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The Role of Interpersonal Brain Synchrony and Liking in Joint Action
An fNIRS Hyperscanning Study on 5-Year-Olds


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# The Role of Interpersonal Brain Synchrony and Liking in Joint Action: An fNIRS Hyperscanning Study on 5-Year-Olds

## Abstract

Research investigating the underlying neural mechanisms of social interactions has experienced a paradigm shift from a one-person perspective towards a multiple-person perspective. Interpersonal brain synchrony (IBS) in prefrontal and temporoparietal cortex areas, often measured with functional near-infrared spectroscopy (fNIRS) has consistently been linked with effective cooperation and joint action. IBS has also been associated with higher levels of liking between individuals. However, the directionality of this effect remains unclear with some studies suggesting a positive feedback loop. A positive effect of liking on cooperative joint action has been investigated in a smaller number of studies. This thesis aimed to investigate the interplay between liking and IBS and their effects on success in a joint action task in dyads of 5-year-old preschool children. It hypothesized a positive correlation between liking and IBS as well as a mediation of the changes in liking over time by IBS. Furthermore, a positive effect of both liking and IBS on success in a joint action task was hypothesized. The participants (*N*=72, 36 dyads) had an average age of 5 years and 5.1 months and 48.7% were female. Liking was rated twice on a three-item composite scale and IBS was measured with fNIRS hyperscanning. Due to low power no significant results were found. More research is necessary to understand the developmental aspects of IBS, liking, and joint action in peers.

*Keywords:* interpersonal brain synchrony, liking, joint action, preschool children, functional near-infrared spectroscopy

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# The Role of Interpersonal Brain Synchrony and Liking in Joint Action: An fNIRS Hyperscanning Study on 5-Year-Olds

## Background[1]

Humans often synchronize their movements during social interactions, both consciously and unconsciously (Mogan et al., 2017). While interpersonal behavioral synchrony has been a topic of research for many decades, measuring interpersonal brain synchrony (IBS) has become more thoroughly investigated in the 21st century (Nam et al., 2020).

Effective cooperation is associated with higher IBS in frontal and temporo-parietal cortex areas (Czeszumski et al., 2022). Studies demonstrate a positive association between IBS and task performance in cooperative tasks (Czeszumski et al., 2021; Zhou et al., 2022). Joint action, a form of cooperation requiring physical coordination, has been found to be facilitated by IBS between participants (Müller et al., 2021).

Research has also linked behavioral synchrony to an enhancement of interpersonal liking (M. Cheng et al., 2020; Ravreby et al., 2022), while the body of evidence investigating the effect of interpersonal liking on IBS is smaller (Gvirts & Perlmutter, 2020). The directionality of the relationship between interpersonal liking and synchrony therefore remains unclear, with some research suggesting a positive feedback loop between liking and behavioral synchrony as well as IBS (Tzanaki, 2022; Valencia & Froese, 2020).

While much of the research on IBS focuses on adults, there are studies with children and adolescents that can provide insights into developmental aspects of relevant skills and behaviors (Rabinowitch & Meltzoff, 2017; van Schaik & Hunnius, 2018; Yang et al., 2023). In this study peer interactions were explored in dyads of preschool children. Positive effects of IBS between children and their parents have been found in several studies, but the

[1] During the creation of this thesis, DeepL and ChatGPT were used. In particular, DeepL was used for translation and both programs were used for linguistic correction of isolated phrases and sentences. After using the tools, the passages were thoroughly reviewed and edited by the author.

associations and implications of interpersonal liking and IBS between peers are yet to be explored. This could shed light on the development of social skills and successful cooperation across the lifespan.

***Synchrony***

In recent years there has been a shift in research regarding the neural mechanisms of social interactions from a one-person perspective to a multiple-person perspective (Ayache et al., 2021). During social interaction, humans often move in synchrony, both consciously and unconsciously (Mogan et al., 2017). Behavioral synchrony has been studied for many decades, and while it was technically possible to do so for decades, the measurement of interpersonal brain synchrony (IBS) has become more thoroughly investigated in the 21st century (Duane & Behrendt, 1965; Nam et al., 2020).

In the last decade, the evidence linking behavioral and physiological synchrony with IBS has been rapidly growing (for reviews see: Czeszumski et al., 2021; Gvirts & Perlmutter, 2020; Nam et al., 2020). By simultaneously measuring the activity of two or more participants, it can be assessed whether their brain activity synchronizes (Funane et al., 2011). In contrast to the measurement of a single participants brain, this makes it possible to explore the neural processes between participants during interactions, which have been described as the “dark matter” of social neuroscience (Przyrembel et al., 2012; Scholkmann et al., 2013). A substantial body of research shows that IBS between children and their parents has positive effects on social and cognitive development (for reviews see: De Felice et al., 2024; Hoehl et al., 2021). While the relevant literature agrees, that IBS plays a substantial role in interpersonal communication, the causational relationship is still unclear (De Felice et al., 2024). IBS has been suggested by some to be the neural basis of social interactions, enhancing empathy, communication and cooperation (Gvirts Provolovski & Perlmutter, 2021), but others believe it is merely a byproduct caused by the simultaneous processing of external stimuli (Hamilton, 2021).

Though not the sole method employed, functional near-infrared spectroscopy (fNIRS) is frequently used to measure this phenomenon (Czeszumski et al., 2020; Nam et al., 2020). It is a non-invasive and easily set up method that measures the hemodynamic response in the cortex (Wilcox & Biondi, 2015). Compared to electroencephalography (EEG), fNIRS is less sensitive to motion artefacts and has better spatial resolution (for a review see: Li et al., 2022). When fNIRS is employed, optodes are placed on specific parts of the head and in contrast to EEG, not all regions of the cortex can be measured. It is therefore necessary to determine areas of interest a priori.

Certain focal brain areas have been identified that are more likely to show synchronization between individuals. Areas that are generally associated with IBS during social interactions include the temporoparietal junction (TPJ) and parts of the prefrontal cortex such as the inferior frontal gyrus (IFG) (Czeszumski et al., 2022; Gvirts & Perlmutter, 2020; Jiang et al., 2012).

***Joint Action***

IBS in frontal and temporo-parietal cortex areas is associated with effective cooperation (Czeszumski et al., 2021, 2022). A positive correlation of IBS and task performance has been found in cooperative tasks in dyads and small teams (Reinero et al., 2020; Zhou et al., 2022). During cooperation participants generally show higher IBS than when they are competing (Cui et al., 2012). Moreover, in a study where participants were either told to cooperate or compete with each other while doing exactly the same tasks, IBS was significantly higher when they were in the mental stance to cooperate (Cho et al., 2020). However, another study found higher IBS during competitive games of rock-paper-scissors, compared to a cooperative condition, where participants tried to perform the same action to win (Kayhan et al., 2022). This suggests that IBS is not exclusively increased during cooperation but also in other interactions requiring coordination with others and might even be impeded when natural interactions are experimentally disrupted.

