Rats (*Rattus norvegicus*) detect temporal rather than melodic changes

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Background. Music and language both have a rhythmic organization, and these fields even share some common rhythmic attributes. In music, meter is one of the fundamental components of rhythm. A metrical structure is perceived when some of the events are felt as more prominent than the others. Meter can be physically evoked by changes in the events (beats) composing a sequence, but it can also be induced by the listener over sequences of regular events. Even though humans readily perceive meter over rhythmic structures, it is not yet known to what extent meter perception is already present in non-human animals. In fact, the "vocal learning and rhythmic synchronization hypothesis" (Patel, 2006) suggests that only vocal learning species (animals that are able to acquire non-innate sounds; Jarvis, 2004) might have the required processing abilities as to induce meter in rhythmic sequences.

Aims. Our aim is to explore the extent to which the basis for meter perception can be found in non-human animals that are not vocal learners and cannot modify their vocal output, such as the rat. We thus want to test whether rats detect and discriminate sequences with different metrical structures shaped by melodic and temporal accents.

Method. 40 naive rats were familiarized with auditory rhythmic sequences that evoked a specific metrical structure. They were individually placed in isolated response boxes with a speaker, a nose-poking detector and a pellet feeder. The animals were trained to poke their nose into the feeder to receive food reward. Once they learned this association, we ran 30 familiarization sessions. During

familiarization, the rats were rewarded with food when poking after stimuli presentation. In test sessions, the animals were presented with 24 familiarization sequences and 16 test sequences (8 familiar sequences and 8 novel sequences). Total number of responses (nose-poking) to familiar and to novel test sequences was analyzed. Importantly, neither familiar test nor novel test sequences were rewarded. Each experiment lasted 2 months approximately. The animals were caged in pairs in a quiet environment.

In a first experiment, we familiarized rats with rhythmic sequences with a duple or triple metrical structure, which was defined by melodic accents. During test sessions they had to discriminate between familiar and novel sequences with different metrical structures (duple vs. triple meter), between familiar and novel isotonic sequences (all tones set at the same pitch frequency) and between familiar and novel non-isochronous sequences (different duration between interval onsets). In a second experiment, rats were familiarized with rhythmic sequences with a long-short tone pattern (LS) or a long-short-short tone pattern (LSS). Each pattern induced a different metrical structure, shaped by temporal accents. In tests, rats were presented with novel temporal sequences. They had to discriminate between rhythmic sequences with different metrical structures, but also between sequences with different rhythmic groupings and between sequences with different time interval ratios.

Results. In Experiment 1, we observed that the animals did not discriminate between duple and triple meter sequences, nor did they discriminate between duple or triple meter sequences and isotonic sequences. Conversely, they were able to discriminate between isochronous, metrical sequences and non-isochronous sequences. Thus, rats probably focused on the temporal structure of the stimuli while disregarding melodic changes. In Experiment 2, the results showed that rats can discriminate between LS and LSS sequences (with constant time interval ratio), between familiar and novel LS sequences or familiar and novel LSS sequences (with constant grouping), and between LSS and LSSSS sequences (with constant meter).

Conclusions. Together, the results from the 2 experiments suggest that rats, a non-vocal learning mammal, can detect differences between rhythmic sequences if changes are present on a temporal level rather than a melodic or tonal level. We did not observe concluding evidence regarding the rats' ability to process meter, but the results suggest that metrical structures with temporal accents (rather than dynamic or melodic accents) would be more informative for the perception of metrical structures in rats.

References

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