The influence of interpersonal synchrony on helping behavior, social bonding, and empathy in children

Mykaela Holt

Department of Psychology, MacEwan University

Honors Psychology

Dr. Tara Vongpaisal

Abstract

The current study examines the influence of interpersonal synchrony on typically developing three- to five-year-old children's empathy and helping behavior. In a replication of a spontaneous helping task developed by Kirschner & Tomasello (2010), fish food is spilled on the way to an imaginary fish tank, creating an opportunity for child participants to help their play partner (adult or same-aged children) at the cost of the immediate gratification of feeding their own fish. Cognitive and affective empathy were measured in an emotion assessment task following the fish food incident using a 7-point Likert scale. Both prosocial and empathy measures were assessed before and after the clapping task, where children clapped to metronome sounds that were either in-synchrony or out-of-synchrony. It was found that helping behavior and empathy were not significantly higher in the synchronous condition when compared with the asynchronous condition. Furthermore, pairwise comparisons of helping and empathy measures prior to and following the clapping task remained unchanged across synchronizing conditions, and there were no differences in the frequency of eye-contact and smiles during the clapping task. Although no trend emerged wherein children were more likely to help same-aged peers when compared with adult playmates, follow-up studies with modifications to the task demands are needed to optimize the performance of child playmates. While our findings do not show an effect of interpersonal synchrony on enhancing the social connections and prosocial abilities of the children in our current sample, further research is needed to explore possible age-related differences that may account for discrepancies observed between the current study and those reported in previous research.

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Prosocial Behavior and In-Group Bias

Prosocial behaviors comprise any action that benefits another (Penner et al., 2005). Such behaviors include helpfulness, sharing, comforting and cooperation, along with more group-orientated behaviors such as volunteering and altruism. There is evidence that prosocial attitudes emerge early in development. For instance, infants as young as four and a half months old preferred "helpers" over "hinderers" after watching a short video of a struggling puppet whose problem was either solved or worsened by another individual, respectively (Hamlin, 2013). Relatedly, two-year-old toddlers have been observed to aid an unfamiliar adult retrieve an out of reach object in the absence of reward, parental supervision, and parental encouragement, indicating that instrumental helping behaviors may be intrinsically motivated (Warneken & Tomasello, 2012). Whether prosocial behavior can be increased through a direct intervention that promotes empathy, however, is a question that has received little research attention.

While the studies described above suggest that humans are inherently prosocial, Hamlin et al., (2013) found that infants' innate moral compass does not envelop all individuals. This was demonstrated by presenting nine- and fourteen-month-old children with two puppets whose snack preferences were either similar or dissimilar with that of the child's. The children then watched a series of puppet shows—starring either the similar or dissimilar puppet—who were helped and then hindered (or vise versa) by two unfamiliar puppets when attempting to accomplish a goal. It was found that children in both age groups favoured the helper puppet when the similar puppet was used but preferred the hinder puppet when the dissimilar puppet was used (Hamlin, et al., 2013). That is, young children showed a preference for unfavorable

treatment directed those who were dissimilar to themselves, thus showing a distinct positive in-group and negative out-group bias.

A similar in-group bias has been exhibited in older children. In one such study, three- to eight-year-old children were paired with an anonymous partner and instructed to distribute pieces of candy between themselves and the absent child (Fehr et al., 2008). A group photo of either the child's classmates or unfamiliar children was presented on the table, cueing the child of their partners in-group or out-group status. The researchers found that both age groups allocated more resources to those identified as the in-group when compared with the unfamiliar out-group (Fehr et al., 2008). Taken together, the results suggest that preferences for members within a child's group begins at an early age, and that these preferences are motivated by self-similarity with in-group members.

Prosocial Behavior and Interpersonal Synchrony

Interpersonal synchrony (moving simultaneously with the actions of another person) can prime in-group biases by creating perceptions of similarity between synchronizing individuals (Cirelli, 2018). Actions such as dancing, marching, chanting, and tapping all serve to create an harmonious atmosphere that facilitates group-cohesion and bonding, leading to greater feelings of empathy, liking, and prosocial behavior towards those participating in the synchronized movement (Cirelli, 2018; Hove & Risen, 2009; Kirschner & Tomasello, 2010; Valdesolo & Desteno, 2011; Wiltermuth & Heath, 2009). Furthermore, while synchronizing with a metronome next to a passive observer does not lead to increased feelings of affiliation towards the individual, simultaneous movement with another does (Hove & Risen, 2009). Thus, interpersonal synchrony, and not just synchrony by itself, is needed to for behavioral change to occur.

Evidence indicating children associate the synchronizing partner as a member of the in-group was demonstrated in a study done by Cirelli and colleagues (2016), who examined the social transitivity of interpersonal synchrony in 14-month-old infants. In their study, the experimenters performed a skit where they engaged in one of two behaviors: greeting an adult confederate warmly and having a short engaging conversation with them (interaction condition) or delivering a separate monologue alongside the confederate (no interaction). While the infant showed increased helping behavior for the confederate in the interactive condition, baseline was maintained toward the confederate in the non-interactive condition. This suggests that infants not only considered their synchronizing partner a member of the in-group but extended this preference for associates of their partner as well (Cirelli et al., 2016).

In continuation of the in-group hypothesis, interpersonal synchrony was found to decrease negative outgroup bias in eight-year old children, who were randomly assigned into two arbitrary groups and performed choreographed dances either synchronously or asynchronously with those of the other group (Tunçgenç & Cohen, 2016a). Interestingly, children in the synchronous condition displayed increased ratings of emotional closeness towards the out-group when compared with baseline attitudes. Furthermore, children in the synchronous condition stood in closer physical proximity to out-group members during an interactive game than those placed in the asynchronous condition, suggesting synchrony can increase acceptance towards those identified as different from themselves (Tunçgenç & Cohen, 2016a). Taken together, the implications of engaging in joint coordinated actions with others can enhance social bonds, reduce negative biases toward others, and increase social function by encouraging group cooperation towards a common goal.

Types of Interaction Partners

Children appear to respond similarly regardless of the identity or age of their synchronization partner. In an experiment conducted by Tunçgenç and colleagues (2015), nine- and twelve-month-old infants were rocked in a car seat while watching a video of two similarly rocked teddy bears. One such teddy bear rocked synchronously with the infant, while the other rocked asynchronously with the infant. When given a choice, the twelve-month-old infants chose the in-synchrony bear more often than the out-of-synchrony bear, with the nine-month-old infants displaying no preference for either (Tunçgenç et al., 2015). The findings show early age-related differences in discrimination and preferences for synchronous behavior.

Similar behaviors occur when a human partner (rather than an inanimate object) are used. In one such study, 14-month old infants were bounced either synchronously or asynchronously with an adult experimenter who was standing directly across from the infant (Cirelli et al., 2014). When coloring with the experimenter afterwards, the infants picked up more dropped markers and did so quicker for their synchronous partner than for their non-synchronous partner (Cirelli et al, 2014), demonstrating that synchrony can increase children's prosocial actions towards older aged partners.

Studies conducted on children and their same-aged peers have revealed complementary findings to those discussed above. For instance, eight-year-old children rated themselves as more similar and closer to a person they tapped synchronously with than those they tapped asynchronously with (Rabinowitch & Knafo-Noam, 2015). Researchers Good & Russo (2016) found that eight-year-old's who participated in a group singing activity displayed more prosocial behaviors than those who participated in a competitive game or art activity, indicating that synchrony can influence prosocial behavior well into childhood.

The influence of interpersonal synchrony on younger children has also been demonstrated. Four-year-old children, for example, have shown increased willingness to share resources following synchronized swinging with an age-matched peer (Rabinowitch & Meltzoff, 2017). In another notable study, four-year-old children who marched and sang together showed greater helping and cooperation in comparison to a similar non-musical task (Kirschner & Tomasello, 2010). Synchrony was also found to bolster helping behaviors and social bonding in four-year-old children in non-musical contexts, as seen through increased instrumental helping, eye-contact, and the number of individual and mutual smiles (Tunçgenç & Cohen, 2016b). Interpersonal synchrony, then, has the potential to increase prosocial behavior towards a synchronization partner, no matter the age or identity of the synchronizing individual.

Research Aims

The primary aim of the current study is to extend previous research by examining if interpersonal synchrony has real world significance in improving children's helping and empathy behaviors. This will be done by replicating established tasks conducted by Tunçgenç & Cohen (2016b), with helping and empathy measurements completed before and after the synchronization task. Because interpersonal synchrony was observed to have a direct influence on affective aspects such as likability (Hove & Risen, 2009) and emotional closeness (Tunçgenç & Cohen, 2016a), it is expected that children's prosocial and empathy behaviors in the synchronous condition will increase from baseline, while those in the asynchronous condition will remain the same.

Additionally, interpersonal synchrony research on children (Tunçgenç & Cohen, 2016b) and adults (Wiltermuth & Heath, 2009) have observed increases in social bonding behaviors, as seen by eye contact, individual and mutual smiles, and feelings of being on the same team. As

such, Tunçgenç & Cohen's (2016b) measurement of social bonding behaviors will be employed to determine if the results can be replicated in the current study.

Unlike research previously conducted with adults (Valdesolo & Desteno, 2011), Tunçgenç & Cohen (2016) found no relationship between empathetic responses and the level of helping behavior across synchronizing conditions. Considering similarities between interpersonal synchrony and mimicry in increasing children's prosocial responses (Hove and Risen, 2009; Stel et al., 2008), and the relationship between mimicry and empathy (Stel et al., 2008), this finding is unexpected. However, the researchers only examined affective empathy, and not cognitive empathy.

Cognitive empathy is defined as the ability to understand what another individual may be thinking and feeling during a certain scenario and is associated with perspective taking (Zoll, & Enz, 2005). In contrast, affective empathy is the ability to feel what one perceives another individual to feel during a specific situation and is linked with personal distress and empathetic concern (Lishner et al., 2011; Zoll, & Enz, 2005). The researchers proposed that affective empathy stems from cognitive empathy, thus making cognitive empathy more readily accessible than affective empathy (Zoll, & Enz, 2005). Although there is evidence that affective empathy is a stronger predictor of prosocial behavior than cognitive empathy (Imuta et al., 2016), the ability to comprehend another's feelings may serve as an additional motivator for helping behavior and provide the child with a greater understanding on how to help. Furthermore, there is a close association between cognitive empathy and theory of mind (ToM), with ToM increasing substantially during the preschool years (Imuta et al., 2016; Peterson et al., 2012; Wellman et al., 2001). As such, we predict that cognitive empathy will be increased to a greater extent than affective empathy following interpersonal synchrony. Furthermore, we predict that rises in both

cognitive and affective empathy will be directly related to the amount of helping behavior observed from the child, as children will not only feel that need to help but they will better understand how to help.

