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Rock With Me: The Role of Movement Synchrony in Infants' Social and Nonsocial Choices

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Matching the timing of one's movements to the movements of others has been proposed to increase affiliation and prosociality. Although coordinated movements facilitate early social interactions, not much is known about the mechanisms and effects of movement synchrony throughout development. Two studies investigated 12-month-olds' (Study 1, N = 40) and 9-month-olds' (Study 2, N = 41) preferences for synchronous others in a social as opposed to a nonsocial context. It was found that movement synchrony exclusively guides infants' social choices at 12 months. In contrast, 9-month-olds did not show any preferences for synchronous movements in social or nonsocial contexts. Results suggest that movement synchrony is important in guiding infants' social preferences and its effects emerge toward the end of the 1st year of life.

Much of the massive flexibility in human social interactions stems from interpersonal coordination, which enables the exchange of crucial cognitive and contextual information (Knoblich & Sebanz, 2008). It is thus important to investigate the emergence and social consequences of interpersonal coordination throughout development.

Human infants are socially oriented from early on. It is well established that even within the 1st year of life, infants prefer looking at face-like stimuli (Dannemiller & Stephens, 1988; Fantz, 1961, 1963) and listening to communicative human sounds (Glenn, Cunningham, & Joyce, 1981; Shultz & Vouloumanos, 2010; Vouloumanos & Werker, 2004) than to equally complex nonhuman stimuli. Furthermore, 15-month-olds not only imitate but also engage in more communicative acts with a stuffed toy that has a face than with one that does not (Johnson, Booth, & O'Hearn, 2001). Not all social stimuli are equally desirable, however. A wide range of studies demonstrates that infants prefer those who are more similar to themselves. They prefer looking at own-race faces (Kelly et al., 2005), imitate native speakers (Kinzler, Dupoux, & Spelke, 2012), and share and collaborate more with people speaking their own language (Kinzler et al., 2012).

Behavioral similarity involving contingency and coordination among interactants may also play a role in children's social development. Longitudinal studies reveal that better behavioral coordination between a mother and child influences a child's later cognition, communicative competency, socio-emotional adaptation (Jaffe et al., 2001), and attachment style (Isabella, Belsky, & von Eye, 1989). Similarly, two recent studies found that 18-month-olds prefer playing with (Fawcett & Liszkowski, 2012) and helping (Carpenter, Uebel, & Tomasello, 2013) adults who have previously mimicked their actions. We propose that coordinated motion cues that indicate similarity and contingency can also influence infants' social preferences.

Numerous studies demonstrated that adults spontaneously fall into synchrony with each other as they walk, move pendulums, or rock in rocking chairs (Richardson, Marsh, Isenhower, Goodman, & Schmidt, 2007; Richardson, Marsh, & Schmidt, 2005; Schmidt & O'Brien, 1997; Zivotofsky & Hausdorff, 2007). Moreover, being in synchrony increases perceptions of similarity (Valdesolo & Desteno, 2011; Valdesolo, Ouyang, & DeSteno, 2010; Wiltermuth & Heath, 2009), rapport (Miles, Griffiths, Richardson, & Macrae, 2010; Miles, Nind,

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& Macrae, 2009), trust (Launay, Dean, & Bailes, 2012), and cooperation (Reddish, Bulbulia, & Fischer, 2014; Reddish, Fischer, & Bulbulia, 2013; Valdesolo et al., 2010; Wiltermuth & Heath, 2009). Yet, establishing coordination through synchronization, that is, sharing the same rhythm and matching one's actions to an external source in terms of both phase and frequency, requires sophisticated precision in (a) perceiving rhythmical signals, (b) producing rhythmical signals, and (c) integrating sensory information to one's own motor production (Phillips-Silver, Aktipis, & Bryant, 2010). So, how do children's abilities to synchronize reveal themselves throughout development?

In social contexts, infants begin showing aspects of social coordination and synchrony from very early in life. Neonates differentiate between rhythms in different languages (Nazzi, Jusczyk, & Johnson, 2000; Ramus, 2002) and coordinate their body movements to human speech (Condon & Sander, 1974). Notably, such coordination is observed only in response to social stimuli, that is, human speech, and not to nonsocial stimuli, such as tapping sounds or white noise (Kato et al., 1983). At 6 weeks, newborns start displaying sensitivity to temporal changes during interactions with their mothers (Crown, Feldstein, Jasnow, Beebe, & Jaffe, 2002), and 4- and 9-month-olds coordinate their gaze and the timing of their vocalizations according to when their mothers start or stop talking (Feldstein et al., 1993; Jasnow & Feldstein, 1986).

