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Synchronized movement experience enhances peer cooperation in preschool children

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ABSTRACT

Cooperating with other people is a key achievement in child development and is essential for human culture. We examined whether we could induce 4-year-old children to increase their cooperation with an unfamiliar peer by providing the peers with synchronized motion experience prior to the tasks. Children were randomly assigned to independent treatment and control groups. The treatment of synchronous motion caused children to enhance their cooperation, as measured by the speed of joint task completion, compared with control groups that underwent asynchronous motion or no motion at all. Further analysis suggested that synchronization experience increased intentional communication between peer partners, resulting in increased coordination and cooperation.

Introduction

Cooperation occurs when two or more individuals work together to solve a problem, perform a joint task, or create a product that could not have been created by one individual. Cooperation is essential for sustaining human culture and plays a key role in child social–cognitive development (Hamann, Warneken, Greenberg, & Tomasello, 2011; Warneken, Chen, & Tomasello, 2006). Moral philosophers and economists have long been interested in what induces people to cooperate (Hume, 1738/1978; Rousseau, 1762/1913). Educators seek to “teach” cooperation to young children (Barron, 2000) to prepare for collaborative learning in school and the workforce (Kuhn, 2015).

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The ability to cooperate depends on a basic motivation and willingness to interact with another individual as well as on specific social–cognitive skills (e.g., Brownell, Ramani, & Zerwas, 2006). Previous studies with adults have shown that success in timing-dependent cooperation tasks, such as two people jointly tilting different ends of a wooden platform so that a ball could move through a maze, can be enhanced by exposing the adults to prior experience of synchronous rocking (Valdesolo, Ouyang, & DeSteno, 2010; see also Lang et al., 2016). These findings indicate that in adults certain forms of cooperation are amenable to rapid modulation through prior shared temporal experiences. The aim of the current study was to examine much younger participants (4-year-old unfamiliar peers) using more precisely controlled treatments of prior synchronous movements.

It is currently unknown whether and how synchronous experience may influence subsequent cooperation among unfamiliar child peers. However, there is an extensive literature on the effects of synchrony, or synchrony-rich interactions such as music, on children's social attitudes and behaviors. To better situate the current study within this literature, we briefly review converging lines of research on children and synchrony.

Effects of shared synchrony and music on children's social behavior

Several studies have examined the impact of synchrony on children's attitudes toward one another. For example, Rabinowitch and Knafo-Noam (2015) showed that synchronous tapping enhances 8-year-olds' judgments of their perceived similarity and closeness to each other. Tunçgenç and Cohen (2016a, 2016b), showed that movement synchrony engenders 7- to 11-year-olds' self-reported feelings of "social bond" between children and more helping between pairs of previously acquainted 4- to 6-year-olds. These studies provide evidence for a positive change in attitudes in pairs or groups of children following synchrony.

Cirelli, Einarson, and Trainor (2014) conducted experiments using music in infants. In their study, 14-month-olds listened to a song while being bounced (knee bends) by an adult and facing another adult who performed knee bends in either synchrony or asynchrony with the rhythm of the song. Results showed that the infants who were bounced in this en face synchrony with an adult increased their propensity to extend help to that experimenter.

Other related studies have investigated how making music together influences older children's social behavior. Good and Russo (2016) reported that elementary school children shared with each other more in a Prisoner's Dilemma game following group singing. However, Kirschner and Ilari (2014) studied the effects of 2- to 4-year-olds jointly drumming with an adult and found no change in helping or sharing behaviors toward that adult. Other research has demonstrated that shared musical experience enhances other types of social behaviors in elementary school children, including prosocial skills (Schellenberg, Corrigall, Dys, & Malti, 2015), empathy (Rabinowitch, Cross, & Burnard, 2013), and a sense of social inclusion (Welch, Himonides, Saunders, Papageorgi, & Sarazin, 2014). In one study with kindergarten children, a shared musical experience (dancing, singing, and playing instruments while music is played in the background) prompted children to approach their familiar peers and to play a game jointly rather than individually (Kirschner & Tomasello, 2010).

Music is both a communicative and aesthetic medium. These forgoing effects of music may be due to synchrony but may also stem from other features of the musical interaction and joint music making. Musical theorists have conjectured that music provides players with an experience of freedom from competitiveness as they focus on sound, color, and contour—similarly to Kant's (1790/1951) *disinterested pleasure* idea, which denotes the aesthetic appreciation of music as the heart of the experience—rather than on the desire for some functional/instrumental outcome. Music making is also a joint creation that encourages flexibility in the face of changing patterns and dynamics, which could contribute to a more general "acceptance" of musical partners (Rabinowitch et al., 2013). In addition, meaning in music is ambiguous (whereas most language interactions strive for precision in meaning), permitting a coexistence of contrasting feelings and perspectives among different individuals (Cross, 2001). These qualities of music could engender positive feelings that persist beyond the musical context and contribute to enhanced social interactions (Cross, Laurence, & Rabinowitch, 2010; Huron, 2001). Therefore, it remains important to tease out the specific role of *synchrony* per se, stripped from a musical context, in enhancing children's prosocial behavior.

