Perception, 1999, volume 28, pages 929 – 934

DOI:10.1068/p2808ed

Guest editorial

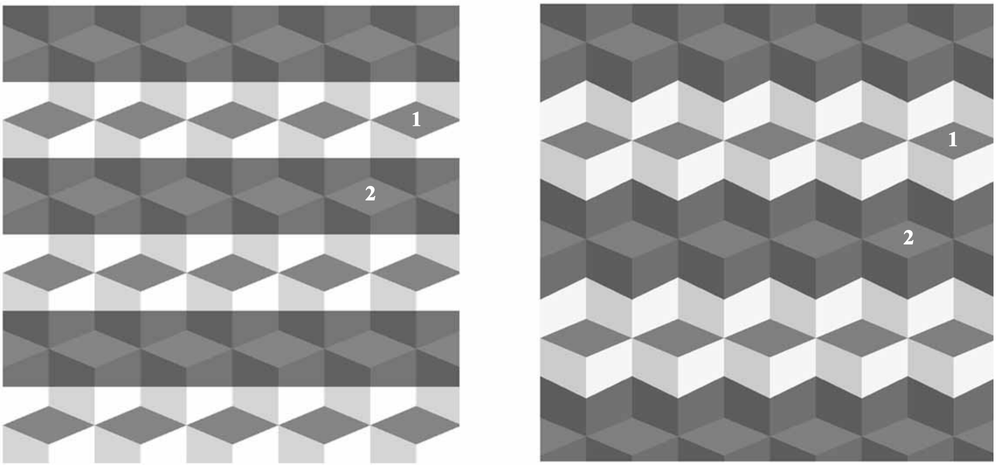
Old wine in new bottles? Some thoughts on Logvinenko's "Lightness induction revisited"

One of the most compelling visual phenomena is simultaneous lightness contrast (SLC). The observation that grey looks darker when set against white than when set against black has intrigued philosophers and scientists for two millennia (see Wade 1996), yet there is still no consensus as to exactly why it happens. In a renaissance of interest in the effects of context on surface colour appearance (eg see the recent special issues of *Perception* 1997, volume 26, numbers 4 and 7) SLC is currently the focus of a controversy which first occupied Hering and Helmholtz in the 19th century. They disagreed over whether SLC was based on peripheral sensory processes sensitive to contrast, or central influences involving assumptions about the configuration of the display as a whole.

Logvinenko's article "Lightness induction revisited", published in the preceding issue of *Perception*, is a good example of how opinion on this question has changed in recent years. Thirty years ago the dominant view was that contrast-sensitive mechanisms were intimately involved with SLC, a view sustained through the studies of Hurvich and Jameson (eg Hurvich and Jameson 1966), whose own ideas were strongly influenced by Hering (eg Hering 1874/1964). Recently, however, the pendulum has swung the other way, and Logvinenko's article typifies the newly found emphasis on perceptual interpretation in SLC.

The seminal study by Gilchrist (1977) is in my view the watershed that precipitated this change in opinion. Using a conventional display consisting of two grey patches on a different surround, Gilchrist observed that the magnitude of SLC was enhanced when the grey patches, normally seen as surrounded by materials of different reflectances, were instead seen as being under different illuminations. Since the luminance contrasts between the patches and their surrounds were kept the same under both configurations, the enhancement of SLC could not be due to the effects of local contrast. Instead, it must have been because of the way the subjects interpreted the display as a whole. Since Gilchrist's study, the dramatic improvement in computer graphics has been used to produce ever more compelling effects on a similar theme (eg Knill and Kersten 1991; Adelson 1993; Anderson 1997; Logvinenko 1999). Complex geometric arrangements evoking vivid impressions of shadows, transparency, shading, and occlusion have replaced the conventional SLC display. The results have been by-and-large impressive. So much so that for many protagonists the question is now no longer whether SLC is due to the effects of contrast or perceptual interpretation, but exactly what rules of perceptual interpretation underly SLC.

