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Last but not least

Abstract. A central tenet of Gestalt psychology is that the visual scene can be separated into figure and ground. The two illusions we present demonstrate that Gestalt processes can group spatial contrast information that cuts across the figure/ground separation. This finding suggests that visual processes that organise the visual scene do not necessarily require structural segmentation as their primary input.

Grouping by contrast: figure – ground segregation is not necessarily fundamental

The term Gestalt refers to the formation of distinct perceptual units that are fundamental to our perceptual construction of the world. Central to the Gestalt approach is the concept of figure/ground separation (Rubin 1915): a 'figure' possesses a 'thing character' that is spatially cohesive and enclosed (ie demarcated by a contour, and filling the entire surface inside its border); a 'ground' possesses a material character that extends behind the figure. Any visual scene can be parsed into figure and ground on the basis of the well-known Gestalt grouping factors (symmetry, proximity, closure, common fate, etc—for review see Spillmann and Ehrenstein 2004).

Here, we present two new visual effects that demonstrate that Gestalt grouping can arise from contrast information that cuts across figure and ground. The effects are interesting because contrast that cuts across a figure/ground separation (or, for that matter, across any scission boundary) cannot be considered part of either the figure perceptual unit or the ground perceptual unit. The effects show, therefore, that contrast information can serve as a driver for Gestalt grouping processes.

The two visual effects are types of contrast asynchronies: a class of stimulus configuration defined by in-phase luminance modulations and out-of-phase contrast modulations (Shapiro et al 2004a, 2004b, 2005). For instance, when two identical discs are modulating from light to dark at the same time, with one disc placed against a light background and the other against a dark background, the discs appear to modulate out of phase with each other (in line with the contrast information). The perception of out-of-phase modulation represents the visual response to the contrast, and not just visual 'salience', because similar effects can be perceived for several types of luminance/chromatic modulations when the discs are equally visible.

The first effect is depicted in figure 1 but is best seen in the supplementary interactive movie (access details are in captions to figures 1 and 2). The display contains four discs whose luminance levels modulate in time, with a sawtooth waveform: the top two discs modulate from dark to light; the bottom two discs modulate from light to dark. When the discs are placed against a grey background (figure 1a), the two discs in the top row group together, and the two discs in the bottom row group together. This grouping pattern is expected because the luminance and contrast of the top two discs modulate in phase with each other, and the luminance and contrast of the bottom two discs modulate in phase with each other. When the discs are placed in front of a split light/dark background (figure 1b), the discs at opposite corners group together (ie the light-to-dark disc against the light background groups with the dark-to-light disc against a dark background). The perception of grouping, therefore, follows the contrast modulation of the discs against the background, not the luminance modulation of the discs by themselves. Supplement 1b shows a similar effect with a triangle waveform.

The demonstrations show that observers tend to group the discs by contrast even though the discs with identical luminance levels get light and dark at the same time. A few observers have commented that they can switch between grouping diagonally and grouping