The ability to perceive and respond to rhythmical stimuli outside of a social context emerges slightly later. Infants can detect changes in rhythmical structures around 2–4 months of age (Trehub & Hannon, 2006). Initial signs of rhythmic engagement with stimuli appear at 5 months (Zentner & Eerola, 2010). Yet, despite being modulated by the changing beats, this rhythmic engagement of body movements cannot be called precise motor synchronization even at 2 years (Zentner & Eerola, 2010). Children approaching preschool age show increased flexibility in tapping to different metronome beats (Provasi & Bobin-Bègue, 2003), although 4.5-year-olds still synchronize better when drumming along to another person's drumming as compared to machine drumming (Kirschner & Tomasello, 2009).

Soon after infants start engaging rhythmically with external stimuli, a preference for matched rhythms starts to emerge. After being bounced to ambiguous rhythms, 7-month-olds preferentially attended more to an auditory rhythm, whose pattern was congruent with the one they had been bounced to (Phillips-Silver & Trainor, 2005). It remains unclear, however, whether this recognition of congruent rhythms would transfer into an active preference (e.g., manual choice) for synchronous stimuli. It has also been shown that 14-month-olds help an adult more after being bounced synchronously than asynchronously with her (Cirelli, Einarson, & Trainor, 2014). This suggests a preference for synchronous over nonsynchronous movements, a hypothesis that the current studies aim to test. Yet, given the importance of coordination in interpersonal relationships and children's demonstrated ability to synchronize better with social partners, we postulate a distinction between synchrony-based preferences in social versus nonsocial contexts.

In the current studies, children were rocked in chairs as they viewed toys (social or nonsocial) that rocked synchronously or nonsynchronously with them and were later given the opportunity to select one of them. Rocking rhythms were constant and equally predictable across conditions (see Cirelli et al., 2014, for a discussion). Social toys were teddy bears that briefly talked and gestured to the children before the rocking phase started. In contrast, nonsocial toys were colorful boxes that made some sounds and were lit up. We hypothesized that 12-month-olds (Study 1) would prefer the synchronously moving toys more in the social condition than in the nonsocial condition. In Study 2, we explored whether 9-month-olds would show the same pattern of preferences as 12-month-olds.

Study 1

Method

Participants

Participants were forty 12-month-olds (M = 374 days, SD = 10.02, 21 girls). All participants were recruited from a database of parents who had indicated interest in taking part in research. Children were mainly from White, middle-class backgrounds, based in a middle-sized European city. Parents received a voucher worth approximately 10€ for their time. Local ethical approval was received prior to the study.

Materials

Rocking chair. A baby car seat was used to manipulate synchronous movement across conditions. During testing, children sat in the chair and watched videos as the chair was rocked from behind by the experimenter (E). The toys featured in the videos were seated in the same chair during recording.

Video stimuli. Life-sized videos were shown from a 55-in. TV screen positioned approximately 1 m in front of the child. The screen was surrounded by a partition of curtains so that it appeared to be a window into another part of the room rather than a regular TV screen (see Figure 1). In total, two teddy bears (social condition) and two colorful boxes with flower pictures on them (nonsocial condition) were recorded while being rocked in the chair (see Video S1 in the online Supporting Information). Toys within a given video were distinguished from one another via their different colors and were rocked at one of two speeds: 594 ms (101 bpm) or 458 ms (131 bpm). Pilot tests showed that these two speeds are easily distinguishable, natural rocking speeds for children.

In the synchrony condition, both the child and the toy were rocked to the same rhythm (either 594 or 458 ms) with identical onset times. This meant that the chairs' positions of maximum amplitude while rocking forward and backward always occurred simultaneously for the child and the toy. In the nonsynchrony condition, the child and the toy were rocked to different rhythms, while the onset times remained identical. This meant that during rocking, the positions of the chairs were not the same, and the distances between the two positions varied at each of their repeating cycles. The following parameters were counterbalanced in the stimuli: (a) colors by right–left side, (b) synchronous toy by right–left side, (c) presentation order of the synchronous versus nonsynchronous toy, and (d) presentation order of the fast versus slow speeds.

At the beginning of each video, E placed the toys in their chairs from the side of the screen one at a time. In the social condition, one of the teddy bears said "Hej! Nu gungar vi!" ("Hi! Let's rock," in English), while nodding its head simultaneously. It then started rocking at one of the two speeds (duration: 40 s). After the first bear stopped, there was a brief pause and then the second bear introduced itself the same way as the first bear and started rocking at the other speed. To replace the utterances and head nods of the social condition, the boxes in the nonsocial condition made a jingling or mechanical rattling sound, while being illuminated with light flashes simultaneously. In both social and nonsocial conditions, the toy introduction lasted for 3 s and involved equal visual and auditory stimulation. Rocking of each toy was presented sequentially to ensure that children had a chance to attend to both toys (see the online Supporting Information for a sample video of the stimuli).