Joint action is a form of cooperation that also requires the physical coordination of two or more people to achieve a common goal (Sebanz et al., 2006). Numerous studies found an association with higher behavioral synchrony (van der Wel et al., 2021). According to a review by Müller and colleagues (2021) IBS is an important underlying mechanism that facilitates the necessary coordination for joint action. During joint action tasks, IBS between participants has been found in their TPJ (Egetemeir et al., 2011) and IFG (X. Cheng et al., 2022) among other regions. In addition, the TPJ has also been associated with self-other distinction and the representation of someone else's belief (Decety & Lamm, 2007; Quesque & Brass, 2019; Samson et al., 2004). These two skills are necessary for successful joint action (Sebanz & Knoblich, 2021).

Given however, the complexity of the social and neural mechanisms underlying interpersonal coordination which is necessary for successful joint action, further factors such as interpersonal liking and its relation to IBS should be explored also.

***Liking***

Interpersonal liking has been found to be enhanced by behavioral synchrony (M. Cheng et al., 2020; Ravreby et al., 2022), while the body of evidence investigating the effect of interpersonal liking on IBS is smaller (Gvirts & Perlmutter, 2020).

Operationalizations of interpersonal liking differ between studies, as well as the term used to describe it. Liking, affiliation, likability, and rapport are sometimes used as though they were synonymous (Zhao et al., 2017). Liking has been measured by asking a participant directly to rate how much they like someone else (Ravreby et al., 2022). Affiliation has also been measured by asking a participant how likable they deem another person to be (Hove & Risen, 2009). The likability of a confederate can be manipulated to change the liking of the participant towards a confederate (X. Cheng et al., 2022; Melton et al., 2023; Zhao et al., 2017). The impression and perceived friendliness of another person, which is also closely related to likability, is part of a scale to measure rapport (Nozawa et al., 2019; Reysen, 2005).

Because of the similarities in operationalization, the results of studies measuring these concepts will be considered as having measured one concept.

The directionality of the influences between interpersonal liking and synchrony is still not clear. Numerous studies have demonstrated that people who like each other move in a more synchronous way (M. Cheng et al., 2020; Ravreby et al., 2022), while others failed to find a significant effect (Melton et al., 2023). Melton and colleagues (2023) found that participants who liked a confederate more, reported a higher perception of behavioral synchrony, despite that not being the case. The discrepancy in these findings might be explained in part by differences in experimental designs. The procedures in the studies having found a positive effect were less rigid and might have felt more natural, leaving more movement control to the participants. Participants were randomly paired and either walked with each other for several minutes (X. Cheng et al., 2022) or spent two minutes playing a mirror game, where they chose freely how to move their hands, trying to be as synchronized as possible (Ravreby et al., 2022). In the study that did not find a significant positive relationship between liking and behavioral synchrony, the participants were paired with a confederate whose likability was manipulated and asked to shake a percussive musical instrument (Melton et al., 2023). During the measurement of synchrony, they were separated by a curtain, obstructing the view and the confederate additionally wore earphones, muffling the sound of the participant's instrument. The trials were 45 seconds long, notably shorter in comparison to the other two designs. Similar to the aforementioned study, where the experimental modification of the well-known game rock-paper-scissors might have impeded IBS (Kayhan et al., 2022), it is possible that behavioral synchrony was more easily achieved, when the participants completed more naturalistic tasks. Furthermore, it was presumably easier for participants to synchronize when they could perceive each other's movements. Further research is necessary to shed light on the underlying mechanisms of these discrepancies.

Regarding the opposite directionality, a meta-analysis of 42 studies found a positive small-to-medium-sized effect of behavioral synchrony on perceived social bonding (Mogan et al., 2017). A positive feedback loop of empathy and behavioral synchrony has been suggested based on social and musical studies (Tzanaki, 2022).

A smaller, emerging body of research has investigated the relationship between liking and IBS. One study found that behavioral synchrony was a predictor for higher liking as well as higher IBS (Nozawa et al., 2019). An opinion piece based on EEG and fNIRS hyperscanning studies asserted that IBS leads to higher reports of connectedness and cohesion (Valencia & Froese, 2020). Oxytocin, a neuropeptide associated with liking and affiliation has been found to enhance IBS in adult men (Levy et al., 2016; Mu et al., 2016). Subsequently a review proposed a positive feedback loop of IBS and social alignment that is enhanced by oxytocin and dopamine release (Gvirts & Perlmutter, 2020).

The effect of liking on cooperation or joint action is still less well researched. In groups, higher affiliation has been associated with better cooperation (Arora et al., 2012). One study found that liking leads to better interpersonal motor coordination (Zhao et al., 2017). Additionally, studies have found that cooperation leads to higher liking and that a lack of joint action experiences can lead to lower liking (Günak et al., 2020).

### *Research with Children*

While there is a growing body of research on the effects of liking and IBS on joint action in adults, less research has been done in children, particularly with dyads of children. There are, however, several studies that investigated relevant mechanisms in children that can give us hints on what to expect in a peer hyperscanning study with children.

One study found that 5-year-old children are more likely to mimic the physical movements of an adult if they were more likable (van Schaik & Hunnius, 2018). A dyad mimicking each other, can facilitate IBS (Nozawa et al., 2019). There is some more literature, exploring the opposite directionality, namely the effects of behavioral synchrony on liking.

Infants as young as 14-months old showed more prosocial behaviors after moving in synchrony with a confederate (Cirelli, 2018; Trainor & Cirelli, 2015). Moreover, higher social bonding with an experimentally construed out-group was found after behavioral synchrony in 7- to 12-year-old children (Tunçgenç & Cohen, 2016). Furthermore, 8- to 9-year old children felt more similar and closer after a synchronous interaction (Rabinowitch & Knafo-Noam, 2015). A review concluded, that behavioral synchrony has positive effects on affiliation in children (Rauchbauer & Grosbras, 2020). These associations between interpersonal liking and behavioral synchrony are similar to those found in adults and therefore warrant presuming that liking and IBS might also have positive effects on each other in interactions between children.

When it comes to joint action between children, developmental considerations about relevant skills are required. Due to kindergarten being mandatory for at least one year in Austria, all children have experience in peer interactions before turning five years old (Halbtägig kostenlose und verpflichtende frühe Förderung in institutionellen Kinderbildungs- und -betreuungseinrichtungen in den Kindergartenjahren 2015/16, 2016/17 und 2017/18 (Bund – Länder), 2015). As mentioned above, the skills of self-other distinction and predicting someone else's actions are necessary for various forms of cooperation including joint action (Meyer & Hunnius, 2020; Sebanz & Knoblich, 2021). Self-other distinction is already developed in 4- to 5-year old children (Milward et al., 2014) and 5-year-old children are also better able to accommodate their actions to their partners' needs during joint action than younger children (Meyer et al., 2016).

One study found that 4-year olds who moved in synchrony were more successful in a joint action task than those who did not (Rabinowitch & Meltzoff, 2017).