Lastly, because synchrony has been shown to influence prosocial behavior in children, the findings of the current project will have implications on devising strategies to help children who have difficulties with social-emotional processing skills.

Method

Experiment 1

Participants

A total of 24 children (12 female and 12 male) of mixed socio-economic status and ethnicities were included in the final sample of the study. Children were recruited from MacEwan's Early Learning Childcare Center and the Leapah's Learning Garden program at Ortona Gymnastics Club. In addition, one child participated in the study on site at the Child Developmental Laboratory at MacEwan University. Children were paired with an adult playmate and randomly assigned to the synchronous (n =12) or asynchronous (n =12) condition. Six children were excluded from the final sample due to unwillingness to participate (n = 3), non-compliance with project tasks (n = 1), experimenter error (n = 1), and failure to notice the spilled fish food (n = 1). Adult playmates included four volunteer students from MacEwan's psychology department, and the research supervisor for the current project. Children aged three- to five-years-old were included in the synchronous condition (M = 56.0 months, SD = 9.42 months, range = 42-67 months) and the asynchronous condition (M = 53.8 months, SD = 5.55 months, range = 47-64 months) of the current study.

Materials and Procedures

In addition to examining differences between groups, measurements of helping behavior (i.e. the fish feeding task) and empathy (i.e. the empathy rating task) were recorded both before and after the clapping task to determine if individual differences in behavior were affected by interpersonal synchrony. Video recordings were taken for the fish-feeding task, and video and audio recording were taken for the clapping task for off-line coding. The entire procedure was completed during a single 15-minute session.

Fish Feeding Task. A replication of the Kirschner & Tomasello (2010) helping task was conducted in the present study. Participants were first shown a bowl of "fish food" containing five different colors of spray painted wooden balls (red, yellow, blue, green, and purple) and told to sort each type of fish food into the tube of its corresponding color (12 items per tube). The purple tube was used as practice, with the child helping the experimenter sort all the purple fish food into the purple tube. The child would then carry the tube over to a fake aquarium to "feed the fish". The aquarium was a box decorated with images of fish that was positioned close to the clapping task set-up. Once the training phase was completed, the child repeated the task alongside an adult playmate, with each sorting the food into their own separate tubes. By design, the tube used by the older playmate had a loosely fitted bottom cap such that when picked up, the food items spilled on the floor. This created an opportunity for helping behaviour to occur at the cost of immediate gratification for the child, as they would have to either delay the desirable task of feeding the fish or proceed without their adult playmate. The fish feeding game was performed a second time with the remaining two fish feeding tubes following the completion of the clapping task.

Video recordings were analyzed offline and coded for the following behaviors: time spent actively helping to pick up the fish food (i.e., as defined by intentionally moving fish food

towards playmate or directly into their partners fish tube), the number of items picked up, and time spend waiting but not helping.

Empathy Rating Task. After the fish feeding game the child was presented with a 7-point Likert scale ranging from very sad (1) to very happy (7), with a neutral score provided in between the two extremes (4) to assess cognitive and affective empathy. A visual representation in the form of cartoon faces were provided for each level of emotion. The experimenter explained the meaning of each face and informed the children that the cards were used to understand each other's feelings. Task comprehension was assessed using two practice questions ("how would you feel if you got to go eat your favorite kind of ice-cream?" and "pretend that your favorite ice-cream spilled on the floor before you were able to eat it. Now how would you feel?"). Once understanding of the task was confirmed, the experimenter proceeded to ask two questions measuring cognitive empathy ("how do you think the fish felt when you fed them their food?" and "how do you think your partner felt when their fish food spilled on the floor?") and two questions measuring affective empathy ("how did you feel when you fed the fish?" and "how did you feel when you saw your partner's fish food spilled on the floor?"). The children were given stickers that they could place in the box under the face that best represented their feelings. All four of the questions (with the exclusion of the two practice questions) were repeated following the second fish feeding task. When questions were directed towards the imaginary fish, low scores (i.e. answers of 1, 2, or 3) indicated low cognitive and affective empathy, while high scores (i.e. answers of 5, 6, or 7) indicated high cognitive and affective empathy. Questions regarding the child's playmate had the opposite pattern, with low scores indicating high cognitive and affective empathy and high scores indicating low cognitive and affective empathy.

Clapping Task. ***Training Phase.*** A laminated paper displaying outlines of each hand was placed in front of both the child and the experimenter, who sat adjacent to each other. The experimenter first demonstrated that the child was to alternatively clap their hands together, and then tap their hands on the cards in front of them. Next, the child was instructed to tap and clap along to metronome sounds that were played through headphones for a total of 45 seconds. The experimenter clapped and tapped along with the child during the first 20 seconds of the track, and then instructed the children to continue clapping and tapping on their own, with the child receiving feedback and praise from the experimenter. The entire audio track was repeated if needed, however, only a maximum of two trials were administered in order to reduce the risk of frustration and fatigue in the young participants.

Test Phase. After training, the child participant and the adult playmate sat across from each other and were given separate hand cards and headphones, which were connected to the Focusrite, Scarlett 6i6 2nd generation 6-in/6-out USB audio interface that allowed audio tracks to be played from a single device. In the in-synchrony condition, children and their play partner heard the same drumbeat track played at 50 BPM. In the out-of-synchrony condition, children and their play partner heard separate drum tracks that were offset in time (50 BPM and 80 BPM). Partners clapped either in-synchrony or out-of-synchrony with their adult playmate based on random assignment to the two conditions. Digital audio recordings and video recordings of the clapping activities were recorded for offline analysis of timing accuracy.

In order to better match each tap with the correct participant, the hand card for the child participant was placed on the table, while the hand card for the adult participant was placed on top of a box covered in aluminum foil. This allowed for audio recordings of clapping sounds to be distinguished acoustically in audio recordings. Interobserver reliability of synchronization,

eye contact, and the number of individual and mutual smiles was calculated by comparing the subjective ratings of two independent observers from the video recordings.

Experiment 2

The secondary aim was to determine if age and familiarity of the synchronization partner influences the level of prosocial behavior and empathy displayed by young children. Due to children's biases towards those in the in-group (Fehr et al., 2008; Hamlin, et al., 2013), a child is more likely to display stronger feelings of affiliation at baseline with familiar peers than unfamiliar adults. However, because evidence suggests interpersonal synchrony can decrease out-group biases between the child and dissimilar others, we predict that while children in the synchronous condition will display more prosocial behaviors and empathy towards familiar same-aged peers during baseline, that these differences will be non-existent following interpersonal synchrony due to the creation of new affiliation bonds (i.e. unfamiliar adults will be viewed as the new in-group following synchronization). For those in the asynchronous condition, it is expected that prosocial behaviors will be higher for familiar, same-aged peers both before and after the clapping task than for unfamiliar adults.

Participants

Ten children (five pairs) (M = 50.8 months, SD = 9.33 months, range = 38-65 months), from Ortona Gymnastics Club were included in the same-aged peer condition; however, these pairs could not be completely analyzed due to failure of the children to properly perform the fish feeding task following interpersonal synchrony. As such, an informal visual analysis of the results is provided, along with a discussion of the observable behaviors that occurred during the helping task.

Materials and Procedures

In same-aged conditions two children instead of an adult-child pair performed each of the 3 tasks (fish feeding game, empathy rating task, and clapping task) following the same procedure discussed above. Each child was trained separately for the clapping task, with one child coloring alongside a volunteer when they were not undergoing training. Paired children were compared with the child-adult pairs to see if any differences in behavior occurred.

Results

Experiment 1

For each participant, baseline measurements of helping behavior and empathy were gathered before the clapping task to determine whether synchronization influenced these measures. Following the clapping task, participants completed the same measures of helping behavior and empathy. We compared the helping behaviors, empathy measurements, and clapping performance of participants who were in-synchrony with their adult playmate with those of participants who were out-of-synchrony with their adult playmate.

Tests of normality conducted separately on various measures revealed that while some measures displayed a normal distribution, others did not. We assume that the robustness of parametric tests will reveal any effects, and therefore conducted parametric statistical analyses on our data hereon.

Spontaneous Helping

We examined three categories of helping behavior: 1) active helping (i.e. time spent assisting partner and the number of items picked up), 2) complete waiting (i.e. remaining beside partner without helping until all items are restored), and 3) partial waiting (i.e. waiting shortly but then leaving before all the partner's items have been collected). An independent *t*-test was used to compare helping behavior and empathy measures between children in the synchronous

and asynchronous groups, while paired *t*-tests compared these measures both before and after the clapping task within groups.

As can be seen by Figures 1 and 2, the clapping task did not exert a discernable effect as there were no significant differences in the amount and duration in children's helping behaviours prior to and following the clapping paradigm in both synchronized and asynchronized clapping tasks. Interestingly, observations of active helping, as measured by duration (seconds) and the number of retrieved items, only occurred among children in the asynchronous condition and not among those in the synchronous condition. However, between- and within-group differences prior to and following the clapping task for both the duration of active helping ($ps > .05$) and the number of items picked up ($ps > .05$) were not significant. Regarding the duration of passive waiting between synchronous and asynchronous conditions, no significant group differences were observed following the clapping task ($ps > .05$). Differences following the clapping task for those who initially waited the entire duration verses those who initially waited part of the duration were also not significant ($ps > .05$).

Although within group differences show a downward trend in passive waiting times following the clapping task for children in the synchronous and asynchronous groups, differences prior to and following the clapping task were insignificant for both those who waited partially ($ps > .05$) and completely ($ps > .05$). In other words, even though two of the four children who waited completely prior to the clapping task did not wait the entire duration following the clapping task in the synchronous condition, their waiting times were not shortened to a significant degree. The same can be said for the four children in the asynchronous condition who waited completely prior to the clapping task and did not wait completely following the clapping task.

Empathy Rating Task

Figure 3 shows the cognitive and affective scores on empathy towards the imaginary fish and adult partners. Within group analyses confirmed that cognitive and affective empathy scores did not differ prior to or following the clapping task for those in synchronous (*p*s > .05) or asynchronous conditions (*p*s > .05). Furthermore, differences in cognitive and affective empathy scores following the clapping task between children in the synchronous and the asynchronous conditions were also not significant (*p*s > .05).

