of galaxies at this redshift, it would suggest that vigorous star formation was already occurring in galaxies by 300 million to 500 million years after the Big Bang. The energetic radiation emitted by these systems could ionize a significant fraction of intergalactic hydrogen within just 500 million years of the Big Bang, consistent with expectations from measurements of the polarization of the cosmic microwave background radiation[7].

Zheng and colleagues' discovery will stimulate further searches for galaxies at this early epoch, and much work remains to be done. Currently, the number of sources that can be dated back to 500 million years after the Big Bang (just two[1,4]) is too small for reliable measures of their number density to be extracted. Moreover, without spectroscopic observations to complement the images, the galaxies' distances from Earth cannot be determined unambiguously. Some progress on both fronts is expected in the coming years from surveys conducted with the Hubble and Spitzer telescopes, as well as with new infrared spectrographs that have been installed on ground-based telescopes.

Within the next decade, however, the exploration of galaxies in the early Universe will be transformed by the construction of giant ground-based telescopes with apertures of 20–40 metres and by the launch of the James Webb Space Telescope. These powerful facilities will not only dramatically increase the number of galaxies known throughout the first 500 million years, but will also provide the spectroscopic capability necessary to confirm their distances. Through spectroscopy of highly magnified galaxies such as that reported by Zheng *et al.*, these studies can even begin to reveal the galaxies' chemical make-up and the kinematics of the gas they contain, leading to a much-improved understanding of when galaxies emerged and how their radiation contributed to the reionization of hydrogen. ■

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NEUROSCIENCE

Attention is more than meets the eye

Our brains focus on important events and filter out distracting ones. An investigation in monkeys reveals a surprising dissociation between the neuronal and behavioural manifestations of attention. See Letter p.434

ALEXANDRA SMOLYANSKAYA & RICHARD T. BORN

Why are drivers more likely to have an accident if they are talking on a mobile phone? The obvious answer is that they are not paying attention to the road. But what is attention, and what goes on in our brains when we are 'paying' it? For decades, psychologists have proposed that we can direct something rather like a mental spotlight towards particular regions of our surroundings, and that this selectively enhances our perceptual sensitivity in that region. For example, if you were instructed to attend to an area to your left (without looking there), you would be able to detect a dimmer light in that region than elsewhere. Indeed, neurophysiologists have shown that attention amplifies the responses of neurons whose preferred spatial region (the neuron's 'receptive field') corresponds to the attended region[1]. However, on page 434 of this issue, Zénon and Krauzlis[2] report that, in monkeys, inactivating a brain structure called the superior colliculus impairs visual attention but retains the enhanced responses of neurons in the brain's cerebral cortex.

In addition to amplifying — or, more precisely, increasing the gain of — neurons' responses, attention tends to make the relevant neurons slightly less 'noisy' and more independent (of their neighbours) in their responses; both changes allow them to collectively encode sensory information more reliably. All of these changes make sense, and seem to account for why an animal's perception is enhanced by attention[3]. This is why Zénon and Krauzlis's results[2] will come as a surprise to many. By inactivating the superior colliculus, which has previously been shown to be important for attention[4], they impaired the monkeys' ability to detect a visual target while ignoring an irrelevant, distracting stimulus in another part of the visual field.

Inactivation of the superior colliculus (by injecting a drug that inhibited neuronal activity) did not create a basic sensory deficit, like a blind spot, because the impairment was evident only when there were competing stimuli[5]. But, despite the severe impairment in the animals' ability to pay attention to the relevant stimulus, all of the known neural correlates of attention (including increased gain) in two sensory areas in the cerebral cortex — the middle temporal area (MT) and the medial superior temporal area (MST) — remained intact. Thus, the authors uncoupled the neuronal changes that are thought to underlie attention from the behavioural manifestation of attention.

What are we to make of this? For a start, we can conclude that the superior colliculus is not the only source of signals responsible for the changes in early sensory areas (those closer to the sensory receptors). We can also conclude that the improvements in the encoding of sensory information in the MT and MST are not sufficient to produce the perceptual effects of attention.

However, although Zénon and Krauzlis found no changes in any of the known neural correlates of attention, it is conceivable that they missed the right neurons — we know that, at any given location in a sensory area, only a subset of neurons contributes to any given task[6]. Moreover, it is possible that inactivation of the superior colliculus impairs the attentional system in other ways, and that the neuronal changes in the MT and MST are insufficient to overcome the deficit. For example, if selective attention emerges as the result of competition among visual representations in multiple brain regions[7], the increases in gain in the MT and MST might simply be overbalanced by the loss of enhancements in other areas more directly connected to the superior colliculus.

