Journal of Nonverbal Behavior (2024) 48:235–251
https://doi.org/10.1007/s10919-023-00445-6

ORIGINAL PAPER

Follow the Leader: Parent- and Child-led Synchrony in Competitive and Cooperative play

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Accepted: 20 October 2023 / Published online: 4 November 2023

Abstract

Social interactions involve both cooperation to achieve a shared goal and competition over shared resources and rewards. The ability to engage in inter-personal coordination is an important measure of socio-emotional and cognitive well-being. Both cooperation and competition require interpersonal coordination, however with different motivational backgrounds. Competition is defined by a higher level of extrinsic motivation, while cooperation is related to more intrinsic motivation. In the context of the parent-child dyad, each individual has different motivations and contributions to the dyad. The parent's and child's sense of competitiveness and contribution to inter-personal synchrony will presumably differ from each other and adapt to one another. The current research employed Motion Energy Analysis, an objective measure of coordination of movements between individuals, to measure motor in-phase and anti-phase synchrony during parent-child cooperative and competitive play, with a focus on parent and child-led synchrony. Findings highlight that parents rate themselves as less competitive than their children rate themselves; with no such difference noted in cooperation. Further, parent-led motor synchrony is defined more by in-phase coordination in competition, especially when the interaction is novel. Alternatively, child-led motor synchrony is more anti-phase during competition. In cooperation parents and children lead synchrony to the same extent and in the same phase. Current findings highlight that parent's and children uniquely adjust their leading behaviors in synchrony in competition, presumably adjusting their behavior to accommodate a complex situation. Given the importance of cooperative and competitive interactions to overall social well-being, and the parent's role of modeling behaviors for their child, findings may direct future guidance and treatment plans that will promote social development.

Keywords Social interaction · Motor synchrony · Competition and cooperation · Parent child interaction · Children

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Introduction

Social interactions largely involve both cooperation to achieve a shared goal and competition over shared resources and rewards, activated in a socially appropriate context (Fülöp, 2022). The ability to engage in inter-personal coordination is an important measure of successful socio-emotional and cognitive well-being (Harrist & Waugh, 2002), and requires a mental representation of the partner's expected actions, and simulation of the other's actions (Ramnani & Miall, 2004). Both cooperation and competition are important social constructs (Abraham et al., 2019; Henrich & Muthukrishna, 2021; Sheridan & Williams, 2006) and facilitate learning, perspective-taking, and emotion-regulation in children (Lobel et al., 2019). Competition and cooperation require interpersonal coordination, however for different reasons. Competition is defined by a higher level of extrinsic motivation, while cooperation is related to intrinsic motivation (Richard et al., 2002). Further, in competition, one must understand the other's point of view in order to promote his/her own personal goals; and in cooperation, it is important to coordinate with the other to achieve a shared goal (Tschacher et al., 2014). Despite the need to understand the other, research has shown lower levels of synchrony in competitive scenarios, such as during debate (Bernieri et al., 1994) or argument (Paxton & Dale, 2013). However, the literature indicates that the type or context also matters, for example, showing greater synchrony in integrative (win-win) rather than distributive (zero-sum) negotiations (Fujiwara et al., 2022). This line of work indicates that understanding the context and the individual motivation involved in the competitive and cooperative interaction may have important implications for interpersonal synchrony, and that interpersonal synchrony may possibly be sensitive to the stakes involved in the social encounter. Play has been thought of as a safe context where the risks are relatively low yet the gains are high, since play offers ample opportunities to learn and practice new skills (Hurwitz, 2002) and fine-tune social behaviors. For example, it offers an environment to self-regulate in response to losing or to wining in an apt manner, so not to discourage others from continuing to play (Vygotsky, 2016).

One unique context of interpersonal interaction is cooperative and competitive play in the parent-child dyad. The first arena in which a child learns to cooperate and compete is through exchanges with his/her parents. As such, the parent holds an important role of scaffolding, orchestrating and controlling elements of the interaction. In doing so the parent initiates behaviors and leads the interaction in a way that facilitates a comfortable environment for their child to follow. For example, the parent has been known to regulate the flow of the interaction by initiating activity when the infant stops, and stopping actions when the infant begins, thereby teaching the child how to engage in a turn-taking rhythm that fits them both (Feldman, 2007; Pereira et al., 2008). Further, parents contingently respond to their infant's cues, leading to augmented infant responses and a synchronized dyadic rhythm (Feldman & Eidelman, 2007; Markova et al., 2019). This type of turn-taking interaction mimics that of a conversation (Wilson & Wilson, 2005) already in pre-verbal infants, and offers the child first examples of a give and take interaction. As children grow and become more independent, they take on a more active role in leading the interaction, however the parent's influence remains crucial (Harrist & Waugh, 2002), and parents continue to modify their behavioral responses when interacting with their children (Yarmolovsky et al., 2023).