Correlations between the two cognitive empathy questions were significant for those in the synchronous condition ($r = .867$, $p = .000$) and approached significance for those in the asynchronous condition ($r = .507$, $p = .092$). However, correlations between the two affective empathy questions were low for both those in the synchronous and asynchronous condition (*p*s = .05).

To confirm if affective empathy arises from cognitive empathy or vice versa, children's cognitive and affective empathy scores regarding their playmate were compared (with lower empathy scores indicating greater empathy and understanding of partners distress over the spilled fish food). Although there was a trend for children to display lower cognitive empathy scores towards their adult playmate than affective empathy scores, no significant differences were found between cognitive and affective empathy prior to the clapping task in the synchronous group (*p*s > .05), or following the clapping task in the either the synchronous (*p*s > .05) or asynchronous (*p*s > .05) group. An exception to this is that cognitive empathy scores were significantly lower than affective empathy scores prior to the clapping task in the asynchronous condition ($t(11) = 3.45$, $p = .005$). Ratings of cognitive and affective empathy towards the

imaginary fish were also not significantly different following the clapping task (*p*s > .05) in either condition.

Children in the synchronous condition tended to display higher empathetic understanding towards their imaginary fish than towards their adult partner for both cognitive ($t(11) = 4.76$, $p < .001$) and affective ($t(11) = 6.01$, $p < .001$) empathy prior to the clapping task; they also displayed higher cognitive ($t(11) = 4.32$, $p = .001$) and affective ($t(11) = 3.15$, $p = .009$) empathy following the clapping task. For the asynchronous group, a similar pattern of results was observed for cognitive ($t(11) = 15.0$, $p < .000$) and affective ($t(11) = 4.09$, $p = .001$) empathy prior to the clapping task, as well as for cognitive ($t(11) = 3.75$, $p = .003$) and affective ($t(11) = 4.60$, $p < .001$) empathy following the clapping task.

It is possible that children waited longer because of greater feelings of empathy towards their adult play partner. To determine if the duration of waiting was associated with self-reported empathy, bivariate correlational analyses were conducted to examine the relationship between these two measures. There were no significant correlations between waiting time and cognitive empathy (*p*s > .05) nor between waiting time and affective empathy (*p*s > .05) following either the synchronous or asynchronous clapping task. The duration of helping behavior was not significantly correlated with cognitive or affective empathy in the asynchronous condition (*p*s > .05).

Clapping Task, Eye Contact, and Smiles

Audio files were coded by associating the temporal wave form peaks with each individual's tap on their hand cards, and then by calculating the difference (i.e. the intertap interval, ITI) between the tap that belonged to the child and the adjacent tap that belonged to the adult play-mate. However, due to experimenter error, audio files were not recorded for two

children in the synchronous condition. As such, synchronization between these pairs was established using interrater reliability from video recordings of the clapping task, as described below.

In order to examine children's accuracy in clapping in-synchrony and out-of-synchrony with their adult play partner, differences in tapping times between partners were calculated and compared to zero using a one-sample *t*-test. The closer the ITI was to zero, the more in-synchrony the children were with their partner. Because there was a significantly greater number of missed tap intervals in the asynchronous (M = 12.3, SD = 5.61) than in the synchronous (M = 5.60, SD = 3.81) condition ($t(20) = -3.22$, $p = .004$), missed tap intervals were included in the final analysis by subtracting the child's tap from the adult's tap used in the previous interval (see Table 1). To account for out-of-phase clapping (i.e. a child claps synchronising with an adult's taps), the audio coding was corrected by subtracting half of the average ITI (calculated within each group) by each individual ITI. Time differences of 0.2 ms or less (for the 50 BPM) and 1.5 ms or less (for the 80 BPM) were included in the final calculation.

Tapping times were found to be significantly different from zero in both the synchronous ($t(9) = 6.92$, $p < .001$) and asynchronous ($t(11) = 7.53$, $p < .001$) conditions, indicating that children were not clapping perfectly in time with their play partners. Despite imperfect synchronization, a significant difference in the tapping times between synchronous and asynchronous conditions were observed, as seen in Figure 4 ($t(20) = -3.35$, $p = .003$).

Figure 5 and Figure 6 reveal no significant differences in eye-contact (ps > .05), or the number of individual (ps > .05) and mutual smiles (ps > .05) between conditions for either rater 1 or rater 2, indicating that children assigned to the synchronous and asynchronous clapping

conditions displayed similar social behaviours during the clapping task. Similarity, no differences in the duration of eye contact were observed between conditions (*p*s > .05).

Interrater Agreement for Clapping Task, Eye Contact, and Smiles

Video coding was analyzed using two independent raters to determine occurrences of eye-contact, individual smiles, and mutual smiles, along with the duration (seconds) of eye contact. Because audio files were missing for two children in the synchronous condition, interrater reliability was also calculated for the clapping task. This was done by dividing the 45-second metronome track into five, nine-second intervals. Children were rated for how synchronous they were on a 7-point Likert scale that ranged from absolutely non-synchronous (1) to absolutely synchronous (7).

Interrater reliability for the number of individual (r = .698, p = .029), and mutual (r = .780, p = .009) smiles ranged from moderate to excellent in the synchronous condition, along with the number of individual (r = .838, p = .004), and mutual (r = .766, p = .16) smiles in the asynchronous condition. While interrater reliabilities for occurrences of eye-contact were excellent in both the synchronous (r = .868, p = .001) and asynchronous (r = .907, p < .001) conditions, the interrater reliability for the duration of eye contact was high and significant only in the synchronous condition (r = .769, p = .006), but not in the asynchronous condition (r = .621, p = .071).

Interrater reliability for the clapping task in the synchronous condition was significant for the first (r = .754, p = .014), second (r = .891, p < .001), fourth (r = .744, p = .016), and fifth (r = .809, p = .005) intervals, and approached significance for the third interval (r = .638, p = .053). Correlations across all intervals were excellent (r = .922, p < .001). As for the two children who were missing audio recordings in the synchronous condition, both raters correctly guessed which

condition the children were in, indicating the child participants were in moderate synchrony with their adult partners.

In contrast, interrater reliability for the clapping task in the asynchronous condition was significant for only the first interval (r = .737, p = .023), while interrater reliabilities for the other four intervals were not significant (ps > .05). As such, correlations between the averages of all the intervals were also not significant (r = .431, p = .194) indicating that the raters were not in agreement when judging asynchronous clapping behaviours between child-adult pairs.

Age Differences in Helping Behavior, Empathy, and the Clapping Task

Due to small sample sizes, the data regarding age differences in each of the tasks are not amenable to statistical analysis. However, the visual inspection revealed that four-year-old's (M = 9.38 s, SD = 3.86 s) had the lowest waiting times in both the synchronous and asynchronous conditions when compared with the three- (M = 17.2 s, SD = 9.37 s) and five-year-old's (M = 16.0 s, SD = 4.69 s). Interestingly, however, only four-year-old's were observed to actively pick up items in the asynchronous conditions (M = 1.00 s, SD = 1.41 s). No discernible age differences in the number of children who waited the entire duration versus those who waited partially were observed, nor were there any apparent age differences in cognitive and affective empathy between synchronous and asynchronous conditions.

Experiment 2

We examined whether children's prosocial behavior and empathy was affected by the age and familiarity of their play partner. It is possible that children feel a greater sense of empathy towards a familiar, same-age playmate than a more experienced, unfamiliar adult playmate. All children paired with same-aged peers were assigned to the synchronous condition by listening to the 50 BPM metronome track only. No asynchronous group was created for comparison.

Spontaneous Helping and Empathy Rating Task

Because of small sample sizes and methodological flaws, data for the prosocial and empathetic tasks are not amenable to statistical analysis. However, visual inspection revealed that children in Experiment 2 had higher cognitive (M = 4.00, SD = 2.83) and affective (M = 5.00, SD = 2.83) empathy scores (i.e. less cognitive and affective empathy) towards their peers than the cognitive (M = 2.25, SD = 2.05) and affective (M = 2.83, SD = 1.75) empathy scores of children paired with an adult in the synchronous condition. They also scored higher than the cognitive (M = 1.58, SD = 1.08) and affective (M = 3.08, SD = 2.23) empathy scores of child-adult pairings in the asynchronous condition. However, comparisons of cognitive and affective empathy measures recorded before the clapping task did not appear to be significantly different from one another within child-child pairs. Similarly, children's scores did not indicate they were more empathetic towards their imaginary fish than they were towards their peers.

An informal analysis of helping behavior and empathy following the clapping task was unable to be completed due to missing data attributed to children intercepting fish food spillages during the second fish feeding task. Thus, manipulation of the helping condition was diverted due to children preventing a repeated occurrence of the same spillage scenario.

Clapping Task, Eye Contact, and Smiles

Due to experimenter error, audio files were not recorded for one child pair. As such, synchronization was established using interrater reliability from video recordings of the clapping task, as described below.

ITIs for child-child pairs were found to be significantly different from zero for the corrected ($t(3) = 7.99$, $p = .004$) audio files, indicating imperfect synchrony between each pair of children. In addition, ITI differences were not significant between synchronous child-child pairs

and synchronous child-adult pairs, as well as between synchronous child-child pairs and asynchronous child-adult pairs (*p*s > .05). In the synchronous condition, however, a greater difference in means were observed between the children clapping with a peer (*M* = 0.432 ms, *SD* = 0.152 ms) than in children clapping with an adult (*M* = 0.228 ms, *SD* = 0.104 ms), than it was for child-adult pairs in the asynchronous condition (*M* = 0.485 ms, *SD* = 0.223 ms).

An independent *t*-test was used to compare the occurrences of eye-contact, shared smiles, and mutual smiles between synchronous child-child pairs and synchronous child-adult pairs, along with synchronous child-child pairs and asynchronous child-adult pairs. However, no differences amongst groups were observed for rater 1 (*p*s > .05) or for rater 2 (*p*s > .05).

Interrater Agreement for Clapping Task, Eye Contact, and Smiles

Interrater agreement for eye-contact occurrence (*p*s > .05) and duration (*p*s > .05), along with the number of individual (*p*s > .05) and mutual (*p*s > .05) smiles, were insignificantly correlated for the child-child pairs in Experiment 2.

Interrater agreement for the clapping task was found to be excellent for the first (*r* = .943, *p* = .008) and second (*r* = .938, *p* = .01) intervals only. However, no significant correlation was found for the remaining three intervals (*p*s > .05), although the interval average was correlated significantly (*r* = .849, *p* = .047). Regarding the missing audio recording for the child-child pair, the two raters agreed that the pair were in moderate synchrony with one another.

Discussion

Experiment 1

The purpose of the current study is to determine the extent children's prosocial behavior is enhanced following interpersonal synchrony, and if this increase is driven by underlying changes in cognitive and affective empathy.

