frontiers | Frontiers in Developmental Psychology

TYPE Brief Research Report
PUBLISHED 27 July 2023
DOI 10.3389/fdpys.2023.1221056

OPEN ACCESS

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RECEIVED 11 May 2023
ACCEPTED 28 June 2023
PUBLISHED 27 July 2023

CITATION
Burke N, Brezack N, Meyer M and Woodward A (2023) Children's social network size is related to their perspective-taking skills. *Front. Dev. Psychol.* 1:1221056. doi: 10.3389/fdpys.2023.1221056

Children's social network size is related to their perspective-taking skills

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Perspective-taking (PT) is an important skill children develop within the first few years of life; however, little is known about how children's social environments relate to PT development. During early childhood, children's social networks undergo dramatic growth. Prior work with adults has shown that network size is related to PT skill, which raises the question of whether and how children's social networks may relate to their emerging PT skills. This question is particularly interesting given that children's social worlds undergo dramatic growth and changes, which is a sharp contrast from adults that have stable social network sizes. The present study measured the social networks of 3-year-old children ($n = 36$; 15 female; 68% White) and found that children in larger social networks demonstrated stronger PT skills, particularly on the more difficult trials on the task. These results indicate the size of children's social networks relates to their PT ability.

KEYWORDS

perspective-taking, social network size, social cognition, social network analysis, social relationships

Introduction

Perspective-taking (PT) is a core human competence – it is a skill that is used in conversation (e.g., Keysar et al., 2000), emotional understanding (e.g., Decety and Jackson, 2006), and spatial reasoning (Schober, 1993). To become a successful social partner, children use their PT skills. PT is often important to react appropriately and in a timely manner in social interactions and it is correlated with later theory of mind skills (Farrant et al., 2006; Harwood and Farrar, 2006; Yeung et al., 2019). PT emerges early in ontogeny (Herold and Akhtar, 2008; Krogh-Jespersen et al., 2015; Liberman et al., 2016) and continues to develop through the second and third year of life (Moll and Tomasello, 2006; Moll and Meltzoff, 2011; Masangkay et al., 2016).

Although 2-year-olds start to exhibit visual PT skill in experimental tasks, PT continues to develop and mature throughout the first several years of development (Peskin and Ardino, 2003). One key type of PT is "Level 1 Visual PT," or the understanding that what you see may differ from what someone else sees (Moll and Tomasello, 2006; Masangkay et al., 2016). Understanding what another person can and cannot see is a crucial and early-emerging type of PT integral to many social interactions. Using Level 1 PT in live, social interactions is complex; children have to reason about both what their social partner can and cannot see, do so in a time-sensitive manner, and act accordingly to successfully engage in social interactions. Even adults make mistakes in interactions that require PT. Keysar et al. (2000) used a Director task where adult participants moved objects on a grid in response

to instructions from a social partner on the other side of the grid. Crucially, participants had full visual access to all objects while their partner's view of some objects was blocked. Although adults certainly understand that differences in perspective can exist, participants had difficulties in tracking which objects their partner could and could not see in this real-time task. This suggests that engaging in PT during communicative interactions is a demanding process.

In the first few years of life PT undergoes significant changes. At a time when children are getting better at PT, they also experience significant changes to their social environments. A recent study measured children's social networks, which was assessed by asking parents to describe their child's typical, weekly activities, to explore how the early social environment varies in the first few years of life. Results showed that children's social networks undergo marked growth from infancy through age 5 (Burke et al., 2022). Older children had larger networks than younger children, their networks were more racially and linguistically diverse, and their networks were more likely to include other children and people outside the immediate family (Burke et al., 2022). The question arises as to whether these variations in early social experience might be related to children's emerging PT ability.

As children come to interact with more, and more varied, social partners they find themselves in increasingly complex and demanding communicative contexts. These complex communicative contexts require them to utilize skills necessary for social interactions – turn taking, following and interpreting referential cues, and taking on the perspective of others, just to name a few. It stands to reason that as the number of social partners children interact with regularly increases, their ability to take on another person's perspective might increase as well.

