Feeling the Beat: Movement Influences Infant Rhythm Perception

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We hear the melody in music, but we feel the beat. People in all cultures move their bodies to the rhythms of music, whether drumming, singing, dancing, or rocking an infant (*1*). Body movement involves motor, proprioceptive (perception of body position), vestibular (perception of movement and balance), visual, and auditory systems (*2*), but few studies have examined auditory-vestibular interactions.

The ability to feel and interpret the strong and weak beats in a rhythm pattern allows people to move and dance in time to music. Typically, the strong beats of a rhythm pattern are played louder, longer, or both, and the metrical structure (what you move to) is derived from, and consistent with, these physical accents (*3*). However, in an ambiguous rhythm pattern with no physical accents, different movements might give rise to different metrical interpretations. In other words, how we move may influence what we hear.

We tested the hypothesis that movement influences the auditory encoding of rhythm patterns in human infants. In experiment 1, we trained 7-month-olds by having them listen to a 2-min repetition of an ambiguous (without accented beats) rhythm pattern (Fig. 1A, row 1, and sound file S1). Half of the infants were bounced on every second beat, and half on every third beat. After training, infants' listening preferences were tested for two auditory versions of the rhythm pattern, which included intensity accents on either every second beat (the duple form) or every third beat (the triple form) (Fig. 1A, rows 2 and 3, and sound files S1 and S3). Infants controlled how long they listened to each version of the rhythm pattern in a head-turn preference procedure (*4*). Infants chose to listen longer to the auditory test stimulus with accented beats that matched the beats on which they were bounced [$t(15) = 4.00$, $P(\text{two-tailed}) = 0.001$] (Fig. 1B). Thus, their bouncing determined whether infants later preferred the auditory rhythm pattern congruent with duple or triple form.

Experiment 2 was identical to experiment 1 except that infants were blindfolded during training. Infants still preferred to listen to the auditory stimulus that matched the metrical form of their movement training [$t(15) = 2.93$, $P = 0.01$] (Fig. 1C), indicating that visual information was not necessary for the effect.

Experiment 3 investigated whether personal motion experience was necessary. During training, infants watched without moving as the experimenter bounced either on every second or on every third beat of the ambiguous rhythm pattern. In this case, infants showed no preference for the two auditory versions [$t(15) = 0.51$, $P = 0.62$] (Fig. 1D), indicating that movement of the infant's own body was critical for the multisensory effect observed in experiments 1 and 2.

In order to confirm that the movement itself did not induce auditory accents due to changing room acoustics as the subjects moved, we trained a group of adult listeners with headphones. Those who bounced (mimicking a model) on every second beat during training identified the duple form as familiar at test, whereas those who bounced on every third beat identified the triple form. Finally, we tested infants' preferences without any movement training and found no preference for either auditory interpretation, again indicating that movement is crucial for the multisensory effect.

These studies illustrate the strong multisensory connection between body movement and auditory rhythm processing when inputs from both sources are experienced concurrently. Because infants did not engage in self-movement, the observed effect likely involves the vestibular and perhaps proprioceptive systems. The early development of the vestibular system (*5*), and infant delight at vestibular stimulation when bounced to a play song or rocked to a lullaby, suggest that we are observing a strong, early vestibular-auditory interaction that is critical for the development of human musical behavior. It has long been known that infants are attracted to music and responsive to its emotional content (*6*, *7*). Our findings provide evidence that the experience of body movement plays an important role in musical rhythm perception.

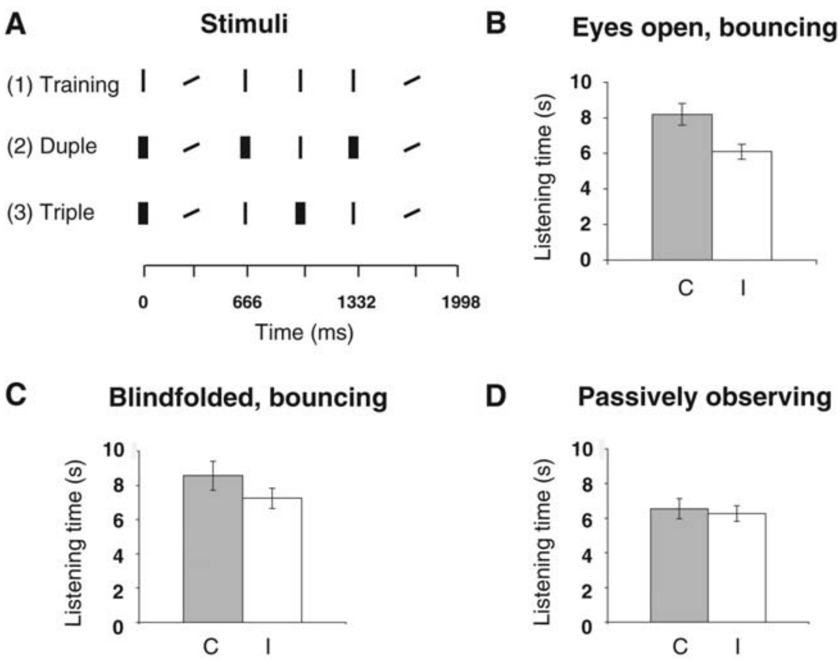

Fig. 1. Influence of bouncing on auditory encoding of rhythm patterns. (**A**) Stimuli. Vertical lines represent the snare drum sounds of the rhythm patterns, and oblique lines represent time-marking slapstick sounds (*4*). (**B** to **D**) Results. The *y* axis represents listening time preference; the *x* axis represents congruency between bouncing (duple or triple) during training and auditory accents (duple or triple) during testing. Error bars represent the standard error of the mean. C, congruent; I, incongruent.

References and Notes

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Supporting Online Material
www.sciencemag.org/cgi/content/full/308/5727/1430/DC1
Materials and Methods
References and Notes
Sound Files S1 to S3

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