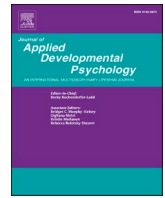




Contents lists available at ScienceDirect

Journal of Applied Developmental Psychology

journal homepage: www.elsevier.com/locate/jappdp

“Are we both right?” relations between theory of mind and epistemic humility in dyadic cooperative problem-solving in 5- to 9-year-old children

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ARTICLE INFO

Keywords:

Theory-of-mind
Epistemic humility
Socio-cognitive conflict
Cooperative problem-solving
Peer interaction

ABSTRACT

The current study addresses the question of the relation between ToM and children's epistemic humility - the tendency to acknowledge the limitations of one's knowledge while being open to another's input during socio-cognitive conflict regulation - in a cooperative problem-solving context. Sixty-four boys and girls between the ages of 5 to 9 years (32 same-gender dyads) were tested for their ToM with the Theory of Mind Test (TMT) and The Test of Emotion Comprehension (TEC), and for their epistemic humility through an analysis of their spontaneous verbal interactions during the resolution of a dyadic spatial transformation task. The results showed that children with higher levels of ToM more frequently showed more epistemic humility when faced with conflicting ideas, even when age was taken into account. The results are discussed in terms of the processes underlying socio-cognitive conflict regulation in peer cooperation and their educational implications.

Research has shown that intellectual disagreements are better solved when participants are capable of intellectual or epistemic humility, i.e., the acknowledgment of their own limitations and an openness to the input of others (e.g., Butera, Sommet, & Darnon, 2019; Johnson, Johnson, & Tjosvold, 2006; Porter et al., 2021). Little is known today about the relations between children's Theory of Mind (ToM) and their epistemic humility. The present study addresses this issue from a socio-interactionist approach in which epistemic humility is investigated in dyadic peer interactions, building on the same data set of Viana, Zambrana, Karevold, and Pons (2016) which analyzed the relationship between children's ToM and their cooperative performance in a spatial task. Originally, the present study aimed to understand the extent to which ToM is related to children's displays of epistemic humility when dealing with socio-cognitive conflict regulation during disagreements, regardless of their performance on the task. The relevance of understanding the relation between children's ToM and their epistemic humility in peer interaction is threefold: theoretically, it can shed light on the mechanisms underlying socio-cognitive conflict resolution; methodologically, it enhances the possibility and relevance of assessing epistemic humility in everyday social interactions; and practically, it can point to educational implications for children's socio-cognitive development, i.e., their ToM and epistemic humility, by discussing the

usefulness of cooperative problem-solving among peers in school settings.

Theory of mind and epistemic humility

ToM refers here to the ability to understand the nature, causes and consequences of beliefs, intentions, desires, and emotions in the self and in others, thereby enabling the explanation, prediction, and manipulation of one's own and others' actions and representations (e.g., Pons & Harris, 2019; Wellman, 2018). In a systematic review of empirical epistemic humility research, Porter et al. (2021) discuss the various ways in which the construct has been defined and measured. In the present study, we rely on the developmental approach used by Danovitch, Fisher, Schroder, Hambrick, and Moser (2019) who consider epistemic humility to be acknowledging the limitations of one's knowledge while being open to input from others. Thus, we investigate epistemic humility here as a socio-cognitive construct that unfolds within social interaction rather than a trait (for a review see Porter et al., 2021).

From a developmental perspective, research on epistemic humility has shown that young children tend to overestimate their knowledge and abilities (e.g., Shin, Bjorklund, & Beck, 2007), with 5-year-old

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<https://doi.org/10.1016/j.appdev.2023.101548>

Received 18 January 2022; Received in revised form 1 May 2023; Accepted 3 May 2023

Available online 11 May 2023

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children rating their knowledge higher than 7- and 9-year-old children (Mills & Keil, 2004). Accordingly, empirical evidence has shown that at around 6 years of age children understand that the cognitive labor involved in a specific task can be divided (Lutz & Keil, 2002), and directing questions at an expert person becomes more frequent as a strategy for generating new knowledge. This improvement in epistemic humility might be explained, for instance, by advances in memory, executive functions, and socio-cognitive abilities, but explanatory factors other than age have not been systematically investigated. Although there seems to be a developmental overlap between epistemic humility and ToM, as a substantial amount of evidence indicates a clear shift in ToM abilities by the age of 5–6, when children understand that people can hold different beliefs and have different knowledge pertaining to the same situation, we know little about the potential links between epistemic humility and ToM.

