

Groups Matter: Investigating the Effects of Homophily in Child Interactions in an Inclusive Classroom

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Abstract—Children’s interactions with peers are central to their social, emotional, linguistic, and cognitive development. While research has focused on children’s pairwise associations, less attention has been given to the characteristics of larger groups of children. This study highlights the importance of a group perspective by exploring whether homophily—the tendency to interact with similar others—extends beyond pairs to groups of children. To identify pairwise interactions between children, we use social contact criteria, and for interacting groups, we operationalize them as F-formations, a widely used concept in computational research for detecting adult groups. We conducted a case study in an inclusive preschool classroom over two consecutive years, involving two different cohorts of children with hearing loss (HL) and with typical hearing (TH). Our findings show that children tend to form groups, particularly groups of size 3 to 5. Homophily is evident among children with TH in both pairs and groups, while for children with HL, homophily is suggested only at the group level. Group-level analysis also reveals patterns not observed in pairwise interactions, such as TH children’s lower overall likelihood of being in a group and their tendency to associate with groups containing a higher proportion of TH peers. These findings suggest that incorporating group interactions provides a more comprehensive understanding of children’s sociality, capturing patterns that cannot be explained by pairwise analysis alone.

Index Terms—F-formation, Social Contact, Child Interactions, Homophily Effect, Group Detection

I. INTRODUCTION

Early peer interactions in classroom settings are essential for children’s social skill development [1], [2]. Inclusive classrooms, where children with developmental disabilities (DD) learn alongside typically developing (TD) peers, aim to provide equal opportunities for engagement [3]. However, children’s interactions in inclusive classrooms evidence a homophily effect in social interactions—children tend to preferentially associate with peers who share similar characteristics [4], [5]. Banarjee et al. [6], for example, examined children with Autism Spectrum Disorder (ASD) and other developmental disabilities (DD). They found that concordant pairs (TD-TD and DD-DD) spend more time in social contact than discordant pairs.

Building on Banarjee et al., we investigate how homophily with respect to hearing status (with or without hearing loss) influences children’s likelihood of associating with peers.

Previous research has primarily examined peer interactions at the pair level [7]. However, children do not interact solely in dyads; prior studies suggest that they also form and engage in larger groups (cliques) [8]. A child’s interactions within a group are not merely an extension of dyadic relationships but can be shaped by the presence of others. For instance, in a group of three, a third child (C) might either strengthen the interaction between two others (A and B) or disrupt it by dominating the conversation. Additionally, A and B may frequently co-occur in groups, yet their association could be more driven by the group’s overall dynamics, which cannot be fully captured through direct dyadic engagement [9].

To detect and analyze these groups, we operationalize them as F-formations [10], a widely used concept in adult group detection tasks during focused encounters. An F-formation is a spatial arrangement where individuals position themselves to create a shared, enclosed space that facilitates interaction. This framework serves as a unit for analyzing social encounters, allowing us to investigate how homophily takes effect in groups. Based on this, we pose the following research questions:

- RQ1: Is homophily with respect to hearing status related to a child’s likelihood of being associated with another child via pairwise interactions?
- RQ2: Does a group’s homophily degree with respect to hearing status influence a child’s likelihood of being associated with that group? That is, we expect children of a given hearing status to be more likely to be associated with groups based on the preponderance of that hearing status.

II. RELATED WORK

A. Studies on Homophily in Child Interaction identified by Pairwise Social Contact

In this section, we focus on the definitions of social contact used in previous studies to operationalize pairwise associations that were employed to study child homophily. Messinger et al. [5] developed a data-driven approach to identify social contact, defining it as occurring when children were within 0.2 to 2 meters of each other. Later studies [7] added a second condition: if children within this proximity were also facing each other within a 45-degree angle, they were considered to be in social contact, as shown in Fig. 1.

Using these criteria, researchers found that social contact time between pairs of children was homophilic: children in concordant pairs (e.g., ASD-ASD) spent a significantly greater proportion of time in social contact than those in discordant pairs. However, pairwise interactions among children do not fully capture children’s social behaviors in group settings.