Logvinenko believes the answer lies with the notion of 'lightness – shadow' invariance. As I understand his use of the term, lightness – shadow invariance is where the lightness (perceived reflectance) of an object remains unchanged when the object is cast in shadow—a form of lightness constancy that takes into account local perturbations in illumination rather than changes in the ambient level (and see Arend 1994). Logvinenko develops his case for lightness – shadow invariance through an examination (with supportive data) of a number of variants of Adelson's (1993) tile pattern, which is shown here in figure 1 (also Logvinenko's figure 1). The difference in lightness, or brightness (perceived luminance), between the equal-in-luminance diamonds labelled 1 and 2 is for most observers greater in figure 1a than 1b. Logvinenko, like Adelson, argues that the enhanced SLC in figure 1a cannot be explained by the effects of local contrast, as the contrasts between the diamonds and their surrounds are similar



(a) (b)

Figure 1. Examples of tile pattern from Logvinenko's article: (a) Adelson's tile pattern and (b) control condition. The diamonds labelled 1 and 2 in both figures have the same reflectance.

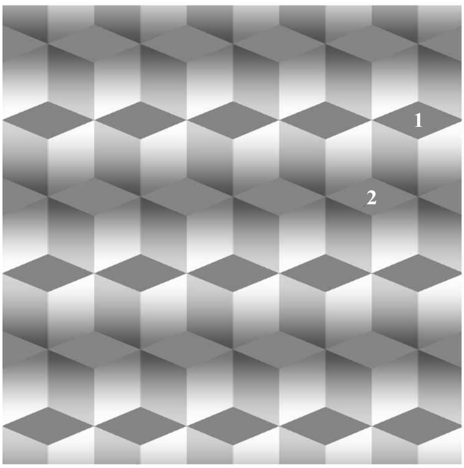


Figure 2. Logvinenko's modified tile pattern, in which the dark regions in figure 1a have been blurred. Again, the diamonds labelled 1 and 2 have the same reflectance.

in both figures. However, Logvinenko also rejects the account of figure 1 offered by Adelson (1993), his critique of Adelson serving as starting point for the development of his own explanation. For Adelson the enhanced SLC is due to the impression of dark transparent stripes in the figure. In his view, we parse the image into its component layers, or 'intrinsic images', and our judgments about the brightness of the test regions are strongly influenced by our estimates of their underlying reflectances. According to Logvinenko, however, Adelson's explanation is wrong because one can obtain enhanced SLC in tile patterns without any perceived transparency, as Logvinenko demonstrates in figure 2 here (Logvinenko's figure 4). In figure 2 the alternating dark and light stripes of the tile pattern have been blurred; now one no longer sees transparent stripes, yet the enhanced SLC is bigger than ever. I find this figure quite beautiful, because the SLC is so compelling. On first seeing it I reached for a pair of scissors to cut out two of the diamonds just to convince myself they really were the same shade of grey—and was surprised, but pleased, to find they were. For me, blurring the transparent overlays in figure 1a has replaced the impression of transparency with that of shading. Turn figure 2 through 90°, and you get an impression of a folded curtain in 3-D—a classic effect of shading. For Logvinenko too, the gradual luminance gradients in figure 2 and many of the other patterns in his article are most often interpreted as illumination gradients. According to Logvinenko, we correct for these perceived illumination gradients when ascribing the lightnesses of objects, and it is this 'lightness – shadow invariance' which explains the enhanced SLC.

Logvinenko counterposes lightness – shadow invariance to the perceived transparency explanation put forward by Adelson. But are these explanations really any different? A dark transparent filter introduces a local perturbation in illumination, similar to a shadow; highlights and shading are other examples of such perturbations. A general-purpose lightness-constancy mechanism would be expected to correct for all types of illumination perturbation when estimating lightness, resulting in enhanced SLC wherever strong impressions of such perturbations were present in the stimulus. For me, Logvinenko and Adelson are talking about the same thing.