On one hand, research on ToM has shown positive associations between ToM and several social, cognitive, and emotional aspects, such as popularity, peer acceptance, school achievement, empathic responsiveness, and friendship (e.g., for a review see Wellman, 2018). Particularly, Emotion Understanding (EU), one of ToM's main dimensions, has been found to be a strong predictor of children's psychological well-being, pro-social competences (including empathy) and school achievement (e.g., Pons & Harris, 2019). On the other hand, links between ToM and epistemic humility have been under-investigated, particularly among children. Epistemic humility has been more frequently studied among adult populations through self-report questionnaires (for a review see Porter et al., 2021). When epistemic humility is investigated among children, behavioral tasks in the laboratory are frequently used to assess, for example, developmental changes in epistemic humility considering the extent to which children delegate and ask an adult expert questions when they recognize they lack sufficient knowledge to answer a specific inquiry (e.g., Aguiar, Stoess, & Taylor, 2012; Danovitch & Keil, 2007). The findings are scarcer and more partial when it comes to examining the relations between ToM and epistemic humility. Some of these studies have shown that ToM might not be relevant to epistemic humility (Danovitch et al., 2019; Danovitch & Noles, 2014) and the authors have called for additional studies that consider different elements of ToM that go beyond perspective taking (Knutsen, Frye, & Sobel, 2014). Moreover, we lack studies in which broader ToM abilities are investigated in relation to social and cognitive skills in real interactions, particularly peer interactions. Investigating cooperative problem-solving among school-age peers can be a step forward towards filling this gap.

Cooperative problem-solving and peer interaction

Cooperative problem-solving requires working towards a joint goal in such a way that the participants must adopt complementary roles and coordinate different points of view to conclude a task (Moll & Tomasello, 2007). Working cooperatively enables a meeting of distinct perspectives, thereby promoting a context for the emergence of socio-cognitive conflict. According to Johnson et al. (2006), during a socio-cognitive conflict, participants need to build a constructive controversy, which Butera et al. (2019) also define as constructive epistemic conflict resolution. A constructive controversy would demand that participants “unfreeze” their cognitive process when faced with disagreement, and therefore, activate epistemic curiosity towards the perspective of the other. Butera et al. (2019) highlight that socio-cognitive conflict can promote cognitive development and learning through constructive controversy only when the participants regulate the conflict oriented by their shared task-goal (“we”-mode). When the regulation focuses on personal performance (“I”-mode), this tends to create competition rather than a constructive epistemic conflict regulation in which each individual considers more than one perspective when dealing with disagreement.

Studies about ToM and cooperation have demonstrated, on one

hand, that 6- to 10-year-olds are capable of using false belief reasoning to make predictions and coordinate their actions with peers (e.g., Curry & Chesters, 2012; Flobbe, Verbrugge, Hendriks, & Krämer, 2008; Grüneisen, Wyman, & Tomasello, 2015). On the other hand, Apperly and colleagues (e.g., Apperly, 2011; Surtees & Apperly, 2012) have documented that perspective taking in social interaction demands an effortful cognitive process, and that people do not necessarily use their ToM abilities when interacting with social partners. Particularly, the role of ToM in situations where the child needs to be more open towards another's knowledge repertoire, i.e., display epistemic humility, has been under-investigated. Previous studies on this topic have frequently assessed children's socio-cognitive skills in social interaction through teacher's report, or while the child interacts with a peer-like puppet and not with a real partner (de Rosnay, Fink, Begeer, Slaughter, & Peterson, 2014; Peterson, Slaughter, & Wellman, 2018). Thus, there is a lack of knowledge on the relations between ToM and cooperation in real-time peer interaction.

Peer interaction is a valid ecological context for the investigation of socio-cognitive conflict regulation because its symmetry in knowledge and power contributes to making the participants more engaged and active in resolving the problem (e.g., Ashley & Tomasello, 1998). Etel and Slaughter (2019), for example, have measured cooperation during peer interaction based on two main criteria also used in other previous studies: communicative behaviors and coordinated actions (see also Brownell, Ramani, & Zerwas, 2006; Warneken, Chen, & Tomasello, 2006). They investigated the relation between these behaviors and ToM among preschoolers in play contexts and the findings suggested that better performance on the ToM scale was associated with a higher level of coordination and communication during cooperation. In cooperative problem-solving contexts, Köymen and Tomasello (2018) have investigated how 5- and 7-year-old peer dyads make decisions collaboratively and they found that school-aged children not only engaged in collaborative reasoning, but they could also use meta-talk to step back from the problem and jointly examine new evidence and produce counterarguments for problem solutions. The authors argue that, in such a situation, the members of the dyad need to evaluate and compare different beliefs and reasons surrounding a problem-solution (Köymen & Tomasello, 2020), and that discourse training can help even 3-year-olds produce more valid counterarguments (Köymen, O'Madagain, Domberg, & Tomasello, 2020).

