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Social Effects of Movement Synchrony: Increased Infant Helpfulness only Transfers to Affiliates of Synchronously Moving Partners

Laura K. Cirelli, and Stephanie J. Wan
Department of Psychology, Neuroscience & Behaviour
McMaster University

Laurel J. Trainor
Department of Psychology, Neuroscience & Behaviour
McMaster University and
McMaster Institute for Music and the Mind, McMaster University and
Rotman Research Institute, Baycrest Hospital

Interpersonal synchrony increases cooperation among adults, children, and infants. We tested whether increased infant helpfulness transfers to individuals uninvolved in the movement, but shown to be affiliates of a synchronously moving partner. Initially, 14-month-old infants ($N = 48$) watched a live skit by Experimenters 1 and 2 that either demonstrated affiliation or individuality. Infants in both groups were then randomly assigned to be bounced to music either synchronously or asynchronously with Experimenter 1. Infant instrumental helpfulness toward Experimenter 2 was then measured. If the two experimenters were affiliates, infants from the synchronous movement condition were significantly more helpful toward Experimenter 2 than infants from the asynchronous movement condition. However, if the two experimenters were not affiliated, synchrony effects on prosociality did not transfer to Experimenter 2. These results show the importance of musical synchrony for social interaction and suggest that infants may use an understanding of third-party social relationships when directing their own social behaviors.

Musical engagement can be a profoundly social experience, enhancing feelings of solidarity among participants. Religious rituals often incorporate singing and dancing, and anthems conjure feelings of patriotism (Dissanayake, 2006; Feld, 1984). The social cohesion model of musical behavior suggests that music may be adaptive by increasing within-group cohesion (Brown, 2000). Because of our propensity to align our movements to underlying musical beats (Repp, 2005), moving together in time, known as

Correspondence should be sent to Laurel J. Trainor, Department of Psychology, Neuroscience & Behaviour, McMaster University, Hamilton, ON L8S 4K1, Canada. E-mail: LJT@mcmaster.ca

interpersonal synchrony, is often achieved in a musical context. Recent work on interpersonal synchrony suggests that individuals who move together are more likely to trust and cooperate with one another (Anshel & Kippler, 1988; Kokal, Engel, Kirschner, & Keysers, 2011; Launay, Dean, & Bailes, 2013; Reddish, Fischer, & Bulbulia, 2013; Wiltermuth & Heath, 2009), rate each other as more likeable (Hove & Risen, 2009), and remember more details about one another (Macrae, Duffy, Miles, & Lawrence, 2008; Valdesolo, Ouyang, & DeSteno, 2010; Woolhouse, Tidhar & Cross, 2016). Four-year-old children who sing and move together while playing a game also show increased cooperation and helpfulness toward each other (Kirschner & Tomasello, 2010).

In a previous study, we showed that interpersonal synchrony causes increased helpfulness even in 14-month-old infants, despite their lack of the motor control needed for movement entrainment (Cirelli, Einarson, & Trainor, 2014a). Specifically, after being bounced to music in a forward-facing carrier by an assistant for two-and-a-half minutes, infants who watched the experimenter bounce in-sync with them were afterward more likely to help that experimenter compared to infants who watched an experimenter bounce out-of-sync with them (either too fast or too slow). In a follow-up study, we investigated whether interpersonal synchrony made infants generally more helpful or whether helpfulness was targeted toward the specific person with whom they experienced the synchrony (Cirelli, Wan, & Trainor, 2014b). This study replicated the finding of increased infant helpfulness following an interpersonally synchronous bouncing experience, but increased helpfulness did not extend toward a neutral stranger who sat passively in the room during the bouncing experience reading a book. These results suggested that interpersonal synchrony acts as a cue to direct prosocial behavior toward a specific individual rather than as a prime for generalized prosocial behavior.

More recent work with 12-month-old infants has supported the idea that interpersonal synchrony guides social preferences (Tunçgenç, Cohen, & Fawcett, 2015). Infants in this study were more likely to reach for and select a teddy bear who had rocked in synchrony with them in a car seat compared to a teddy bear who had rocked out-of-synchrony with them. Such preferences were not found in a nonsocial control condition, with synchronously and asynchronously moving boxes that were nonagents. This study suggests that at least by 12 months of age, infants already have a desire to affiliate with a synchronously moving social partner.

These studies support the idea that affiliation is the motivation underlying prosocial behaviors. This idea is also supported by work showing that 18-month-olds primed by a photograph evoking affiliation are then more likely to display helping behaviors toward an adult stranger (Over & Carpenter, 2009a). Older children primed to think about ostracism are also more likely to display affiliative imitation toward an adult stranger (Over & Carpenter, 2009b). Together, these studies show that when group inclusion is a goal, we display affiliative behaviors and that prosocial acts such as helpfulness are a proxy for affiliation.

Prosocial behavior is also related to friendships. Children share more with friends than with strangers (Olson & Spelke, 2008), and expect *others* to share more with their friends than with strangers (Paulus & Moore, 2014). Our studies to date investigating infant helpfulness following interpersonal synchrony (Cirelli et al., 2014a,b) support the idea that infants may socially evaluate synchronously (or asynchronously) moving partners, and use these evaluations to direct their affiliative behaviors. It is possible that synchronous bouncing leads to increased attention and that infants use the familiarity that might arise from increased attention to assess whether a stranger is a potentially good social partner. We test this in the present study by including a measure of how much the infants looked at the experimenter in the synchronous compared to asynchronous conditions. Whether through attention or some other mechanism, our studies indicate that interpersonal synchrony is one condition that leads to increased affiliation.