In any event, the leitmotif common to Logvinenko and Adelson is, perhaps, old wine in new bottles. Just as Logvinenko's figure 2 is the 'shading equivalent' of Adelson's tile pattern, Adelson's tile pattern is the 'transparency equivalent' of Gilchrists's (1977) classic display described earlier, which demonstrated enhanced SLC with highlights. Furthermore, all these demonstrations are anticipated by Helmholtz's 'veiling hypothesis' of colour contrast (Helmholtz 1866/1962).

Helmholtz mainly considered the chromatic version of SLC, simultaneous colour contrast (SCC), in which a grey patch on a coloured surround appears tinted with the complementary colour of the surround. Helmholtz believed that all forms of SCC resulted from 'errors of judgment'. In some cases SCC occurred because of the mistaken assumption that the grey patch was covered by a transparent veil the colour of the surround, the eye compensating for the presence of the veil when estimating the colour of the patch (pages 282 – 287). An earlier experiment by Heinrich Meyer in 1855 appears to have been particularly influential. Meyer had shown that the red tinge seen in a grey patch on an intense green background became even redder when both were overlaid with a piece of transparent white paper, which had the effect of desaturating the green background. Helmholtz suggested that the overlay of transparent white paper helped create the illusion that the grey patch was being viewed through a green veil. However, because the eye receives from the grey patch a composition of light normally associated with grey, we infer that the patch must be pinkish, as the effect of the green veil would be to absorb the long wavelengths associated with the pinkish tint. Thus, according to Helmholtz, we have learned to 'correct' for the effects of intervening, transparent media, just as we have learned to 'correct' for the prevailing illumination in assessing the intrinsic lightness of objects. A Helmholtzian account of achromatic SLC would be based on an analogous argument. We assume that the patch on the brighter background is more intensely illuminated than that on the darker background. However, because the intensity of light reaching the eye is the same for both patches, an inference is made that the patch on the bright background must be of lower reflectance, and that is how it is perceived.

Helmholtz believed that other types of judgment error were also involved in SCC (eg see Helmholtz, pages 274 – 278; also Turner 1994, pages 108 – 113, for a recent review), but the relevance of his veiling hypothesis to the demonstrations by Gilchrist (1977), Adelson (1993), and Logvinenko (1999) is clear. These demonstrations all contain pictorial cues which elicit an impression of a 'veil', a local perturbation in illumination, whether a highlight (Gilchrist's demonstration), transparency (Adelson's figure 1a here), or shading (Logvinenko's figure 2 here). In each case the visual system estimates the lightness of the test region that it would have if the veil were removed. We 'err' in figures 1a and 2 only in the sense that we fail to correctly perceive the lightnesses of the diamonds as they are defined on the page in front of us, not as they are, at least notionally, 'under' the transparent or shading overlays.

Can we account for SLC with a single mechanism? Given what we know about vision in general, I think this unlikely. Take colour vision. Our visual system has three cones, rather than two or four. A post-receptoral stage combines cone outputs into two colour-opponent mechanisms—'red–green' and 'blue–yellow'. These post-receptoral mechanisms are combined, in ways we do not yet understand, to enable us to distinguish a myriad of colours. In addition, mechanisms operate to discount overall, and perhaps local, variations in the spectral content of illumination, to produce colour constancy. All these components of the colour vision process have independently measurable behavioural consequences (for example, trichromatic vision depends only on having three cones, and not on the way cone signals are combined). Is it not reasonable to suppose that lightness and brightness perception is a multi-component *system*, just like colour vision?

