Université Paris Cité
École Doctorale 261 3CH – Cognition, Comportements, Conduites Humaines
Laboratoire de Psychologie du Développement et de l'Education de l'Enfant (UMR 8240)

Development of explicit and implicit theory of mind in preschool and school-age children: the role of language, executive functions, and socioeconomic context

Présentée par **Julia HOUDAYER**

Thèse de Doctorat en **Psychologie**
Dirigée par **Olivier Houdé** et **Lara Bardi**

Présentée et soutenue publiquement le 4 décembre 2025
Devant un jury composé de :

Sébastien GOUDEAU	Professeur à Université de Poitiers	Rapporteur
Alice GOMEZ	Professeure à l'Université Lyon 1, INSPÉ	Rapportrice
Olivier MASCARO	Chargé de recherche à l'Université Paris Cité	Examinateur
Charlotte GROSSE WIESMANN	Professeure à l'Institut Max Planck	Examinatrice
Annabel NIJHOF	Docteure à l'Université de Gand	Examinatrice
Olivier HOUDÉ	Professeur à l'Université Paris Cité	Directeur de thèse
Lara BARDI	Maîtresse de conférences à l'Université de Gand	Co-directrice de thèse
Grégoire BORST	Professeur à l'Université Paris Cité	Membre invité

Acknowledgements

I would like to thank all the jury members, Annabel Nijhof, Charlotte Grosse Wiesmann, Olivier Mascaro, Alice Gomez and Sébastien Goudeau, for agreeing to evaluate this work. Thank you for participating in the defense, it is a great honor for me that you accepted to share your expertise.

Je tiens à remercier Olivier Houdé, mon directeur de thèse, de m'avoir offert l'opportunité de réaliser cette thèse au sein du LaPsyDÉ, et d'avoir accepté de m'accompagner et d'encadrer ce travail durant ces trois années.

Je tiens particulièrement à remercier Grégoire de m'avoir accueillie au laboratoire et de m'avoir permis d'y réaliser mon doctorat. Je te remercie sincèrement pour ta disponibilité, et d'avoir toujours pris le temps de m'accompagner et de me conseiller. J'ai énormément appris scientifiquement durant ces années de thèse grâce à tes conseils et ton encadrement. Travailler avec toi a été à la fois très enrichissant et un réel plaisir.

Lara, I would like to thank you for your supportive supervision and constant kindness. Thank you for always taking the time to talk things through and for advising me in the best possible way. I find you truly inspiring, and I've learned a lot scientifically from you. It's been a real pleasure working with you, and I hope that we will be able to continue!

Je remercie également sincèrement Lorna, d'avoir toujours été disponible et à l'écoute lorsque c'était nécessaire. Merci pour ton accompagnement et pour ta rigueur scientifique, ainsi que pour ton soutien lors de ces derniers mois. Merci de toujours nous accompagner et d'être présente pour nous de la façon dont tu l'es. J'ai beaucoup appris grâce à toi.

Alex, merci d'avoir pris le temps de me conseiller lorsque j'en avais besoin, et de m'avoir accompagnée tout au long de ce travail. Merci également à tous les membres permanents du laboratoire pour tous les échanges et les précieux conseils, j'ai adoré faire ma thèse dans ce laboratoire.

Je tiens également à remercier les membres de mon comité de suivi individuel, Sébastien Goudeau, Emilie Cappe, Eva Flore Msika et Jade Lanfranchi, pour leurs précieux conseils et retours.

Je remercie également toutes les personnes qui m'ont aidée de toutes les façons possibles pour la collecte des données associées à cette thèse. Merci plus spécifiquement à Sibylle, Chloé, Léa, Alizée, et Charlotte, que j'ai eu le plaisir d'encadrer en stage et qui ont grandement contribué à ce que ces projets voient le jour. Special thanks to Paul for the great talks, the very kind support and for being such a nice person. I learned a lot working with you.

Un immense merci également à tous les enseignants et enseignantes, aux familles, et aux enfants d'avoir accepté de participer et consacré de leur temps aux différentes études de cette thèse.

Un immense merci aux doctorant.e.s et post-doctorant.e.s du laboratoire, encore présent.e.s ou déjà docteur.e.s. J'ai passé trois années mémorables grâce à vous. Merci pour les discussions (scientifiques et moins scientifiques), l'entraide, la solidarité, les échanges, et surtout le précieux soutien. Vous avez rendu ces années de thèse tellement plus riches, belles et intéressantes. C'est une chance d'avoir la possibilité de faire sa thèse dans un environnement aussi joyeux, bienveillant et inspirant. Merci sincèrement pour tout. Merci particulièrement à celles et ceux qui sont devenu.e.s des ami.e.s, et qui se reconnaîtront. Merci d'avoir été si présent.e.s à la fin de cette période de rédaction, votre soutien a énormément compté. Merci pour tous ces jolis moments. Je suis certaine qu'il y en aura beaucoup d'autres.

Enfin, merci à mes ami.e.s pour leur soutien constant, et un grand merci à ma famille. Merci de m'avoir toujours aidée et soutenue de la meilleure des façons. Merci d'avoir été si bienveillants, présents et attentionnés lorsque c'était le plus nécessaire.

Abstract

Theory of Mind (ToM) refers to the ability to perceive both oneself and others as psychological beings with distinct mental states, such as beliefs, desires, intentions, and emotions. ToM develops at different rates depending on whether it relies on explicit or implicit processes. Explicit ToM, which involves conscious and deliberate reasoning, typically emerges around the age of 4 or 5. Implicit ToM, which allows us to spontaneously consider the mental states of others in our environment, is present from early infancy. However, the relation between these two forms of ToM remains a matter of debate. Moreover, while most studies have examined implicit ToM in children up to 2 to 3 years of age, how this capacity continues to develop during the preschool and early school years, and which factors contribute to that development, remains unclear. Environmental factors, such as socioeconomic status (SES), have been shown to influence the development of explicit ToM, with SES possibly exerting its effect through children's language abilities and executive functions (EF). In contrast, the influence of cognitive and linguistic factors on implicit ToM is still debated, and the role of environmental factors is largely unexplored. This thesis aims to investigate how language, EF, and SES influence the development of both implicit and explicit ToM in preschool and school-aged children. In Study 1, we investigated whether language and EF mediate the relation between SES and explicit ToM. A cross-sectional study (N = 375) was conducted in children aged 3 to 7. Using structural equation modeling, a first parallel mediation model showed that language fully mediated the relation between SES and explicit ToM. A second moderated mediation model, including age as a moderator, indicated that this mediation through language did not vary with age. In Study 2, given the lack of implicit ToM tasks designed for preschool and school-aged children, we adapted a widely used adult paradigm to assess implicit ToM in children. We investigated whether children aged 3 to 7 would be influenced by the perspective of an agent, even when that perspective was irrelevant to the task. Using the same sample as in Study 1, we found that children in this age range were only affected by their own perspective, revealing an egocentric bias in this age range. However, spontaneously considering the agent's perspective (i.e., implicit ToM) was associated with explicit ToM, suggesting a link between the two forms of ToM. Finally, implicit ToM was independent of language, EF, and SES. In Study 3, we used an accelerated longitudinal design (N = 354) to examine the developmental trajectories of implicit and explicit ToM in children aged 3 to 7 using mixed-effects models. Results showed that implicit ToM continues to develop across this age range. Moreover, implicit ToM was related

to explicit ToM but independent of language, EF, and SES, confirming the findings of Study 2. Furthermore, the development of explicit ToM was predicted by language, EF, and SES. Among these predictors, language emerged as the strongest. Taken together, these studies suggest that while implicit and explicit ToM are related during the preschool and early school years, they are influenced by different factors. Explicit ToM, including second-order reasoning, is strongly associated with language throughout development. Moreover, distinct developmental trajectories of explicit ToM can be observed across different socioeconomic backgrounds. In contrast, the spontaneous form of ToM continues to develop during these years but appears largely independent of general linguistic and cognitive abilities, as well as socioeconomic background. Methodological challenges associated with the assessment of ToM in children are considered. Finally, several limitations and future directions are discussed, including the importance of developing appropriate tasks to assess ToM in representative samples.

Keywords. Implicit Theory of Mind; Explicit Theory of Mind; False beliefs; Language; Executive functions; Socioeconomic status; Development.

Résumé

Développement de la théorie de l'esprit explicite et implicite chez les enfants d'âge préscolaire et scolaire : le rôle du langage, des fonctions exécutives, et du contexte socioéconomique

La théorie de l'esprit (TdE) désigne la capacité à se percevoir et à percevoir les autres comme des êtres psychologiques dotés d'états mentaux (croyances, désirs, intentions et émotions). La TdE se développe à des rythmes différents selon qu'elle repose sur des processus explicites ou implicites. La TdE explicite, consciente et délibérée, émerge généralement vers l'âge de 4 ou 5 ans. La TdE implicite, qui permet de prendre spontanément en compte les états mentaux d'autrui, est présente bien plus tôt chez les enfants. En revanche, la relation entre ces deux formes de TdE reste débattue. Par ailleurs, si la majorité des études ont examiné la TdE implicite chez les enfants jusqu'à l'âge de 2 à 3 ans, la façon dont cette capacité évolue chez les enfants d'âge préscolaire et scolaire, ainsi que les facteurs contribuant à ce développement, sont encore mal compris. Les facteurs environnementaux, tels que le statut socio-économique (SES), influencent la TdE explicite, possiblement via le langage et les fonctions exécutives (FE) des enfants. En revanche, l'influence du langage et des FE sur la TdE implicite reste débattue, et le rôle des facteurs environnementaux est largement inexploré. Cette thèse vise à examiner comment le langage, les FE et le SES influencent le développement de la TdE explicite et implicite chez les enfants d'âge préscolaire et scolaire. Dans l'étude 1, nous avons examiné si le langage et les FE médiaient la relation entre le SES et la TdE explicite. Une étude transversale (N = 375) a été menée auprès d'enfants âgés de 3 à 7 ans. Des analyses de modèle d'équation structurelle ont révélé, dans un modèle de médiation parallèle, que le langage médiait la relation entre le SES et la TdE explicite. Un modèle de médiation modérée, incluant l'âge comme modérateur, a indiqué que cette médiation par le langage ne variait pas en fonction de l'âge. Dans l'étude 2, nous avons adapté un paradigme largement utilisé chez les adultes pour évaluer cette capacité chez les enfants d'âge préscolaire et scolaire. Nous avons cherché à déterminer si des enfants de 3 à 7 ans prenaient en compte la perspective d'un agent, même lorsque celle-ci n'était pas pertinente pour la réalisation de la tâche. En utilisant le même échantillon que dans l'étude 1, nous avons observé que les enfants n'étaient influencés que par leur propre perspective, révélant un biais égocentrique dans cette tranche d'âge. Toutefois, la prise en compte de la perspective de l'agent (i.e., la TdE implicite) était liée à la TdE explicite, suggérant

un lien entre les deux formes de TdE. Enfin, la TdE implicite était indépendante du langage, des FE et du SES. Dans l'étude 3, nous avons utilisé une approche longitudinale accélérée (N = 354) pour examiner les trajectoires développementales de la TdE explicite et implicite chez des enfants de 3 à 7 ans, à l'aide de modèles à effets mixtes. Les résultats ont montré que la TdE implicite continue de se développer au cours de cette période. De plus, la TdE implicite était liée à la TdE explicite, mais indépendante du langage, des FE et du SES, confirmant les résultats de l'étude 2. Le développement de la TdE explicite était prédit par le langage, les FE et le SES. Parmi ces prédicteurs, le langage apparaissait comme le prédicteur le plus fort. L'ensemble de ces études suggère que, bien que la TdE explicite et implicite soient liées chez les enfants de 3 à 7 ans, elles ne dépendent pas des mêmes facteurs. La TdE explicite, y compris de second ordre, est fortement associée au langage tout au long du développement. De plus, des trajectoires développementales distinctes pour la TdE explicite peuvent être observées selon le contexte socio-économique. Les contraintes méthodologiques liées à l'évaluation de la TdE chez l'enfant sont considérées. Enfin, plusieurs limites et pistes de recherche futures sont discutées, en soulignant l'importance de concevoir des tâches appropriées pour évaluer la TdE dans des échantillons représentatifs.

Mots-clés. Théorie de l’esprit implicite ; Théorie de l’esprit explicite ; Fausses croyances ; Langage ; Fonctions exécutives ; Statut socio-économique ; Développement.