Indeed, over the first two years after birth, infants are quickly developing the social and cognitive abilities required to select appropriate social partners. When choosing social partners, infants seem to readily use cues such as attractiveness (Langlois & Roggman, 1987), infant directed speech (Schachner & Hannon, 2011), and acts of prosociality (Dunfield & Kuhlmeier, 2010; Hamlin, Wynn, & Bloom, 2007; Hamlin & Wynn, 2012) to direct their social preferences. They also may use cues to in-group membership, such as race and spoken language, in a similar manner (Kelly et al., 2007; Kinzler, Dupoux, & Spelke, 2007; Pascalis et al., 2005). For example, when interacting with native compared to foreign language speakers, six-month-old infants look longer at native speakers (Kinzler et al., 2007), ten-month-olds are more likely to accept objects from them (Kinzler, Dupoux, & Spelke, 2012), and 14-month-olds are more likely to mimic them (Buttelmann, Zmyj, Daum, & Carpenter, 2013). Together, these results suggest that infants seem to use social cues to determine who is a part of their social group and who is not, shaping how they behave toward such individuals. Even if these social decisions are simply being driven by mechanisms like familiarity or preference rather than reflecting cognitive evaluations about who is part of an infant's group, the resulting behavior is still an adaptive response that encourages affiliation with in-group members.

By evaluating social interactions that they themselves are not part of, infants also begin to understand third-party coalition over the first two years after birth, and quickly develop the prerequisites for making assumptions about third-party group membership (for a review, see Platten, Hernik, Fonagy, & Fearon, 2010). By at least as young as 9 months of age, infants expect that two people who share food quality evaluations will later affiliate, but that two people with opposing evaluations will not (Liberman, Kinzler, & Woodward, 2014). Infants as young as 5 months of age even expect a neutral agent to approach an agent who previously helped them, but avoid an agent who previously hindered them (Hamlin et al., 2007). Hamlin et al.'s experiments (Hamlin et al., 2007; Hamlin & Wynn, 2012) also show that infants use information about these third-party relationships to direct their own social evaluations, choosing to affiliate with a "helper" over a "hinderer." These studies suggest that infants can use cues such as shared evaluation and valenced interaction to form assumptions about third-party coalitions and that these assessments influence their own evaluations of these individuals.

The current study extends these findings by exploring whether an infant assesses and integrates social cues about an individual *and* that individual's relationships when directing their social behavior. Namely, if an infant experiences interpersonal synchrony with one experimenter, will they direct prosociality toward a social affiliate of that person? Does interpersonal synchrony act as a cue to direct prosociality not only to an individual, but to that individual's group members as well? Based on principles of transitivity (Hallinan, 1974) and cascading benefits (Levine & Kurzban, 2006), if A chooses B as a friend and B chooses C, then A should choose C. This concept of transitivity within social networks is related to reciprocal altruism (Trivers, 1971), but adds to the idea that reciprocity in clustered social networks increases payoffs for each member (Levine & Kurzban, 2006). Even preschool children have been shown to achieve triadic closure (becoming friends with their friend's friend) in their preschool classes (Schaefer, Light, Fabes, Hanish, & Martin, 2010). Therefore, we predicted that after synchronous (but not asynchronous) bouncing to music with an experimenter, infants would display greater helpfulness toward a second nonbouncing experimenter only if that experimenter demonstrated an affiliation with the first experimenter. If interpersonal synchrony driven by musical engagement is a social cue that encourages not only dyadic prosociality, but also extends to third-party affiliates, this would suggest that musical behavior can act as a social cue in complex social settings.

We also measured the amount of direct eye contact that each infant made with the experimenter during the bouncing experience, to test the person-perception hypothesis of interpersonal synchrony (Macrae et al., 2008). This hypothesis suggests that individuals who move together pay more attention to one another during the movement experience. Work with adults has supported this hypothesis by showing that increased attention toward synchronously moving individuals enhances social memory (Macrae et al., 2008; Woolhouse, Tidhar, & Cross 2016). We therefore hypothesized that infants in the synchronous movement conditions would make more direct eye contact with the experimenter than infants in the asynchronous movement conditions. Infant temperament was also measured using the parent-report Infant Behavior Questionnaire (IBQ) (Rothbart, 1981), so that personality correlates could be accounted for in our analyses.

METHODS

Participants

The 48 14-month-old infants (24 girls; *M* age = 14.7 months; *SD* = 0.3 months) who completed the experiment were recruited from the Developmental Studies Database at McMaster University. This sample size was determined before data collection began based on counterbalancing order and power in previous experiments using similar methods. The infants were from homes where English was spoken over 50% of the time. Only infants capable of walking without assistance were recruited, due to the requirement of mobility in the instrumental helping tasks used. The age of 14 months was selected as this is the youngest age at which instrumental helping tasks can be used to reliably measure prosociality (Warneken & Tomasello, 2006, 2007). Participants lived in Hamilton, Ontario, or surrounding neighborhoods and were therefore of mixed ethnicities. An additional 9 infants participated, but were excluded due to excessive fussiness. All experimental procedures were approved by the McMaster University Research Ethics board (MREB), and informed consent was obtained from all parents.

