Journal of Experimental Child Psychology 102 (2009) 299–314

Contents lists available at ScienceDirect

Journal of Experimental Child Psychology

journal homepage: www.elsevier.com/locate/jecp

Joint drumming: Social context facilitates synchronization in preschool children

Sebastian Kirschner *, Michael Tomasello

Department of Developmental and Comparative Psychology, Max Planck Institute for Evolutionary Anthropology, D-04103 Leipzig, Germany

ARTICLE INFO

Article history:
Received 19 December 2007
Revised 22 July 2008
Available online 12 September 2008

Keywords:
Music
Evolution
Human behavior
Rhythmic entrainment
Sensorimotor synchronization
Interpersonal coordination
Child development
Social cognition
Joint action
Shared intentionality

ABSTRACT

The human capacity to synchronize body movements to an external acoustic beat enables uniquely human behaviors such as music making and dancing. By hypothesis, these first evolved in human cultures as fundamentally social activities. We therefore hypothesized that children would spontaneously synchronize their body movements to an external beat at earlier ages and with higher accuracy if the stimulus was presented in a social context. A total of 36 children in three age groups (2.5, 3.5, and 4.5 years) were invited to drum along with either a human partner, a drumming machine, or a drum sound coming from a speaker. When drumming with a social partner, children as young as 2.5 years adjusted their drumming tempo to a beat outside the range of their spontaneous motor tempo. Moreover, children of all ages synchronized their drumming with higher accuracy in the social condition. We argue that drumming together with a social partner creates a shared representation of the joint action task and/or elicits a specific human motivation to synchronize movements during joint rhythmic activity.

Introduction

Humans have the ability to entrain their movements to an external rhythm such as a beating drum (Wallin, Merker, & Brown, 2000). Such *rhythmic entrainment* of periodic body movements to rhythmic sound patterns is a fundamental component of music and dance, themselves integral elements of natural human behavior (Clayton, Sager, & Will, 2004).

* Corresponding author. Fax: +49 341 3550 444.
E-mail address: kirschner@eva.mpg.de (S. Kirschner).

0022-0965/$ - see front matter © 2008 Elsevier Inc. All rights reserved.
doi:10.1016/j.jecp.2008.07.005

Many animals move their limbs in a metrical alternating fashion, but the underlying motor pattern generators are mostly automatic and refer only to the animals' own bodies (Marder & Bucher, 2001). Yet in a few arthropod and anuran species, the males use periodic movements to create acoustic courtship signals and can synchronize these sounds to the signals of other nearby males (Gibson & Russell, 2006; Greenfield, 1994; Kotiaho, Alatalo, Mappes, & Parri, 2004). However, *Homo sapiens* is the only known species where both sexes engage in spontaneous synchronization of periodic body movements to acoustic rhythmic pulses (Patel, 2006). Furthermore, this rather unusual skill among primates develops relatively early in human ontogeny, long before sexual maturity (Fitch, 2006).

Patel, Iversen, Chen, and Repp (2005) further emphasized the complexity and flexibility of human "beat perception and synchronization," as they called it. For example, adults can synchronize the movements of various body parts to external rhythms over a great range of tempi, also at rates that are multiples or fractions of the same underlying pulse (Drake, Jones, & Baruch, 2000; Large & Palmer, 2002; Snyder & Krumhansl, 2001). The special relationship between the auditory system and rhythmic body movement is evidenced by the finding that visual rhythms induce only very poor rhythmic entrainment in humans (Patel, Iversen, Chen, & Repp, 2005; Repp & Penel, 2004).

Within the first year of life, human infants learn to discriminate acoustic rhythmic patterns and can discern the metrical structures that underlie musical pieces (for a review, see Trehub & Hannon, 2006). Infants as young as 7 months infer different meters from the same auditory rhythm when they get bounced at different periodic accents, illustrating the multisensory interactions between rhythm perception and movement (Phillips-Silver & Trainor, 2005). However, infants at that age do not actively synchronize their movements to an external beat (Longhi, 2003, cited in Patel, 2006). According to the tapping literature, such *sensorimotor synchronization* (Repp, 2005) is not clearly present in young children until around 4 years of age (McAuley, Jones, Holub, Johnston, & Miller, 2006). The testing paradigms used to infer this developmental shift were basically the same as those used in adult studies, where participants are asked to tap their finger or hand in synchrony with an auditory stimulus (for reviews, see Aschersleben, 2002; Repp, 2005). Nevertheless, although 4-year-olds are quite competent in this sensorimotor synchronization task, their range of accessible tempi is smaller than that of adults and, significantly, the best results are yielded by *interstimulus intervals* (ISIs) of approximately 400 ms (equating to 150 beats/min), which is in the range of the *spontaneous motor tempo* of children of this age (Drake et al., 2000; Fitzpatrick, Schmidt, & Lockman, 1996; McAuley et al., 2006; Provasi & Bobin-Bègue, 2003).

There is very little research on rhythmic entrainment in children before 4 years of age. First, Fitzpatrick and colleagues (1996) reported that 3-year-olds were basically unable to clap their hands in time with a metronome. Second, Provasi and Bobin-Bègue (2003) found that 2.5-year-olds sometimes managed to tap in synchrony with an isochronous beat (occurring at equal intervals), but only when the tempo was at an ISI of 400 ms—again, a beat within the range of their spontaneous motor tempo. In that study, participants needed to tap on a horizontal touch screen in phase with a short sound of an animal's call that occurred at 400, 600, or 800 ms ISI (equivalent to 150, 100, or 75 beats/min, respectively). The taps caused a picture of the corresponding animal to appear on the screen, but only when tapping occurred in time with the sound (as a nonverbal reinforcement). The same participants who were successful at an ISI of 400 ms, however, failed to slow down their tapping so as to synchronize with the call sequence at 600 and 800 ms ISI. In contrast, many of the 4-year-olds managed to tap in phase with the stimulus at all tempi presented. Third, Eerola, Luck, and Toiviainen (2006), focusing on whole-body dancing movements, found a similar developmental pattern for children of 2 to 4 years of age. Although the younger children showed periodic movements that were at times in synchrony with the original piece of music, they did not adjust the period of their hopping, swaying, or circling to the song played at tempi much slower than 150 beats/min.

However, none of these studies with younger children used a social context to elicit sensorimotor synchronization. In our view, successful research on the origins of rhythmic entrainment must take into account the natural environment in which this behavior most likely evolved (e.g., Bispham, 2006; Fitch, 2006; Huron, 2001; McNeill, 1995; Merker, 2000). Specifically, before the invention of sound recording and reproduction devices during the 1870s, every musical context involving synchro-