully considered it, it is possible that there may be some connection between gloss-perception and the perception of self-luminous areas.

To conclude, this paper has discussed several affective visual features of glossy surfaces. I have also tried to relate these subjective qualities to the objective physical qualities of glossy surfaces. These explarations, although incomplete, seem consistent with personal observations, and suggest possible schemes for perceiving gloss by an artificial vision system.

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