Procedure

The experiment consisted of three phases: (1) the experimenter affiliation familiarization phase, (2) the interpersonal movement phase, and (3) the prosocial test phase. Three researchers were involved: (1) the assistant, who held and gently bounced the infant in time to music in a forward-facing infant carrier during phase 2; (2) Experimenter 1, who performed in phase 1 and then bounced facing the infant during phase

2, but was not involved in phase 3; (3) Experimenter 2 who also performed in phase 1, was not involved in phase 2 (and therefore blind as to whether the infant participated in synchronous or asynchronous movement with Experimenter 1), and later performed instrumental helping tasks in phase 3 (see Table 1). The roles played by the two experimenters were counterbalanced across conditions. The procedures of the interpersonal movement phase and prosocial test phase were based on those used by Cirelli et al. (2014a,b). Sex of the participants was also balanced across conditions.

Familiarization phase

Before the first phase began, the assistant interacted with the infant, while Experimenter 1 obtained parental consent. The assistant then exposed the infant to the objects that were later used during the prosocial test phase (i.e., paper ball, clothespin, and marker). The parent completed a demographics questionnaire as well as three scales (activity, approach, and smiling) from the IBQ (Rothbart, 1981). At this time, Experimenter 2 waited alone in the sound-attenuating chamber.

Everyone then joined Experimenter 2 in the sound-attenuating chamber. The parent sat on a chair in the corner with the infant on his or her lap. The assistant sat beside the parent. Experimenters 1 and 2 performed one of two dramatic skits, depending on the experimenter relationship condition to which the infant was randomly assigned. For infants assigned to the "experimenter affiliation" condition, the skit demonstrated that the two experimenters were part of the same social group (see Appendix S1). They engaged in a friendly dialogue, displayed similar gestures, and independently solved a similar problem (i.e., finding lost hats). For infants assigned to the "experimenter individuality" condition, the skit demonstrated that the two experimenters were independent from one other (see Appendix S1). Instead of participating in a friendly dialogue, Experimenter 1 performed a short monologue, and then Experimenter 2 performed a short monologue, but they did not interact together. The monologues were written to match the emotional content, approximate length, and general plot development of the "positive experimenter affiliation" skit.

Interpersonal movement phase

In this next phase, the parent helped place the infant in the forward-facing carrier worn by the assistant, and then sat on a chair behind the pair, out of the infant's line of sight. Experimenter 2 left the sound booth, thereby remaining blind to the movement condition, and Experimenter 1 stood facing the infant, roughly 4.5 feet away. Experimenter 1 held a button box and pressed a button to trigger the interpersonal movement phase via Presentation software running on a Windows XP computer. This

TABLE 1
Roles of Each Experimenter in the Three Phases of the Experiment

Experimenter	*Familiarization phase*	*Interpersonal movement phase*	*Prosocial test phase*
Assistant	Sits with parent	Holds and bounces baby	Leaves the room
E1	Performs skit	Faces baby and bounces	Leaves the room
E2	Performs skit	Leaves the room	Performs the three helping tasks

program presented the 140-sec Musical Instrument Digital Interface (MIDI) version of the Beatles' *Twist and Shout* at 100 beats per minute (BPM) through a Denon amplifier (PMA-480R) connected to an audiological loudspeaker (GSI) 6.5 feet away from the right side of the infant (same stimulus as in Cirelli et al., 2014b). The assistant gently bounced the infant to the beat of this song, bending at the knees so that the lowest part of her trajectory aligned with every second downbeat. Experimenter 1 wore Denon AH-D501 headphones and listened to a bounce instruction track that contained woodblock sounds overlaid on pink noise, and bounced so that the lowest part of her trajectory aligned with these woodblock sounds. In the synchronous condition, this bounce instruction track played at 100 BPM, to ensure that her movements were tempo and phase aligned to the movements of the assistant (and therefore the infant). In the asynchronous condition, this bounce instruction track played at 140 BPM, so that she bounced faster than the assistant and infant and was therefore temporally incongruent with the movement of the infant. It should be noted that the asynchronous condition therefore contained both tempo and phase misalignments between the movement of the infant and the experimenter, as is typically done in adult studies on the effects of synchronous movement (for example, see Hove & Risen, 2009; Valdesolo & Desteno, 2011; Wiltermuth & Heath, 2009). This point is addressed further in the Discussion. In our previous experiment (Cirelli et al., 2014a), in the asynchronous conditions, we used bouncing on the part of the experimenter that was either faster or slower than that of the infant, but found no difference between these two manipulations. Therefore, in the present study, we used only faster bouncing on the part of the experimenter in the asynchronous condition.

During this phase, Experimenter 1 recorded in real time when the infant made direct eye contact with her. Because this was coded live, no reliability measures can be reported here. She did this by pressing a button on a small hand-held box that recorded looking times through Presentation software running on a Windows XP computer so that looking times could be compared between synchronous and asynchronous conditions. The assistant and Experimenter 1 wore Nintendo Wii remotes at their waists to record their vertical motion over time using WiiDataCapture_v2.1 (© University of Jyväskylä, Burger & Toiviainen, 2013). Due to equipment malfunction, these data were not recorded for 16 of the 48 participants. Data were successfully recorded for 14 infants in the synchrony condition and 18 infants in the asynchrony condition. Following the methods of Cirelli et al. (2014a,b), these data were used to verify that the vertical accelerations of the assistant and Experimenter 1 were significantly more correlated in the interpersonal synchrony conditions (mean Pearson's $r = .62$, SEM = 0.06) compared to the interpersonal asynchrony conditions (mean Pearson's $r = .03$, SEM = 0.01).

