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Infants' use of interpersonal asynchrony as a signal for third-party affiliation

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Abstract

Infants use social cues to form expectations about the social relationships of others. For example, they expect agents to approach helpful partners and avoid hindering partners. They expect individuals with shared food preferences to be affiliates and individuals with opposing food preferences to be nonaffiliates. Interpersonal synchrony and asynchrony are important signals that adults use to guide third-party understanding. Specifically, we expect synchronous partners to be higher in rapport than asynchronous partners. Here, using a within-subjects design, we investigated if 12- to 14-month-old infants ($n = 62$) also use interpersonal synchrony and/or asynchrony to make sense of third-party social relationships. A violation of expectations paradigm adapted from Liberman and colleagues was used. Infant looking time was recorded while watching videos of two women. The women moved either synchronously or asynchronously during familiarization trials, and subsequently interacted either in a friendly way (waving) or an unfriendly way (turning away) on test trials. Results revealed that infants expected asynchronous partners to be nonaffiliates but showed no significant expectation for synchronous partners. These results suggest that infants use interpersonal movement to understand their social world from as early as 12 months of age.

Keywords

Affiliation, infancy, interpersonal synchrony, social cognition, violation of expectation

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Introduction

As infants learn to navigate their social worlds, they must not only make sense of their own social relationships but also learn to assess social relationships between others. Recent research shows that infants use signals such as food preference (Liberman, Kinzler, & Woodward, 2014), social dominance (Mascaro & Csibra, 2012), imitation (Powell & Spelke, 2016), prosocial action (Hamlin, Wynn, & Bloom, 2007; Kuhlmeier, Wynn, & Bloom, 2003), and spoken language (Liberman, Woodward, & Kinzler, 2017) to predict third-party relationships. The current study investigates whether interpersonal movement synchrony—the temporal alignment of one's movements with those of another individual—and/or a lack of movement synchrony are also signals for third-party affiliation.

When experienced firsthand, interpersonal movement synchrony has prosocial consequences. For example, adults rate a person who taps in- versus out-of-synchrony with them as more likeable (Hove & Risen, 2009) and are more willing to help this person (Kokal, Engel, Kirschner, & Keysers, 2011). Adults are also more willing to cooperate with individuals who have walked in- versus out-of-step with them (Wiltermuth & Heath, 2009). Musical behaviors that encourage high levels of interpersonal synchrony, such as singing and dancing, can enhance interpersonal trust, cooperation, and feelings of group closeness (Pearce, Launay, & Dunbar, 2015; Tarr, Launay, Cohen, & Dunbar, 2015; Wiltermuth & Heath, 2009). These findings support

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the social cohesion model of musical behavior, which suggests that musical behaviors foster in-group bonding and are therefore socially adaptive (Brown, 2000; Freeman, 2000; Huron, 2003; Roederer, 1984).

The prosocial consequences of interpersonal synchrony also influence the social behavior of children and infants. Eight-year-olds feel closer and more similar to synchronously compared to asynchronously tapping peers (Rabinowitch & Knafo-Noam, 2015) and seek out close physical proximity with them (Tunçgenç & Cohen, 2016). Pairs of 4-year-olds who engage in musical play together (which encourages high levels of interpersonal synchrony) are later more helpful and cooperative than pairs who engage in non-musical play (Kirschner & Tomasello, 2010). Fourteen-month-old infants who are bounced in- versus out-of-synchrony with an experimenter are later more likely to help this person by handing her objects she needs in order to complete a task (Cirelli, Einarson, & Trainor, 2014; Cirelli, Wan, & Trainor, 2014; Cirelli, Wan, & Trainor, 2016; Cirelli, Wan, Spinelli, & Trainor, 2017; Trainor & Cirelli, 2015). Interestingly, this boost in infant helping following interpersonal synchrony is only directed to the movement partner or friends of the movement partner but not to a neutral stranger uninvolved in the movement experience (Cirelli et al., 2014a; Cirelli et al., 2016). Finally, 12- but not 9-month-old infants who are rocked either synchronously or asynchronously with a teddy bear will later preferentially reach for the synchronously moving toy when given a choice between the two (Tunçgenç, Fawcett, & Cohen, 2015). These studies demonstrate that experiencing interpersonal synchrony firsthand influence child and infant social behavior.