The abovementioned studies, however, have not investigated the role of ToM abilities in dealing with divergent knowledge in cooperative problem-solving among peers. In addition, considering the ideas of constructive controversy and epistemic humility (Butera et al., 2019; Johnson et al., 2006; Porter et al., 2021), we argue that the ability to examine new evidence and compare contradicting reasons and beliefs would demand epistemic humility in the first place: that is, that one values the perspective of others when facing disagreement. The extent to which a more developed ToM would be associated with epistemic humility during socio-cognitive conflict regulation in peer interaction has so far not been investigated.

The present study

The present study investigates the relations between children's ToM and their epistemic humility during socio-cognitive conflicts during a cooperative spatial problem-solving task. This addresses relevant gaps in the field such as the lack of studies assessing: 1) the associations between ToM and epistemic humility; 2) a broader measure of ToM including emotion understanding; 3) the role of epistemic humility in real life (i.e., peer interaction). Therefore, the results can advance our knowledge of: 1) the potential links between ToM and socio-cognitive skills used in peer interaction, namely, epistemic humility; 2) the socio-cognitive processes underlying cooperative activities and the epistemic conflict resolution which is frequently demanded in school settings.

We have chosen to look at collaboration during a spatial task because

it demands a “coordination of perspectives” (Piaget & Inhelder, 1948) in which children need to identify the appearance of an object as something dependent on the spatial position from which it is viewed. With regards to cooperation, the task consequently comprises the cognitive process of projecting relationships between objects, as well as the social process of understanding the relation between two different perceptions, as exemplified by the “If I were in your place, I would see what you see” line of thinking (Fishbein, Lewis, & Keiffer, 1972), thus being suitable for the investigation of relations between ToM and children's epistemic humility in cooperative tasks. In one of our previous studies (Viana et al., 2016), we assessed 5-to-9-year-old children solving a spatial transformation problem under both individual and cooperative conditions, as well as their individual ToM abilities. The results indicated that: 1) the children performed better under the cooperative condition than under the individual one; 2) and that the children's performance in the individual and cooperative spatial tasks, that is, whether they succeeded or not in correctly resolving the problem, could be predicted by their ToM, even when age and gender were taken into account. In this previous study, however, the child was the unit of analysis and interactions between the children were not examined. As the interaction was video recorded, it was possible to go back and code and analyze the interactions at a dyad level as well, which could illuminate the extent to which ToM not only plays a role in successful performance in a cooperative spatial task, but also children's epistemic humility in peer interaction during socio-cognitive conflict resolution.

Our main hypothesis is that dyads with higher levels of ToM will show more epistemic humility towards the propositions offered by their partners during socio-cognitive conflicts, even when age is considered.

Method

Participants

Using G*Power 3.1.9.2., it was estimated that 68 participants would be needed to detect medium to large effects ($f = 0.15$) at power (0.8) and $\alpha = 0.05$ to test our main hypothesis. Following approval by the Norwegian Centre for Research Data (NSD) and the Ethical Committee in Brazil, the parents of 90 children from two middle-class private schools in Recife (Brazil) agreed to sign a consent form giving permission for their children to be asked to participate. All the invited children agreed to participate in the study.

To avoid floor and ceiling effects, children who did not succeed on the simplest item ($n = 14$), or who achieved the maximum score ($n = 10$) under the individual condition set by the spatial task, were excluded from the sample (Doise & Mugny, 1984). One female dyad had to be excluded due to technical issues with the video recording. Thus, the total sample included 64 5- to 9-year-old typically developing children with Portuguese as their native language ($Mage = 7.11$ years, $SD = 1.18$; 32 females). The children were divided into two age groups ($n = 34$ in the Younger group, aged 5;7–7;5; and $n = 30$ in the Older group, aged 7;6–9;8). These age groups were created to obtain more variation in terms of ToM abilities: We expected that the younger group would have the understanding of the reflective dimension of the mind in progress, and that the older group would have more established reflective ToM abilities. Because we wanted to facilitate that children would work together to resolve the problem, and because asymmetry in knowledge and gender might create competitive relationships (Buchs, Butera, Mugny, & Darnon, 2004), the dyads consisted of children of the same gender, similar age, from the same classroom, who had shown similar performance on the individual version of the spatial task and on the ToM tasks used in the study. Information from the children's ranking of their friends in the classroom was also used to ensure that the children in each dyad were neither best friends nor not friends at all. This way any potential advantages of interacting with a best friend were avoided and the disadvantages of entering into social conflict when interacting with classmates they disliked was reduced (e.g., Kuhnert, Begeer, Fink, & de

Rosnay, 2017). The final dyadic sample was therefore composed of 32 dyads (17 in the youngest group, 16 female dyads).