Indeed, theoretical approaches suggest that co-development in leader follower relationships over time lead to the best interacting system, and this adjustment is sensitive to contextual factors (Valcea et al., 2011). This is plausibly an important notion in the parent-child interaction, with both individuals adjusting to the other throughout the relationship. For example, the parent and the child show flexibility adapt to each other's needs and adjust their leadership/follower behaviors in a context dependent manner (Lunkenheimer et al., 2011), such as in cooperative as compared with competitive play. Within any relationship it is important to find a balance between gaining a sense of agency and depending on the other (Keller & Cacioppe, 2001). Yet, the parent-child dyad is a special case. When a parent and child play a game together, they each have their own personal motivations to succeed. At the same time, the parent takes into account their child's needs based on past experiences, and weighs their own desire to succeed, as well as their desire to see their child succeed now and in the future (Bell & Richard, 2000; Thai et al., 2019; van Houtum et al., 2021). On the other hand, the child who feels secure with their parent will have more room for autonomy and personal goal seeking (McElhaney et al., 2009). This dynamic may lead the child to feel comfortable enough to compete with their parent in a safe environment, offering an opportunity to learn appropriate social interactions. Likewise, the parent may adapt their behavior to help promote the most accommodating and appropriate environment for their child (Yarmolovsky et al., 2023). As children grow and develop a greater sense of agency, parents are challenged with the task of allowing the child independence and providing support and assistance along the way. As such, it is important to view the bidirectional influence of each individual in the parent-child dyad in coordinating with each other, which comprises not only of individual real time contribution, but also a consideration of past expectations and influences of future anticipations (Loulis & Kuczynski, 1997).

One important measure of inter-personal coordination is that of movement synchrony. Movement synchrony is an objective measure of non-verbal coordination of movements between individuals (Ramseyer, 2020). Literature has shown that behavioral coordination predicts relationship quality and outcome and encourages social bonding in dyadic interactions (Cirelli et al., 2014; Nyman-Salonen et al., 2021; Pan et al., 2022) as well as increased pro-social behavior, and higher levels of endorphins (Sullivan et al., 2014). Several studies indicate that motor synchrony increases cooperation and is associated with positive relationships (Hove & Risen, 2009; Miles et al., 2010; Wiltermuth & Heath, 2009). Literature examining competition, however, is much more sparse, with one study showing increased motor synchrony in competitive as compared with cooperative debate, attributed to higher affect associated with competition (Tschacher et al., 2014) and greater synchrony in integrative rather than distributive negations (Fujiwara et al., 2022). Other studies show lower levels of synchrony in competitive debate (Bernieri et al., 1994) or argument (Paxton & Dale, 2013). In neural imaging research, one study found increased neural synchrony between partners in a competitive situation, with no such effect in a cooperative setting (Liu et al., 2015), while other works have found increased neural coordination in cooperation as opposed to competition (Cui et al., 2012).

One under-explored line of research that may help explain differences in findings is in-phase and anti-phase synchrony. In-phase synchrony is characterized by movements that occur in perfect union, while anti-phase is defined by alternating movements. While both represent coordination, research has shown that in-phase and not anti-phase synchrony is related to a raise in endorphins associated with prosocial and cooperative behavior (Sullivan et al., 2014). While research in competitive scenarios is lacking, we may expect more anti-phase synchrony in a typical competitive interaction that is defined by alternating behaviors in turn to promote an individual and less prosocial goal (Tschacher et al., 2014).

Among parent-child interactions, to our knowledge no data exists regarding motor synchrony in competition and cooperation, or regarding in-phase and anti-phase synchrony. Few studies have however explored parent-child neural synchrony. One such work employed a computerized go/no go task that has cooperative and competitive components, yielding varying findings. One study noted neural synchrony in both cooperation and competition (Kruppa et al., 2021; Reindl et al., 2018), and another found synchrony only in cooperation (Reindl et al., 2018). Likewise, research exploring father-child interaction showed increased neural synchrony in a cooperative task rather than an individual task (Nguyen et al., 2021). It is likely that synchrony in different domains represents distinct processes (Reindl et al., 2022). Therefore, the current research explores, for the first time, motor synchrony both in-phase and anti-phase, in parent-child cooperative and competitive play, with a focus on who leads the synchronous interaction.

An objective way of measuring movement synchrony is Motion Energy Analysis (MEA), which calculates pixel changes for a specific region of interest between frames of video recordings (Ramseyer, 2020). MEA then creates a time series of data that quantifies movement, and if multiple regions of interest are created (ex., two participants), they can be compared using cross correlational analysis (Boker et al., 2002). Using cross-correlation analyses, it is possible to see which member of the interaction leads the motor synchrony in a given interaction (Ramseyer, 2020; Völter et al., 2022), as well as whether the synchrony is in-phase or anti-phase.

Measuring motor synchrony allows us to assess how parents and children synchronize their behavior both simultaneously, as well as how each individual contributes to the interaction with room for a leader follower dynamic. The current research measured motor synchrony in parent-child cooperative and competitive dyadic play, with a focus on parent and child-led synchrony. We hypothesized that parents would report feeling less competitive than children, due to their individual motivations in the dyad. Further, we expected that movement synchrony would occur both in competition and cooperation during parent-child interactions (Tschacher et al., 2014). Considering the differential motivations that exist in the parent child dyad, we expected that competitive drive would be related to synchrony differently between the partners. That is, due to the parent's motivation to see their child succeed, we expected that parental competitiveness would be related to increased prosocial in-phase synchrony (Sullivan et al., 2014) in competition with their child; and given the child's motivation to succeed, we expected that child competitiveness would be related to more in-phase synchrony in cooperation, as this behavior is in line with the rules for winning in the cooperative condition, to work together. Finally, while in cooperation, we expected no apparent differences in who leads the motor synchrony; differences in leading behavior were expected in parent-child competition. Parents were expected to adapt in ways that would assist and encourage their child's success in an environment where their children feel comfortable. Therefore parents were expected to lead the synchronized interaction in a similar phase and manner during competition as in cooperation, when extrinsic motivation and emotional valence are high. Finally, child-led synchrony was expected to be more related to the less prosocial anti-phase synchrony while parent-led synchrony was expected to be more associated with cooperative in-phase synchrony.

