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Interpersonal Movement Synchrony Facilitates Pro-social Behavior in Children's Peer-Play

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Manuscript accepted for publication by *Developmental Science*

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This research was supported by a British Academy Fellowship awarded to E.C. We thank Brendan Fong and Bruce Mortimer for their help with the preparation of materials and all the schools, parents and children for taking part.

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Research Highlights

- Four- to 6-year-old children help each other more after performing rhythmic movements synchronously compared to non-synchronously in a peer-play context
- Children who move in synchrony smile together more and engage in more eye contact
- Movement synchrony can potentially be used to facilitate pro-sociality among peers in clinical and educational settings

Abstract

The emergence of pro-social behaviors and social interaction skills is a major focus of research on children's development. Here, we consider one important feature of human social interactions, interpersonal movement synchrony, and explore its effects on pro-sociality among young children. Coordinated movements are a crucial part of mother-infant interactions, with important social effects extending well into childhood. Musical interactions are also known to facilitate bonding between infants and caretakers and pro-sociality among peers. We specifically examine the pro-social effects of interpersonal movement synchrony in a naturalistic peer-play context among 4- to 6-year-old children. We assessed the amount of helping behavior between pairs of children following an activity that they performed synchronously or non-synchronously. Children who engaged in synchronous play, as compared with non-synchronous play, showed significantly more subsequent spontaneous helping behavior. Further, more mutual smiling and eye contact were observed in the synchronous condition and amounts of mutual smiling and eye contact during the movement task correlated with amount of helping behavior observed. Neither measure mediated the condition-wise effects on helping, however. These results are discussed in terms of their contribution to existing literature and their broader implications for the development of pro-sociality and coordinated movements in early childhood.

Keywords: movement synchrony, peer play, social bonding, helping behavior, pro-sociality, social interactions

Interpersonal Movement Synchrony Facilitates Pro-Social Behavior in Children's Peer-Play

Human sociality is manifest from early in ontogeny. The social bonds that infants and young children form with their caretakers and peers are characterized by feelings of emotional closeness and connectedness and they enable reciprocal cooperative relationships (Eisenberg, Fabes & Spinrad, 2006). During the early childhood period, considerable development is observed in children's social-cognitive skills and motivations. Increasingly, social interaction extends beyond the immediate family to include socializing with peers. Physical play, marked by the performance of highly coordinated, synchronized movements among participants, is a prominent aspect of children's peer-to-peer interactions (Powell, Woodfield & Nevill, 2015; Timmons, Naylor & Pfeiffer, 2007). It offers rich opportunities for social-cognitive development, including cooperation and bonding (Biddle & Asare, 2011). Yet, there is little research investigating how physical play influences children's pro-sociality. To explore this question, the current paper investigates how synchronized movements in physical play affect pro-social behavior.

Cognitive and evolutionary theories of human social behavior suggest that coordinated movements facilitate pro-social behavior via aligning the participants' emotional states (Ehrenreich, 2006), strengthening social bonds (Dunbar & Shultz, 2010; Durkheim, 1915) and signaling successful collaboration (Knoblich & Sebanz, 2008). In development, coordinated movements between caretakers and infants predict children's later social, cognitive and communicative competency (Jaffe et al., 2001) and attachment style (Isabella, Belsky, & von Eye, 1989). Studies with adults have shown that synchronous movements (i.e., in which participants perform rhythmical movements with the same onset time) increase participants' perceptions of similarity, social closeness (e.g., Valdesolo, Ouyang & DeSteno, 2010; Tarr, Launay & Dunbar, 2016), empathy (Valdesolo & DeSteno, 2011), trust (Launay, Dean & Bailes, 2013) and cooperative behavior (e.g., Wiltermuth & Heath, 2009; Reddish, Fischer & Bulbulia, 2013).

Infants show the first signs of rhythmic engagement with external stimuli at 5 months as they move their bodies differently according to changing tempi (Zentner & Eerola, 2010). Yet, infants do not synchronize their movements with an external rhythm until the age of 2 (Zentner & Eerola, 2010). Between 2½ and 4 years of age, children's synchronization abilities improve, as displayed by increased flexibility and accuracy in their tapping along to a metronome beat (Kirschner & Tomasello, 2009; Provasi & Bobin- Bègue, 2003). By age 4,

children can synchronize with external rhythms when the movements are simple (Rose, 2014) and the tempi are within their ability range (i.e., 300-400ms ISI; see: Provasi & Bobin-Bègue, 2003).