Procedure, tasks, and scoring

The study had a non-experimental and cross-sectional design. The data collection consisted of two sessions carried out at the children's schools: 1) Theory Mind tasks; 2) Cooperative spatial transformation task. Each session lasted around 10 min, with an average interval of 15 days between the first and second tasks.

Theory of mind

Children were tested individually for their ToM using items extracted from the Theory of Mind Test (TMT; Pons & Harris, 2002), and the Test of Emotion Comprehension (TEC; Pons & Harris, 2000). Thus, a composite score was created based on the work of Giménez-Dasí, Pons, and Bender (2016). We selected six components that did not overlap and that represented different levels of difficulty: perspective taking (three items) - understanding that the perception of an object changes when people look at the same object from different positions; understanding of false belief (three items) - people's behaviors are guided by their knowledge, whether true or false; understanding of second-order false belief (three items) - people can hold knowledge about other people's knowledge; recognition of basic emotions (five items), i.e., happiness, sadness, fear, anger, and neutral; understanding the impact of situational variations on emotions (five items) - different situations can trigger different emotions; and understanding desire-based emotions (two items) - two people with different desires can have different emotions when facing the same situation. The Cronbach's alpha for the 21 items included to assess ToM abilities was 0.5. It is important to note that the TEC has been translated into 25 languages and it has shown good test-retest reliability, as well as concurrent, criterion and construct validity (for a review see Pons et al., 2014). In addition, the TMT is based on an extensive review of the literature and includes well know tasks within the field of Theory of Mind development for which both the validity and reliability have been extensively tested (for a review see Wellman, 2018).

In the TMT, the child had to attribute a cognitive mental state to the main character in a picture by pointing to one of the two possible answers illustrated below a scenario. In the TEC, the child had to attribute an emotion to a story's protagonist(s) by pointing to the most appropriate of the four possible emotional outcomes, represented by the facial expressions of the story's protagonist(s). The final ToM score represents the sum of the correct answers, ranging from zero to 21. Because the analyses in the present study were conducted at a dyad level, a ToM score for the dyad was calculated by summing the ToM score of each child in the dyad and dividing it by two. The dyad's ToM score could therefore also vary from zero to 21 ($M = 18$, $SD = 1,21$).

Epistemic humility

Epistemic humility was measured by a cooperative spatial transformation task. An adapted version of the “The Reconstruction of the Village” task, developed by Doise and Mugny (1984) and derived from Piaget's famous “three mountains” task (Piaget & Inhelder, 1948) was used. Fig. 1 provides an overview of the task (see Viana et al., 2016 for details). Children were placed in face-to-face positions (position X and position Y) and received three or four houses similar to those placed by the researcher on the cardboard model, and they were instructed to replicate the village they could see. Each child received only a certain number of houses (either one or two) and were only allowed to touch and move their “own” houses (Buchs & Butera, 2004). To move each other's houses, children had to first ask their partner, which could increase the chance of creating a socio-cognitive conflict.

The simplest item had three houses with no rotation required. The second item demanded the position of the houses to be rotated by 90° and an inversion of the left-right and front-back orders of the houses. The third and fourth items had four houses, and both required 180°