Are we able to rule out, then, a component of SLC due to the effects of contrast? The evidence for a contrast component in SLC is, I believe, overwhelming (eg see Whittle 1994a, 1994b for a summary of psychophysical studies in support of the notion of 'contrast brightness'). This contrast component of SLC is, I believe, an 'error' arising in the process which aims for lightness constancy in the face of changes in the ambient level of illumination. By linking lightness to contrast we succeed in illumination-level invariance but at the same time incur a penalty—lightness non-invariance with respect to changes in surround reflectance. Although the visual system appears to partially overcome the problem of integrating the array of local contrast signals in the scene, it never completely succeeds. In this view, SLC results from a failure of integration (see Whittle, op. cit.). It would be going beyond my remit to detail the evidence for the contrast component in SLC, but I have taken the liberty of including a simple demonstration which I think makes the point. Figure 3 shows a remarkable degree of lightness/brightness induction from luminance gradients which are not easily interpretable, and certainly not perceived by this writer, as illumination gradients.[1] The induced brightness/lightness in the figure has the effect of rendering the uniform, and ramped-in-luminance stripes, almost indistinguishable, except in their perceived phase. Figure 2 does not sit easily with a purely configurational approach to lightness/brightness perception. On the other hand its appearance is nicely predicted by the response of a simple bandpass linear filter approximately tuned to the stripe frequency of the pattern. I emphasise that this demonstration in no way diminishes the importance of the other factors involved in SLC that we have been discussing.

I argue that contrast remains the most parsimonious account of the residual SLC in figure 1b, as for any figure where the two test regions appear surrounded by different materials rather than veiled in different illuminations. In his classic work *The Principles of Psychology*, William James criticised Helmholtz's veiling hypothesis precisely for this reason; SCC occurred even under conditions where it was quite implausible to suppose that the test regions were differently illuminated (James 1890/1981, pages 662–674). Whether it was fair of James to impute to Helmholtz the belief that all forms of SCC could be explained by the veiling hypothesis is questionable (eg see Turner, op. cit.), but in doing so James nevertheless highlighted the pitfalls often inherent in attempts to provide a single account of a complex phenomenon.

Both Hering and Helmholtz had important things to say about SLC and SCC (and see Kingdom 1997), and, in keeping with this sentiment, I suspect most of Logvinenko's demonstrations require *both* a contrast-sensitive and illumination-interpretive explanation.

(1) The figure is a modified version of a figure shown in Moulden and Kingdom (1991). It is based loosely on the grating induction effect (McCourt 1982). The recent paper by Blakeslee and McCourt (1997) shows that grating induction and classical simultaneous brightness contrast are essentially the same phenomena.