Rationale for the current study

The current study advances the extant work in this area in several ways. First, we operationalized and tested synchrony in a way that does not involve a musical connotation. Second, we explored the effects of synchrony on peer cooperation. Although previous work on the effects of music and synchrony on children has focused on prosocial behaviors such as helping and sharing, it is noteworthy that these are often tested in a way that is *unidirectional* in nature—Child A shares with Child B with no reciprocity entailed. The cooperative behavior we examined is *bidirectional* and intrinsically involves mutual accommodations and adjustments to the other's behavior in real time. Third, the study explored the influence of synchrony on social behavior between unfamiliar peers rather than between child and adult (in contrast to Cirelli et al., 2014 and Kirschner & Ilari, 2014). Child–adult interactions might involve, for example, the adult purposely adjusting his or her behavior toward the child or other factors (Punch, 2002). Therefore, it is useful for social developmental theory to study the social behavior between children as an outcome measure.

In choosing the age of participants to study, we considered the time course for the development of cooperation. The first unambiguous signs of cooperative behavior are reported to emerge during the second year of life (e.g., Brownell & Carriger, 1990; Brownell et al., 2006; Warneken & Tomasello, 2007). By the age of 4 years, children are capable of engaging in complex goal-directed cooperative tasks (Ashley & Tomasello, 1998). Thus, we sought to test whether engaging 4-year-old dyads in a synchronous experience could modulate their subsequent performance of cooperative tasks.

Importantly, we devised an apparatus that delivered rhythmic synchrony experience in a precise and quantifiable manner to pairs of children who had never met before and tested whether this caused significant increases in peer-to-peer cooperative behavior. For evaluating the efficacy of the synchrony treatment, we also tested separate groups of peers who experienced asynchrony as well as a baseline group.

Method

Participants

Participants were recruited by telephone from the university's computerized participant pool and tested in a laboratory at the university or were recruited on-site and tested at a children's museum in a dedicated room. Preestablished criteria for admission into the study were that the children had no known developmental concerns and had not previously met, according to parental report. The final sample consisted of 162 typically developing 4-year-old children (M_{age} = 53.21 months, SD = 3.06) paired into same-sex dyads. Additional dyads were excluded due to unwillingness to use our apparatus (n = 2) or tiredness/unwillingness to continue in one or both dyad members (n = 4). According to parental report, the sample was middle to upper middle class, with 71.0% White, 4.9% Asian, 0.6% African American, 20.4% mixed race, and 3.1% not disclosed, with 11.7% of the participants being of Hispanic ethnicity. The different ethnicities and races were distributed approximately equally across experimental conditions.

Design

Children (N = 162) were randomly assigned in equal numbers to one of three independent groups: synchrony, asynchrony, or baseline. There were 27 dyads in each of the three groups, of which 14 were female dyads. Sample size was chosen based on a related study with a similar number of dyads (Rabinowitch & Knafo-Noam, 2015). All children participated in randomly ordered rounds of testing, each consisting of swinging together (except for the baseline group; see below), which was followed by the behavioral task.

Apparatus for manipulating synchrony

The experimental treatment used an apparatus specifically designed to deliver the experience of synchrony to child peers in a controlled fashion.

Swing set

We constructed a swing-like apparatus that could move two children in a synchronous or asynchronous manner (Fig. 1). The apparatus consisted of two swings connected to a top aluminum rod. The swing seats were made of plastic and equipped with a safety bar. Black and white striped fabric was positioned in the children's periphery to provide a clear visual reference of movement (Held & Hein, 1963). The movement of the swings was measured by using a beam break sensor to detect each time the swing passed position 0 (orthogonal to the floor), as indicated by the red beam in Fig. 1.

Timing

In pilot studies, we attempted to use an autonomous, motor-driven pendulum swing, but we found it to be too inexact because children differed in weight and moved in the seat, influencing the swing rate and cycle time. Thus, we used trained musicians (>10 years of training) to push the swings according to a specified cycle time.

