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„The Role of Interpersonal Motor Synchrony in Children's Social Expectations "

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Theoretical Background

Humans have the impressive ability to coordinate activities without much conscious cognitive effort (Hoehl et al. 2021). Whether walking, rocking, making music or other activities we tend to coordinate actions with others or external stimuli all the time. For example, (Zivotofsky & Hausdorff, 2007) found that people synchronized their walking spontaneously, although they were not instructed to do so. Even newborns show the tendency to synchronize, as evidenced, for example, by synchronizing their leg movements with adult speech (Condon & Sander, 1974), or engaging in parent-infant synchronies, including gaze or vocalizations (Feldman, 2007). Interpersonal synchrony, which can be described as movements matched in time between at least two individuals, has been shown to have powerful effects on social development, such as preparing for human dialogue or shaping the capacity for empathy (Feldman, 2007), suggesting that synchrony is highly relevant for social learning as dialogue is part of an infant's earliest interactions and emotional resonance underlies human relationships across the lifespan (Feldman, 2007). Another study showing that motor synchrony between a learner and an instructor is associated with better learning performance (Pan et al., 2021) also emphasizes the relevance of investigating the relationship between (social) learning and synchrony. Moreover, remarkable effects of synchrony on prosocial behavior, such as enhanced helping or sharing have been found (eg. Wiltermuth and Heath, 2009; Rabinowitch and Meltzoff , 2017). The blurring of boundaries between the self and the other (Hove, 2008), social bonding through social cognition (Macrae et al., 2008) and positive affect such as affiliation (Hove & Risen, 2009) or social cohesion (Ehrenreich, 2007) are discussed as possible mechanisms for mentioned effects in the existing research literature.

Whereas previous studies have described the social affective and behavioral outcomes of interpersonal synchrony and attempted to elucidate the underlying mechanisms, it remains unclear whether and in what form synchrony also leads to the expectation of certain behaviors from the interacting partner. Expecting, in the sense of anticipating or predicting outcomes of others' actions and knowing what others are going to do next is crucial to successfully interact with others (Verfaillie & Daems, 2002). Interpersonal motor synchrony makes the actions of interaction partners more predictable to each other (Hoehl et al., 2021), suggesting that synchrony not also induces certain behavior, but also might enhance expectations of the interaction partner's behavior.

In the present paper, we investigate the influence of motor synchrony on social expectations of the behavior of the interactive partner in preschool children. In doing so, we specifically investigate whether expectations on social learning behavior and prosocial

behavior, both of which are associated with synchrony, increase when the two participants were previously in synchrony compared to asynchrony.

Interpersonal Synchrony

From the beginning of a child's life, social interactions are of enormous importance for (early) child development. Social exchanges, in form of social gaze, affectionate touch or vocalizations, enable a first understanding about oneself and others (Feldman, 2007). A significant part of these social interactions follows coordinated or even synchronous patterns (Feldman, 2007). Synchrony can be described as a 'dynamic process by which hormonal, physiological, and behavioral cues are exchanged between parent and young during social contact.' (Feldman, 2012, p. 42). While in the first months of an infant's life mothers usually provide contingency to the child's behavior, thus providing precursors of synchronous interactions, three-month-old infants already engage in synchrony themselves, which is when a so-called face-to-face synchrony between parent and child can be observed (Feldman, 2007). Also, certain signals like gaze, vocal, affective, and tactile signals are coordinated for the first time (Feldman, 2012). At this age, infants also begin to participate in triadic synchrony, in which they adjust their behavior not only to the interacting partner but also to the nonverbal cues between the parents (Gordon & Feldman, 2008). This ability to be an interactive participant in a system with multiple people and inputs, supports the development of social skills (Feldman & Masalha, 2010). Additionally, caregivers provide an important set of synchronous experiences for children, engaging in musical behaviors such as singing, clapping, dancing and bouncing with them (Feldman, 2017). This matching of cues between two or more people during social contact can be referred to as interpersonal synchrony (Feldman, 2017). Interpersonal synchrony can occur in different forms (dyadic, triadic), can be measured on different levels such as physiological synchrony, which includes synchronization of neural oscillations, heart rhythms or certain hormones, or behavioral synchrony, including matching body movements or affective states (Markova et al., 2019), and can have noteworthy outcomes in both children and adults. As already mentioned, people tend to synchronize automatically, evidenced by a study that shows that people synchronized their walking spontaneously (Zivotofsky and Hausdorff, 2007). Results from Richardson and colleagues (2005) show that people in a rocking chair even rocked against the natural motion of the chair to be in synchrony with each other, revealing that the tendency to synchronize movements with other people not only happens automatically and without instruction, it is so strong that natural frequencies are overcome to establish interpersonal synchrony.

Interestingly, it can also occur under complete conscious conditions of direction and explicit instruction (Wiltermuth & Heath, 2009), and still show social outcomes. For example, it has been demonstrated that feelings of similarity and social proximity are enhanced after executing consciously instructed synchronous movements (Valdesolo et al., 2010; Tunçgenç & Cohen, 2018). Hove & Risen (2009) conducted three studies in which participants finger-tapped either synchronously or asynchronously with an experimenter to the ticking of a metronome. Participants reported higher affiliation towards the experimenter when they tapped synchronously with the experimenter compared to asynchronously. In the following, further social outcomes of interpersonal synchrony, which were crucial for the hypothesis generation of our study are indicated.

Synchrony and Imitation

Coordinated movements have been shown to predict children's later social, cognitive and communicative competency (Jaffe et al., 2001), highlighting that interpersonal synchrony is a social tool that facilitates social learning. Furthermore, recent results showed that enhanced motor synchrony between a learner and an instructor after a 6 Hz brain stimulation was associated with learning performance of songs (Pan et al., 2021). Although motor synchrony was not directly induced in this study it emphasizes the importance of the link between motor synchrony and social learning.