Procedure

Each session consisted of a social and a nonsocial condition (counterbalanced). Each trial had two phases, the rocking phase followed by the choice phase. Before the experiment, E played with the children briefly to familiarize them with the environment. At all times, parents stayed in the room with children. They were asked to help keep their children motivated while watching the videos (e.g.,

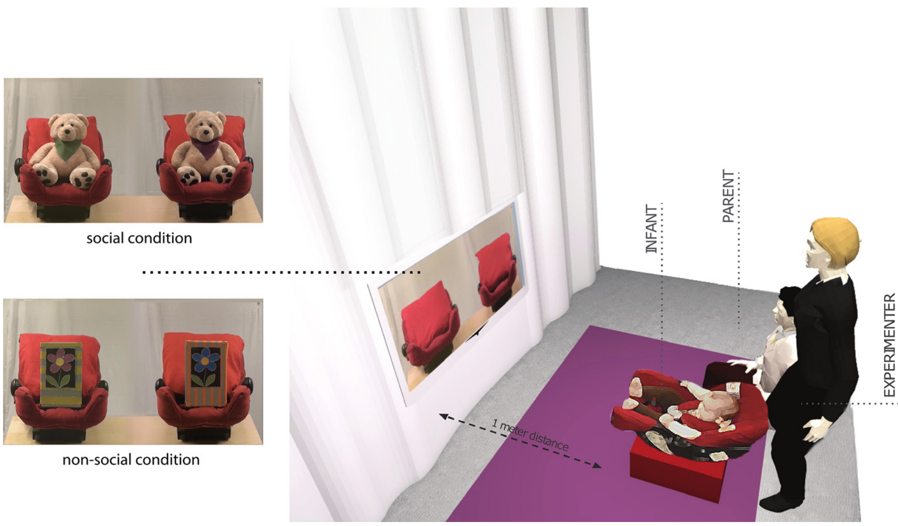

Figure 1. Depiction of the room setting and still frames from the social and nonsocial stimuli.

by pointing to the screen and saying, "Look," but never by giving specific information about what was happening) and while responding to E during the choice task phase (e.g., with general encouragement but no specific directions).

Phase 1: Rocking. At the beginning of this phase, children were seated securely in the chair in front of the TV. In order to create the perception of a live demonstration, children observed E show each toy, saying, "Titta!" ("Look!" in English) and take it behind the curtains that surrounded the screen. The toy was seen on the TV screen as being placed in its chair by E. This was repeated for the second toy on the other side of the screen. For the duration of each toy's rocking in the video, E rocked the child at one consistent speed, indicated by a beat she heard from her earphones. Having the child rock at one speed throughout the session resulted in one toy per trial rocking at the same speed as the child (synchronous toy) and the other at a different speed (nonsynchronous toy). On finishing the rocking phase, E brought the toys back from behind the screen and put them on the carpet.

Phase 2: Choice task. For the choice task, the children were seated on the carpet in front of their parents. E showed each toy to the children in sequence, saying, "Titta!" ("Look"), giving them sufficient time to look at each toy and back at the experimenter. Following this, she asked the children which one they like best (saying, "Vilken tycker du bäst om?" and "Which one do you like best?"). Children indicated their preference by crawling and reaching for a toy from approximately 1 m away. If they did not respond, E made a second attempt asking, "Varsågod! Vilken tycker du bäst om?" ("Here you are! Which one do you like best?"). After making their choice, children were seated back in the chair for the second trial.

The entire session was video recorded for coding purposes.

Coding

The first toy the children touched with a visually guided reach was counted as their preferred choice. To eliminate accidental touches being counted as choices, children had to look at the toy they were reaching for. If there was no choice within 3 min, the trial was excluded. Six of 80 trials were excluded from analyses because of fussiness (2), parental interference (2), or children's delay in responding (2). To examine whether children found the toys similarly appealing and attended to them equally during the rocking phase, we conducted a looking time analysis. Children in all conditions attended to the 40-s rocking stimuli equally well (M = 31.35 s for social-synchrony, M = 31.87 s for social-nonsynchrony, M = 32.43 s for nonsocial-synchrony, and M = 30.99 s for nonsocial-nonsynchrony), one-way analysis of variance (ANOVA), $F(3, 39) = 0.414$, $p = .743$. Across conditions, there were no differences in the number of times parents attempted to redirect their children's attention to the screen (i.e., prompting; M = 1.54 for social-synchrony, M = 1.33 for social-nonsynchrony, M = 1.83 for nonsocial-synchrony, and M = 1.85 for nonsocial-nonsynchrony), one-way ANOVA, $F(3, 39) = 0.900$, $p = .443$.