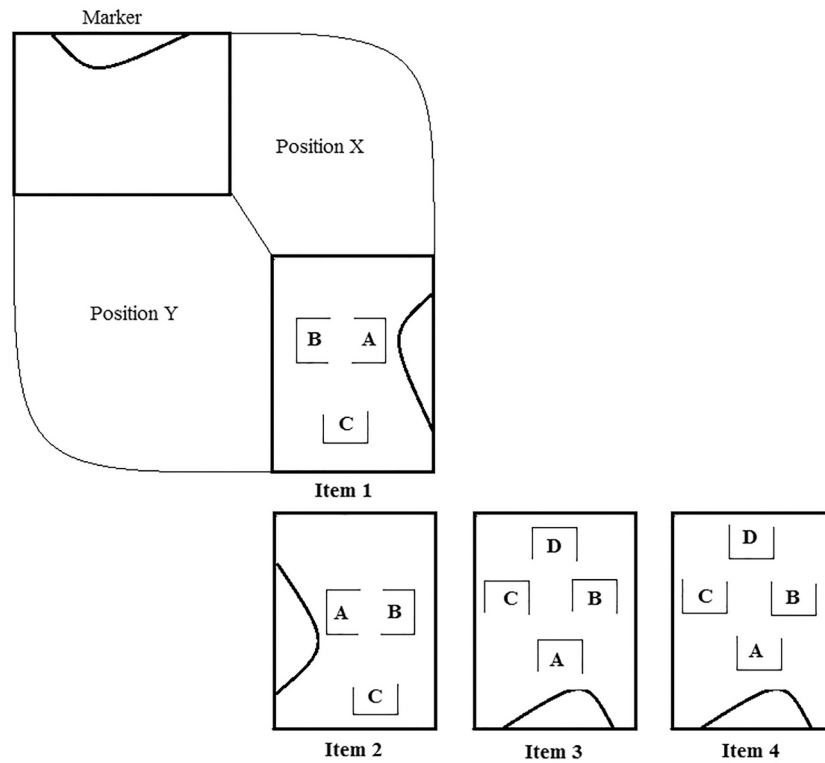


Fig. 1. Spatial task: four levels of complexity based on the number of houses and degrees or rotation.

rotations and inversions of the left-right and front-back orders. In this study, the focus of the analysis was on the interaction and not on the children's performance (see Viana et al., 2016 for results on the children's cooperative performance), but more specifically on the children's display of epistemic humility during socio-cognitive conflict.

Epistemic humility was calculated following two main steps. The first step was to identify the occurrence of socio-cognitive conflicts. Based on the work of Zapiti and Psaltis (2012), socio-cognitive conflict was recognized when a child disagreed with the strategy already exhibited by the partner, for example, by picking up a house already placed by the other child or by proposing a new solution. The number of socio-cognitive conflicts varied across the dyads from 3 to 18 ($M = 8,75$, $SD = 3.83$).

In the second step, we coded every time a child displayed epistemic humility towards a partner's conflicting idea. This coding system was both data-driven and inspired by previous studies of socio-cognitive conflict (Gauducheau & Cuisinier, 2005; Johnson et al., 2006) and epistemic humility, and particularly by the developmental approach of Danovitch et al. (2019) who measured the construct in behavioral tasks based on how one acknowledges the limitations of one's knowledge by being open to the input of others. Thus, epistemic humility is here considered not as a trait but as a behavior displayed during social interactions, and measured as such when the child was open to the partner's input and showed willingness to take into account the other's perspective and ideas ("I see your point" reasoning). Examples of epistemic humility are: the child incorporates the partner's suggestion in a problem solution; the child asks questions about his or her partner's ideas; the child expresses uncertainty about his/her own ideas. As illustrated by these examples, we did not discriminate how effectively the child made use of the other's information or suggestions (e.g., examination of evidence/presentation of counterevidence, level of persuasion, etc.), but rather whether the child was not rigid about his/her own position and valued the other's point of view (Porter et al., 2021). In other words, their willingness to be open to another's input.

A second coder coded 31.25% of the data (10 dyads) independently.

We computed the Intraclass correlation Coefficient (ICC) using a Two-way mixed model. The Cronbach's alpha for correlations between the coding of the two coders for the epistemic humility responses was 0.94.

Taking into account that the number of socio-cognitive conflicts varied among the dyads, and because each child could be more or less talkative, the proportion of "epistemic humility" in relation to the child's talkativeness - and not the raw frequency of the behavior - was used to test our hypothesis. We therefore coded all comments that emerged during the interaction. Responses to socio-cognitive conflicts such as ignoring the partner's comments and suggestions, or saying the partner was wrong without any justification, were coded as rejection. Other comments related to, for instance, the difficulty of the task or comments unrelated to the task itself were coded as "other". Thus, in order to calculate the proportion of epistemic humility, the sum of the frequencies of "epistemic humility" was coded at the utterance level and therefore divided by the total number of utterances made by the child during the resolution of the task (the sum of the occurrences of "epistemic humility", "rejection" and "other"). This means that a dyad could not exhibit two or more instances of epistemic humility in a given utterance. The final score therefore varied from zero to one. Table 1 shows the mean proportion of each type of response per child. Similar to the ToM score, a score for the dyad's level of epistemic humility was calculated by summing the proportion of epistemic humility for each child and dividing it by two. Therefore, it also varied from zero to one ($M = 0,63$, $SD = 0.12$).

Fig. 2 illustrates the descriptive statistics related to the display of

Table 1
Means and standard deviations of the proportion of responses per child during problem-solving.

	M	SD
Epistemic Humility	0.63	0.20
Rejection	0.26	0.21
Others	0.11	0.15

N = 64.