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Code available at: TUDelft-SPC-Lab repository

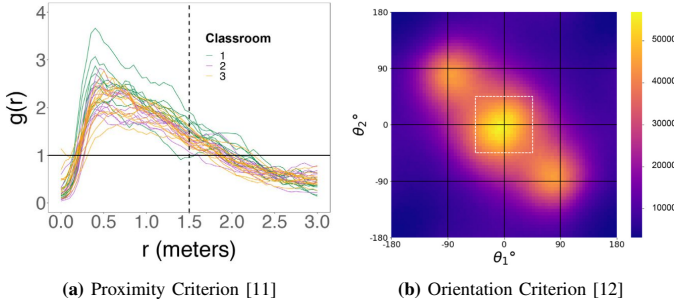


Fig. 1. Social contact determination based on proximity (1a) and orientation (1b). Fig. 1a shows the radial distribution function, $g(r)$, indicating distances where the probability of social contact is higher than chance ($g(r) = 1$). Each line depicts one observation day for a given cohort. Fig. 1b presents a heat map of children’s orientation angles (θ_1 to θ_2) for peers within 1.5 m. The color bar indicates number of tenth-of-a-second observations in 1000s.

B. Automated Group Detection by Conceptualizing Groups as F-formations

Detecting interacting groups requires a structured way to define what constitutes a group. One widely adopted framework for this purpose is the so-called F-formation. According to Kendon [10], “An F-formation arises whenever two or more people sustain a spatial and orientational relationship in which the space between them is one to which they have equal, direct, and exclusive access.” In practice, an F-formation consists of three social spaces: o-space, p-space, and r-space (see Fig. 2) [11], [12].

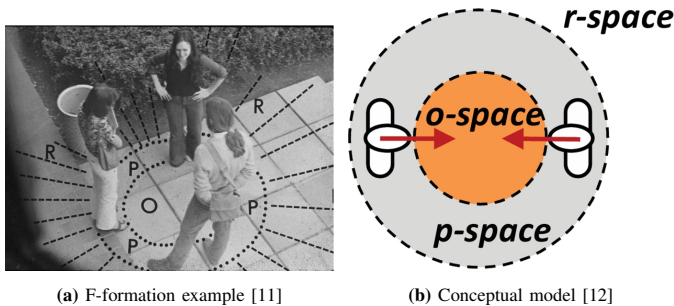


Fig. 2. An example of a conversational group organized as an F-formation (left) and a conceptual model (right) showing the o-space, p-space, and r-space that constitute the F-formation.

Building on this conceptual foundation, two main approaches are used to detect interacting groups as F-formations, each representing a different perspective on interpreting F-formations. The first approach directly models spatial arrangements mathematically [13], [14], while the second adopts a graph-theoretic perspective, representing social scenes as edge-weighted graphs [15]–[19].

Setti et al. [20] conducted a comparative study of two most cited approaches from these categories: the Hough for F-formation (HFF) method developed by Cristani et al. [12] and the Dominant Set (DSFF) clustering method proposed by Hung and Kröse [15]. Setti et al. concluded that when utilizing both position and orientation information—despite potential noise—HFF yields the most effective results. However, when

only body position data is available (which is the typical output from current body trackers), DSFF works better.

Beyond F-formation-based approaches, several recent studies have attempted to characterize group-level interactions in child populations using alternative modeling strategies [21]–[23]. These efforts underscore a shared interest in understanding children’s spontaneous group behavior across different analytical frameworks.

III. METHODS

A. Dataset

Data were collected over two years in an inclusive classroom using the Ubisense tracking system. The participants included two separate cohorts of children (and their teachers). [24]. To track their positions, the children wore vests equipped with Ubisense tags placed above their left and right hips, as shown in Fig. 3. The system recorded position and height data at a frequency of 1 Hz when static and up to 4 Hz when in motion.



Fig. 3. Vest and RFID trackers. Vest with pockets for Ubisense tags.