Faithful imitation, just like synchrony, is a very useful tool used by adults and children, that enables social learning. Imitation is a technique that allows especially young children to acquire new knowledge and skills. Moreover, it is of major importance for the development of cultural and social behavior (Meltzoff & Moore, 1999) and is believed to enable social learning of conventional knowledge and rituals. Interestingly, children's tendency to imitate is so strong that they even imitate actions that are perceivably unnecessary to achieve an instrumental goal, so called 'over-imitation' (Lyons et al. 2007). Over-imitation, surprisingly, is a robust phenomenon, as children copy irrelevant actions even when it is possible to tell those actions are not necessary to reach the goal (Horner & Whiten, 2005) when it results in less efficient performance (Nagell et al., 1993) or when they are explicitly instructed not to do so (Lyons et al., 2007). However, the body of research on this behavior, unique to humans (Nielsen & Blank, 2011), has grown over the past several years. Numerous social as well as causal accounts try to plausibly explain over-imitation. Nielsen and Blank (2011) for example propose that children over-imitate to affiliate with the other, whereas others suggest that children do so because of the desire to be like adults (Rabinowitch & Meltzoff, 2017), because they believe they are expected to do so (Lyons et al., 2011), because they are

predisposed to learn from others (Csibra & Gergely, 2009) or because they think it is part of a social norm (Keupp et al., 2013). Nevertheless, a single heuristic seems to be insufficient to be able to account for this complex phenomenon (Over & Carpenter, 2013), which is highlighted by the fact that children's over-imitation behavior depends on intentionality (faithful vs. selective copying) (Over & Carpenter, 2012), goals (learning goals vs. social goals), the group and the social context (Over & Carpenter, 2013). However, not only do children perform over-imitation themselves, they also expect others to do so. Kenward (2012) let three- to five-year-old children observe a puppet that did not perform the unnecessary action showed by an adult before, leading to protest from the children.

In this study, we want to take a closer look at the complex mechanisms involved and propose that motor synchrony might play a role. To do so, we tested whether synchrony increases expectations of the interaction partner's over-imitation behavior compared to asynchrony.

Synchrony and Prosocial Behavior

Previous studies show that motor synchrony is also associated with prosocial behavior from early in life (Tunçgenç & Cohen, 2018). Trainor and Cirelli (2015), for example, found that 14-month-old infants helped the experimenter after having been bounced to music in synchrony, while they did not help neutral strangers. Motor synchrony has been also shown to increase spontaneous helping behavior among peers (Tuncgenc & Cohen, 2018). Remarkably, prosocial effects are so strong, that people acting in synchrony with others cooperated more in group economic exercises, even in situations requiring personal sacrifice (Wiltermuth and Heath, 2009). Similarly, synchrony leads to enhanced sharing behavior, which is known to be an important form of prosocial behavior. Rabinowitch and Meltzoff (2017) found that four-year-old children who executed synchronous movements on a swing with an unknown peer tended to distribute resources to their partner generously, as long as they did not have to share unequally or to reduce their part of the share. Aligning the participants' emotional states (Ehrenreich, 2007) and establishing social bonds (Shultz & Dunbar, 2010) are discussed as possible mechanisms behind the effect on prosocial behavior. Thus, while it is now well recognized that children are more likely to share fairly with individuals with whom they have previously been in synchrony with, in this study, we seek to determine whether children also expect the other person to share fairly with them in return after they have performed motor synchrony together.

Already very young children at the age of 15 months seem to recognize unequal distribution as they pay more attention to unequal outcomes, thus children at the age of 15

months seem to expect an equal distribution (Sommerville et al., 2013). Also, children tend to share more with friends and expect others to share more with them as well (Moore, 2009; Olson & Spelke, 2008, Paulus & Moore, 2014). Paulus and Moore (2014) found that the development of sharing and the expectations of sharing follow a similar path and that this behavior emerges around the age of four years. Moreover, children at the age of three- to five protested when a puppet distributed items unfairly, even when the puppet distributed those items to a third person (Rakoczy et al., 2016), supporting our hypothesis that preschool children between four and six years of age expect others to share more equally after having been in motor synchrony with them compared to asynchrony.

Present Study

To sum up, in this study, we propose that motor synchrony might have an influence on children's expectations of the interactive partner's social learning behavior and prosocial behavior. Specifically, we investigate whether expectations on over-imitation and sharing increase after having been in synchrony, compared to asynchrony. Effects of synchrony can be shown in very young children (e.g., Tunçgenç et al., 2015; Wiltermuth & Heath, 2009). Also, the tendency to over-imitate, which can be observed in children at the age of three, increases over the following years of life until it can be described as robust at the age of five (McGuigan et al., 2007). In parallel, sharing expectations develop around the age of four (Paulus & Moore, 2014).

Here, we hypothesize that four- to six-year-old preschool children who were previously in motor synchrony with an (a)synchronous partner will protest more when (1) the (a)synchronous partner (in our case a puppet) does not perform over-imitation actions and when (2) the puppet shares stickers unfairly, compared to children who were previously in asynchronous motor activity with the puppet.

Method

Participants

In the present study, 59 four- to six-year-old children were tested. According to sample size calculations with G*Power 3.1 (Faul et al., 2009), the optimum number of participants would be 54 (expected effect size d= 0.5, $p < .05$, and desired power 1-ß= 0.8). Due to several Corona-related university closures and resulting delays in testing, 46 participants (f= 26; m=20; M= 63.4 months; n_{sync}=22; n_{async}=24), excluding two pilot-testings and 11 dropouts, were considered for this analysis. Participants were recruited from the

database of the University of Vienna, and information was handed out to various kindergartens in Vienna. The project was pre-registered and approved by the local ethics committee.