A second coder blind to the conditions and the hypotheses coded a randomly selected 25% of the videos to examine reliability. The two coders had excellent agreement on all measures. Cohen's kappa was computed for the categorical measure of children's choices; there was 100% agreement, $\kappa = 1.00$, $p < .0001$. The coders' ratings were highly correlated for duration of looking time, Cronbach's $\alpha = .91$, and for number of instances of parental prompting, Cronbach's $\alpha = .95$. The second coder also coded for experimental bias by indicating whether any of the toys had been emphasized more by E as she offered them to the child; no instances of such bias was found.

Results and Discussion

A 2 (synchronous vs. nonsynchronous) × 2 (social vs. nonsocial) within-subjects design was employed. The dependent variable was a dichotomous choice between the two toys in a given condition. Our expectation that 12-month-olds would prefer synchronously moving toys more in the social than in the nonsocial condition was confirmed, $\chi^2(1) = 8.70$, $p = .003$, $\phi = .36$. Children chose synchronous toys above chance in the social condition (66% of participants), binomial $p = .041$, but not in the nonsocial condition (38% of participants), binomial $p = .199$. Children had no overall preferences to select toys based on other factors and their synchronous toy choices were not influenced by those factors (see Table 1).

These results suggest that movement synchrony is influential in guiding 12-month-olds' social preferences. Children did not show a general preference for synchronously moving others; instead, it was only social entities who were preferred for their synchronous movements. To trace any developmental pattern on preferences for movement synchrony, we conducted a second study with 9-month-old infants.

Table 1
Summary Results for the Influence of Various Factors on 12-Month-Olds' Toy Choices

	Percent of choices (overall)	Binomial *p* (overall)	Percent of choices (sync choices)	Binomial logistic regression *p* (sync choices)
Child's gender				
Male			52.63	.195
Female				
Trial number				
First trial			43.59	.187
Second trial				
Child's rocking speed				
594 ms			57.89	.204
498 ms				
Toy's rocking speed				
594 ms	55.41	.295	53.85	.985
498 ms				
Side of presentation				
Right	58.11	.201	56.41	.566
Left				
Order of presentation				
First	45.83	.724	51.28	.144
Second				
Toy color				
Green bear	60.00	.311	62.50	.402
Purple bear				
Orange box	61.54	.200	53.33	.700
Yellow box				

Study 2

Method

Participants

Participants were forty-one 9-month-olds (M = 276 days, SD = 10.79, 20 girls). One additional child was excluded for not completing the study due to fussiness. Participants were recruited as in Study 1.

Materials and Procedure

The stimuli and procedure were identical to Study 1, except that for 17% of the children, not yet capable of locomoting, the toys were brought within their reach so that they could make their choice.

Coding

The same coding scheme was applied as in Study 1. Five of 82 trials were excluded from the analyses because of fussiness (1), parental interference (1), or children's delay in responding (3).

Looking time analyses revealed that children attended to the stimuli equally across conditions (M = 31.36 s for social-synchrony, M = 30.70 s for social-nonsynchrony, M = 30.04 s for nonsocial-synchrony, and M = 29.75 s for nonsocial-nonsynchrony), one-way ANOVA, $F(3, 39) = 0.562$, $p = .641$. The number of times parents prompted children did not differ across conditions (M = 1.23 s for social-synchrony, M = 1.38 s for social-nonsynchrony, M = 1.55 s nonsocial-synchrony, and M = 1.83 s for nonsocial-nonsynchrony), one-way ANOVA, $F(3, 39) = 1.073$, $p = .362$. Interrater reliability analyses with Cohen's kappa on children's choices revealed perfect agreement, $\kappa = 1.00$, $p < .0001$. The two coders' ratings were also highly correlated for looking times, Cronbach's $\alpha = .86$, and number of instances of parental prompting, Cronbach's $\alpha = .92$. Further, the second coder did not detect any experimenter bias.

Results and Discussion

Unlike 12-month-olds, 9-month-olds did not display a differential preference for synchronously moving toys across social and nonsocial conditions, $\chi^2(1) = 0.21$, $p = .646$. In fact, they did not show preferences for synchronous entities in either the social condition (44% of participants), binomial $p = .63$, or nonsocial condition (61% of participants), binomial $p = .87$, suggesting that they had not yet developed a preference for entities that have previously moved in synchrony with their own movement.

Binomial logistic regression analyses demonstrated that children's choices were not influenced by other factors, nor was there an interaction with condition (see Table 2). Children had an overall preference to select slow-rocking toys more than fast-rocking toys, binomial $p = .039$, indicating they have sufficient memory of the kinematics of the toys. There was no interaction between toy speed and condition, $p = .364$; children were no more likely to choose slow-rocking toys in the social versus the nonsocial condition. In sum, it can be concluded that 9-month-olds did not have a preference for synchronously rocking toys.