To my knowledge there are no hyperscanning studies with dyads of younger children however, a substantial body of research has explored IBS and cooperation between children and adults, mainly with the participating children's parents (for a review see: Alonso et al., 2023). Similarly to the results of studies on adult dyads (Cho et al., 2020; Cui et al., 2012), studies on child-parent dyads found that IBS increased only during cooperation, but not during competition (Nguyen et al., 2020; Nguyen, Schleihauf, et al., 2021). One study found that higher IBS predicted better performance in a following cooperative task in child-parent dyads (Reindl et al., 2018). Reindl and others (2018, 2022) also compared IBS during cooperation in parent-child dyads with dyads of adult strangers and children. They observed higher IBS only when children were cooperating with their parent but not with an adult stranger. However, this does not necessarily mean that IBS does not have an influence on peer cooperation between strangers in children. As mentioned above, imitation can be a facilitator of IBS and 14-month-old infants were found to imitate an unknown peer more when they observed familiar actions, but unknown older children and adults were imitated more in novel actions (Zmyj et al., 2012). The researchers suggest that this could be because imitation serves mainly as a communicative tool between peers as opposed to a tool for learning from older children and adults. Furthermore, higher IBS was found in dyads of adolescents than adults during a cooperative task (Yang et al., 2023). It can therefore be assumed that also younger children who participate in cooperative play with each other might show IBS.

### *Research Gap*

The body of research regarding the interplay of liking and IBS, as well as their effect on different forms of cooperation has been growing quickly in the last few years, yet there are still many open questions. This may possibly be in part due to definitions of theoretical constructs and operationalizations being vastly different throughout studies.

While studies did find an association of interpersonal liking or similar concepts and IBS, the directionality of the effect is not yet clear (Nozawa et al., 2019; Valencia & Froese, 2020). Some research does suggest a positive loop of IBS and liking (Gvirts & Perlmutter, 2020).

Furthermore, while cooperation and joint action have been found to enhance liking, the possible effects of liking on joint action are still not at all clear (Arora et al., 2012; Günak et al., 2020).

Many studies find that dyads or small groups with higher IBS are more successful in cooperative and joint action tasks (Czeszumski et al., 2021, 2022; Reinero et al., 2020; Zhou et al., 2022). However, this is mostly measured simultaneously. Further research is necessary to determine whether IBS facilitates joint action.

Lastly, even though many of these questions have been investigated in at least a few studies, to my knowledge none of them were conducted on dyads of preschool children. While there was no increased IBS during cooperation between 5- to 9-year-old children and adult strangers, this is yet to be explored between two strange children (Reindl et al., 2018, 2022). Interactions between two similarly aged children, who are strangers, could be considerably different than those between a child and an adult stranger (Zmyj et al., 2012).

The developmental aspects of IBS, liking, and joint action in peers are therefore still to be explored.

**Current study**

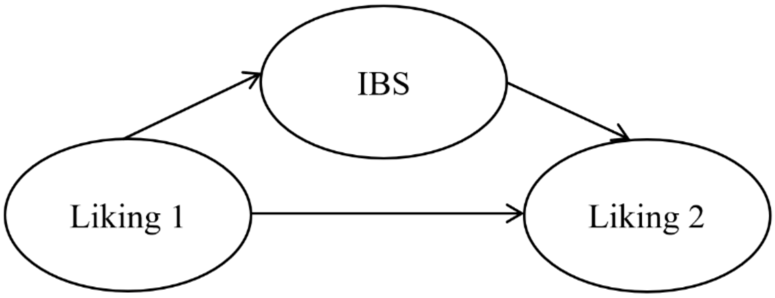
This thesis investigated the effects of liking and IBS on success in a joint action task in preschool children. During social interactions, brain activity in the IFG and TPJ is frequently found to synchronize between two or more subjects (Czeszumski et al., 2022; Nam et al., 2020).

Previous research showed a positive association of IBS and liking (Valencia & Froese, 2020). In line with this I predicted that IBS in the IFG and TPJ and liking will be positively correlated (Hypothesis 1).

Furthermore, a positive loop of liking and IBS, has been suggested (Gvirts & Perlmutter, 2020). In this study the liking between two children was measured twice, making it possible to analyze temporal changes and potentially interrelated effects with IBS. In line with previous research, I predicted both a positive effect of liking after the first impression on IBS (Hypothesis 2a) and a positive effect of IBS on liking later on (Hypothesis 2b) as well as a partial mediation of the development of liking by IBS (Hypothesis 2c). A visual representation of hypothesis 2c can be found in Figure 1.

**Figure 1**

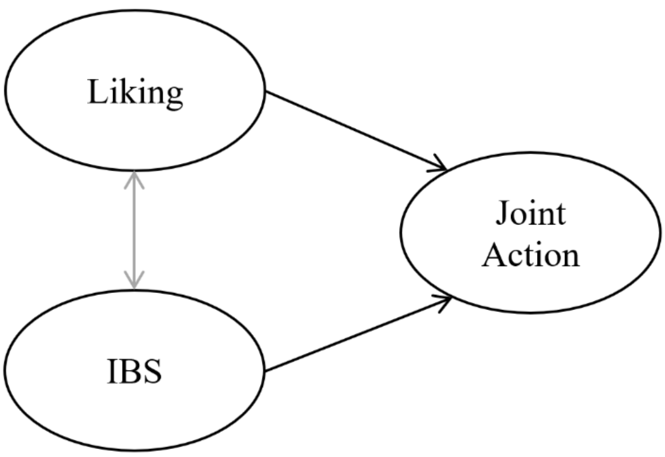
*Hypothesis 2c*




Cooperation and also more specifically joint action have been found to be enhanced – if not facilitated by IBS (Czeszumski et al., 2021, 2022; Reindl et al., 2022; Reinero et al., 2020). A positive influence of liking has been reported in a smaller number of studies (Zhao et al., 2017). In line with this I predicted that success in a joint action task will be greater in dyads with higher liking (Hypothesis 3), and dyads with higher IBS (Hypothesis 4). Visual representations of hypotheses three and four can be found in Figure 2.

**Figure 2**

*Hypotheses 3 and 4*



# Method

## Sample

The sample was recruited for the "Laughing Together Children" project via the "Wiener Kinderstudien" (Vienna Children's studies) database at the University of Vienna and data was collected between January and September 2024. It consisted of 41 dyads of children that were between 5.0 and 5.11 years old. The exclusion criteria were neurological or psychiatric disorders and severe auditory or visual impairments. One dyad had to be excluded due to auditory impairments of one participant. Additionally, four more dyads were excluded after one of the participants failed a comprehension check, inserted in the liking measurement (see section Measures). Furthermore, four dyads were excluded from all analysis including IBS measures because the participants refused or asked to prematurely abort the fNIRS measurement. Lastly, six dyads could not be included in IBS analyses due to the signal quality being insufficient for analysis or other problems in the collection of fNIRS data. This led to 26 dyads being included in IBS analysis.

The participants ($N$=72, 36 dyads) that were included in the analysis had an average age of 5 years and 5.1 months (median 5 months). Each dyad was matched in sex and the participants were less than 6 months apart in age. 48.7% of dyads and participants were female. Before arriving at the testing session, participants that were matched into a dyad were strangers.

According to their parents 65 (85.5%) participants were right-handed while ten (13.2%) were left-handed and in one case the parents were unsure. The family's socioeconomic status (SES) had a median of 7 when parents rated it on a scale from 1 to 10 ($M$ = 6.85, $SD$ = 1.23) and 80.9% of participants had at least one parent with a university degree. All participants attended kindergarten or a similar institution.