Research with adults has demonstrated a relation between social network size and PT. Stiller and Dunbar (2007) tested adults' PT skills in a narrative task where participants answered questions about the intentionality of different characters. The PT score was a weighted average of the level of intentionality participants failed the PT task as well as the number of correct responses. Participants also completed a questionnaire that assessed their social network. PT, as indexed by intentionality scores on the task, was positively correlated with social network size. This finding is consistent with the broader literature indicating that social network size is correlated with the neural substrates of social cognition for both adults and non-human primates (Bickart et al., 2011; Sallet et al., 2011). For example, Sallet et al. (2011) used a pseudo-randomized design to discover that monkeys living in larger social groups showed increases in brain size and functioning, suggesting that the social context is the driver for neurological changes.

Adults' social network size is relatively stable over time (Suitor and Keeton, 1997; Perry and Pescosolido, 2012), but, as noted previously, children's networks grow and become more complex during development. These findings raise the question of whether growth and variation in children's social networks is related to social cognitive skills that are emerging during early childhood. Consistent with this possibility, prior studies have indicated relations between children's social perspective-taking or theory mind abilities and variations in the social partners with whom they regularly engage, including siblings (e.g., Perner et al., 1994; Jenkins and Astington, 1996; McAlister and Peterson, 2006), friends (Wright and Mahfoud, 2012; Shahaeian, 2015), adults (Lewis et al., 1996), mixed-aged classroom peers (Wang and Su, 2009), and multilingual exposure (Fan et al., 2015; Liberman et al., 2016). No study to date has asked whether the sheer number of social partners in a child's life relates to their social cognitive skill. The current study explored this question.

The present study

We examined whether the size of children's social network was correlated with their Level 1 PT skill. We assessed 3-year-olds' PT using a controlled, and relatively challenging, behavioral task (Brezack et al., 2021). In this task, children completed multiple trials which varied in the kind of visual perspective that children were required to take. We drew on a subsample of children who were tested in Brezack et al. (2021) for whom we were also able to collect information about social networks by having parents complete *The Child Social Network Questionnaire* (Burke et al., 2022). We predicted that children with larger social networks would show a more robust ability to respond appropriately in the PT task. We also evaluated whether variation in the language diversity of children's networks related to their PT performance. Prior studies suggest that children with exposure to multiple languages demonstrate superior perspective-taking skills (Greenberg et al., 2013; Fan et al., 2015; Liberman et al., 2016) and false belief understanding (Goetz, 2003). Those analyses revealed null results (see Supplemental material) and we focus this manuscript on how Network Size relates to PT.

Methods

Participants

Participants were recruited from Chicago, IL using a database of families who volunteered to participate in early childhood research. Only subjects that heard at least 75% of English at home were recruited to participate in this study because the PT task required proficiency in the English language. As a result, 70% of the participants ($n = 21$) were monolingual English speakers. Thirty-six 3-year-olds ($M_{age} = 37.3$ months; range = 36.0–38.9 months) participated in the behavioral PT task as part of a larger study on PT development (Brezack et al., 2021). The present study was a follow-up study to the behavioral PT task. After the children participated in the PT study, parents were contacted over the phone to participate in *The Child Social Network Questionnaire*, which is a tool that measures children's early social networks (Burke et al., 2022). The parents of 31 children ($M_{age} = 37.2$ months, range 35.3–38.8 months; $n = 15$ female, $n = 16$ male) completed the phone interview (time between test and parent interview: 10 days – 164 days). For this study we were constrained to the 36 subjects that initially completed the PT task, which then dictated our final sample size. The final sample of 31 children was 67.8% European-American, 6.5% African-American, 3.2% Hispanic, 3.2% Asian, and 12.9% multiracial and 73% of the sample ($n = 22$) had mothers with a bachelor's degree or higher.