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Table of Acronyms

ToM	theory of mind
SES	socioeconomic status
ISCO	international standard classification of occupations
ISEI	international socioeconomic index
OECD	organization for economic co-operation and development
PISA	programme for international student assessment
EF	executive functions
AL	anticipatory looking
VOE	violation of expectation
ASD	autism spectrum disorder
HFA	high-functioning autism
TPJ	temporo parietal junction
mPFC	medial prefrontal cortex
WEIRD	western, educated, industrialized, rich, democratic
RT	reaction time
TV	two-vector
GLM	generalized linear model
CLM	cumulative link model
LM	linear model
CLMM	cumulative link mixed model
LMM	linear mixed model
PCA	principal component analysis
GVIF	generalized variance inflation factor
FDR	false discovery rate
EFA	exploratory factor analysis

CFA	confirmatory factor analysis
SEM	structural equation model
MLR	maximum likelihood robust
FIML	full information maximum likelihood
WLSMV	weighted least squares mean and variance
CFI	comparative fit index
TLI	tucker-lewis index
RMSEA	root mean square error of approximation
SRMR	standardized root mean square residual

PART I.

General introduction

1. Human beings as social beings

Our ability to find meaning in life has been shown to be directly associated with what researchers call the *sense of belonging* (Lambert et al., 2013). Belonging refers to the subjective experience of being accepted and included in a broader social system (e.g., family, peers, cultural groups, or communities) (Allen et al., 2021; Hagerty et al., 1992). Across disciplines, from psychology and education to evolutionary and cultural studies, there seems to be broad agreement that the need to belong is universal and fundamental (Allen et al., 2021, 2018; Baumeister & Leary, 1995; Hagerty et al., 1992; Lambert et al., 2013; Mellor et al., 2008; Rouchy, 2002). Indeed, belonging plays a central role in goal pursuit and identity formation, especially during adolescence (Allen et al., 2018). It contributes to stability, shared meaning, and collective engagement (Haslam et al., 2009; Lambert et al., 2013). In educational contexts, a strong sense of school belonging has been linked to better academic outcomes, smoother transitions to adulthood, and increased prosocial behaviors (i.e., acts that benefit others; Demanet & van Houtte, 2012; Sari, 2012; Tanti et al., 2011).

Although it can be fulfilled in various domains, belonging most often arises from direct emotional and social connections with others (Allen, 2020; Stillman et al., 2009). From an evolutionary perspective, authors argue that humans have evolved to rely more on their social groups than on their physical environment for survival (Stillman et al., 2009). According to this view, even the brain and immune system appear wired to detect social threats and seek relational safety (Slavich, 2020), as suggested by the social safety theory (Slavich et al., 2023) that proposes that much of human behavior is shaped by the drive to preserve social bonds. Similarly, the belongingness hypothesis (Baumeister & Leary, 1995) suggests that human culture has partly evolved to satisfy this fundamental psychological need.

This is well illustrated by situations of ostracism, where individuals are ignored or socially excluded. According to the temporal need–threat model (Williams, 2009), even subtle forms of rejection can provoke emotional distress and psychological pain, activating brain regions involved in physical pain (Eisenberger et al., 2003). In response, individuals often become highly motivated to restore connection, increasing their efforts to form new social bonds (Maner et al., 2007; Wirth et al., 2010). Beyond ostracism, social isolation has well-documented health effects. Meta-analytic findings show that being socially isolated increases the risk of mortality by about 30% (Holt-Lunstad et al., 2015), while lack of connection with others has been associated with depression, sleep disturbances, cognitive decline, cardiovascular issues, and

weakened immunity (Hawkley & Capitanio, 2015). These findings highlight the human need to build, maintain, and navigate relationships. This ability can best be understood through the lens of social cognition: the set of mental operations that underlie social perception, interpretation, and interaction. This broad concept forms the focus of the first part of this introduction.

1.1 Social cognition as a learning tool

1.1.1 Social cognition: definition

Social cognition refers to the mental processes that enable individuals to perceive, interpret, and respond to the social world (Adolphs, 1999). While language is the most recognizable form of communication among adults, it is far from being the only one (Frith & Frith, 2007). Facial expressions, gaze direction, and body posture, among other cues, provide highly valuable information in social contexts (Frischen et al., 2007; Hugenberg & Wilson, 2013). For instance, depending on the context (Hamilton, 2016), a prolonged look can lead to avoidance (Ellsworth et al., 1972) or indicate love and connection (Kellerman et al., 1989). Similarly, gaze may serve to withdraw from an uncomfortable situation or express social interest (Hamilton, 2016). The ability to interpret eye gaze is therefore particularly useful. Moreover, recognizing emotions on someone's face gives us insight into the person expressing the emotion (e.g., she doesn't like this meal), but also the situation. For instance, it can help us understand what to feel positive about, or what to avoid, saving time and offering a useful advantage in potentially threatening environments (Pourtois et al., 2013). Likewise, perceiving and interpreting body movements allows us to infer others' goals and intentions in people (Sartori et al., 2011). For instance, based on someone's posture or orientation toward an object or event, we can estimate how likely they are to act in a particular way, thus making their behavior, and more generally the environment, more predictable (Saxe, 2006). Social cognition also enables learning through observation, offering a major developmental advantage. For instance, it allows us to avoid direct trial-and-error learning by relying on others' experiences, especially negative ones (Frith & Frith, 2007). Importantly, these mechanisms are not exclusive to adults. Research shows that even before they can verbalize their experiences, infants demonstrate clear sensitivity to social cues from a very young age, which forms the basis for later, more complex social understanding.

1.1.2 Development of social cognition

One of the earliest signs of humans' social nature is newborns' preference for faces (Hugenberg & Wilson, 2013). Within the first hour of life, infants preferentially track face-like stimuli over non-face-like ones (Johnson et al., 1991). This early sensitivity to social cues marks the beginning of a gradual and increasingly sophisticated understanding of the social world.

In the following section, I will review five abilities observed in young children, which illustrate infants' early capacity to engage with and make sense of their social environment: joint attention, understanding of goal-directed actions, emotion perception, social referencing, and the emergence of trust.

1.1.2.1 Joint attention

Joint attention refers to the ability to coordinate one's attention with another person's toward an object, an event, or more generally a feature of the environment (Scaife & Bruner, 1975). This skill is essential to social interactions, as it allows partners to share the same referential during an exchange. It is also crucial for infants to learn about the world, since most objects and events they encounter are novel. For example, when presented with a new object, children use their ability to align their attention with a caregiver's to identify which object is being referred to (Moore et al., 2014). This fundamental social-cognitive skill emerges during the first year of life, when children begin to engage in triadic interactions (Carpenter et al., 1998).

In their seminal paper, Butterworth and Jarrett (1991) described how infants progressively develop the ability to engage in joint visual attention with others through three successive stages: (a) the *ecological stage*, emerging around 6 to 9 months; (b) the *geometric stage*, around 12 months; and (c) the *representational stage*, by 18 months (Figure 1). In the ecological stage, infants can detect the general direction of an adult's gaze. For instance, when seated in front of a caregiver with several targets placed at different angles, and the caregiver fixates one of them, 6-month-olds reliably turn in the correct direction but often stop at the first object encountered, failing to discriminate between targets that are close to one another. In the geometric stage, around 12 months, infants begin to extend the caregiver's line of sight and identify the precise referent, correctly locating the specific target rather than just the correct side. Finally, in the representational stage, around 18 months, infants understand that gaze can be directed toward

objects outside their own visual field. In this case, children are able to turn around and look behind them when their caregiver fixates a target located out of sight.

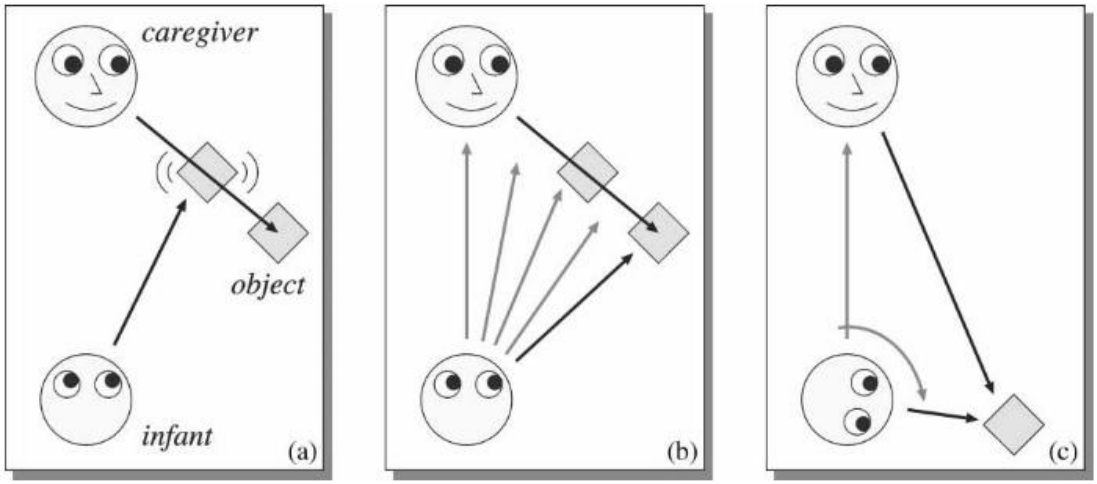


Figure 1. Three forms of joint attention according to Butterworth & Jarrett. (a) the ecological stage; (b) the geometric stage; and (c) the representational stage. Figure from Nagai et al., 2003**.**

Although infants show early signs of joint attention, this capacity continues to develop throughout the first two years of life. While distinctions of joint attention are not always identical across studies and theoretical perspectives, authors often divide this skill into two main categories, namely responses to joint attention (RJA) and initiations of joint attention (IJA). RJA refers to the ability to follow the gaze or gestures of another person to establish a shared point of reference, whereas IJA occurs when children use gestures and gaze to invite others to pay attention to objects, events, or themselves (Mundy & Newell, 2007).

Research on RJA suggests that gaze-following is present from 2 months of age and increases between 7 and 11 months (Scaife & Bruner, 1975; Shepherd, 2010). Between 3 and 6 months, infants already show the ability to turn their head when an adult looks at a puppet, demonstrating gaze-following capacities (D'Entremont et al., 1997). Around 6 months, they are able to follow the gaze of an adult toward a set of targets (Butterworth & Jarrett, 1991), and between 4 and 6 months they also begin to follow pointing gestures (Bertenthal et al., 2014). However, in the presence of distractors (e.g., targets that are close to one another), RJA tends to show a later linear development, occurring between 9 and 18 months (Mundy et al., 2007), with efficient

and precise use of adult gaze to locate targets emerging between 12 and 15 months (Carpenter et al., 1998).

By contrast, IJA is more complex and develops later, from around 12 months of age (Cameron-Faulkner et al., 2015; Liszkowski et al., 2004; Mundy et al., 2007). This difference between the two components is explained by the fact that IJA relies on more volitional control systems in the brain, which develop later in childhood (Rothbart et al., 1994). This interpretation is supported by behavioral and neural evidence showing an increase in IJA between 12 and 24 months of age (Eggebrecht et al., 2017). Beyond joint attention, infants also rapidly begin to interpret the purpose behind others' actions.

1.1.2.2 Perception of goal-oriented actions

Understanding others' intentions is fundamental to social cognition. It allows us to interpret actions accurately, since the same behavior can mean very different things depending on the underlying goal (Tomasello et al., 2005). Research has shown that well before acquiring language, infants make inferences from their environment. They are not passive observers of others' behavior, they form expectations about actions, suggesting that they perceive them as goal-directed (Baldwin & Baird, 2001; Gergely et al., 1995; Woodward, 1998). But what cues do children rely on to make such inferences? Studies suggest that infants use signals such as gaze direction, pointing gestures, or reaching and grasping behaviors to interpret others' actions and anticipate their goals (Sodian & Thoermer, 2004).

For instance, by around 10 months of age, infants can understand goal-directed actions, whether they are successful or not. When observing an agent who either succeeded or failed to reach an object, infants later showed surprise if the agent took an indirect path to that same object, suggesting they had formed an expectation about the agent's appropriate behavior based on its original goal (Brandone & Wellman, 2009).

In another study using an anticipatory looking paradigm (which measures where participants expect an action to happen), researchers tested whether infants could predict future behavior based on their understanding of goals. Eleven-month-old infants watched videos in which a human hand grasped one of two objects. Then the objects' positions were switched, and the hand made an incomplete reach, stopping midway between the two. In a control condition, the human hand was replaced by a mechanical clamp. Infants in the hand condition looked toward the object that had previously been the goal, despite its new location, whereas those in the clamp

condition did not. These results suggest that infants identify and track agents' goals to anticipate future actions, and that this process is specific to intentional agents (Cannon & Woodward, 2012), although more recent attempts to replicate this finding have failed (Ganglmayer et al., 2019).