**Procedure**

All participants included in the analysis for this thesis were in the experimental group and were shown humorous animal videos, whilst a control group watched animal videos that were not intended to be humorous. There were three experimenters present during each testing session, two front experimenters that interacted with the participants and one technical experimenter, that mainly stayed behind an opaque curtain. Three cameras recorded the behavior of the participants and an audio recorder was used to measure laughter more precisely. Since this thesis is part of a bigger research project, the participants completed several tasks that were not included in this analysis. The procedure of the whole session is roughly outlined in Table 1.

**Table 1**

*Rough Outline of the Procedure*

| Task | Brief Description | Duration |
|---|---|---|
| Bonding 1 | Sitting on a carpet next to each other; parents still in room | 1.5 |
| Preparation | ECG, fNIRS, microphone; parents leave after calibration | 20-25 |
| Liking 1 | Privately rating the liking toward the other participant | 4 |
| Prosociality 1 | Privately sharing stickers with an unknown outsider child | 1 |
| Tangram | Arranging tangram puzzles alone and together | 13-15 |
| Videos | Watching humorous animal videos | 10 |
| Free play | Playing undisturbed with playmobile figurines | 5 |
| Liking 2 | Privately rating the liking toward the other participant | 2 |
| Prosociality 2 | Privately sharing stickers with the other participant | 1 |
| Joint Action | Building towers together | 10-15 |
| Bonding 2 | Sitting on a carpet next to each other | 1.5 |

*Note.* Duration in minutes. ECG = electrocardiogram.

While the parents of the participants waited in another room, they filled out questionnaires assessing the SES (see Appendix), personality traits (Rothbart et al., 2001) and assumed momentary mood of their child (Ebesutani et al., 2011). After the last task they were invited back into the lab and filled out a second questionnaire assessing the assumed momentary mood of their child. As a reward participants received 14 star-shaped stickers from the prosociality tasks, a certificate, and a toy, while the parents received 10€ as compensation for expenses.

**Measures**

***Liking***

The task to measure interpersonal liking within the dyad was presented as a "game of secrets" (see Appendix). To create privacy, an opaque separator was put up between the participants and they were introduced to a 5-point Likert scale of smiley faces ranging from very dissatisfied to very happy (Antonopoulou et al., 2019). The participants were instructed not to reply aloud, but solely by pointing to a smiley. The experimenter demonstrated how they would use the scale to reply to questions regarding their preferences in food. As a control to check whether the smiley-scale was comprehended they were first asked about preferences in food and leisure. The items used to measure liking were adapted by Wolf and colleagues to children from a scale for adults (Boothby et al., 2018): "“How much would you like to play with the other boy/girl (again)?" "How much do you like the other boy/girl?" and "How much would you like the other boy/girl to be your friend?”" (Wolf et al., 2021, S. 4). We translated the questions to German and changed "boy/girl" to "child". The items were not given in a randomized order.

The questions are asked twice. First, at the beginning of the study, after the participants spent approximately 20 minutes in the same room during the preparation. Second, after most of the tasks have been completed, before the joint action task. The scale for Liking 1 had acceptable internal consistency (Cronbach's $\alpha = .73$) and the scale for Liking 2 had good internal consistency (Cronbach's $\alpha = .80$).

The participants were asked both times how much they like chocolate ice cream. If the difference in their rating was bigger than two, it is assumed they did not comprehend the smiley scale, and they were hence excluded from analysis. As mentioned above, four dyads were excluded due to this criterion.

The scores of both participants are averaged into an intradyadic liking score and this was used in analysis.

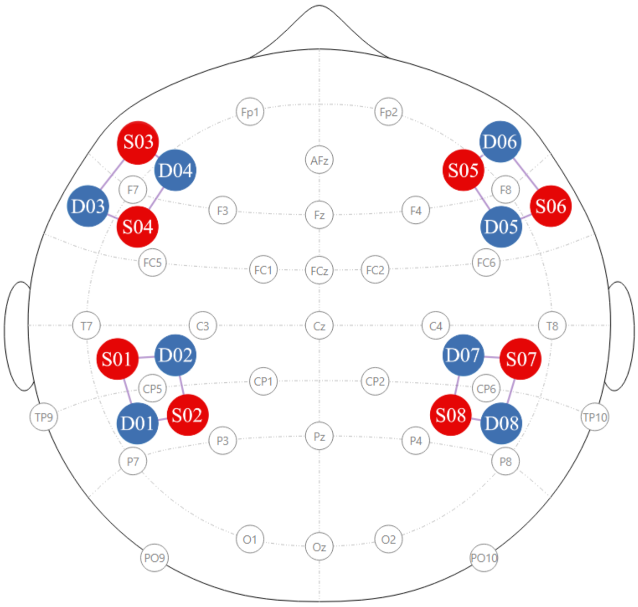
***Interpersonal Brain Synchrony***

**fNIRS Data Acquisition.** Shortly after the participants arrived and the informed consent was signed by their parents, their head circumference was measured, and a well-fitting cap was selected between sizes ranging from 48cm to 52cm circumference. The optodes were inserted into the caps behind an opaque curtain while other preparations took place. The caps were then placed on the participants' heads after being fully prepared. To ensure correct placement, the head was measured again, and the cap was aligned before fixing it to prevent shifting during the testing session.

Two NIRSport 8-8 devices (NIRx Medizintechnik GmbH, Germany) were used to measure changes in oxygenated and deoxygenated hemoglobin. Using the tandem mode in NIRStar 15-3 we simultaneously measured both participants' activity. For each participant a set of 16 optodes, consisting of eight light sources and eight detectors, were placed on the head forming four squares with sides of 30 mm (Fu & Richards, 2021; Pinti et al., 2020). Each of these squares was placed around one of the following regions of interest (ROI) on 10-20 configurated EEG caps. Four optodes each measured activity in the IFG around the F7 and F8 mark (Nguyen, Abney, et al., 2021), and in the TPJ around the CP5 and CP6 mark (Nguyen, Schleihauf, et al., 2021). Figure 3 maps the placement of the optodes on the head. Every detector measured the absorption of the light coming from two adjacent sources,

**Figure 3**

*Placement of fNIRS Optodes*




*Note.* This graphic was made on NIRSite 2023.9 and edited for better clarity.

S = source; D = detector.

resulting in 16 channels. The light absorption was measured at the wavelengths 760 and 850 nm.

The data was recorded during tasks between the two sets of liking questions. First, while the participants were watching two video compilations, showing humorous compilations of videos of animals lasting 5 minutes each and secondly while they engaged in a 5-minute-long free play together. These two sections were chosen because they are more naturalistic compared to other sections and because particularly during the videos the participants were expected to move very little. Strong motion artefacts lower the signal quality hence why it was of importance to us to choose sections in which participants are less likely to move a lot.

**fNIRS Processing.** The raw fNIRS data files were converted, segmented, and preprocessed in MATLAB R2022b using the HomER2 toolbox (Huppert et al., 2009). The sections used in this analysis were five minutes each for the two humorous compilations of animal videos and four minutes of the free play period with the first minute being cut.

