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Discriminating children

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Comprehending baby-think

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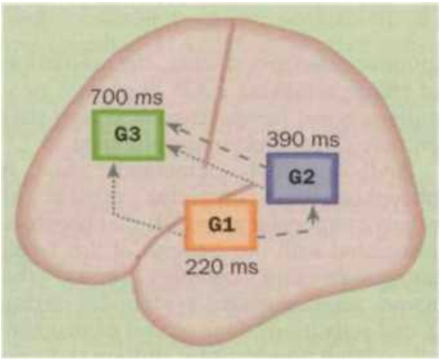
How can we capture the rich cognitive life of young infants? Behavioural observations are restricted by the limited repertoire of infant responses: they can look and suck, and that is about it. Although



Suggested sequence of information flow in the brain. The boxes Gl to G3 represent the approximate location of the inferred generators underlying the three peaks of electrical activity picked up on the surface of the skull, together with the average time of occurrence of the peaks from stimulus onset. We assume that each generator corresponds to a neural network performing a particular computational function. Dashed and dotted arrows denote two possible hypotheses concerning the information flow between the generators.

these responses have told us a great deal about the cognitive capacities of infants', to learn more we have to investigate more directly. On page 292 of this issue" Dehaene-Lambertz and Dehaene use the high-density, event-related potential (ERP) technique adapted to two-month-old babies to find out how they process simple syllables. One undifferentiated response is as much as could be hoped for from behavioural measures with infants of this age. The high-density ERP technique, combined with a simple and ingenious experimental design, has enabled three temporally and spatially separate responses to be identified that correspond to three separate processes. Moreover, the infant brain takes less than 400 milliseconds to discriminate a phonetic contrast.

Phonetic perception over the first year of life has been particularly well studied behaviourally: surprisingly, infants during the first few months of life can discriminate all the phonetic contrasts, irrespective of whether they are actually used in their native language. Thus, infants must start with a universal representation, that is, one appropriate for all the languages in the world. They end up as adults with a language-specific representation. For instance, Japanese adults, unlike Japanese infants, cannot hear the difference bet tween R and L, two sounds that don't have a separate existence in Japanese. We know nothing of the structural changes underlying such behavioural development. It is possible that the universal format is destroyed as the infant consolidates the contrasts of the native language. Alternatively, the universal format may be preserved for a while but be inhibited by the language-specific one. These questions can hardly be addressed with standard behavioural discrimination techniques.

The high-density ERP method[1] has been successfully adapted to two-month-old infants by Dehaene-Lambertz and Dehaene. Compared with other brain-imaging techniques, it has the advantage of being non-invasive: a light net of wet electrodes is simply laid on the infant's head (see front cover). Compare this to a PET scan, in which radioactivity has to be injected. The ERP method relies on the fact that a burst of localized activity in the cortex acts as a current 'generator', producing an electrical field that can be picked up by electrodes on the scalp as changes in potential. Temporal resolution of this kind of surface recording is not new; what is new is that, because of the high density of the electrodes, the location of the generators can be inferred much more precisely from the pattern of surface activity — and that this can readily be accomplished with infants.

The new application of this technique looks promising. The authors presented infants with a series of four identical syllables (the standard), followed by a fifth that was either identical or phonetically different (deviant). They observed three distinct responses, or peaks of electrical activity, to these syllables. Their Fig. 3 shows the pattern of electrical activity on the surface of the head for the first two peaks: the anterior positivity synchronous with posterior negativity reflects the presence of generators within the temporal lobes. Apart from being distinct temporally and spatially, these two generators differ functionally. This can be seen in the responses to the fifth syllable, where peak 2, unlike peak 1, discriminates between phonetically different syllables. The final peak, seen as an anterior negativity, occurs only when the deviant syllable is presented. Because the negativity was rather diffuse over the centro-frontal regions, its generator could not be accurately localized. But the authors make a good argument that, it may arise from an anterior cortical or subcortical neural circuit (such as the anterior cingulate cortex).

What can we say about the three sources of activity? One interpretation, perhaps the most intuitive, is that information flows from one brain area to the next in a sequence corresponding to the temporal sequence (see figure, dashed arrows), but this is not the only interpretation. For example, there could be a direct connection between Gl (the generator underlying Dehaene-Lambertz's and Dehaene's peak 1) and G3 (dotted arrows). To test this, we would look for a manipulation that would cause Gl but not G2 to dishabituate, and see whether G3 followed it. The most obvious option is that Gl is sensitive to changes in intensity or pitch whereas G2, being dedicated to phonetic processing, is insensitive to such changes. In this case, if G3 were connected to both G2 and Gl then it would respond to prosodic changes as well as phonetic ones.

It would be exciting to track the evolution of these responses over the first year of life. Thus, presenting Japanese babies with a 'ra-la' contrast, we expect to see a loss of dishabituation in at least one cortical response at the end of the first year, corresponding to the disappearance of the behavioural response to this contrast. The interesting thing would be if some other cortical response still dishabituates to this, non-native, contrast, indicating that some universal processing is still preserved. The high-density ERP technique would readily lend itself to answering such questions.

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