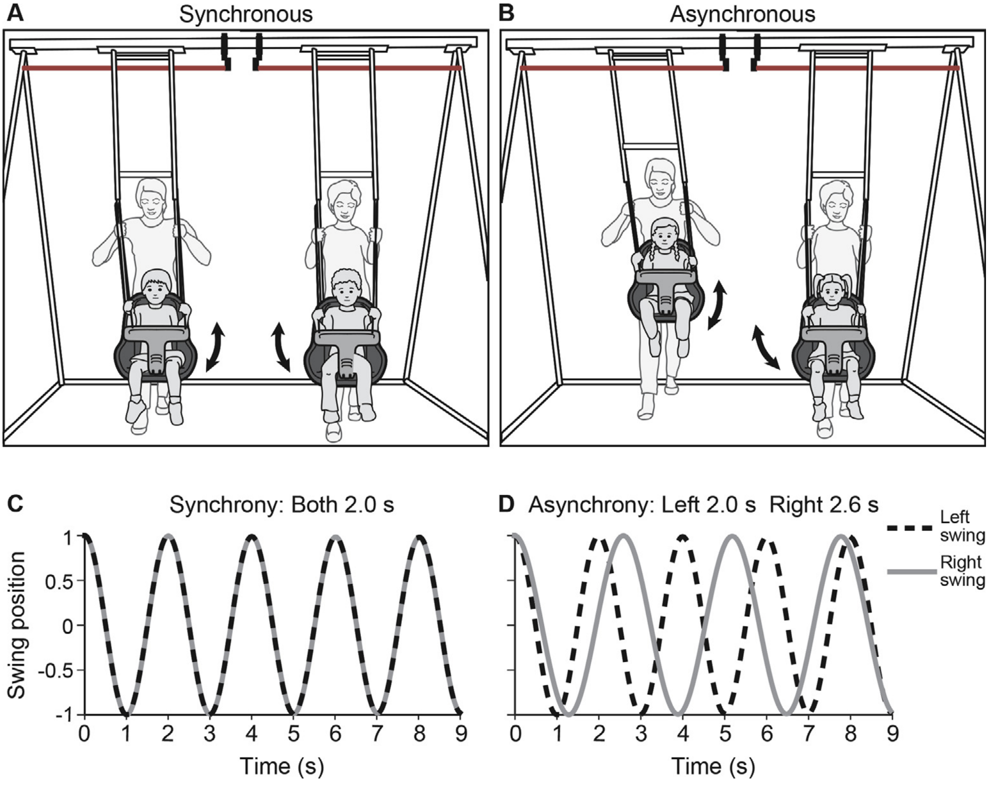

Fig. 1. Synchrony and asynchrony treatment groups. (A, B) Illustrations of 4-year-old peers swinging in (A) synchrony and (B) asynchrony. An infrared beam (red line) fed time stamps to a computer when the plane was broken. (C, D) Averaged swing positions (for a left swing cycle time of 2.0 s) in (C) synchrony and (D) asynchrony. The times when swings were at the −1 position (closest to experimenter) and at the +1 position (farthest from experimenter) were derived from the infrared time stamps using a cosine function to approximate the swing trajectory.

In the synchronous group, the child peers swung in unison with each other. They moved at the same rate and in phase with each other at a cycle time of either 2.0 or 2.6 s, determined by random assignment. In the asynchronous group, one child in the dyad was swung at a cycle time of 2.0 s and the other at a cycle time of 2.6 s. Children in the baseline group were not swung at all.

The swing periodicity was monitored via computer and showed that the intended treatment was achieved. Measured mean cycle time for the 2.0-s swing was 1.999 s ($SD = 0.03$) and for the 2.6-s swing was 2.599 s ($SD = 0.03$). In the synchrony group, the mean, median, and modal temporal gap between the two swings as they passed through the 0 point were 0.01, 0.01, and 0.00 s, respectively. The two experimenters pushed the swings by following two bouncing balls on a computer screen positioned 3.5 m in front of the swing set, with beeps indicating when the swings were supposed to cross the 0 point; these signals were also visible and audible to the children.

Apparatus for assessing cooperation

Cooperative Button-Push task

The Cooperative Button-Push task (Fig. 2A) was adapted from a game developed by Brownell and colleagues (2006). In the original version, two children needed to pull handles in a specially designed device, either simultaneously or in sequence, for a musical toy to start playing. Task-related behaviors were then coded to evaluate the extent of cooperation and social understanding exhibited by the participants.