Frequencies much higher or lower than those reflecting the hemodynamic response coupled to the brain activity, were filtered out. Motion artefacts were corrected with spline interpolation and wavelet filtering (Dans et al., 2021). The scalp coupling index (SCI) for each channel was computed by correlating the heartrate frequency of both wavelengths (Pollonini et al., 2014). Channels with an SCI lower than .75 were excluded. Subsequently the data of each participant and section was visually inspected and excluded if the heart band was not clearly visible at approximately one Hertz (Nguyen et al., 2020).

An ROI was excluded from analysis if less than two of the four channels measuring it had sufficient quality to be analyzed (Nguyen et al., 2020). If there was at least one ROI that could be analyzed in both participants in a dyad, they were included in analysis. As mentioned above, this led to the exclusion of 6 out of 36 dyads.

For an estimation of IBS, we used wavelet transform coherence (WTC) (Grinsted et al., 2004), with which it is possible to correlate two time series as a function of frequency and time (Nguyen et al., 2020). The mean coherence across time and frequency, was computed separately for each segment in all ROIs of sufficient quality.

***Joint Action***

Successful joint action was assessed with a children's game called Burg-Ritter (English: castle-knights) that requires physical cooperation to be successful (Tiggemann, 2007). The goal is to build towers out of colorful wooden blocks and figurines. The participants were not allowed to move the pieces directly with their hands. They were instructed to exclusively use a tool made of a hair tie that had four strings attached, with a wooden pearl on each end. Each participant held two of the pearls and by pulling on them, the hair tie could be stretched and loosened to pick up and drop the pieces at the correct spot. After a demonstration by two experimenters and a practice round, there were four trials. The first two towers were made of three pieces and the second two towers of four. After four failed attempts at placing a piece at its position, the trial was ended, and the next one started. If the participants wanted to quit before attempting to build all towers, they were assigned zero points for all towers they did not attempt to build. Every successful piece was counted separately and cumulatively. A tower of three pieces will therefore lead to $1 + (1 + 1) + (2 + 1) = 6$ points. The maximum score a dyad could achieve by completing all towers is 32.

**Analysis**

The participants' liking data was converted to dyadic data by forming the mean in Microsoft Office Excel all analysis was computed in IBM SPSS Statistics (Version 29.0.0.0).

For hypothesis one the WTC as an indicator of IBS was correlated with Liking 1 and Liking 2 scores. The sample size (N = 37 dyads) required to detect a moderate correlation ($r = .4$) achieving a power of 80% ($\beta = .80$) and a significance level of $\alpha = .05$, was not met.

Due to the small number of fNIRS data in each of the recorded tasks that had sufficient quality for analysis (see Table 2), the mean of all three segments and both lateralizations of the ROIs was used for analysis.

Hypotheses 2a and 2b were computed with linear regressions, expecting a positive effect of Liking 1 on IBS and a positive effect of IBS on Liking 2. The sample size (N = 57 dyads) required to detect a small-to-medium effect (Cohen's $f^2 = .07$) in a regression analysis with one predictor, achieving a power of 80% ($\beta = .80$) and a significance level of $\alpha = .05$, was not met.

Hayes' Process macro (Hayes, 2018) was used to compute a mediation with Liking 1 scores as independent variable, IBS as mediator and Liking 2 as outcome variable will be done to test hypothesis 2c (see Figure 1). I expected a partial mediation, with liking 1 scores having a stronger effect on liking 2 scores than IBS. Hypotheses 3 and 4 were tested with a covariation, expecting both Liking 2 scores, and IBS to have a positive effect on success in the joint action task (see Figure 2). The sample size (N = 144 dyads) required to detect a small-to-medium effect (Cohen's $f^2 = .07$) in a regression analysis with two predictors, achieving a power of 80% ($\beta = .80$) and a significance level of $\alpha = .05$, was not met.

**Table 2**

*Descriptive Information of WTC*

| Variable | *N* | Min | Max | *M* | *SD* |
|---|---|---|---|---|---|
| IFGr video 1 | 15 | .25 | .42 | .36 | .05 |
| IFGl video 1 | 13 | .27 | .48 | .37 | .07 |
| TPJr video 1 | 1 | .30 | .30 | .30 | - |
| TPJl video 1 | 4 | .37 | .46 | .42 | .04 |
| IFGr video 2 | 9 | .26 | .47 | .37 | .07 |
| IFGl video 2 | 12 | .32 | .51 | .39 | .07 |
| TPJr video 2 | 3 | .28 | .41 | .33 | .07 |
| TPJl video 2 | 6 | .32 | .50 | .37 | .07 |
| IFGr free play | 13 | .25 | .42 | .31 | .05 |
| IFGl free play | 16 | .23 | .48 | .32 | .08 |
| TPJr free play | 2 | .37 | .37 | .37 | .00 |
| TPJl free play | 3 | .31 | .37 | .33 | .03 |
| IFGr all segments | 19 | .27 | .42 | .35 | .04 |
| IFGl all segments | 19 | .23 | .44 | .35 | .05 |
| TPJr all segments | 4 | .28 | .37 | .33 | .05 |
| TPJl all segments | 8 | .31 | .50 | .38 | .06 |
| Total | 26 | .30 | .45 | .35 | .04 |

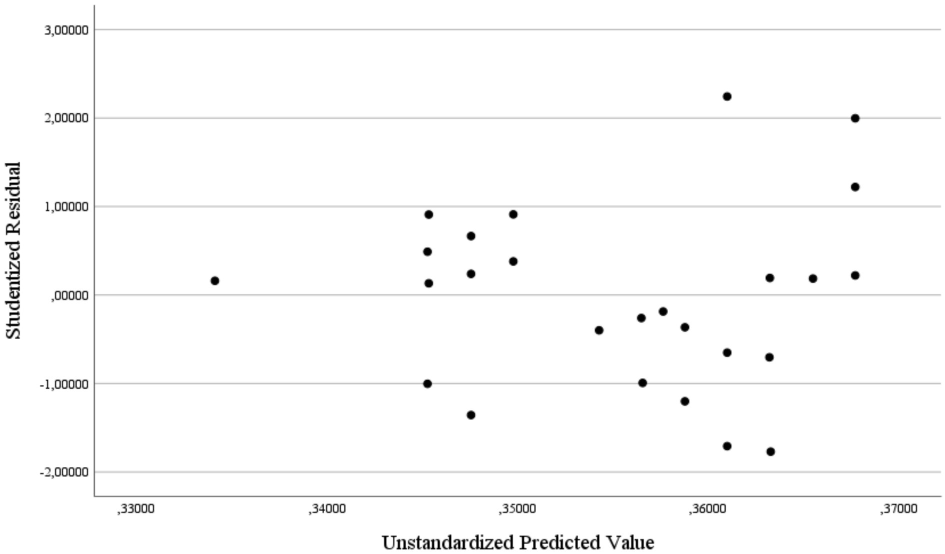
*Note.* All segments = mean of video 1, video 2, and free play; Total = mean of all ROIs and all segments.

Despite combining all segments of WTC data, there was no dyad, in which all four ROIs had sufficient quality for analysis, therefore the mean of all ROIs was used for regressions and mediation.