Interestingly, infants seem to understand the directedness of actions even before they are able to perform them themselves (Woo et al., 2024). In a recent study, 3-month-old infants in a pre-reaching stage (meaning they could not yet reach for objects) were presented with a series of experiments. In one condition, an agent repeatedly reached for the same object in different locations, then reached for a different object. In another condition, the agent's hand passively fell on the same object in different locations, and then on a different one. In addition to the active versus passive nature of the movement, a key difference was that in the first condition, the agent looked at the object (which indicated intentionality), whereas in the second, he did not. Results showed that in the intentional condition, infants looked longer when the agent reached for a new object. This might suggest that they had formed an expectation about the target of the action. In contrast, in the passive condition, infants did not look longer when the object changed, indicating no clear expectation. This pattern suggests that infants were sensitive to the presence or absence of intention, even without first-person experience of reaching. Just as infants develop expectations about the goals behind others' actions, they also pay attention to the emotional cues that accompany these behaviors.

1.1.2.3 Emotion perception and social referencing

When people express emotions, they usually do so through identifiable cues, some of which can be understood by infants, even within the first year of life (Grossmann, 2010).

For instance, behavioral studies have demonstrated that by 6 months, infants reliably differentiate varying intensities of both happy and angry faces (Striano et al., 2002). Neuroimaging studies have also shown infants' sensitivity to emotions. In an Event-Related Potential study, 7-month-old infants were shown fearful, happy, or neutral faces. They exhibited distinct neural responses to fearful faces and showed longer looking times for these expressions (Leppänen et al., 2007). Moreover, this sensitivity is not limited to visual cues, as another study found that 7-month-olds' brains responded differently to voices expressing positive, negative, or neutral emotions (Blasi et al., 2011).

Beyond the perception of emotions, infants also begin to form expectations about appropriate emotional response in context. One study examined whether infants aged 14 to 18 months could associate specific negative emotions (such as fear, anger, or disgust) with relevant events (Ruba et al., 2019). In one experiment, infants saw a surprising event (e.g., a jack-in-the-box suddenly popping out), followed by either a congruent reaction (fear) or an incongruent one (disgust). Infants looked significantly longer in the incongruent condition, suggesting that they expected the experimenter to express fear when seeing a surprising event.

A similar finding emerged in a study with 8- to 10-month-old infants who watched animated agents attempting to achieve goals (e.g., stopping another character). The agents either succeeded or failed, and then displayed a positive or negative emotion. Infants were surprised when an agent reacted positively to failure or negatively to success, indicating an emerging ability to connect emotional expressions to goal-directed outcomes (Skerry & Spelke, 2014).

Emotional expressions also serve as important social signals to guide behavior in uncertain situations. This process, known as social referencing (Feinman, 1982), involves using others' emotional reactions to guide one's own response to novel objects or events. For example, infants aged 6 to 22 months showed different patterns of attention toward a new object depending on whether their parents expressed joy or fear with regard to this object. 10-month-olds, in particular, showed avoidance behaviors when parents expressed fear (Walden & Ogan, 1988).

To ensure that infants interpreted emotional cues as object-specific, researchers have emphasized the need for studies involving more than one object (Zelazo et al., 2009). Using such a design, Repacholi (1998) presented 14- to 18-month-old infants with two boxes. The experimenter expressed joy toward one and disgust toward the other. Infants across all age groups looked significantly more into the box associated with the joyful reaction.

Taken together, these findings suggest that infants can perceive emotional expressions but also use them to guide their behaviors.

1.1.2.4 Emergence of trust

In addition to showing social referencing from an early stage, infants also demonstrate selectivity in how and from whom they use emotional cues. For instance, when presented with emotional reactions to a spider from either a stranger or their mother, infants relied only on their

mother's emotional expressions to guide their behavior (Zarbatany & Lamb, 1985). This reflects the broader importance of trust in learning from others, as we are generally more inclined to accept information from those we consider trustworthy. Even in infancy, sensitivity to the source of information is already present.

As Harris et al. (2017) point out, children rely on social and emotional cues to guide their behavior in novel situations, but two factors play a key role, namely the contextual ambiguity and the credibility of the informant.

First, infants primarily use social cues in ambiguous situations. In one study, 18-month-old infants were presented with three slopes: safe, risky, and borderline. They took their mother's advice into account only in the ambiguous cases, but ignored encouragement on the dangerous slope and disregarded discouragement when the slope was safe (Tamis-LeMonda et al., 2008). This selective ignorance (Mercier, 2020) reflects the tendency to ignore advice that contradicts one's direct perception when the situation is unambiguous.

Second, infants are also selective in who they trust. By 12 months, they already show sensitivity to an informant's competence. In a study by Stenberg (2013), two adults interacted with toys, one demonstrating competence (e.g., naming the toy correctly or assembling its parts), while the other demonstrated incompetence (e.g., failing to assemble it). When an ambiguous toy (a mechanical dinosaur) was introduced, one of the adults displayed a positive or negative reaction toward it. Infants explored the toy less when the reaction was negative, regardless of who gave it. However, when the reaction was positive, infants explored more if it came from the competent adult. The same pattern was found for negative reactions. Specifically, they were more trusted when coming from the competent adult, thus showing selective trust. In summary, children tend to show the tendency to give more weight to information from reliable individuals, especially under uncertainty.

A large-scale review by Tong et al. (2020), based on three meta-analyses, examined whether children's selective trust is primarily driven by epistemic (e.g., competence, past accuracy) or social (e.g., familiarity, niceness, group membership) traits. The findings showed that children aged 3 to 6: (a) tend to trust competent informants more, and this effect strengthens with age; (b) show a preference for informants with positive social characteristics; and (c) around age 4, begin to prioritize epistemic traits over social ones, placing competence above likability.

A recent study explored the early emergence of trust using a non-verbal search paradigm (Mascaro & Kovács, 2022). Infants aged 15 to 24 months saw a reward being hidden in one location. Then, a communicative cue suggested the reward had been moved elsewhere. Several variables were manipulated, such as the informant's knowledge status, the familiarity and ostensive quality of the cue (e.g., pointing versus placing a marker, direct eye contact). Infants often followed the cue, even over their own memory, especially when the informant was knowledgeable and the cue was ostensive. However, this trust diminished when presented with clear counterevidence. Interestingly, older toddlers were more likely than infants to trust poorly knowledgeable informants, and unfamiliar cues were more readily accepted when presented ostensively. These results suggest that from early in life, children not only learn from others, they also learn how to decide who to learn from. Trust, in infancy, seems already shaped by how information is presented and who presents it, not just by the content of the message.

By age 4, children begin to show signs of epistemic vigilance, i.e., the ability to detect misinformation and adjust accordingly (Mascaro & Sperber, 2009). In one study, children had to locate candy hidden in one of two boxes, guided by a puppet described as a liar ("Be careful, the frog is a big liar! It always tells lies."). To succeed, children had to infer that the puppet's statement was false and do the opposite as the puppet said. Children aged 4 succeeded at this task, showing an emerging capacity to resist unreliable sources.

In summary, while infants display early signs of trust, their ability to evaluate, filter, and regulate whom they trust becomes more efficient with age. The ability to assess whom to trust and when, reflects a stronger understanding of others' intentions and beliefs. This capacity is a central component of what has been called theory of mind.

1.2 Theory of Mind, a central component of social cognition

1.2.1 ToM: definition

Theory of Mind (ToM) has been the focus of extensive research over the past five decades. The term was first introduced by the ethologists Premack and Woodruff in a famous study on chimpanzees, exploring whether chimpanzees could infer the mental states of others (Premack & Woodruff, 1978). This was followed by the first applications of the concept in developmental psychology (Bretherton & Beeghly, 1982; Hughes & Devine, 2015). ToM refers to the ability to perceive both oneself and others as psychological beings with distinct mental states, such as belief, desires, intentions, and emotions (Astington & Dack, 2000; Baron-Cohen et al., 1985;

Wimmer & Perner, 1983). It enables us to interpret and explain people's actions based on these mental states. Since most of our behaviors are guided by what we think, want, or feel, understanding these internal states is essential for making sense of others' actions. Moreover, attributing mental states allows us not only to explain behavior, but also to anticipate it. This ability to predict what others might do based on what they believe or want is a fundamental part of social interaction, and therefore, of social cognition more broadly (Astington & Dack, 2000).

1.2.3 Historical foundations in perspective taking

The origins of ToM research can be traced back to Piaget's work on children's social egocentrism (Hughes & Devine, 2015; Piaget & Inhelder, 1956). In the famous Mountain Task**,** designed to assess visual perspective-taking, Piaget examined whether children could adopt the point of view of another person. Children were shown a model with three mountains, each a different color. A doll was placed on a different side than the child, also facing the mountains. The experimenters then presented the child with various images of the mountains from different angles and asked which one matched the doll's view of the mountains. Children under the age of 6 or 7 typically selected the picture corresponding to their own perspective, failing to consider the doll's point of view. Based on these findings, Piaget concluded that children before age 8 are egocentric and unable to adopt another person's visual perspective (Piaget & Inhelder, 1956).

Flavell et al. (1981) then proposed a more nuanced developmental model of perspective-taking, distinguishing between two levels. Level 1 perspective-taking, which emerges early, refers to the ability to determine what another person can or cannot see. Level 2, which develops later, involves understanding that two people can see the same object differently, depending on their spatial position.

Although perspective-taking is closely related to ToM (Barnes-Holmes et al., 2004) and is sometimes used to assess it (Fu et al., 2023), these tasks rely mostly on visuospatial processing and may not require children to reason about others' belief or intentions (Baron-Cohen et al., 1985). In contrast, the most widely used task to assess ToM is the false belief task**,** which directly assesses the ability to understand that others can hold beliefs that can contradict with reality (Wellman et al., 2001).

1.2.4 Understanding false beliefs

1.2.4.1 Developmental milestone

The first false belief task was developed by Wimmer & Perner (1983), shortly after the work of Premack and Woodruff. In this task, known as *Maxi and the chocolate* (Figure 2) the experimenter tells the child a story in which Maxi places a chocolate bar in a green cupboard.



Figure 2. Illustration of Max and the chocolate task. Figure from Desgranges et al., 2012.

While Maxi is out of the room, his mother moves the chocolate to a blue cupboard. When Maxi returns, the experimenter asks the child: "Where will Maxi look for the chocolate?" The goal is to assess whether the child understands Maxi's false belief about the chocolate's location. The very same principle was then applied to other tasks, involving two characters and an object that is moved in the absence of one of the characters (e.g., the Sally and Anne task, Baron-Cohen et al., 1985).

In such false belief tasks, children are asked to predict a character's actions based on their false belief about an object's location. Success in these tasks reflects the child's ability to recognize that someone can hold a belief that differs from reality, and from their own belief. Children under the age of 4 often fail in doing so, answering based on their own knowledge of the object's actual location (e.g., saying the chocolate is in the blue cupboard) rather than taking the character's perspective (e.g., saying it's in the green cupboard, where the character last saw it).

These tasks have become central in the assessment of ToM (Wellman et al., 2001), because understanding false belief is considered a key milestone in realizing that mental states can differ from the real world (Dennett, 1979). ToM is often described as representational, meaning that individuals must understand that people have internal representations of reality, which may or may not match the actual state of the world (Perner, 1991; Wellman et al., 1990).

Another widely used false belief paradigm is the unexpected content task, the most well-known being the Smarties task (Perner et al., 1987). In this version, children are shown a closed Smarties box and asked what they think is inside (most children answer “Smarties”). The experimenter then opens the box to reveal that it actually contains pencils, then closes it again and asks: “If your friend comes into the room right now, what will they think is inside the box?” Once again, this task assesses the child’s ability to consider the perspective of someone who has not witnessed all the events and to inhibit their own knowledge in favor of the other person’s belief.

As many studies have shown, before age 4, children often struggle to answer based on someone else’s perspective when it contradicts their own. This was confirmed by a large meta-analysis by Wellman et al. (2001), which combined 178 studies on false belief performance. Results showed that children are 50% accurate around 44 months, and reach 75% accuracy by around 56 months, confirming a developmental shift between 4 and 5 years of age, regardless of the type of false belief task used.