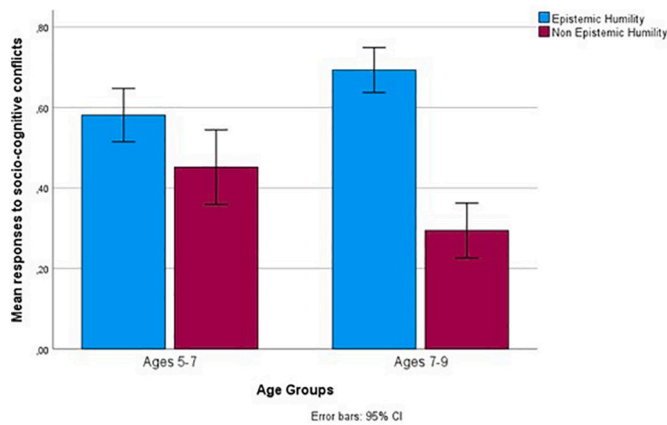


Fig. 2. Responses to socio-cognitive conflict by age groups.

epistemic humility in the two age groups, and the behaviors coded as “rejection” and “others” in one category named “non-epistemic humility”.

Statistical analyses

SPSS Statistics 22.0 was used for all analyses in the current study. Two different Analysis of Variance were used for preliminary analyses of the effect of age and gender on the dyad’s epistemic humility and ToM. The main hypothesis was tested through a correlational analysis and regression analysis to examine the specific contribution of ToM to the children’s epistemic humility, with age taken into account.

Results

Preliminary analyses

To assess the effect of age and gender on the dyad’s epistemic humility, a two-way Analysis of Variance Age x Gender was conducted. The results showed that age had a large effect on epistemic humility, $F(1,28) = 7.50, p = .011, \eta^2 = 0.09$, but neither gender nor the age and gender interaction had any effect. Regardless of their gender, older children tended to be more cognitively open to another’s input ($M = 0.70, SD = 0.17$) compared to children in the younger group ($M = 0.58, SD = 0.17$). Another two-way Analysis of Variance Age x Gender was conducted to assess the ToM level of the dyad. The results indicated a large age effect on ToM, $F(1,28) = 12.73, p = .001, \eta^2 = 0.31$, but no effect of gender or interaction effect between age and gender. Regardless of their gender, the older dyads had better ToM ($M = 17.37, SD = 1.43$) compared to dyads in the younger group ($M = 18.68, SD = 1.53$).

Links between ToM and epistemic humility

The correlation matrix with Means and Standard Deviations for each variable are presented in Table 2. The results indicated that both ToM and epistemic humility were strongly correlated with age but not with

Table 2 Correlation matrix, with means and standard deviations for each variable.

	M	SD	2	3	4
1.ToM	18	1,22	0.55***	0.55***	0.03
2. EH	0,63	0.13		0.44**	-0.15
3. Age	1.47	0.51			0.6
4. Gender	0.50	0.51			

N = 32 dyads. EH = Epistemic Humility; Gender (0 = boys, 1 = girls); Age groups (1 = younger, 2 = older).

* $p < .05$, ** $p < .01$, *** $p < .001$.

gender. In addition, a positive strong correlation was also found between ToM and epistemic humility.

Based on the results of the correlation analysis, a regression analysis was conducted to examine how much of the variance in children’s epistemic humility could be explained by ToM when age was taken into account. The results showed that the model explained 33% of the variance in children’s epistemic humility, $F(2,31) = 7.07, p = .003$. When the model was reviewed, only ToM was seen to be a significant predictor of the children’s epistemic humility, $\beta = 0.43; p = .024$, with higher ToM being associated with the display of more epistemic humility during socio-cognitive conflict, regardless of the children’s ages (see Table 3).

Discussion

The goal of this study was to investigate the relation between children’s ToM and their epistemic humility in peer interaction during socio-cognitive conflicts during a cooperative spatial problem-solving task. Our main hypothesis was confirmed as the children’s epistemic humility varied not only as a function of age, but also due to their ToM abilities. Dyads with higher ToM abilities more often valued their partner’s perspective during disagreements, regardless of their age. Although previous findings have demonstrated that ToM has beneficial implications regarding different dimensions of children’s social interaction, including prosocial behavior, argumentation, communicative behaviors and action coordination (e.g., de Rosnay et al., 2014; Etel & Slaughter, 2019; Grüneisen et al., 2015; Lecce, Caputi, Pagnin, & Banerjee, 2017; Peterson et al., 2018; Viana, Zambrana, Karevold, & Pons, 2019), these results show that there is also a relationship between ToM and children’s epistemic humility when regulating socio-cognitive conflicts in a cooperative problem-solving situation.