We adapted this game by creating a computerized task that allowed a precise quantitative measurement. In our version, the children attempted to coordinate their behavior as they pushed button panels for the computer screen to make a sound and show an image. The children could play until they succeeded, and performance was evaluated as the number of attempts until success. The task consisted of a series of boxes sequentially appearing on a computer screen. For the top of the box to open (and an animated figure to pop up), both children needed to simultaneously push their buttons. This required the child peers to coordinate their actions to achieve the goal; both of the 4-year-olds needed to push the button at the same time (just as in the original Brownell et al. (2006) task, where children needed to pull the handles at the same time). Simultaneous button pushing could be precisely defined in this task; it was the difference between the two participants' button-pushing times of $\Delta T \leq 80$ ms (measured via computer). This 80-ms cutoff time to define "simultaneity" was determined in a pilot study, which revealed that such a ΔT was challenging and yet attainable for 4-year-olds as a window for simultaneity, and so it was programmed into the software (using Inquisit 4) for triggering the fig-

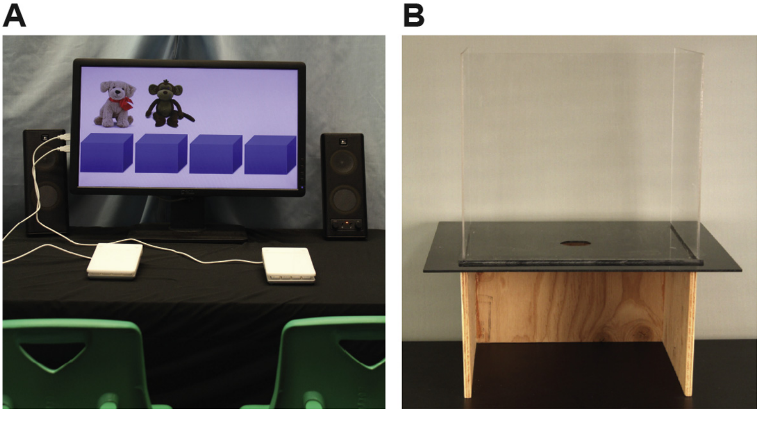

Fig. 2. Apparatus used. (A) Cooperative Button-Push computer device, with two of four animal figures in popped-up position. (B) Cooperative Give-and-Take apparatus from Giver's perspective. The vertical Plexiglass screen blocks the Giver from reaching the hole from the top; a wood panel blocks access to the hole from underneath on the opposite side, where the Taker would be positioned.

ure pop-ups before the experiment began. The children's task was to repeatedly push the buttons until success. Successful (simultaneous) button pushes triggered an opening of a box with an animated figure popping up followed by a 3-s tune, marking success on that trial. The animated figures were images of a dog, monkey, lion, and giraffe. A different brief tone indicated failed attempts. The buttons pushed by the children were made of white Plexiglass (13 × 9 cm).

Cooperative Give-and-Take task

The Cooperative Give-and-Take task (Fig. 2B) was administered to test the generality of the effect beyond the Cooperative Button-Push task. This task required the 4-year-olds to pass objects from one to the other through a hole in a specially designed apparatus (adapted from Warneken, Gräfenhain, & Tomasello, 2012). Participants were positioned at opposite sides of the device, so that one child ("Giver") could only access the hole from the bottom (a Plexiglass screen blocked direct access) and the other child ("Taker") could only access the hole from the top. Each child was given a black 12.5-cm-diameter bucket. The Giver needed to sequentially pass through the hole four plastic red tubes and a marble from his or her bucket. The Taker needed to retrieve these objects as they were handed up through the hole and then place each in his or her own bucket.

Procedure

Pairs of same-sex children who had never before met were randomly assigned to one of three experimental groups—synchronous group (synchronous movement experience), asynchronous group (asynchronous movement experience), or baseline group (no prior movement experience)—for measuring performance in the absence of any treatment. Following the treatment, each dyad was administered the Button-Push and Give-and-Take cooperative tasks (as well as a third unrelated task designed to evaluate children's individual sense of fairness [Fehr, Bernhard, & Rockenbach, 2008] to be reported elsewhere).

For the synchrony and asynchrony groups, each task was administered in three phases: (a) demonstration of the task, (b) swinging treatment (2.5 min), and (c) a test period assessing children's performance on the behavioral task. Children first received these three phases (a–c) for one behavioral task (e.g., Cooperative Button Push) and afterward received these three phases for the other behavioral task (e.g., Cooperative Give-and-Take), with the order of these tasks counterbalanced.

The behavioral task was demonstrated and explained prior to the swinging treatment to reduce the delay between the treatment (e.g., synchrony experience) and the test of the cooperation tasks. Children from the baseline group were given the behavioral task demonstration and then directly tested on the cooperation tasks. The main purpose of the baseline was to obtain naive cooperation levels in the absence of a specific treatment. Our hypothesis predicted better cooperation following synchrony compared with asynchrony, but this could be due to either synchrony enhancing cooperation or to asynchrony reducing cooperation relative to naive performance. The baseline condition could help to distinguish between these possibilities.

Dyad members of all groups were briefly introduced to each other by first name at the start of the experiment. There was no other rapport-building phase. Test sessions were video-recorded.