Prior research shows that movement synchrony is associated with pro-sociality from early in life. At 12 months, infants prefer social partners who have previously moved synchronously, compared to non-synchronously, with them (Tunçgenç, Cohen & Fawcett, 2015). After being bounced synchronously with an adult, 14-month-old infants spontaneously help the adult more than if they had been bounced non-synchronously (Cirelli, Einarson & Trainor, 2014). Further, this effect on helping behavior extends to the affiliates of the synchronized partners (Cirelli, Wan & Trainor, 2016) but not to neutral others (Cirelli, Wan & Trainor, 2014). Regarding peer-to-peer effects of movement synchrony, recent studies with 7- to 12-year-old children showed that moving synchronously with peers facilitated children's feelings of similarity, closeness and connectedness both within pairs and across groups (Rabinowitch & Knafo-Noam, 2015; Tunçgenç & Cohen, 2016). These findings are suggestive of pro-social effects, but measures of attitude have yet to be corroborated with measures of costly pro-social behavior (Ajzen & Fishbein, 2005).

Although these studies support the proposed movement synchrony-pro-sociality link, certain limitations motivate the current research. Firstly, due to restrictions in motor abilities, rhythmic movements in the infant studies were executed by the experimenters. In real-life interactions, however, actions are self-propelled and such active movements convey animacy, agency and communicative intent (Gergely & Csibra, 2003). Therefore, the current study explored how active behavioral synchrony influences children's pro-social behavior. Secondly, previous research took single measures of pro-sociality (e.g., social preferences, helping, self-report). Yet, pro-sociality is potentially expressed and therefore measured across a variety of both explicit and implicit attitudes and behaviors (Csibra & Gergely, 2009; Dunfield, 2014; Rubin, Bukowski & Parker, 2006). In order to capture the more implicit and emotional aspects of social bonding, we assessed helping behavior, eye contact, mutual smiling and empathy. Previous research on musical interactions showed that after engaging in a music-making activity, 4.5-year-old children helped and collaborated with their partners more than children who had engaged in an activity that did not involve music-making (Kirschner & Tomasello, 2010). The joint music-making condition likely enhanced synchronous movement, as the children were required to walk in step as they sang songs and produced music. In the present study, we isolated this aspect of musical interactions and

examined specifically whether synchronous movement increases pro-sociality in young children. The context for the activities was peer-play games that captured elements of children's everyday social-physical play.

In two between-participants conditions, children played a game, where they performed rhythmic clap-and-tap movements either synchronously or non-synchronously with each other. Subsequently, they played another game (adopted from Kirchner & Tomasello, 2010) that assessed helping behavior. Helping behavior was chosen as a measure of pro-sociality because of its early emergence (Warneken & Tomasello, 2006) and robustness during early childhood (Dunfield, 2014). We also examined the amount of mutual smiles and eye contact within pairs via post-hoc video coding. Finally, we asked children how they felt while playing the games and while witnessing their partner's distress in the helping task. Following previous research (Tarr, Launay, Cohen & Dunbar, 2015; Valdesolo & DeSteno, 2011), we hypothesized greater enjoyment of the movement game in the synchrony than in the non-synchrony condition. It has been also suggested that bodily alignment arising from synchronous movements can enhance empathy (Feldman, 2007; Valdesolo & DeSteno, 2011), which strongly predicts children's helping behavior and social bonds with friends (Denham, Bassett, Brown, Way & Steed, 2013; Zahn-Waxler, Radke-Yarrow & Brady-Smith, 1977). We therefore hypothesized that more helping behavior, mutual smiles, eye contact and empathy would occur following synchronous than non-synchronous movement. Potential mediation effects of empathy, mutual smiles and eye contact on helping behavior were also examined.

Method

Participants

Seventy-six children (38 girls, M = 5;1, SD = 6.6, range: 48-76 months) participated in sex- and age-matched pairs within their schools. A priori sample size followed Kirschner and Tomasello (2010). Participants were distributed evenly and age distribution was similar across conditions (19 girls in synchrony condition, M_{sync} = 5;2, $M_{non\text{-}sync}$ = 5;1). Assignment to the conditions was random; in cases where teachers reported a pair to be best friends, re-randomization was done.

An additional 8 pairs (female) were tested but excluded from final analysis due to experimenter error (3), failure to coordinate with individual beat during training (1) or because the 'accident' in the helping task was unnoticed by the 'Responder' children (4).

Participants came from mixed ethnicities and socio-economic backgrounds. Permission was obtained from the school authorities and parents prior to testing.

Materials and Procedure

The experiment procedure comprised of a warm-up activity (Picnic Game) and 3 main tasks (Clap & Tap Game, Fish Feeding Game and Emotion Cards). The independent variable was synchrony with two levels (synchrony vs. non-synchrony). The dependent variable, pro-sociality, was measured through assessing helping behavior and more implicit indicators of social closeness, namely mutual smiles and eye contact within pairs. Figure 1 depicts the room set-up. Detailed information on the training phases of the main tasks is provided in the Supplementary Materials. All sessions were video recorded for coding purposes.