Methods

Participants

Twenty-one parent-child dyads were recruited for the study. Children were between 8 and 12 years old (mean=9.8 ± 1.2; 61% female), and their parents ranged between 37 and 48 years old (mean=42.8 ± 4.8; 81% female). All parents and children gave their informed consent prior to participating in the experiment. All families were white, middle to upper-middle class and all earned above average income according to Israeli standards. Sample size was determined using G*power software (Faul et al., 2009) with the aim to detect a medium to large effect size, using a significance level of 0.05 and a power of 0.8, yielding a sample size of 20. To preserve an inclusive policy and to not infringe on natural family specific dynamics, each family decided whether the mother or father would participate in the research, leading to four father-child dyads joining the research. To ensure that the parent's gender did not account for significant results, an ANOVA was conducted comparing parent and child led synchrony as a function of parental gender, yielding nonsignificant results (Parent Led=$F(1,61)=0.678$, $p=.412$; Child Led=$F(1,61)=1.033$, $p=.314$). Additionally, main findings were not different when fathers were removed from the analysis.

Task

Parent-child dyads were tasked with playing the tower building game Jenga©, in which participants must remove blocks form a stack and place them on top of the tower with the goal of keeping the tower standing for as long as possible (Fig. 1). In the current design, participants were asked to play the Jenga game in 3 experimental conditions: Individual, Cooperation and Competition. In each condition participants were given 5 min to play based on specific rules and were instructed to continue playing until told to stop. In the case of a

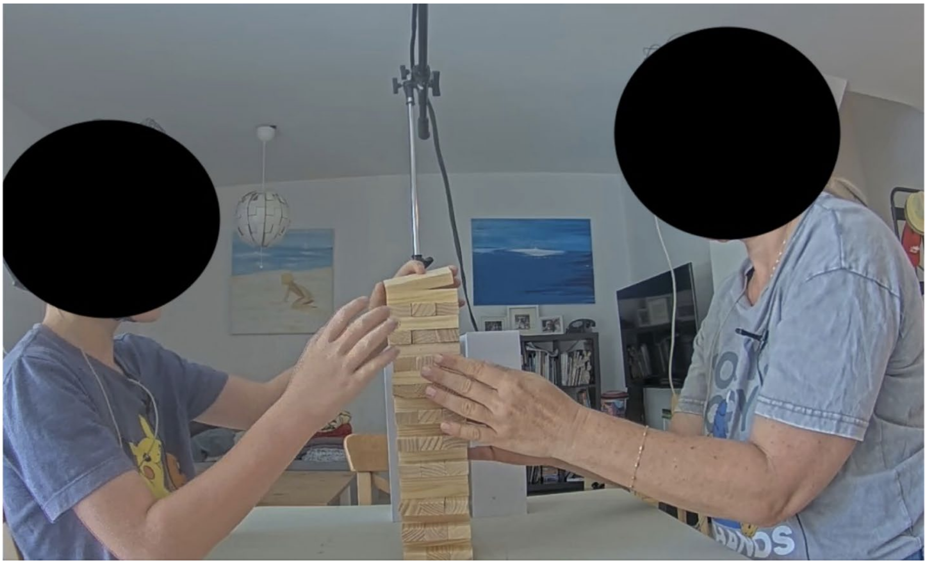

Fig. 1 Masked image of the experimental setup

tower falling participants were asked to sweep the blocks into a bag on the side of the table and they were provided with two extra sets of blocks that were ready to continue playing. Participants were instructed to remain seated in their chair throughout the task. If they stood up, they were reminded to please stay in their seat.

The individual condition was designed as a baseline observation of how individuals manipulate the tower blocks on their own. Each participant was seated one across from the other with a barrier placed between them so they could not see their partner. They were instructed to remove blocks from the tower and place them on top without allowing the tower to fall. The individual block was always performed first so not to prime the condition with cooperative or competitive motivation. Following the individual block, the cooperation and competition blocks were introduced in counter balanced order. In the cooperation condition, participants were seated across from each other with a set of Jenga© placed between them and were instructed to take turns removing one block at a time and placing it on top of the tower. In this condition participants were told to work together with the shared goal of not allowing the tower to fall, and in the case that the tower fell both participants lose. In the Competition block participants received identical instructions, however they were told that they are competing against one another and if the tower falls the player who caused it to fall loses. All interactions were video recorded from the profile view.

Cooperation Competition Self-Report

At the end of the experimental task participants were asked to fill out a short questionnaire rating how competitive and cooperative they felt during the experimental procedure, and how cooperative and competitive they rate themselves in general. Responses were scored on a 10-point Likert scale, with 10 being the highest and 1 being the lowest. This questionnaire provides insight into the self-reported levels of competition and cooperation that each individual rated themselves during the study and in general.