Procedure

Children and their parents were invited to the WieKi Lab, which belongs to the Research Unit of Developmental Psychology of the University of Vienna. Parents signed the informed consent and a confirmation that their child was filmed during the procedure. Parents had to wait in another room to not disturb the process. When the child felt very uncomfortable the parent could sit in the same room in the back and was asked not to interact with the child. Experimenter 1 (E1) conducted the experiment and explained the different tasks, while Experimenter 2 (puppet), operated a hand puppet named Charlie throughout the whole process, and performed the tasks together with the child. In the beginning, all children colored with the puppet in a warm-up task, in order to get familiar with the experimental situation and the puppet. Children then were randomly assigned to one of two conditions, the synchrony or the asynchrony condition, in which children either moved synchronously or asynchronously with the puppet during a Clap-and-Tap task (Tunçgenç & Cohen, 2018). Clap-and-Tap task consisted of executing clapping and tapping movements to 'tick-tock' sounds they heard for 45 seconds through headphones. More precisely, whenever a 'tick' sound occurred, participants and the puppet had to clap their hands, whereas they had to tap with their hands on the table whenever they heard a 'tock' sound. 'Tick-tock' sounds were interrupted by a 'whoop', which is when arms should have been raised. During the Clap-and-Tap tasks, both the child and the (a)synchronous partner wore motion trackers in form of wristbands to measure if the manipulation of behavioral synchrony during the Clap-and-Tap task was successful.

Afterwards, both groups were led through two over-imitation and two sharing tasks. In the over-imitation tasks, children had to take out an item out of a box. In a first step, E1 showed the child how to get the toy (here: marble or fish) out of the box, whereas the puppet was asked not to watch during this action. To get the toy out of the box, E1 used two irrelevant actions, one of which involved superficial contact with the box (here: stroking the bottom of the box or tapping the box with the magnetic stick; a so-called 'superficial-contact action') and the other of which involved operating an instrument on the box (here: operating a switch or opening a door; a so-called 'pseudo-instrumental action'), as well as one functional action (actually taking the toy out of the box). In a second step, children were asked to show the puppet how to get the item out of the box. A very neutral instruction was used 'I'll show

you how I get the toy out of the box.' and 'Now show Charlie how you get the toy out.' to let the child decide whether to (over-)imitate or not. In a final step the puppet took the last item out of the box but without over-imitating the child, irrespective of how many irrelevant actions the child showed to the puppet. We then coded the child's reaction to the puppet's omission of the irrelevant actions. Additionally, at the end of each over-imitation task children were asked 'Did Charlie do it well?' by E1, to measure the child's explicit judgment of the puppet's behavior.

In addition to the over-imitation tasks, children went through two sharing tasks. In these tasks the puppet was asked to distribute 10 items (stamps or stickers) to itself and the child. The puppet then distributed the items unfairly, six items to itself and four items to the child. Again, we coded whether the child showed protest and children were asked the explicit question 'Did Charlie do well?' after each sharing task. One over-imitation task was always paired with one sharing task. Over-imitation tasks and sharing tasks (the type of box with the corresponding actions and type of stickers) were counterbalanced. After the first set of tasks, the Clap-and-Tap task was repeated. For the entire procedure, a hand puppet was used as an (a)synchronous partner and play partner for the participants (see Figure 1).

Materials

To perform the clap-and-tap task, headphones were used through which sounds played from a tablet could be heard on a 45-second audio track. Beat intervals were either be 300ms or 333ms (100bpm and 90 bpm) and presented for 4x10 second-intervals. The velocity signal was recorded with a sampling rate of 25 Hz. For better orientation during tapping, the children were given colored stencils with handprints on it. During this task, participants as well as the (a)synchronous partner wore motion trackers in form of wristbands.

For the over-imitation tasks, we used two transparent boxes from which toys could be taken out in different ways. A switch was attached to the first box. On the second box, a door, a hole and a tube were attached. In addition, a magnetic stick was used here to get the magnetic toys out of the box.

Stamps and a stamp passport were used for the first sharing task, and stickers for the second.

Figure 1

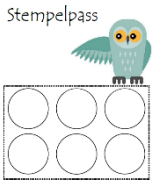
Material Used in This Study

a. 

b. 

c. 

d. 

e. 

f. 

g. 

Note. a. Clap-and-Tap task (Tuncgenc & Cohen, 2018). b. Motion Trackers. c. Over-imitation box 1. d. Over-imitation box 2. e. Passport for sharing task 1. f. Stickers for sharing task 2. g. puppet

Coding

Post-hoc video coding was conducted using ELAN 6.1 (2021). It was coded whether the child performed over-imitation (1 = yes, 0 = no) and whether the superficial contact action, the pseudo-instrumental action, or both were over-imitated. In addition, the behavioral reaction of the child was measured, more precisely the verbal protest and the non-verbal protest in form of gaze behavior in the over-imitation and the sharing tasks (see Table 1). The child's protest was considered an operationalization for the child's expectations or violation of expectations of the puppet's behavior. For the verbal protest the coding scheme of Keupp et al., (2013) was adapted, where protest behavior was coded as either normative protest (3), imperative protest (2), signs of protest (1), or no protest (0). A child showed normative protest when he/she uses explicit normative vocabulary, for example ‘No, you have to do it like that!’. An imperative protest was when the child told the puppet to act a certain way, for example ‘You could do it like that’ or ‘Use the switch!’. A child showed signs of protest when he/she used nonverbal gestures to tell the puppet that it missed an action or when it used ambiguous language, such as ‘No!’. The types of protest were hierarchically ordered, with a normative protest being the highest form. For each task, the highest form of protest was coded (e.g., when all three types of protest occur, the participant gets ‘normative protest’ (3) as its overall code for the specific task). This means, that at the end each participant got one sum

score for the over-imitation tasks and one sum score for the sharing tasks. (e.g., if the participant showed "normative protest" in both over-imitation tasks, the sum score for the expectation of over-imitation was six). Two separate raters coded 20% of the video material in order to calculate inter-rater reliability. Agreement of the two raters in verbal protest was high (κ=.898; p = .002). Additionally, the answers to the explicit question 'Did Charlie do well?' were coded binary, yes (0) or no (1). This means, that at the end each participant got another sum score for the over-imitation tasks and one for the sharing tasks, which refer to the explicit questions. Inter-reliability for the coding of the explicit question was high (κ= .819; p < .001). In addition, the gaze behavior was coded after the possible violation of expectation in form of social looking (the orienting looks to E1 or the parent). Here, we coded the number and duration of social looks, as well as the time period in which it was possible for the child to show social looking (from the moment in which the puppet showed the functional action or in which the puppet or shared unfairly, to the moment in which the explicit question was asked). In the end, the relative duration of social looking was relevant for our analysis. The coding agreement of social looks between the two raters was high (ICC= .918; *p=.002*).

