

Why does the left brain excel in speech production and dexterity? On time processing and hierarchical binding

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In most people, only the left hemisphere of the brain is able to produce speech while both hemispheres can perceive speech. This could represent a consequence of a specialization of the left half of the brain for the control of action in general or result from a specialization of the left hemisphere in generating linguistic structure or from a combination of both factors. In a series of behavioral and functional imaging experiments, we investigated which speech features are more strongly controlled by the left compared to the right human hemisphere. The left hemisphere was more strongly involved in controlling temporal speech features during speaking while the right hemisphere controlled spectral speech features more strongly. Both auditory association and the prefrontal cortex contributed to this functional lateralization.

To further dissect the role of the left hemisphere in time processing we investigated rhythmic auditory-paced finger tapping. We could identify a left-hemisphere benefit for the control of relative fast tapping rhythms while the right-hemisphere showed a benefit when tapping a slow rhythm on top of the relative fast auditory beat rate, but only when this rhythm was syncopated and not yet overlearned. A series of magnetoencephalography and functional magnetic resonance studies revealed that the left more than the right auditory association cortex represented the fast auditory beat rate in an amplitude modulation of low beta oscillations and that the right more than the left auditory association activated more strongly for the generation of the slow rhythm.

In sum, our results suggest a left-hemispheric preference for the processing of relative fast auditory features. This could grant the left half of the brain the advantage to link motor gestures with their sensory consequences when children learn how to speak and use their limbs. The right hemisphere contributes to this process by processing relative slow rhythms unless they can be integrated with faster rhythms in a complex Gestalt within the left hemisphere. This hierarchical integration of relative rhythms may represent a prerequisite for syntactic processing, another strongly left-lateralized brain function.