1.2.4.2 Advanced ToM

Despite the early shift observed in children between 4 and 5 years of age, ToM continues to develop during middle childhood. For example, although children can explicitly adopt another person’s perspective around age 5, the ability to consider multiple, sometimes conflicting perspectives typically emerges later, around ages 6 or 7 (Perner & Wimmer, 1985). This more advanced ability is known as second-order ToM, and reflects a deeper understanding of mental states, allowing individuals to reason about what one person thinks about another person’s thoughts.

False belief tasks have also been adapted to assess this higher-order ability. In a classic version of such a task (Perner & Wimmer, 1985), the experimenter tells the child the following story: John and Mary are at the park when they see an ice cream truck. Mary wants ice cream but has forgotten her money, so she tells the ice cream seller that she will go home and come back later. While she is gone, John sees the truck leaving the park. On the way, the ice cream seller passes by Mary’s house, and she learns from him that the truck will now be at the church**.** Importantly, John does not know that Mary spoke to the seller. Later, John visits Mary’s house, and her mother tells him that Mary went to buy ice cream. The child is then asked: "*Where does John*

think Mary went to buy the ice cream?" To answer correctly, children need to understand John's false belief about Mary's belief, which is the key characteristic of second-order ToM.

Second-order ToM is then followed by more complex aspects of ToM, such as understanding irony, sarcasm, metaphors, bluff, or white lies (Fu et al., 2023), which continue to develop in middle childhood (Osterhaus & Koerber, 2021), adolescence (Dumontheil et al., 2010), and adulthood (Apperly et al., 2009).

While many studies confirm the developmental shift and the future progression of ToM skills, the question of how ToM develops has been at the center of many theoretical debates.

1.2.5 Major theoretical accounts of ToM

Some argue that ToM emerges very early, while others argue that ToM development is the product of largely domain-general processes and is acquired gradually through life (Wellman, 2014). Three main theoretical accounts have been proposed, as described by Hughes & Devine (2015) and more recently reviewed by Schlicht (2023). Below I give a general overview of the three competitive historical accounts of ToM, namely the theory-theory, simulation theory and modularity theory.

1.2.5.1 Theory-theory

On the one hand, the (constructivist) theory-theory was framed by Gopnik & Wellman (1992), built from behaviorism, and later functionalism (Schlicht, 2023). According to this view, we use a "theory" to understand people around us, in the sense that mental states are non-visible, theoretical entities that we can use to predict behavior, and thus make sense of the world (Carruthers & Smith, 1996; Gopnik, 2010; Gopnik & Meltzoff, 1997; Gopnik & Wellman, 1992). The general assumption of the theory is that children construct a naïve theory about mental states (Wellman, 2017). They would learn theory of mind, just as they do in other cognitive domains, through experience and by revising the theories they construct about the mind when they face evidence that invalidates them (Gopnik & Meltzoff, 1997). With these theories that children build about mental states, they can understand both their own behaviors and those of people in their environment (Gopnik, 2010), by making predictions, interpretations, and explanations about the mind. The main idea is that children, when learning about the mental world, can be considered as scientists in the sense that: a) they compute statistical probabilities of events (Kushnir et al., 2010), in line with the Bayesian approach and

supported by evidence showing infants' sensitivity to statistical regularities (Saffran et al., 1999); b) they conduct experiments by actively exploring their environments; and c) they learn from the experiments of others through observation. Authors supporting this view also recognized that children experience a radical change around the age of 4 or 5, as evidenced by children's performance in classical false belief tasks (Wellman et al., 2001). In sum, children acquire and learn ToM much like they do in other domains (even though Gopnik and colleagues acknowledged a partly innate capacity that might direct infants' attention toward social stimuli, Schlicht, 2023).

1.2.5.2 Simulation theory

On another hand, the simulation theory suggests that children understand what others feel or think by mentally simulating these states based on their own first-hand experiences (Harris et al., 1989). They would do so by using a "like-me" analogy (Hughes & Devine, 2015), which allows them to interpret others' mental states by referencing their own experiences (Meltzoff, 2007). According to this view, we automatically recruit our own cognitive and emotional resources to imagine what others are experiencing (Gallese, 2005). Imagination is therefore considered central to understanding others' mental states (Schlicht, 2023). One finding used by simulation theorist as evidence in favor of the theory is the discovery of mirror neurons, neurons located in the ventral premotor cortex of monkeys (Rizzolatti et al., 1996). Authors found that these neurons were activated not only when the monkey performed an action (e.g., grasping an object), but also when it observed another individual performing the same action (Rizzolatti, 2005), especially when the action is goal-directed. Further research has shown that mirror neurons are also active during the perception of touch and pain, indicating a link to social cognition (Keysers, 2011; Schlicht, 2023). In humans, neuroimaging studies have shown similar patterns. For instance, activation in the anterior insula is observed both during personal experiences of disgust and when observing others expressing it. Furthermore, damage to this area impairs both processes (Wicker et al., 2003). In another study, mirror neurons showed stronger activation when actions were presented within a meaningful context (e.g., grasping a cup on a set table) than when isolated from context. This would support the idea that mirror neurons contribute to intention understanding, reinforcing the simulation theory's claim that we understand others' intentions through embodied mechanisms (Iacoboni, 2008). In this view, mirror neurons help us identify the goals behind observed actions and thus serve as an essential component in attributing mental states to others (Gallese & Sinigaglia, 2011). However, several critiques argue that mirror neurons may not be necessary for mentalizing (Hickok, 2014),

especially in light of evidence for a distinct mentalizing network in the brain (Amodio & Frith, 2006; Saxe, 2009), with a more plausible view being that they play a supporting role among several mechanisms involved in social understanding (Schlicht, 2023).

1.2.5.3 Modularity theory

Finally, according to the modularity theory, our ability to understand mental states is both innate and domain-specific (Leslie, 1991). The modularity theory comes from Fodor's modularity account (Fodor, 1975) which distinguishes between a central system and modular systems that allow us to process information. Modules, according to Fodor (1983), are innate (present from birth and not learned), domain-specific (specialized), and encapsulated (automatic and independent from other cognitive domains). The modularity theory of ToM also shares ideas with Carey and Spelke's theory of core knowledge (Schlicht, 2023), according to which we have four innate systems of knowledge for representing objects, agents, numbers, and geometrical relations (Carey & Spelke, 1996). Some modularity theorists further argue that the mind is entirely modular, with modules that could be localized in the brain and that could change after birth (Carruthers, 2002). A detailed model (Figure 3) has been proposed in this line of research, especially regarding autism spectrum disorder (ASD). According to this model (Baron-Cohen, 2005), six mechanisms support mindreading. Three of these develop from birth to 9 months, including the intentionality detector (for perceiving intentions and desires), the eye-direction detector (for gaze orientation), and the emotion detector (for emotions understanding). Between 9 and 14 months, the shared attention mechanism emerges (enabling triadic relations), followed around 14 months by the empathizing system (allowing the responses to emotions). Finally, around 48 months, the ToM mechanism develops, allowing for false belief understanding.

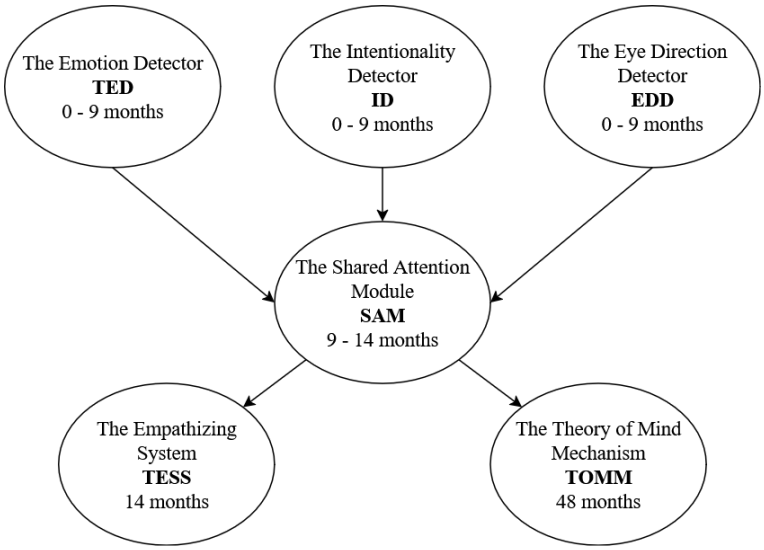


Figure 3. Baron-Cohen's Empathizing system. Figure from Stephenson et al., 2021.

Empirical evidence from ASD has often been used to support this view. Indeed, individuals with ASD typically show specific impairments in social communication as well as restricted and repetitive sensory-motor behaviors (Lord et al., 2018). Because such deficits appear in social cognition but not in other cognitive domains (Baron-Cohen et al., 1985), this would support the domain-specificity claim that is central to the modularity theory (Leslie, 1991). However, this account has been challenged by findings showing that individuals with ASD may succeed in false-belief tasks under certain conditions (Happé, 1995), by failures to replicate earlier results (Kissgen & Schleiffer, 2002), or by evidence that some form of ToM are impaired, the more automatic and implicit one, whereas the explicit form can be learned and recruited through compensatory strategies (Senju et al., 2009). These findings highlight the importance of distinguishing between implicit and explicit processes in ToM (Frith & Frith, 2008).

To conclude, children progressively develop their social cognition abilities, from sensitivity to faces to the processing of complex social cues, which continues to develop into adulthood (Figure 4). In the following section, we turn to the implicit form of ToM.

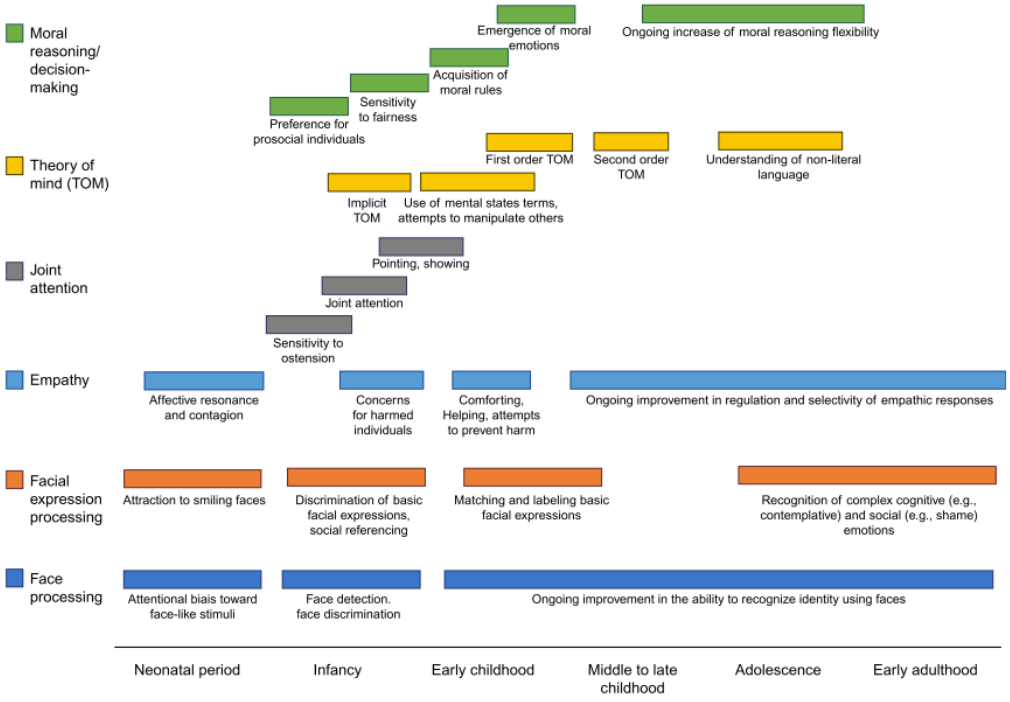


Figure 4. Developmental steps of social cognition from neonatal period to early adulthood. Figure from Beaudoin & Beauchamp, 2020.

2. Implicit and explicit ToM

The developmental milestone observed around age 4, as mentioned earlier, has been replicated across many studies (Wellman et al., 2001). However, when researchers adapted false belief tasks to better fit infants' behavioral abilities, using implicit measures rather than explicit verbal responses (that they are not able to produce yet), findings suggested that infants, from a very early age, are able to attribute false beliefs to agents (Onishi & Baillargeon, 2005). These results challenged the traditional idea of a developmental shift occurring only around age 4 in false belief understanding. Many studies then followed, using new experimental paradigms to demonstrate that infants might be able to represent beliefs using spontaneous processes, a capacity now referred to as implicit ToM. Implicit ToM is more generally defined as the ability to represent mental states automatically, unconsciously, and spontaneously in others (Clements & Perner, 1994). This line of research gave rise to what has been called the "developmental paradox": infants appear to show sensitivity to false beliefs in implicit tasks, whereas children under 5 typically fail in classical explicit tasks. This section will first present evidence for implicit ToM in infancy, then review the main theoretical accounts of the developmental paradox, and finally consider evidence of implicit ToM later in development.

