

Correspondence

Face modules, face network: The cognitive architecture of the brain revealed through studies of face processing

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To the Editor:

The helpful editorial by Drs. Chatterjee and Farah1 reminds us of what may be the most enduring controversy in neurology, between what they label the "holists" and "localizationists" (often termed topists). Persistence of this controversy is attributable to the continued accumulation of evidence claimed by each side to be inconsistent with the opposite view.

In fact, there has been available for over a century a unifying view that is consonant with most of the evidence. This view, originating with John Hughlings Jackson,² is quite ingenious and, considering the time of its origin, remarkably prescient.

Jackson began by considering two facts, equally true and seemingly contradictory. He wrote:

"The fact that the symptoms are local implies, I hold, that there is of necessity a local lesion. I submit that one-sided spasm, or spasm beginning in one side, implies local change in the central nervous system ... where the fits always start on one side and always in the very same fingers, it is simply incredible that there is no persistent local lesion. The fact that the patient is seemingly quite well betwixt the paroxysms does not negative this view in the least ... [On the other hand] no fact is better recognized than that a large part of one cerebral hemisphere may be destroyed when there are no obvious symptoms of any kind... .

If a small number, or, let us say, a square inch, of convolutions were cut away by the knife, there would be no loss of power, no paralysis. This is admitted. How then can discharge of this square inch produce violent convulsions? If lack of the part leads to no loss of function, how can discharge of that part lead to excessive function?"

Jackson's solution to this paradox was to suppose that in any arbitrary piece of cortex the face, hand, and leg were all represented, but unequally. If the lesion (for example, a small tumor) were located in an area where the representation of the hand was greater than of the other parts, the fit would start in the hand. But if the same area were ablated, no paralysis of the hand would ensue, because the hand was also represented in other places.

Jackson's proposal fits with the view of Graziano et al.³ resulting from their recent experiments stimulating the motor cortex.

In another place Jackson stated his belief in graded representations.

"I have never acceded to the opinion that speech is to be localized in any one spot, although I do believe most firmly that the region of Broca's convolutions is, so to speak, "the yellow spot" for speech, as the macula lutea is the centre of greatest acuteness of vision, although the whole retina sees". (Jackson, 1876).⁴

Chatterjee and Farah¹ state that modularity (an architecture consisting of "anatomically and functionally separate systems" acting as "self-contained processors," specialized for specific tasks) is supported by "disproportional impairments." For example, face recognition is disproportionately impaired in patients with relatively little object agnosia, and retention of face recognition is common in patients with dyslexia. These facts are unassailable. However, a network enthusiast would respond that even when a network is not biased by pre-existing differences in anatomic connection (typical of brain networks) it can develop topographically separated regions of greater representation for different functions so that local lesions can affect some functions disproportionately vs other functions. Double dissociation certainly can show that two functions are differently represented, but not necessarily that these functions depend on circumscribed, dedicated modules. Quartz and Sejnowski⁵ recently reviewed evidence to support their suggestion that subcortical and cortical structures exhibit different developmental strategies, the former being more reasonably considered modular.

It deserves emphasis that how restricted an active region appears in a functional MRI map depends directly on the probability criteria used in making the map; the active regions do not have sharp boundaries. Moreover, as shown recently by Haxby et al.,⁶ even if the locus of highest activity (Jackson's "yellow spot") is disregarded, using only the less active surround one can identify the category (faces, cats, houses) of visual stimuli. Haxby et al.⁶ also show that the same cortical regions can participate in a number of different subnetworks so that representations of different stimuli are both widely distributed and overlapping.

Chatterjee and Farah¹ rightly emphasize the importance of cortico-cortical connections. Still unsettled is whether what are being connected are graded, overlapping terrains fluctuating around concentrations of representation, vs anatomically circumscribed modules having dedicated specializations. Reply from the Editorials: Anjan Chatterjee, MD and Martha J. Farah, PhD Philadelphia, PA

The question of how physical systems, such as brains, can represent knowledge is a daunting one. Perhaps for this reason, people have tended to approach it with the simplifying strategy of posing binary questions. Many of these questions are closely related to one another, using different terms to capture the same underlying dichotomy: between a system in which a given representation is physically and functionally localizable—that is, occupies one relatively compact portion of the system, physically segregated from other representations, and whose activity is independent of most other parts of the system, and a system in which a given representation is distributed holistically over relatively broad areas, which are shared with other representations,

and wired up to influence and be influenced by a multitude of other representations.

We agree with Bogen and Berker that this dichotomy is a false one, and that its resolution has been suggested in a variety of contexts-though we had not appreciated how venerable some of those contexts were! Indeed, it is interesting to note the parallel evolution of this insight across many disciplines, including the neurology of Jackson's time.

Initially, the binary question is posed: in 19th century neurology, the question was "Is brain organization localist or holistic?"² In 1990s brain imaging, it was "Do these two tasks or stimuli, such as face and object recognition, activate distinct or coextensive brain areas?"⁷ When single unit recording was first undertaken in higher perceptual cortices, the question was "Do individual cells detect whole objects, such as hands and faces, or only low level features common to all objects?"⁸ In early cognitive science models of human information processing, it was "Is mental representation local or distributed?"⁹

As each field matured, the questions evolved. Jackson saw that the more informative question was to inquire into the respective contributions of the local "yellow spot" and the other participating tissue.⁴ In the paper cited by Bogen and Berker, Haxby et al.⁶ mapped the overlapping (neither segregated nor coextensive) neural responses to particular stimulus categories. Neurophysiologists now ask what aspects of a stimulus are represented by a given neuronal response, and how that locally represented or "detected" aspect participates in the distributed representation of stimuli.¹⁰ And cognitive scientists now treat distributedness as a continuously varying dimension of a representational system, with different degrees of distributedness suited for different computational tasks.¹¹

References

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