Despite findings from Tunçgenç & Cohen (2016b), the results from the current study reveal that interpersonal synchrony does not lead to increased instrumental helping and social bonding behaviors in three- to five-year-old children when paired with an adult partner. Furthermore, no changes in either affective or cognitive empathy were found following synchronization, while helping behavior—measured as the time spent passively waiting for their adult playmate—was not significantly correlated with empathy measures.

Clapping Task

We considered whether the children's ability to synchronize with their playmate affected the results. The most sensitive way of determining this was to examine the timing pattern of children's tapping with their play partner. In perfectly synchronous tapping, there should be no difference in the tapping patterns between play partners. However, timing patterns extracted from the audio recordings from the synchronous and asynchronous conditions were found to differ significantly from zero, indicating that perfect synchrony did not occur in either condition due to children struggling to match their taps with the corresponding metronome speed. This result is surprising, considering metronome speeds found to be suitable for young children (i.e. previously 150 BPM to 200 BPM; see Provasi & Bobin-Bègue, 2003) were optimized and reduced in tempo in the current study (i.e. to 50 BPM and 80 BPM, respectively). However, interpersonal synchrony was significantly better for children in the synchronous condition, as the clapping of children in the asynchronous condition contained a higher number of missed ITIs in the auditory analysis. Thus, while neither group sustained perfect synchrony, those in the asynchronous condition experienced greater difficulty in following an asynchronous beat−as demonstrated by more missed beats−than those attempting a synchronous one. As such, it is likely that the ability of the child to connect socially with their adult playmate in the

asynchronous condition was diminished to a greater degree than that in the synchronous condition due to reduced tapping consistency.

Interestingly, video analysis of the synchronous condition revealed significant interrater agreement for all but one on the five nine-second intervals, whereas many intervals in the asynchronous conditions displayed disharmonious agreement between raters. Why this occurred is uncertain, although it suggests that greater variation in tapping occurred in the asynchronous condition than the synchronous condition. This validates the temporal analysis of tapping behavior discussed above, as it suggests that children in the asynchronous condition had more trouble matching their taps to their designated metronome speeds. Furthermore, no children in the synchronous condition were assigned the metronome tempo of 80 BPM, unlike some children in the asynchronous condition. Therefore, it is likely that the faster tapping requirement, along with the added confusion of their adult playmate tapping at a different rate than themselves, resulted in greater variability and inconsistency in children's tapping responses in the asynchronous condition. Lastly, it is possible that the criterion for interpersonal synchrony was too broad or imprecise, making it difficult for raters to assess asynchronous responses. As such, future research should provide clearer definitions of what constitutes interpersonal synchrony and what does not.

Prosocial Behaviors

Between Subject Comparison. Previous research has shown consistent differences in prosocial attitudes between those who experience interpersonal synchrony and those who do not, with children displaying increased helping behaviors towards their synchronization partner (Cirelli, 2018; Cirelli et al., 2014; Cirelli et al., 2016; Kirschner & Tomasello, 2010; Tunçgenç & Cohen, 2016a; Valdesolo & Desteno, 2011). Despite past positive findings, no significant

differences in helping behavior emerged between synchronous and asynchronous conditions in the current sample, suggesting that interpersonal synchrony may be insufficient for increasing instrumental helping in preschool aged children.

While numerous cross-sectional studies suggest that both spontaneous and compliant prosocial behaviors emerge early in infancy and continue to increase between the ages of three to six years (Eggum et al., 2011; Eisenberg et al., 2015; Eisenberg and & Fabes, 1998; Hay et al., 1999; Liew et al., 2011; Warneken and Tomasello, 2006; Warneken and Tomasello, 2007; Zahn-Waxler et al., 1992), prosocial behaviors may be less likely to occur when a personal cost is required. For instance, Svetlova and colleagues (2010) found that 30-month-old children were less likely to spontaneously help a frustrated or distressed adult when helping required self-sacrifice. In the current study, acting in a prosocial manner involved delaying attendance to an appealing task in order to assist an unfamiliar adult in a tedious chore. It is possible, then, that the pleasure of feeding the fish was too salient for the young participants to ignore, leaving them unwilling to help the adult playmate they experienced interpersonal synchrony with. This conclusion is consistent with Hay and colleagues (1991), suggestion that preschool aged children are more cognizant of the cost of altruistic behavior than younger toddlers and may be less willing to help as a result. In the case of the current study, the preschool children may have had a greater understanding of what they would be missing if they paused to help their adult playmate, leading to reduced prosocial behavior.

Another explanation for our findings is that while the child participants may have wanted to help, they were unable to exercise the strategies needed to successfully delay gratification. Studies examining delayed gratification in preschoolers have found that three-year-old children do not engage in consistent self-control methods (Mischel, & Mischel, 1987) and often fail to

achieve the larger, delayed reward as a result (Garon et al., 2012; Hayne et al., 2011; Hayne & Imuta, 2011; Imuta et al., 2014; Payne et al., 2015; Scarf et al., 2013; Suddendorf et al., 2011). Because the fish tank remained in the child's line of sight, it is possible that the desire to feed the fish without delay may have been too appealing for the child to resist, especially considering that the participants used in this sample were younger on average than children in previous interpersonal studies.

A third alternative is that while children under five-years-old regularly engage in prosocial acts (Eggum et al., 2011; Eisenberg et al., 2015; Eisenbergand & Fabes, 1998; Hay et al., 1999; Liew et al., 2011; Svetlova et al., 2010; Warneken and Tomasello, 2006; Warneken and Tomasello, 2007; Zahn-Waxler et al., 1992), and are aware of the perspectives of others (Flavell et al., 1981; Moll & Meltzoff, 2011; Moll & Tomasello, 2006; Sodian et al., 2007; Surtees & Apperly, 2012), their ability to notice the actions of adults is significantly reduced when compared with their reciprocity towards same-aged peers (Holt & Yuill, 2014). Furthermore, the use of a multi-user computer interface produces a greater number of other-awareness responses in a joint attention task than a single user computer interface in typically developing children, suggesting that children's ability to attend to the actions of both same-aged peers and adults is not yet fully developed (Holt & Yuill, 2014). In the current sample, some children claimed they did not notice the spillage of their playmates fish food, even if they were observed waiting for the adult. More scaffolding may be required to increase other awareness towards the spilled fish food in preschool aged children.

Within Subject Comparison. Interestingly, most child participants did not engage in helping behavior, nor were there any significant differences in passive waiting times observed following the clapping task. However, a trend for children to wait for less time following the

clapping task did emerge in both synchronous and asynchronous conditions. While this finding is unexpected, it is possible the lack of prosocial behavior following interpersonal synchrony arose because children expected their adult playmate to learn from their mistakes and handle their fish food with a greater degree of care during the second fish feeding game. Annoyance may have resulted when this did not occur, reducing any feelings of affiliation and empathy that developed during the clapping task. An alternative explanation is that the children may have viewed the adult as an authority figure and were waiting for permission to proceed without them. When the adult did not react after being left behind the first time, it may have driven the children to leave sooner during the second food spillage, as they were more confident they would not be punished for doing so.

Cognitive and Affective Empathy

Despite trends indicating children have higher cognitive than affective empathy, differences in empathy were not observed following the clapping task, nor did the empathy ratings vary between synchronous and asynchronous conditions. Furthermore, no correlations existed between empathy ratings and the time spent passively waiting for their playmate to pick up the fish food, indicating that empathy may not be a key motivation for instrumental helping behavior.

Support for the notion that instrumental helping does not induce empathetic responses in children is found in Svetlova and colleagues (2010) demonstration of helping behavior. The researchers found that 18- and 30-month-old children responded maximally to instrumental helping tasks but struggled when helping required an inference of their playmates emotional state (Svetlova et al., 2010). Considering toddlers have been observed to help before any need is indicated (Rheingold, 1982), it is likely that instrumental helping behaviors do not require

empathetic understanding of another's subjective experience. In conjunction with this, adults in the current study did not seem overly distressed by the food spillage. As such, it is possible the adult's lack of negative emotion may not have elicited an empathetic response in the child to begin with. Alternatively, neutral reactions to the spilled fish food may have resulted in the child experiencing greater feelings of uncertainty regarding the adult's emotional state, leading to variable child responses. In conjunction with this, children displayed higher cognitive and affective empathy towards their imaginary fish than towards their adult playmate, indicating the perceived emotional state of their adult partner was less certain than that of the imaginary fish.

Furthermore, items assessing the children's affective empathetic responses did not clearly distinguish between personal distress and empathetic concern. For instance, children may have felt distress upon seeing their partner's spilled fish food without feeling increased empathy towards their partner or vice versa, with both subjective states resulting in lower rating scores. Additionally, unlike the questions measuring cognitive empathy, correlations between affective empathy questions were nearly non-existent, suggesting that affective empathy questions were not measuring what they were intended to measure. For instance, the question "how did you feel when you fed the fish?" was ambiguous, as high rating scores could represent either inflated affective empathy or the child's mood.

Lastly, many children under the age of eight lack the cognitive and/or verbal abilities to answer self-reports accurately (Eisenberg & Miller, 1987), and appear to be strongly influenced by demand characteristics (Eisenberg-Berg & Hand, 1979) and experimenter gender (Eisenberg & Lennon, 1983). In the current study, verbal-behavioral discrepancies (such as a child expressing happiness while simultaneously pointing to a sad face) were common, along with split responses (a children putting stickers under both the extremely happy and extremely sad

faces). Children also tended to gravitate towards the either the maximum (extremely happy) or minimum (extremely sad) responses while ignoring the emotional options in between. Therefore, while empathy towards their adult playmate may have been increased, the language or cognitive ability necessary to properly express or understand the questions may have prevented an accurate representation of the children's feelings.

Social Bonding Behaviors

Contrary to reported findings from Tunçgenç & Cohen (2016b), occurrences and duration of eye-contact, along with the number of individual and mutual smiles, were not higher in the synchronous condition than the asynchronous condition during the clapping task. Since interrater reliability for social bonding behaviors ranged from moderate to excellent (apart from eye-contact duration in the asynchronous group) in both the synchronous and asynchronous groups, the null results cannot be attributed to poor interrater agreement. It is possible, however, that the current study's exclusion of "whoop" sounds (in which children rapidly stood up and sat down upon hearing) that were intermittently played throughout Tunçgenç & Cohen's (2016b) original interpersonal synchrony task reduced the engagement in the clapping task of the current study. Many children in the current study struggled to match their taps with the metronome speed and needed continuous encouragement to complete the full 45-second duration; as such, frustration with the task demands could have negated the effects of interpersonal synchrony on social bonding behaviors.