Cooperative Button-Push procedure

For the demonstration of this task, the two experimenters sat at the table where the buttons and screen were placed, and the children watched. Experimenter 1 explained to the children how to play the game. Then, Experimenters 1 and 2 each pushed their own buttons, showing that simultaneous button pushing led to the visual reward of the animal figures popping up from the box on the screen. Following this, children were informed where they would sit (in the chairs where the adults now sat) and which button each of them would use. Importantly, the children did not try the game themselves during the demonstration; they had no hands-on experience or a chance to practice. Immediately prior to testing, the experimenters reminded the children that they needed to press their buttons together. The children were asked to perform the game for a block of four trials (using a different animated pop-up figure each time). In each trial, the children pushed their buttons repeatedly until successful completion, whereby both buttons were pushed simultaneously. The average trial duration was 18.4 s (*SD* = 15.4), that is, about 18 s before children achieved coordination and the animated pop-up figure appeared.

Cooperative Give-and-Take procedure

For the demonstration of this task, the experimenters showed the children how the toys could be passed through the hole from beneath the black surface and retrieved. As the children watched, Experimenter 1 ("Giver") picked each of the toys from her bucket and passed it under the black surface and through the hole to Experimenter 2 ("Taker"), who retrieved the toy and put it in her bucket. A Plexiglass barrier in front of the Giver prevented direct giving and taking; thus, the Giver needed to pass objects from beneath a hole in the tabletop surface, so that the Taker could reach and retrieve them. The children did not touch or handle the toys or try the game during the demonstration. Immediately prior to testing, the experimenters reminded the children that the Giver needed to pass the toys through the hole one at a time to the Taker, and they were asked to perform the task as quickly as they could. The roles of the Giver and Taker were assigned randomly. Each trial was performed until it was successfully completed.

Scoring and dependent measures

Cooperative Button-Push task

During each trial, both participants pushed their buttons until they were able to successfully push them simultaneously. We counted the number of nonsimultaneous ("failed") button pushes preceding the first simultaneous ("successful") button push during the trial. Each button push by a child that was not simultaneous with a button push by the other child was counted as a failed button push. This measurement was objectively obtained using the computer software record (Inquisit 4 software recording button pushes). The number of failed button pushes from both children during a trial was averaged across the four test trials (each trial ended with a simultaneous button push; all dyads were able to achieve this), so that a lower number of failed button pushes was used to indicate better coordination and cooperation. The rationale was that children who were more coordinated would be able to more swiftly achieve simultaneous button pushing.

Intention communication

It was evident from watching the children in the Cooperative Button-Push task that many of them spontaneously created gestures that seemed to signal a prior intent to cooperate to their peer. Children often used stylized large hand motions ("flourishes" or "signals") indicating that they were about to push the button. Thus, for each trial, a score was also assigned to reflect how high the children lifted their hand above the button before pushing it. This was scored from the videotape by two independent coders. The scoring per trial was as follows: (a) a score of 1.0—both members of the dyad clearly lifted (>5 cm) a hand above the button before pressing it; (b) a score of 0.5—only one of the children did so; (c) a score of 0—neither child did so. The hand-lift score assigned to the dyad was the mean for the four trials. (Although hand lifting of only one dyad member could communicate the intent to button press, joint hand lifting is more likely to indicate mutual intention communication and thus received a higher score—1.0 vs. 0.5.) A measure of scoring agreement (kappa) for a random sample of 26% of the trials showed good agreement. The intra- and inter-scorer agreement were both κ = .90. A small portion of data (2.5%) could not be scored (e.g., the child obstructed the video view).

Cooperative Give-and-Take task

This measure of successful cooperation was scored from the videotape by two independent coders. Time to success was defined as the time gap (latency) between when each object became visible in the hole to when the Taker successfully grabbed it. Because the distribution of the raw time to success was skewed (skewness = 4.5, *SE* = 0.27; kurtosis = 23.59, *SE* = 0.53), we applied a log10 transformation to the values (skewness and kurtosis values decreased to 1.96 and 5.59, respectively; see Lundwall, Dannemiller, & Goldsmith, 2015), which were then averaged over the four trials. The four trials with the red tubes were used for analyses because the marble often slipped through the hand of the Taker; however, statistical results remained significant with and without the marble. Scoring agreement was calculated using a random sample of 26% of the trials. The intra-class correlation coefficient (ICC) was high for both the intra-scorer (.93) and inter-scorer (.92) assessments. A small percentage of the data (3.5%) could not be scored.