Prosocial test phase

Before beginning the prosocial test phase, the infant was taken out of the carrier, and the assistant and Experimenter 1 left the sound-attenuating chamber. Experimenter 2, who was blind to the movement condition, returned to the booth to perform the instrumental helping tasks. The order of the three tasks (the paper ball, marker, and clothespin tasks) was counterbalanced across participants. These measures of infant instrumental helping were based on those developed by Warneken and Tomasello (2006, 2007) and were used in the previous experiments on infant social behavior following interpersonal synchrony (Cirelli et al., 2014a,b). There were three trials per task during which the experimenter dropped an object that she needed in order to complete her goal.

These 30-sec long trials were broken down into three parts. During the first 10 sec of the trial, the experimenter reached for the dropped object, focusing her gaze on the item. For the next 10 sec, the experimenter still reached for the object but now alternated her gaze between infant and object. During the final 10 sec, the experimenter explicitly mentioned the name of the desired item (e.g., "my marker!"). The trials ended when the infant handed back the desired object or once 30 sec had elapsed.

Clothespin task. Experimenter 2 attracted the attention of the infant, showed the infant a dishcloth, and then clipped the dishcloth to a clothesline using one clothespin. When she attempted to clip up the second corner, she pretended to accidently drop the clothespin. She reached for the clothespin for 30 sec, using the procedure outlined above. At the end of the trial, the experimenter successfully pinned the retrieved clothespin or a new clothespin onto the dishcloth before proceeding to the next trial/task.

Paper ball task. Experimenter 2 attracted the attention of the infant and then successfully tossed a paper ball into a bucket on a 3-foot table in front of her. On her next toss, she initiated the first trial by overshooting, so that the second ball landed in front of the table, out of her reach. After the trial, the experimenter successfully tossed in the retrieved paper ball or a new paper ball before proceeding to the next trial/task.

Marker task. Experimenter 2 attracted the attention of the infant and then began to draw a picture of a flower using one marker, on the table in front of her. She showed the infant her picture as she continued. While drawing, she initiated the first trial by knocking down another marker that was resting on the table. After the trial, the experimenter either used the retrieved marker or a new one to continue drawing her picture before proceeding to the next trial/task.

Video coding

Video footage, recorded on a mounted Canon PowerShot SD1000, and a Samsung 65× Intelli-zoom or a GoPro HERO3+, was used to later calculate overall helping rates for each infant. There were two raters: the primary rater (author LC), blind to the infant's interpersonal movement condition when coding, and a secondary rater, blind to all hypotheses and conditions. Each rater coded all videos by recording how many of the objects each infant handed back (of a maximum of three objects per task) and when in the trial these objects were handed back. If the infant handed back the object within the 30-sec window, they were awarded a full point. If they handed back the object *after* the 30-sec window elapsed, they were awarded half a point. Each infant's overall helping rate was calculated as (score[task 1] + score[task 2] + score[task 3]) / (3 tasks × 3 trials) × 100%. In addition to overall helping rates, spontaneous helping rates were calculated as total helping during the first 10 sec of each trial, and delayed helping as helping 11 sec or later into each trial. Inter-rater reliability was extremely high, $r = .994$, $p < .001$. The ratings by the primary rater were used in the analyses.

RESULTS

One male infant in the asynchronous/positive-affiliation condition was excluded from the analysis based on a predetermined z-score outlier cutoff of $Z = \pm 2$ for helpfulness rating[1]. No significant correlations were found between infant overall helpfulness or early or late helpfulness and parent-rated IBQ scores on smiling, activity, or approachability (all p's > .250).

Overall helping

The Pearson correlations between helpfulness on each pair of helping tasks were high (clothespin to paper ball, $r = .77$, $p < .001$; clothespin to marker, $r = .75$, $p < .001$; paper ball to marker, $r = .70$, $p < .001$). A mixed-design ANOVA was used to assess the effect of task order on helpfulness and to ensure that task order did not interact with movement condition or experimenter relationship condition. There was an effect of task order, in that children were significantly more helpful on the second and third tasks than on the first, $F_{(2,64.9)} = 4.16$, $p = .030$. However, there was no significant interaction between task order and either movement condition, $F_{(2,64.9)} = 0.24$, $p = .725$, or experimenter relationship, $F_{(2,64.9)} = 0.06$, $p = .901$, so tasks were collapsed to assess overall helpfulness.

An ANOVA with interpersonal movement condition (synchronous versus asynchronous) and experimenter relationship (affiliate versus individual) as between-subjects factors was used to investigate the effect of these variables on overall infant helpfulness. Consistent with our hypothesis, there was a significant interaction between interpersonal movement and experimenter relationship, $F_{(1,43)} = 5.07$, $p = .029$, $n_p^2 = 0.11$ (Figure 1). There was no main effect of experimenter relationship, $F_{(1,43)} = 0.71$, $p = .404$, suggesting that the skits themselves did not affect overall amount of helping, but rather that the two skits differentially affected the amount of helping after synchronous versus asynchronous bouncing. The main effect of interpersonal movement did not reach significance.

Post hoc independent-samples t-tests were used to further investigate the interaction by assessing the effect of interpersonal movement on helping in each of the experimenter relationship conditions separately. In the "experimenter affiliation" condition, infants from the synchronous movement condition were significantly more likely than infants in the asynchronous movement condition to display helpfulness toward Experimenter 2, $t_{(21)} = 3.12$, $p = .005$ (Figure 1). Infants from the synchrony condition helped 44.94% more than infants from the asynchrony condition, difference score 95% CI [14.94%, 74.94%]. In the "experimenter individuality" condition, on the other hand, there was no significant difference in the helping rates of infants in the synchronous or asynchronous movement conditions, $t_{(22)} = 0.18$, $p = .857$.