With adults, there is evidence that interpersonal synchrony also provides information about the relationships of others. A study by Lakens (2010) demonstrated that synchrony affected the perceived similarity between two stick figures. Figures who waved with a high degree of synchrony were perceived by observers to be more similar than those who waved with a lower amount of temporal coordination (Lakens, 2010). Observers were also more likely to expect synchronously waving human actors to behave as a social unit (Lakens & Stel, 2011). Observers also judged women walking in synchrony to be higher in entitativity (the degree to which individuals act as a group or unit, Campbell, 1958) and rapport than those walking out-of-step (Edelman & Harring, 2015). These studies suggest that synchrony influences how we perceive the unity of a group when judging third-party relationships. When adults see people move together, they assume that these people form a cohesive, social unit.

Infants may also use interpersonal synchrony as a signal for third-party affiliation. Powell and Spelke (2013) found that when group cues of proximity and synchrony are combined, infants as young as 7 months of age expect animated characters to act alike and have similar goals. However, in these experiments, the effects of proximity and synchrony were not investigated separately.

Along with the results of Powell and Spelke's (2013) work, a recently growing body of research has focused on other signals infants use to understand and make predictions about third-party relationships. For example, after observing an interaction between a neutral agent and both a hinderer and helper, infants as young as 10 months of age expect a neutral agent to approach a helper and avoid a hinderer (Hamlin et al., 2007; Kuhlmeier et al., 2003). Fifteen-month-olds use interaction cues to form predictions about third-party social dominance relationships (Mascaro & Csibra, 2012). Five-month-olds expect imitators to affiliate with their targets (Powell & Spelke, 2016).

Liberman, Kinzler, and Woodward (2014) have shown that signals for food preference similarity influence 9-month-old infants' third-party social evaluations using a novel violation of expectation paradigm. During familiarization, infants watched two experimenters display either a shared or an opposing preference for a food item. During test trials, infants watched a video showing the same two women interact in either a friendly or an unfriendly way. Infants looked longer to unfriendly versus friendly social interactions between pairs with shared food preferences and longer at friendly versus unfriendly social interactions between pairs with opposing food preferences. This suggests that 9-month-old infants expect individuals with shared food preferences to be affiliates, and those with opposing food preferences to be nonaffiliates. Liberman and colleagues (2017) have found a similar effect when familiarization trials show either same language or different language speakers. This is a promising methodology for investigating what signals infants can use when assessing third-party social relationships, and at what age these signals become salient.

The present investigation examines whether infants between 12 and 14 months of age use interpersonal synchrony to shape third-party relationship expectations. To our knowledge, this question has only been addressed previously with adult samples. By adapting the violation of expectations paradigm developed by Liberman and colleagues (2014), we investigated whether infants would form different expectations about how synchronous and asynchronous partners will later interact using a within-subjects design. We predicted that infants would expect synchronous movers to interact in a positive way and that they would expect asynchronous movers to interact in a negative way. We also collected information about infant social temperament using three subtests ("Smiling," "Approach," and "Activity") of the Infant Behaviour Questionnaire (IBQ) (Rothbart, 1981) in order to determine if infant sociability predicted interest level and performance during the primary task. The two age-groups (12 and 14 months) were selected based on the above-mentioned papers describing infant social responses to *experienced* synchrony. With 14-month-old infants (see Trainor & Cirelli, 2015), experienced synchrony leads to robust effects on prosocial behaviour. Therefore, we expected infants of this age to also use witnessed synchrony and asynchrony in others to guide third-party social expectations. However, less is known about 12-month-old infants, with only one study indicating that experienced synchrony with teddy bears directs infant social preferences (Tunçgenç et al., 2015). Here, we test 12-month-olds to investigate whether social cognitive effects of witnessed synchrony follow a similar developmental trajectory as experienced synchrony.

Method

Participants

Twelve-month-old infants ($n = 32$, 17 boys; $M_{\text{age}} = 12.1$ months; $SD = 0.3$ months) and 14-month-old infants ($n = 32$, 16 boys; $M_{\text{age}} = 14.7$ months; $SD = 0.3$ months) participated in the experiment. Two additional 12-month-olds participated but were excluded due to excessive fussiness ($n = 1$) or equipment failure ($n = 1$). Five additional 14-month-olds participated but were excluded due to excessive fussiness ($n = 4$) or experimenter error ($n = 1$). Infants were recruited from the Developmental Studies Database at McMaster University. The experimental procedures were approved by the McMaster Research Ethics Board.