2.1 Implicit ToM: evidence from infancy

Implicit ToM has been first evidenced in infants. Below I describe three paradigms that have been mostly used to show that infants could process mental states spontaneously, including the violation of expectation, the anticipatory looking, and the interactive (helping behaviors) paradigms.

2.1.1 Experimental paradigms

2.1.1.1 Violation of expectation

The violation of expectation (VOE) paradigm was originally developed to study object permanence in infants (i.e., the understanding that objects continue to exist even when they are out of sight, Baillargeon et al., 1985; Bower, 1974; Piaget & Inhelder, 1956). The idea, as adapted by Baillargeon and colleagues, was to show infants an *impossible* event that would violates physical expectations (a solid object passing through another), and to assess whether infants look longer at the impossible event, suggesting surprise and, by inference, a mental

representation of objects properties (Baillargeon et al., 1985). Initially used to explore infants' expectations about the physical world, this paradigm was later adapted to investigate their understanding of the psychological world. Looking-time methods such as VOE paradigms have reshaped the understanding of infants' capacities (Margoni et al., 2023).

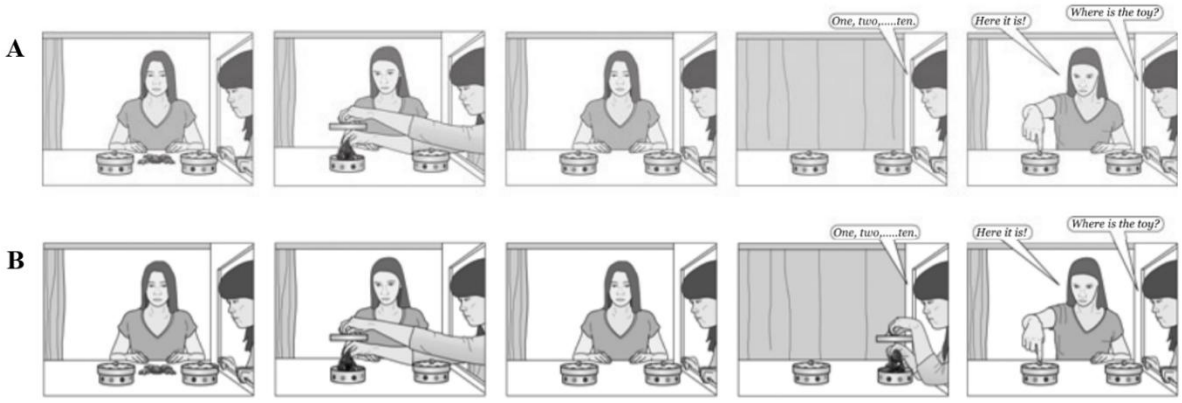


Figure 5. Familiarization (A) and test (B) trials in a violation-of-expectations task. Figures adapted from He et al., 2011.

In a pioneering study in the ToM field, authors tested whether 15-month-old infants could demonstrate an early, implicit understanding of false belief using an adapted VOE task (Onishi & Baillargeon, 2005). They presented infants three types of trials: familiarization, belief-induction, and test trials. In familiarization trials, infants watched an agent play with a toy (a watermelon slice), place it in one of two colored boxes on a table, and later search for it in that same box. In a belief-induction trial, the toy was moved (either to the other box, or placed again in the same box), either in the presence or absence of the agent. This led the agent to hold a true or false belief about its location. In the test trial, the agent reached into one of the boxes. Authors argued that if infants understood the agent's false belief, they should be surprised when the agent acted in a way that contradicted their belief (i.e., reaching directly for the correct box when they shouldn't know the toy had moved). Results showed that infants looked significantly longer when the agent acted in a way inconsistent with their belief, interpreted by the authors as an indication that infants expected the agent to act according to what they believed. These findings were interpreted as an indication that by 15 months infants may already old an implicit form of ToM. Unlike the original VOE paradigm which relied on physical violations, this version involved a psychological violation (the agent did not act in accordance with their mental state). An example of such a task is depicted in Figure 5.

2.1.1.2 Anticipatory looking

Another main paradigm used to test implicit ToM is the anticipatory looking (AL) paradigm (Clements & Perner, 1994). A seminal study aimed to test whether even younger children (around 25 months) could show signs of false belief understanding (Southgate et al., 2007), with a non-verbal anticipatory looking task using eye-tracking. Children were first habituated to watch an agent retrieve an object from one of two boxes. Then, a classic false belief scenario was shown, in which the object changed location while the agent wasn't watching. To avoid a reality bias (i.e., where knowledge of the real location interferes with the child's response, Mitchell & Lacohee, 1991), the object was removed from the scene without the agent noticing. When the agent returned, the child's looks were recorded to see where they anticipated the agent would search. Results showed that 85% of children looked toward the box corresponding to the agent's false belief, suggesting that they formed expectations based on the agent's belief, not on the actual location of the object. Further evidence of such a capacity has since been shown in even younger infants, as early as 17 or 18 months (Senju et al., 2011; Surian & Geraci, 2012). An illustration of a typical sequence of an AL task is presented in Figure 6.

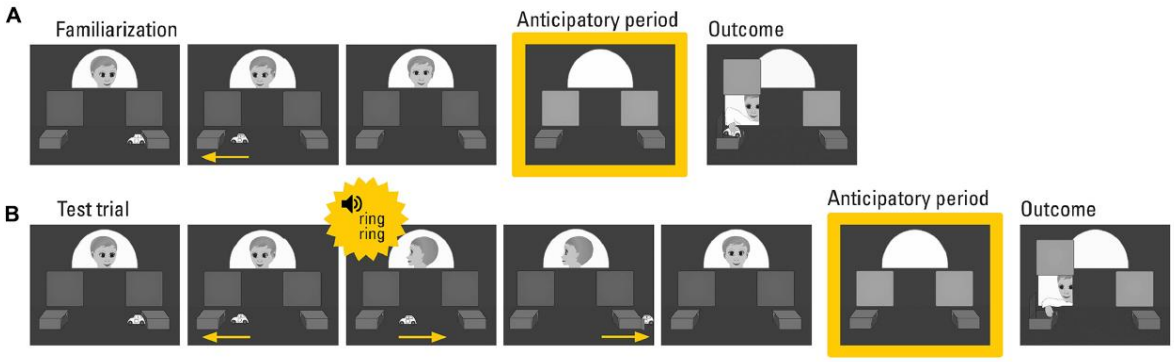


Figure 6. Sequence a familiarization and test trial of an anticipatory looking task. Figure from Schuwerk et al., 2016.

2.1.1.3 Helping behaviors

Another approach to assess infants' implicit ToM involves action-based tasks, where researchers rely on helping behaviors to infer whether infants understand others' mental states (Buttelmann et al., 2009). For example, in the classic false belief scenarios, helping someone

find a toy in a new location, one they could not possibly know about, would suggest that the child understands that the person holds a false belief.

In the first study using this paradigm, 2.5-year-old infants were presented with a scenario in which a toy was moved from one box to another (Buttelmann et al., 2009). Depending on the condition, an adult either witnessed the move (true belief) or was absent (false belief). The adult then attempted to open the first box, the one where the toy had initially been placed but was now empty. This was used to test whether infants would help the adult by opening the other box, the one that now contained the toy, suggesting that the child noticed the false belief of the adult.

Results showed that 83% of children in the false belief condition opened the correct (the new one, containing the toy) box. According to the authors, this suggests that children inferred the adult's goal (finding the toy) and recognized their false belief about its location. The child's helping behavior was thus interpreted as evidence of an implicit and early form of ToM. Since then, different versions of this paradigm have been developed to further explore infants' ability to act based on others' beliefs (Knudsen & Liszkowski, 2012; Southgate et al., 2010).

2.1.2 Theoretical accounts

Five main theoretical accounts have emerged in response to the evidence of implicit ToM in infants, aiming to explain the developmental paradox (Hughes & Devine, 2015; Schlicht, 2023). These accounts can be divided into two broad categories. On the one hand, the behavioral rules account, the submentalizing account and the shared intentionality account argue that infants' performances in the tasks described above do not reflect ToM. On the other hand, the early competence account, the implicit–explicit distinction, and the dual-system account suggest that infants' behavior does reflect some form of mental state representation (to different degrees according to the accounts, some arguing for a proper belief representation, whereas other don't) (Schlicht, 2023).

2.1.2.1 Non-mentalistic accounts

2.1.2.1.1 Behavior rules

According to authors defending this view, infants' performance in spontaneous ToM tasks does not reflect an actual understanding of mental states. Instead, it is argued that infants rely on behavioral rules (Povinelli & Vonk, 2004), derived from statistical regularities in behavior,

without accessing the mental state level (e.g., an agent will act on the basis of the perceptual information that was available to them). From this perspective, the two types of tasks (implicit and explicit) assess different cognitive abilities (Low & Perner, 2012; Perner, 2010; San Juan & Astington, 2012).

According to Povinelli and Vonk, behavior in false-belief tasks need not be explained by mental-state attribution, as simple behavioral rules can generate the same predictions. Although their rationale concerns primates, this reasoning has been extended to infants (Low & Perner, 2012). In this account, a behavior-mental rule like "people look where they believe the object is" can be substituted with a behavior-behavior rule such as "people look where they last saw the object."

Perner (2010) illustrates this with the false belief task: an agent A places an object O in location L1, and the object is moved to L2 while the agent is away. The child must predict where A will search. A mentalistic explanation would be: "If a person saw O go into L1 and didn't see it move to L2, then they *believe* it is in L1.", whereas a behavioral one would be: "If a person saw O go to L1 and did not see it move, then they *will go* to L1." Both approaches predict the same behavior, but only one requires mental state attribution.

2.1.2.1.2 Submentalizing account

The submentalizing account, proposed by Heyes (2014), defines submentalizing as general-purpose cognitive mechanisms that simulate the effects of mentalizing in social contexts. According to Heyes, what is often interpreted as spontaneous mental state attribution, implicit ToM, is in fact not genuine mentalizing. It only appears to be so, while actually relying on more basic processes. In her paper, the author argues that explanations invoking mentalizing in implicit tasks can systematically be replaced by submentalizing explanations.

She illustrates this with the well-known dot perspective task (Samson et al., 2010). In this task, participants see an avatar standing in the middle of a room, facing a wall either to the left or to the right. Red dots are painted on the room's walls. Depending on her orientation, the avatar can see all (all the dots are in front of her), some (some are in front while some are behind her), or none of the dots (all the dots are behind her), while the participant always sees them all. On each trial, a screen with a digit between 0 and 3 first appears, followed by the image of the avatar in the room with the dots on the walls. Participants must then judge whether it corresponds to the number of dots visible either from their own perspective (self trials) or from

the avatar's perspective (other trials). Trials can be congruent (both the participant and the agent can see the same number of dots) or incongruent (the participant sees more dots than the avatar). Results show that participants respond more slowly in self-incongruent trials, in which they have to judge for their perspective, but the avatar doesn't see the same number of dots as they do.

While this has been taken as evidence of implicit ToM (the avatar's perspective is thought to interfere automatically on the participant's own), Heyes, however, offers a different explanation. She argues that the crucial factor is not the agentive nature of the avatar but its directional features, which bias visual attention. In this account, the task does not involve representing what the avatar can see, but rather relies on an attentional mechanism that codes the number of dots on one side of the display. The avatar's head orientation, like "the tip of an arrow", automatically shifts attention toward one side, creating conflict in incongruent trials. Supporting this claim, authors argue, when replacing the avatar with a simple arrow, the same interference effect was observed (Santiesteban et al., 2014). This would suggest that the original findings do not reflect mentalizing processes, but rather involuntary attentional shifts (Heyes, 2014).

2.1.2.1.3 Shared intentionality account

Another more recently developed account is the shared intentionality account (Tomasello, 2018). According to this view, infants' success in implicit ToM tasks does not require an understanding of false belief. Rather, infants represent the epistemic states of agents, in the sense that they keep track of what others have seen, and thus what they know, and predict behavior accordingly. Crucially, this does not imply comparing the agent's knowledge with one's own (potentially conflicting) knowledge. In implicit tasks, it is sufficient to monitor what the agent has or has not seen and anticipate how this will guide behavior.