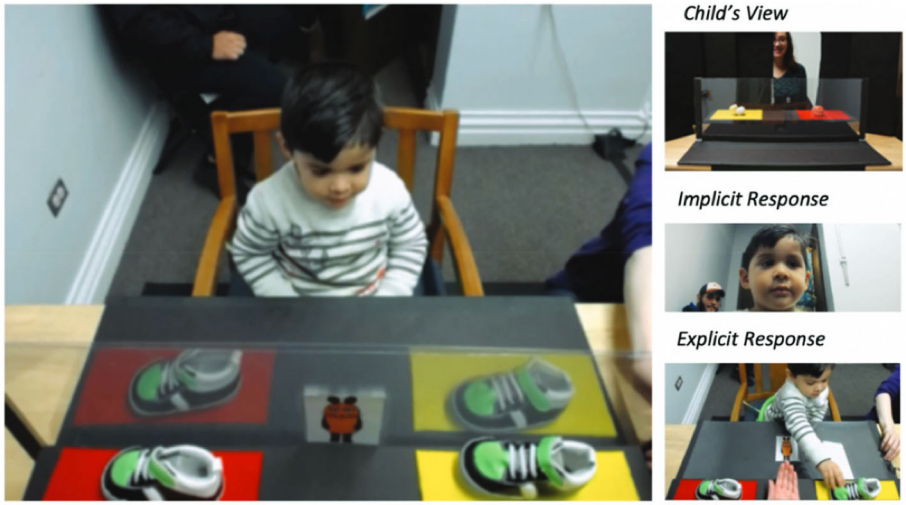

FIGURE 1
An example of the perspective-taking task set-up from Brezack et al. (2021). The Child's View shows an example of what the child saw when one of the doors was closed. In the picture shown, the experimenter can see the item on the red square and cannot see the item on the yellow square.

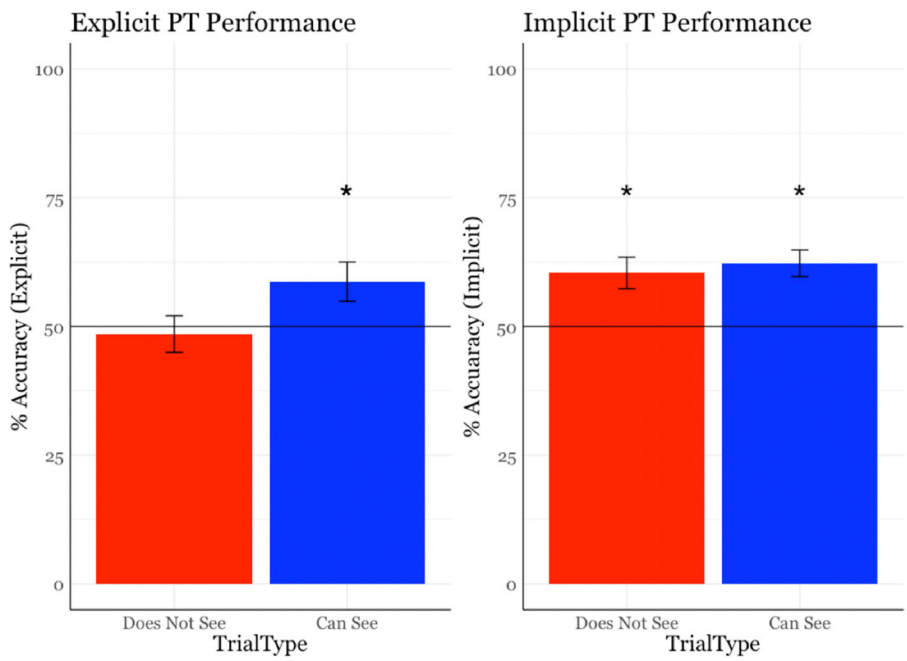

FIGURE 2
Performance on Explicit PT and Implicit PT. Bar graphs of Explicit PT and Implicit PT performance split by Trial Type (Can See and Does Not See) are shown. Chance is 50% and error bars and +1−1 standard error.