Data were collected in academic years (2022–2023 and 2023–2024), which we refer as datasets 2223 and 2324, respectively. Both datasets were collected from the same classroom with different time spans and participants (see Table I). The classroom measured approximately 16×16 m, with furniture layout as in Fig. 4.

TABLE I
COMPARISON OF DATASET 2223 AND 2324

Characteristic	Dataset 2223	Dataset 2324
Time Span	Oct. 2022 – Jun. 2023	Sep. 2023 – Jun. 2024
Num. days recorded	13	19
Num. children	13 (9 females)	14 (9 females)
Num. Hearing Loss children	6 (3 females)	8 (5 females)
Mean Age (months)	42.31 ± 4.46	40.07 ± 3.70
Mean children present per day	10.69 ± 1.26	10.58 ± 1.39
Mean log time per child (min/day)	163.77 ± 40.53	184.48 ± 23.60

B. Preprocessing Data

An initial noise reduction was performed on the raw data by excluding any entries where the height of the children’s sensors exceeded 1.25 meters, a reasonable assumption for preschool children. The data then was resampled at 0.1-second intervals and smoothed using a Kalman filter [25].

Position and orientation were calculated from the two tracking devices. A child’s position was determined as the midpoint between the recorded locations of the two tags for that child, while body orientation (only used in the pairwise analysis) was calculated relative to the $+x$ -axis in Fig. 4.

C. Identifying Pairs Using Social Contact Determination

To demonstrate the impact of incorporating group information into existing pairwise studies, we first replicate the established pairwise analysis for identifying pairs based on social contacts [6]. As shown in Fig. 1, two children are considered to be in social contact if they are co-located within a distance of 0.2 to 2.0 meters and maintain a relative orientation within 45 degrees of each other. The pairs are identified using social contacts at each 0.1-second and then aggregated into 1-second units.

D. Detecting Groups as F-formations

1) *Dominant-sets as F-formations (DSFF)*: Following much of the existing literature on adult group detection, mentioned in Section II-B, we conceptualize interacting child groups in our classroom as F-formations. That is, we assume some adherence to maintaining an o-space.

Since it is unclear if F-formations exist in child interactions, we conservatively abstained from exploiting pre-trained models from adult F-formations that might learn biases in the data distributions that could be related to other factors e.g. furniture, group-specific social dynamics, etc. [17], [19]. Moreover, no video data was collected to enable direct labeling of the child interaction data for model fine-tuning. With respect to self-supervised approaches, there is little formal knowledge about how interacting groups of children arrange themselves [26]. Consequently, we focused on agnostic methods, using the DSFF approach by Hung and Krose [15]. This approach does not require assumptions about how children orient themselves in groups and relies only on proximity.

DSFF models F-formation detection as a graph-based optimization problem, identifying dominant sets—maximal cliques in edge-weighted graphs. Given an affinity matrix describing the pairwise closeness between participants, the algorithm iteratively extracts groups by maximizing internal connectivity using replicator dynamics [27]. A peeling strategy is used to iteratively identify and remove cliques from the graph until singletons remain. To prevent the meaningless groupings once only singletons remain, a stopping criterion was used that ensures that the average weighted degree between all identified cliques in previous iterations of the peeling strategy does not deviate significantly; once that occurs, the remaining nodes in the graph must be singletons (see [15] for more details).

2) *Implementation of DSFF*: Following the DSFF approach, we first constructed a coordinate dictionary capturing the positions of all visible children for each scene at each time frame. Using this data, we built an affinity matrix A for this scene and each element a_{ij} represents the pairwise affinity between children i and j , and is calculated based on Equation (1):

$$a_{ij} = \begin{cases} 0 & \text{if } i = j \\ e^{-\frac{d_{ij}}{2\sigma^2}} & \text{if } i \neq j \end{cases} \quad (1)$$

Here, d_{ij} is the Euclidean distance between children i and j in the x and y ground plane. σ parameterizes the spatial

sensitivity for i and j to be considered in a group. We considered a range of 0.2 to 2 meters, which mirrors the distance used for the social contact proximity criterion [5].