General Discussion

The current studies show that similarity in the timing of movements is an important factor informing

Table 2
Summary Results for the Influence of Various Factors on 9-Month-Olds' Toy Choices

	Percent of choices (overall)	Binomial p (overall)	Percent of choices (sync choices)	Binomial logistic regression p (sync choices)
Child's gender				
Male			50.00	.922
Female				
Trial number				
First trial			50.00	.654
Second trial				
Child's rocking speed				
594 ms			57.50	.148
498 ms				
Toy's rocking speed				
594 ms	62.34	.040*	57.50	.438
498 ms				
Side of presentation				
Right	59.74	.110	57.50	.593
Left				
Order of presentation				
First	45.45	.494	45.00	.671
Second				
Toy color				
Green bear	65.79	.073	66.66	.938
Purple bear				
Orange box	61.54	.200	70.59	.604
Yellow box				

*p < .05.

infants' social preferences for others. Twelve-month-olds, but not 9-month-olds, prefer those who have moved synchronously with them to those who have moved nonsynchronously. Results suggest that this preference does not stem from a general preference for synchronous movement; children did not exhibit a preference for nonsocial entities that moved synchronously. Previous studies have begun to provide evidence for the emergence of a preference for synchronous movements during infancy (Cirelli et al., 2014). Yet, this is the first evidence suggesting an active, social preference based on similarity in the timing of movements.

Our second study shows that preference for synchrony in social settings is not yet in place at 9 months. Indeed, 9-month-olds did not show preferences for movement synchrony at all. One reason for this might be difficulties in perceiving synchronicity. Auditory beats or up-and-down bouncing movements, as used by Phillips-Silver and Trainor (2005), rather than viewing back-and-forth movements, may be more salient stimuli for detecting synchrony. Another possibility is that even though children perceived synchronicity and had preliminary preferences for synchronous entities, their preference was not strong enough to be revealed in our choice task. While a head-turn preference procedure, as was used previously (Phillips-Silver & Trainor, 2005), is less demanding than our task, we know that even 5-month-olds can express their preferences by selecting from among toys that have acted in different ways (Hamlin & Wynn, 2011; Hamlin, Wynn, Bloom, & Mahajan, 2011). Thus, the choice measures used in our studies were age appropriate.

Still, which aspects of synchronous interactions induce the observed effects is largely unknown. It has been proposed that temporal contingency rather than topographical similarity between actions might be responsible for the prosocial effects of synchrony (Catmur & Heyes, 2013; Cirelli et al., 2014). Temporal contingencies can foster causality links and perceptions of agency (Fonagy, Gergely, & Target, 2007; Rochat, 1998). Indeed, infants are sensitive to temporal contingencies between actions and outcomes even in the absence of visual cues (Bahrick & Watson, 1985). Arguably, however, both temporal contingency and topographical similarity facilitate prosociality, albeit in different ways. More studies investigating how these and other factors interact in a wider range of coordinated movements are needed to shed light on this question.

Research on action timing in children's early development has been scarce. One apparent reason for this is infants' limited motor abilities to move in synchrony with others. We tried to overcome this challenge by having infants seated in a chair and rocked by an adult. Contrary with previous methods, where infants were bounced in baby carriers attached to the experimenters' upper bodies (Cirelli et al., 2014; Phillips-Silver & Trainor, 2005), our movement manipulation did not require bodily contact between the experimenter and infant, potentially making the infant's experience more focused on the interaction with the synchronously and nonsynchronously moving individuals. Furthermore, despite lacking self-propulsion, children in our study had first-person experience about the rocking movement. Thus, the synchrony manipulation was designed to be as impactful as possible, given participants' limited motor skills. Nevertheless, the current methodology leaves it to future research to address whether self-propelled actions would have a more pronounced effect on children's preferences.

In the current studies, the social agents presented to children were teddy bears that nodded their heads and uttered some words. In contrast, the nonsocial items were colorful boxes that lit up and made some sounds. One critique could be that the social condition was not interpreted as such. Previous research shows, however, that children perceive toys as social entities, particularly ones having eyes and a face and that perform contingent, communicative acts (Johnson, Slaughter, & Carey, 1998; Johnson et al., 2001). Infants' judgment of nonhumans as social beings based on certain features is also reflected in their prosocial behaviors (Legerstee & Markova, 2008; Over & Carpenter, 2009). In addition, research on early social interactions shows that mothers often talk about the internal states of dolls and toy animals, which influences children's imitation and pretend play (Haight & Miller, 1992; Zinober & Martlew, 1985). Therefore, we are confident that the teddy bears in our study, which had a face and communicated with the participants, possessed sufficient cues to be understood as social agents. To help draw the links to real-life social interactions, future research can explore this issue further by manipulating the synchronizing partners' agency levels and presenting them in a reciprocal communication context.