Perspective-taking task

After informed consent, children participated in the PT task. In the PT task, children participated in a social communicative interaction with an experimenter (E1). Children sat across from E1 at a table. The child's task was to hand E1 a requested toy, which the child could identify through considering the experimenter's visual perspective on the toys. More specifically, on each trial, children chose one of two identical toys to give to E1 based on audio prompts that required children to take E1's perspective. E1 could only see one of the two toys while the child could always see both toys (Figure 1). To begin each trial, E1 opened one of two doors of a puppet stage (either right or left side) so she could see one of the two toys (see Brezack et al., 2021 for more details). Then, children heard an audio prompt that indicated which toy they should hand E1. Children were prompted to either hand E1 the toy that she could see (Can See trials: "It's the one [*E1 name*] can see!") or the toy that she could not see (Does Not See trials: "It's the one [*E1 name*] does

not see!"). On the Can See trials, E1 and the child could both see the requested toy. On the Does Not See trials, E1 could not see the requested toy. These two trial types were included in the design to reflect different visual access scenarios.

Children were separated from the toys by a clear plastic barrier. After the audio prompt instruction played, a second experimenter waited 2 seconds (during which children's eye gaze was measured) before lowering the barrier so the child could choose a toy and pass it to E1. Children's toy choice after the barrier was lowered was coded as an explicit measure of PT performance, which reflected children's ability to act on their PT understanding in a communicative exchange. Eye gaze during the 2-second window was coded off-line for a measure of implicit PT performance, which was hypothesized to reflect children's analysis of another's perspective. There were two blocks of PT trials, with Can See and Does Not See trials interleaved, the correct answer side counterbalanced, and eight trials per block. There were also two blocks of control trials. The control trials were either Red trials ("It's on the *red* side!") or Yellow trials ("It's on the *yellow* side!"). The requested toy corresponded to the color of the mat on which the toy sat. The control trials did not require PT. A warm-up phase preceded the task to familiarize children with what E1 could and could not see, and a single trial that did not require PT was presented after each block of trials to ensure children were paying attention to the task. After completing the PT task, children were tested on the Toolbox Picture Vocabulary Test (TPVT) to assess their vocabulary. See Brezack et al. (2021) for additional task details.

Calculating perspective-taking performance

Children's visual PT performance was assessed with two measures of PT understanding: an explicit measure of PT and an implicit measure of PT. Explicit PT performance was measured by calculating the proportion of trials on which the child correctly handed E1 the toy E1 could see or could not see, thereby accurately accounting for E1's perspective. Implicit PT performance was measured by eye gaze: The proportion of time children spent looking at the correct object compared to the distractor object was measured during the time window immediately following the audio prompt ("It's the one *[E1 name]* [can see/does not see]!") until the frame before the clear barrier was lowered. Explicit and Implicit PT proportions were arc-sine square-root transformed for analysis. Coding was performed in Mangold International GmbH (2017) at a rate of 30 frames per second by a coder blind to the research hypotheses. A separate coder coded 22.2% of the original sessions; reliability was high [explicit PT: Cronbach's alpha = 0.999; ICC = 0.999, $F(7) = 836.5$, $p < 0.001$; Implicit PT: Cronbach's alpha = 0.978; ICC = 0.969, $F(7) = 46.4$, $p < 0.001$].

The child social network questionnaire

The Child Social Network Questionnaire is a method designed to assess infants' and children's social networks (Burke et al., 2022). Young children's social networks are composed of the people that the child interacts with on a regular basis – a child's social network captures both the number of people they interact with on a regular basis (Network Size) and attributes of the people, which make-up the diversity of the social network (race, languages they speak, gender). *The Child Social Network Questionnaire* is administered in two parts: (1) a parent interview to collect information about children's typical week of activities, and (2) a survey to collect demographic information for each person the child sees regularly.

For the parent interview, the participants' parents were contacted over the phone after they completed the PT task in the lab. The goal of the parent interview was to generate a list of people the child interacts with on a regular basis. Parents were asked to describe their child's "typical week" of activities at the time that their child participated in the behavioral study. Parents' description of their child's typical schedule served as a memory prompt and allowed the experimenter to assess children's reoccurring social relationships. The interview followed structured questions in order to extract children's reoccurring social relationships and to ensure parents were not underreporting the more distal relationships that children have [see Burke et al. (2022) for more details]. From the interview, a list of people the child interact with on a regular basis could be derived, which is the child's social Network Size. After the phone interview, parents received a customized Qualtrics link with a demographic survey for each of the people in their child's social network.