Age differences in Prosocial Behavior, Empathy, and Emotional Bonding

Sample sizes in the current study were too small to perform a statistical analyses of age differences. However, a visual analysis revealed that, on average, four-year-old children waited

less than both the three- and five-year-old children. Future research should examine this potential age-related difference using larger sample sizes.

Experiment 2

The effect of interpersonal synchrony on prosocial behavior and empathy could not be properly examined between same-aged peers due to children's interference with the manipulations of the task. As a result of learning, the majority (3 of 5) of children took preventative action by placing a hand at the bottom of the fish feeding tube during transportation, effectively stopping the fish food spillage. For the two child that did spill their food before and after the clapping task, their same-aged peer left before the second food spillage occurred, and thus did not notice their partner's delay until their fish were already fed. Future studies should employ a same-age confederate to ensure that the manipulation is standardized across trials.

Like findings from Experiment 1, synchronization levels differed significantly from zero in the clapping task, indicating imperfect synchrony between children despite all pairs being placed in the synchronous condition. Furthermore, no differences were found between child-child pairs and child-adult pairs in either the synchronous or asynchronous group, even when missed ITI were included in the analysis. However, average ITI for child-child pairs were closer to the average ITI of child-adult pairs in the asynchronous condition than the synchronous group, suggesting that synchronization between child-child pairs was especially poor. Considering adult tapping behavior is more systematic than that of children, this is not surprising. As for results from the video analysis, interrater agreement of interpersonal synchrony for child-child pairs was not significant. As such, stricter criterion for what constitutes interpersonal synchrony and what does not is warranted.

No differences in social bonding behaviors of smiles and eye-contact were observed between child-child pairs and child-adult pairs in synchronous or asynchronous groups—a finding that may be a result of poor interpersonal synchrony between same-age peers. Contrary to Experiment 1, the frequency and duration of eye-contact, along with the number of individual and mutual smiles, were not correlated between the two independent raters. Examination of interrater agreement with a larger sample size is needed to clarify this observation.

No child communicated distress over their spilled fish food and remained cheerful while retrieving the items. A few children even expressed high enjoyment over having to pick up the spilled fish food, further reinforcing the idea that instrumental helping behavior may be intrinsically motivated in young children (Rheingold, 1982; Warneken & Tomasello, 2012).

Only one child-child pair displayed high helping behaviors prior to and following the clapping task, as while the fish food failed to spill during the second fish feeding task, the child still helped their playmate sort their fish food into the fish tube. The rest of the children were focused on their own assigned tasks and did not appear to care whether their peer's fish food spilled or not, indicating that children are not more likely to behave in a prosocial manner towards familiar peers than they are towards unfamiliar adults.

Interestingly, a few children claimed that they did not notice the spilled fish food, even if they helped their partner pick up the food. One child was even observed to walk back to his partner's fallen food items after feeding his own fish, but still did not acknowledge the food spillage. As mentioned previously, other awareness is not fully developed in young children (Holt & Yuill, 2014). While research suggests children are more aware of the mental states of same-aged peers than those of adults, these findings suggest that other awareness is still a problem when interacting with same-aged peers.

Limitations and Directions for Future Research

Interpersonal synchrony studies with adults have reported challenges in achieving true synchronization using a metronome-based paradigm. For instance, Hove & Risen (2009) found insufficient synchronization occurred after two and a half to three minutes of tapping along with the metronome. This is 105 to 135 seconds longer than the synchronization time frame used in the current study. In contrast, Rabinowitch & Knafo-Noam (2015) found three minutes to be satisfactory in achieving interpersonal synchrony for eight-year-old children, and Tunçgenç & Cohen (2016) recorded significant differences in four-year-old prosocial behavior between synchronous and asynchronous groups after only 45 seconds. Future research should determine an optimal range of synchronization time that is needed to increase the likelihood of observing prosocial behavior, affiliation, and likability.

Despite reducing metronome speeds from those used by Rabinowitch & Knafo-Noam (2015; 75 BPM and 100BPM) and Tunçgenç & Cohen (2016; 180 BPM and 200 BPM) to 50 BPM and 80 BPM in the current study, children still had difficulty in matching their taps to the correct metronome speed. Considering that children's ITI differed significantly from zero in both the synchronous and asynchronous conditions, and that visuo-motor skills are not yet fully developed in the preschool years (Memisevic & Hadzic, 2013), it is unlikely that true synchrony was obtained in either condition. As such, insufficient interpersonal synchronization may have led to differences that were not significant in prosocial behavior, empathy, and social bonding measures.

A possible adaption to improve synchronization is to use passive, rather than active synchronization tasks. This is done by having an adult manually lead a child through interpersonal synchrony, as opposed to the child producing synchronous movements themselves.

For instance, Rabinowitch & Meltzoff (2017) pushed children in-synchrony or out-of-synchrony using a swing set. Similarly, Marsh and colleagues (2013) used a rocking chair paradigm to determine the extent spontaneous synchrony occurred in children with autism—a methodology that could be easily adapted such that the child's rocking was controlled by the experimenter.

The current study did not provide a warm-up session before the fish feeding task was performed, and many children displayed signs of discomfort with their adult playmate as a result. Considering there is evidence that shyness may serve as an inhibitor of prosocial responding in kindergarten and grade one children (Findlay et al., 2006; Liew et al., 2011), it is possible that the limited interaction between the child and their adult playmate before engaging in directed tasks may have negatively influenced helping behavior (although such findings are not always consistent, see Ladd et al., 2011). Alternatively, the child may have viewed the adult as older and more capable than themselves, and therefore not in need of help. Future research should include warm-up games to establish familiarity between partners, in order to increase baseline helping behaviors.

Only instrumental helping behavior was assessed in this study. While other studies have examined the influence of synchrony on instrumental helping (Cirelli et al., 2014; Cirelli et al., 2016; Kirschner & Tomasello, 2010; Tunçgenç & Cohen, 2016b), affiliation (Tunçgenç & Cohen, 2016a; Tunçgenç & Cohen, 2016b), likability (Rabinowitch & Knafo-Noam, 2015; Tunçgenç et al., 2015), cooperation (Good & Russo, 2016; Kirschner & Tomasello, 2010), and sharing (Rabinowitch & Meltzoff, 2017) in children, there has yet to be any research done on the influence of interpersonal synchrony on emotional and altruistic helping in the three- to six-year-old children. Future research should test this by adapting the study conducted by Svetlova and colleagues (2010) to include an interpersonal synchrony component.

Many children appeared to think the fish feeding game was a competition and expressed great pleasure in beating their partner to the fish tank. Future research could address this by providing clarification regarding the nature of the game.

Due to small sample sizes and an unequal distribution of age groups between synchronous and asynchronous conditions, age differences in synchronization ability, prosocial behavior, and empathy were unable to be properly analyzed. Future research should examine the developmental trend of interpersonal synchrony from infancy to adulthood in order to determine whether synchronization exerts a greater influence on younger or older populations.

As mentioned previously, self-reported empathy does not correlate well with observed prosocial behavior in children (Eisenberg & Fabes, 1990), likely because children inaccurately articulate their emotions as a result of developmental constraints in language and cognitive ability (Eisenberg & Miller, 1987; Imuta et al., 2016). However, parent-reports of empathetic behavior have been found to significantly correlated with their children's prosocial behavior towards both humans and animals, with higher cognitive and affective empathy scores predicting which children display more prosocial behaviors (Dadds et al., 2008). Future studies should incorporate parent ratings to confirm children’s baseline cognitive and affective empathy ratings, and to determine if resulting empathetic gains from interpersonal synchrony are maintained in the long-term. Furthermore, questions that better distinguish between personal distress/enjoyment and empathetic concern should be considered in future research.

Empathetic individuals tend to engage in mimicry more than unempathetic others (Chartrand and Bargh, 1999; Sonnby-Borgstrom, 2002). Additionally, those who engage in mimicry experience increased feelings of affliction and empathy towards those they are mimicking (Stel et al., 2008). Previous research using functional magnetic resonance imaging

(fMRI) suggests the right inferior frontal gyrus plays a strong role in intentional emotional mimicry (Lee, et al., 2006; Likowski et al., 2012). To date, no such brain imaging techniques have examined the effects of interpersonal synchrony on empathy. Because both interpersonal synchrony and mimicry have been found to increase prosocial behavior (Hove and Risen, 2009; Stel et al., 2008), future research should determine if similarities in brain activation exist between interpersonal synchrony and mimicry.

There were instances where the child may have received feedback from their partner while completing the emotional rating scale. For example, one volunteer responded with "you're right" when the child placed their sticker underneath the sad face following the question "how do you think your partner felt when their fish food spilled on the floor?". Non-verbal cues, such as the facial expression or body language of the child's playmate, and verbal cues (in the case of Experiment 2 when both children filled out the emotion rating scales) may have also influenced responses of the target child.

Sex differences in the development of cognitive and affective empathy (Denham et al., 2015; Pons et al., 2004) as well as in prosocial behavior (Kirschner & Tomasello, 2010) have been observed. Although the current study suggests that cognitive and affective empathy is not sufficient to initiate helping behavior, future research should examine if sex differences and other mediating variables (such as perspective taking, parental and sibling influences (Bryant & Crockenberg, 1980), ToM (Imuta et al., 2016), and positive mood (George, 1991)) are increased by interpersonal synchrony. If an explanation as to why sex differences in prosocial behavior can be provided, then increasing prosocial behavior in youth has a greater likelihood of success.

Lastly, there is evidence that children with autism spectrum disorders (ASD) have difficulty feeling empathy and relating to those with dissimilar interests (Charman et al., 1997).

Furthermore, unlike typically developing individuals, children with ASD have trouble naturally synchronizing with others, a fact that may contribute to reduced feelings of attachment (Marsh et al., 2013). Since previous research has shown that directed synchronized tasks increase prosocial behavior in children (Cirelli, 2018; Cirelli et al., 2014; Cirelli et al., 2016; Good & Russo, 2016; Kirschner & Tomasello, 2010; Rabinowitch & Knafo-Noam, 2015; Rabinowitch & Meltzoff, 2017; Tunçgenç & Cohen, 2016a; Tunçgenç & Cohen, 2016b; Tunçgenç et al., 2015), research including aspects of the current study (i.e. collecting baseline measures, and determining the effects previous affiliation and age has on interpersonal synchrony and prosocial behavior) could have implications on devising strategies to help children with abnormal social-emotional processing skills. As such, future research should examine the effect of interpersonal synchrony on prosocial behavior in children with ASD, along with those who have other socio-cognitive impairments. If interpersonal synchrony does lead to increases in prosocial behavior in children with ASD, synchronization could be used as a possible treatment method to improve their social connections. However, the long-term effects of interpersonal synchrony on prosocial behavior, as well as the extent to which interpersonal synchronization will generalize to prosocial behavior across physical (school, home) and social (teacher, parent, peer) contexts, should first be assessed. Studies such as these will determine the specificity with which interpersonal synchrony can enhance outcomes in special populations.