Motion Energy Analysis (MEA) and Motor Synchrony (MS)

MEA software applies an automated method of calculating changes in motion in video recordings by monitoring the change in pixels between frames in predefined regions of interest (ROIs) set to represent an individual (Ramseyer, 2020). Video recordings of all three Jenga conditions were analyzed using the MEA software with one ROI per participant, excluding the middle of the table where overlap between the two participants occurred. Videos were inspected for any light or movement anomalies (i.e., movement or changes in light in the frame not coming from the parent or the child). Two videos were edited to remove anomalies, one in the individual condition and one in the cooperation condition. In both cases short segments were removed, with very little influence on the amount of data extracted.

MEA software output was then used to calculate MS, employing the rMEA package for R-studio (Kleinbub & Ramseyer, 2021). Data was smoothed, rescaled and cleaned of outliers using the approach outlined in Kleinbub and Ramseyer (2021). Motor synchrony was calculated using cross correlation function (CCF) analyses with a maximum of 5s lags in each direction, a window of 30s in 10s increments. Parameters were chosen based on methodological considerations and current data inspection. To assess parent and child led synchrony, the average CCF over all parent led and all child led lags were calculated, leading to a single parent lead MS score and a single child lead MS score per dyad, with positive CCF values representing in-phase synchrony and negative CCF values representing anti-phase synchrony. Additionally average overall CCF across all leads was calculated for a single overall synchrony score per dyad.

Results

Synchrony Versus Pseudo Synchrony and Manipulation Check

To ensure that actual synchrony above chance level occurred, pseudo-synchrony was measured by calculating CCF for all possible random pairs in all 3 conditions (7812 shuffled dyads). Analysis of variance comparing random versus real synchrony in cooperation, competition and individual conditions was conducted, yielding a significant main effect ($F(3, 7871)=42.27$, $p<.0001$, $\eta^2=0.016$; Fig. 2). Bonferroni corrected post hoc comparisons show that synchrony in the random condition was lower than real synchrony in the competition and cooperation conditions ($p<.0001$, 95% CI= [-0.057,-0.027]; $p<.0001$, 95% CI [-0.068,-0.037]; respectively). Importantly, no differences were noted between the individual condition and the random pairs; no differences were seen between competition and cooperation; and competition and cooperation conditions yielded greater synchrony than the individual control condition ($p<.0001$, 95% CI [-0.062, −0.018]; $p<.0001$, 95% CI [-0.072, −0.039]; respectively). These findings validate both that synchrony above chance level occurred during both cooperative and competitive conditions; and that the individual condition acts as a baseline with no movement synchrony occurring above chance level.

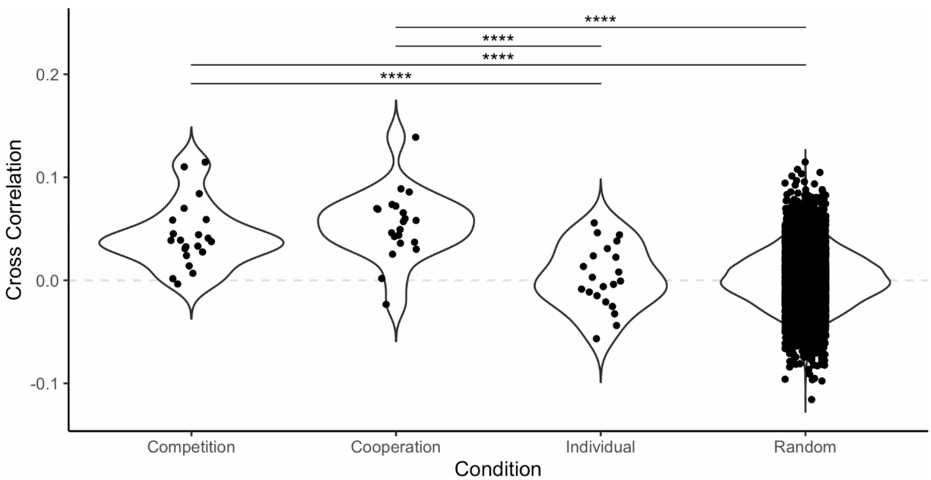

Fig. 2 Cross correlation as a function of competitive, cooperative and individual conditions, as well as a random shuffle of all possible random pairs. **** indicates $p<.0001$

Self-Reported Competitive and Cooperative Behaviors

To understand how parents and children viewed their own sense of competitiveness and cooperativeness, we analyzed their responses to the cooperation/competition questionnaire. A three-way ANOVA was conducted with self-reported responses as the dependent variable and cooperation/competition, in general/during the study, and parent/child as independent variables. Results indicate a cooperation/competition main effect, $F(1,155) = 61.93$, $p < .0001$, $\eta^2 = 0.28$, such that overall both parents and children ranked themselves higher on the cooperative than the competitive scale. Further, a cooperation/competition by parent/child interaction effect was found $F(1,155) = 9.094$, $p = .003$, $\eta^2 = 0.06$. Post hoc analyses indicate that parents rate themselves as less competitive than their children $F(1,155) = 8.430$, $p = .004$, $\eta^2 = 0.05$, with no differences noted in self-rated cooperation (Fig. 3).

