Representation of sound sequences in the auditory dorsal stream after sensorimotor learning in the rhesus monkey

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Introduction
Performing auditory action sequences, such as singing and speaking, or playing a musical instrument, requires learning associations between motor commands and sensory feedback. Listening to sound sequences, however, also activates premotor and parietal cortices, as human imaging studies have shown. To understand the evolution of language and music, it will be important to find out whether structures involved in the processing of learned sequences are conserved through phylogeny. Here, we aim to identify the brain structures in the rhesus monkey that are involved in the processing of storage and sound of storage, which were produced during training with an auditory-motor task.

Behavioral Training and Stimuli

Sensory-motor training in two monkeys: (A-B) Apparatus (“monkey piano”) consisting of four levers that, when pressed, produce sequences at different pitches and in a pitch sequence. Training was performed in each animal’s home cage while the other monkey was present in the room. In this way, each monkey learned to produce one sequence (“self-produced”) and was passively exposed to another sequence (“non-self-produced”) that equating familiarity of both sequences used the same keys (pitches) but in different order. FMRI data was obtained while monkeys performed the vocal task during scanning. The vocal task consisted of 90 time points for each condition: self-produced sequence and non-self-produced sequence. Imaging parameters were: sparse sampling EPI (TR=2.7 s, TE=50 ms, flip angle=90), 32 slices, and 1.33 x 1.33 x 1.5 mm voxel size.

Results

1. Both self-produced and non-self-produced sequences activated classical auditory regions (inferior cell field and auditory cortex). 2. Both self-produced and non-self-produced sequences activated ventral premotor area (F5) in the right hemisphere. In addition, activation of the anterior interposed area (VIP) by the non-self-produced sequence revealed additional premotor activation (dorsal premotor). 3. Basal ganglia (ventral pallidum and putamen) and left anterior cingulate were activated by the self-produced sequence contrasted with the non-self-produced sequence. 4. The results showed involvement of premotor and parietal cortices in processing the learned sensorimotor associations and thus support the expanded model of the dorsal stream.

Conclusions

References

4. Basal ganglia (ventral pallidum and putamen) and left anterior cingulate were activated by the self-produced sequence contrasted with the non-self-produced sequence.
5. The results showed involvement of premotor and parietal cortices in processing the learned sensorimotor associations and thus support the expanded model of the dorsal stream.

Visual responses of monkey (R) while listening to self-produced sequence contrasted against non-self-produced sequence revealed additional premotor activation (dorsal premotor). Basal ganglia (ventral pallidum and putamen) and left anterior cingulate were activated by the self-produced sequence contrasted with the non-self-produced sequence. The results showed involvement of premotor and parietal cortices in processing the learned sensorimotor associations and thus support the expanded model of the dorsal stream.

Monkeys are unique in the rhesus monkey strain, including premotor regions, while listening to familiar, self-produced auditory sequences, which may constitute a necessary precursor mechanism for the processing of speech and music.