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Figures and Tables

Table 1

Missed Intertap Intervals (ITI) Between Synchronous and Asynchronous Conditions

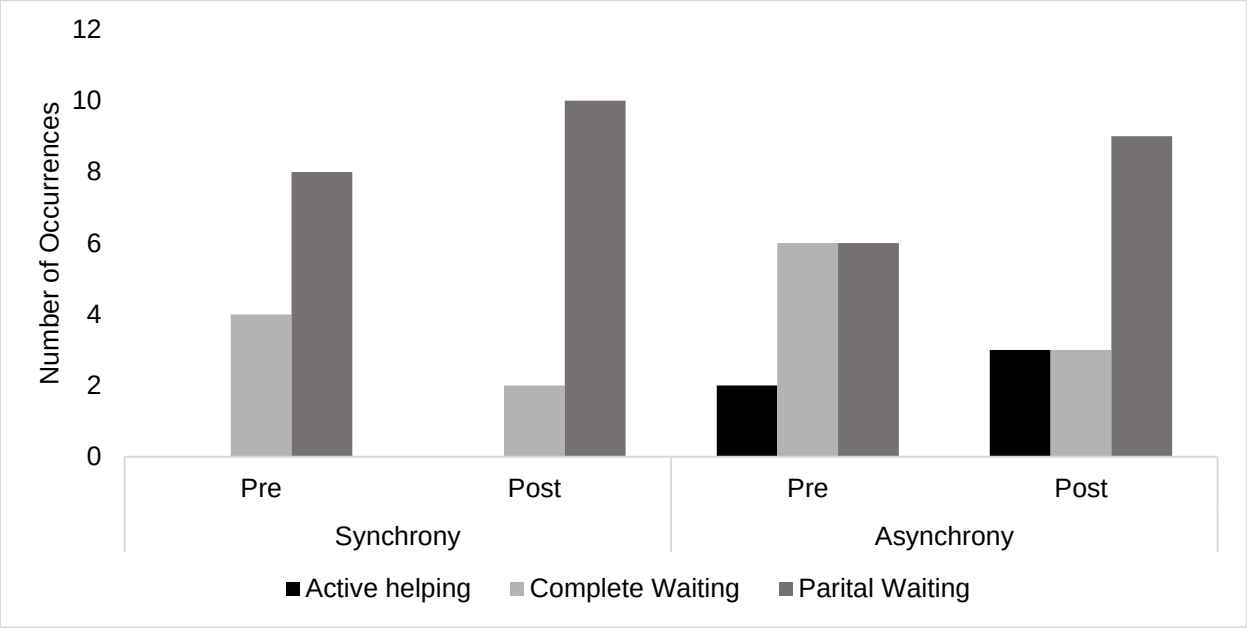
Condition	*M*	*SD*	Missing ITI	*t*
Synchrony	0.23	0.10	5.60	-3.22*
Asynchrony	0.49	0.22	12.3	

*$p < .01$.

Note. The presented data is derived from corrected audio files.

Figure 1

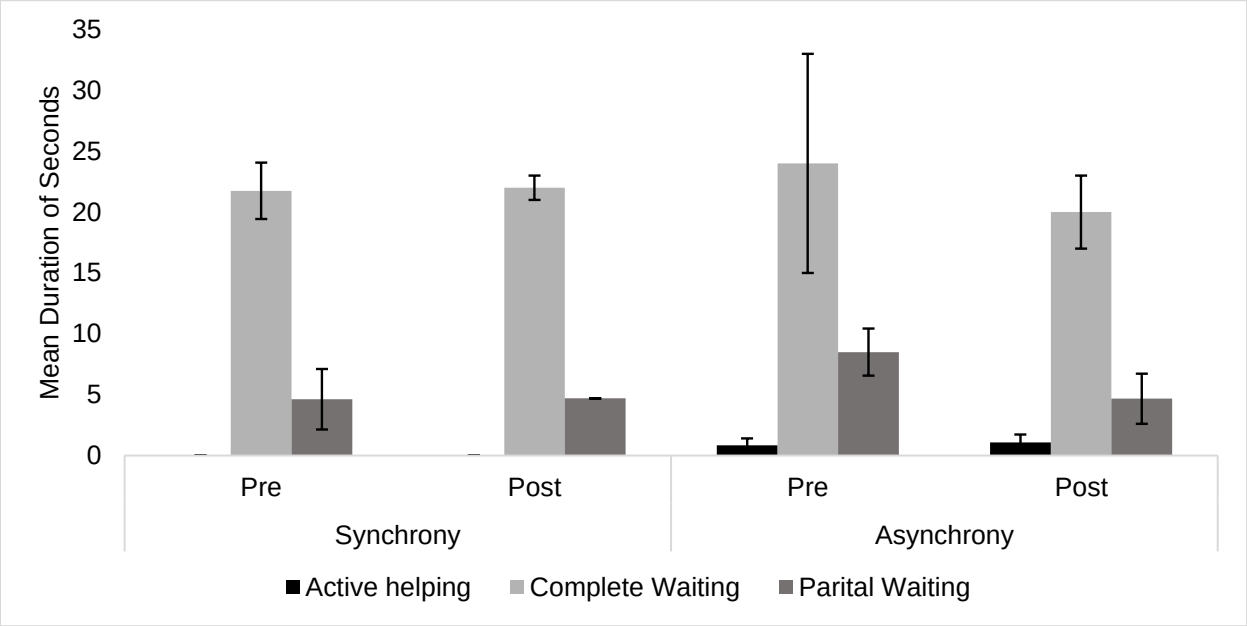
Occurrences of Helping Behavior



Note. The number of times active helping and waiting behaviors occurred between synchronous and asynchronous conditions for child-experimenter interactions, as measured before and after the clapping task.

Figure 2

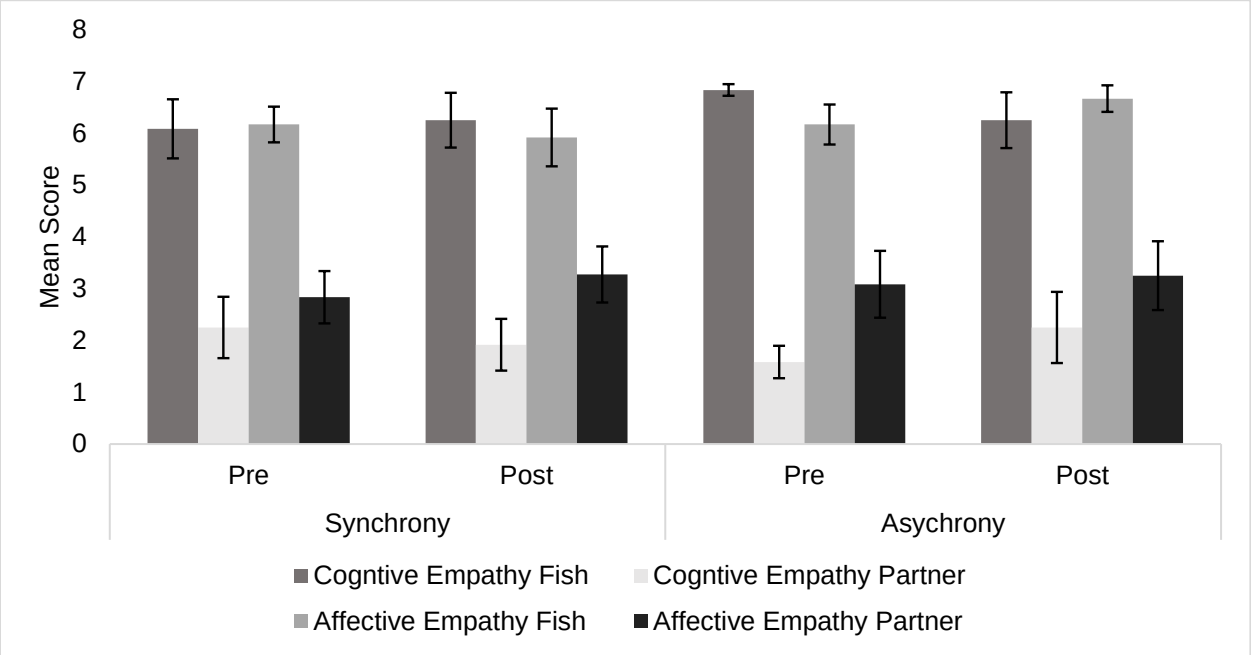
Duration of Helping Behavior



Note. The mean duration of seconds children helped and waited for adult partners between synchronous and asynchronous conditions, as measured before and after the clapping task.

Figure 3

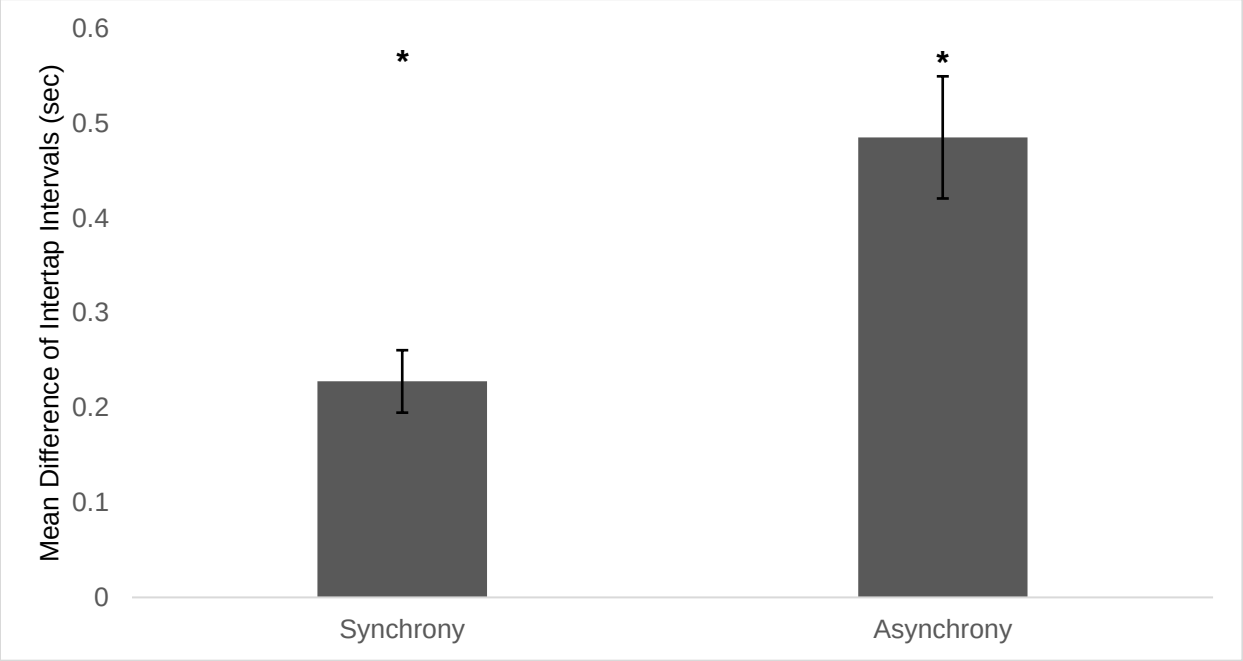
Self-Reports of Cognitive Empathy and Affective Empathy



Note. The mean score of children's cognitive empathy and affective empathy towards the imaginary fish and their adult partner in synchronous and asynchronous conditions, as measured before and after the clapping task.