Network Size

There are several metrics that can be calculated from *The Child Social Network Questionnaire*; however, the present study focused on Network Size. Network Size was the total number of people (also called "nodes") the child sees on a regular basis. This number was determined from the phone interview. A parent had to report that the child knew each person individually for that person to be counted as a node. For example, if a parent reported that the child was in daycare or preschool, the experimenter would ask, "Are there any kids in the class that stand out as friends?" Parents reported between 0 and 10 different friends, and each friend was an individual node. Most nodes in children's social networks were individual people; however, there were some "group level" nodes. For example, there were nodes for "daycare/preschool class". This node represents a group of children in which no children were individuated as the child's friend.

Results

Our analysis plan was pre-registered and is available here: https://osf.io/8snkc/?view_only=290776b79b574e6581b984f505af7c21. Below we present our findings from the Network Size analysis. Originally, the study was preregistered to analyze average PT performance across the trial types. However, there was a significant difference in children's performance on Can See vs. Does Not See trials, rendering it important to include trial type (Can See vs. Does Not See) as a factor in the analysis. With this one amendment, the analyses followed the preregistered plan. Linear Mixed Effects Models were run with Trial Type as a factor and Subjects as a random effect because each subject contributed two scores (one for each trial type). As preregistered, TPVT was tested to see if it related to Explicit or Implicit PT performance, but no