Motor Synchrony During Parent Child Play

When exploring parent-child synchrony during cooperative and competitive play, the data show that the highest level of motor synchrony occurs when both partners move simultaneously (lead time = 0) for both conditions (mean competition = 0.141 ± 0.074; mean cooperation = 0.136 ± 0.069), however there is also above chance level synchrony both when the child moves first and the parent follows and when the parent moves first and the child follows (Fig. 4).

To test our hypotheses regarding parent led and child led movement synchrony in competitive and cooperative play, a two-way ANOVA with repeated measures was conducted. To calculate this, average CCF was included as the dependent variable, and within subject variables included leader (parent, child) and condition (cooperation, competition). Results yielded a significant leader main effect ($F(1,20) = 5.820$, $p = .026$, $\eta^2 = 0.040$), and a leader by condition interaction effect ($F(1,20) = 8.302$, $p = .009$, $\eta^2 = 0.054$; Fig. 5). Post hoc analyses

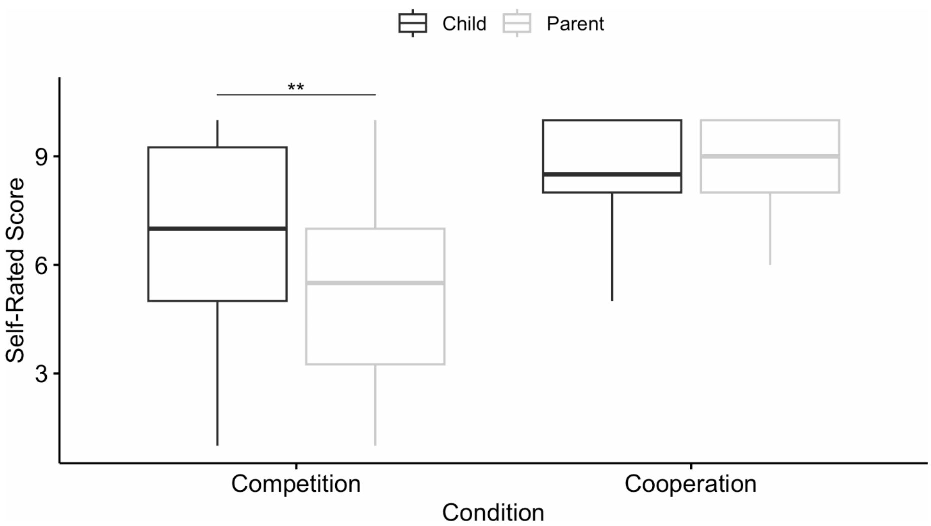

Fig. 3 Scores from the self-rated cooperative/competitive questionnaire as a function of cooperation or competition condition and parent/child. ** indicates $p < .01$

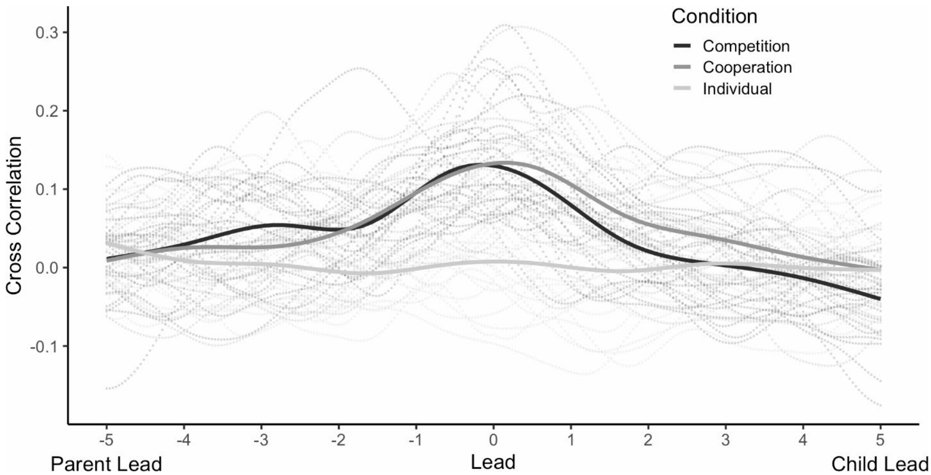

Fig. 4 Cross correlation scores as a function of condition over all possible leads

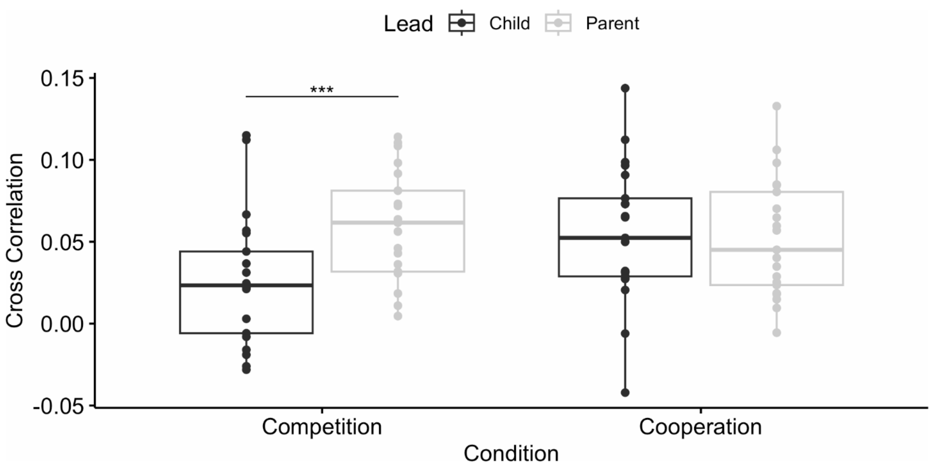

Fig. 5 Cross correlation as a function of lead type and condition. *** indicates $p<.001$