Procedure

The infant sat on his or her parent's lap for the entire experiment, which took place in a sound-attenuating chamber. The parent wore opaque masking glasses and headphones playing masking music, making them blind to the stimuli presented to the infant.

The experimenters (2) were also blind to the stimuli, viewing the infant from outside the sound-attenuating chamber through a live video feed (Sirius USB 2.0 camera). Each experimenter independently live coded infant looking times by pressing an assigned key when the infant was looking at the screen. This information was recorded from both experimenters through a Max 8 Video software program running on a Macintosh computer. To begin the experiment, an orienting stimulus (a flashing picture of a teddy bear) was presented on the screen to attract the infant's attention. The orienting stimulus also appeared between each trial to ensure that the infant was looking at the screen before each stimulus was presented. When both experimenters reported via key press that the infant was looking at the orienting stimulus, the next trial would begin. Looking was defined as the time during the trial when both experimenters agreed that the infant was looking (the time when both experimenters had keys pressed down). Inter-coder reliability was calculated for 14 of the 64 infants (22% of participants, 7 from each age-group). The correlation between the two coders' judgments of looking time for each trial was computed, and the average inter-coder correlation was high, M Pearson's $r = .95$.

The experiment consisted of Block A, which included Familiarization Phase 1 followed by Test Phase 1. This was followed by Block B, which included Familiarization Phase 2 followed by Test Phase 2. During the Familiarization Phases, infants watched six repeated trials of a 20-s video (Figure 1; Movie S1 and S2). These trials began when the infant was looking at the screen and played in their entirety while infant looking time was recorded. This video showed two women facing each other, wearing contrasting colored shirts. The women bounced up and down by bending at the knees while a Musical Instrument Digital Interface (MIDI) version of the song "Twist & Shout" (by The Beatles) played from a Denon amplifier (PMA-480R) connected to two audiological loudspeakers (GSI) placed equidistant on each side of the infant. The bouncing was either synchronous (both women bouncing in phase at 100 bpm) or asynchronous (one woman bouncing at 100 bpm, in line with the music, and the other bouncing too quickly at 140 bpm). The actresses were instructed to display a neutral but pleasant facial expression in all familiarization videos.

During Test Phase 1, infants watched 12 test trial videos showing the same two women interacting, with alternating friendly and unfriendly interactions (6 trials of each interaction type, so 6 test pairs). In the friendly interaction videos, the women started facing forward, then turned toward each other, smiled, waved, and said "hi" to each other. In the unfriendly interaction videos, the women started facing forward, turned to look at each other and then immediately turned away from each other, frowned, crossed their arms, and said "hmph." Once each video of the interaction played in its entirety (3.5 s for both trial types), the final frame of the video remained on the screen until either the infant looked away for 2 s or 60 s had elapsed (see Figure 1 for screenshots and Movie S3).

During Block B, Familiarization 2, a different set of women (different women wearing different colored shirts) repeated the bouncing from Familiarization 1, displaying the opposite movement condition (i.e., if Familiarization 1 was synchronous, Familiarization 2 was asynchronous, and vice versa). Test Phase 2 was similar to Test Phase 1 but used interaction videos with this second set of women.

Counterbalancing led to eight possible order conditions (synchronous or asynchronous pairs shown in Familiarization 1; positive or negative interaction videos shown first during the test trials; actress Pair 1 or Pair 2 playing the synchronous pair). Infant gender and age-group was balanced across order conditions.

Afterward, parents also completed the three subtests ("Smiling," "Approach," and "Activity") of the IBQ (Rothbart, 1981) and a demographics questionnaire.

Results

Two 12-month-old infants (1 male and 1 female) were excluded from analyses using a z-score outlier cutoff of $Z = \pm 3$ for average test trial looking.