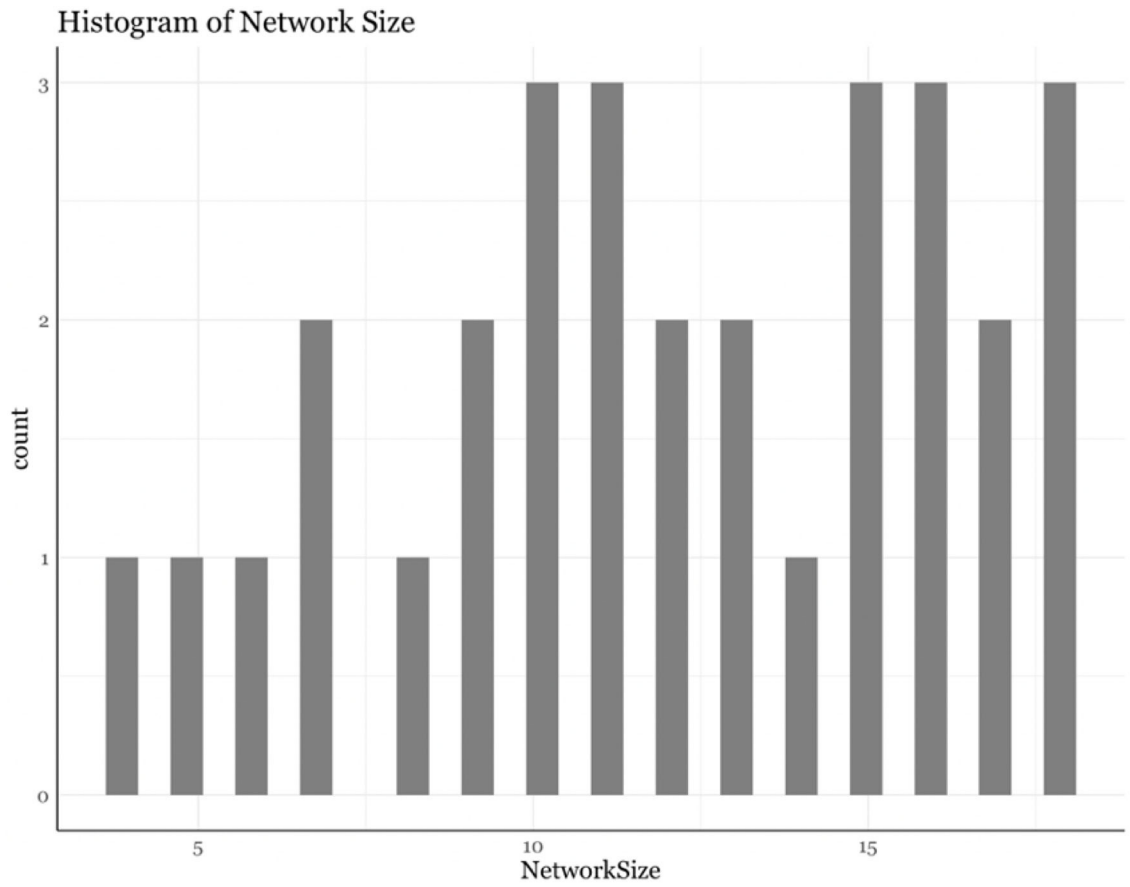

FIGURE 3
Histogram of network size.

relations were found (all p's > 0.05), so TPVT was not included in subsequent analyses.

Perspective-taking task performance

Before asking about relations between PT and properties of children's networks, children's performance on the PT task was assessed at a group level. A 2x2 (Trial Type: Can See/Does Not See x Measurement Type: Explicit/Implicit) repeated-measures ANOVA revealed a main effect of Trial Type, such that children performed better on the Can See trials than the Does Not See trials [$F_{(1,86)} = 8.40$, $p < 0.01$, $\eta^2 = 0.09$]. There was no significant main effect of Measurement Type [$F_{(1,86)} = 1.93$, $p > 0.05$, $\eta^2 = 0.02$], suggesting no difference between Explicit and Implicit PT, and there was no significant interaction [$F_{(1,86)} = 1.87$, $p > 0.05$, $\eta^2 = 0.02$; Figure 2].

Follow-up t-tests with FDR corrections confirmed that for Explicit PT, children performed above chance (0.50) for the Can See trials ($M = 0.59$, $SD = 0.21$; $t(29) = 2.31$, $p < 0.05$), but performance did not differ from chance on the Does Not See trials ($M = 0.49$, $SD = 0.19$; $t(29) = -0.09$, $p > 0.05$). For Implicit PT, children performed above chance on Can See trials ($M = 0.62$, $SD = 0.13$; $t(29) = 4.44$, $p < 0.001$) and on Does Not See trials ($M = 0.57$, $SD = 0.15$; $t(29) = 2.99$, $p = 0.01$). Thus, though children demonstrated awareness of another's perspective in both Can See and Does Not See trials when measured implicitly, they did not consistently implement this understanding in their explicit performance for the Does Not See trials. These results parallel those of the full sample of 36 children reported in Brezack et al. (2021).

Network size and perspective-taking

On average, children's Network Size was 12 people ($SD = 4.01$ people, one outlier removed: 26; Figure 3). When Network Size and Trial Type were included as predictors of Explicit PT, a main effect of Trial Type emerged ($ß = 0.89$, $p < 0.01$) such that performance was higher on Can See trials than Does Not See trials. As predicted, the model revealed a main effect of Network Size ($ß = 0.15$, $p = 0.05$), indicating that children with more people in their social networks demonstrated better Explicit PT performance. There was also a significant interaction between Network Size and Trial Type ($ß = 0.22$, $p < 0.05$; Figure 4). A simple slopes analysis revealed that children perform better as their Network Size increases for the Does Not See trials only (Does Not See trials: $ß = 0.15$, $p = 0.05$; Can See trials: $ß = -0.06$, $p = 0.43$).

The same model was performed to test the effect of Network Size on Implicit PT performance. No predictors reached significance (all p's > 0.05; Supplementary material). There was