Figure 4

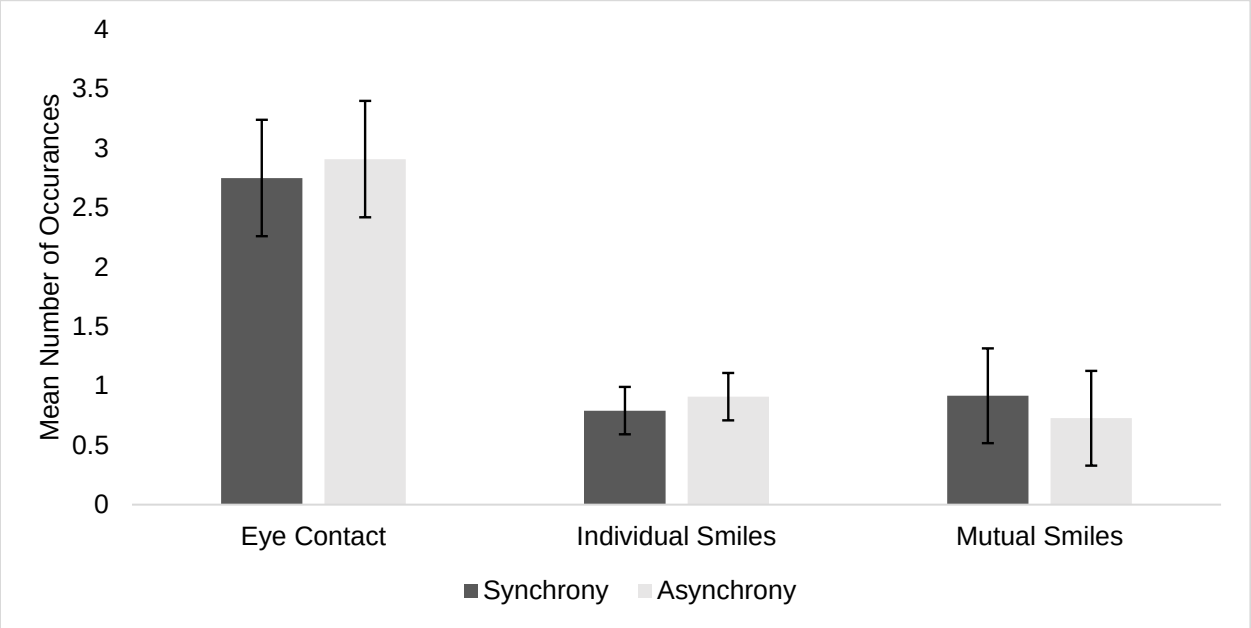
A Comparison of the Clapping Task Between Conditions



Note. The corrected mean difference of ITI between synchronous and asynchronous conditions for child-experimenter interactions, where *$p < 0.01$.

Figure 5

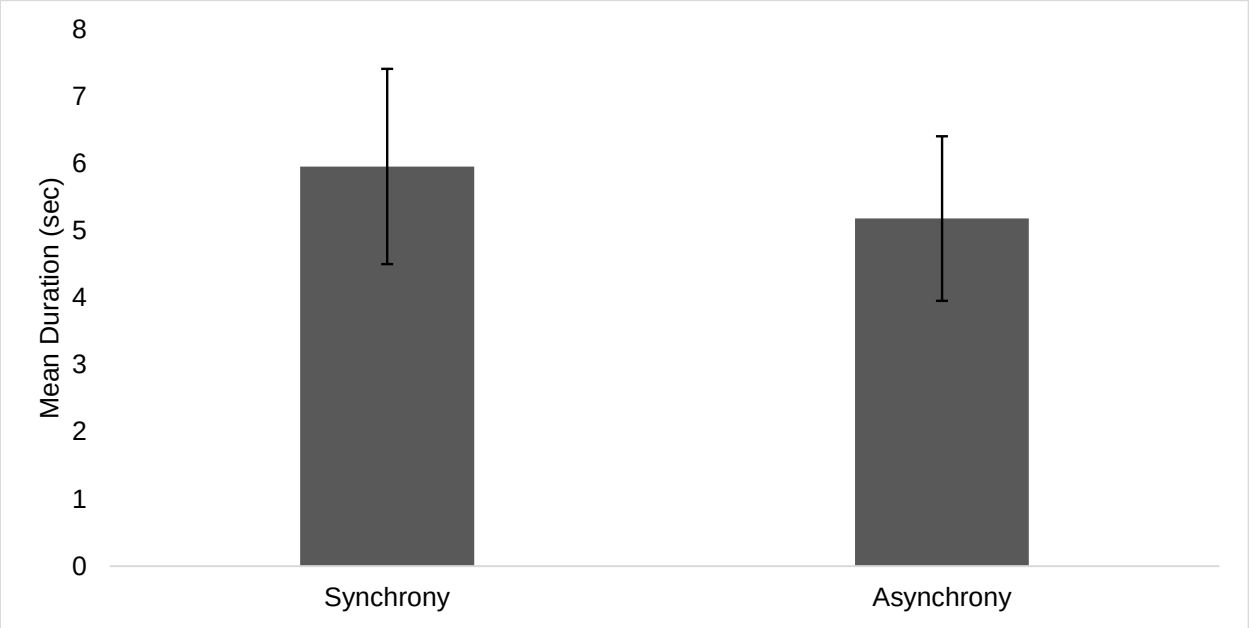
Social Bonding Measures Between Synchronous and Asynchronous Conditions



Note. The mean occurrences of eye contact, individual smiles, and mutual smiles that took place during the clapping task. Determined by the average number of occurrences across two individual raters.

Figure 6

Duration of Eye Contact Between Synchronous and Asynchronous Conditions



Note. The mean duration (seconds) of eye contact that took place during the clapping task. Determined the average number of occurrences across two individual raters.

Appendix A

Synchrony Script (Child-Adult Pairs)

[Participant is brought into the room]

Experimenter — Hello, my name is Mykaela, and this is *(name of adult volunteer)*. Today we are going to play a few games. Please take a seat over by these colorful tubes while I explain the rules.

[Lead participant to tubes]

[Once participant is comfortable take a seat beside them.]

Experimenter — The first game we will be playing is known as the fish feeding game. See that fish tank over there *(points to fake fish tank on other side of the room).* It's filled with tons of hungry fish. We need to feed them their food.

Here is all the fish food *(show colored fish food inside bowl)*. Some are yellow, some are blue, some are green, some are red, and some are purple. To feed the fish, we need to sort all the food into its same colored tube. So, if we are going to feed the purple fish with the purple tube, what color of food should we put in the tube? *(Wait for child's response).* Can you help me sort the purple food into the purple tube? *(put purple food into the purple tube)*. Do you see any more purple food? *(Wait for child to respond).* Ok, since there is no more purple food, we are going to put the purple cap on the purple tube. Do you want to do it? *(lets child put the purple cap on the purple tube).*

Now, follow me (*lead participant to fish tank*). To feed the fish, you remove the cap from your tube. Can you take the cap off and pour the food into the tank? *(lets child take cap off and dump food into fish tank).* Great job!

Once you are done you can put the cap on and leave the empty tube beside the fish tank like this (*demonstrate*).

Experimenter Does everything make sense?

Experimenter Ok, now you are going to do the same thing but with *(say name of adult volunteer).* This time, you are going to sort all the yellow food into the yellow tube, and *(say name of volunteer)* is going to sort all the blue food into the blue tube, Once your tube has been filled put the cap on the tube. You can now go feed your fish!

[Researcher will then pretend to be engrossed in something and will not watch the proceedings. If child tells you the fish food spilled, look up and say 'put them back in the tube' and then look back down at pretend task. Once child is done, lead them to the table with the hand cards]

Experimenter Thank-you for feeding the fish!

Experimenter We are going to play another quick game where I ask you questions about the game we just played. In this game, I am going to ask you a question, and you use this card here *(tap emotion card)* to tell me how you felt about the game.

Experimenter You see, here is a happy face, here is a sad face and here is a face that is not happy nor sad, just relaxed. To show each other how we feel, we peel off a sticker and stick it on one of the boxes here (*indicate row with finger).* If we are feeling very happy, we put our sticker here, *(point at the happiest face).* If we are feeling kind of happy, but not very happy, we put our sticker here or here (*indicate the two boxes beside the very happy face)* If we are feeling very sad, we put our sticker here (*point at the saddest face).* If we don't feel very sad, but still a little sad, put a sticker here or here. *(indicate the two boxes beside the saddest face*) If we feel just normal; so not happy nor sad, we put our sticker in the middle *(pointing at the neutral face).* This is just a way to show each other how we feel.

[Make sure to respond to children's responses to the questions below using neutral phrases, like "very good". Don't say things like "Me too!" or "good answer!"]

Experimenter — For the first question, put your sticker in one of these boxes here *(indicate row with finger; only ask the child these questions and not the adult)*

How would you feel if you got to go eat your favorite kind of ice-cream after this?

Pretend that your favorite ice-cream spilled on the floor before you were able to eat it. Now how would you feel?

How did you feel when you feed the fish?

How do you think the fish felt when you feed them their food?

how do you think *(say name of adult volunteer)* felt when their fish food spilled?

