Vision Sciences Society Annual Meeting Abstract | September 2019

Effects of the Spatial Spectrum on the Perception of Reflective and Refractive Materials

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Journal of Vision September 2019, Vol.19, 243. doi:https://doi.org/10.1167/19.10.243a

Abstract

Highly reflective and refractive materials such as gemstones, polished metals, shimmering water, glazed ceramics and the like, act as touchstones of visual wonder for humans. While this might simply be indicative of a “sparkly good!” mechanism of prehistoric origin, the question remains how the human visual system uses this information to identify materials. Since the 15th century, painters (e.g., van Eyck, Heda, Claesz) have been acutely aware of the depiction of these materials. Even contemporary comic illustrators make it a priority to depict this phenomenology via denotative mechanisms like ’lucaflection’ (Mort Walker). It is intuitively tempting to assign the heavy lifting of material perception to the specularity of the material. Indeed, transparency and translucency seem to be special cases of our day-to-day experiences with materials — the vast majority of which that seem relatively opaque. However they are frequently not as opaque as they may seem (grapes, for example) and even those that are completely so still have sub-surface interactions with light that make for complicated depiction. In a series of experiments we show that the spatial composition of the illuminating environment has a strong effect on material perception of non-trivial objects made from ostensibly opaque materials. Broad (i.e., low-frequency dominant) fields of illumination result in fiducially black materials to be perceived as ‘metal’ while sparse fields (small, isolated high frequency information) biased perception of metal toward ‘black plastic’. Preliminary work with transparent and translucent materials suggests the same mechanisms may be at work — The structure of refracted environmental information plays an even more significant role than that of the specular highlights. Finally, multi-scale analysis of the illumination environment shows clustering more consistent with the empirical perceptual impressions of the surface than with the actual surface material.