NEUROSCIENCE

Seeing the World in the Same Way

Luiz Pessoa

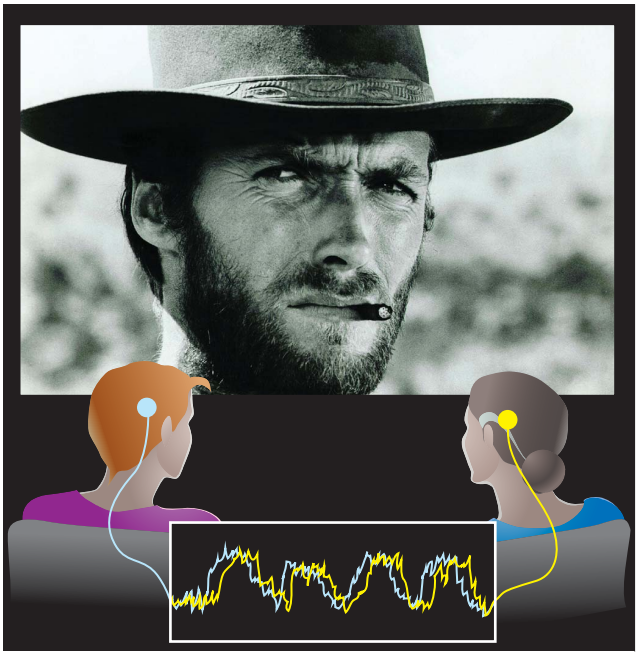
As you watch Clint Eastwood in the 1966 movie classic *The Good, the Bad, and the Ugly*, what is happening in your brain? Is what happens in your brain the same as what happens in mine? Do we all see the world in the same way? This is the central question posed by Hasson *et al.* (*1*) in their brain imaging study reported on page 1634 of this issue.

Functional magnetic resonance imaging (fMRI) allows scientists to noninvasively investigate the organization of the human brain. fMRI is sensitive to blood oxygenation levels and is believed to reflect the integrated activity of large groups of neurons (*2*). Experiments with fMRI have shown that the human visual cortex is parceled into a set of brain areas that have relatively simple responses to the components of visual stimuli (*3*) such as patterns of texture. However, other regions of the visual cortex display more complex response behaviors. One such region, situated in what anatomists call the fusiform gyrus, is activated strongly when participants view images of human faces (*4*, *5*). Another region is situated in the collateral sulcus and is activated strongly when subjects view images of outdoor scenes, including buildings (*6*).

In a typical fMRI experiment, participants view a fixed set of controlled stimuli and perform a task. For instance, they may be asked to view a set of photographs of objects presented in a sequence of frames and to indicate every time an object is repeated. fMRI signals are then compared for two conditions, for example, viewing photographs of faces and photographs of buildings. Such comparisons are the basis for generating so-called brain activation maps that assess whether evoked signals are stronger during one condition relative to another. In such maps, activated regions are thought to indicate increased neuronal processing at a specific site in the brain and can be used to assess the degree of functional specialization of a given region.

Hasson *et al.* adopted a completely different strategy for their fMRI study. Instead of a fixed set of experimental stimuli, participants simply watched an uninterrupted 30-min segment of *The Good, the Bad, and the Ugly* (see the figure). The investigators asked whether fMRI signals in one person's brain could predict signals in another person's brain. Remarkably, they found a large degree of correlation between the brains of pairs of participants who watched the same movie segment. On average, close to 30% of the cortical activation of one person's brain could be predicted by the fMRI signals from another individual's brain. To correlate the signals in the brains of two individuals, Hasson *et al.* initially "normalized" each brain into a common coordinate system, a routine procedure in fMRI research. Thus, the locations in one person's brain could be roughly aligned with the same locations in another individual's brain. The remarkable degree of correlation in brain activation among different individuals suggested to the authors that individual brains "tick together" in synchronized spatiotemporal patterns when exposed to the same visual environment (in this case, the movie). To rule out the possibility that the observed correlations reflected extraneous factors, such as the loud noise of the scanner, they tested a subset of their participants as they lay passively in the dark with their eyes closed for 10 min. Under these conditions, only negligible correlations were observed.

How is it that fMRI signals in one person's brain can predict the signals in another person's brain so well? Surely, we all experience a given movie in different ways that depend on both our personal history and our mood at the time of watching the movie. One possibility is that the correlations that Hasson *et al.* observed might reflect the attentional and emotional impact of the movie scenes. It is known that both attention and emotional content strongly modulate visual processing and affect fMRI signals (*7*–*9*). This interpretation is consistent with the authors' finding that a substantial component of brain activation appears to be related to viewing emotionally salient and surprising segments in the movie—for instance, scenes containing gunshots and explosions.



Watching me, watching you. When two people watch a movie, do they experience it in the same manner? Hasson *et al.* (*1*) investigated this question by having participants watch a segment of the Clint Eastwood movie *The Good, the Bad, and the Ugly* while undergoing fMRI. They then used the fMRI signals (blue) from one person's brain as that person watched the movie, to predict the signals (yellow) in another person's brain when that individual watched the same movie segment. Signals from one brain predicted, on average, the signals of another brain over 25 to 30% of the cortical surface.

It appears, however, that the observed interbrain correlations were not entirely due to attentional and emotional alertness. To address this issue, Hasson *et al.* subtracted from the fMRI time series a nonselective component. They defined this component as the average time course of activation over a large region of visual cortex (that is, a portion of the cortex that encompassed parts of the occipital and temporal lobes). Even after this was done, the correla-

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tion between pairs of brains was still close to 25% of the cortical surface.