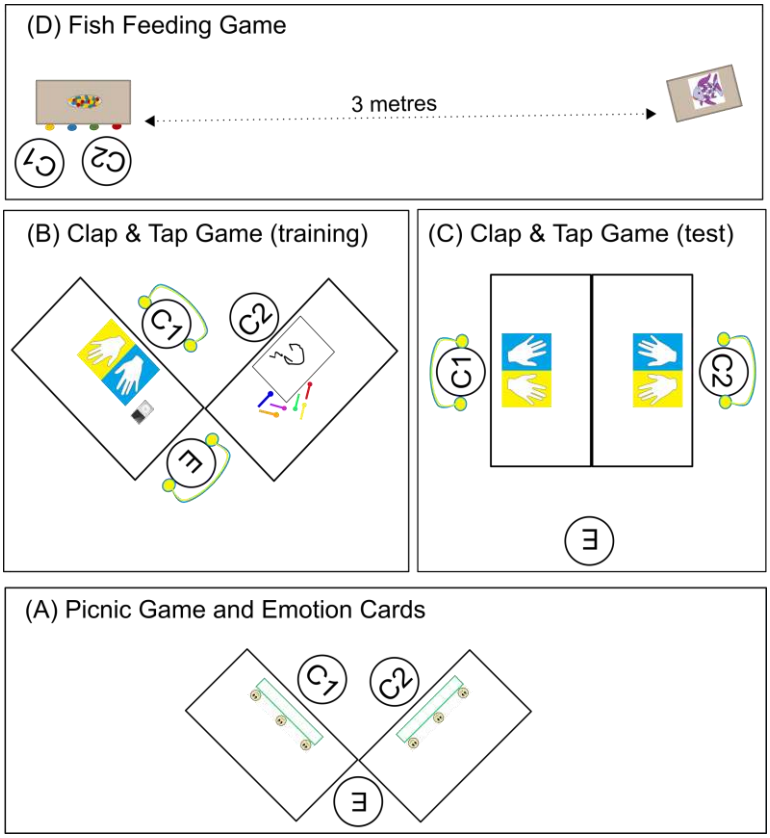

Figure 1. Room set-up in different phases of the study.

Picnic Game. Children engaged in a pretend picnic game with toy food items as a warm-up activity. The warm-up activity also served as training for the Emotion Cards (see Supplementary Materials).

Clap & Tap Game. Following the warm-up, the Clap & Tap Game commenced. The game required the children to perform certain movements in time to beats that they heard from their individual headphones. The auditory track was composed of four 10-second intervals of tick-tock sounds, during which the children alternately clapped and tapped with both hands on a 'hands sheet' in front of them (see Figure 2b). The tick-tock intervals were separated from each other by a brief *whoop* sound, during which the children quickly stood up and sat back down on their seats. The whoop sound was included to make the game more interesting and to add visual emphasis to the movement activity.

The tick-tock beats were either 300ms or 333ms; both tempi were age-appropriate to the children's synchronization ability range (i.e., rhythms between 300ms and 400ms ISI, see: Provasi & Bobin-Bègue, 2003). Pilot testing confirmed that these beats were easy to follow and sufficiently different from each other to establish pair-wise non-synchrony. The choice of movements was based on previous research that had confirmed young children's synchronization proficiency in clapping and tapping (Fitzpatrick, Schmidt & Lockman, 1996; Frega, 1979; Rose, 2014).

Each child was first trained individually on how to play the game, while the other child did a drawing task at a separate table (see Figure 1b). Training started with E demonstrating how to perform the moves and continued until the children successfully performed the moves in time to the beats for the full duration of the 45-second auditory track. After training, the children sat opposite each other to perform the activity together in the test phase (see Figure 1c). Children in the synchrony condition heard the same beats from their headphones (300ms used in half of the synchrony sessions), while children in the non-synchrony condition heard beats at different tempi. To avoid possible interference effects, all children were informed beforehand that they might hear the same or different beats and that their task was to do the moves in time to their own beats. E remained condition-blind until the test phase and moved away from the table during the test phase.

Fish Feeding Game. Subsequently, the spontaneous helping task commenced (adopted from Kirschner & Tomasello, 2010). The game entailed putting 'fish food' (small balls) in tubes, one for each child, and pouring the food into a 'fish box', which supposedly contained hungry toy fish (see Figure 2c). One tube, by design, had a broken bottom cap, which caused the contents to spill across the floor as soon as it was lifted. We assessed whether the child with the intact tube (the 'Responder') would spontaneously help the child

with the broken tube. Assignment to the Responder role was counterbalanced across tempi and left-right side and determined before the session commenced. To minimize potential authority and by-stander effects on children's helping behavior, E left the room for the test phase (duration: 2 minutes).