How did you feel when all *(say name of adult volunteer)* fish food spilled on the floor?

Experimenter — Next, we are going to play the clap and tap game.

Experimenter — You see the pictures of the two hands on this sheet? Now, we will clap and then tap with both hands on the table by putting our hands on these pictures *(demonstrating how to alternately clap and tap)*. Can you do it? *(E waits until the child claps and taps a few times).* Now, while we do this, we will also listen to some ticking sounds from our headphones and try to tap with the tick-tocks. Let me show you first and then you will do it.

[E takes the hands sheet in front of her and demonstrates clapping-tapping for a couple seconds. When finished, E instructs the child to practise as well, and continues to clap with the child for the next 20 seconds of the track. Where necessary, E gives instructions and provides praise to the child. A maximum of two trials are administered to avoid fatiguing and frustrating the child]

Experimenter Great Job! We will now play the game in a different way

[Do not state that they would play it 'together' or 'facing each other'. E then changes the configuration of participants tables to prepare the set-up for the test phase, and turns on audio recorder]

Experimenter Begin clapping and tapping like we practiced when you hear the tick tock noises. Ok, ready, set, go!

[Wait for participants to finish game]

Experimenter Thank you very much for playing these games with me. Before you leave, I realized we only fed the blue and yellow fish, and the red and green fish are still hungry. Can you feed the red fish by filling the red tube with red food while *(says name of adult volunteer)* will fill the green tube with green food to feed the green fish. Once you are done you can leave the empty tube beside the fish tank and sit back down at the table.

[Researcher will then pretend to be engrossed in something and will not watch the proceedings. If child tells you the fish food spilled, look up and say 'put them back in the tube' and then look back down at pretend task.]

Experimenter Perfect. Now we know all the fish ate their dinner. Thank you for feeding the fish!

I am going to ask you the same questions I asked when we first played the fish feeding game. Once again, use this card here *(tap emotion card)* to tell me how you felt.

Experimenter Remember, there is a happy face here, a sad face there and another one in the middle that is neither happy nor sad. To show each other how we feel, we peel off a sticker and stick it on one of the boxes on our emotion cards.

How did you feel when you were feeding the fish?

How do you think the fish felt when you were feeding them their food?

How do you think *(say name of adult volunteer)* felt when their fish food spilled?

How did you feel when all *(say name of adult volunteer)* fish food spilled?

Experimenter Awesome, that's it for today. Thanks for feeding the fish!

Synchrony Script (Child-Child Pairs)

[Participants are brought into the room]

Experimenter Hello, my name is Mykaela, and this is *(name of adult volunteer)*. Today we are going to play a few games. Please take a seat over by these colorful tubes while I explain the rules.

[Lead participants to tubes]

[Once participants are comfortable take a seat beside them.]

Experimenter The first game we will be playing is known as the fish feeding game. See that fish tank over there *(points to fake fish tank on other side of the room).* It's filled with tons of hungry fish. We need to feed them their food.

Here is all the fish food *(show colored fish food inside bowl)*. Some are yellow, some are blue, some are green, some are red, and some are purple. To feed the fish, we need to sort all the food into its same colored tube. So, if we are going to feed the purple fish with the purple tube, what color of food should we put in the tube? *(Wait for children's response).* Can you help me sort the purple food into the purple tube? *(put purple food into the purple tube)*.

Do you see any more purple food? *(Wait for children to respond).* Ok, since there is no more purple food, we are going to put the purple cap on the purple tube. Who wants to do it? *(lets child put the purple cap on the purple tube).*

Now, follow me (*lead participants to fish tank*). To feed the fish, you remove the cap from your tube. Can you take the cap off and pour the food into the tank? *(lets the other child take cap off and dump food into fish tank).* Great job!

Once you are done you can put the cap on and leave the empty tube beside the fish tank like this (*demonstrate*).

Experimenter Does everything make sense?

Experimenter Ok, now you are going to do the same thing, but this time *(Say name of participant 1)*, you are going to sort all the yellow food into the yellow tube, and *(say name of participant 2)* you are going to sort all the blue food into the blue tube, Once your tube has been filled put the cap on the tube. You two can now go feed your fish!

[Researcher will then pretend to be engrossed in something and will not watch the proceedings. If children tell you the fish food spilled, look up and say 'put them back in the tube' and then look back down at pretend task. Once child is done, lead them to the table with the hand cards]

Experimenter Thank-you for feeding the fish!

Experimenter We are going to play another quick game where I ask you questions about the game we just played. In this game, I am going to ask you a question, and you use this card here *(tap emotion card)* to tell me how you felt about the game.

Experimenter You see, here is a happy face, here is a sad face and here is a face that is not happy nor sad, just relaxed. To show each other how we feel, we peel off a sticker and stick it on one of the boxes here (*indicate row with finger).* If we are feeling very happy, we put our sticker here, *(point at the*

happiest face). If we are feeling kind of happy, but not very happy, we put our sticker here or here (*indicate the two boxes beside the very happy face)* If we are feeling very sad, we put our sticker here (*point at the saddest face).* If we don't feel very sad, but still a little sad, put a sticker here or here. (*indicate the two boxes beside the saddest face*). If we feel just normal; so not happy nor sad, we put our sticker in the middle *(pointing at the neutral face)*. This is just a way to show each other how we feel.

[Make sure to respond to children's responses to the questions below using neutral phrases, like "very good". Don't say things like "Me too!" or "good answer!"]

Experimenter

For the first question, put your sticker in one of these boxes here (*indicate row with finger*)

How would you feel if you got to go eat your favorite kind of ice-cream after this?

Pretend that your favorite ice-cream spilled on the floor before you were able to eat it. Now how would you feel?

How did you feel when you feed the fish?

How do you think the fish felt when you feed them their food?

[Ask ONLY the participant who had the intact tube the next two questions]

Experimenter

(Say name of participant 1) how do you think *(participant 2)* felt when their fish food spilled?

(Still addressing participant 1) How did you feel when all *(participant 2's)* fish food spilled on the floor?

[Participant 2 does need to be asked these questions since it was their fish food that spilled]

Experimenter — Next, we are going to play the clap and tap game. I am going to explain and practice this game with (*gestures to participant 1)* first, while (*gestures to participant 2)* can work on this dot-to-dot drawing puzzle with *(say name of volunteer)*. Once *(participant 1)* knows the rules then we will switch. Any questions?

[Experimenter points participant 2 towards the volunteer. E then turns to participants 1]

Experimenter — You see the pictures of the two hands on this sheet? Now, we will clap and then tap with both hands on the table by putting our hands on these pictures *(demonstrating how to alternately clap and tap)*. Can you do it? *(E waits until the child claps and taps a few times).* Now, while we do this, we will also listen to some ticking sounds from our headphones and try to tap according to the tick-tocks. Let me show you first and then you will do it.

[E takes the hands sheet in front of her and demonstrates clapping-tapping for a couple seconds. When finished, E instructs the child to practise as well, and continues to clap with the child for the next 20 seconds of the track. Where necessary, E gives instructions and provides praise to the child. A maximum of two trials are administered to avoid fatiguing and frustrating the child]

Experimenter — Now that your training is complete, *(say name of participant 1)* can work on the dot-to-dot puzzle with *(says name of volunteer)* while *(says name of participant 2)* can train with me.

[Participants switch seats. Repeat training for participant 2]

Experimenter — We will now play the game in a different way

[Do not state that they would play it 'together' or 'facing each other'. E then changes the configuration of participants tables to prepare the set-up for the test phase and turns on audio recorder]

Experimenter Begin clapping and tapping like we practiced when you hear the tick tock noises. Ok, ready, set, go!

[Wait for participants to finish game]

Experimenter Thank you very much for playing these games with me. Before you leave, I realized we only fed the blue and yellow fish, and the red and green fish are still hungry.

To make sure all the fish get fed, we are going to fill the green tube with green food, and the red tube with red food. So *(says name of 1st participant)* you will use the red tube to feed the red fish and *(says name of 2nd participant)* you will use the green tube to feed the green fish. This way we will know all the fish had their dinner. Once you are done you can leave the empty tube beside the fish tank and sit back down at the table.

[Researcher will then pretend to be engrossed in something and will not watch the proceedings. If child tells you the fish food spilled, look up and say 'put them back in the tube' and then look back down at pretend task.]

Experimenter Perfect. Now we know all the fish ate their dinner. Thank you for feeding the fish!

I am going to ask you the same questions I asked when we first played the fish feeding game. Once again, use this card here *(tap emotion card)* to tell me how you felt.

Experimenter Remember, there is a happy face here, a sad face there and another one in the middle that is neither happy nor sad. To show each other how we feel, we peel off a sticker and stick it on one of the boxes on our emotion cards.

How did you feel when you were feeding the fish?

How do you think the fish felt when you were feeding them their food?

[Ask ONLY the participant who had the intact tube the next two questions]

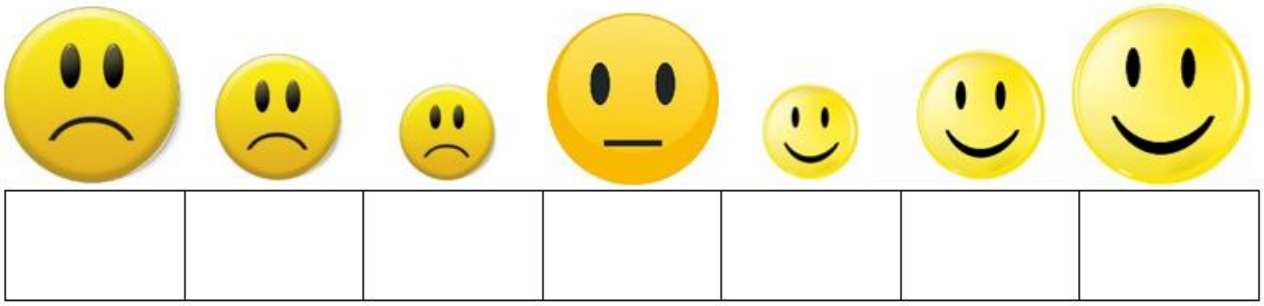
Experimenter	*(Say name of participant 1)* how do you think *(participant 2)* felt when their fish food spilled?
	(*Still addressing participant 1)* How did you feel when all (*participant 2's)* fish food spilled?

[Participant 2 does need to be asked these questions since it was their fish food that spilled]

Experimenter	Awesome, that's it for today. Thanks for feeding the fish!

Appendix B

Emotion Card Likert Scale



Fish Feeding Apparatus