Table 1

Coding Scheme

Type of protest	Type of coding			
Verbal protest behavior (Keupp et al., 2013)	Normative protest (3)	Imperative protest (2)	Signs of protest (1)	No protest (0)
Gaze behavior	Number of social looks	Duration of social looks (in seconds)	Duration period of social looks (in seconds)	Relative social looks (duration of looks/ duration period)
Explicit judgment of puppet's behavior ('Did the Charlie do well?')			No (1)	Yes (0)

Results

As mentioned before, as a manipulation check, data from motion trackers was analyzed to measure if the manipulation of behavioral synchrony during the Clap-and-Tap task was successful. Synchrony scores were estimated using phase coherence (M_{sync}=.612; SD_{sync}=.24; $Range_{sync}$= .08-.95 and M_{async}=.48; SD_{async}=.16; $Range_{async}$= .24 - .77). The over-imitation rate was very high throughout both conditions. 96% of the children over-imitated at least one action in one of the two over-imitation tasks. Verbal protest rate was low with only 10.9% of the children showing verbal protest in the over-imitation tasks and 31.3% in the sharing tasks.

To test the first hypothesis (H1), more specifically to test whether motor synchrony is associated with higher expectations of the synchronous partner's over-imitation behavior, three different sub-analyses were conducted. For this purpose, two children (P6 and P39) who did not show over-imitation in either of the two over-imitation tasks were excluded from the analysis, resulting in a total number of 44 participants (n=44). First, to determine whether motor synchrony increases the odds of exhibiting verbal protest behavior after the partner omitted over-imitation, an ordinal logistic regression was conducted. The variable 'total protest over-imitation', presenting the sum of the verbal protest scores according to Keupp et al. (2013) from both over-imitation tasks, acted as dependent variable. The experimental condition represented the independent variable. In addition, age and sex were added as factors. The experimental condition did not represent a significant factor *(p=.884)* of verbal protest behavior. The factors sex *(p=.4)* and age *(p=.613)* also failed to be associated with verbal protest behavior. Second, another ordinal logistic regression, with the summed answer-scores of the explicit questions of both over-imitation tasks as dependent variable and condition as predictor variable, was calculated. Synchrony could not be associated with the explicit judgment about the behavior of the (a)synchronous partner in the over-imitation tasks *(p=.857).* Factors of age (*p=.876)* or sex (*p=.478*) were not related to the answers either. Third, a linear regression was performed to check whether synchrony has an effect on gaze behavior in terms of social looking. Therefore, the summed duration of social looks in both over-imitation tasks functioned as dependent variable and the experimental condition (synchronous or asynchronous) as independent variable. In addition, sex and age were again added as factors. Neither the experimental condition *(p=.479),* sex *(p=.524)* or age *(p=.739)* could be associated with social looks. Considering all three sub-analyses, it can be concluded that children did not have higher expectations of their synchronous partners' over-imitation behavior after performing synchronous movements compared to asynchronous movements.

To analyze the second hypothesis (H2), again three sub-analyses were performed. All existing participants (n=46) were included in these analyses. First, to test whether synchrony has an influence on the verbal protest behavior in the sharing tasks an ordinal logistic regression was conducted. Verbal protest scores of both sharing tasks were summed and used as dependent variable, the experimental condition was used as independent variable. Additionally, sex and age were used as factors. Again, neither synchrony (*p=.162*), sex (*p=.581*), nor age (*p=.678*) were significant factors of the model. Second, another ordinal logistic regression was applied to test whether synchrony is related to higher explicit judgment of the (a)synchrony partner's behavior as 'wrong'. The experimental condition represented the factor, the summed answers of the explicit answer-scores in both sharing-tasks represented the dependent variable. Sex and age were added as factors. Neither synchrony (*p=.309)* nor sex (*p=.33)* or age (*p=.97*) could be related to response behavior. Third, a linear regression was conducted to test whether synchrony leads to higher social looking, compared to asynchrony. The relative duration of all social looks in the sharing tasks represented the dependent variable, condition, sex and age were included as predictors. Although the experimental condition is statistically significant (*p=.014*) as a coefficient, it is not valid to interpret it as a factor since the overall model has no statistical significance (*p=.057*), indicating a very unstable model. Neiter sex *(p=.476)* nor age *(p=.22)* were significant factors for social looking in the sharing tasks. Altogether, these findings suggest that synchrony is not associated with higher expectations of the (a)synchronous partners' over-imitation or sharing behavior.

For exploratory purposes, we performed post-hoc analyses. We examined differences in the frequency of occurrence of the two over-imitation actions. Descriptive statistics show that in the first over-imitation task, 93.9% of the children over-imitated the pseudo-instrumental action, whereas 66.7% of the children performed the superficial contact action. We applied a Wilcoxon test showing that this difference was statistically significant (*p<.001*; see Figure B1). Another Wilcoxon test was performed to determine if the rates of the pseudo-instrumental versus superficial contact actions differed in the second over-imitation task. No significant difference in the rate could be detected (*p=.618*; see Figure B2). Consequently, it was found that the frequencies of over-imitation of the pseudo-instrumental actions in the first task differed significantly from those in the second task (*p<.001*). The over-imitation rates of the superficial contact actions in the first task were not significantly different from those in second task (*p=.284*). Furthermore, a Wilcoxon test was applied to test whether the verbal protest rate in the over-imitation tasks differed from that in the sharing tasks. Children

protested significantly more in sharing tasks than in over-imitation tasks (*p<.001;* see Figure B3). Finally, a paired samples t-test revealed that the relative social looking time of the over-imitation tasks differed significantly from that of the sharing tasks (p=.021; Cohen's d=-.354; see Figure B4).