To determine the optimal value for σ , we qualitatively evaluated the grouping results within this range, under different values of σ for randomly selected scenes. Following this, the F-formations are identified using DSFF at each second.

E. Mixed-Effects Modeling of a Child’s Likelihood of Associating with Another Child or a Group

To examine how homophily based on hearing status influences a child’s likelihood of associating with another child or with a group, we employed multilevel mixed-effects models. We detail the components of our modeling approach as follows.

1) *Model Specification*: Fixed effects in the models include Hearing Status (HL vs. TH), Dataset (2223 vs. 2324), and TH proportion of a pair or a group. Here, Hearing Status HL and Dataset 2223 serve as the baseline reference categories. For each identified pair or group, the TH proportion is calculated as:

$$\frac{\text{The number of children with TH}}{2 \text{ (for pairs) or Group Size (for groups)}} \quad (2)$$

The TH proportion is centered around 0, where -0.5 indicates a group consisting entirely of HL children, and 0.5 indicates a group consisting entirely of TH children.

Random intercepts account for individual variability by modeling observations (Level 1) nested within children (Level 2). The dependent variable is the likelihood of a child being in a social association (either pairwise or group-level), as defined below. Interaction effects remain in the models when statistically significant.

2) *Modeling Approaches*: For pairwise analysis, a linear mixed-effects model is adopted using the `lmer` function from the `lme4` package in R [28]. The likelihood of a child being in a pairwise social association is defined as:

$$\frac{\text{Time a pair is in social contact}}{\text{Time both are present in the classroom}} \quad (3)$$

This approach follows prior research on the homophily effect [6].

A child is considered part of a group if they belong to a detected F-formation. The likelihood of a child being associated with a group is defined as:

$$\frac{\text{Time a child is in a group}}{\text{Time the child is in the classroom}} \quad (4)$$

Initial analyses indicated that residuals from the linear mixed-effects model for group-level data violated the normality assumption. To address this, a generalized linear mixed-effects model is implemented using the `glmmTMB` function [29]. Given that the dependent variable is highly right-skewed, strictly positive, continuous, and bounded within (0,1), we utilize Beta regression with a logit link function to ensure predictions remain in the (0,1) range.

3) *Model Results Reporting*: Model estimates, including standard errors, confidence intervals, test statistics, and p -values, are reported using the `tab_model` function from the `sjPlot` package. Notably, the estimates provided in Tables III are exponentiated coefficients (i.e., odds ratios): an odds ratio less than 1 indicates a negative effect, whereas an odds ratio greater than 1 indicates a positive effect.

IV. EXPERIMENTS

A. DSFF Implementation

We adopted the DSFF method implementation from Swofford et al. [18] and constructed the affinity matrix according to Hung et al. [15]. Since Swofford et al. did not report specific DSFF implementation results, we validated our implementation using the *Idiap* dataset, following the evaluation method from Setti et al. [20], and obtained comparable results.

Since no annotations were available to evaluate the choice of σ , we relied on visual inspection of the plotted positions and detected groups. Using randomly selected frames, we observed that smaller σ (e.g., 0.2) led to overly tight clusters, while larger values (e.g., 2.0) made clusters too dispersed. A sigma between 0.8 and 1.0 struck a good balance. We adopted sigma = 1 for later analysis.

A visualization of a randomly selected timestamp is shown in Fig. 4. Two groups were detected: one consisting of children 35, 37, 57, and 55, and another consisting of children 48, 53, and 54.

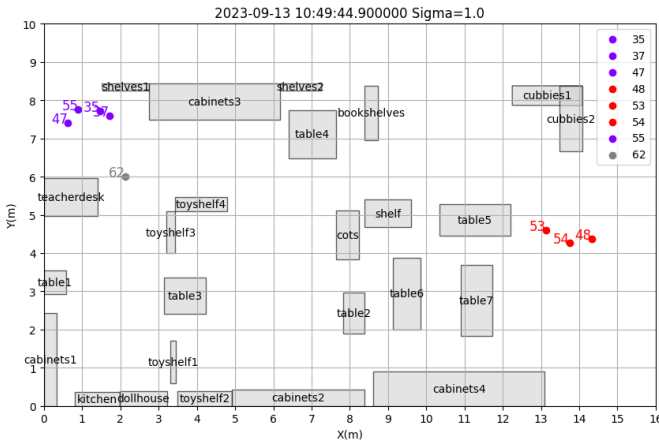


Fig. 4. Grouping result at timestamp 2023-09-13 10:49:44.900 with furniture: different colors represent different extracted groups, while grey indicates singletons (e.g. child 62).

