

and the evidence on attention and emotion could best be described as incomplete, inconclusive, and contradictory.

Second, the research of Lynch and his colleagues, which comprises the principal focus of his target article, addressed the concepts of attention, emotion, and motivation only minimally. Some reference was made to certain neural units that appeared to respond differentially in the presence and absence of food or liquid incentives. But such evidence, although suggestive, falls short of what is needed to support a global concept like motivation. Apparently the only study involving single cell recordings in the PPC that specifically compared motivating conditions ("food objects, neutral stimuli, and aversive stimuli") found no consistent differences among them (Rolls et al. 1979). Lynch questions the reliability of Rolls et al.'s data, but even so, this hardly adds support to Lynch's use of the motivation concept. As for the relevance of Lynch's data to emotion, I am not sure where in his research this concept was addressed except, perhaps, when it was observed that "... neither reach nor HM neurons discharged during defensive or aggressive movements, as when the monkey pushed or scratched the experimenter during prolonged passive examination of hand and arm joints." In this case, of course, the units of interest might, if anything, be said to have responded in the *absence* of emotion. Attention is a most difficult concept. Often the best evidence for attention comes from contrasting a state when attention *presumably* occurs with a state when it *presumably* does not. "Presumably" is relevant here, because Lynch never gives us a clear definition of what he means by attention. It would be tautological to describe a cell's and a monkey's behaviors, attribute attention to them, and then use those behaviors as the definition of attention.

To summarize, concepts such as attention, emotion, and motivation have long been invoked in conjunction with the study of the effects of PPC damage. The evidence for their use has never been particularly strong or clear, and Lynch perpetuates their use with equally vague data. The question is whether the use of such concepts facilitates, retards, or is superfluous to our understanding of the functions of the PPC.

It seems to me that the use of concepts like attention, emotion, and motivation in the past (to which I also plead guilty) has not really helped us to understand the function of PPC. Indeed, such concepts seem even less appropriate, useful, or necessary if one considers the PPC's basic functional unit, as Lynch does, to be the "cortical column." It seems excessive to attribute attention, emotion, or motivation to cortical columns.

Functional concepts such as "sensory processing" and "motor processing" are more reasonably constructed in terms of the data on PPC (and other cortical areas). With respect to a given *behavioral* unit, sensory processing might be said to reflect the antecedent or causal side of the behavioral unit, and "motor processing," the consequent or effect side. Although such processing is a part of the behavioral unit, there is also the "black box" state between sensory and motor processing, which leads us to seek connecting concepts and, perhaps, their physiological and anatomical substrates. It is in this connecting role that attention, emotion, and so on are usually invoked. The problem is that these concepts mean more than their users typically intend, yet there is little that one can do to eliminate the excess meaning. Can a useful substitute for connecting concepts like attention and the like be found?

There is no space here to develop the argument fully, (some further related points may be found in Thomas & Ingram 1979, pp. 41-42), but may I suggest that the basic logical connectives (viz. affirmation, conjunction, disjunction, conditional, biconditional, and their respective complements), could be used to advantage. Lynch points us in this direction, unintentionally I believe, when he speaks of the activities of some neurons being "conditionally dependent" upon one factor or another. The logical conditional may be expressed: If A, then B. The question is whether A and B can be meaningfully specified in terms of aspects of sensory and motor processing without resorting to concepts like attention, emotion, and motivation.

I believe that the answer to this question is "yes," and again Lynch has provided a useful hint as to how we might proceed. At one point he

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Attention, motivation, and emotion: *Entia non sunt multiplicanda praeter necessitatem*

Drawing from his own data and from those of others associated with Mountcastle, Lynch argues strongly for the view that posterior parietal cortex (PPC) is more than a "sensory association area." Other functional concepts attributed by Lynch to cells in the PPC include the "initiation and control of certain motor acts" and the "modulation of the sensory and motor processes by attentional, motivational, and emotional factors." It is with the latter three factors that this commentary (and Occam's razor – the Latin quotation in my commentary title is from Pearson 1892, p. 482) are concerned.

Ordinary language concepts, such as attention, motivation, and emotion, may coincide intuitively with the anthropomorphic, empathetic experiences that a *human* investigator could have in contemplating the difficulties of *human* patients with PPC damage. While it is reasonable to anthropomorphize from human to human, it is quite another matter, in terms of empirical evidence and theoretical concepts, to do so from human to monkey. But even with this "philosophico-methodological" point aside, there are two major problems with applying the concepts of attention, motivation, and emotion to the data Lynch has presented.

First, Lynch has used these concepts to describe and explain his data at least partly on the basis of the literature he has reviewed. But neither the involvement of attention nor that of emotion receives clear support from the human and nonhuman evidence that he cites. Motivation was not separately reviewed with reference to PPC function,

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tells us that any of several objects that the monkey "knew to be food" was an effective stimulus. "Knew to be food" suggests that the class concept "food" had been learned or was already known by the monkey, and it seems reasonable to suggest that there might be cells or cortical columns that respond selectively to the stimulus class "food." Such food-sensitive cortical units could respond in *conjunction* with or *conditional* upon the activities of other cortical units that would respond to a set of physiological cues associated with food-deprivation. If you had the conjunctive input to a cortical column of "food"-sensitive units *and* "food-deprivation"-sensitive units, one type of responding would be seen. With the absence of this conjunction – say, food detection without food-deprivation information – another type of discharge rate would be seen. This is only a description of certain sensory conditions, yet we have specified the relevant and measurable variables without invoking the concept of motivation. We might then go on and define motivation in terms of the variables in this conjunction – but to do so would seem to be superfluous.

It should be feasible to construct all relationships among the activities of cortical columns in terms of sensory and motor processes and the logical connectives. It may be that when our descriptions are sufficiently complete in these terms, we will indeed have found that entities such as attention, emotion, and motivation were unnecessary ... hence, Occam's razor.