To illustrate the consistency of the effect across individual participants, the number of infants in each of the four conditions who helped on more than 50% of the tasks is reported next. When assessing infant helpfulness directed toward the experimenter

[1]Removing this participant from the dataset reduces variability in the sample, but it does not change the statistical trends. If this infant is kept in the sample, the interaction between movement condition and experimenter affiliation trends toward significance for overall helping ($F_{(1,44)} = 3.71$, $p = .06$) and reaches significance for spontaneous helping ($F_{(1,44)} = 4.98$, $p = .031$). Post hoc tests of these interactions also show the same significant effects as when this participant is removed.

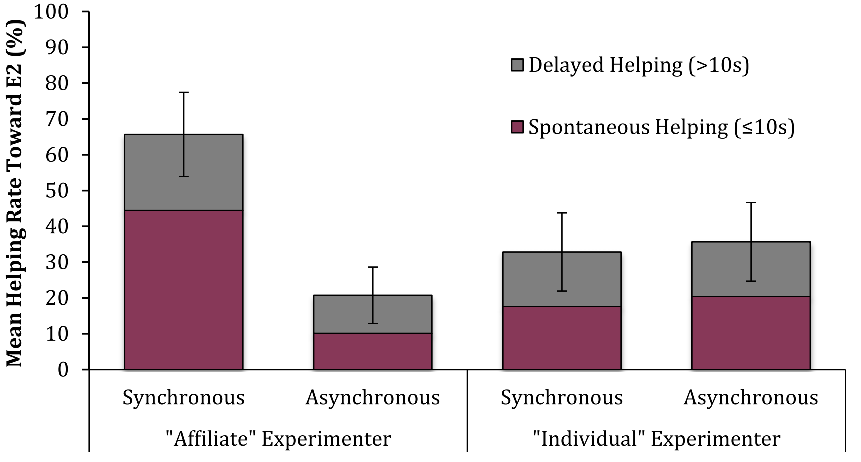

Figure 1 Overall mean infant helpfulness (mean % of trials on which infants helped) toward Experimenter 2 from the four between-subjects conditions. Spontaneous helping (helping within the first 10 sec of the trial) and delayed helping (helping later than 10 sec into the trial) are both shown. When Experimenters 1 and 2 were affiliates, infants who had previously moved synchronously with Experimenter 1 were significantly more helpful when interacting with Experimenter 2 than infants who had previously moved asynchronously with Experimenter 1. However, when Experimenters 1 and 2 behaved individually, there was no difference in helpfulness toward Experimenter 2 as a function of the movement condition with Experimenter 1. These effects are especially apparent with spontaneous helping. Error bars represent standard error of the mean for overall mean infant helpfulness.

affiliate, 75% of infants in the synchrony condition and only 18% of infants in the asynchrony condition helped on more than half of the trials, $\chi^2(1, N = 23) = 7.46$, $p = .01$. In terms of helpfulness directed toward the experimenter demonstrating individuality, 33% of infants in the synchronous condition and 33% in the asynchronous condition helped on more than half of the trials, $\chi^2(1, N = 24) = 0$, $p = 1.0$.

Spontaneous and delayed helping

Similar ANOVAs were used to analyze spontaneous (within the first 10 s) and delayed (after the first 10 s) helping. There was a significant interaction between movement condition and experimenter relationship for spontaneous helping, $F_{(1,43)} = 5.78$, $p = .021$, $n_p^2 = 0.12$. As with overall helping, in the "experimenter affiliation" condition, infants from the synchronous movement condition were significantly more likely than infants in the asynchronous movement condition to display spontaneous helpfulness toward Experimenter 2, $t_{(13.9)} = 2.90$ $p = .012$. Infants from the synchrony condition helped 34.34% more than infants from the asynchrony condition within the first 10 sec of the trials, difference score 95% CI [8.83%, 59.86%]. In the "experimenter individuality" condition, there was no significant difference in the spontaneous helping rates of infants in the synchronous or asynchronous movement conditions, $t_{(22)} = -0.29$, $p = .773$.

For delayed helping, no significant main effects or interactions involving of movement condition or experimenter relationship were found. This suggests that infants not only helped the affiliate of the bouncing experimenter more following synchronous versus asynchronous movement, but that helping early in trials was especially strong.

Looking times

An independent-samples *t*-test revealed that there was no significant difference between total infant eye contact time with Experimenter 1 in the synchronous versus asynchronous bounce conditions, $t_{(45)} = -1.36$, $p = .182$. The average duration of each period of eye contact with the experimenter was calculated by measuring total time each infant spent looking at the experimenter divided by the total number of glances. This measure also did not differ as a function of interpersonal movement condition, $t_{(45)} = 0.88$, $p = .383$. Additionally, correlations between total eye contact and total helpfulness ($r = -.06$, $p = .671$), or average eye contact duration and total helpfulness ($r = .13$, $p = .375$), did not reach significance, suggesting that infants who made more direct eye contact with the experimenter during the interpersonal movement phase did not subsequently help the second experimenter more during the prosocial test phase. ANOVAS with both interpersonal movement condition and experimenter relationship as between-subject conditions also did not reveal any significant main effects or interactions on either total eye contact or gaze length (all p's $> .26$).