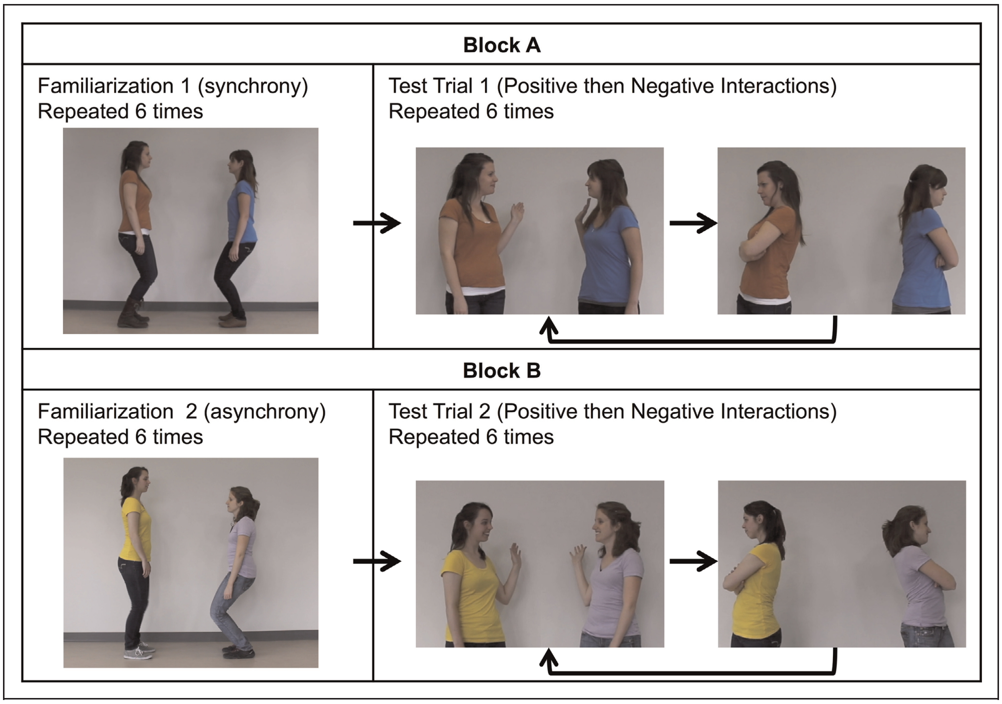

Figure 1. An example of how the procedure would progress for infants in one of the eight counterbalanced conditions. Depicted here, Block A, Familiarization 1 consists of a synchronous pair, test trials begin with positive interactions, and actress pair A is synchronous. In Block A, infants in this condition began with the 20 s synchrony familiarization video repeated six times in its entirety while looking time was recorded. Then, infants watched test trial videos (here, positive and then negative interactions). During each test trial, the final frame of each video was displayed until infants looked away for 2 s or a 60 s maximum time was reached, and overall looking time was calculated. In Block B, infants watched a new pair of women bouncing asynchronously in the familiarization phase. Familiarization was followed, as before, by test trials. The women shown in the figure have provided written consent to publish these images.

Familiarization trials

Preliminary analyses confirmed that gender ($p = .581$), movement condition order (synchrony or asynchrony presented in Block 1, $p = .139$), actress pair (Pair 1 or Pair 2 moving synchronously, $p = .424$), and test trial order (friendly or unfriendly videos shown first, $p = .647$) had no significant effect on average familiarization trial looking time. The data were therefore collapsed across these counterbalanced variables for the following analyses.

Average looking to familiarization trials did not correlate with IBQ measures of smiling ($p = .64$) or approach ($p = .29$) but did correlate negatively and weakly with activity level, Pearson's $r = -.14$, $p = .029$. Infants rated higher by their parents as more active had lower average looking times during familiarization. Adding this variable as a covariate in the following analysis did not influence statistical decisions and interactions between activity and variables of interest did not reach significance (all p's > .32), so activity was not included as a covariate below.