Before analysis, the data was tested for all necessary assumptions of linear regressions. Since a scatterplot of the unstandardized predicted values against the studentized residuals revealed heteroscedasticity in the regression testing hypothesis 2a, this regression was computed with bootstrapping using 1000 samples (see Figure 4).

**Figure 4**

*Scatterplot Revealing Heteroscedasticity in Hypothesis 2a*




The scatterplots of residuals against predicted values showed no non-linear effects. No outliers were identified being off more than three standard deviations from the mean. Additionally, the analysis of Cook's distances and leverages did not indicate any outliers. Durbin-Watson tests revealed no autocorrelation with values between 1.821 and 2.194. There was also no multicollinearity found with all tolerances above 0.9 and variance inflation factors close to 1. Shapiro Wilk tests revealed no violations of normality in any variables or studentized residuals.

## Results

Table 3 shows the descriptive results of all measured variables.

**Table 3**

*Descriptive Information of the Measured Variables*

| Variable | *N* | Min. | Max. | *M* | *SD* |
|---|---|---|---|---|---|
| Liking 1 | 36 | 2.33 | 5.00 | 4.00 | 0.73 |
| Liking 2 | 36 | 2.00 | 5.00 | 3.87 | 0.80 |
| IBS total | 26 | .30 | .45 | .35 | .04 |
| Joint Action Score | 36 | 0.00 | 29.00 | 12.42 | 8.53 |

*Note*. r = right; l = left

**Table 4**

*Pearson Correlations of Liking and IBS*

| Variable | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 1. Liking 1 | - | | | | |
| 2. Liking 2 | .60** <br> $n$ = 36 | - | | | |
| 3. IFG | .21 <br> $n$ = 24 | .32 <br> $n$ = 24 | - | | |
| 4. TPJ | .05 <br> $n$ = 11 | .10 <br> $n$ = 11 | .23 <br> $n$ = 9 | - | |
| 5. IBS all | .25 <br> $n$ = 26 | .31 <br> $n$ = 26 | .96** <br> $n$ = 24 | .92** <br> $n$ = 11 | - |

*Note*. ** $p < .01$

**Hypothesis 1**

Table 4 shows the correlation between Liking and the WTC as an indicator of IBS. Neither of the Liking scores significantly correlated with IBS. Liking 1 and Liking 2 showed a high positive correlation.

**Hypotheses 2**

Higher Liking 1 scores did not significantly predict higher IBS ($F(1, 24) = 1.58$, $p = .22$) and higher IBS did not significantly predict Liking 2 scores ($F(1,24) = 2.635$, $p = .12$).

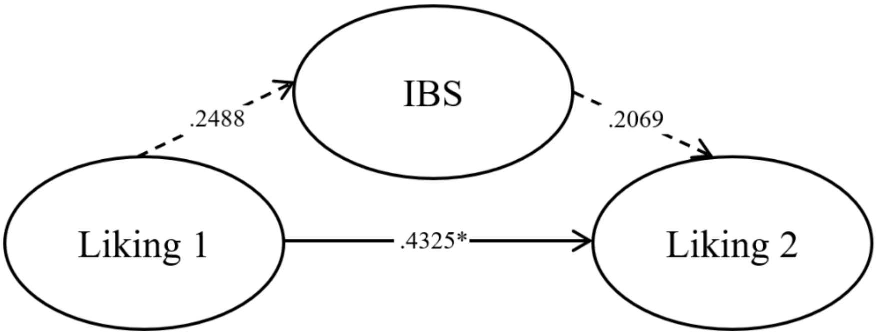
The mediation model revealed a significant positive effect of Liking 1 on Liking 2 ($R^2 = .274$, $F(2, 23) = 4.35$, $p = .03$). Only the direct path was significant (β = .43, $t(25) = 2.36$ $p = .03$). Liking 1 did not significantly predict IBS (β = .25, $t(25) = 1.26$, $p = .22$), and IBS did not predict Liking 2 (β = .20 , $t(25) = 1.13$, $p = .28$). Figure 5 shows the standardized path coefficients of the model.

**Hypotheses 3 & 4**

There was no significant positive effect of Liking 2 and IBS on success in the joint action task ($R^2 = .105$, $F(2, 23) = 1.355$, $p = .278$). The standardized effect sizes of Liking 2 (β = -.191 $p = .367$) and IBS (β = -.209 $p = .325$) were not significant but hinted at negative effects.

**Figure 5**

*Standardized Path Coefficients of the Effects of Liking 1 and IBS*




*Note.* * $p < .05$

## Discussion

This thesis aimed to identify the interplay of interpersonal liking and IBS on joint action in preschool children. IBS was not found to significantly correlate with liking, nor did it mediate changes in liking over time. Neither liking nor IBS were found to have a significant positive effect on success in a joint action task.

### Limitations

#### *Sample*

The statistical power was low in all analyses, and it is therefore possible that significant effects were not found due to the small sample size. Due to various problems with fNIRS data acquisition, approximately 37% of dyads could not be included in the IBS analysis, which was part of all hypotheses bar one. Furthermore, it is possible that dropouts were partly systematic, because the technology works better in participants with lighter hair and skin tones.

Additionally, the sample was recruited via the University of Vienna's "Wiener Kinderstudien" database, which consists only of children whose parents signed them up to take part in scientific experiments. This could indicate a bigger interest in research, with most parents having acquired a university degree. Furthermore, most parents claimed to have a higher-than-average SES. It is therefore likely that the sample is not representative of the general population of 5-year-old children.

***Procedure***

The data used for this thesis was part of a larger project. As mentioned earlier (see Table 1) the participants completed a multitude of tasks that were not included in the analysis for this thesis. Therefore, possible hypothesized effects on intradyadic liking, IBS and successful joint action were not considered, which likely reduced the explained variance. The high number of variables and tasks also resulted in testing sessions lasting approximately two hours including preparation and debriefing. When the participants performed the joint action task, they had already completed more than one hour of the session.

***Analysis***

Many studies analyze WTC in each ROI separately and find different results, specifically higher IBS in the right TPJ (Kayhan et al., 2022; Saxe & Wexler, 2005). For this thesis, this was not possible due to the small number of dyads with sufficient data quality. Especially in the TPJs there were only four (left TPJ) and eight (right TPJ) dyads that could be analyzed.

Additionally, analyzing all ROIs as covariates was not possible because there was no dyad in which data in all ROIs had sufficient quality. Combining the data of all ROIs might have led to blurred results if IBS was higher in one region but not others. Due to differences in the quantity of data in the ROIs, the results likely might have been skewed towards ROIs that were measured in a smaller number of dyads.

**Interpretations and Implications**

As mentioned above, due to the limited power for all analyses, the absence of significant results cannot necessarily be interpreted as a lack of effects. I will thus not discuss the implications of insignificant results.

The intradyadic liking at different points in time was strongly positively correlated. Liking 1 predicted Liking 2, accounting for approximately 27% of variance in Liking 2 scores. The direct effect was found to be significant, while the indirect effect mediated by IBS was not. This suggests that the interpersonal liking of preschool children tends to remain relatively stable over the course of approximately one hour. As seen in Table 4, the mean of Liking 2 was not higher than Liking 1, suggesting that playing and watching videos together did not increase liking.