Our preliminary results first indicated that older children were more likely to be open to their partner’s propositions for solving a problem compared to younger children. Previous studies on epistemic humility showed a developmental trend was indeed present when assessing the accuracy with which children assess their own knowledge (Lyons & Ghetti, 2011). Accordingly, with age children tend to be more open to the knowledge of others and more ready to consult others when they feel less knowledgeable about resolving a specific inquiry (Aguiar et al., 2012). According to Piaget and Inhelder (1948), interference from the self-perspective would be expected between 5 and 7 years of age, while the use of information about the minds of others becomes more accurate through middle childhood (e.g., Epley, Morewedge, & Keysar, 2004). This is also in line with our results on the effect of age on ToM abilities, which replicates previous findings showing that ToM follows a clear developmental trend, both in boys and girls (e.g., Harris, de Rosnay, & Pons, 2005; Wellman, 2018). Beyond this replication, these findings add to our knowledge by showing that epistemic humility not only varies as a function of age, but also due to children’s ToM abilities.

ToM and epistemic humility in cooperative problem-solving

Our main findings showed that children with higher levels of ToM also displayed more epistemic humility when faced with conflicting ideas during cooperative problem-solving. This means that understanding the mind in terms of beliefs, perspectives and emotions relates to the ability to be more cognitively open to the knowledge of others when dealing with disagreements during peer interactions. Previous theoretical and empirical studies have highlighted that a constructive

Table 3 Linear regression for children’s epistemic humility.

Predictors	B	SE	T	p
Age	0.21	0.05	1.13	0.2660
ToM	0.43	0.02	3.0	.024

N = 32.

regulation of the epistemic conflict is likely to happen when one tries to consider the different points of view emerging during disagreement, whilst trying to show that one holds the right solution and the other holds a wrong perspective tends to lead to relational conflicts (e.g., Butera et al., 2019; Johnson et al., 2006). Thus, by showing a positive association between ToM and being cognitively open to the other's point of view during problem-solving ("I see your point" way of thinking), the findings suggest that ToM is a useful ability for school-age children when they need to regulate socio-cognitive conflicts in cooperative problem-solving tasks.

Broadly, our results are in line with previous studies done with 6- to 10-year-olds showing that ToM is associated with action coordination among peers (e.g., Curry & Chesters, 2012; Flobbe et al., 2008; Grüneisen et al., 2015; Viana et al., 2019) and conversational skills used in social interaction (Bartsch, Wade, & Estes, 2011; de Rosnay et al., 2014). Interestingly, epistemic humility can be acknowledged as a first step through which the child builds knowledge through cooperation (e.g., Heijst, de Jong, van Aslst de Hoog, & Krischner, 2019) by expressing uncertainty about his/her own knowledge and a willingness to incorporate the other's point of view into the problem solution. Hence, the findings suggest that ToM plays a role in successful cooperation. In addition to that, considering our earlier results with the same sample on the relation between ToM and cooperative spatial performance, we suggest that the mechanisms behind this successful cooperation can be better investigated in future studies by replicating the current design with a larger sample in which a mediation model could be applied to assess whether or not epistemic humility mediates the relation between higher levels of ToM and children's cooperative performance.

It is noteworthy that when we look more specifically into studies on ToM and epistemic humility, previous findings did not show a positive association between the two constructs (Danovitch et al., 2019; Danovitch & Noles, 2014). However, there are some clear differences between these investigations and the present study regarding how ToM and epistemic humility were measured. Most of the past studies assessed ToM solely based on perspective taking and false belief tasks, and epistemic humility was measured through an experimental/laboratory design in which a child interacted with an adult. Therefore, the theoretical and methodological implications of the current results can inform the debate about whether ToM has a positive implication for real social interaction, and if so under what conditions (e.g., Pons & Harris, 2019; Viana, Lucena, Zambrana, Harris, & Pons, 2022). For example, Apperly (2011) also found that adults with higher ToM do not necessarily use perspective taking skills in their social interactions. Nevertheless, like the studies done by Danovitch and colleagues (Danovitch et al., 2019; Danovitch & Noles, 2014), most of the studies conducted by Apperly and colleagues took place in an experimental setting where the participants interacted with an avatar, whereas in our study the children interacted with a same-aged partner in a familiar school environment. Nevertheless, Lucena (2018) has also not found a relation between ToM and the ability of 3–5-year-old children to enter a play that has already been established by two other children in their daycare center. In this case, although the children were also interacting with a same-aged partner, they were younger than the children in the present study, and the interaction was more complex, with two children playing freely and a third child trying to enter an ongoing play interaction, the situation thus being more cognitively demanding.