A repeated-measures analysis of variance (ANOVA) with movement condition (synchrony or asynchrony) and familiarization trial number (1–6) as within-subjects factors and age-group (12- or 14-month-olds) as a between-subjects factor was used to analyze looking times during familiarization trials. There was no main effect of movement condition, $F(1,60) = 0.46$, $p = .500$; no main effect of age-group, $F(1,60) = 1.34$, $p = .251$; and no interactions with these variables and other variables ($p > .29$). Importantly, the expected main effect of trial number was revealed, $F(5,300) = 37.24$, $p < .001$, $\eta_p^2 = .383$. Looking decreased across familiarization trials (see Figure 2). Specifically, looking to the first familiarization trial ($M = 16.9$ s) was

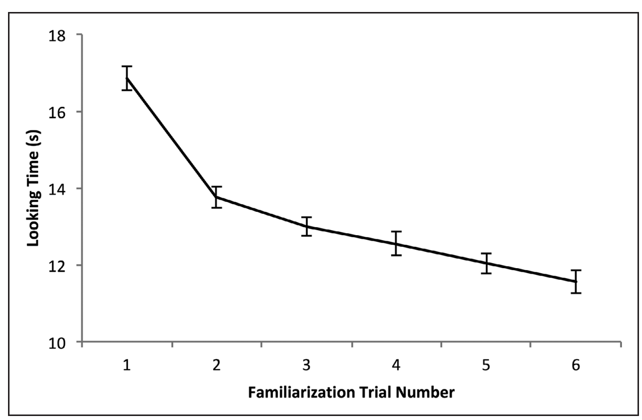

Figure 2. Mean looking time (s) across six familiarization trials, collapsed across movement condition and age. Looking decreased across trials. Within-subject error bars represent standard error of the mean (Cousineau, 2005).

significantly longer than looking to the last familiarization trial ($M = 11.6$ s), $t(61) = 10.82$, $p < .001$.

Test trials

Average looking to test trials did not correlate with IBQ measures of smiling ($p = .47$) or approach ($p = .89$) or activity level ($p = .30$).

We expected infants to show differential looking to friendly and unfriendly interactions, and that these patterns of looking would differ across movement conditions. If infants assume that synchronous partners are more likely to be friends than non-friends, they should be surprised and look longer at test trials depicting unfriendly compared to friendly interactions for these pairs. If they assume that asynchronous partners are more likely to be non-friends than friends, they should be surprised and look longer at test trials depicting friendly compared to unfriendly interactions for these pairs. To assess this hypothesis, proportion looking toward friendly compared to unfriendly interactions was computed for each of the six test trial pairs in each movement condition (e.g., for test Pair 1 (time looking to friendly trial)/[(time looking to friendly trial) + (time looking to unfriendly trial)]). Average proportion scores were then calculated across all six trials in each movement condition. A proportion of .50 suggests that friendly and unfriendly interactions were looked at equally across test pairs. A proportion over .50 indicates more looking at friendly compared to unfriendly interactions.

Preliminary analyses confirmed that gender ($p = .304$), movement condition order (synchrony or asynchrony presented in Block 1, $p = .248$), actress pair (Pair 1 or Pair 2 moving synchronously, $p = .088$), and test trial order (friendly or unfriendly videos shown first, $p = .379$) had no significant effect on these proportion looking scores. The data were therefore collapsed across these counterbalanced variables for the following analyses.

A repeated measures ANOVA with movement condition (synchronous or asynchronous) as a within-subjects factor and age-group as a between-subjects factor was used to analyze proportion looking to friendly interaction scores. There was no main effect of age-group, $F(1,60) = 0.83$, $p = .366$ and no interaction between movement condition and age-group, $F(1,60) = 0.46$, $p = .503$. There was, however, the predicted main effect of movement condition, $F(1,60) = 4.85$, $p = .031$, $\eta_p^2 = .08$. Infants spent a larger proportion of time looking at friendly over unfriendly interactions in the asynchrony condition compared to the synchrony condition (see Figure 3). In fact, 45 of the 62 infants showed this pattern of results, $\chi^2(1, N = 62) = 12.65$, $p < .001$. In the synchrony condition, proportion looking to friendly over unfriendly interactions ($M = .51$, $SD = .06$) did not differ from chance level of .50, $t(61) = 1.73$, $p = .089$. However, in the asynchrony condition, this proportion was significantly greater than chance ($M = .53$, $SD = .05$), $t(61) = 4.72$, $p < .001$, suggesting that infants looked longer when asynchronous pairs interacted in a friendly compared to an unfriendly way.