DISCUSSION

The results demonstrated that 14-month-old infants who were bounced to music in synchrony with an adult experimenter were later more likely to display helpfulness (especially spontaneous helpfulness) toward a second experimenter who was shown to be affiliated with the first experimenter. On the other hand, if the two experimenters displayed individuality, synchronous compared to asynchronous bouncing with one experimenter had no effect on helpfulness toward the second experimenter. It is important to note that watching the two experimenters display affiliation or individuality had no overall effect on infants' helpfulness (i.e., no main effect of the initial skit). Infants only showed increased helpfulness to the second experimenter if the two experimenters had been shown to be "friends" *and* they were bounced in synchrony with the first experimenter.

Our previous studies showed that infants bounced in synchrony with an experimenter are subsequently more likely to help that experimenter compared to infants bounced out of synchrony with that experimenter (Cirelli et al., 2014a,b). Furthermore, we showed that such behaviors are targeted at bouncing partners in that synchronous bouncing with one experimenter did not lead to increased helpfulness toward a neutral experimenter with whom the infant had not previously experienced synchronous movement (Cirelli et al., 2014b). The present experiment further elucidates the effects of synchronous movement on the development of social relationships by showing that increased helpfulness after synchronous bouncing does extend to affiliates of the bouncing partner but not to people showing no specific affiliation to that person. It is also important to note that this is the first study in which the effect of synchrony on infant social behavior has been measured using a methodology in which the experimenter performing the helping tasks is completely blind to the movement condition.

The effect of synchronous movement on affiliate-directed infant helping was especially driven by increased *spontaneous* helping, paralleling the pattern of results found in previous studies measuring bounce-partner-directed helping (Cirelli et al., 2014a).

The experimental protocol dictates that during the first 10 s of the trial, the experimenter does not directly involve the infant in the problem and only looks at and reaches for the out-of-reach object. After this first 10 sec, the experimenter makes eye contact with the infant and eventually vocalizes about their specific need. In that regard, spontaneous helping (i.e., helping during the first 10 sec) may represent a form of prosocial behavior closer to altruistic behavior, whereas delayed helping may involve compliance. Spontaneous helping may also reflect that the infant feels more involved with and attentive toward the experimenter's actions. In a study by Carpenter, Uebel, and Tomasello (2013), spontaneous helping was also specifically increased in 18-month-olds who were mimicked by an experimenter, suggesting that early helping is encouraged when infants feel a connection with the recipient. The targeted effect of interpersonal synchrony on spontaneous helping may support the idea that musical engagement (which encourages interpersonal synchrony) fosters joint intentionality between actors (Kirschner & Tomasello, 2010).

In our first study (Cirelli et al., 2014a), parent ratings from the IBQ of infant willingness to approach novelty correlated with infant helping rates. In our second study (Cirelli et al., 2014b), ratings of approach and smiling correlated with helpfulness directed toward the neutral stranger, but not toward the bouncing experimenter. We hypothesized that while infant temperament may predict helpfulness toward a neutral individual, such individual differences may be overridden by an informative interaction (such as synchronous bouncing) between a stranger and the infant. The lack of correlation between IBQ measures and helpfulness in any of the conditions in the present experiment was surprising. However, the present experiment differed from our previous experiments in that the initial skit acted like an initial familiarization phase. Perhaps this increased the familiarity of the experimenters for the infant, so that factors, such as their subsequent interpersonal movement experience, became stronger determinants of infant helpfulness compared to infants' general temperament and general willingness to approach novelty as measured by the IBQ.

Interestingly, the infants in the synchronous bouncing condition did not initiate and hold direct eye contact with the bouncer significantly more than the infants in the asynchronous condition, which would have provided support to the person-perception hypothesis. This null result may indicate that prosocial behavior following synchrony is not being driven by increased eye contact, but instead by unrelated factors such as increased perception of self-similarity, feelings of empathy, or an understanding of joint action (Kirschner & Tomasello, 2010; Valdesolo & Desteno, 2011). On the other hand, this finding may also reflect methodological limitations. Looking time is an indirect measure of attention, and so infants may increase their attention to a synchronously bouncing partner without necessarily increasing direct eye contact. We measured only direct eye contact, but it is possible that there were differences across conditions in general looking toward the experimenter. Additionally, while it is well noted that 14-month-old infants can follow gaze direction, few studies indicate that infants of this age maintain direct eye contact for prolonged period of time (Corkum & Moore, 1998; Moll & Tomasello, 2004). It should also be noted that the experimenter coding eye contact live could not be blind to the bouncing condition. As such, the hypotheses driven by the person-perception hypothesis should continue to be explored in future studies with both children and adults.

Another question of interest is the importance of the music itself for increasing prosociality. Although music, with its predictable beat, is an ideal stimulus to synchronize movements between people, it is possible that synchronous movement without music might have led to similar effects. Music does, however, have emotion regulation effects on infants (Corbeil, Trehub, & Peretz, 2015) and might still contribute positively to the infants' experience during the interpersonal movement phase. It is also not clear how the mechanisms driving prosociality following experimentally manipulated interpersonal synchrony are related to mechanisms at play during coordinated, responsive, and sensitive mother–infant interactions (mother–infant synchrony), known to foster positive social outcomes (see Reyna & Pickler, 2009 for a review). It is also unknown how experiences with interpersonal synchrony might extend to influencing social cognitive outcomes in children. Thus, questions about the underlying mechanisms driving the social effects of interpersonal synchrony remain for future studies.

