

So, could accidental parthenogenesis in humans ever give rise to a new parthenogenetic lineage? Probably not, as the developmental and genetic constraints in humans and other mammals would most likely prevent the emergence of adaptive parthenogenesis in natural populations [1]. As it turns out, even the most famous speculation about parthenogenesis, Jesus Christ's birth, owes its existence not to a miracle but to a human error during the translation of Isaiah 7:14 from Hebrew to Greek: The Hebrew word *almah* can refer to a young woman of marriageable age, whether married or not [15]. The 'young woman' became a 'virgin' in the gospel according to Matthew, where *almah* was translated as the Greek *parthenos*.

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## Binocular Vision: Joining Up the Eyes

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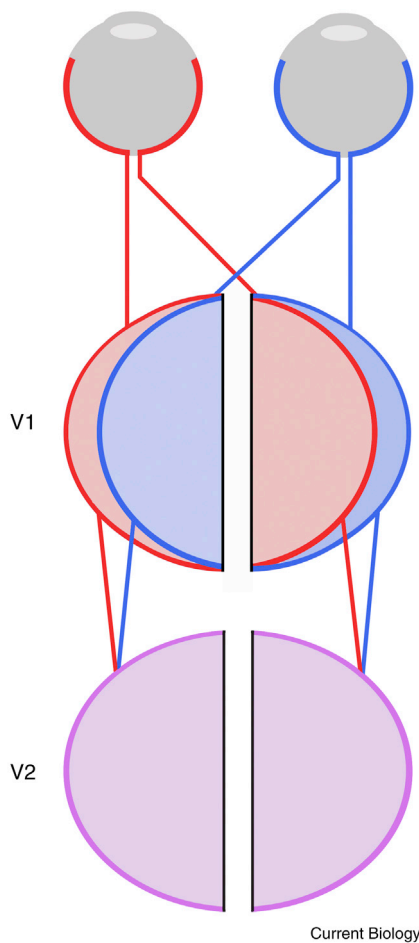
To provide a unitary view of the external world, signals from the two eyes must be combined: a new study pinpoints the location in the human brain where the requisite combination occurs.

A fundamental feature of human vision is that, despite having two eyes, we normally see only one representation of the world around us. This phenomenon, imaginatively termed cyclopean perception by the late Bela Julesz [1], requires a seamless combination of two completely separate neural signals and imposes on the brain a substantial computational burden that a cyclops would be spared. There are, however, a number of benefits to having two eyes that collectively outweigh the computational cost. Perhaps the most obvious, although not necessarily the evolutionary driver, is insurance against loss of an eye. Another is that it permits a

wider field of view (only modestly wider in humans but much wider in horses, sheep and many other mammals). The most studied benefit is that having two eyes permits stereoscopic vision: the construction of accurate estimates of the distances of nearby objects based on subtle differences between the two retinal images. These benefits depend on the replacement of two representations of the world by a single, cyclopean representation. Where in the brain does this happen? It might be expected that a harmonious coalition of left and right would be constructed at the very first processing stage at which both signals are present in proximity: the thalamus;

however, it has long been known that this is not the case and that the answer is “somewhere in the visual cortex”. In this issue of *Current Biology*, Barendregt *et al.* [2] present evidence from functional magnetic resonance imaging (fMRI) that the transformation occurs between the primary visual cortex, known as V1, and the second visual area, V2.

Whether a given neuron is responsive to light stimulation in either eye or is driven only by one eye has been addressed in many neurophysiological studies, starting with the pioneering work of Nobel Prize winners Hubel and Wiesel, who found that the primary visual cortex of macaques contains a mixed bag of cells, some



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### Figure 1. Binocular combination leading to cyclopean perception.

A schematic diagram incorporating the new finding [2] is shown. The optic nerves from the left eye (red) and right eye (blue) exchange fibres in a familiar cross-over pattern such that in the first cortical processing stage (V1), the left half of each retinal image connects to the left hemisphere and the right half to the right. In V1, separate representations of the two overlapping retinal images are preserved. Due to the blocking effect of the nose and face, each extends further ipsilaterally than contralaterally. V1 projects to V2, where there is a convergence of information to create a single, cyclopean representation of the external world (purple).

responding to visual stimuli only through one eye, some responding well through both eyes, and some that respond through both but are strongly dominated by one eye [3]. Thus, in macaque V1, the process of binocular combination has commenced but is far from complete. As visual areas beyond V1 began to be defined in the 1970s [4], it became clear that binocularity of neurons rapidly becomes much more firmly established

in V2, V3 and beyond. Even in V2, most neurons respond to both eyes with little or no preference [5,6]. Seemingly, information about eye-of-origin has largely been discarded.