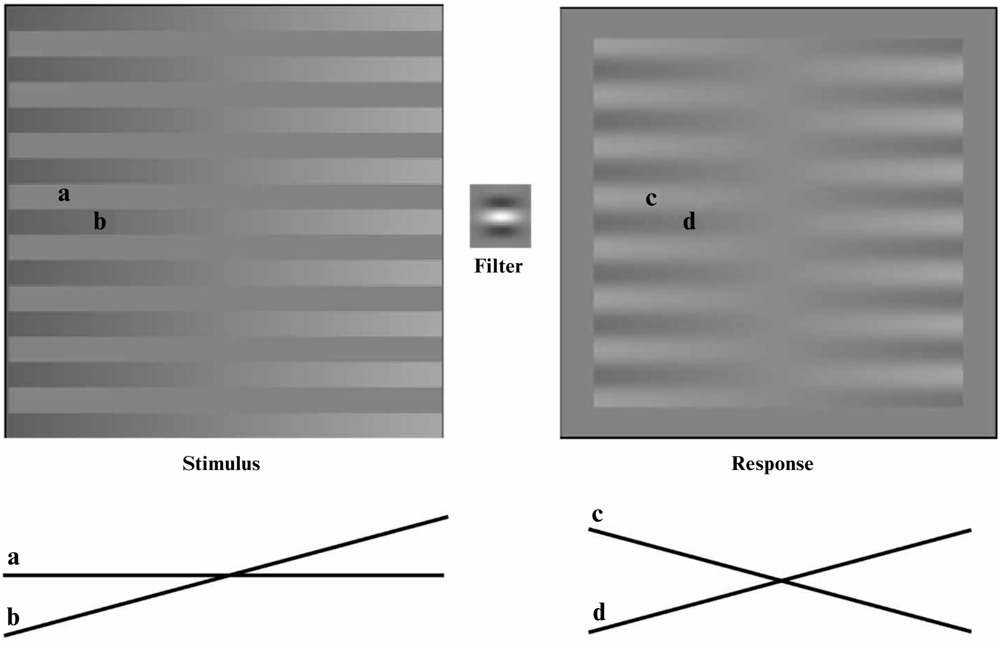


Figure 3. Demonstration of ramp-induced brightness. The stimulus on the left consists of uniform horizontal stripes alternating with ramped-in-luminance stripes (the ramp starts with dark on the left); the luminance profiles for stripes a and b are shown below. It is difficult to tell which stripes are uniform and which have the ramp, so complete is the brightness induction. On the right is shown the convolution response of a horizontal Gabor filter (middle) matched approximately in scale to the frequency of the stripes. The response accords with the percept of the stimulus, as shown in the luminance profiles of stripes c and d.

Logvinenko has produced some novel stimuli which forcefully demonstrate how easily we can be fooled when ascribing the lightness to surfaces; ironically, it seems, because of processes aimed at achieving veridicality. His article is a timely contribution to the ongoing debate about what factors determine SLC.

Fred Kingdom
McGill Vision Research Unit, 687 Pine Avenue West, Room H4-14, Montréal, PQ H3A 1A1, Canada

Acknowledgement. I would like to thank Anthony Hayes, Pauline Pearson, and Nick Scott-Samuels for their helpful comments when preparing this manuscript.

References

Adelson E H, 1993 "Perceptual organization and the judgement of brightness" *Science* **262** 2042 – 2044

Anderson B L, 1997 "A theory of illusory lightness and transparency in monocular and binocular images" *Perception* **26** 419 – 453

Arend L E, 1994 "Surface colors, illumination, and surface geometry: Intrinsic-image models of human color perception", in *Lightness, Brightness, and Transparency* Ed. A L Gilchrist (Hillsdale, NJ: Lawrence Erlbaum Associates) pp 159 – 213

Blakeslee B, McCourt M E, 1997 "Similar mechanisms underlie simultaneous brightness contrast and grating induction" *Vision Research* **37** 2849 – 2869

Gilchrist A L, 1977 "Perceived lightness depends on perceived spatial arrangement" *Science* **195** 185 – 187

Helmholtz H von, 1866/1962 *Treatise on Physiological Optics* volume 2, translated by J P L Southall (1962, New York: Dover) pp 264 – 301 (volume 2 originally published in 1866)

Hering E, 1874/1964 *Outlines of a Theory of the Light Sense* translated by L M Hurvich, D Jameson (1964, Cambridge, MA: Harvard University Press) (original work published in 1874)
Hurvich L M, Jameson D, 1966 *The Perception of Brightness and Darkness* (Boston, MA: Allyn and Bacon)
James W, 1890/1981 *The Principles of Psychology* (1981, Cambridge, MA: Harvard University Press) (original work published in 1890)
Kingdom F A A, 1997 "Simultaneous contrast: the legacies of Hering and Helmholtz" (Guest editorial) *Perception* **26** 673 – 677
Knill D C, Kersten D, 1991 "Apparent surface curvature affects lightness perception" *Nature (London)* **351** 228 – 230
Logvinenko A D, 1999 "Lightness induction revisited" *Perception* **28** 803 – 816
McCourt M E, 1982 "A spatial frequency dependent grating induction effect" *Vision Research* **22** 119 – 134
Moulden B, Kingdom F, 1991 "The local border mechanism in brightness induction" *Vision Research* **31** 1999 – 2008
Turner R S, 1994 *In the Eye's Mind. Vision and the Helmholtz – Hering Controversy* (Princeton, NJ: Princeton University Press)
Wade N J, 1996 "Descriptions of visual phenomena from Aristotle to Wheatstone" *Perception* **25** 1137 – 1175
Whittle P, 1994a "The psychophysics of contrast brightness", in *Lightness, Brightness, and Transparency* Ed. A L Gilchrist (Hillsdale, NJ: Lawrence Erlbaum Associates) pp 35 – 110
Whittle P, 1994b "Contrast brightness and ordinary seeing", in *Lightness, Brightness, and Transparency* Ed. A L Gilchrist (Hillsdale, NJ: Lawrence Erlbaum Associates) pp 111 – 157