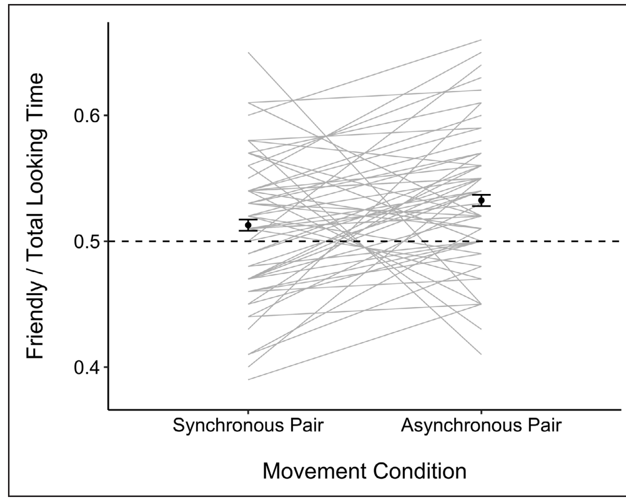

Figure 3. Distribution of mean looking time proportion scores to the friendly interaction ((time looking to friendly trials)/[(time looking to friendly trials) + (time looking to unfriendly trials)]) calculated for each trial pair and then averaged across movement condition). Values over 0.5 suggest that more time was spent looking at friendly compared to unfriendly interactions. Individual infant data are plotted with grey lines. Filled black circles represent mean proportion looking scores. Within-subject error bars represent standard error of the mean (Cousineau, 2005).

To further investigate the role of age on the effect, correlations with age (in days) and proportion looking time were run. Age did not correlate with proportion looking in the synchrony condition ($p = .26$), asynchrony condition ($p = .86$), or with a difference score between these two measures ($p = .45$). These null results provide no support for the hypothesis that infant become more sensitive to expected social consequences of synchronous compared to asynchronous movement synchrony in others between 12 and 14 months of age.

Discussion

Here, we report that infants between 12- and 14-months-old use interpersonal movement to guide social expectations. When watching synchronous and asynchronous movers interact in friendly and unfriendly ways, infants responded differently depending on movement style. More specifically, infants were surprised to see asynchronous partners interact in a friendly compared to an unfriendly way but did not demonstrate such expectations for synchronous partners. These results support the idea that interpersonal movement synchrony and/or asynchrony can signal group membership. Adults, for example, judge synchronous movers to be more socially cohesive and more likely to be part of the same cohesive unit than asynchronous movers (Lakens, 2010). Here, we show that by 12 to 14 months of age, infants are already attending to the interpersonal movements of others and interpret this information as socially meaningful. Future studies may investigate how even younger infants perform on this task, given the null findings with respect to age in the present study.

The primary goal of the asynchrony condition was to present two women moving asynchronously with one another (interpersonal asynchrony). We included background music in these videos to maintain infant interest levels and to prevent infant distress (Corbeil, Trehub, & Peretz, 2016). However, this means that the asynchronous bouncing videos presented one woman moving synchronously and the other moving asynchronously with the background music. That is, audiovisual asynchrony and interpersonal asynchrony are both present. It is therefore difficult to determine which asynchrony drives infants' expectations during the test trials. On the one hand, detection of interpersonal asynchrony relies on unimodal perception and occurs within a social context (comparing one person's movements to another person's movements). On the other hand, detection of audiovisual asynchrony relies on cross-modal asocial perception. By at least 8 months of age, infants are able to detect audiovisual asynchrony between a person's movements and a musical beat (Hannon, Schachner, & Nave-Blodgett, 2017). It is possible that the infants in the present study identified the woman bouncing too quickly as a social outsider. Supporting this idea, adults rated an actress walking out-of-step with the beat of background music (audiovisual asynchrony) as less trustworthy than one walking in-step (Knight, Spiro, & Cross, 2017). However, adults also rate interpersonally synchronous hand wavers in a non-musical context as higher in entitativity than asynchronous wavers (Lakens, 2010; Lakens & Stel, 2011). In addition, experienced interpersonal synchrony shapes infant social preference and prosociality even in non-musical contexts (Cirelli et al., 2017; Tungçenç et al., 2015). This supports the idea that the social effects of synchrony do not require a musical context. Therefore, we speculatively propose that interpersonal asynchrony, and not audiovisual asynchrony, drive the present results. However, future studies are required to disentangle these effects. Regardless, infants are attending to asynchrony (whether interpersonal or audiovisual) and using it to form social expectations.