It should be noted that asynchrony here was defined as a tempo difference between the infant and experimenter, which is typical in studies on social effects of interpersonal synchrony. One question is whether movement at the same tempo is the crucial variable for increasing prosocial behavior or whether movement phase is important as well. In other words, if movements between participants were phase-shifted but at the same tempo (i.e., contingent) would similar social effects emerge? In such a context, movements are at the same tempo, but do not occur at exactly the same time. One example of this is antiphase bouncing, where one person is at the lowest point of his or her trajectory when the other is at his or her highest point, and vice versa. Indeed, we investigated the effect of antiphase bouncing on infant helpfulness in a previous study and found that compared to tempo-shifted asynchrony, antiphase bouncing led to similar increases in helping behavior as in-phase bouncing (Cirelli et al., 2014a). Thus, it appears that tempo-matched (i.e., contingent) movement may be the most important determinant of social effects of movement. Still, future studies with adults using more sensitive measures of prosociality than is possible in infant studies could directly investigate whether and how phase-shifted asynchrony influences social behavior.

The results of the present investigation may have important implications with respect to 14-month-olds' understanding of third-party relationships. Previous work has shown that infants can direct their prosociality toward "good" social partners (Cirelli et al., 2014a,b; Dunfield & Kuhlmeier, 2010; Hamlin et al., 2007; Hamlin & Wynn, 2012) and that they appear to form social expectations about third-party affiliation by at least as young as 9 months of age (Liberman et al., 2014). The present paper is the first to suggest that infants might transfer cued prosociality to the positive affiliate of a "good" social partner. Understanding which individuals in their social environment have coalitions is an important skill to develop (Platten et al., 2010), and these findings suggest that by 14 months of age, infants may be using these skills to direct their own affiliative behaviors.

This interpretation of the social decisions being made by the infants rests on the skit manipulation. As tools implemented to study the generalizability of interpersonal synchrony's social effects, the skits that were used in this study were designed to contrast many cues to affiliation between the experimenter relationship conditions. The two skits were matched in general valence, plot, and length. However, future programs of research should investigate which specific components of these skits led to the effects found in this study. Importantly, because there was no overall main effect of experimenter relationship condition on infant helpfulness when collapsed across interpersonal movement conditions, the affiliation skit did not simply prime infants to display helpfulness indiscriminately. The affiliation skit *only* promoted increased helpfulness when it was followed by a synchronous movement experience with one of the experimenters. So infants were not simply put in a "prosocial mood" after watching the affiliation skit, which contains cooperative, synchronous, and potentially more interesting events. In that case, all infants watching the affiliation skit, regardless of movement condition, should have been more helpful than those watching the individuality skit. Rather, the interaction between movement condition and experimenter relationship suggests that infant helpfulness was determined by a combination of third-party information gained through the skit and the first-person experience of interpersonal synchrony.

In conclusion, previous studies demonstrated that infants are more likely to help an adult who previously moved in synchrony with them compared to an adult who previously moved out of synchrony with them (Cirelli et al., 2014a,b), suggesting that synchronous movement helps to form positive social relationships as young as 14 months of age. In the present study, we found that infants help an affiliate of a synchronously moving partner more than an affiliate of an asynchronously moving partner, but that interpersonal movement does not influence behavior toward adults showing individuality. The social effect of interpersonal synchrony only transfers to someone not involved in the movement experience if that person has behaved as an affiliate of the bouncing partner. This suggests that the positive social relationship established through synchronous movement between an infant and adult partner extends to the social group of that partner, but not to all adults in general. This study is the first to suggest that infants may transfer affiliative behaviors to "friends" of a cued social partner, suggesting that transitivity within social networks may be present in early social behavior. Overall, our findings support that interpersonal synchrony, a key component of musical behavior, is a profoundly social experience that fosters interpersonal cohesion at both the individual and group levels, and does so early in development.

REFERENCES

Anshel, A., & Kippler, D. (1988). The influence of group singing on trust and cooperation. *Journal of Music Therapy*, *25*, 145–155.

Brown, S. (2000). Evolutionary models of music: From sexual selection to group selection. In Francois. Tonneau, & Nicholas S. Thompson (Eds.), *Perspectives in ethology, volume 14: Evolution, culture and behaviour* (pp. 231–281). New York: Kluwer Academic/Plenum Publishers.

Burger, B., & Toiviainen, P. (2013) Mocap toolbox—a Matlab toolbox for computational analysis of movement data. In Roberto. Bresin (Ed.), *Proc. 10th sound and music computing conference* (pp. 172–178). Stockholm, Sweden: KTH Royal Institute of Technology.

Buttelmann, D., Zmyj, N., Daum, M., & Carpenter, M. (2013). Selective imitation of in-group over out-group members in 14-month-old infants. *Child Development*, *84*, 422–428.

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

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

Cirelli, L. K., Wan, S. J., & Trainor, L. J. (2014b). Fourteen-month-old infants use interpersonal synchrony as a cue to direct helpfulness. *Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences*, *369*, 20130400.

