NEUROSCIENCE

Left Hemisphere Cerebral Specialization for Babies While Babbling

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Baby babbling is the universal developmental milestone before the onset of language production in humans, yet little is known about whether the neural determinants of this behavior are fundamentally linguistic (*1*, *2*) or reflect only oral-motor developments (*3*, *4*). In adults, the presence of right asymmetry in mouth aperture during linguistic tasks as contrasted with left or equal mouth opening during nonlinguistic tasks has been widely used as a key measure of left hemisphere cerebral specialization for language (*5*). Given the noninvasive nature of mouth asymmetry studies, this technique is ideally suited to inferring whether functional cerebral asymmetries of babies' earliest productions exist. If babbling is fundamentally linguistic in nature, then left hemispheric specialization should be reflected in right mouth asymmetry while babbling. If babbling is fundamentally motoric in nature, then equal hemispheric participation should be reflected in equal mouth opening while babbling. The results will provide insight into the neural basis of babbling and hence into the origins of human language.

To control for any language-specific effects of mouth asymmetry, we videotaped 10 babies acquiring either English ($n = 5$) or French ($n = 5$). The babies were studied between the ages of 5 and12 months, according to the age at which each baby first entered the syllabic babbling stage. Once this developmental milestone was achieved, we examined three types of oral activity produced by the babies: babbles, nonbabbles, and smiles (table S1). Babbles were defined as vocalizations that contained a reduced subset of possible sounds (phonetic units) found in spoken language, had reduplicated (repeated) syllabic organization (consonant-vowel alternations), and were produced without apparent meaning or reference; all vocalizations lacking any of these three criteria were coded as nonbabbles. Spontaneous smiles were coded as an additional control of babies' specificity of mouth opening for distinctive types of oral activity (*5*).

At 50 ms (three video frames) from initial lip opening, two "blind" independent coders scored 150 randomly selected segments of babbles, nonbabbles, and smiles according to whether greater right, left, or equal mouth opening was observed. A standard Laterality Index (LI) (*5*) was computed for each baby for their production of babbles, nonbabbles, and smiles: $LI = (R - L/R + L + E)$, and mean LI scores were calculated for each group of babies (English and French). Thus, a mean positive LI score indicated more instances of right mouth opening, and a mean negative LI score indicated more instances of left mouth opening for the given production.

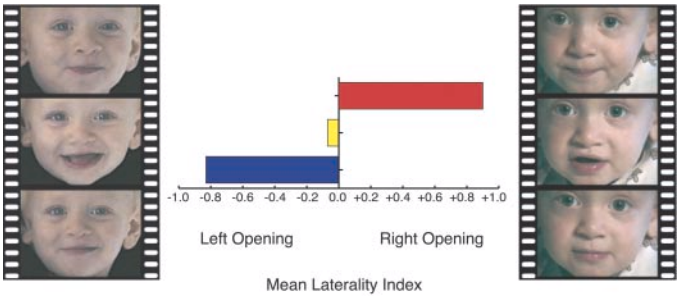

Fig. 1. Consecutive frames from video recordings showing a baby's left mouth opening while smiling (**left**) and right mouth opening while babbling (**right**). Mean LI scores for all of the babies were as follows: babble = +0.88 (red), nonbabble = −0.08 (yellow), and smile = −0.82 (blue).

The mean LI scores indicated that all babies had right mouth asymmetry while babbling, equal mouth opening while nonbabbles were produced, and left mouth asymmetry while smiling (Fig. 1). Statistical analysis was performed with a two-way mixed analysis of variance: group (English and French) × production (babble, nonbabble, and smile). No significant effect of group was detected ($F = 0.09$, NS), indicating that no significant differences were found between the English and French babies (table S1). A significant main effect was discovered for production ($F = 236.91$, $P < 0.001$), and all pair-wise comparisons were significant ($P < 0.001$), indicating that the babies' mouth opening differed depending on whether a babble, nonbabble, or smile was produced (Videos S1 to S3).

The origins of language in humans have remained elusive as a result of controversy over the neural basis of babbling. Like adults, the right mouth asymmetry observed in babies suggests left hemisphere asymmetry for babbling, reflecting the human left hemisphere control of natural language. If babbling were simply a way for the baby to flex the motor control system for the mouth, tongue, and throat—no different from the system used in chewing—then symmetry in mouth opening would have been observed. Instead, we witnessed an asymmetrical pattern of mouth opening for babbling, which supports the fundamentally linguistic view that babbling reflects babies' sensitivity to and production of patterns in the linguistic input (*1*). We thus conclude that babbling represents the onset of the productive language capacity in humans, rather than an exclusively oral-motor development.

This discovery demonstrates left hemisphere cerebral specialization for babies while babbling, which, in turn, suggests that language functions in humans are lateralized from a very early point in development. Moreover, the smile results illustrate the specificity of the right-sided mouth advantage of babbling behavior in babies, corroborate classic neuropsychological adult studies (*6*), and suggest that, like adults (*7*), babies' emotional expression may be controlled by the right hemisphere even at the early age of 5 months. Ongoing research is exploring the feasibility of using this mouth asymmetry technique as a means for detecting potential language deficits in babies even before they utter their first words, which represents the earliest measure of its type to date and sheds light on the emergence and neural foundation of higher human cognition.

References and Notes

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Supporting Online Material

www.sciencemag.org/cgi/content/full/297/5586/1515/DC1
Table S1
Videos S1 to S3

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