Discussion

Effects of synchrony on people's social learning and (pro-)social behavior are widely discussed (e.g. Mogan et al., 2017). However, the number of empirical studies on the effect of synchrony on expectations of others' social behavior is sparse. This study aimed to examine this gap and investigated whether effects of motor synchrony on children's expectations of others' behavior can be found. Considering studies associating synchrony with social learning (e.g. Feldman, 2007a), we hypothesized that (H1) synchrony also increases expectations of others' social learning behavior, in comparison to asynchrony. For this purpose, we used over-imitation as an operationalization for social learning as imitation is one of the most important tools for social learning. Additionally, based on studies supporting that synchrony leads to prosocial behavior, such as increased helping (Trainor and Cirelli, 2015) or sharing (Rabinowitch & Meltzoff, 2017) we hypothesized that (H2) synchrony also enhances expectations of prosocial behavior of the synchronous partner, compared to asynchrony. We chose sharing behavior as the operationalization for prosocial behavior in this study because considering others when distributing resources is a key aspect of human social interaction and culture (Fehr et al., 2008).

We measured children's expectations by observing (a) their verbal protest, (b) explicit judgment about the other's behavior and (c) gaze behavior after the synchronous or asynchronous partner omitted the actions to over-imitate or shared unfairly. Against our expectations, no results supporting our hypotheses were found in this study. Thus, it can be concluded that synchrony has no effects on children's expectations of their (a)synchronous partners' over-imitation and sharing behavior. However, before jumping to conclusions, we would like to discuss important aspects of the studies, such as possible explanations for the results and limitations of the study.

Main Discussion

A possible reason for no effects being found could be that mere joint interaction (playing the Clap-and-Tap task), regardless of whether the movement was synchronous or asynchronous, was already enough to produce small effects in both conditions (eg. Mogan et al., 2017), which might have led to no differences in effects in either condition. Children are

more likely to share with others when reciprocal interaction has previously occurred (Barragan & Dweck, 2014), assuming that they would most likely expect others to share with them after reciprocal interaction as well as after synchronous interaction. Moreover, we considered affiliation as a possible mechanism for hypothesized synchrony effects, however, studies have shown that not only synchrony but also mimicry increases affiliation (Hove & Risen, 2009). Thus, asynchronous movement could perhaps be classified as mimicry or reciprocal action, producing the same effects as synchrony. If this was the case, however, other studies in which synchronous and asynchronous conditions were used would not have found clear results either. Also, Mogan and colleagues (2014) found that exact behavioral matching increases social bonding behaviors and perceptions above general coordinated behavior. Nevertheless, the two conditions should be more clearly distinguished in future studies to avoid effects of mimicry, reciprocity, or joint coordination. However, it is problematic to make these conclusions after we had only one synchronous and one asynchronous condition in our study, but no baseline condition, in which no (a)synchrony manipulation is applied. With such a baseline condition, it could be more precisely stated whether effects due to the above-mentioned phenomena such as mimicry, coordination or reciprocity equally occurred or simply no difference could be found to a baseline without a common (a)synchrony task.

Furthermore, the lack of significant findings might be partly explained by the very low protest rate in both conditions. What reasons could account for the very low protest rate of the children in our study, especially in over-imitation tasks? First, considering previous studies that discuss the application of norms as a possible mechanism for over-imitation (eg. Keupp et al., 2013), one could argue that children in our study did not show protest, because they did not see over-imitation as normatively binding, which is why a protest would not be necessary. However, completely disregarding the power of context, which might have influenced children in their protest behavior. Studies showed that children protest against norm violations in games (Rakoczy et al., 2008) and that they indicate an awareness that simple joint game-like actions underly normative structure (Rakoczy et al. 2008). The title of the study "Playing and Learning", the playful context and the fact that each task was announced as a game, would assume the application of a ‘game norm’. Norm behavior here would be to follow the rules of the game, consequently we would also have expected a protest if the norm was violated. The open instructions ‘I'll show you how I do it.’ and ‘Now you can take out a marble as you like.’ do not represent an explicit set of rules, but rather leave the mode of execution open, suggesting an instrumental rather than a game act, which might explain the

low protest rates. The instructions of the experimenter or the labeling of the tasks can strongly influence the context and thus the behavior that is considered normative in this context (Rakoczy et al., 2008). Rakoczy et al. (2008) investigated this context-relative normativity of game acts and found differences in children's protest behavior depending on the type of announcement made by the actor (to play or not to play the game). According to these findings, Keupp et al. (2013) found that children protested against omitting the irrelevant action of an over-imitation task more when the instructions are method oriented than goal oriented. In our study, we rather applied goal-oriented instructions using the phrase 'The goal of the game is to get a marble out of the box.', which could also be responsible for the low protest rates. Future studies could attempt to manipulate this context-influencing component, and subsequently determine whether this leads to altered protest behavior, also in terms of synchrony. Second, in the past, the affiliation hypothesis, which states that children over-imitate to affiliate with a partner, was partly invalidated by its inability to explain the protest to omitting over-imitation of a third party (e.g. Kenward, 2012). Our results may revive this discussion and reintroduce the affiliation hypothesis and additionally propose the desire to affiliate as a plausible mechanism for not protesting. Future studies should additionally interrogate affiliation to provide a more accurate understanding of the underlying mechanisms.