of the interaction effect with Bonferroni corrections indicate that during competition parent-led synchrony (mean $=0.05 \pm 0.03$) is higher than child-led synchrony (0.03 ± 0.04; $t(20)$=-4.05, $p<.0006$); while in cooperation no such differences were seen (mean parent $=0.05 \pm 0.04$; mean child $=0.05 \pm 0.04$). Findings support our hypothesis that in competition parents lead the synchronous interaction with higher amounts of in-phase synchrony, while their children's synchrony is more represented by lack of synchrony or anti-phase synchrony in this condition.

To check how presentation order influences synchrony, a mixed model ANOVA was conducted with CCF as the dependent variable, leader (parent, child) and condition (cooperation, competition) as within subject variables and order as the between subject variable. Results indicate a lead main effect ($F(1,19)=5.649$, $p=.028$, $\eta^2=0.044$), as well as order by condition ($F(1,19)=5.387$, $p=.032$, $\eta^2=0.044$), and condition by lead ($F(1,19)=9.994$, $p=.005$, $\eta^2=0.055$) interaction effects. Additionally, a condition by lead by order triple interaction was found ($F(1,19)=7.110$, $p=.015$, $\eta^2=0.040$; Fig. 6). Bonferroni corrected post hoc analyses indicate a condition main effect specifically for child-led synchrony ($F(1,19)=6.11$ $p=.016$, $\eta^2=0.074$), such that more in-phase synchrony occurs in cooperation and more anti-phase synchrony is seen in competition. For parent-led synchrony, a condition by order interaction effect was seen ($F(1,19)=15$ $p=.001$, $\eta^2=0.196$), such that more in-phase parent led synchrony occurs in competition only when the competition task occurs first ($F(1,19)=5.04$, $p=.028$, $\eta^2=0.064$) compared to when it occurs second, and no significant difference is seen for cooperation.

Next a logistic regression analysis was conducted to explore whether child-led synchrony is related to in-phase or anti-phase synchrony. Phase type was calculated based on whether CCF was positive (in-phase) or negative (anti-phase), and included as the dependent variable. Lead was included as the independent variable. Findings indicate that the log-odds of exhibiting in-phase synchrony significantly decreased in child-led ($\beta = -1.1333$, $p=.0368$), compared to parent-led synchrony. The model demonstrated good fit with a residual deviance of 50.352 on 82 degrees of freedom and an AIC of 54.352.

Reported Competitive and Cooperative Behavior Relations with Motor Synchrony

To understand the relationships between self-reported competitive and cooperative feelings during the study and synchrony in cooperation and competition tasks; Pearson's correlation analyses were conducted comparing child and parent cooperative and competitive ratings and overall motor synchrony during cooperation and competition as well as parent and

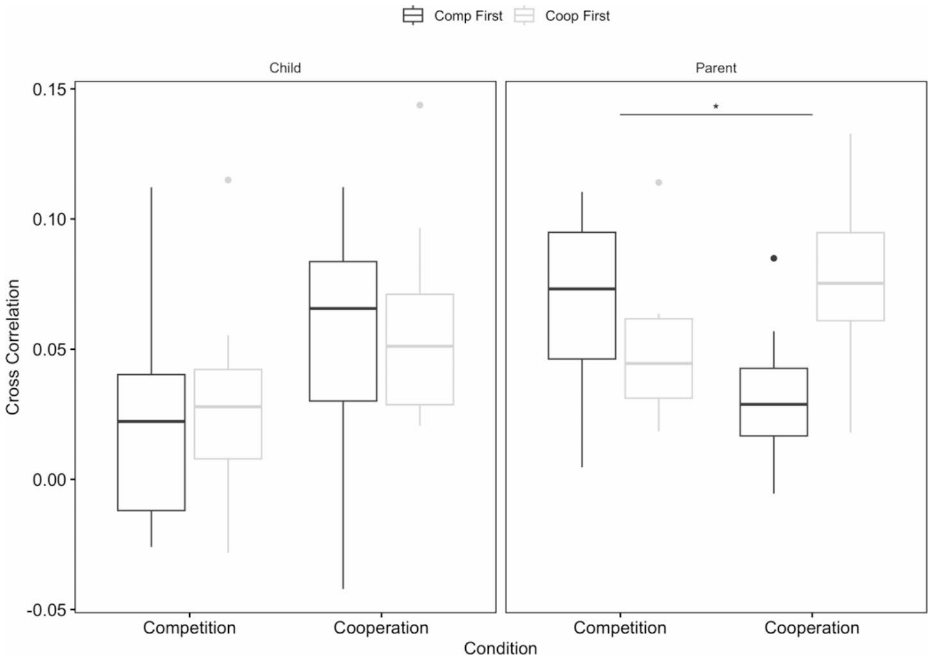

Fig. 6 Cross correlation as a function of lead type, condition and presentation order. ** indicates $p<.01$

child led motor synchrony. Results indicate that child competitiveness with their parent is positively related to motor synchrony during cooperation, and parent competitiveness with their child is positively related to motor synchrony during competition. Additionally, parent competitiveness is positively related to both child led cooperation and competition. Finally, child competitiveness is positively related to parent led cooperation synchrony (Table 1).