Another possibility is that attention follows a two-stage mechanism: a first stage produces the gain changes in early sensory areas, whereas a later stage selects among these enhanced signals. In this model, the superior colliculus would act as part of the selection filter, the activity of which determines whether signals from a particular sensory region will be used to guide behaviour. Without the superior colliculus, the corresponding part of visual space is effectively filtered out, or ignored, as it is for patients with brain damage who have 'unilateral neglect'[8] — they may fail to eat food from one side of their plate, for example, or to shave one side of their face.

Such a filtering stage would explain why humans often miss large changes in the visual scene. In one famous example, observers are asked to count the number of passes of a basketball among teammates, and they fail to notice a person in a gorilla suit who wanders

50 Years Ago

Concern is expressed about continuing traffic in heroin. In some areas, limitation of the use of opium appears to have encouraged opium addicts to turn to heroin, which has been more readily available. The controls on the illicit production of heroin and on the traffic of this drug need to be enforced more strictly. Much stress is laid by the [World Health Organization Expert] Committee on the necessity for providing the medical profession as early as possible with complete and accurate information on the addiction-producing and habit-forming properties of new drugs and on their therapeutic properties. The further development of media for disseminating such information should be encouraged.

From *Nature* 22 September 1962

100 Years Ago

Man is worth many sparrows; he is worth all the animal population of the globe, and if there were not room for both, the animals must go. I will pass no judgment on those who find the keenest pleasure of life in gratifying the primeval instinct of sport. I will admit that there is no better destiny for the lovely plumes of a rare bird than to enhance the beauty of a beautiful woman … But I do not admit the right of the present generation to careless indifference or to wanton destruction. Each generation is the guardian of the existing resources of the world; it has come to a great inheritance, but only as a trustee … [T]here is no resurrection or recovery of an extinct species, and it is not merely that here and there one species out of many is threatened, but that whole genera, families, and orders are in danger.

From *Nature* 19 September 1912

through the scene[9]. This happens even though neurons in an early visual area accurately represent — and can therefore be used to detect — the gorilla and all such highly salient changes. At some stage, even these otherwise obvious events are filtered out, presumably to focus processing on the behaviourally relevant information. We speculate that inactivation of the superior colliculus, as described by Zénon and Krauzlis, may impair this latter stage.

It must be that a brain area other than the superior colliculus is responsible for the gain changes observed in MT and MST neurons. One possible candidate is a region of the cortex known as the frontal eye fields, which are involved in visual attention and eye movements. Indeed, there is evidence that electrical stimulation of the frontal eye fields can produce gain changes in early sensory areas similar to those produced by attention[10]. Future experiments will be necessary to determine how the activities of the superior colliculus and those of areas such as the frontal eye fields are coordinated to converge on an attended location. In particular, as the convergence of enhanced signals has been proposed to occur in a region of the parietal cortex called the lateral intraparietal area[11], it will be important to determine whether inactivation of the superior colliculus leads to more-pronounced deficits in the effects of attention on neurons in this area than those observed in the MT and MST.

Zénon and Krauzlis's results suggest that there are at least two cooperating stages: attentional-gain modulation and subsequent selection. Their work therefore calls for further studies of how such systems interact to endow us with a mechanism that we depend on every day: the option to ignore our mobile phones and focus on the road ahead. ■

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MATERIALS CHEMISTRY

Liposomes derived from molecular vases

Liposomes are ubiquitous components of skin moisturizers and other personal-care products. Modified liposomes prepared from receptor-like molecules open up fresh opportunities for therapeutic and industrial applications.

CYRUS R. SAFINYA & KAI K. EWERT

The imaginations of diverse groups of scientists, from physicists to pharmacologists, have been captured by liposomes — simple mimics of highly complex cell membranes. Typical liposomes are spheres with walls consisting of bilayers of amphiphilic lipids (molecules that have hydrophilic, polar head groups and hydrophobic, non-polar tails). Their unique structure enables them to trap hydrophobic molecules within their bilayer and hydrophilic molecules within their interior (Fig. 1a). Writing in *Chemical Communications*, Kubitschke *et al.*[1] add another dimension to this cargo-carrying ability with their report of liposomes derived from vase-shaped cavitands[2], which are receptor-like molecules that wrap around 'guest' compounds. The cavitands can encapsulate these guest molecules and present them at high densities at the liposome surface, a capability that might be useful for drug delivery.

Liposomes — also known as vesicles — were serendipitously discovered in 1964 during investigations of phospholipids[3]. The demonstration of their encapsulation properties, and the remarkable structural resemblance between liposomes and cell membranes in electron micrographs, led to the realization that lipids form the main permeability barriers of biological membranes. Today, by far the largest use of liposomes and their encapsulating properties is in the multibillion-dollar personal-care industry[4], as moisturizers and carriers of nutrients in gels and cream formulations. But they have also emerged as a research tool, within which biologists can isolate and