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Probing Beat Induction in Rhesus Monkeys: Is Beat Induction Species-Specific?

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ABSTRACT

Background

The ability to perceive a regular beat in music and synchronize to it (e.g., by foot tapping or dancing) is a common and widespread human skill. A skill that can be considered conditional on the existence of music (Honing, 2012). Nevertheless, it is still unclear whether this ability should be considered species-specific (Fitch, 2009).

It was recently shown that rhythmic entrainment, long believed a human-specific skill, can be demonstrated in a selected group of bird species (Hasegawa *et al*., 2011), and, somewhat surprisingly, not in more closely related species such as nonhuman primates (Zarco *et al*., 2009). This observation supports the *vocal learning hypothesis* (Patel, 2006) that suggests rhythmic entrainment to be a by-product of the vocal learning mechanisms that are shared by humans and several bird and mammal species, but that are only weakly developed, or lacking entirely, in nonhuman primates (Janik & Slater, 1997).

Most existing animal studies on rhythmic entrainment have used behavioural methods to probe the presence of beat perception, such as tapping tasks (Zarco *et al*., 2009) or measuring head bobs (Patel *et al*., 2009). However, if the production of synchronized movement to sound or music is not observed in certain species, this is no evidence for the *absence* of beat induction; With behavioural methods it is difficult to separate the contributions of perception and production. However, with more direct electrophysiological measures it is possible to show whether or not nonhuman primates are able to detect the beat in a similar way as human newborns (Winkler *et al*., 2009), as such testing whether the vocal learning hypothesis is also an explanation for beat induction.

Aims

In the current study we measure auditory event-related brain potentials (ERP) in a rhesus monkey (*Macaca mulatta*) using the mismatch negativity component (MMN) as an index of (the violation of) rhythmic expectation (*cf.* Honing, 2012). First, we tested whether an MMN can be elicited in rhesus monkeys at all (using deviant tones at random positions in the sound stream). Second, we investigated whether an MMN can be elicited for omissions (by inserting gaps at random positions in the sound stream). Consequently, we probed the presence of beat induction by selectively omitting parts of a musical rhythm (randomly inserting gaps at the first position of a musical unit, i.e. the 'downbeat').

Method

One rhesus monkey participated in the experiments. Experiment 1 tested with a two-tone oddball paradigm whether an MMN can be elicited in principle (conditional to Exp. 2 and 3). Experiment 2 investigated whether an MMN can be elicited for omissions as well. And, finally, Experiment 3 is a replication of an experiment, previously done with adults and newborns, that probes beat induction by selectively omitting parts of a rhythm (Honing *et al*., 2009; Ladinig *et al*., 2009; Winkler *et al*., 2009).

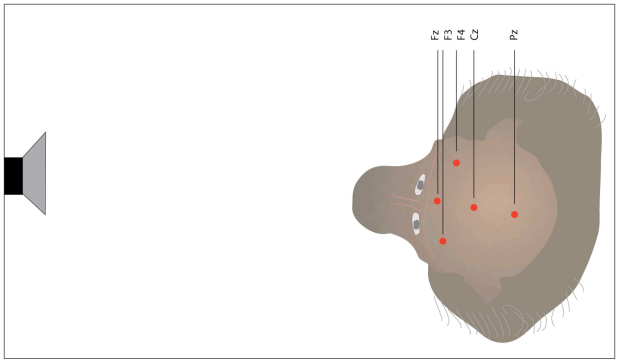

Fig. 1. A rhesus monkey (*Macaca mulatta*) listening to a varying rhythmic pattern while an EEG is measured. Electrode positions Cz, Fz, Pz, F3 and F4 are marked on the skull.

Results and Conclusion

We measured auditory event-related potentials (ERPs) in a rhesus monkey, probing a well-documented component in humans, the mismatch negativity (MMN). We show for the first time in a rhesus monkey that, in response to infrequent deviants that were presented in a continuous sound stream, a comparable ERP component can be detected with negative deflections in early latencies. This result is in line with an earlier study with a single chimpanzee (*Pan troglodytes*) that showed a similar MMN-like response using the same paradigm (Ueno *et al.,* 2008). Consequently, using more complex stimuli, we tested whether rhesus monkeys can not only detect gaps (omissions at random positions in the sound stream) but also the beat (omissions at the first position of a musical unit, i.e. the 'downbeat'). In contrast to what has been shown in human adults and newborns (using identical stimuli and experimental paradigm), preliminary analyses suggest that the monkey is *not* able to detect the beat in music. These findings are in support of the hypothesis that *beat induction* (the cognitive mechanism that supports the detection of a regular pulse from a varying rhythm) is species-specific.

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Keywords

Rhythm; meter; event-related brain potentials (ERPs); cognitive biology

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