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Analytics Isomorphism and Speech Perception

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response from Churchland and Ramachandran (1993). They disagree with Dennett because they think that the brain is not merely “finding out” in the perceptual completion of the blind spot and artificial scotomata. They also disagree with Dennett’s claim that there are no neural responses devoted to the blind spot, citing Fiorani et al. (1992) as showing the contrary. As far as we can see, however, Churchland and Ramachandran do not think that the brain fills in in the sense of providing a roughly continuous spatial representation. In fact, on the basis of Ramachandran’s other writings (1992a; 1992b; 1993a; Ramachandran & Gregory 1991), it seems to us that they might be prepared to accept some variant of the second story we attribute to Dennett – the one in which the brain attaches a label. In any case, we think the debate would be better conducted in relation to issues about isomorphism and linking propositions. We go on to discuss this in section 5.2.

11. Note that these frequencies are much lower than the frequencies usually revealed in flicker studies, which have cut-off frequencies of more than 30 Hz and peak around 4 to 6 Hz.

12. Given that the experimental animals (cats) were anesthetized, the same caveats discussed in section 4.5 apply here when interpreting the relationship between neural and perceptual events.

13. These results are consistent with the work of Cornsweet and Teller (1965), which showed that increment thresholds are unaffected by changes in the appearance of backgrounds when the physical characteristics of those backgrounds are held constant.

14. We cannot review here all the details of the experiments performed by Eskew (1989), but we would like to note that several of his findings suggested that a complete account in terms of adaptation and eye movements is not likely: “Although eye movements and adaptation might play a role in the chromatic diffusion phenomenon, an additional mechanism which is sensitive to the effect of the contour would be required to account for the gap effect” (Eskew 1989, p. 726).

15. Nevertheless, Todorović goes on to say that, “given the lack of relevant data, the single-cell type of bridge locus is a heuristically useful assumption.” We disagree, for the reasons stated in section 4.5.

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Analytic isomorphism and speech perception

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Abstract: The suggestion that analytic isomorphism should be rejected applies especially to the domain of speech perception because (1) the guiding assumption that solving the lack of invariance problem is the key to explaining speech perception is a form of analytic isomorphism, and (2) after nearly half a century of research there is virtually no empirical evidence of isomorphism between perceptual and lower-level processing units.

A problem with some work in cognitive science is that the empirical data are too highly leveraged theoretically. Pessoa, Thompson and Nee’s target article provides terrific relief from such work, for its significance lies precisely in its deflationary theoretical inter-

pretation of the empirical findings it cites. There is empirical evidence for neural filling-in, but its importance is doubly qualified. For one thing, neural filling-in cannot be promoted to a methodological principle. Empirical isomorphism does not imply analytic isomorphism. Moreover, even in cases where there is neural filling-in or isomorphism between neural activity and perceptual experience more generally, it becomes less significant once we see that perception is not (just) a matter of what the brain is doing, but of what the animal is doing as well. Put differently, if we do not care (as much) about representations, a fortiori, we do not care about whether they are isomorphic to the subject’s experience.

Still, the central methodological moral of “finding out about filling-in” is not, I think, that we should downgrade the status of filling-in as a theoretical category, but that we should reject analytic isomorphism. For as Pessoa et al. point out, analytic isomorphism states a criterion of adequacy not just for explanations of vision, but for cognitive neuroscientific explanations more generally. By way of reinforcing this claim, I would like to suggest that their criticism of analytic isomorphism is especially applicable to the domain of speech perception. Indeed, I will suggest that rejecting analytic isomorphism provides the key to progress in explaining speech perception.

The particular form that analytic isomorphism takes in speech perception research is the assumption that the goal of a theory of speech perception is to solve “the lack of invariance problem.” With a few recent and notable exceptions, solving the lack of invariance problem has been taken to be a criterion of adequacy for explanations of speech perception for nearly fifty years. “Lack of invariance” refers to the widely recognized fact that there is no one-to-one correspondence between units of acoustic structure and perceived phonemes. A single consonant sound, for example, may be realized acoustically in a variety of ways depending on the surrounding phonetic context. This lack of invariance only becomes a problem, however, if one assumes that there must be an isomorphic mapping between the subject’s perceptual experience and underlying physical structure. And this is just what has been assumed.

Thus, identifying an initial stage of processing in which processing units are structurally isomorphic (e.g., segmented, linearly concatenated) to perceived phonemes is taken to be a criterion of adequacy for an explanation of speech perception. Although these processing units are not always explicitly identified in neural terms (sometimes they are identified in acoustic or articulatory terms), it is the doctrine of analytic isomorphism that underwrites the goal of solving the lack of invariance problem, for the latter assumes that there must be isomorphism between the subject’s perceptual experience and lower-level processing units (called “invariants”).

As it is put in one well-known article, “invariant gestures” of some description there must be, for they are required, not merely for our particular theory of speech perception, but for any adequate theory [emphasis in original] (Liberman & Mattingley 1985, p. 3). The difficulty is that speech perception research guided by the framework of analytic isomorphism, has made little progress. Put bluntly, by the standards embodied in analytic isomorphism, there are no adequate theories of speech perception. Despite nearly half a century of searching, virtually no empirical invariants have been found. Only one theory has identified even a candidate for an invariant property, but it has done so for only one class of consonants, and it is present only about 85% of the time (Stevens & Blumstein 1981). Thus, it seems that analytic isomorphism, as embodied in the goal of solving the lack of invariance problem, will have to be rejected before progress in explaining speech perception will be made.

Pessoa et al. caution against inferring analytic isomorphism from the evidence of particular cases of empirical isomorphism (e.g., cases of neural filling-in). But in the domain of speech perception, analytic isomorphism survives despite the virtual absence of empirical confirmation. This suggests that in speech perception, at least, analytic isomorphism functions not merely as a methodological principle, but as dogma. If so, it is likely to prove
more difficult to eradicate. A personal-level, activity-based approach, however, such as the one favored by Pessoa et al. for vision, may well be the place for speech perception research to start.

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NOTES
1. In Appelbaum (1995) I treat this claim much more extensively, although I do not use the term “analytic isomorphism.”
2. These include Brownman and Goldstein (1996), McClelland and Elman (1986), and Nusbaum and Henley (in press).
3. Gestures are here taken to be forms of neural representations.