Overall findings highlight that parents rate themselves as less competitive than their children rate themselves. Further, parents' self-rated level of competitiveness is positively related to synchrony in competition with their child, as well as child led synchrony in cooperation and competition. Additionally, children's self-reported competitive rating is positively associated with synchrony during cooperation. These relations are complemented by motor synchrony differences, such that when parents lead, their motor synchrony is represented by in-phase coordination in competition more so than children, and in cooperation no such differences are apparent. Further, when examining the effect of condition order, in-phase parent-led synchrony was even higher when the competitive condition occurs first.

Discussion

Research shows that the ability to compete holds a crucial role in human evolution, with some theories suggesting that social competition is critical to the development of human intelligence (Flinn et al., 2005). As such, the parent's role as the child's first exposure to social interaction, and a model for teaching their child to effectively compete is fundamental for their child's development. However, little is known about the parent's and children's behavior during competition with each other. The current findings reveal an important effect in the parent's increased self-reported sense of competitiveness as compared with the child's, as well as differential displays of motor synchrony leading when parents and children compete with each other.

The current research evaluated the parent's and the child's contribution to synchronous social interactions during cooperative and competitive play using self-assessment of cooperation and competition, as well as motor synchrony. Findings highlight that parents regulate their sense of competitiveness and parents and children adapt their modes of competitive behavior when competing with each other. Findings were such that parental self-reported sense of competitiveness was lower than children's sense of competitiveness. Further, par-

Table 1 Correlations between motor synchrony and parent and children's competitive or cooperative self-ratings

		1	2	3	4	5	6	7	8	9	10
1	Comp ALL CCF	1									
2	Coop All CCF	**0.48***	1								
3	Child Led Comp CCF	**0.89*****	**0.55****	1							
4	Parent Led Comp CCF	**0.83*****	0.25	**0.49***	1						
5	Child Led Coop CCF	**0.45***	**0.86*****	**0.5***	0.26	1					
6	Parent Led Coop CCF	0.35	**0.81*****	0.42	0.14	0.41	1				
7	Parent Comp Rating	**0.58****	0.4	**0.57****	0.42	**0.46***	0.19	1			
8	Child Comp Rating	0.29	**0.51***	0.21	0.28	0.36	**0.52***	**0.49***	1		
9	Parent Coop Rating	0.2	0.08	0.31	0.01	-0.1	0.31	0.22	0.25	1	
10	Child Coop Rating	0.21	0.31	0.28	0.07	0.15	0.4	0.19	**0.49***	0.3	1

ent led motor synchrony is greater, representing more in-phase synchrony, than child led motor synchrony when parents and children competed with each other; while both parents and children lead motor synchrony to the same extent in cooperation. Findings shed light, for the first time, on the parent and child's role when competing with one another.

Notably, when considering the order of the social interaction (i.e. which condition occurred first), parent-led synchrony was the highest in competition when the competition condition occurred first. This may strengthen the notion that parents and children adapt to each other based on condition. That is, the complexity of the competitive condition, combined with the novel social interaction (Lomas et al., 2017) resonates with evolutionary-based behavioral patterns driven to increase the likelihood of survival (Flinn et al., 2005). Findings show that indeed in a play context, a novel competitive circumstance creates an even more potent situation that possibly signals both parent and child to adapt and elicits more strongly a parent-led synchrony, where the parent initiates the movement and the child follows.

Interestingly, the trend seen in rating of trait competitiveness is unique, and no differences were seen in cooperative rating between parents and children. Findings do however show that both parents and children rate themselves higher on the cooperative scale than on the competitive scale, possibly due to the negative association that comes with competitiveness (Richard et al., 2002). That is people may prefer to see themselves as more cooperative rather than competitive. Despite this, competitiveness is considered an important aspect of development and is often encouraged in certain scenarios (i.e., sports, educational achievements, etc.; Richard et al., 2002). In some cases, competition has been found to improve performance. For example, higher levels of creativity were seen in competitive as compared with non-competitive conditions (Eisenberg & Thompson, 2011). One study points to differential competitive behavior among friends as compared with non-friends, finding increased positive affect and more rule following when competing with friends (Fonzi et al., 1997; Richard et al., 2002). This seems to suggest that we compete differently with those close to us, therefore parent-child competition offers an ideal scenario to learn how to compete with close others in a socially appropriate manner.

The ability to appropriately compete with others in a play context may help shape future social interactions. Effective, socially appropriate competition incorporates both cooperative teamwork and personal development over performance (Daniels, 2007). In the context of the parent-child relationship, dynamic dyadic emotional processes are important for future socio-emotional development (Lunkenheimer et al., 2020). Therefore, honing in on these important skills in a safe space with a parent may have important implications for development of emotional regulation and social development and overall adaptive social interactions. In the current research parents and children showed their ability to flexibly adapt to one another, sometimes with the parent taking the lead and the children following, sometimes the child taking lead and the parent following and sometimes both synchronizing simultaneously.