Although the results were not significant, they hinted at a negative effect of liking and IBS on success in the joint action task. The participants watched humorous videos, combined with possible fatigue this might have made them excited and over aroused. It is possible that motivation and performance decreased, and the participants did not exert themselves as much but preferred to play for fun. Especially participants who liked each other more, were more synchronized and therefore possibly enjoyed the testing session more, might be less motivated to try hard and be successful in the joint action task. Had they been significant, this might be an explanation for the hypothesized positive effects of liking and IBS being negative instead.

**Future Directions**

Given the limited conclusions that could be drawn from this thesis, further research is necessary. Future studies could adopt similar methodical approaches with larger sample sizes to allow confirmation or rejection of the null hypotheses. Additional measures could shed light on further interesting questions. Reindl and colleagues (2018) found that IBS between parents and children during an earlier task predicted cooperative performance in a later task, while simultaneous measurements showed no such association. Future research could investigate the temporary effects of IBS on cooperation between children, analyzing both before and during the task. Additionally, exploring whether subsequent IBS differs in dyads based on their success in cooperative tasks could provide deeper understanding of the causal direction or possible feedback loops.

In addition to the emergence and temporal development of IBS, it might also be interesting for future research to explore what longer-term effects IBS has on child development. IBS between children and parents has been linked to developmental benefits (for reviews see: Alonso et al., 2023; De Felice et al., 2024). Further research is, however, needed to clarify whether IBS between peers offers similar advantages. Future studies could consider longitudinal designs to investigate changes in social skills, likability and peer relationships, and their association with IBS and successful cooperation. Since adolescents have been found to show higher IBS during cooperation than adults (Yang et al., 2023), investigating this across different age groups could reveal more developmental trends.

Lastly, given that much of psychological research is conducted on so-called WEIRD (acronym for: western, educated, industrialized, rich, democratic) samples, future research should aim to survey more diverse samples (Apicella et al., 2020). On the one hand, more emphasis must be placed on heterogeneity in the SES when recruiting the sample. On the other hand, it is important that more resources are provided for research in other cultures.

**Conclusion**

In conclusion, this thesis investigated the interplay of liking and IBS, and their effects on successful joint action in preschool children. Participants rated their interpersonal liking before, and after watching videos and completing playful tasks with each other. Afterwards their cooperation was assessed with a game requiring joint action. Due to the small sample size, no significant effects could be detected and therefore no conclusions were drawn. Further research is necessary to explore what factors influence the development of liking over time as well as the interpersonal sympathetic and neural mechanisms underlying successful cooperation across the lifespan.

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# List of Figures



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# List of abbreviations

| | |
|---|---|
| ECG | Electrocardiogram |
| EEG | Electroencephalography |
| fNIRS | Functional near infrared spectroscopy |
| Hz | Hertz |
| IBS | Interpersonal brain synchrony |
| IFG | Inferior frontal gyrus |
| ROI | Region of interest |
| SCI | Scalp coupling index |
| SES | Socioeconomic status |
| TPJ | Temporoparietal junction |
| WTC | Wavelet transform coherence |

# Appendix

**Abstract**

Research investigating the underlying neural mechanisms of social interactions has experienced a paradigm shift from a one-person perspective towards a multiple-person perspective. Interpersonal brain synchrony (IBS) in prefrontal and temporoparietal cortex areas, often measured with functional near-infrared spectroscopy (fNIRS) has consistently been linked with effective cooperation and joint action. IBS has also been associated with higher levels of liking between individuals. However, the directionality of this effect remains unclear with some studies suggesting a positive feedback loop. A positive effect of liking on cooperative joint action has been investigated in a smaller number of studies. This thesis aimed to investigate the interplay between liking and IBS and their effects on success in a joint action task in dyads of 5-year-old preschool children. It hypothesized a positive correlation between liking and IBS as well as a mediation of the changes in liking over time by IBS. Furthermore, a positive effect of both liking and IBS on success in a joint action task was hypothesized. The participants ($N$=72, 36 dyads) had an average age of 5 years and 5.1 months and 48.7% were female. Liking was rated twice on a three-item composite scale and IBS was measured with fNIRS hyperscanning. Due to low power no significant results were found. More research is necessary to understand the developmental aspects of IBS, liking, and joint action in peers.

*Keywords:* interpersonal brain synchrony, liking, joint action, preschool children, functional near-infrared spectroscopy

**Zusammenfassung**

Die Erforschung der neuronalen Mechanismen, die sozialen Interaktionen zugrunde liegen, hat einen Paradigmenwechsel von einer Ein-Personen-Perspektive zu einer Mehr-Personen-Perspektive vollzogen. Interpersonelle Gehirnsynchronität (IBS) in präfrontalen und temporoparietalen Kortexbereichen, welche häufig mit funktioneller Nahinfrarotspektroskopie (fNIRS) gemessen wird, wurde durchweg mit effektiver Kooperation und interpersoneller Koordination in Verbindung gebracht. IBS wurde ebenfalls mit einem höheren Maß an Sympathie zwischen Individuen in Verbindung gebracht. Die Richtung des Effekts bleibt jedoch unklar, wobei einige Studien auf eine positive Rückkopplungsschleife hindeuten. Ein positiver Effekt von Sympathie auf interpersonelle Koordination wurde in einer geringeren Anzahl von Studien untersucht. Ziel dieser Arbeit war es, das Zusammenspiel von Sympathie und IBS und ihre Auswirkungen auf den Erfolg bei einer Aufgabe, welche interpersonelle Koordination erforderte, in Dyaden von 5-jährigen Vorschulkindern zu untersuchen. Es wurde eine positive Korrelation zwischen Sympathie und IBS sowie eine Mediation der Veränderungen von Sympathie über die Zeit durch IBS angenommen. Darüber hinaus wurde ein positiver Effekt von Sympathie und IBS auf den Erfolg in einer Koordinationsaufgabe angenommen. Die Versuchspersonen ($N$=72, 36 Dyaden) hatten ein Durchschnittsalter von 5 Jahren und 5,1 Monaten und 48.7% waren weiblich. Die Sympathie wurde zweimal auf einer Skala aus drei Fragen bewertet und IBS wurde mit fNIRS-Hyperscanning gemessen. Aufgrund von geringer statistischer Macht wurden keine signifikanten Ergebnisse gefunden. Weitere Forschung ist notwendig, um die Entwicklungsaspekte von IBS, Sympathie und interpersoneller Koordination zwischen Kindern zu verstehen.