Another limitation could be that the agents were presented via video rather than live, possibly making them less impactful for children. This method was selected, because using videotaped stimuli minimizes human error in rocking rhythm and eases replicability. Research has shown that integrating video demonstrations with matching auditory and visual cues and contingent social behaviors facilitates children's learning from video stimuli (see Barr, 2010; Troseth, 2010, for reviews). Accordingly, our videos were complemented with sounds that matched the movements of the objects shown. While presenting the video stimuli, the experimenter provided the children with contingent social information. Moreover, our TV screen looked as if it were a window into another room that was behind the curtains, creating a more realistic setup. Studies using a similar video presentation method demonstrate that 10-month-olds can make decisions based on information presented from the screen (Kinzler, Dupoux, & Spelke, 2007, 2012). Hence, we are confident that the video stimuli were sufficiently comprehended by both age groups to guide subsequent choices.

Moving in time with others has important implications in social interactions, potentially facilitating coordination and increasing prosocial attitudes and behaviors among participants. How the links between movement synchrony and social behaviors are formed has been largely unexplored. In two studies, we showed that an active preference for movement synchrony develops toward the end of the 1st year of life. This preference occurs exclusively in social contexts, as indicated by children's selection of synchronously moving toys only when they were presented as social agents. Future research on the links between movement synchrony and social preference will provide a deeper understanding of the role coordination plays in children's social development.

References

Bahrick, L. E., & Watson, J. S. (1985). Detection of intermodal proprioceptive-visual contingency as a potential basis of self-perception in infancy. *Developmental Psychology*, *21*, 963–973. doi:10.1037/0012-1649.21.6.963

Barr, R. (2010). Transfer of learning between 2D and 3D sources during infancy: Informing theory and practice. *Developmental Review*, *30*, 128–154. doi:10.1016/j.dr.2010.03.001

Carpenter, M., Uebel, J., & Tomasello, M. (2013). Being mimicked increases prosocial behavior in 18-month-old infants. *Child Development*, *84*, 1511–1518. doi:10.1111/cdev.12083

Catmur, C., & Heyes, C. (2013). Is it what you do, or when you do it? The roles of contingency and similarity in pro-social effects of imitation. *Cognitive Science*, *37*, 1541–1442. doi:10.1111/cogs.12071

Cirelli, L. K., Einarson, K. M., & Trainor, L. J. (2014). Interpersonal synchrony increases prosocial behaviour in infants. *Developmental Science*, *17*, 1003–1011. doi:10.1111/desc.12193

Condon, W. S., & Sander, L. W. (1974). Synchrony demonstrated between movements of the neonate and adult speech. *Child Development*, *45*, 456–462. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/4837718

Crown, C. L., Feldstein, S., Jasnow, M. D., Beebe, B., & Jaffe, J. (2002). The cross-modal coordination of interpersonal timing: Six-week-olds infants' gaze with adults' vocal behavior. *Journal of Psycholinguistic Research*, *31*, 1–23. doi:10.1023/A:1014301303616

Dannemiller, J. L., & Stephens, B. R. (1988). A critical test of infant pattern preference models. *Child Development*, *59*, 210–216. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/3342713

Fantz, R. L. (1961). The origin of form perception. *Scientific American*, *204*, 66–73. doi:10.1038/scientificamerican0561-66

Fantz, R. L. (1963). Pattern vision in newborns. *Science*, *140*, 296–297. doi:10.1126/science.140.3564.296

Fawcett, C., & Liszkowski, U. (2012). Mimicry and play initiation in 18-month-old infants. *Infant Behavior and Development*, *35*, 689–696. doi:10.1016/j.infbeh.2012.07.014

Feldstein, S., Jaffe, J., Beebe, B., Crown, C. L., Jasnow, M., Fox, H., & Gordon, S. (1993). Coordinated interpersonal timing in adult-infant vocal interactions: A cross-site replication. *Infant Behavior and Development*, *16*, 455–470. doi:10.1016/0163-6383(93)80004-R

Fonagy, P., Gergely, G., & Target, M. (2007). The parent–infant dyad and the construction of the subjective self. *Journal of Child Psychology and Psychiatry*, *48*, 288–328. doi:10.1111/j.1469-7610.2007.01727.x

Glenn, S. M., Cunningham, C. C., & Joyce, P. F. (1981). A study of auditory preferences in nonhandicapped infants and infants with Down's syndrome. *Child Development*, *5*, 1303–1307.