Children's looking

Synchronous swinging may allow more opportunities for eye contact between child peers than asynchronous swinging. With parental permission, a video camera was positioned facing the swing set, and a coder subsequently scored children's looking for 18 dyads (8 synchronous dyads and 10 asynchronous dyads) during the treatment phase. (Other dyads could not be filmed because this camera either malfunctioned or was unavailable for the test session; two additional cameras were always used to film the behavioral outcome tasks, with one camera focused on each task.) Children's looking was scored from the videotape by two independent coders. The coders recorded the time per swing session during which children looked at the other's face. There was no significant difference, $t(16) = 0.195$, $p > .80$, between the synchronous dyads ($M = 22.65$ s, $SD = 15.61$) and the asynchronous dyads ($M = 24.06$ s, $SD = 14.91$). A second coder also scored the looking behavior with satisfactory agreement: The ICC was .98 for the intra-scorer agreement and was .95 for the inter-scorer agreement.

Results

Cooperative Button-Push task

In the Button-Push task, the 4-year-olds needed to push a button at the same time to obtain a visual reward of seeing a pop-up animated figure (Fig. 3A). The number of failed button presses prior to success was automatically calculated over four trials by the computer software. An analysis of variance (ANOVA) showed a significant effect of experimental group, $F(2, 80) = 3.34$, $p = .04$, $\eta_p^2 = .08$. As predicted, children randomly assigned to the synchrony group performed significantly better ($M = 9.87$ failed button presses before success, $SD = 4.74$) than children from either the asynchrony group ($M = 14.37$, $SD = 10.11$), $p = .02$, or the baseline group ($M = 15.08$, $SD = 8.31$), $p = .04$, as determined by pairwise comparisons using Fisher's least significant difference (LSD) procedure (see Fig. 3B).

Cooperative Give-and-Take task

An ANOVA showed a significant effect of experimental group, $F(2, 78) = 4.12$, $p = .02$, $\eta_p^2 = .10$. The relevant means are displayed in Fig. 3D. Pairwise comparisons using Fisher's LSD procedure revealed that children who had been randomly assigned to the synchrony experience performed significantly faster ($M = 1.02$ s, $SD = 0.03$, or -0.03 log s) than children from either the asynchrony group ($M = 1.53$ s, $SD = 1.17$, or 0.08 log s), $p = .01$, or the baseline group ($M = 1.50$ s, $SD = 1.42$, or 0.08 log s), $p = .01$.

Intention communication

In the Cooperative Button-Push task, many children used large, stylized hand-lifting motions (Fig. 4A) in a manner that may have been a signal to their partner that they were about to push the button (see "Scoring and dependent measures" section in Method). To examine whether hand lifting was associated with task performance, we split the dyads into two groups. An examination of the distribution of scores suggested a simple dichotomous division (median split), with 56.25% of dyads achieving a hand-lift score of 1.0 and the remaining dyads being distributed between 0.0 and 1.0. Thus, we created two groups corresponding to "high" (1.0) and "low" (<1.0) hand lifting. The results showed that dyads with high hand-lift scores performed significantly better on the Cooperative Button-Push task ($M = 10.23$ failed button presses, $SD = 6.1$, $n = 45$) than dyads with low hand-lift scores ($M = 16.86$ failed button presses, $SD = 9.3$, $n = 35$), $t(78) = 3.83$, $p < .001$, Cohen's $d = 0.84$ (Fig. 4B). We next compared the extent of hand lifting as a function of experimental test group. An ANOVA showed significant variation by experimental group, $F(2, 79) = 5.39$, $p = .006$, $\eta_p^2 = .14$, and pairwise