*Stichwörter*: interpersonelle Gehirnsynchronität, Sympathie, interpersonelle Koordination, Vorschulkinder, funktionelle Nah-Infrarot-Spektroskopie

## Questionnaire for Parents in German

### Elternfragebogen

Bitte füllen Sie den Fragebogen möglichst vollständig und nach bestem Wissen aus. Einige der unveränderlichen Angaben werden in der Datenbank hinterlegt, damit Sie dieselben Fragen bei einer weiteren Studienteilnahme nicht noch einmal ausfüllen müssen. Alle Angaben sind selbstverständlich freiwillig und werden vertraulich behandelt.

| **Kind** |
|---|

**1. Füllen Sie bitte folgende Informationen zu den Geburtsdaten Ihres Kindes aus:**

Geburtsdatum: ______________________

Geschlecht: ☐ männlich ☐ weiblich ☐ divers

Schwangerschaftswoche: ____________

Gewicht bei Geburt (in g): _____________

APGAR Score nach **10 Minuten:** _____________

Anzahl Geschwister: _____________ Platz des Kindes in Geschwisterreihe: _____________

Bei Interesse an einer Studienteilnahme mit **Geschwisterkindern** (Kinder zwischen 0 u 6 Jahren)

Name + **Geburtsdatum**: _____________________________________________________

Name + **Geburtsdatum**: _____________________________________________________

**2. Welche Sprache(n) werden im Alltag hauptsächlich mit Ihrem Kind gesprochen? (**Sprachen, die Eltern oder Bezugspersonen regelmäßig mit dem Kind sprechen (kein passiver Input wie z.B. Fernsehen oder Lieder)

________________________________________________________________________________

**3. Welche Händigkeit hat Ihr Kind?**

☐ Rechtshändig ☐ Linkshändig ☐ Beidhändig ☐ noch nicht sicher

**4. Füllen Sie bitte folgende Informationen zum sozialen Kontext ihres Kindes aus:**

Geht ihr Kind in den Kindergarten oder vergleichbare Institutionen (Kleinkindergruppen etc.)?
☐ ja ☐ nein

Falls ja, seit wann? _____________

Mit wie vielen anderen Kindern hat Ihr Kind durchschnittlich Kontakt innerhalb einer Woche?

_____________

Wie oft in einer Woche hat Ihr Kind Kontakt zu anderen Kindern?

☐ keinmal ☐ einmal oder zweimal in der Woche ☐ mehrmals die Woche ☐ jeden Tag

**Eltern**

**5. Wer ist derzeit die Hauptbezugsperson des Kindes:** ☐ Mutter ☐ Vater ☐ andere Bezugsperson: ________________

**6. Elternteil 1:** ☐ Mutter ☐ Vater ☐ andere Bezugsperson ________________

7. Geburtstag Elternteil 1: ________________

8. Muttersprache(n) Elternteil 1: ________________

9. Welche Sprache(n) verwenden Sie im Umgang mit Ihrem Kind hauptsächlich? ________________

10. Höchster Bildungsabschluss Elternteil 1:

☐ Ohne ☐ Pflichtschule ☐ Lehre ☐ BHS ☐ AHS ☐ Universität

11. Kulturelle Zugehörigkeit Elternteil 1: Menschen können sich unterschiedlichen Kulturen zugehörig fühlen. Manche Menschen empfinden sich zum Beispiel als österreichisch, andere als türkisch, wieder andere als österreichisch-türkisch. Wie ist das bei Ihnen? Wie sehen Sie sich selbst? (falls in Vertretung, bitte für das nicht anwesende Elternteil/ Bezugsperson einschätzen)

________________________________________________________________________________

**12. Elternteil 2:** ☐ Mutter ☐ Vater ☐ andere Bezugsperson________________

13. Geburtstag Elternteil 2: ________________

14. Muttersprache(n) Elternteil 2: ________________

15. Welche Sprache(n) verwenden Sie im Umgang mit Ihrem Kind hauptsächlich? ________________

16. Höchster Bildungsabschluss Elternteil 2:

☐ Ohne ☐ Pflichtschule ☐ Lehre ☐ BHS ☐ AHS ☐ Universität

17. Kulturelle Zugehörigkeit Elternteil 2: Menschen können sich unterschiedlichen Kulturen zugehörig fühlen. Manche Menschen empfinden sich zum Beispiel als österreichisch, andere als türkisch, wieder andere als österreichisch-türkisch. Wie ist das bei Ihnen? Wie sehen Sie sich selbst? (falls in Vertretung, bitte für das nicht anwesende Elternteil/ Bezugsperson einschätzen)

________________________________________________________________________________

**Anweisungen**: Stellen Sie sich vor, dass diese Leiter zeigt, wo die Menschen in Österreich stehen. Oben auf der Leiter stehen - diejenigen, die das meiste Geld, die beste Ausbildung und den angesehensten Beruf haben. Am unteren Ende stehen die Menschen, denen es am schlechtesten geht – diejenigen, die das wenigste Geld, die geringste Bildung und den am wenigsten angesehenen Beruf oder gar keine Arbeit haben. Je weiter oben Sie sich auf dieser Leiter befinden, desto näher sind Sie den Menschen an der Spitze; je weiter unten Sie sind, desto näher sind Sie den Menschen ganz unten.

**Wo würden Sie sich auf dieser Leiter einordnen?**

Bitte kreuzen Sie die Sprosse mit einem großen "X" an, auf der Sie sich Ihrer Meinung nach im Vergleich zu anderen Menschen in Österreich derzeit befinden.

**Experimental Script for Liking and Smiley Scale in German**

Einführung in das Spiel „Geheimnis Spiel“ und der Skala: Gesichter zeigen und erklären

- Mit Essen erklären
    - *Ich mag Vanilleeis sehr stark* (auf Smiley 5 zeigen)
    - *Ich mag Brokkoli wirklich gar nicht* (auf Smiley 1 zeigen)
    - *Und wenn es Pommes gibt, ist mir das egal* (Smiley 3)
    - *Schnitzel mag ich gerne, aber nicht so sehr* (Smiley 4)
- Beispielfrage zu den Kindern stellen: *Das ist jetzt ein Geheimnis, zeigt mit eurem Finger auf das Gesicht, was ihr aussucht und sagt nichts dazu*
    - *Wie gerne mögt ihr Schokoladeneis? Könnt ihr es mir mit einem Gesicht zeigen?*
    - *Wie gerne mögt ihr Spinat?*
    - *Wie gerne mögt ihr Ball spielen? Könnt ihr es mir mit einem Gesicht zeigen?*

Eigentliche Liking Frage

*Und jetzt werde ich euch Fragen stellen über das andere Kind, das auf der anderen Seite der Wand ist.*

*Das ist jetzt wieder ein Geheimnis, zeigt mit eurem Finger auf das Gesicht, was ihr aussucht und sagt nichts dazu*

*Likingfrage 1: Wie gerne magst du mit dem anderen Kind spielen? Bitte zeig auf das Gesicht*

Gesichter erklären

- Sehr trauriges Gesicht: *Du magst gar nicht mit dem anderem Kind spielen.*
- Neutrales Gesicht: *Dir ist es egal, ob du mit dem anderen Kind spielst.*
- Glückliches Gesicht: *Du magst sehr gerne und viel mit dem anderen Kind spielen.*

*Likingfrage 2: Wie gerne magst du den anderen Jungen/Mädchen?*

*Likingfrage 3: Wie gerne magst du mit dem anderen Kind befreundet sein? Zeig es mir mit den Gesichtern.*

1 sehr schlecht | 2 schlecht | 3 mittel | 4 gut | 5 sehr gut