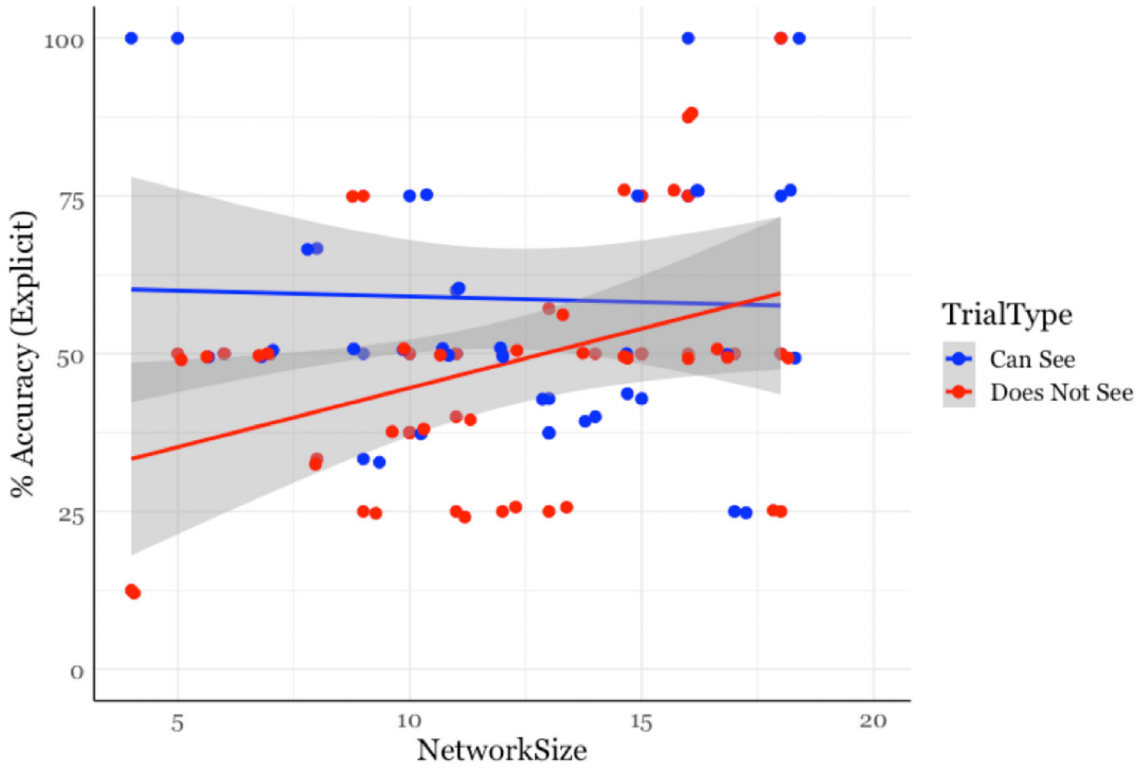

FIGURE 4
Network Size and Explicit PT. Scatterplot of Network Size in relation to Explicit PT Performance. Dots are colored by Trial Type: Can See and Does Not See. Best fit lines are included, shaded areas represent 95% confidence intervals.

no evidence that Network Size was related to children's Implicit PT performance.

Summary of results

Children with larger social networks had significantly better Explicit PT skills and this effect was qualified by an interaction between Network Size and Trial Type, such that children performed better on the Does Not See trials, the harder trials, as their network size increased. There was no evidence to suggest that Network Size was related to Implicit PT performance. The Network Size finding with Explicit PT was in line with research with adults - children with larger social networks performed better on the PT task, likely driven by the more difficult PT trials.

Per our pre-registration, we also explored how Network Size related to the control trials to explore the extent that these network properties specifically related to PT as opposed to children's ability to engage in a task. The model revealed null results (all p's > 0.05; Supplemental material). While there was no evidence that Network Size was related to general task performance, there was evidence that the number of people children interact with on a regular basis related to their PT ability.

As stated above, our pre-registered analyses to explore how linguistic diversity related to PT revealed null results (all p's not significant; Supplementary Figure 1); there was no evidence that the diversity of language speakers in children's networks were related to their PT performance.

Discussion

We found that variation in the size of children's social networks was related to their PT skill, particularly for the more challenging aspects of the PT task. Extending prior work that has explored how siblings and similar aged peers relate to children's social cognitive capacities, we discovered that the more people a child interacts with on a regular basis is related to superior perspective-taking skills.