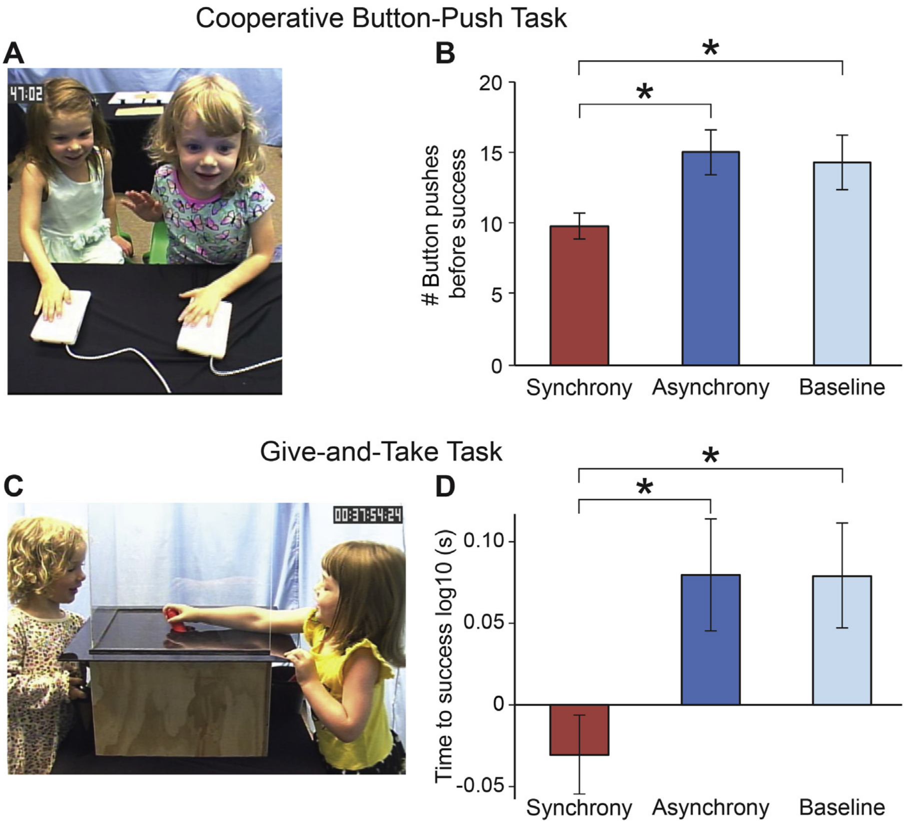

Fig. 3. Cooperative tasks. (A) Illustration of child peers performing the Cooperative Button-Push task. (B) ANOVA shows that performance on the Button-Push task differs as a function of experimental group; significant post hoc pairwise comparisons are indicated. (C) Illustration of child peers performing the Cooperative Give-and-Take task, with receiving child (Taker) on the right. (D) ANOVA shows that performance on the Give-and-Take task differs as a function of experimental group; significant post hoc pairwise comparisons are indicated. $^{*}p < .05$. Error bars = ±1 standard error.

comparisons (Fisher's LSD) revealed that dyads in the synchrony treatment exhibited significantly larger hand-lift scores ($M = 0.95$, $SD = 0.16$) than those in the asynchronized treatment ($M = 0.74$, $SD = 0.29$), $p = .002$ (Fig. 4C). The baseline group ($M = 0.84$, $SD = 0.19$) was midway between and did not significantly differ from either the synchrony group, $p = .09$, or the asynchrony group, $p = .11$).

Discussion

A treatment of joint synchronized movement was sufficient to influence 4-year-old children's cooperative behavior with a peer. Compared with asynchronized movement or no movement at all, this synchronous experience decreased the time required for completing two joint tasks, indicating better cooperation between the children. The nature of the synchronous experience was well specified in this study; the movements on the swings were precisely quantified and under experimental control, so we are able to say with certainty what was the nature of the prior experience.

The current work goes beyond previous studies in five ways that are important for social–cognitive theory and for isolating the mechanisms involved. First, we investigated interactions between child *peers* rather than between child and adult. Second, our outcome measure involved *cooperative behavior* on two different tasks, whereas most of the previous work with children has involved helping behav-