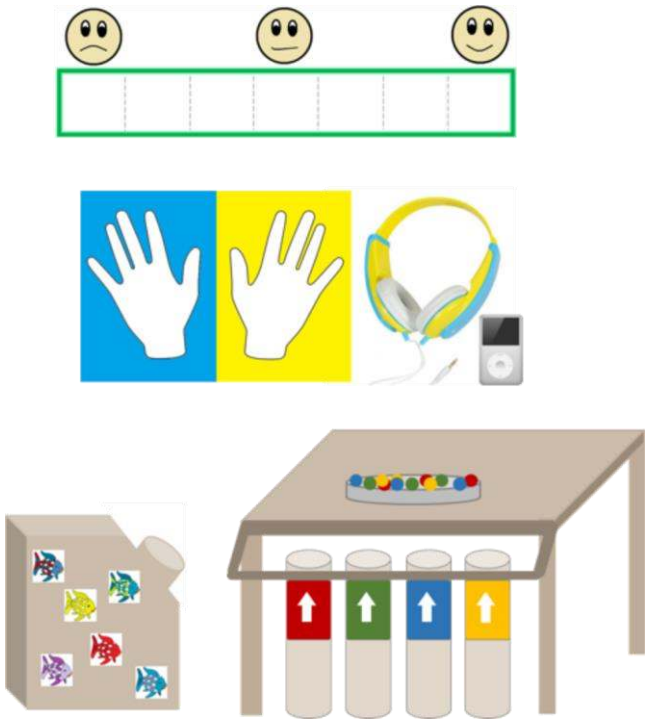

Figure 2. The toys used in the experiment. Top panel shows the Emotion Card, middle panel shows the Clap & Tap Game instruments (the hands sheet, headphones and audio player) and the bottom panel shows Fish Feeding Game toys (fish box, table, tubes and fish food).

Emotion Cards. Following the Fish Feeding Game, we asked children questions about their experiences with the games. Children responded by placing stickers on their Emotion Cards (for similar usage of scales, see: Chambers, Giedbrecht, Craig, Bennett & Huntsman, 1999; Denham et al., 2003). These were 7-point Likert type scales with boxes on them to indicate where to place the stickers (see Figure 2a). The leftmost box was described orally as representing *very sad*, the middle box as *normal*, and the rightmost box as *very happy* (each point illustrated with corresponding frowning, neutral and smiley faces). The children were asked to rate how they felt (1) as they played the Fish Feeding Game, (2) when they noticed the broken tube, and (3) as they played the Clap & Tap Game. For each question, E first gave children their individual scales and then asked the question orally. Children did not have visual access to each other's answers.

Coding

All inter-rater reliability coding was done by two individuals, both of whom were blind to the conditions and one blind to the hypothesis. Post-hoc video coding was conducted to confirm that synchrony was achieved in the synchrony condition and non-synchrony in the non-synchrony condition, and that the synchrony levels were significantly different across conditions. The coders rated participants' synchrony levels (i) by making a blind guess on which condition the pair was in, and (ii) by rating the frequency of synchronous instances in the pairs' movements on a Likert-type scale (1 = *absolutely non-synchronous*, 4 = *sometimes synchronous, sometimes non-synchronous*, 7 = *absolutely synchronous*). Five ratings were taken per session, corresponding to the four clap-and-tap intervals and an overall rating for the three occurrences of standing-and-sitting at the *whoop* sound. Binomial tests revealed that the accuracy of the blind guesses was excellent for both raters (*ps* < .0001). Average synchrony ratings of the two raters confirmed that pairs in the synchrony condition were more synchronous (M = 5.64, SD = .92) than pairs in the non-synchrony condition (M = 1.79, SD = .67), Rater 1: $t(36) = 9.04$, $p < .0001$; Rater 2: $t(36) = 7.36$, $p < .0001$; inter-rater reliability: $\kappa = .96$, 95% CI [.95 to .99], $p < .0001$. Subsequent analyses testing the effects of synchrony vs. non-synchrony were therefore conducted based on this dichotomous split.

For exploratory purposes, the effect of level of synchrony was assessed by splitting the data four ways based on the pairs' synchrony ratings, yielding post-hoc categories of 'synchrony', 'moderate synchrony', 'moderate non-synchrony' and 'non-synchrony'. Detailed results of these analyses are in Supplementary Materials.

Helping behavior was assessed using Kirschner and Tomasello's (2010) coding scheme: The Responders' behaviors were divided into three categories according to the amount of help they provided (see Table 1). Inter-rater reliability was excellent, $\kappa = .96$, 95% CI [.90 to 1.00], $p < .0001$.

Table 1

Coding Scheme Used to Categorize Responders' Behaviors.