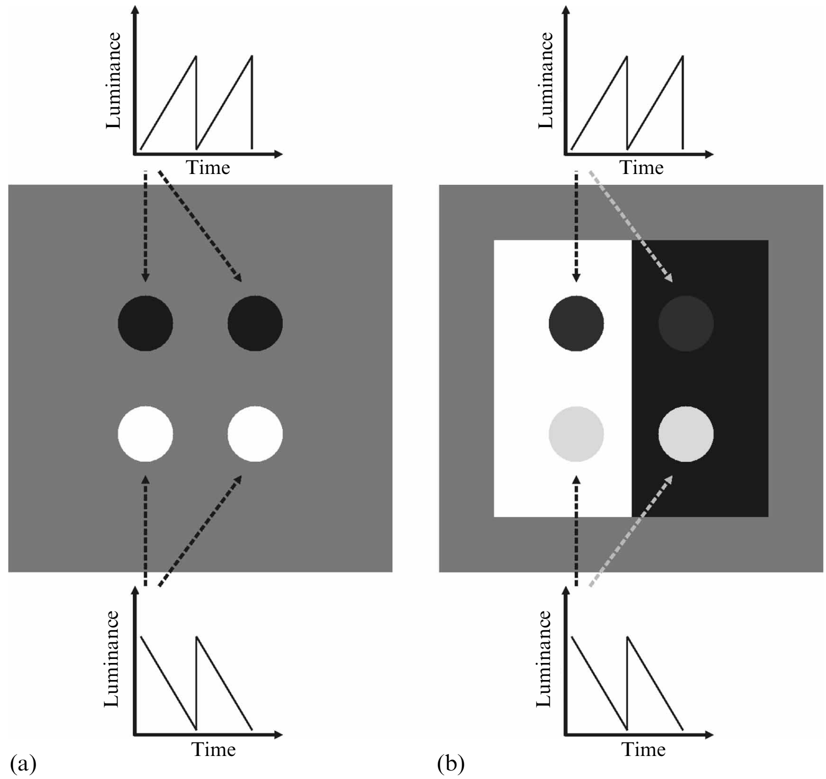
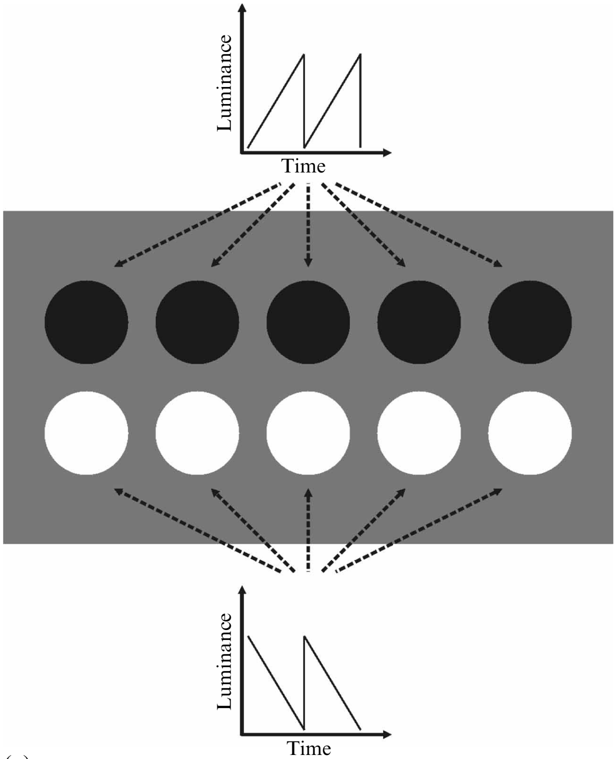


Figure 1. The visual effects depicted here are best viewed in the supplementary file (see http://www.perceptionweb.com/misc/p5733/). Luminance levels of four discs modulate in time, with a sawtooth wave form. Two modulate from dark to light (top row); two modulate from light to dark (bottom row). When the background is grey (a), the dark-to-light discs group together, and the light-to-dark discs group together; when the background is split light/dark (b), the discs along the diagonals group together. Supplement figure 1b shows a similar demonstration with colour – luminance discs.

horizontally when the discs are placed in front of the split light/dark background, implying that these observers are able to switch between a framework based on contrast information and a framework based on luminance information. The interactive supplements also show a similar effect for a colour/luminance display where the discs are always equally visible; this indicates that observers are responding to the contrast information and not simply to the perceptual salience of the discs.

The second effect shows that grouping can also occur for motion generated by contrast information (second-order motion). Figure 2 and the supplementary interactive movie show five discs that modulate from dark to light (top row) and five discs that modulate from light to dark (bottom row), with a sawtooth waveform. The background is grey in figure 2a (blue in the supplementary file) and is two spatially shaded gradients in figure 2b (light-to-dark on top, and dark-to-light on bottom). Against grey, the discs in the top row group together, and the discs in the bottom row group together. This grouping pattern is expected since the luminance information and the contrast information in each row modulate in phase with each other (similar to figure 1a). Against the shaded gradients, the grouping reaches across vertical pairs of discs and follows a sweeping motion that shifts from disc to disc across the display. The motion makes sense in terms of contrast information—the phase of contrast for each disc is shifted relative to the neighbouring disc(s)—but not in terms of the luminance information, which remains unchanged from the grey background condition (see figure 6 in Shapiro et al 2005).