We had hypothesized that infants would expect synchronous movers to be friends and asynchronous movers to not be friends. However, our findings suggest that the effect of movement condition on social expectation is driven by infant expectations only for asynchronous movers. Infants did not appear to have a clear expectation for synchronous movers. While this null effect in the synchrony condition is difficult to interpret, this may be related to a "negativity bias" in evaluating third-party affiliation. A general negativity bias is well documented in work with adults, children, and infants (for a review, see Vaish, Grossman, & Woodward, 2008). For example, infants as young as 3-months-old show an aversion to negatively valenced characters but no preference for positively valenced over neutral characters (Hamlin, Wynn, & Bloom, 2010). The negativity bias is theorized to represent an adaptive value for identifying negative and potentially dangerous, social information. The present results are also in line with those of Liberman and colleagues (2017) using the looking time paradigm adapted here. In this study, infants watched friendly and unfriendly interactions between same language speakers and different language speakers. While expectations for same language speakers were inconsistent, infants looked longer at friendly compared to unfriendly interactions between different language speakers.

These results suggest that infants use movement asynchrony as a social signal both during firsthand experiences (Cirelli et al., 2014a; Tungçenç et al., 2015) and during third-party observations. These results contribute to a growing body of research on third-party understanding in infants. It appears that infants begin to use different signals for affiliation at different ages. For example, food preference, similarity of language, and acts of prosociality are used by infants as young as 9- to 10-months-old (Hamlin et al., 2007; Kuhlmeier et al., 2003; Liberman et al., 2014, 2017). Signals of social dominance are used by 15-month-olds to predict third-party interactions, and to a lesser extent, by 12-month-olds, but no evidence has been found in younger infants (Mascaro & Csibra, 2012). The results of the present study suggest that asynchrony becomes a social signal that infants use when forming predictions about third-party relationships at as early as 12 months of age. Future research could investigate why certain signals become salient in infancy earlier than others.

It should be noted that this interpretation rests on the assumption that infants are interpreting the "friendly interaction" videos as conveying a positive social interaction and the "unfriendly interaction" videos as conveying a negative social interaction. Based on this assumption, we interpret our results to suggest that infants expect asynchronous partners to be nonaffiliates. An alternative interpretation of the results could be that infants find it more cognitively taxing to process asynchrony during familiarization, which may encourage them to attend more to positively valenced videos during test. However, if this was the case, infants would likely show differential looking patterns to synchronous and asynchronous familiarization trials, which was not found here. Our findings, along with those of Liberman and colleagues (2014, 2017) using a similar test trial paradigm, support the assumption that infants are interpreting the test videos as depicting social affiliation and social aversion.

These findings have implications not only for infant social cognition but also for music cognition. As discussed in the introduction, musical behaviors, such as singing, dancing, and musical production, encourage high levels of interpersonal synchrony. Interpersonal synchrony experienced firsthand encourages prosocial behaviors (e.g., Hove & Risen, 2009; Trainor & Cirelli, 2015; Wiltermuth & Heath, 2009). Observed in third parties, interpersonal synchrony signals affiliation (Lakens, 2010; Lakens & Stel, 2011). This lends support to the social cohesion model of musical behavior, which proposes that musical behaviors are universal and pervasive because they encourage in-group bonding and signal in-group behavior (Brown, 2000; Freeman, 2000; Roederer, 1984). Along with our previous work showing that 14-month-olds use interpersonal synchrony to guide their own prosocial behaviors (Cirelli et al., 2014a, 2014b, 2016, 2017), the present studies suggest that infants also use synchrony to guide third-party social expectations. Together these findings suggest that in real world settings, infants experience musical behaviors as social both when they themselves are involved and also when they watch others sing and dance together.

Conclusion

Here, we show that infants as young as 12 months of age use third-party interpersonal asynchrony to shape social expectations. Specifically, infants are more surprised to see asynchronous compared to synchronous movers interact in a friendly compared to an unfriendly way. These results add to the literature on the development of third-party social understanding and support the social cohesion model of musical behavior.

Contributorship

LKC was the primary researcher and LJT the senior researcher, but all authors contributed to ideas and writing of the manuscript. LKC and SJW created the stimuli, and LKC, SJW, and TCJ tested participants.

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Supplementary material

Supplementary material for this article is available online.

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