Helping Categories	Category Description
Absolute help	Responder actively helps (e.g., picks up balls, holds the lid) and/or waits to play until the problem is solved
Moderate help	Responder partially helps and/or waits besides the other child showing concern and mutual commitment, but leaves to play before the problem is solved
Zero help	Responder does not help or wait for the other child, does not show concern and/or does not excuse him/herself before leaving

Clap & Tap Game phases were coded to examine children's enjoyment levels and eye contact during the task. For enjoyment levels, the coders counted (a) the number of smiles each child displayed ("individual smiles") and (b) the number of times children smiled simultaneously while maintaining eye contact with each other ("mutual smiles"). Following Ekman & Friesen (1982), a smile was defined as the simultaneous upward movement of the muscles around the eyes and the corners of the mouth. For the measure of eye contact, the number of seconds the children spent actively focused on each other's eyes/faces was recorded (e.g., eyes meeting accidentally while turning the head were not included). Eye contact duration was coded for each clap-and-tap interval and stand-sit occurrences and these were summed to obtain the total duration per session. For more detailed analyses regarding within-session patterns in mutual smiles and eye contact, see Supplementary Materials. Inter-rater agreement for all of these coding categories was strong, individual smiles: $\kappa = .78$; mutual smiles: $\kappa = .90$; eye contact: $\kappa = .77$, all ps $< .0001$.

Results

Effect of Synchrony on Helping Behavior

Helping categories were analyzed to assess whether children in the synchrony condition displayed more helping behavior than children in the non-synchrony condition. Ordinal logistic regression analysis, with condition as the predictor variable, was used in accordance with the ordinal structure of the helping categories. The odds of children in the synchrony condition displaying more help were 29.402 greater than those of children in the non-synchrony condition, 97.5% CI: 6.40 to 184.64, *Wald* $\chi^2(1) = 16.19$, $p < .0001$. Factors

of Age, Sex or Tempo did not predict helping behavior. Figure 3 shows the frequency of occurrence for each helping category by condition.

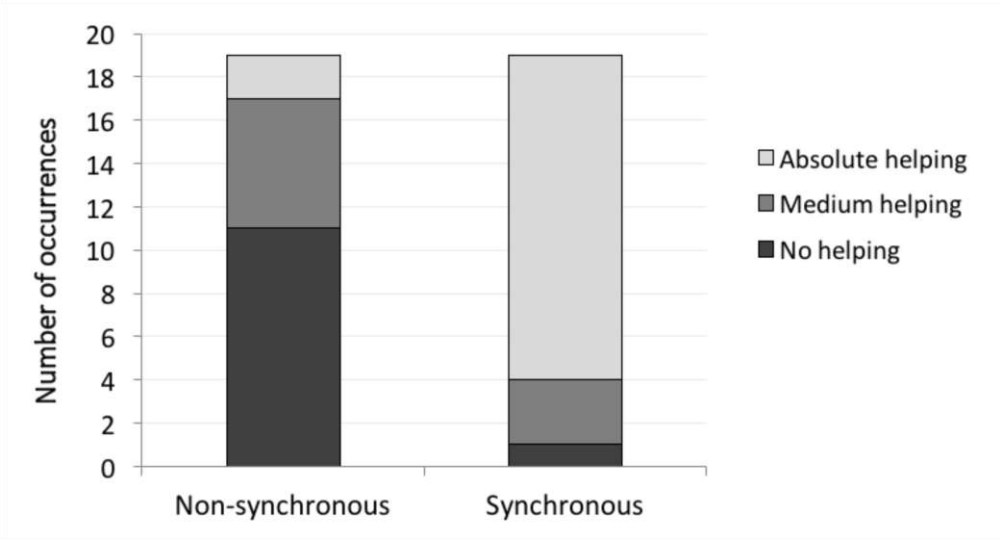

Figure 3. Helping categories by frequency of occurrence.

Effect of Synchrony on Emotion Card Responses, Smiles and Eye Contact

Wilcoxon signed-rank test revealed equal enjoyment during the Fish Feeding Game across conditions, $Z = 718.5$, $p = .37$, $M_{sync} = 5.12$, $M_{non\text{-}sync} = 5.53$ (see Figure 4). Children across conditions did not report feeling any happier or sadder at the moment of the accident, $Z = 460.5$, $p = .77$, $M_{sync} = 3.00$, $M_{non\text{-}sync} = 2.80$; for Responders only: $Z = 103.5$, $p = .47$, $M_{sync} = 2.88$, $M_{non\text{-}sync} = 2.20$. This indicates that how happy or sad the children felt during the accident did not influence their helping behavior. However, enjoyment levels during the Clap & Tap Game trended toward significance in the hypothesized direction: $Z = 751$, $p = .08$, $M_{sync} = 6.68$, $M_{non\text{-}sync} = 6.03$.