The investigators also confirmed that a region in the fusiform gyrus, which is known to respond strongly to faces, showed similar robust responses during (unconstrained) viewing of the movie. Likewise, a region in the collateral sulcus produced vigorous responses when subjects viewed images of indoor and outdoor scenes, including buildings. In fMRI analysis, experimenters typically use the sequence of stimulation (which is known in advance) to predict the response. However, because of the unconstrained nature of the movie visual stimulus, Hasson *et al.* had to resort to a different strategy. They inverted the usual analysis process and used the signal amplitude at a given location to predict which type of stimulus was effective in eliciting a response. By doing so, they could construct a "movie" that was based on the edited sequence of all movie frames that evoked strong activation. Hence, they could determine, for example, that the fusiform gyrus responded strongly to close-ups of face images during the movie. Hasson *et al.*'s study is important, then, because it shows that the response properties observed in previous fMRI studies, which were based on controlled experimental situations, are valid for situations that are closer to real life [see (*10*, *11*) for fMRI studies using less constrained situations].

Perhaps just as important as Hasson *et al.*'s findings about interbrain correlations is their observation that large regions of activated cortex could not be predicted from another individual's brain activity. These regions include portions of the parietal cortex and, notably, the majority of the prefrontal cortex. Thus, there might be, after all, ample cortex for you and I to experience *The Good, the Bad, and the Ugly* in a unique way. It also means that there is enough work to keep neuroscientists busy for quite some time.

References

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GEOCHEMISTRY

What Biogenic Minerals Tell Us

Danielle Fortin

Biogenic minerals are generally those formed in the presence of biological cells (mainly bacteria; see the figure) and structures outside cells (*1*). These minerals, which come in a variety of types and shapes, are often small (on the order of nanometers) and occur in close association with the bacterial cell wall. Several studies (*2*–*7*) have shown such an association in natural samples taken from a wide range of environments, as well as in synthetic samples produced under laboratory conditions that mimic natural conditions. Some studies have also reported the formation of biogenic minerals inside microbial cells (*8*, *9*). Although the occurrence of biogenic minerals in natural environments is well documented, the exact formation mechanisms are still poorly understood. A clear understanding of these mechanisms is essential in order to assess how bacteria interact with metals in present and ancient environments. In addition, a clear demonstration that bacteria can template mineral crystallization is also crucial because it might lead to the development of new tools in the search for evidence of past life on Earth and other planets.

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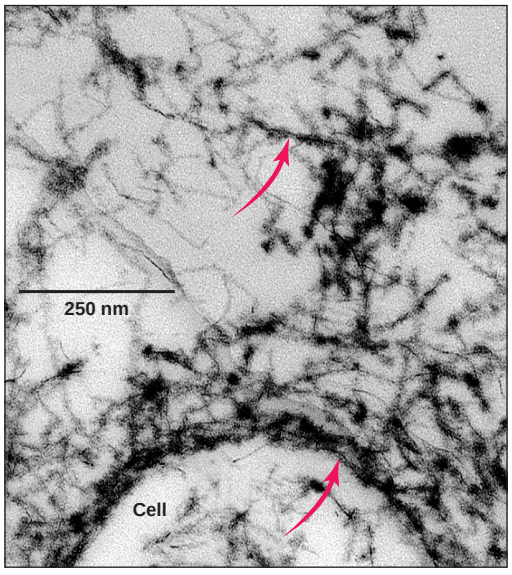
Many researchers accept that bacteria can trigger mineral formation under saturation conditions through active reactions (from physiological and metabolic activity) and passive reactions (from surface reactivity of the cell wall or extracellular structures such as exopolymers) (*1*), but the reasons why bacteria favor or promote mineral nucleation are still unclear. One general explanation is that bacteria do so to prevent cell entombment and death by mineral metabolic by-products. Even though the survival of microbial cells is a logical explanation, an alternative is reported on page 1656 of this issue by Chan *et al.* (*10*). These authors propose that neutrophilic iron-oxidizing bacteria promote the formation of elongated iron oxide minerals (identified as akaganeite) onto extracellular polymers (polysaccharides) in order to enhance metabolic energy generation.

Chan *et al.* analyzed natural biominerals in an iron oxide–encrusted biofilm collected in a flooded mine. With the help of high-resolution synchrotron spectromicroscopy [x-ray photoemission electron microscopy (X-PEEM) and x-ray absorption near-edge structure (XANES)] and high-resolution transmission electron microscopy (HRTEM), they were able to show that microbially produced polysaccharides can template the nucleation of pseudo–single crystals (that is, having the appearance of single crystal structure) of akaganeite (with aspect ratios of about 1000:1). Unlike previous electron microscopy studies that showed bacteria-mineral associations and concluded that bacteria were likely involved in mineral formation (*2*, *3*, *5*, *7*), the study by Chan *et al.*



Bacterial oxides. Transmission electron microscopy (TEM) image shows natural bacterial exopolymers covered with poorly ordered iron oxides. The sample was collected in the oxic sediments of a neutral-pH freshwater lake. The arrows indicate the position of very thin crystals of iron oxides on the cell wall and within the extracellular exopolymers. The elongated fine crystals appear to be covered by a more amorphous form of iron oxide.

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