Corbeil, M., Trehub, S. E., & Peretz, I. (2015). Singing delays the onset of infant distress. *Infancy*. doi:10.1111/infa.12114.
Corkum, V., & Moore, C. (1998). The origins of joint visual attention in infants. *Developmental Psychology*, *34*, 28–38.
Dissanayake, E. (2006). Ritual and ritualization: Musical means of conveying and shaping emotion in humans and other animals. In S. Brown, & U. Voglsten (Eds.), *Music and manipulation: On the social uses and social control of music* (pp. 31–56). Oxford and New York: Berghahn Books.
Dunfield, K. A., & Kuhlmeier, V. A. (2010). Helping in infancy. *Psychological Science*, *21*, 523–527.
Feld, S. (1984). Communication, music, and speech about music. In Yearbook for Traditional Music, Vol. 17 (pp. 1–18).
Hallinan, M. T. (1974). A structural model of sentiment relations. *American Journal of Sociology*, *80*, 364–378.
Hamlin, J. K., & Wynn, K. (2012). Young infants prefer prosocial to antisocial others. *Cognitive Development*, *26*, 30–39.
Hamlin, J. K., Wynn, K., & Bloom, P. (2007). Social evaluation by preverbal infants. *Nature*, *450*, 557–559.
Hove, M. J., & Risen, J. L. (2009). It's all in the timing : Interpersonal synchrony increases affiliation. *Social Cognition*, *27*, 949–960.
Kelly, D. J., Liu, S., Ge, L., Quinn, P. C., Slater, A. M., Lee, K., … Pascalis, O. (2007). Cross-race preferences for same-race faces extend beyond the African versus Caucasian contrast in 3-month-old infants. *Infancy*, *11*, 87–95.
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.
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.
Kirschner, S., & Tomasello, M. (2010). Joint music making promotes prosocial behavior in 4-year-old children. *Evolution and Human Behavior*, *31*, 354–364.
Kokal, I., Engel, A., Kirschner, S., & Keysers, C. (2011). Synchronized drumming enhances activity in the caudate and facilitates prosocial commitment–if the rhythm comes easily. *PLoS ONE*, *6*, e27272.
Langlois, J., & Roggman, L. (1987). Infant preferences for attractive faces: Rudiments of a stereotype? *Developmental Psychology*, *23*, 363–369.
Launay, J., Dean, R. T., & Bailes, F. (2013). Synchronization can influence trust following virtual interaction. *Experimental Psychology*, *60*, 53–63.
Levine, S. S., & Kurzban, R. (2006). Explaining clustering in social networks: Towards an evolutionary theory of cascading benefits. *Managerial and Decision Economics*, *27*, 173–187.
Liberman, Z., Kinzler, K. D., & Woodward, A. L. (2014). Friends or foes: Infants use shared evaluations to infer others' social relationships. *Journal of Experimental Psychology. General*, *143*, 966–971.
Macrae, C. N., Duffy, O. K., Miles, L. K., & Lawrence, J. (2008). A case of hand waving: Action synchrony and person perception. *Cognition*, *109*, 152–156.
Moll, H., & Tomasello, M. (2004). 12- and 18-Month-old infants follow gaze to spaces behind barriers. *Developmental Science*, *7*, F1–F9.
Olson, K. R., & Spelke, E. S. (2008). Foundations of cooperation in young children. *Cognition*, *108*, 222–231.
Over, H., & Carpenter, M. (2009a). Eighteen-month-old infants show increased helping following priming with affiliation. *Psychological Science*, *20*, 1189–1193.
Over, H., & Carpenter, M. (2009b). Priming third-party ostracism increases affiliative imitation in children. *Developmental Science*, *12*, F1–F8.
Pascalis, O., Scott, L. S., Kelly, D. J., Shannon, R. W., Nicholson, E., Coleman, M., & Nelson, C. A. (2005). Plasticity of face processing in infancy. *Proceedings of the National Academy of Sciences of the United States of America*, *102*, 5297–5300.
Paulus, M., & Moore, C. (2014). The development of sharing behavior and expectations about other people's sharing in preschool children. *Developmental Psychology*, *50*, 914–921.
Platten, L., Hernik, M., Fonagy, P., & Fearon, R. (2010). Knowing who likes who : The early developmental basis of coalition understanding. *European Journal of Social Psychology*, *40*, 569–580.
Reddish, P., Fischer, R., & Bulbulia, J. (2013). Let's dance together: Synchrony, shared intentionality and cooperation. *PLoS ONE*, *8*, e71182.

Repp, B. (2005). Sensorimotor synchronization: A review of the tapping literature. *Psychonomic bulletin & review*, *12*(6), 969–992.

Reyna, B. A., & Pickler, R. H. (2009). Mother-infant synchrony. *Journal of Obstetric, Gynecologic, and Neonatal Nursing*, *38*, 470–477.

Rothbart, M. K. (1981). Measurement of temperament in infancy. *Child Development*, *52*, 569–578.

Schachner, A., & Hannon, E. E. (2011). Infant-directed speech drives social preferences in 5-month-old infants. *Developmental Psychology*, *47*, 19–25.

Schaefer, D. R., Light, J. M., Fabes, R. A., Hanish, L. D., & Martin, C. L. (2010). Fundamental principles of network formation among preschool children. *Social Networks*, *32*, 61–71.

Trivers, R. L. (1971). The evolution of reciprocal altruism. *Quarterly Review of Biology*, *46*, 35–57.

Tunçgenç, B., Cohen, E., & Fawcett, C. (2015). Rock with me: The role of movement synchrony in infants' social and nonsocial choices. *Child Development*, *86*, 976–984.

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

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

Warneken, F., & Tomasello, M. (2006). Altruistic helping in human infants and young chimpanzees. *Science (New York, N.Y.)*, *311*, 1301–1303.

Warneken, F., & Tomasello, M. (2007). Helping and cooperation at 14 months of age. *Infancy*, *11*, 271–294.

Wiltermuth, S. S., & Heath, C. (2009). Synchrony and cooperation. *Psychological Science*, *20*, 1–5.

Woolhouse, M. Tidhar, D., & Cross, I. (2016). Effects on interpersonal memory of dancing in time with others. *Frontiers in Psychology*, *7*, 167.

SUPPORTING INFORMATION

Additional supporting information may be found in the online version of this article:

Appendix S1. Experimenter Affiliation Skits.