Analyses on individual smiles, mutual smiles and eye contact while playing the Clap & Tap Game revealed significantly higher occurrence in the synchrony condition compared to the non-synchrony condition, individual smiles: $M_{sync} = 4.92$, $M_{non\text{-}sync} = 2.92$, $F(1, 74) = 76.00$, $p < .0001$, A = .27; mutual smiles: $M_{sync} = 3.89$, $M_{non\text{-}sync} = 1.37$, $F(1, 36) = 20.17$, $p < .0001$, $\eta^2 = .56$; eye contact: $M_{sync} = 23.95$ seconds, $M_{non\text{-}sync} = 12.36$ seconds, $F(1, 36) = 11.42$, $p = .002$, , $\eta^2 = .32$. Altogether, these findings suggest that synchronous activity was associated with more mutual enjoyment and eye contact than non-synchronous activity.

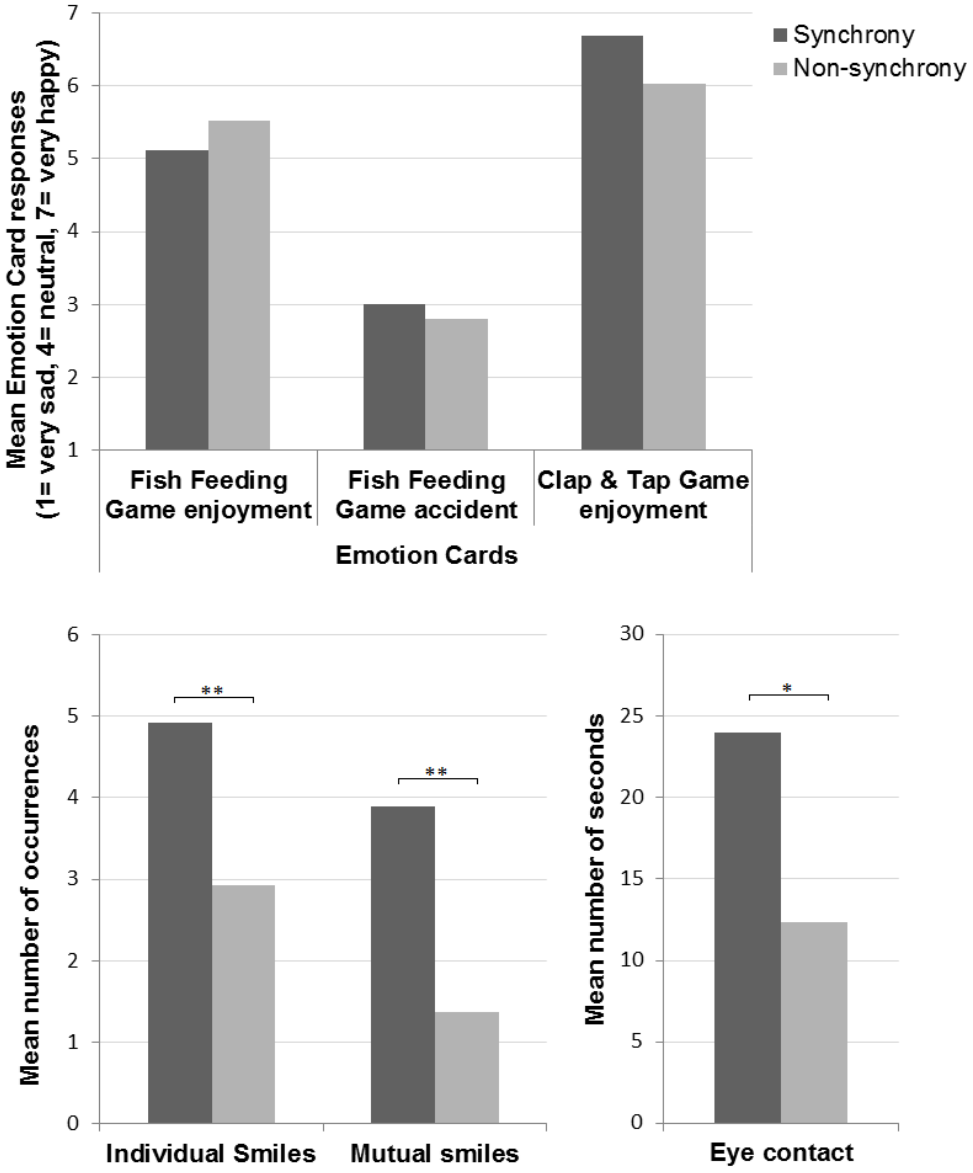

Figure 4. Effect of condition on emotion card responses (top panel), individual and mutual smiles (bottom left panel) and eye contact (bottom right panel); where * p < .01 and ** p < .0001.

