RESEARCH SUMMARY

Infant brains, like those of adults, are known to respond specifically to both familiar and unfamiliar human voices, but little is known about how this response is acquired. Two recent papers summarised separately below have shed light on how young babies begin to make sense of voices and to respond to emotion in them.

Mother and Stranger: An Electrophysiological Study of Voice Processing in Newborns

Beauchemin, M., González-Frankenberger, B., Tremblay, J., Vannasing, P., Martínez-Montes, E., Belin, P., Béland, R., Francoeur, D., Carceller, A-M., Wallois, F. and Lassonde, M.

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Functional magnetic resonance studies using adult human volunteers have identified specific brain regions that respond to human voices, and shown that these areas become tuned to familiar voices over unfamiliar ones. These brain responses have not yet been seen in infants, although behavioural studies have shown that even newborn infants react preferentially to their mother's voice over that of a female stranger. This study, by Maryse Lassonde and colleagues at the Department of Psychology, Université de Montreal, Canada, working with collaborators in France, the UK and Cuba, is the first to use electrophysiology to examine the response of newborn babies' brains to the voices of their mothers and of strangers.

Sixteen newborn infants between eight and 27 hours old participated in the study. They had all been born at the Ste-Justine Hospital in Montreal to native French speakers, and were full term and healthy with normal Apgar readings and with no history of deafness or language problems in their families. At the time of the study, the infants were asleep on their mothers' laps in a quiet, comfortable environment; previous work has shown that neonates are able to recognise and process information while sleeping.

The infants were presented with a random sequence of vocal stimuli comprising, in all cases, the French vowel sound /a/ as in "allô" (French for hello); all stimuli were of the same length and volume. These sounds were recorded by two unfamiliar females and by the babies' mothers. Eighty-five percent of the time, the sound presented was from one unfamiliar female (the frequent unfamiliar voice); 7.5% of the time it was from a different unfamiliar female (the rare unfamiliar voice) and 7.5% of the time it was from that infant's mother. Each sound was very short, lasting for

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only one-fifth of a second, and there was just under a second between the start of each one.

To control against the effect of complete novelty, the rare unfamiliar voice used was that of the research nurse who had been seen by the mothers throughout their pregnancies and who had accompanied mothers and babies to the testing room. The same nurse was involved in all cases; she was a mother herself and so could be expected to speak as to an infant with the characteristic, slow, high-pitched inflection used by care-givers to infants across cultures and known as “motherese”. During the experiment, neuronal activity in the babies’ brains was recorded precisely, 250 times a second, using a 128-sensor Geodesic net positioned around their heads. The mean responses to the mother’s voice and the two strangers’ voices were calculated, as were the respective differences between the mother’s and the rare stranger’s voices and the frequent unfamiliar voice.

Analysis of the responses showed that all infants responded to the sounds in similar ways. There were two significant time points, one towards the centre and the other towards the end of the stimulus period, when the electrical response to the mother’s voice was significantly stronger than that to the frequent unfamiliar one. In contrast, differences between the responses to the two unfamiliar voices were slight and failed to reach statistical significance. The researchers then looked at the pattern of electrical activity across the brain during the stimuli. At the point early in the stimulus period when the response to the mother’s voice was strongest, the brain area that was most active in response to the mother’s voice was the left posterior temporal lobe, which in adults is known to be involved in language processing. The strongest response at the later time point was in the right central area of the brain. A different processing pattern was seen in the response to the stranger’s voice, with only a slight and transient involvement of the left temporal lobe. Far more of the sampling points showed left-brain dominance in response to the mother’s voice than in response to the stranger’s.

These findings suggest that, from birth or from very soon after, newborn infants respond differently and more actively to their mother’s voice than to the voices of female strangers. Furthermore, the mother’s voice preferentially activates a part of the brain that is involved in processing and learning language. Language is acquired early and easily by normal babies unless they suffer extreme social isolation; this study provides a clear link from birth between the special nature of the mother-infant interaction and that crucially important skill of language acquisition.

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The Developmental Origins of Voice Processing in the Human Brain

Grossmanm, T., Oberecker, R., Koch, S.P. and Friederici, A.D.
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In adults, the main centre for voice processing in the brain has been localised precisely to the superior temporal cortex, but this response is not seen in very young infants. This second study of infant voice processing, by Tobias Grossmann from Birkbeck, University of London, UK and German colleagues, uses slightly older infants than that of Lassonde and her co-workers to examine the way in which this critical brain function develops during the first months of life.

Behavioural studies have indicated, as mentioned above, that even newborn babies prefer human voices to other sounds and the voices of their mothers to those of strangers. Young babies are also able to detect emotion in voice and respond particularly strongly to positive emotions, but only if their native language is spoken. The ability to discriminate between different emotions from voices, however, seems to arise only later in the first year.

Grossmann and his co-workers performed two studies of infant neural processing of voices using near-infrared spectroscopy (NIRS), which measures oxygenated and deoxygenated haemoglobin levels as markers of brain activity, to localise such activity in response to the stimuli. This has the advantage over other spectroscopy techniques in studies of infant brains because it does not need the participants to remain still, and so can be used with older infants who are fully awake and aware. In the first study, 16 four-month-old and 16 seven-month-old infants were presented with a variety of auditory stimuli including human voices while their brain responses were recorded; in the second, 18 seven-month-old infants were presented with the same set of emotionally neutral German verbs spoken with rhythm, stress and intonation (together known in linguistics as “prosody”) reflecting in turn happy, neutral and angry emotions. All infants had been born at full term and were developing normally.

Results from the first study showed significant differences between the brain responses of four- and seven-month-old infants to voices and neutral sounds. Voices, but not other sounds, led to increases in oxy-haemoglobin levels (indicating increased brain activity) in three brain areas in the older, but not in the younger, infants. These included the left and right temporal cortex, close to the region responsible for voice processing in the adult brain. This indicates that the specialised voice processing seen in adult brains begins to emerge in infants between four and seven months of age.

The second study showed, in line with some previous studies, that infants are able to distinguish emotions from speech tones by seven months. In these infants, both happy- and angry-sounding speech elicited a stronger response than neutral tones in a right temporal region that had previously been identified as one of those implicated in the voice response. The strongest responses were observed to the angry-sounding voices, which is consistent with the “negativity bias”, a proposed evolution-

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driven heightened response to negative information. Happy tones, however, caused a response in a part of the right inferior frontal cortex that had not been identified as involved in the general voice response. This part of the cortex, however, has previously been implicated in the adult response to happy intonation, and is thought to be involved in detailed information processing. Infant-directed speech, or “motherese”, shares many of the characteristics of general happy speech; it is thought that infants may pay particular attention to this type of intonation and that this facilitates language learning. It may also be of note that the right brain hemisphere seems to be significantly more involved in processing emotion in speech.

Grossman and his co-workers concluded the paper by speculating on the implications of their findings for neurodevelopmental disorders. Adults and children with autistic spectrum disorders find particular difficulty in recognising emotion from speech patterns. These findings suggest that the neurological changes that are necessary for this distinction begin to arise by the age of seven months, and, by implication, that analysis of brain responses to emotional speech might provide a diagnostic tool for identifying children at risk of developing such disorders even at this early age.

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