

In This Issue

Attention to Detail

The soil-dwelling nematode *C. elegans*, a millimeter long, has neurons that number exactly three hundred and two. Aspiring brain builders might hope that such a simple system, smaller than the human's by a factor of roughly a billion, would readily be understood. Bad news. This flatworm's potassium channels, it is now being discovered, come in at least scores and possibly hundreds of different varieties (Wei, Jegla, & Salkoff, 1996). It is not at all clear why so few neurons need so many types of potassium channels, but it underscores the point that even a single neuron is immensely complex, and it doesn't bode well for comprehending the whole.

In a similar vein, in the depths of the lobster's stomatogastric ganglion twitches the pyloric motor circuit, containing a total of 14 well-defined neurons. If any neural circuit behaves simply, this should be it. Yet this tiny central pattern generator exhibits all manner of modes and behavior depending on the chemicals it's bathed in (Harris-Warrick, Coniglio, Barazangi, Guckenheimer, & Gueron, 1995; Simmers, Meyrand, & Moulins, 1995).

In the face of such perversity, any hint of a simplification, especially at the organismic level, is met with rejoicing. A bounteous such windfall occurred in 1953, when one man's medial temporal lobes were exchanged for the most profound view of the mechanisms of memory in history. H.M. appeared to be perfectly normal in all respects but one: You could meet him for the first time, as many times as you liked. He had no recollection of his postoperative past at all. But everything else seemed to be preserved: emotion, comprehension, attention, and even some "implicit" forms of associational and motor learning. The lesson was that this "episodic" or "declarative" memory could be completely removed without affecting anything else and so did not need to be considered in attempts to understand the remainder of the brain (Cohen & Eichenbaum, 1993; Scoville & Milner, 1957). One could forget about the hippocampus as one tackled, for example, the neocortex and attention. A crisp, beautiful dissociation.

What an unwelcome development, then, if this should turn out not to be the case. Timothy Rickard and Jordan Grafman, in this issue, ascribe amnesics' deficit to a more

general lack of "configural learning," whereby new combinations of preexisting cortical elements are created and without which some simple associative learning tasks cannot be assimilated. Their arguments are similar in spirit to other authors'; see, for example, MacKay, Stewart, and Burke, last issue. ". . . if a task," Rickard and Grafman predict, "logically requires that one or more new configurations of elements must be formed to be learned completely . . . dense amnesics will never completely learn the task. . . ." The task in question is, essentially, scissors-paper-rock, a game without any obvious episodic memory component and which therefore might naively be supposed to be amnesic-accessible. Their findings suggest to them that it is not. The last refuge of a dissident might be to wonder if their three-phase method of introducing the task doesn't ingrain a response that is not easily overcome when the task's true tricky nature is unleashed. But if this objection is met, the results are a problem for the diehard dichotomist's point of view.

There is another lesson of H.M., however, beyond this beleaguered ostensible irrelevance of explicit memory to everything else. That attention might need no hippocampus is one thing. That the hippocampus needs attention is another. H.M. dramatically demonstrated the hippocampal substrate of episodic memory—the memory of things to which we attended, of which we were conscious, the recall of which makes us once again conscious of these and only these things. That we tend to remember our dreams only when we wake up in the middle of them shows that we do not remember everything we attend (Cicogna, Cavallero, & Bosinelli, 1991). But it certainly seems that the sine qua non of remembrance is attention at the time of the original event. Because this remembrance is handled by the hippocampus, one might make a small leap to suppose that whatever is encoded by the hippocampus was attended. The details of hippocampal encoding, rather than being rejected as irrelevant to the rest of cognition, might be used as clues to its nature. The explosive exploration of hippocampal plasticity and connectivity that ensued from the case of H.M. could be viewed as an exploration of the footprints of attention.

Or you could forget about its footprints and tackle the problem head-on. There are plenty of more direct clues,

some of them breathtakingly sensible. Neurons in MT and V4, for example, fire more strongly in response to a stimulus in their receptive field when their owner attends to that location (Connor, Preddie, Gallant, & Van Essen, 1997; Treue & Maunsell, 1996), these responses apparently being selectively gated through the pulvinar by the posterior parietal lobe. MT and V4, again, become more active in toto when the brain is concentrating on a scene's motion or colors, respectively (Corbetta, Miezin, Dohmeyer, Shulman, & Petersen, 1991)—selection along two other dimensions.

Such multimodal selection—deciding which of various attributes should catch the eye—appears to be the prerogative of the anterior cingulate gyrus. And here we are back in the murk. The cingulate, far from being, as originally proposed, a monolithic slab solely interpreting situations for the instruction of emotion, is found to be as diverse as any other cortical swath (Vogt, Finch, & Olson, 1992). Just behind the region that cares about pain and the piece that generates heartfelt hoots is a chunk the unilateral excision of which produces a strange neglect (Watson, Heilman, Cauthen, & King, 1973) and that consistently shows up on the scanners during tasks requiring concentrated attention (Corbetta et al., 1991; Davis, Taylor, Crawley, Wood, & Mikulis, 1997). It has been proposed to be a master controller of “executive attention,” responsible for “selection of targets from competing inputs” in some manner whose details are very far from clear (Posner, 1994).

Given the region's history, the finding may come as no great surprise that it is more active, during emotional situations, in subjects with greater attentiveness to emotional nuance (Lane et al., this issue). These results extend the anterior cingulate's attentive responsibilities to yet another domain, but one that seems well consistent with what it seemed to be doing already.

Thank God. Perhaps the cingulate and the remainder of the brain will continue to unfold their secrets without confusing mishap. We should, of course, be so lucky. But we can always hope that this mishmash of maddening detail, reworked and rewired for three billion years, has a gist that we can understand and reproduce, because, if it does, one day the stomatogastric ganglion will not seem so unsettling, and we will get on with the business of building a brain.

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