The developmental shift around age 4 corresponds to the ability to coordinate different perspectives. Tomasello distinguishes between subjective perspective (those of the agent and the child) and objective perspective (what is "really" the case). As the author points out, 3-year-olds do not respond randomly in false-belief tasks. Instead, they answer in line with their own perspective, which also corresponds to the objective situation (the "pull of the real"). Thus, they assume that others' behavior must be guided by reality, and they do not yet succeed in coordinating subjective and objective perspectives. To understand false belief, however, one

must recognize that another person's perspective may diverge from what is objectively the case. At age 3, children are in the process of conceptual development, but they are not yet able to compare and coordinate perspectives.

The shared intentionality provides the framework for this coordination. Through joint attention, children come to understand that they and a partner attend to the same object, but from different perspectives. Over time, this ability extends from objects to mental content. For instance, in conversation, children learn that the same proposition can be viewed differently, and that perspectives may conflict (e.g., "Your jacket is on the coatrack." / "No, it's not."). Such interactions foster the construction of an objective perspective (often expressed linguistically as factual statements) that can be distinguished from both self and other. Children gradually coordinate three perspectives (their own, the partner's, and the objective one) and realize that some perspectives are inaccurate, while others may be compatible (e.g., "animal" and "dog" can be used for the same referent).

In this view, the acquisition of false-belief understanding the product of social interaction, joint attention, and linguistic exchanges. Joint attention and communication allow children to coordinate perspectives with others, and thereby gradually construct their ToM.

2.1.2.2 Mentalistic accounts

2.1.2.2.1 Early competence

Authors defending the early competence (or continuity) account (Baillargeon et al., 2010; Carruthers, 2013; Luo & Baillargeon, 2010) argue that the differences in performance in false belief tasks between infants and preschool-aged children lie in the task itself, and specifically, in the executive and attentional demands of traditional false belief measures (Carruthers, 2013). Not all (Luo & Baillargeon, 2010), but some authors supporting this view share arguments with the nativist, modular account of ToM (Carruthers, 2013). Indeed, Fodor argues that children's failure in false belief tasks is simply a reflection of limited problem-solving abilities (Fodor, 1983; Schlicht, 2023).

Baillargeon developed a *response* account to explain the paradox (Baillargeon et al., 2010; Scott & Baillargeon, 2009). According to this view, false belief tasks require the child to engage in three different processes: a) represent the false belief; b) access this representation and select a response; and c) inhibit their own knowledge of the situation. The explicit, verbal versions of

the false belief task require children to go through all three steps, whereas the spontaneous versions require only the first one. Therefore, explicit and implicit ToM would reflect the same innate ability, with traditional tasks masking children's capacity to attribute false beliefs (Baillargeon et al., 2010; Carruthers, 2013; Hughes & Devine, 2015).

According to some authors defending this account, the classical false belief question (e.g., "Where will Max look for the chocolate?") can in fact assess three different things: a) do you know where the chocolate is? b) do you know what Max knows? and c) can you help Max find the chocolate? (Carruthers, 2013; Schlicht, 2023). Authors argue that the performance observed in children before age 4 or 5 reflects the fact that they are very likely to interpret the question in the third way. This, according to the authors, is in line with the helping behavior observed in infants and suggests that their responses may reflect more a lack of language or executive abilities than a lack of false belief understanding (Carruthers, 2013).

2.1.2.2.2 Implicit versus explicit

Some authors distinguish between two *forms* (Hughes & Devine, 2015) of knowledge, including an implicit and an explicit form (Clements & Perner, 1994). For instance, Perner & Roessler (2012) argue that explicit knowledge is deliberate and involves representing a regularity (e.g., "if x, then y") at a conscious, declarative level. Implicit knowledge, on the other hand, is procedural and does not rely on representing the regularity itself, the response is automatic and unconscious. According to the authors, infants may respond appropriately to others' beliefs without consciously representing them (Perner & Clements, 2000; Perner & Roessler, 2012).

They argue that failure before age 4 in classic false belief tasks can be explained by three main factors. In such task, a) children must interpret behaviors as intentional actions. In Maxi's case, predicting where he will look involves inferring his reason for acting. b) This requires distinguishing between objective reasons (e.g., looking where the chocolate actually is, the green cupboard), and subjective reasons (e.g., looking where Maxi believes it is, the blue cupboard). The ability to attribute subjective reasons depends on understanding that what makes sense from Maxi's perspective may differ from reality. c) The capacity to represent multiple perspectives, including others' subjective points of view, only emerges around age 4.

In contrast, infants' looking behavior in spontaneous tasks may be explained by what the authors call *experiential records*, namely that infants track what the agent has or hasn't experienced (seen), and this record is activated when the agent returns. At that moment, infants

recall what the agent saw and use that to anticipate future actions. This mechanism does not require finding practical reasons or justifying the agent's action, unlike in explicit tasks.

2.1.2.2.3 Dual system

The two-systems account was developed by Apperly and Butterfill (Apperly & Butterfill, 2009; Butterfill & Apperly, 2013; De Bruin & Newen, 2014). The general idea is that early implicit and later explicit ToM rely on different cognitive processes. This view aligns with the dual-process theory proposed by Kahneman (2011) and echoes other two-systems models applied to belief understanding (e.g., Call & Tomasello, 2008). In this framework, implicit ToM is fast, automatic, unflexible, and unconscious, whereas explicit ToM is slower, controlled, flexible, and conscious (Apperly & Butterfill, 2009).

This distinction resembles what has been observed in numerical cognition: infants show early sensitivity to numbers, while more flexible mathematical abilities develop later through learning (Apperly & Butterfill, 2009). Similarly, we would have two systems for belief reasoning. The first system would be especially useful in real-time interactions, such as communication or strategic decision-making (Sperber & Wilson, 1986), while the second system would enable justification and reasoning about behavior, for instance in legal or moral contexts. Crucially, the second system is associated with general cognitive resources, such as working memory and language, supported, according to the authors, by findings showing that explicit ToM performance is affected by cognitive load (Bull et al., 2008; Newton & De Villiers, 2007).

To explain infants' success in implicit tasks, the authors propose a "minimal" ToM. (Butterfill & Apperly, 2013). This theory contrasts with a "full-blown" ToM (Hughes & Devine, 2015) that involves representing propositional attitudes (beliefs, desires, intentions), providing causal explanations of actions, and justifying behavior. Instead, minimal ToM allows for tracking of certain belief-like states without fully representing them as such. The model is based on four principles. First, agents are seen as goal-directed, in the sense that specific patterns of action (e.g., reaching) are associated with specific outcomes (e.g., obtaining food), without requiring deep understanding of intentions. Second, agents can only act on objects they have encountered, what is outside their field of perception does not exist for them. Third, objects are registered in the location where they were last seen: if the agent didn't witness the displacement, they will still register the object at the original location. Fourth, agents act based on these registrations,

even when they are no longer accurate. These principles allow predictions of others' behavior based on what they have seen, without requiring the full concept of beliefs.

Infants would succeed in implicit ToM tasks because they would rely on minimal, belief-like tracking rather than a full conceptual understanding of mental states. Since explicit belief reasoning relies on language and more general cognitive demand, it is not yet available to infants. Thus, Apperly and Butterfill argue that passing classical false belief tasks requires explicit, linguistically structured judgments, which only become available around age 4 or 5.

2.1.3 The replication crisis

Even after numerous theoretical accounts, the developmental paradox remains highly debated. Some authors acknowledge that the available evidence is insufficient to conclusively confirm or reject competing theories, and very few offer explanations broad enough to account for the full range of empirical findings across infancy, childhood, and adulthood.

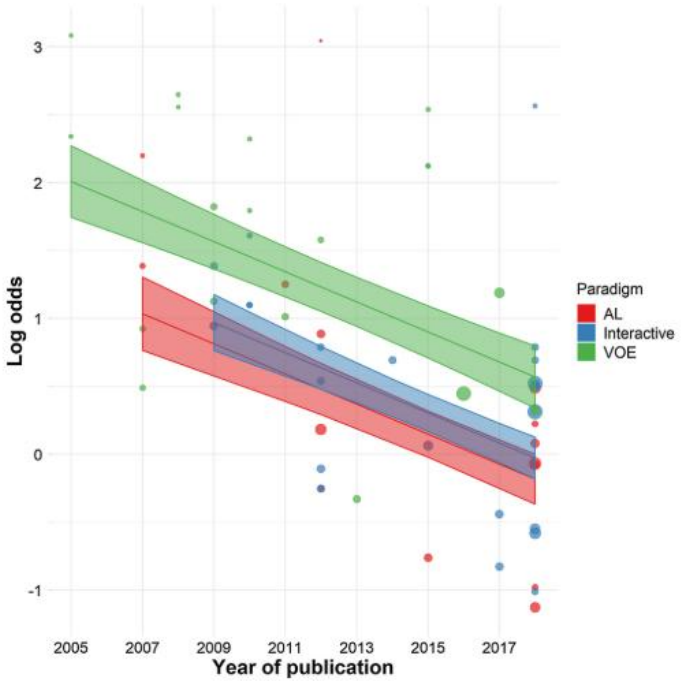


Figure 6. Log odds of correct performance depending on the year of publication for the anticipatory looking, the interactive or the violation-of-expectation paradigms. Figure from Barone et al., 2019.

In addition, a challenge for implicit ToM in young children has been the replication crisis (Kulke & Rakoczy, 2018). In a large-scale replication study, the authors highlighted

inconsistencies between the original AL papers and the ones that followed. Building on this, a meta-analysis examined the robustness of the three most widely used implicit ToM paradigms in infants (Barone et al., 2019). This meta-analysis included 33 studies with 1469 infants (approximately 20 months) tested with VOE, AL, or interactive tasks (e.g., helping behaviors), and considered moderators such as age and paradigm type. Results revealed a significant effect of paradigm (Figure 6). VOE yielded the strongest and most reliable results, interactive tasks showed weaker but still significant effects, while AL paradigms produced no consistent effect. These findings suggest substantial variability across studies, with VOE emerging as the most robust measure.

2.2 Comparing implicit and explicit ToM: empirical evidence from infants, children, and adults

In recent years, to decide between competing theoretical accounts, many studies have examined the relation between implicit and explicit ToM across development. Adult evidence, where explicit ToM is fully established, asks whether implicit processes still contribute, and whether they dissociate from explicit ToM. Moreover, developmental evidence, especially longitudinal, asks whether infant implicit ToM predicts later explicit ToM. For instance, the early-emergence account expects continuity between implicit and explicit ToM, whereas the two-systems and submentalizing accounts predict relative independence (for different reasons). The following section reviews evidence testing these predictions in adults and children.

2.2.1 Adults' ToM

After investigating spontaneous processes in infants, some studies tested whether this process also occur in adults. Indeed, adults need a fast automatic system to navigate through social interactions (Apperly & Wang, 2021). Their verbal and non-verbal communication seems to require keeping track of what people know and think, and lack of effort and speed observed in everyday communication suggest that social inferences are quick and efficient (Wilson & Sperber, 2002). However, the use of indirect, non-verbal, and spontaneous measures of ToM in adults remains limited. Below, I review evidence of spontaneous ToM in adults.

2.2.1.1 The ball detection paradigm

A widely used paradigm for studying spontaneous mentalizing in adults is the *ball detection task* (Kovács et al., 2010). It was designed to test whether an agent's simple presence is enough

to trigger automatic belief-tracking in participants, even though that belief is of no use for completing the task. In the original version (Kovács et al., 2010), participants completed a visual detection task involving short animated videos. Each video began with an agent (a Smurf) placing a ball on a table, in front of an occluder. The scenarios then varied depending on two elements: (a) whether the ball remained behind the occluder or left the scene, and (b) whether the agent left before or after the ball's final position was determined. This created four belief conditions: 1) P+A+ (both the Participant and the Agent believe the ball is present); 2) P+A− (only the Participant believes the ball is present); 3) P−A+ (only the Agent believes the ball is present); and 4) P−A− (none of them believe the ball is present). At the end of the video, the occluder felt on the table and revealed that the ball was either present or absent. Participants were instructed to press a key as soon as they saw the ball and to press a separate button when the agent left the scene (used as an attention check). Importantly, the agent's beliefs were never mentioned and were completely irrelevant to the task. As expected, participants responded faster when they themselves believed the ball would be present. Crucially, they were also faster in the P−A+ condition than in the P−A− condition. This effect, now commonly referred to as the *ToM index*, reflects the facilitating effect of the agent's belief on the participant's object detection. Indeed, faster responses in the P-A+ indicates that the positive belief of the agent about the ball's presence helped participants to be faster at indicating that the ball was present. Notably, this effect disappeared when the agent was replaced by a pile of boxes, suggesting that the belief attribution was not due to low-level visual cues (Heyes, 2014).