After having discussed possible reasons for the low protest we should now address the question why significantly more protest was shown in the sharing tasks. Compared to over-imitation tasks children protested significantly more and showed significantly longer social looking times in sharing tasks. Interestingly, children distinguish in their behavior with regard to a game norm, which may have been applied here in the over-imitation tasks, and a moral norm, which may have been applied in the sharing tasks. Three-year-old children actively protested to the violation of moral norms by both group members and group strangers, but they enforced conventional game norms only for members of the group (Schmidt et al. 2012), which could explain the differences in protest rates and lead to the assumption that expectations about the behavior of others might also be selective. This emerging theory of expectation selectivity would imply that children might have different expectations of the other person depending on the type of the interaction. Moreover, an equal distribution could also be more relevant for the children, since it concerns (possible) property of the children, which has to be defended, while the damage with omitting over-imitation is clearly smaller than with unfair distribution, meaning that costs of not protesting are higher in the sharing tasks (Eisenberg, 1998).

Furthermore, not only very low verbal protest was shown by the children, also little explicit protest was made. Only 18.8% of the total explicit questions asked were answered 'yes'. A major limitation of our study design is the suggestive, ‘forced-choice’ nature of the question. The question ‘Did Charlie do this well?’ makes it difficult to answer with ‘No’, whereas offering both answer choices, such as ‘Did Charlie do well or poorly?’ would be a more neutral form with both answer choices as equally desirable. This reduces the explanatory power of this part of the hypothesis. Keupp et al. (2013) also found differences in response behavior to a similarly posed explicit question depending on the context (method-oriented vs. goal-oriented), which again could be the reason for the low 'No' response rate in our study. We also need to question whether there is a more adequate method for young children to measure explicit judgment or expectations of others' behavior. Possibly, letting children directly demonstrate expected behavior of how the puppet should have acted (possibly with the puppet in the children's hands) would be a more appropriate method that does not require a direct verbal response. This also leads to the question of whether the performed operationalization appropriately represents the expectations of the behavior of others. In previous studies observing verbal protest behavior such as explicit judgements of third-party actions against an individual who violates norms was used to measure the normative understanding of children (e.g. Rakoczy et al., 2008; Kenward, 2012; Keupp et al., 2013). This form of evaluation has been shown to produce highly consistent findings at least from around five years of age onward (Rakoczy et al., 2009), but can this be used in the same way for the concept of expectations of such behavior?

Interestingly, in some cases children stated that Charlie did well, even when they verbally protested against the puppet’s behavior. Although two- or three-year-old children are often able to detect and distinguish between what is morally bad and what is bad according to convention, children may perceive actions as normative, without encoding reasons for this normativity (Kenward, 2012), which could explain the dissonance between children behavior and their explicit judgment. Aware of the difficulties in eliciting verbal judgments from young children, we included social looking, which appears to be a valid measure of a child's violation of expectation, even more valid than looking time (Dunn & Bremner, 2017). Although more than a third of the children (34.78%) showed social looking in at least one of the tasks, no associations could be made with (a)synchrony. Nevertheless, in some children an expression of surprise or disappointment can be recognized after unfair distribution or omission of the over-imitation actions, which, however, are not reflected in our coding scheme. A challenge for future research is to find more suitable measurement methods for

complex psychological phenomena as violation of expectation and to specify already existing ones.

Limitations

In addition to the limitations of the study already mentioned above it could be criticized that the children were too young to perform the clap-and-tap task coordinately, after studies have shown that children are only able to synchronize with a rhythm or another person after the age of seven or eight years (McAuley et al., 2006). Almost one-third (28.26%) of the participants did not clap according to their condition. However, we adopted the task from Tuncgenc & Cohen (2018), in which effects could be found at an average age of 5.1 years (mean age in this study = 5.3 years) of the participants. One solution would be to replace the similar 'tick-tock' sounds with more distinguishable sounds, for example ‘clap and tap’ sounds, so that sounds can be more easily associated with the corresponding actions.

Additionally, it can be mentioned that the duration of the synchrony manipulation, 45 seconds per run, is relatively short. Cirelli and colleagues (2014) already used a short duration of 145 seconds in their study, which led to only small effects. This can again be contradicted by the effects found when performing the same clap-and-tap task in Tuncgenc and Cohen (2018), where odds for helping were 29.4 greater for children in the synchronous condition than for children in the asynchronous condition after performing the Clap-and-Tap task only once for 45 seconds. In future studies, the duration of the synchrony manipulation could also be varied to determine what minimum duration is sufficient to find significant effects. Another limitation is the number of participants. As already mentioned, according to the power analysis, at least 54 children should have participated in the study in order to be able to count on effects of the assumed size. Due to Corona-related closures of the University, it has not been possible to reach this number of participants at the scheduled time. We included 46 participants in our analyses. However, meanwhile testing was completed and the 54 participants targeted can be included in further analyses. Thus, our results should definitely be compared with future results with the full sample.

Discussion of post-hoc Analyses

Regardless of our main hypotheses, the data of the study show interesting aspects that can contribute to the understanding of the phenomenon of over-imitation. Supporting previous studies (e.g., Hoehl et al., 2019), in the first over-imitation task of our study the pseudo-instrumental action (pressing the switch) was over-imitated significantly more often than the superficial contact action (stroking one side of the box). Interestingly, the number of children over-imitating the pseudo-instrumental action decreases significantly in the second over-

imitation task, resulting in no difference between the over-imitation of the pseudo-instrumental and the superficial contact action. These results are consistent with the dual-process theory presented by (Schleihauf & Hoehl, 2020), which states that action sequences, especially when it is not entirely clear whether the actions are irrelevant, trigger type one processing, i.e., an intuitive, cognitively rather undemanding process that leads to blanket copying. If the irrelevance of the action is clear, however, as here for example by omission of the irrelevant action by the puppet, type two processing is activated, whereby it can be decided whether to over-imitate or not. This decision in turn depends on the social motivation and goals. Furthermore, within their dual-process theory Schleihauf and Hoehl (2020) they also present a possible explanation for more faithful imitation of pseudo-instrumental actions compared to superficial-contact actions, that is, that different actions trigger a different process type. However, even in the second over-imitation task, both, the superficial (56.5%) and the pseudo-instrumental actions (52.2%) were over-imitated by more than 50% of the children, suggesting that there might have been social motivations for over-imitation, such as affiliation, social norms or learning goals.