Haight, W., & Miller, P. J. (1992). The development of everyday pretend play: A longitudinal study of mothers' participation. *Merrill-Palmer Quarterly*, *38*, 331–349.

Hamlin, J. K., & Wynn, K. (2011). Young infants prefer prosocial to antisocial others. *Cognitive Development*, *26*, 30–39. doi:10.1016/j.cogdev.2010.09.001.Young

Hamlin, J. K., Wynn, K., Bloom, P., & Mahajan, N. (2011). How infants and toddlers react to antisocial others. *Proceedings of the National Academy of Sciences of the United States of America*, *108*, 19931–19936. doi:10.1073/pnas.1110306108

Isabella, R. A., Belsky, J., & von Eye, A. (1989). Origins of infant–mother attachment: An examination of interactional synchrony during the infant's first year. *Developmental Psychology*, *25*, 12–21. doi:10.1037/0012-1649.25.1.12

Jaffe, J., Beebe, B., Feldstein, S., Crown, C. L., Jasnow, M. D., Rochat, P., & Stern, D. N. (2001). Rhythms of dialogue in infancy: Coordinated timing in development. *Monographs of the Society for Research in Child Development*, *66*(2, Serial No. 265).

Jasnow, M., & Feldstein, S. (1986). Adult-like temporal characteristics of mother–infant vocal interactions. *Child Development*, *57*, 754–761.

Johnson, S. C., Booth, A., & O'Hearn, K. (2001). Inferring the goals of a nonhuman agent. *Cognitive Development*, *16*, 637–656. doi:10.1016/S0885-2014(01)00043-0

Johnson, S., Slaughter, V., & Carey, S. (1998). Whose gaze will infants follow? The elicitation of gaze following in 12-month-olds. *Developmental Science*, *1*, 233–238. doi:10.1111/1467-7687.00036

Kato, T., Takahashi, E., Sawada, K., Kobayashi, N., Watanabe, T., & Ishii, T. (1983). A computer analysis of infant movements synchronized with adult speech. *Pediatric Research*, *17*, 625–628. doi:10.1203/00006450-198308000-00004

Kelly, D. J., Quinn, P. C., Slater, A. M., Lee, K., Gibson, A., Smith, M., . . . Pascalis, O. (2005). Three-month-olds, but not newborns, prefer own-race faces. *Developmental Science*, *8*, F31–F36. doi:10.1111/j.1467-7687.2005.0434a.x

Kinzler, K. D., Dupoux, E., & Spelke, E. S. (2007). The native language of social cognition. *Proceedings of the National Academy of Sciences of the United States of America*, *104*, 12577–12580. doi:10.1073/pnas.0705345104

Kinzler, K. D., Dupoux, E., & Spelke, E. S. (2012). "Native" objects and collaborators: Infants' object choices and acts of giving reflect favor for native over foreign speakers. *Journal of Cognition and Development*, *13*, 67–81. doi:10.1080/15248372.2011.567200

Kirschner, S., & Tomasello, M. (2009). Joint drumming: Social context facilitates synchronization in preschool children. *Journal of Experimental Child Psychology*, *102*, 299–314. doi:10.1016/j.jecp.2008.07.005

Knoblich, G., & Sebanz, N. (2008). Evolving intentions for social interaction: From entrainment to joint action. *Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences*, *363*, 2021–2031. doi:10.1098/rstb.2008.0006

Launay, J., Dean, R. T., & Bailes, F. (2012). Synchronization can influence trust following virtual interaction. *Experimental Psychology*, *60*, 53–63. doi:10.1027/1618-3169/a000173

Legerstee, N., & Markova, G. (2008). Variations in 10-month-old infant imitation of people and things. *Infant Behavior and Development*, *31*, 81–91. doi:10.1016/j.infbeh.2007.07.006

Miles, L. K., Griffiths, J. L., Richardson, M. J., & Macrae, C. N. (2010). Too late to coordinate: Contextual influences on behavioral synchrony. *European Journal of Social Psychology*, *40*, 52–60. doi:10.1002/ejsp

Miles, L. K., Nind, L. K., & Macrae, C. N. (2009). The rhythm of rapport: Interpersonal synchrony and social perception. *Journal of Experimental Social Psychology*, *45*, 585–589. doi:10.1016/j.jesp.2009.02.002

Nazzi, T., Jusczyk, P. W., & Johnson, E. K. (2000). Language discrimination by English-learning 5-month-olds: Effects of rhythm and familiarity. *Journal of Memory and Language*, *43*, 1–19. doi:10.1006/jmla.2000.2698

Over, H., & Carpenter, M. (2009). Eighteen-month-old infants show increased helping following priming with affiliation. *Psychological Science*, *20*, 1189–1193. doi:10.1111/j.1467-9280.2009.02419.x