It has since been extensively adapted in studies with both typical and atypical populations, and offers several advantages, including the absence of ceiling effects and a continuous measure of mentalizing (Bardi, et al., 2017a; Bardi et al., 2019; Bardi, et al., 2017b; Boccadoro et al., 2019; Deschrijver et al., 2016; El Kaddouri et al., 2020; Hudson et al., 2021; Kovács et al., 2014; Low et al., 2020; Nijhof et al., 2016, 2018). Indeed, subsequent studies have replicated this ToM index. For example, Deschrijver et al., (2016) adapted the task to study spontaneous ToM in individuals with high-functioning autism (HFA). The Smurf was replaced by Buzz Lightyear from the cartoon *Toy Story*, but the task structure remained unchanged. The authors replicated the ToM index in neurotypical participants but not in individuals with HFA. Furthermore, the ToM index correlated with the severity of social autistic traits, supporting its reliability as a measure of spontaneous mentalizing.

The task has also been used to investigate whether implicit ToM relies on the same neural mechanisms as those involved in explicit ToM. Research using explicit false belief tasks has identified a *mentalizing network* involving, among other brain regions, the bilateral temporo-parietal junction (TPJ) and the medial prefrontal cortex (mPFC) (Amodio & Frith, 2006; Frith & Frith, 2003; Saxe, 2010; Saxe & Kanwisher, 2003). Some of the brain regions involved in ToM are presented in Figure 7.

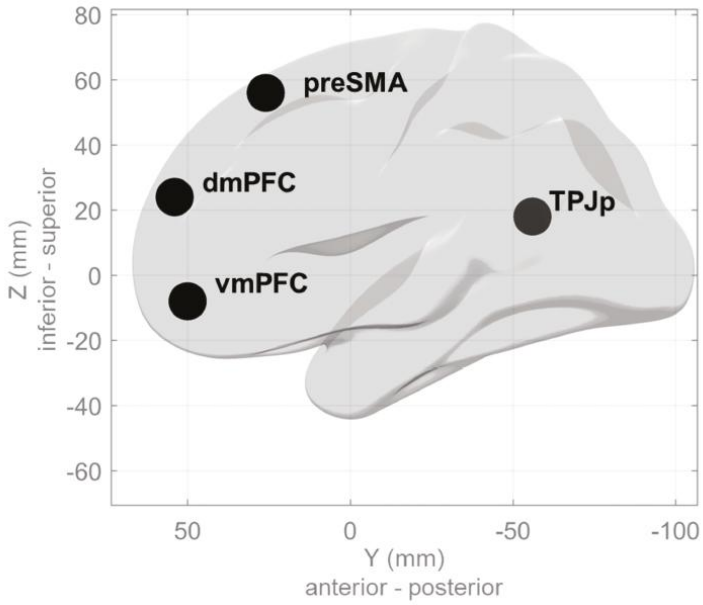


Figure 7. Some of the brain regions associated with theory of mind, including the posterior temporo-parietal junction (TPJp), and three medial prefrontal cortex clusters: the ventromedial prefrontal cortex (vmPFC), the dorsomedial prefrontal cortex (dmPFC), and the pre-supplementary motor area (preSMA). Figure from Golec-Staśkiewicz et al., 2024.

Using the implicit task, Kovács et al. (2014) found activation in both the TPJ and the mPFC, with stronger TPJ activity in false belief conditions compared to true belief conditions. This implication of the TPJ was further demonstrated in typical population (Boccadoro et al., 2019), but also confirmed in a study comparing brain activation between adults with HFA and controls (Nijhof et al., 2018). In the control group, the TPJ showed greater activation for false beliefs, a difference not observed in the HFA group.

To directly compare spontaneous and explicit ToM processing in a within-subject design, Nijhof et al. (2016) created an additional explicit version of the task. The only difference between them was the inclusion of catch questions on 20% of trials. In the implicit version, the

catch question was about the color of the cap of Buzz (which was now either blue or red), whereas in the explicit version the question was about the belief of Buzz concerning the ball's location. The ToM index was successfully replicated in both conditions, with no significant difference between them. Bardi et al. (2017a) extended this approach using fMRI and found overlapping neural activity in the TPJ which was more active for false beliefs than for true beliefs, regardless of task version (implicit or explicit). Activity in the mPFC was also observed, particularly when there was a VOE at the level of the participant's and the agent's beliefs. These results support a partial shared neural basis for implicit and explicit ToM.

Finally, because earlier versions of the task differed in timing across conditions, a factor that could have accounted for the effects (Phillips et al., 2015), the task was further modified so that the agent's departure occurred at the same time in every condition, and the timings were equal between all conditions and events (El Kaddouri et al., 2020). Despite this change, the storyline and belief manipulations remained unchanged. Results showed significant effects of both participant and agent beliefs, and a significant ToM index effect, providing thus a reliable task to assess spontaneous mentalizing in adults.

In summary, the ball detection task offers a reliable measure of spontaneous belief tracking. The ToM index has been replicated across numerous studies using the Buzz Lightyear version of the task (Bardi, et al., 2017a; Bardi et al., 2019; Boccadoro et al., 2019; Bardi et al., 2017b; Deschrijver et al., 2016; El Kaddouri et al., 2020; Hudson et al., 2021; Kovács et al., 2014; Low et al., 2020; Nijhof et al., 2016, 2018). Although some studies failed to replicate the effect when modifying task parameters or environments (Cheema et al., 2024; Phillips et al., 2015; Rothmaler & Grosse Wiesmann, 2023), the overall findings seem to be robust. Moreover, findings from adults seem to show an association between implicit and explicit ToM. Below I review further evidence from children's literature.

2.2.2 Evidence from preschoolers' literature

2.2.2.1 Infants' implicit ToM predicts preschoolers' explicit ToM: evidence from longitudinal data

This was followed by work focusing more directly on the predictive role of implicit ToM. The first longitudinal attempt to test whether early implicit ToM (for a review, see Sodian et al., 2020) predicts later explicit ToM followed children from 15 to 48 months (Thoermer et al., 2012). The study found that AL at 18 months significantly predicted performance on an explicit

false-belief location task at 48 months, although this link was absent for the false-belief content task. These findings were interpreted as evidence for developmental continuity (Baillargeon et al., 2010). Subsequent studies reported similar results, namely that implicit ToM at 18 months predicted false belief reasoning about moral transgressions at age 5 (Sodian et al., 2016), and false belief understanding at ages 4 to 5 (Kloo et al., 2020).

In contrast, other longitudinal studies failed to replicate such associations (Poulin-Dubois et al., 2020, 2023). For example, infants' performance on VOE and helping tasks at 14–18 months did not predict later explicit false-belief understanding at 4–5 years (Poulin-Dubois et al., 2020). These results, however, must be interpreted with caution, since neither the infant (implicit) nor the preschool tasks (explicit) reproduced the earlier findings (for a discussion, see Sodian, 2023).

Taken together, these mixed findings do not settle the debate but provide some support for the continuity account, while also highlighting the need for further evidence. In addition, much less is known about the developmental course of implicit ToM itself. Studies assessing implicit ToM beyond infancy remain scarce (Clements & Perner, 1994; Grosse Wiesmann et al., 2017; Low, 2010; Speiger et al., 2025), with the majority of the literature focusing either on infants or on adults. Thus, although longitudinal findings suggest possible links between implicit and explicit ToM, the trajectory of implicit ToM after the age of 2 remains unclear. In the next section, I review studies that directly assess how implicit and explicit ToM interact in preschool and school-aged children.

2.2.2.2 Assessing both implicit and explicit ToM in preschool and school aged children

Evidence in favor of the two-systems account has recently been provided. For instance, Grosse Wiesmann et al. (2017) tested 3- and 4-year-olds on AL and explicit false-belief tasks. Both age groups succeeded on the implicit tasks, but only 4-year-olds passed the explicit ones. Importantly, the authors report no correlation between implicit and explicit ToM. Extending this behavioral dissociation to the neural level, a recent study examined cortical markers (thickness and surface area) supporting implicit and explicit ToM in 3- to 4-year-olds (Grosse Wiesmann et al., 2020). Children completed an AL task to assess implicit ToM, classic false-belief tasks for explicit ToM, and underwent MRI scanning. Whole-brain correlations between performance and cortical structure revealed distinct neural patterns for the two types of ToM. Explicit ToM was associated with surface area in the right precuneus and right TPJ and with

cortical thickness in the left posterior middle temporal gyrus and precuneus, regions consistent with those found in adult explicit ToM. In contrast, implicit ToM was linked to surface area in the right supramarginal gyrus and thickness in a more dorsal portion of the left precuneus. Notably, no overlap between the two sets of regions was observed.

In contrast, other findings suggest continuity between implicit and explicit ToM. In preschoolers aged 3 and 4, gaze responses in an AL task significantly predicted explicit answers to false-belief questions (Low, 2010). Moreover, a large-scale longitudinal study tested children at ages 2, 3, and 4 using the same AL paradigm and explicit false belief tasks, and reported a trend toward a positive relation at age 3 and a significant association at age 4 (Kaltefleiter et al., 2022).

Similarly, a longitudinal study examined how implicit ToM develops between 2 and 4 years of age using an AL task (Grosse Wiesmann et al., 2018). Children correctly anticipated where an agent with a false belief would search only from age 4, but not at ages 2 or 3. Notably, this coincides with the age at which children typically begin to succeed on explicit false-belief tasks. Moreover, the study found a relation between implicit and explicit measures, although the association lacked robustness between the different measures of implicit and explicit ToM.

2.2.2.3 The altercentric bias

A novel line of research has examined implicit ToM through the phenomenon of the *altercentric bias*. This bias is defined as the tendency for another's perspective to interfere with our own cognitive processing (Kampis & Southgate, 2020). For instance, it has been shown that when others' perspectives differ from our own, this can alter our performance, even when processing them is not required (a process very similar to the one observed in the ball detection task). Prior findings suggest that altercentrism follows a U-shaped trajectory: present in infancy (Southgate, 2020), it tends to disappear in childhood before re-emerging in adulthood (Fogd et al., 2024, 2025; Manea et al., 2023).

Children aged 3 to 5 participated in the sandbox task. In this task, an experimenter first hid an egg in a sandbox and then left the room. A second experimenter moved the egg to a new location. When the first experimenter returned, he engaged the child in a distraction task before asking them to retrieve the hidden object. In the false belief condition, the first experimenter had an incorrect belief about the egg's location. In the true belief condition, he had witnessed the relocation. Altercentric bias was operationalized as the difference in children's deviation

from the correct location between the false and true belief conditions. More specifically, children with a larger bias would deviate more from the correct location in false than in true belief, specifically toward the location the agent falsely believed to be correct. Children also completed a classic explicit false belief task. The overall sample showed no significant altercentric bias. However, once explicit ToM performance was taken into account, it appeared that only children who passed the explicit task showed an altercentric bias, while those who failed did not. In a subsequent experiment, the task order was reversed, with children completing the explicit ToM measure after the sandbox task. Under these conditions, the altercentric bias disappeared, suggesting the presence of such bias only when beliefs are made salient first (Speiger, Rothmaler, Bravo, et al., 2025; Speiger, Rothmaler, Liszkowski, et al., 2025).

These findings suggest that altercentric interference in preschoolers arises only in children who succeed at explicit ToM reasoning, and only when belief-related reasoning is activated beforehand. This suggests a close link between implicit and explicit ToM and tends to confirm the U-shaped trajectory of this bias.

In this section, I reviewed evidence from implicit ToM paradigms across infancy, adulthood and childhood. Because several findings can be accommodated by competing accounts, no single framework is decisively supported. On one hand, direct assessments of implicit ToM in children beyond preschool remain scarce, with most studies using tasks developed for infants. On the other hand, studies on the altercentric bias suggest a substantial variability between individuals (Fogd et al., 2024). These gaps motivate a closer investigation of contextual moderators and individual differences. The next section therefore examines how cognitive and linguistic factors can influence both implicit and explicit ToM development.

3. The role of language and executive functions in ToM

As children develop their ToM skills, they also gradually construct their language and executive functions (EF) abilities. These two factors have consistently been identified as central to explicit ToM development. However, while studies have mostly investigated the role of these processes in explicit ToM, their contribution to implicit ToM remains poorly understood. Consequently, in most studies, ToM tacitly refers to explicit ToM. In the next section, I first review theoretical accounts and empirical evidence of how language and EF support explicit ToM development, followed by evidence of their possible contribution to implicit ToM**.**

3.1 Language, EF, and explicit ToM

3.1.1 Language and explicit ToM

Language has often been described as a key mechanism for the development of explicit ToM. In the next section, I first describe theoretical accounts of the link between language and explicit ToM, and then considers evidence from two main approaches, including training studies and correlational studies.