B. Mixed-effect Analysis Results

1) *Pairwise Homophily Study on Children with Respect to Hearing Status*: Table II presents the results of the effects analysis examining how a child’s likelihood of forming a pairwise association is influenced by their hearing status, the proportion of TH peers in this pair (TH Proportion), and the dataset, with the interaction between hearing status and TH proportion considered. From the table, we observe that, the significant positive interaction between Hearing Status [TH]

and TH Proportion (estimate = 0.03, $p < 0.001$) indicates that children with TH were significantly more likely to form pairwise associations with TH peers, suggesting a preference for homophily. Additionally, the Dataset variable ($p = 0.045$) suggests that pairwise association were more likely in the Dataset 2324.

2) *Group Analysis on Children with Respect to Hearing Status*: Table III presents the results of the analysis examining how a child’s likelihood of being associated with a group is influenced by their hearing status, the proportion of TH peers within the group, and the dataset, with two- and three-way interactions among these variables considered. The estimates (log odds for group analysis) indicate a negative effect when the estimate is less than 1 and a positive effect when the estimate is greater than 1. From the table, we observe that, children with TH tend to have fewer group associations than children with HL (estimate = 0.43, $p < 0.001$). The TH Proportion variable has a significant negative effect (estimate = 0.58, $p < 0.001$), indicating that overall, children are less likely to associate with groups that have a higher proportion of children with TH than groups with a higher proportion of children with HL. This effect suggests a homophily effect for children with HL due to the lower likelihood of being in higher TH proportion groups. The effect for TH children is modified by the interaction between Hearing Status [TH] and TH Proportion. This interaction suggests homophily in groups: children with TH are more likely to be associated with groups that have a higher proportion of children with TH (estimate = 4.45, $p < 0.001$).

During our observations of frequently formed groups, we found that these groups typically consist of 3 to 5 members. To illustrate this, we present a plot in Fig. 5 showing the number of groups observed per second across different group sizes. As the plot demonstrates, groups of size 3, 4, and 5 are most commonly observed in both datasets.

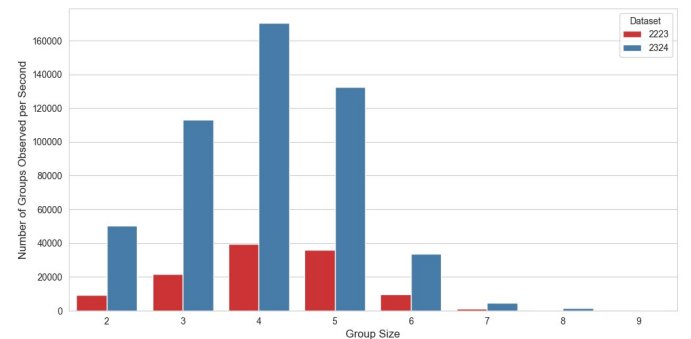


Fig. 5. The number of groups observed per second for different group sizes.

V. CONCLUSION AND FUTURE WORK

This study aims to showcase the significance of incorporating group-level information into existing research on children’s social interactions. We argue that considering groups of size two and larger provides a deeper understanding of social patterns than pairwise analyses alone.

