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Charles Bonnet hallucinations

Cortical bricks and mortar

D H ffytche

The cortical microanatomy of cells in retinotopic regions may determine the geometry of hallucinations

> . . . il voit les Bâtiments s'élever sous ses yeux et lui offrir toutes les Parties qui entrent dans leur Construction extérieure.[1]

Charles Bonnet's visually impaired grandfather, although remembered (through the eponymous syndrome) for his hallucinations of figures, animals, and objects, also saw brickwork and scaffolding patterns. Largely ignored in the literature, these grid-like phenomena are experienced by more than 70% of patients with visual hallucinations secondary to eye disease. They are also reported by patients with visual pathway infarcts and by normal sighted subjects during visual sensory deprivation, stroboscopic stimulation, the hypnagogic state, and under the influence of psychedelic drugs. Their ubiquitous and stereotyped nature led Heinrich Klüver to propose that the pattern geometry reflected a fundamental visual mechanism, although he realised that its identification would await future developments in visual neuroscience. In this issue, Burke provides new psychophysical observations of his own hallucinated brickwork and dot patterns which bring us a step closer to understanding their underlying neurobiology (this issue, pp 535–41).[2]

Burke's hallucinations followed the development of bilateral macular holes and were seen in sufficient detail to estimate the visual angle subtended by repeating pattern elements. When transformed into cortical distance, Burke found a striking similarity between the separation of brickwork courses in his hallucinations and the separation of cytochrome oxidase stripes in the extrastriate visual cortical area, V2. Similarly, he found the separation of hallucinated dots matched the separation of cytochrome oxidase blobs in the primary visual cortex, V1. Cytochrome oxidase staining identifies cortical subcompartments which, Burke argues, are particularly susceptible to deafferentation due to their high metabolic demands. In macaque visual cortex, V1 blobs have a higher concentration of cells specialised for colour than the surrounding interblob regions. Similarly, V2 stripes, depending on their thickness, have a higher concentration of cells specialised for orientation/direction or colour. The retinotopic organisation of V1 and V2 is such that neighbouring cells along the axis of a V2 stripe or along a row of V1 blobs code a specific trajectory within the visual field. Burke proposes that, following deafferentation of macular visual cortex, increased spontaneous activity in V2 stripes results in stereotyped brickwork hallucinations and, in V1 blobs, dot pattern hallucinations.

A link between cortical architecture and the geometry of pathological visual percepts was suggested as early as 1941 by Karl Lashley, with respect to his own migraine aura, and several anatomical explanations have been offered.[3 4] Burke's hypothesis moves the field forward in that his is the first to account for different types of pattern hallucination and, in particular, to provide a plausible explanation for brickwork. Our current understanding of visual hallucinations is that they result from activity within populations of cells which correlate with percepts of specific visual attributes. If Burke's proposal is correct, it suggests that, in retinotopic regions at least, the cortical microanatomy of such cells defines the geometry of their associated hallucinations—in a sense, "seeing" the brain from the inside.

J Neurol Neurosurg Psychiatry 2002;**73**:472

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