Mediation Effects of Emotion Card Responses, Smiles and Eye Contact

Children's self-reported emotional states, smiles (individual and mutual) and eye contact during the Clap & Tap Game were examined for potential associations with helping behavior. Ordinal logistic regression analyses on helping categories with Responders' emotion card responses as the predictor variable did not reveal any significant associations, all *p*s > .05, nor did the number of individual smiles predict helping behavior, 97.5% CI [0.93, 1.62]; *Wald* $\chi^2(1) = 1.94$, $p = .16$. However, the frequency of mutual smiles and the duration of eye contact predicted subsequent helping behavior; mutual smiles: *OR* = 1.60,

97.5% CI [1.16, 2.31], *Wald* $\chi^2(1) = 7.32$, $p = .007$; eye contact: *OR* = 1.06, 97.5% CI [1.01, 1.12], *Wald* $\chi^2(1) = 4.94$, $p = .03$.

To explore this link further, we assessed whether mutual smiles and eye contact mediated the relationship between synchrony and helping behavior. Analyses were performed using the {lavaan} package in R. No indirect effects were found and the main effects of the mediators (mutual smiles and eye contact) on helping behavior disappeared when the effect of condition was controlled for (see Figure 5), 97.5% CI, -0.34 to 0.31, $p = 0.83$. Thus, it can be concluded that performing the movements synchronously led to an increase in eye contact, mutual smiles and helping behavior independently and that condition best accounts for the differences observed in helping behavior.

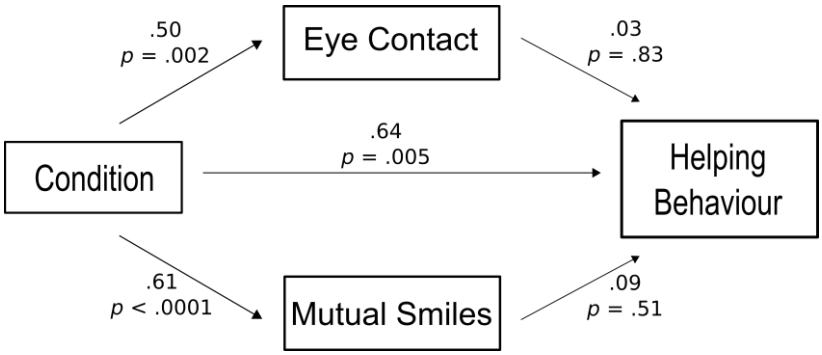

Figure 5. Standardized regression coefficients for the relationships between condition and helping behavior (categories) as mediated by the duration of eye contact and frequency of mutual smiles. Synchrony variable is dummy coded, with the higher value indicating synchrony condition.

Discussion

This study found that, compared to non-synchronous movement, performing movements in synchrony with a peer led to more spontaneous helping among young children. Further, we found that synchronous movement was associated with increases in enjoyment, eye contact and mutual smiles between the partners. The findings extend our understanding of the effects of synchronous movement on pro-social behavior in children and begin to reveal the broad range of social effects of movement synchrony in children's peer-play interactions.

A number of previously unexplored aspects of the synchrony-pro-sociality link were investigated in the current research. Studies by Cirelli and colleagues (2014a; 2014b) assessed helping behavior of infants, who were moved to certain rhythms synchronously/non-

synchronously with another adult. However, from infancy onwards, self-propelled actions signal animacy, agency and communicative intent (Gergely & Csibra, 2003) and are imitated more by infants (Elsner, 2007). Recently, Rabinowitch and Knafo-Noam (2015) demonstrated positive effects of active movement synchrony on feelings of similarity and closeness among 8-9 year-old children. The current study extends these findings by (i) testing the effects of synchrony in a younger population and (ii) including an active behavioral measure of pro-sociality (i.e., helping task), as well as implicit interactional measures (i.e., mutual smiling and eye contact).

The findings also shed light on how musical interactions may lead to pro-social outcomes. In their study revealing increased helping behavior following a music-making activity, Kirschner and Tomasello (2010) discuss the factors entailed by music that may underpin this effect, including synchrony. In the current study, subtle manipulation of this factor alone yielded levels of helping comparable to those attained following musical interactions. The significant difference between our synchrony and non-synchrony conditions and the large effect sizes found demonstrate that movement synchrony influences pro-social behavior in young children. Differently from Kirschner and Tomasello, we did not find any sex differences in helping behavior. This is in line with some previous synchrony studies with children (Rabinowitch & Knafo-Noam, 2015; Tunçgenç & Cohen, 2016). One recent study showed that rhythmic movement activities levelled out baseline sex differences observed in negative feelings toward out-group members (Tunçgenç & Cohen, 2016). It may thus be that our Clap & Tap Game similarly diminished sex differences in helping behavior. Further research is required to corroborate and understand these results.

