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Babies know bad dancing when they see it: Older but not younger infants discriminate between synchronous and asynchronous audiovisual musical displays

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ABSTRACT

Movement to music is a universal human behavior, yet little is known about how observers perceive audiovisual synchrony in complex musical displays such as a person dancing to music, particularly during infancy and childhood. In the current study, we investigated how perception of musical audiovisual synchrony develops over the first year of life. We habituated infants to a video of a person dancing to music and subsequently presented videos in which the visual track was matched (synchronous) or mismatched (asynchronous) with the audio track. In a visual-only control condition, we presented the same visual stimuli with no sound. In Experiment 1, we found that older infants (8–12 months) exhibited a novelty preference for the mismatched movie when both auditory information and visual information were available and showed no preference when only visual information was available. By contrast, younger infants (5–8 months) in Experiment 2 did not discriminate matching stimuli from mismatching stimuli. This suggests that the ability to perceive musical audiovisual synchrony may develop during the second half of the first year of infancy.

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Introduction

The capacity to dance to music is a human universal. In all cultures, people move spontaneously to music, entraining their body movements to the timing of a musical pulse or beat (Large, 2000; Nettl, 1983; Repp, 2005; Snyder & Krumhansl, 2001). Although commonplace, this capacity is not trivial but rather depends on complex and multisensory cognitive processes that develop with age and experience. Dancing to music requires listeners to actively infer a beat from a rich and dynamic musical stimulus, modulate attention toward regularly occurring time points within auditory, visual, and tactile sensory input, form expectations about future events that guide self-generated movements, and continuously monitor these movements for error (Jones & Boltz, 1989; Large & Jones, 1999; Repp & Su, 2013). The current study took an initial step toward understanding the development of these multisensory musical capacities by investigating whether or not young infants can tell when a seen dancer is in or out of synchrony with the beat of heard music.

The term musical "beat" refers to a regularly occurring salient moment in time, often equally spaced or quasi-isochronous, when human listeners are most likely to tap their fingers or feet during music listening (Honing, Bouwer, & Háden, 2014; Lerdahl & Jackendoff, 1983). The musical beat can be considered just one (the most salient) level of the musical "meter," which is made up of multiple hierarchically nested faster and slower levels of pulsation, typically related to the beat by integer ratios (Lerdahl & Jackendoff, 1983; London, 2002). For example, a waltz and a tango might both have 100 beats per minute, but a waltz has a higher level slower pulse every three beats, whereas a tango has higher level pulses every two and four beats. The beat is often highlighted by acoustic features such as louder or longer notes, but a beat can also be perceived in the absence of loudness or duration changes (Brochard, Abecasis, Potter, Ragot, & Drake, 2003; Iversen, Repp, & Patel, 2009) and even when there is no acoustic event (Longuet-Higgins & Lee, 1984; Snyder & Krumhansl, 2001). Thus, beat perception is to a surprising extent a top-down, subjective, and listener-driven process; we infer and predict the location of musical beats, and the percept of a beat is not solely the result of bottom-up perceptual input (Honing et al., 2014; Trainor & Hannon, 2013).

Beat perception and production play a central role in human musicality. Beat perception and production are relatively rare among other species even after extensive training (Cook, Rouse, Wilson, & Reichmuth, 2013; Hattori, Tomonaga, & Matsuzawa, 2013; Honing, Merchant, Háden, Prado, & Bartolo, 2012; Schachner, Brady, Pepperberg, & Hauser, 2009; Zarco, Merchant, Prado, & Mendez, 2009). By contrast, this ability emerges spontaneously in most humans during early childhood without explicit musical training. Within days of birth, infants show sensitivity to the beat in simple musical stimuli; while listening to drum patterns, newborns exhibit larger event-related potential (ERP) responses (mismatch negativity) when events are omitted on strong versus weak beat positions (Winkler, Háden, Ladinig, Sziller, & Honing, 2009), and violations of temporal intervals or tempo in metronome-like rhythmic stimuli give rise to behavioral and neural detection responses in 2-month-olds (Baruch & Drake, 1997; Otte et al., 2013). By the middle of the first year, infants categorize rhythms by their underlying beat; for example, 7-month-olds habituated to a set of varied rhythmic sequences that all shared the same underlying beat subsequently exhibited larger dishabituation responses (indicating perception of greater novelty) to rhythms that violated the familiar beat versus those that maintained the beat they heard during the prior habituation phase (Hannon & Johnson, 2005).

Infants also begin to integrate their own body movements with their auditory perception sometime during the first year. For example, when bounced on every second or third beat of an ambiguous rhythm, 7-month-olds later prefer listening to a version of the rhythm containing loudness accents that match the prior bouncing pattern, suggesting that they encode the temporal position of the bounces as reflecting the beat (Phillips-Silver & Trainor, 2005). Some evidence suggests that 3- to 5-month-olds engage in repetitive rhythmic body movements, such as kicking and arm waving, more often in the presence of music than during silence or other non-musical stimuli, such as speech (Fujii et al., 2014; Ilari, 2015; Zentner & Eerola, 2010); however, these movements are relatively infrequent (8% of the trial at most, observed in only some infants).