Finally, it must be mentioned that, since mentioned explanatory attempts of our data for a better understanding of interesting phenomena, such as over-imitation, norm understanding or expectation selectivity were conducted post-hoc, further studies explicitly designed to address open questions are needed.

Conclusion

This study aimed to examine gaps in the broadly studied research area on interpersonal synchrony. These included possible effects of synchrony on expectations of the interactive partner's social learning and prosocial behavior, which have been entirely unexamined so far. In our study, no significant results were found regarding our main hypotheses, concluding that synchrony cannot be associated with expectations of over-imitation and sharing behavior, thus with social learning behavior or prosocial behavior. However, the importance of the study should not be relativized by the non-significant results, since it provides an important basis for discussion regarding the social effects of synchrony and their underlying mechanisms, debated hypotheses of motives for over-imitation. Moreover, it adds new highly interesting data to the still poorly discussed phenomenon expectation selectivity.

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Appendix A

Abstract

Interpersonal motor synchrony, which can be described as movements matched in time between at least two individuals, is a phenomenon that encounters throughout every human's life. Whether walking, playing, singing, or dancing, we often engage in motor synchrony with others. Effects of synchrony on human's social perception, affect, affiliation, social learning and prosocial behaviors such as sharing are widely discussed. However, it remains unclear whether interpersonal synchrony also enhances expectations of others' social learning and prosocial behavior. In this study, we aim to examine children's expectations of others' sharing and over-imitation behavior, which is the imitation of actions that are not relevant to achieve the goal, after interpersonal motor synchrony. To do so, 46 four to six-year-old children moved in (a)synchrony with an interacting partner (puppet) and afterwards went through over-imitation and sharing tasks, in which the puppet did not over-imitate and did not share fairly. To elicit children's expectations, three measures were used: (a) children's spontaneous verbal protest against the puppet's behavior, (b) children's explicit judgment about the puppet's behavior and (c) their social looking after the puppet's behavior. We expected children in the synchrony condition to have stronger expectations of the puppet's over-imitation and sharing-behavior and thus, show more protest and social looking, in comparison to children in the asynchrony condition. No results supporting our hypotheses were found in this study. Nevertheless, the relevance of this study should not be diminished as it contributes to the state of research on complex psychological phenomena regarding synchrony, over-imitation and fairness.

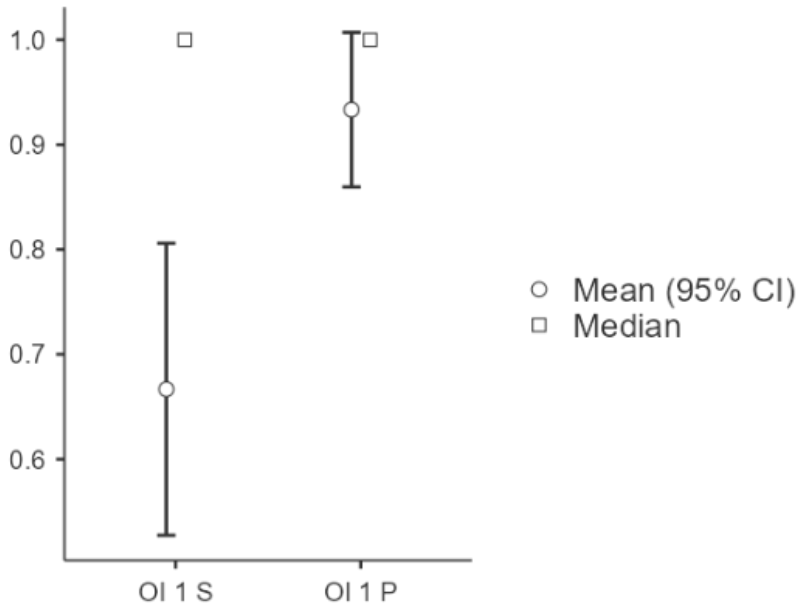
Zusammenfassung

Interpersonale motorische Synchronität, die als zeitlich abgestimmte Bewegungen zwischen mindestens zwei Personen beschrieben werden kann, ist ein Phänomen, das jedem Menschen im Laufe seines Lebens begegnet. Ob beim Gehen, Spielen, Singen oder Tanzen, wir bewegen uns oft synchron mit anderen. Die Auswirkungen der Synchronität auf die soziale Wahrnehmung, Emotion, Zugehörigkeit, soziales Lernen und prosoziale Verhaltensweisen wie Teilen werden vielfach diskutiert. Es bleibt jedoch unklar, ob interpersonale Synchronität auch die Erwartungen an soziales Lernen und prosoziales Verhalten anderer erhöht. In dieser Studie wollen wir die Erwartungen von Kindern an das Teil- und das Über-Imitations-Verhalten, d.h. das Nachahmen von Handlungen, die für die Erreichung eines Ziels nicht relevant sind, nach interpersonaler motorischer Synchronität untersuchen. Zu diesem Zweck bewegten sich 46 vier- bis sechsjährige Kinder (a)synchron mit einem Interaktionspartner (Puppe) und durchliefen anschließend Über-Imitations- und Teil-Aufgaben, bei denen die Puppe nicht über-imitierte und nicht fair teilte. Um die Erwartungen der Kinder zu ermitteln, wurden drei Messungen durchgeführt: (a) spontaner verbaler Protest der Kinder gegen das Verhalten der Puppe, (b) explizites Urteil der Kinder über das Verhalten der Puppe und (c) ihr „social looking“ nach dem Verhalten der Puppe. Wir erwarteten, dass Kinder in der synchronen Bedingung stärkere Erwartungen an die Über-Imitation und das Teilverhalten-Verhalten der Puppe haben und daher mehr Protest und social looking zeigen, im Vergleich zu Kindern in der asynchronen Bedingung. In dieser Studie wurden keine Ergebnisse gefunden, die unsere Hypothesen unterstützen. Dennoch sollte die Relevanz dieser Studie nicht geschmälert werden, da sie einen Beitrag zum Stand der Forschung über komplexe psychologische Phänomene in Bezug auf Synchronität, Über-Imitation und Fairness leistet.