Therefore, although our study does not provide a causal relationship between ToM and epistemic humility, it suggests that understanding the mind plays a role in being open to another's knowledge during socio-cognitive conflicts, and that ToM and the display of epistemic humility in peer interaction are interconnected. In light of previous studies, the relationship between them is potentially influenced by different contextual factors, such as the age of the participants, the nature of the task – being less or more cognitively and emotionally demanding – and the nature of the social interaction and the dyad composition, for instance, child-child versus child-adult or dyadic versus group

interaction. Future studies based on longitudinal designs including a larger age range could elucidate these issues. Investigating, for example, how epistemic humility leads to meta-talk and the production of relevant counterarguments (e.g., Köymen et al., 2020; Köymen & Tomasello, 2018) could also illuminate the relationship between being cognitively open to another's knowledge and cognitive performance when working collaboratively.

Educational implications

Considering that the task used in the present study has some features that resemble school activities, i.e., the children could communicate freely, they were engaged in a game-playing task, and they were interacting with classmates, some educational implications might be inferred. Indeed, some previous studies have highlighted the finding that epistemic humility predicts mastery behavior when learning, e.g., implementing more effort to learn a topic when they initially failed at a task (Porter, Schumann, Selmezy, & Trzesniewski, 2020). In addition, Porter, Catalán Molina, Lucas, Oberle, and Trzesniewski (2022) have shown that classroom environments that emphasize mastery-oriented teaching practices predict changes in expressed epistemic humility. Thus, considering the present findings, one might infer that promoting ToM in the classroom environment through cooperative activities could be of relevance to children's epistemic humility, and as such, their learning process.

It is important to note that our data did not test for the direct impact of a ToM intervention on children's openness to other's knowledge, but we might consider that programs enhancing ToM in schools could improve epistemic humility typically demanded in educational activities. If it is the case that not only social interaction promotes ToM, but that the way children interact in cooperative contexts also changes due to ToM abilities, it might be important to improve children's ToM by explicitly talking about mental and emotional states during classroom activities. Intervention research programs conducted in schools might further elucidate the efficiency of activities promoting children's ToM that consequently can support their development of a more open attitude towards another's perspective during socio-cognitive conflicts, which in turn can boost cooperation and promote better cognitive learning outcomes.

Limitations, future directions, and conclusions

A larger sample size would have allowed for more in depth analyses of how epistemic humility might mediate the relationship between ToM and cooperative performance. In addition, language, intelligence, and executive functions should be included in future analyses as these factors are related to ToM and epistemic humility (e.g., Danovitch et al., 2019; Pons & Harris, 2019; Wang, Devine, Wong, & Hughes, 2016). Indeed, more specifically, language is a variable to be controlled for as training studies have shown that improvements in language play a significant role in fostering false-belief understanding (e.g., Lohmann & Tomasello, 2003). It would be interesting to assess whether a child's language skills moderate the relation between ToM, epistemic humility and cooperative spatial performance.

Moreover, an examination of whether one would observe the same results if the dyads were composed asymmetrically, using, for instance, dyads of children with different levels of ToM, would be informing. In addition, training studies aimed at strengthening ToM abilities might provide stronger evidence for the relation between ToM and children's cognitive openness to others' knowledge during socio-cognitive conflicts, or alternatively, evidence of whether or not an intervention aimed at improving epistemic humility in socio-cognitive conflicts has an impact on their levels of ToM? Likewise, it is relevant to investigate other types of cooperative problems (e.g., sensory-motor task and free play) and tasks that require children to employ more effort during the use of cognitive and linguistic processes beyond epistemic humility,

such as the production of counterevidence, argumentation and persuasion (e.g., Köymen et al., 2020; Peterson et al., 2018).

In summary, we have shown that ToM to some extent can be associated with children's displays of epistemic humility during social interactions, as we found evidence for the link between having knowledge about another's mental and emotional states and being cognitively more open to another's perspective during socio-cognitive conflicts in a cooperative problem-solving task. Although ToM may not always be required or used in social interactions, it appears to be useful and applicable in cooperative problem-solving situations among school-age children because it facilitates a positive attitude towards the knowledge and ideas of others. This is essential if one is to disengage from one's own point of view to resolve a conflict and/or build a joint solution to a problem. The results from the current study therefore indicate that ToM is an essential socio-cognitive process underlying the development of peer cooperation among children between 5 and 9 years of age. Effectively, ToM helps children see that they can be wrong even when they think they are right, a realization that paves the way for efficient task-relevant collaborations.

Author statement

The 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.

Data availability

The authors do not have permission to share data.

Acknowledgments

The authors thank the children for their participation in this project and the parents who authorized their participation; Carina Pessoa Santos for helping with data collection; Maria Isabel Pedrosa and the members of the developmental group of Labint (Laboratory of Human Social Interaction) of the Federal University of Pernambuco (Recife/Brazil) for providing the video recording equipment and for giving support to the analysis of the pilot of this study; and participating schools for giving us access to their facilities.

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