Cooperation and competition theories also note that the two are not necessarily separate entities, and in fact they often occur in tandem and on a continuum (Fülöp, 2022; Richard et al., 2002). That is, in one interaction an individual can move in and out of competition and cooperation with their partner or be both cooperative and competitive simultaneously. Current findings in fact show that child competitiveness is related to increased synchrony during cooperation, suggesting that in the cooperation task, the competitive drive of the child is still at play. Therefore, the more competitive a child feels, the more they exhibit in-phase synchrony with their parent in general, likely in an attempt to follow the rules and accomplish their shared goal of working together in order to win (Fülöp, 2022). Similarly, child competitiveness is related to in-phase parent-led cooperative synchrony, reflecting similar adaptive behaviors in cooperation to those seen in general in competitive scenarios in the parent-child interactions. In contrast to this, parent competitiveness was found to be related to overall in-phase synchrony during the competition task, plausibly suggesting that the more competitive parent is more engaged in the competitive task with their child, and parental engagement is related to a reciprocal responses between the partners (Weiss & Hayashi, 1995). Further, findings that parent competitiveness are related to more in-phase child-led synchrony mimics more the behavior of the children in competition in general, showing less pro-social in-phase synchrony and more individually motivated anti-phase synchrony when following their child.

Taking into consideration the negative association often connected to competition, along with the parents' desire to empathize with their child and see them succeed; parent-child competition creates a unique and important scenario for the dyad in which the parent may have conflicting motivations. On the one hand the parent's role includes modeling behavior (Davis et al., 2018) and therefore they presumably take on the role of teaching their child to compete in social scenarios through modeling competitive play. On the other hand the parent has an intrinsic drive to empathize with their child and see them succeed (Bell & Richard, 2000). Additionally, children may be able to lean on their parents and learn how to compete in an effective manner (Singer et al., 2006). Current results suggest that parents and children behave differently when competing with each other. That is, when parents lead synchrony in competition their synchrony is mostly in-phase, similar to the way that they act in cooperation; an effect that is even stronger when the competitive condition occurred first. Children on the other hand behave more individually in competition, with anti-phase child-led synchrony observed in competition, which is more indicative of the less prosocial competitive interactions (Sullivan et al., 2014).

Importantly, a leader-follower interaction is a bidirectional process, with both sides influencing one another. Therefore, we can expect both parties to lead and follow synchrony throughout the interaction. In fact, a pattern of dynamic leader/follower roles is a pattern indicative of successful social interactions (Feldman, 2012; Launay et al., 2016). Current findings represent this pattern, with data showing that most in-phase synchrony occurs when partners act simultaneously, at lag zero, indicating that synchrony occurs at high rates in general. Future studies may explore this notion with diverse samples to explore what characteristics are associated with synchrony. However, both parent-led and child-led synchrony can also be seen above chance level in the current sample, suggesting that both individuals lead in synchrony at some point throughout the interaction. Due to the bidirectional nature of the interaction, both leaders and followers are influential in developing a successful system, working together and adapting to one another (Valcea et al., 2011). In this light, the current data extends literature on infant-parent interactions (Markova et al., 2019), suggesting that in childhood and adolescents parents still adapt their behavior based on their child's need, while the child adapts accordingly to follow suit, particularly when managing conflicts in competitive contexts. Alternatively, when the child leads, the pattern of synchrony represents more individually motivated anti-phase behavior, possibly representing the parent's effort to allow their child to take control and follow their child's lead. Future studies may explore nested models and more micro-behaviors in individual turns to further clarify the parent-child role in competitive play, as well as factors that may contribute to synchrony on a macro level, such as attachment. Additionally, the current sample exemplifies typically developing children and their parents, providing an archetype example of parent-child competition. Future studies in non-typical populations may provide insight into interactions that deviate from the norm. Finally, the turn-taking nature of the Jenga game may help shape the motor synchrony exhibited. While the differences in synchrony noted between partners seems to indicate that the coordination goes beyond similar movement patterns associated with the game, future studies may explore synchrony in different cooperative and competitive play scenarios.

Overall, the current findings highlight the notion that parents and children synchronize during cooperation and competition, however the interaction in competition is unique. Parent-led in-phase synchrony and child-led anti-phase synchrony occurs more in competition, while in cooperation both parents and children led synchrony in a similar way. Therefore, parents behave in competition as they do in cooperation with their child, showing high levels of parent-led in-phase synchrony. Given the importance of cooperative and competitive interactions and interpersonal synchrony to overall social well-being, and the parents critical role of modeling such behaviors for their child, findings may have important implications in considering future guidance and treatment plans that will promote social development.

Acknowledgements We thank the individuals who participated in this study, as well as the team at the Developmental Neuropsychology lab for their assistance and support.

Author Contributions All authors contributed to the study conception and design. Material preparation, data collection, analysis and initial write up were performed by JY. RG contributed to data interpretation, as well as editing of the manuscript. All authors read and approved the final manuscript.

Funding This study was funded by the Israel Science Foundation (ISF 1510/16).

Data Availability The data that support the findings of this study are available from the corresponding author upon request.

Declarations

Competing interests The authors declare no competing interests.

Ethics Approval and Consent to Participate This research was approved by the Bar Ilan Department of Psychology ethics committee. Informed consent was obtained from all participants and their guardians.

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