Appendix B

Figure B1

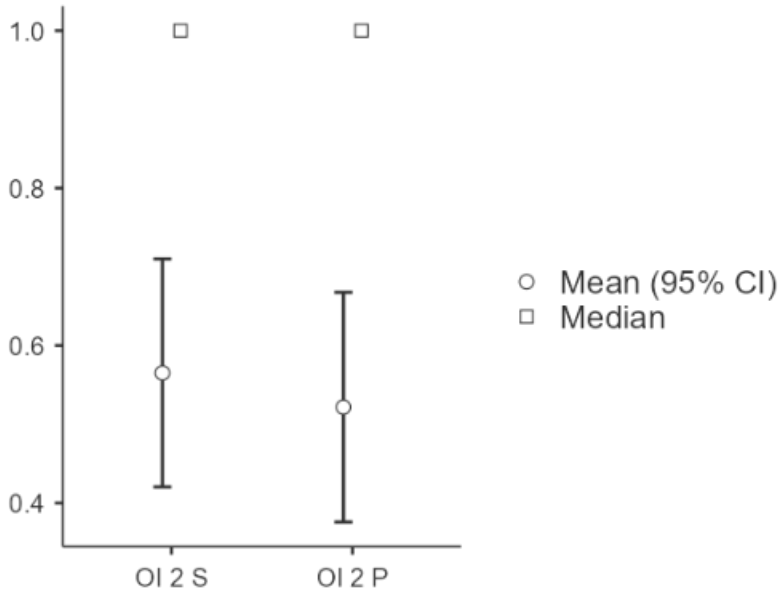
OverIimitation Divided by Action Type in Task 1



Note. Means of superficial contact action (stroking the box) and pseudo-instrumental action (using the switch) in the first over-imitation task, showing significant differences in over-imitation of the action (*p<.001*).

Figure B2

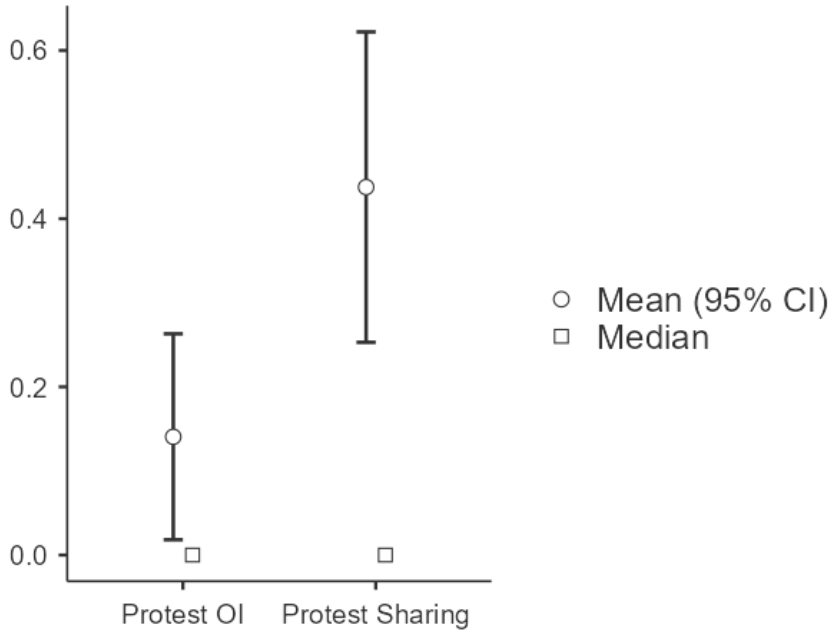
Over-Imitation Divided by Action Type in Task 2



Note. Means of superficial contact action (tapping the box with a stick) and pseudo-instrumental action (opening and closing a door) in the second over-imitation task, showing no significant differences in over-imitation of the action (*p=.618*).

Figure B3

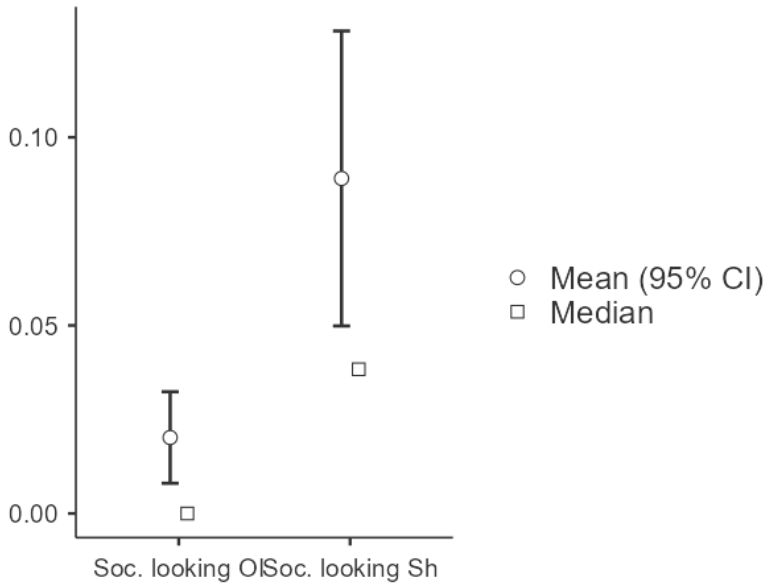
Verbal Protest Rate in Over-Imitation and Sharing Tasks



Note. Means of verbal protest in both over-imitation and sharing tasks, showing significant differences of verbal protest rate in both tasks (*p*<.*001*).

Figure B4

Relative Social Looking Time in Over-Imitation and Sharing Tasks



Means relative social looking time in both over-imitation and sharing tasks, showing significant differences of social looking time in both tasks (*p*<.*001*).

Appendix C

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