The present study also assessed enjoyment levels, mutual smiling and eye contact between the partners. Children's self-reports trended toward more enjoyment while playing the Clap & Tap Game in the synchrony condition, which was corroborated by the significant difference in individual smiles across conditions. This is in line with previous research showing a positive association between infants' frequency of smiles and rhythmic coordination with auditory stimuli (Zentner & Eerola, 2010). Neither self-reported enjoyment levels nor individual smiles predicted subsequent helping behavior. However, analyses of eye contact and mutual smiles revealed higher occurrences of both in the synchrony than in the non-synchrony condition and that both predicted helping behavior. Previous research has shown that eye contact occurring during synchrony enhances memory for partners' physical features and utterances, which has implications for subsequent interaction (Macrae, Duffy,

Miles & Lawrence, 2008; Woolhouse, Tidhar & Cross, 2016). Mutual smiling and eye contact also characterize children's initial interactions with their caretakers (Trevarthen, 1993) and their friendships in early childhood years (Goldman & Buysse, 2007). In the current study, these variables may have acted as markers of affiliation and shared positive affect, leading to a greater degree of pro-sociality (Kleinke, 1986). However, mutual smiles and eye contact did not mediate the effect of condition on helping behavior, suggesting that synchronous movement independently affected the changes in mutual smiles, eye contact and helping behavior.

Positive social outcomes following synchronous movement may stem from a number of factors. Previous studies have found that participants perceived themselves as more similar to their partners in traits such as appearance, personality and artistic taste following synchronous movement (Rabinowitch & Knafo-Noam, 2015; Valdesolo & DeSteno, 2011; Valdesolo, Ouyang & DeSteno, 2010; Wiltermuth & Heath, 2009). Research also shows that people generally prefer to interact and cooperate with those who are more similar to themselves (e.g., Haun & Over, 2015). No direct measure of similarity was taken in the current study. Still, it may be that synchronous movements fostered perceptions of similarity, which, in turn, led to higher amounts of helping behavior.

Another mechanism that could explain the synchrony-pro-sociality link is empathic concern (Valdesolo & DeSteno, 2011). Responders' ratings of how they felt at the moment of the accident did not offer support for this possibility. It could be that children had difficulty expressing their emotions retrospectively. Their responses might have been influenced by their interactions during the time period between the moment of the accident and the administration of the emotion scale and/or by concerns of social correctness, such as appearing sorry for others' misfortunes. Coding the children's emotional expressions at the moment of the accident could therefore have provided valuable supplementary evidence; however, this was not possible due to restricted camera angle. Based on previous research, coding of facial expressions could yield more tacit cognitive processes of emotional processing (Ekman, 1993; Gross & John, 1997; Izard, 1992). To assess the role of empathy, future research should include multiple measures of emotion expression.

Future research can also address some other limitations of the current study. Firstly, to better substantiate and understand the links between synchrony and pro-sociality, it is important to examine the directionality of the observed outcomes. Does synchrony facilitate

social closeness, interactivity and pro-sociality and/or does non-synchrony engender perceptions of low-level antagonism, dissonance and dissimilarity? Examination of within-session changes in the current study (comparing the first and last clap-tap intervals) in mutual smiles and eye contact offers preliminary clues. While there was virtually no change in either mutual smiles or eye contact in the non-synchrony condition, both increased in the synchrony condition (see Supplementary Materials). The proposal that synchrony facilitated pro-sociality, rather than non-synchrony reducing it, would be in line with Rabinowitch & Knafo-Noam (2015)'s findings showing no differences in perceptions of similarity and closeness between non-synchronous and solo conditions, but significantly higher ratings both after synchrony. Further, another recent study has shown an increase in bonding following synchronous movement but no decrease following non-synchrony (Tunçgenç & Cohen, 2016). Future studies should use baseline measures to systematically investigate how synchrony and non-synchrony contribute to pro-sociality.

Another limitation of this study concerns the possibility of a minimal group effect, rather than synchrony effect. The information given to children prior to the Clap & Tap Game that they might hear the same or different beats might have created the conditions for perceptions of groupishness. Following this instruction, intended to avoid interference of confounds (e.g., about partners' competence), children were told to follow their individual beat played through their personal headphones. Minimal group manipulations typically involve a group identity-building element in addition to the announcement of belonging to different groups, such as wearing group-colored vests or doing a group activity (e.g., Dunham, Baron & Carey, 2011). Therefore, we believe that a minimal group interpretation is unlikely. Still, future research should explore ways of eliminating this possibility.

Extending the growing literature on the importance of coordinated movements for cognitive and social development, this study found that children helped each other more after a synchronous activity that resembles typical playground games found everywhere. Investigations in this area hold great promise for illuminating the connections among motor, social and cognitive development, ultimately expanding our understanding of the ontogenetic and evolutionary roots of human social behavior. The findings potentially identify a subtle, effective and economical method to facilitate children's pro-social behavior that may also helpfully inform clinical, educational and socio-political interventions. Future research should investigate the specific mechanisms as well as wider social benefits of interpersonal movement synchrony across a range of activities.

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