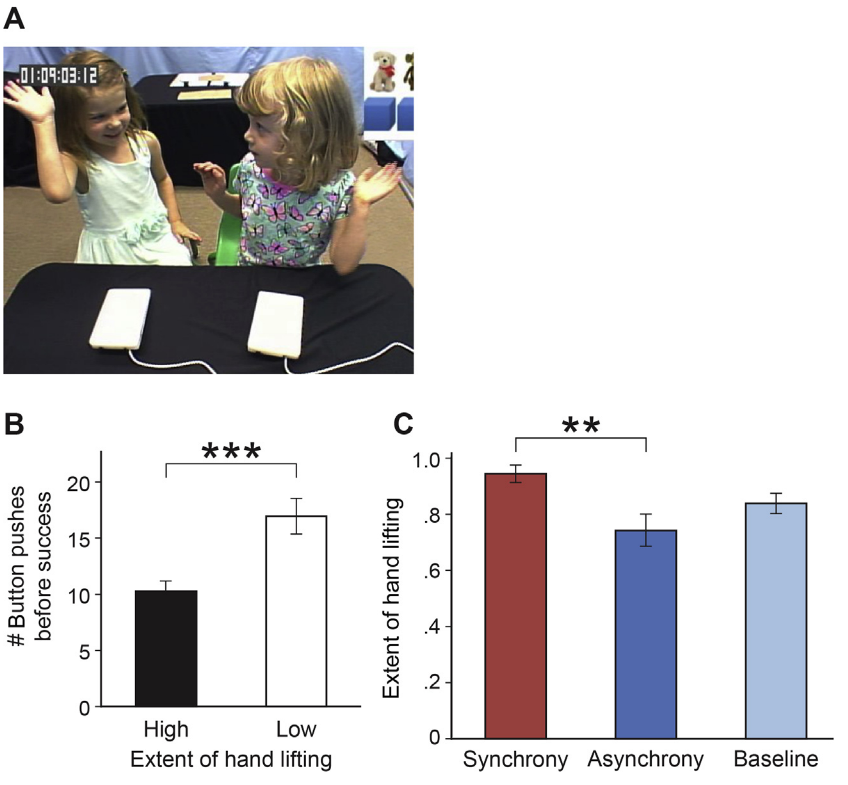

Fig. 4. Hand lift as a communicative signal. (A) Children lifting their hands in a stylized manner during the Cooperative Button-Push task. (B) Relation between extent of hand lifting and joint performance score in the Cooperative Button-Push task. The dark bar shows the number of button pushes prior to success for trials in which there was high signaling ($n = 45$; high hand-lift scores). The white bar shows the number of button pushes prior to success when there was low signaling ($n = 35$; low hand-lift scores). (C) ANOVA results show that the extent of children's hand lifting significantly varied as a function of experimental group, with significant pairwise comparison indicated. $^{**}p < .01$; $^{***}p < .001$. Error bars = ±1 standard error.

ior. Third, in the current design, we have now extracted *movement synchronization*, devoid of musical context, and found that synchrony experience increases children's subsequent cooperative behavior (of course, this does not exclude a prosocial contribution of additional features of music). Fourth, we isolated *synchrony and not more general rhythmic experience* as a key factor affecting cooperation. *Both* the synchronous and asynchronous treatment groups experienced rhythmic movements (both groups of children were rhythmically swung). However children in the synchronous group showed significantly increased levels of cooperative performance compared with the equally rhythmic, but not synchronous, group (more general rhythm, but not synchrony, was used with adults; Lang et al., 2016). Fifth, the outcome is not restricted to a task relying on simultaneous matching movements (as used in the adult studies by Lang et al., 2016 and Valdesolo et al., 2010). We found significant effects in the Button-Push task, where children did the same action at the same time, and also in the Give-and-Take task, where they cooperated by adopting *complementary* roles (with one child inserting an object from beneath the black tabletop surface and the other child taking it from above the surface).

The central question that arises from this work is how an episode of synchronous experience, under experimental control, works to increase subsequent peer cooperation. Although we can provide only speculative answers, the current data support two relevant inferences.

First, cooperation requires more than one person working individually, and a key element in cooperation is communicating the intent to cooperate—the signaling of goals/intentions between partners so that individuals can work as a team and coordinate their efforts (Warneken et al., 2012). Therefore, it is interesting that in the Cooperative Button-Push task, the peers used large hand motions and other signals (Fig. 4A) to indicate to their peer partner that they were about to push the button. Although large hand excursions were *not physically necessary* for success, lifting a hand in this stylized manner could serve to communicate intent to button push, which would enable the other peer to coordinate their simultaneous push. Thus, a proximal mediator of enhanced cooperation might be the increase in nonverbal communication to the peer partner—intentful signaling of prospective behavior. This communication would allow the children to contact their buttons at the same time and succeed in making the animated figure pop up.

At a more abstract theoretical level, one might speculate about the motives and mechanisms that induce children to act the way they do after the synchrony experience. Broadly put, the critical mechanisms underlying the synchrony effect could be perceptual–cognitive or social–emotional (these are not mutually exclusive, of course).

According to the former, synchronized swinging should draw children's attention to temporal relationships—start points, end points, and simultaneous movements in space (Khalil, Minces, McLoughlin, & Chiba, 2013). By focusing attention on the temporal domain, children may have been better able to coordinate their behaviors in time (e.g., the button task required temporal processing of "simultaneity"). In future studies, it would be interesting to explore specifically whether general attention, as well as more general executive function capacities, contributes to cooperation (see Brownell et al., 2006, for a related study). The perceptual–cognitive explanation alone, however, would seem to best fit the simultaneous Button-Push task. Something more is suggested by the second task, in which complementary roles (not simultaneity per se) were adopted by the children.

According to a more social–emotional view, experiencing synchronous movements induces feelings of affinity or "likeness" with the partner (Meltzoff, 2007), which might enhance cooperation. Temporally coordinated actions, including synchronous communication, play a significant role in the development of positive parent–infant relationships (Feldman, 2007). In adults, synchronization has been shown to affect a range of prosocial attitudes. This might help to account for why children from the synchrony group were more communicative with each other (i.e., engaged in the hand-lifting signaling) when compared with children from the asynchrony group. Further research will be necessary to better distinguish between these two options and to reveal more details about the deeper mechanisms underlying the synchrony effect demonstrated here.

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