Neurophysiology, with its tiny electrodes that can measure the activity of single neurons, provides vastly more detailed information than functional MRI can ever hope to do, but it carries the problem that it is difficult to deduce macroscopic organization from a sample of microscopic observations. Furthermore, humans and macaques are less closely related than the assumptions of equivalence sometimes apparent in the literature on visual processing might suggest. For these two reasons, human fMRI thrives, even in the relatively few domains in which macaque neurophysiological data are plentiful. Barendregt *et al.* [2] sought to examine the overall reference frame in which the visual cortex represents the visual scene, at each of several levels of cortical processing. They simulated a simple situation in which, because of its proximity to the face, a single object casts an image in different parts of the two retinæ. They then asked whether the representation of the object in the visual cortex reflects these two retinal locations (retinal representation) or the singular location of the object itself (cyclopean representation).

To do this, Barendregt *et al.* [2] obtained maps of the visual field by estimating the ‘population receptive field’ at each point in the grey matter of the visual cortex. This technique rests on two principles. The first is that when a visual stimulus is moved slowly through the visual field, across a screen in front of the observer, the timing of the response elicited at a given point on the cortical surface reveals the point on the retina to which neurons at that cortical locus are connected. The retina is systematically mapped onto the cortical surface and the timings of fMRI responses recorded at hundreds of different points (voxels) can be used to construct a complete cortical map of visual space, known as a retinotopic map [7,8]. Each visual area (V1, V2, V3 and so on) has its own map.

However, visual neurons do not in fact represent points on the retina, but instead integrate information across patches on the retina, the spatial extents of these

patches varying widely, both within and among cortical visual areas. The second principle addresses this fact: the larger the retinal area to which a voxel in visual cortex is connected, the longer will be the duration of the response to a stimulus that moves through the population receptive field. This principle can be used to construct maps of population receptive field size from the response durations recorded at each voxel in the retinotopic map [9]. By combining these two measurements and fitting a model that has both a spatial location and a width, or area, a map of both population receptive field location and population receptive field size can be constructed [10].

Barendregt *et al.* [2] derived population receptive field maps based on responses to a stereoscopically presented moving bar and asked whether the maps better fitted a prediction based on two monocular representations or an alternative prediction based on a combined, cyclopean representation. In V1, the former fitted better, but in V2 the results were more consistent with a combined representation (Figure 1). In several cortical areas beyond V2, the cyclopean view persisted. Given that V2 receives its excitatory input from V1 and is therefore higher in the processing chain, this suggests that a transformation from monocular representations to integrated binocular vision occurs between V1 and V2.

The analysis performed by the authors was binary, forcing each visual area into one of two discrete categories by asking which framework accounts for more of the variance in the data. The reality may be more complex than suggested by this categorization approach, which cannot accommodate any mixture of frameworks within a single visual area. Given the presence of binocular neurons in macaque V1, coupled with the finding that visual adaptation induced in human V1 through one eye is to some extent evident when tested with the other [11], it is likely that the process of binocular combination starts in V1 in humans, even if it is not yet sufficiently developed to dominate the fMRI response.

Similarly, there is room in the authors’ data [2] for monocular representations to be preserved by a minority of neurons in V2 and beyond. It is plausible that the required degree of monocular processing

differs among computational objectives. For the recognition of faces, for example, it is hard to argue against combining the retinal images as early as possible. However, for determining the three-dimensional trajectories of moving objects from differences in image speed between the two eyes [12,13], a precise estimate of speed and direction must first be derived from each eye separately and a more leisurely pace of binocular combination may therefore be warranted. The transformation from retinal to cyclopean might thus be most effective if it occurred flexibly, at different levels in different contexts.

The elegant work of Barendregt *et al.* [2] provides a key step towards characterizing binocular combination in the human cerebral cortex and it will be interesting to see whether their approach can be extended to quantifying binocularity in situations that impose differing binocular demands. It would be possible in principle to derive a non-binary (if noisy) index of ‘cyclopeanness’ from the ratio of the variances explained by the two models. Perhaps, with some further thought and experimentation, a more sophisticated metric could be developed. Cyclopeanness could then be assessed for different types of stimulus. An interesting approach would be to replace

the black stimulus bar with a bar defined only as a dynamic random dot stereogram [1], which requires binocular combination for its existence and is completely undetectable in each monocular image. This is the ultimate, pure cyclopean stimulus. In macaques, neurons that can detect such stimuli are reportedly about equally common (30%) in V1 and V2 [14]; if this is also true in humans, we would expect a very different result with such stimuli from that reported by Barendregt *et al.* [2].

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## Chromosome Condensation: Weaving an Untangled Web

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The compaction of diffuse interphase chromatin into stable mitotic chromosomes enables the segregation of replicated DNA to daughter cells. Two new studies characterise, both *in vivo* and *in vitro*, the essential contribution of the vertebrate condensin complex to chromosome organisation.

Chromosome condensation, the formation of thread-like chromosomes from interphase chromatin, is one of the most striking and earliest-described

morphological changes in cells entering mitosis. As a consequence of condensation, chromatids become compacted into threads, are imparted

longitudinal rigidity to withstand spindle forces, and disentangle from their sister chromatids. However, the molecular events accompanying this large-scale