(a)

Figure 2. The visual effects depicted here are best viewed in the supplementary file (see http://www.perceptionweb.com/misc/p5733/). There are two rows of five discs each; the top row modulates from light to dark, and the bottom row from dark to light (sawtooth pattern) on a medium grey background. When the background is grey (a), the discs group by row. When the background consists of two gradients (b—from light to dark on top, from dark to light on bottom) apparent motion sweeps from right to left in both rows. In this condition, the elements of different luminance levels in the top and bottom row are grouped together and seem to move in unison.

The implication is that the grouped appearance depends upon information that is not solely part of the figure (ie the discs) and not solely part of the ground (ie the shaded gradients). The processes responsible for grouping, therefore, do not necessarily rely upon information that has been organised into objects or into layers. This interpretation is consistent with models that suggest that grouping can arise from temporal correlations of elemental modulation (for review see Blake and Lee 2005), and with evidence for visual processes that operate across coplanar divisions (eg Spehar and Zaidi 1997).

Any visual scene can be described by a variety of stimulus characteristics (spatial frequency, luminance, contrast, temporal frequency, chromaticity, etc). The visual system represents these properties through parallel neural channels, each of which responds to only a small range within a few of these dimensions. Presumably, the processes that organise the visual scene must do so by selecting responses from a sub-population of the neural channels. The visual effects in this paper show that processes responsible for Gestalt grouping are capable of selecting neural channels that respond to contrast information. The effects also suggest the possibility of multiple types of grouping processes. The visual system contains dorsal and ventral streams that respond differentially to motion and to objects; conceivably, each of these streams has its own set of processes for organising the visual scene.

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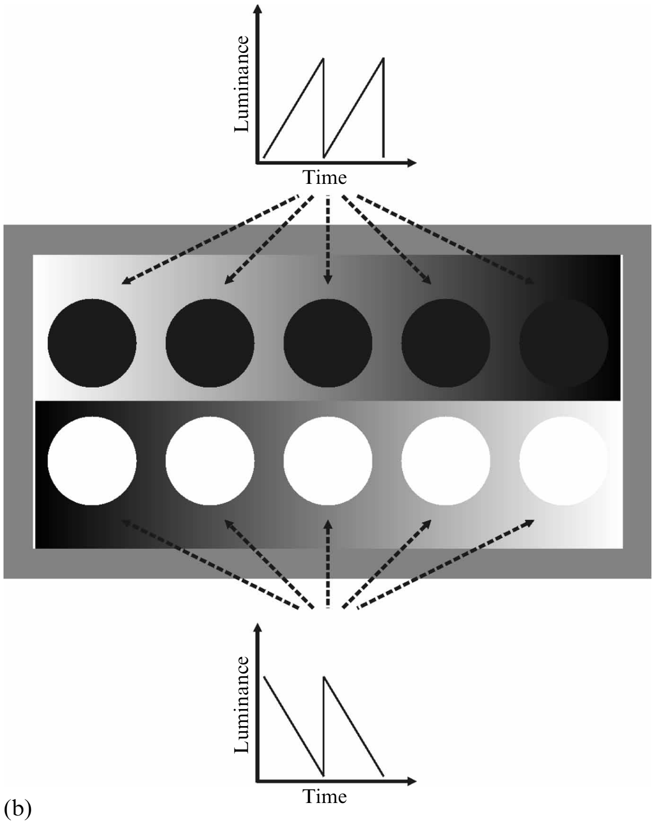

(b)

Figure 2 (continued)

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