

# Julesz's joyfulness

**British 'natural magicians' of the nineteenth century could turn two flat images into one three-dimensional form. Later, Bela Julesz believed his stereograms showed how the brain turns images from two eyes into one reality.**

**Martin Kemp**

Why two eyes result in one mental image has perplexed investigators of vision from the very beginning. However effective the techniques forged by artists and photographers to evoke three dimensions on a flat surface, the absence of parallax cues remained a serious limitation. It is surprising that the idea of presenting a slightly different image of the same object to each eye did not occur to the Jesuit 'magicians' of the Baroque era. In the event it was British exponents of 'natural magic' in the 1830s who performed the trick.

It is unclear whether credit for this should be given to James Elliot of Edinburgh in 1834, as claimed by the disputatious David Brewster, or to Charles Wheatstone, whose 1838 publication backdated his invention by at least six years. But it was Wheatstone's two-mirror stereoscope that entered the public arena. His earliest images, linear drawings of

geometrical solids which lacked other spatial clues, had already shown how fundamental the process of stereopsis was in the presentation of "a solid figure... in such a manner that no effort of imagination can make it appear as a representation on a plane surface".

The making and viewing of stereo-images was progressively refined over the years, but the next fundamental move came with the invention of the random-dot stereogram in its definitive, computerized form by Bela Julesz in 1959. He showed how the "cyclops within us" exploits stereo processing to unscramble two apparently unintelligible random-dot arrays in which a central region is invisibly 'lifted' and displaced to the right in the left image and vice versa. Using an appropriate viewing device, or crossing our eyes in front of the images, we discern the displaced zone as if it were a shape suspended in front of the background.

Looking back on Julesz's 1971 book, *Foundations of Cyclopean Perception*, it is

striking how much it stands in line of succession from Brewster's *Letters on Natural Magic* (1832) and his monographs on the kaleidoscope and stereoscope, and how different in tone it is from David Marr's posthumously published *Vision* in 1982, in which a "cooperative algorithm" is posited as a computational alternative to Julesz's more mechanistic explanatory framework.

**Julesz, like Brewster, stands within a tradition of culturally expansive science. Not only does Julesz joyfully make big claims for the technical innovation as the gateway to a theory of "global stereopsis" and as a "real paradigm" but he also aspires to place his discovery on a "broad foundation by using analogies from many disciplines, including music". Characteristically, he calls his technique "random counterpoint".**

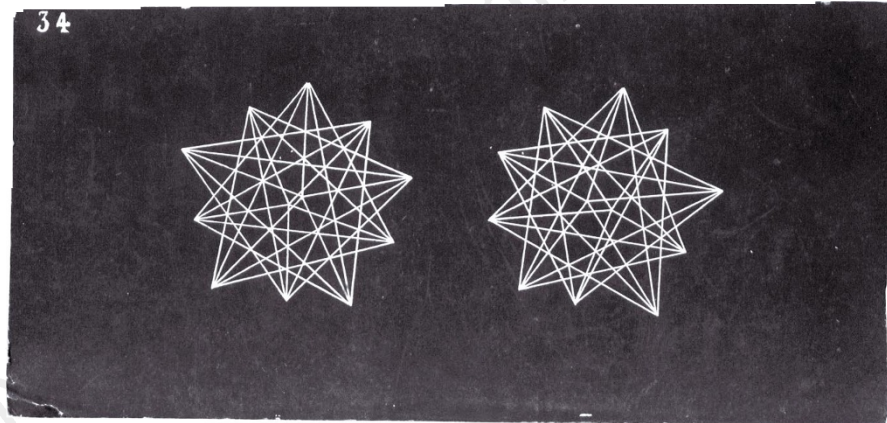
He claimed that random-dot stereograms allow experimenters to communicate directly with internal processing. This access to "the mind's retina" bypasses the peripheral processes in a way that "eclipses" monocular clues and isolates stereopsis "without rivalry". He proposed that, if the classic experiments on perception and illusion could be replicated in random-dot stereograms, the processes would be identifiable as centrally located within the brain rather than attributable to the retina.

His intended audience comprised, primarily, "students" and "workers in visual perception", together with "clinicians" who might want tests for stereopsis, and "the mathematician and designer" interested in "the visualization of complex surfaces". He also stressed that his illusions would, "last, but not least, delight the layman or student of the visual arts".

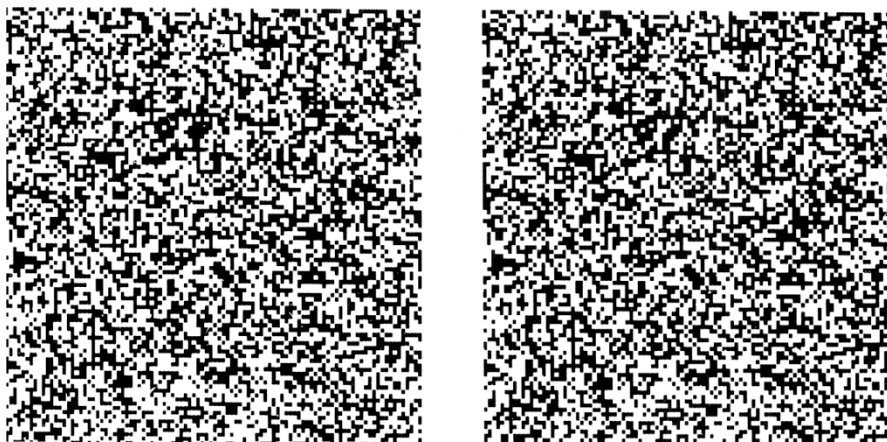
It is not my intention here to present a historical choreography of the successive refinements and interactions between the experimental 'grit' and the algorithmic modelling. Rather, I offer a reminder of how the experimental psychologists' modern bag of tricks, however esoteric the techniques and theories, can still serve to induce popular awe at the 'natural magic' residing with our perceptual system — with a sense of joy that is undiminished from the age that saw the invention of the stereoscope. □

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Quotations from Julesz are taken from B. Julesz, *Foundations of Cyclopean Perception* (Univ. Chicago Press, 1971).



Early stereo card of a stellated octahedron, for use with a lenticular stereoscope.



Get in touch with your inner cyclops: crossing the eyes should reveal a diamond hovering above the textured background. Julesz believed these random-dot stereograms gave researchers direct access to "the mind's retina" (from B. Julesz, *Foundations of Cyclopean Perception*).