Our findings support the prediction generated from a social network perspective – children in larger networks have superior social cognitive skills because they interact with more people on a regular basis, thus providing them more opportunity to use those skills. A recent study found that an interesting aspect of young children's early social networks is that there is rapid growth during the first few years of life – as child age increased, so did network size (Burke et al., 2022). Interestingly, as children's network size increased several other aspects of their early social environments also changed. As network size increased, children interacted with a greater proportion of peers, people outside their family, and had a decrease in the proportion of high intense relationships (Burke et al., 2022). Several of these dimensions of social experience could relate to children's social cognitive skills, and assessing only one of them could miss the effects of other, potentially confounded, dimensions. Taken together, these findings raise the question of what other aspect of children's environment might be related to perspective-taking. For example, is network size indexing some other aspect of experience that might be related

to perspective-taking, like the amount of adults or peers children interact with or whether the child goes to school? We explored this possibility with the present dataset and did not see any significant relations between other network variables and children's PT (Supplementary Table 1 and Supplementary Figure 4). Our small sample negated our ability to test interactive models of these variables, which limits what we can and cannot say about this data; however, while we see no evidence that these other aspects of children's early social environments are related to their PT ability, we do see evidence that Network Size is related to PT performance. This suggests that the unique number of social partners a child interacts with on a regular basis is related to their PT skills.

Our results are consistent with research with adults and nonhumans primates that has supported the "Social Brain Hypothesis," - the view that the complexity of the social environment influences brain structure and function (Dunbar, 1998; Barrett et al., 2003; Bickart et al., 2011; Sallet et al., 2011). Given that the current findings are correlational, it is not possible to assess the causal relations. It cannot be known whether larger social networks influence children's PT, or instead whether children with better PT skills end up in larger networks. Children have relatively little autonomy in choosing their social environments in that most of their early social environments are dictated by parent childcare decisions, but even so, variation in social cognitive skill could influence children's social opportunities. For example, parents of shy children may be less likely to put their child in situations they judge to be socially challenging. Further research is needed to investigate these issues, for example, by making use of natural "experiments" that vary children's social circumstances (e.g., Lillard et al., 2017).

An important limitation of this current study is that children were mostly high socio-economic status (SES). In the adult social network literature adults from high-SES backgrounds have less closely knit networks and fewer family members are represented in their network (Campbell et al., 1986; McPherson et al., 2005). There are different theories that suggest adults who are high- vs. low-SES may have different functions for the nodes in their network. High-SES individuals do not need to rely on individuals outside of the home for the economic security of their household; they can afford to have less closely knit networks and networks that have more weak ties (Granovetter, 1983). It is important to explore the structure of networks for children of lower-SES backgrounds and test whether experience similarly relates to children's social cognitive development.

In summary, this study tested whether children's perspective-taking skills were related to their network size and found that children in larger social networks had better PT skills. This effect was especially apparent in more difficult visual perspective situations, like when the child saw an object their partner could not see. Importantly, this study highlighted the importance of using social networks to explore how variations in early social experience relates to social cognition. Overall, these results indicate the size of children's social worlds relate to their ability to consider things from another person's point of view.

Data availability statement

The dataset presented in this study can be found in online repositories. The names of the repository/repositories and accession number(s) can be found at: https://osf.io/8snkc/?view_only=290776b79b574e6581b984f505af7c21.

Ethics statement

The studies involving human participants were reviewed and approved by the IRB at the University of Chicago. Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin. Written informed consent was obtained from the minor(s)' legal guardian/next of kin for the publication of any potentially identifiable images or data included in this article. Written informed consent was obtained from the individual(s) for the publication of any identifiable images or data included in this article.

Author contributions

NBu came up with the idea for the study, collected the social network data, performed all data analysis for the manuscript, and was the primary writer for the manuscript. NBr and MM collected the PT data and provided written feedback on drafts of the manuscript. MM also provided feedback on the analysis. AW provided feedback on the experimental design, analysis, and was the primary source of feedback for the manuscript. All authors contributed to the article and approved the submitted version.

Funding

This research was supported by an NIH grant (P01 HD064653) awarded to AW.

Acknowledgments

We would like to thank the children and families who participated in this research.

Conflict of interest

MM declared that they were an editorial board member of Frontiers, at the time of submission. This had no impact on the peer review process and the final decision.

The remaining authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fdpys.2023.1221056/full#supplementary-material

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