TABLE II
HOMOPHILY EFFECT ON PAIRWISE ASSOCIATION LIKELIHOOD

Predictors	Estimates	std. Error	CI	Statistic	p
(Intercept)	0.04	0.00	0.03 – 0.04	20.95	< 0.001
Hearing Status [TH]	0.00	0.00	-0.00 – 0.01	0.52	0.600
TH Proportion	-0.01	0.00	-0.02 – 0.00	-1.26	0.209
Dataset [2324]	0.00	0.00	0.00 – 0.01	2.01	0.045
Hearing Status [TH] × TH Proportion	0.03	0.01	0.02 – 0.04	4.20	< 0.001
Random Effects					
σ^2	0.00				
τ_{00} Child	0.00				
ICC	0.00				
N Subject	25				
Observations	1614				

TABLE III
HOMOPHILY EFFECT ON GROUP ASSOCIATION LIKELIHOOD. ESTIMATES ARE LOG ODDS AND A VALUE < 1 INDICATES A NEGATIVE EFFECT.

Predictors	Estimates	std. Error	CI	Statistic	p
(Intercept)	0.01	0.00	0.01 – 0.01	-122.72	< 0.001
Hearing Status [TH]	0.43	0.03	0.38 – 0.48	-14.02	< 0.001
TH Proportion	0.58	0.04	0.51 – 0.66	-8.21	< 0.001
Dataset [2324]	0.75	0.04	0.68 – 0.83	-5.55	< 0.001
Hearing Status [TH] × TH Proportion	4.45	0.41	3.72 – 5.32	16.39	< 0.001
Hearing Status [TH] × Dataset [2324]	0.93	0.08	0.79 – 1.09	-0.92	0.355
TH Proportion × Dataset [2324]	1.81	0.16	1.53 – 2.14	6.86	< 0.001
(Hearing Status [TH] × TH Proportion) × Dataset [2324]	1.24	0.16	0.97 – 1.59	1.71	0.087
Random Effects					
σ^2	1.26				
u_{00} Child	0.00				
ICC	0.00				
N Person	27				
Observations	40738				

We operationalized pairwise interactions using published social contact criteria [6] and the groups as F-formations using the Dominant Set for F-formations approach [15]. We then applied both pairwise and group-level mixed-effect analyses to investigate how homophily with respect to hearing status influences a child’s association with another child or group.

In response to RQ1, our analysis indicates that homophily characterizes social contact patterns among TH children: TH children exhibited a tendency to be in social contact with TH peers. However, this pattern was not observed for HL children.

Regarding RQ2, the results indicate that children with TH are more likely to be associated with groups with a higher proportion of TH peers (the interaction effect). A similar (but more indirect) pattern is observed for children with HL (a direct effect indicating decreased likelihood of associating with groups with a higher TH proportion). We also found that, overall, TH children are less likely to be associated with a group compared to HL children. In addition, our analysis indicates a preference for forming groups of a specific size (i.e., groups of 3, 4, and 5). The mechanisms responsible for these phenomena require further study. Also, the most common group sizes might be influenced by the choice of σ , which DSFF is sensitive to.

Overall, both pairwise and group-level analyses reveal a homophily effect in which children with TH tend to form pairs and larger groups that contain a higher proportion of

children with TH. The group analyses also suggest a similar homophilic tendency for children with HL that is not evident in the pairwise analyses.

Fundamentally, the results provide a framework for extending pairwise analyses to larger groups. These analyses indicate a proclivity for forming groups of specific sizes (between 3 and five children). More subtly, the group-level analysis uncovers patterns that would be overlooked using a strictly pairwise approach, such as the overall lower likelihood of TH children being part of a group.

Notably, pairwise interactions can be seen as one situation within the broader context of group formation and occur less frequently compared to larger groups, further emphasizing the need for a group-level perspective. By incorporating group-level analysis, we can gain a more comprehensive understanding of children’s social interactions.

In terms of limitations and future work, it is important to emphasize that operationalizations of social contact in this data could not be validated via audio and video recordings, or posthoc interviews with children. It remains an open question as to whether children of this age group form F-formations as observed in adults. In addition, incorporating body orientation, other attentional cues, and temporal dynamics may improve the modeling of child social contact in groups. Given the privacy challenges of obtaining video and audio data to triangulate behavioral observations to sensor data, creative

data-driven approaches may be needed to find evidence for the exact nature of child group interactions.

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