Phillips-Silver, J., Aktipis, C. A., & Bryant, G. A. (2010). The ecology of entrainment: Foundations of coordinated rhythmic movement. *Music Perception: An Interdisciplinary Journal*, *28*, 3–14. doi:10.1525/mp.2010.28.1.3

Phillips-Silver, J., & Trainor, L. J. (2005). Feeling the beat: Movement influences infant rhythm perception. *Science*, *308*(5727), 1430. doi:10.1126/science.1110922

Provasi, J., & Bobin-Bègue, A. (2003). Spontaneous motor tempo and rhythmical synchronisation in 2½- and 4-year-old children. *International Journal of Behavioral Development*, *27*, 220–231. doi:10.1080/01650250244000290

Ramus, F. (2002). Language discrimination by newborns: Teasing apart phonotactic, rhythmic, and intonational cues. *Annual Review of Language Acquisition*, *2*, 1–14. doi:10.1075/arla.2.05ram

Reddish, P., Bulbulia, J., & Fischer, R. (2014). Does synchrony promote generalized prosociality? *Religion, Brain & Behavior*, *4*, 3–19. doi:10.1080/2153599X.2013.764545

Reddish, P., Fischer, R., & Bulbulia, J. (2013). Let's dance together: Synchrony, shared intentionality and cooperation. *PLoS ONE*, *8*, 1–13. doi:10.1371/journal.pone.0071182

Richardson, M. J., Marsh, K. L., Isenhower, R. W., Goodman, J. R. L., & Schmidt, R. C. (2007). Rocking together: Dynamics of intentional and unintentional interpersonal coordination. *Human Movement Science*, *26*, 867–891. doi:10.1016/j.humov.2007.07.002

Richardson, M. J., Marsh, K. L., & Schmidt, R. C. (2005). Effects of visual and verbal interaction on unintentional interpersonal coordination. *Journal of Experimental Psychology: Human Perception and Performance*, *31*, 62–79. doi:10.1037/0096-1523.31.1.62

Rochat, P. (1998). Self-perception and action in infancy. *Experimental Brain Research*, *123*, 102–109.

Schmidt, R. C., & O'Brien, B. (1997). Evaluating the dynamics of unintended interpersonal coordination. *Ecological Psychology*, *9*, 189–206. doi:10.1207/s15326969eco0903_2

Shultz, S., & Vouloumanos, A. (2010). Three-month-olds prefer speech to other naturally occurring signals. *Language Learning and Development*, *6*, 241–257. doi:10.1080/15475440903507830

Trehub, S. E., & Hannon, E. E. (2006). Infant music perception: Domain-general or domain-specific mechanisms? *Cognition*, *100*, 73–99. doi:10.1016/j.cognition.2005.11.006

Troseth, G. L. (2010). Is it life or is it Memorex? Video as a representation of reality. *Developmental Review*, *30*, 155–175. doi:10.1016/j.dr.2010.03.007

Valdesolo, P., & Desteno, D. (2011). Synchrony and the social tuning of compassion. *Emotion*, *11*, 262–266. doi:10.1037/a0021302

Valdesolo, P., Ouyang, J., & DeSteno, D. (2010). The rhythm of joint action: Synchrony promotes cooperative ability. *Journal of Experimental Social Psychology*, *46*, 693–695. doi:10.1016/j.jesp.2010.03.004

Vouloumanos, A., & Werker, J. F. (2004). Tuned to the signal: The privileged status of speech for young infants. *Developmental Science*, *7*, 270–276. doi:10.1111/j.1467-7687.2004.00345.x

Wiltermuth, S. S., & Heath, C. (2009). Synchrony and cooperation. *Psychological Science*, *20*, 1–5. doi:10.1111/j.1467-9280.2008.02253.x

Zentner, M., & Eerola, T. (2010). Rhythmic engagement with music in infancy. *Proceedings of the National Academy of Sciences of the United States of America*, *107*, 5768–5773. doi:10.1073/pnas.1000121107

Zinober, B., & Martlew, M. (1985). Developmental changes in four types of gesture in relation to acts and vocalizations from 10 to 21 months. *British Journal of Developmental Psychology*, *3*, 293–306. doi:10.1111/j.2044-835X.1985.tb00981.x

Zivotofsky, A. Z., & Hausdorff, J. M. (2007). The sensory feedback mechanisms enabling couples to walk synchronously: An initial investigation. *Journal of Neuroengineering and Rehabilitation*, *4*, 28. doi:10.1186/1743-0003-4-28

Supporting Information

Additional supporting information may be found in the online version of this article at the publisher's website:

Video S1. Sample Video of the Stimuli Used in the Experiments