3.1.1.1 Theoretical accounts and specific language components involved

On one side, some theorists argue that the association between ToM and language is only superficial. For instance, modular theorists (as described in the section 1.2.5) argue that both abilities are linked only because of the verbal demands of classic false belief tasks (Bloom & German, 2000). On the other side, other authors claim that language does play a fundamental role in ToM. According to Astington & Baird (2005), the nature of language can be decomposed into different facets, which have different implications in explicit ToM. These are described in Table 1.

Functions			**Structures**	
Representation (verbal thoughts)	Communication (discourse)		Language in general	Mental terms
	Pragmatics	Linguistic environment	Semantics	Syntax

Table 1. Implications of language in explicit theory of mind. From Astington & Baird, 2005.

More recently**,** De Villiers & De Villiers (2014) described the three classes of arguments that have been put forward to explain the language–explicit ToM link. 1) According to the first class of argument, this association is explained by the content of explicit ToM itself. Hearing mental states terms would allow children to learn labels for the mental state that they, and others, experience (e.g., *want, like, think*). By mapping observed behavior onto mental-state terms, children would gain access to other people's mental states and their own. This view aligns with findings that children who grow up in families where talk about mental states is frequent are better at understanding others' intentions, desires, emotions and beliefs (Dunn & Brophy, 2005). 2) According to the second class of arguments, this association is explained by conversations. Specifically, it is argued that engaging in conversations provides many cues to the interlocutors' mental states, even without explicit mental-state terms. For instance, if one speaker says, "Look at the lizard!", and the other replies, "It's a salamander!", understanding the exchange requires inferring that the first speaker holds a mistaken belief, which is recognized and corrected by the second (de Villiers & de Villiers, 2014). To understand the conversation, we must therefore infer mental states even when they are not explicitly stated. Thus, conversations help identify mistaken beliefs and, more broadly, attitudes toward the world, as hearing two different perspectives on the same event helps children appreciate that multiple perspectives can coexist (de Villiers & de Villiers, 2014; Harris, 2005). 3) According to the third class of arguments, this association is explained by children's own language abilities. For instance, grammatical abilities, especially mastery of embedded complement

clauses which include mental state terms (e.g., “He thought that the animal was a lizard, but it was really a salamander”), enable children to represent differences between perspectives. Mastery of mental-state verbs and embedded clauses gives children the resources to reason about other people’s minds (de Villiers & de Villiers, 2009) as this type of sentence allows children to distinguish between mental states and reality (Hale & Tager-Flusberg, 2003; Lohmann & Tomasello, 2003).

3.1.1.2 Evidence of the association

3.1.1.2.1 Training studies

Training studies have also been informative about the link between language and explicit ToM (Lohmann & Tomasello, 2003; Sellabona et al., 2013). Many of these interventions explicitly include language (for a review, see Hofmann et al., 2016), for example by exposing children to mental state vocabulary (Guajardo & Watson, 2002; Ornaghi et al., 2011) by engaging them in rich conversations where mental states are explicitly labeled (Slaughter & Gopnik, 1996). This allows then to assess the causal role that language plays in explicit ToM.

For instance, training studies showed that providing training on sentential complements with mental-state verbs used to describe a deceptive object (particularly useful to understand that one object can be seen and understood differently according to different perspectives) improved 3-year-old children explicit ToM abilities. In addition, the simple fact of exposing children to narration including sentential complements (without the deceptive object) improved children’s explicit ToM, whereas the mere experience of deception without language was not sufficient to improve their abilities (Lohmann & Tomasello, 2003). Comparable results were found in another training study with preschoolers who initially failed both false belief and complement-clause tasks. Children trained on sentential complements improved significantly in false belief reasoning, while children trained directly on false belief tasks also improved, but without corresponding gains in complement syntax. This suggests that complement syntax facilitates explicit ToM development, though it may not be strictly necessary, and that the relation is likely unidirectional rather than reciprocal (Hale & Tager-Flusberg, 2003). Other studies have also shown that explicit ToM could be improved by using discussions or narratives training that highlights mental states from various age range and populations (Bianco et al., 2016; Guajardo & Watson, 2002; Lecce, Bianco, et al., 2014; Nash, 2001; Ornaghi et al., 2011).

3.1.1.2.2 Longitudinal evidence and meta-analysis

Numerous studies have documented a link between language abilities and explicit ToM across development (Astington & Baird, 2005; de Villiers & de Villiers, 2014). Longitudinal studies have also assessed the direction of the association and have shown that early language predicts later explicit ToM, whereas the reverse is less consistently supported (Astington & Jenkins, 1999; de Villiers & Pyers, 2002; Ruffman et al., 2003). Nonetheless, some studies do report bidirectional associations (e.g., Ebert, 2020; Slade & Ruffman, 2005). For instance, Ebert (2020) followed 231 children from preschool to adolescence across four testing sessions to examine the longitudinal associations between language, explicit ToM, and later reading abilities. Results showed that language abilities at age 3 predicted growth in explicit ToM from preschool through adolescence. Conversely, explicit ToM at age 5–6 predicted later vocabulary growth (from 5 to 12 years).

A meta-analysis of 104 studies further quantified this relation (Milligan et al., 2007). The authors found a moderate-to-large association between language and explicit ToM. All facets of language examined (general language, semantics, receptive vocabulary, syntax, memory for complements) were significantly related to false-belief performance, though variation in effect size emerged across measures (e.g., receptive vocabulary showed weakest effect sizes compared to general language). Importantly, analyses of directionality indicated that language more strongly predicted explicit ToM than explicit ToM predicted language, even though both directions were significant.

Taken together, these studies provide strong evidence for a systematic link between language and explicit ToM development. The association appears particularly robust when general language abilities are measured, and there is growing support for a reciprocal, though asymmetric, relation over time. It also appears that all theoretical accounts have received substantial empirical support, suggesting that different facets of language each contribute to the development of explicit ToM (de Villiers & de Villiers, 2014).

3.2 Influence of EF

The other variable frequently found to correlate with explicit ToM is EF, with numerous studies finding a link between the two across development. In the following section, I provide a definition of EF and their core components, I then briefly review the five theoretical accounts

proposed to explain the association between explicit ToM and EF, and finally describe empirical findings that support the different theoretical accounts.

3.2.1 Definition of EF

EF are a set of high-level cognitive processes that enable individuals to deliberately regulate their thoughts and actions in order to achieve goals (Diamond, 2013). In a seminal model, Miyake et al. (2000) proposed three core components of EF: updating, shifting, and inhibition. These components are now commonly referred to as working memory, cognitive flexibility, and inhibitory control. Working memory refers to the ability to hold information in mind while mentally manipulating it (Diamond, 2013). It also involves updating this information dynamically by replacing it with new, relevant information. Cognitive flexibility is defined as the capacity to switch between tasks, rules, or strategies in response to changing demands (Diamond, 2013). It allows individuals to adapt their approach to a problem or adjust to new instructions. Finally, inhibitory control refers to the ability to resist external distractions or automatic responses in order to produce an appropriate response in situations involving conflict (Diamond, 2013). It enables individuals to suppress impulsive behaviors and override automatic or dominant responses when necessary (Diamond, 2013; Miyake et al., 2000).

3.2.2 EF and explicit ToM

3.2.2.1 Theoretical accounts

Five accounts have been described by Perner & Lang (1999) in order to explain the explicit ToM-EF relation. The first account posits that EF are a prerequisite for explicit ToM (Carlson & Moses, 2001). According to this view, the development of explicit ToM requires self-awareness, which in turn requires self-monitoring (a component of EF) (Russell, 1996). Beyond self-monitoring, inhibitory control and cognitive flexibility are thought to be necessary to shift between perspectives and to inhibit one's own perspective when required to consider another's. Thus, the rationale behind this view is that without EF skills, the development of explicit ToM would not be possible.

The second account proposes the opposite view, namely that EF depend on explicit ToM (Lang & Perner, 2002). According to this view, the ability to represent both one's own and others' mental states enables the control of thoughts and behaviors (Wimmer, 1989). As children gradually come to understand that mental states underlie behavior (i.e., develop meta-

representational thinking), they begin to use this understanding to regulate and control automatic responses, a process referred to as meta-representational control (Lang & Perner, 2002; Perner & Lang, 1999; Wade et al., 2018). Understanding that mental states influence behavior would lead to the insight that mental states themselves can be intentionally regulated to guide action. Both the first and second accounts therefore propose a functional relation between explicit ToM and EF (Perner & Lang, 1999).

The third view considers EF to play a peripheral role in explicit ToM (a similar position has been proposed for language, as discussed in the previous section). Authors argue that success in false belief tasks depends on certain EF abilities. For instance, they need to hold relevant information in memory, track changes in the scenario, and inhibit their own perspective to adopt that of the other agent (Russell et al., 1991). From this perspective, the observed link between EF and explicit ToM is attributed to the executive demands of the tasks themselves, and is thus considered incidental (Perner et al., 2002).

The fourth view is known as the *cognitive complexity and control* (CCC) theory. This account argues that the observed link between explicit ToM and EF is due to overlapping conceptual demands. Both types of tasks (those assessing EF and those assessing false belief understanding) would require formulating embedded conditional rules (if–if–then; Frye et al., 1995). According to this account, if a task does not require such complex rule-based reasoning, there should be no link between EF and explicit ToM. This hypothesis specifically applies to the dimensional change card sort (DCCS) task (Zelazo, 2006). In this task, children must sort cards depending on specific rules (i.e., sort card by color or shape). The conditional logic is the following: *If* the rule is to sort by color, and *if* the card is blue, *then* it goes with the blue flower target. Authors argue that a similar logic is applied in false belief tasks: *If* I must answer from Max's perspective, and *if* he is looking for the chocolate, *then* he will search in the green cupboard (Perner & Lang, 1999).

Finally, the fifth account suggests that EF and explicit ToM share common neural substrates and influence each other mutually (Brownell et al., 2000)**.** Authors supporting this view argue that EF and explicit ToM activate similar brain regions. According to this perspective, EF and explicit ToM rely on a shared neural architecture (Wade et al., 2018), which should be reflected in a bidirectional relationship between them at the behavioral level as well (Austin et al., 2014).

3.2.2.2 Empirical evidence of the association

3.2.2.2.1 Behavioral associations

The association between EF and explicit ToM is well documented. A substantial body of evidence shows that the two are linked in the preschool years (Carlson et al., 2002; Hughes, 1998) and, although the findings are less extensive, also in middle childhood (Lagattuta et al., 2010; Miller et al., 2018). Longitudinal studies are particularly informative for testing the direction of this relation. Some have reported that explicit ToM or early social cognition predicts later EF development, consistent with the view that explicit ToM is necessary for EF development (Mcalister & Peterson, 2013; Wade et al., 2016). Nevertheless, most of the longitudinal evidence suggests the opposite pattern, namely that EF support subsequent explicit ToM development between ages 2 and 5 (Carlson et al., 2004; Doenyas et al., 2018; Flynn, 2007; Marcovitch et al., 2015; Müller et al., 2009). Concerning the bidirectional association hypothesis, training studies in children showed that interventions targeting false belief have improved EF, whereas EF training has enhanced both EF and explicit ToM (Kloo & Perner, 2003). Yet, since explicit ToM training did not improve explicit ToM performance, these results remain difficult to interpret (Devine & Hughes, 2014; Moses & Tahiroglu, 2010). Some longitudinal studies have further indicated a bidirectional association between EF and explicit ToM (Austin et al., 2014; Hughes & Ensor, 2007), although support for an influence of explicit ToM on EF remains weaker than for the reverse direction. Beyond the preschool years, longitudinal findings are fewer but still informative. For instance, working memory has been found to predict explicit ToM growth, over and above inhibitory control, in children aged 9–10, whereas explicit ToM did not predict working memory over time (Lecce et al., 2017). Conversely, an opposite pattern has also been reported in preschoolers, where inhibitory control was associated with explicit ToM whereas working memory was not (Carlson et al., 2002).

In addition, a meta-analysis showed a significant association between explicit ToM and EF (Devine & Hughes, 2014). While the association also showed some variations between the EF tasks employed, all tasks showed a significant correlation with false beliefs, ranging from small to moderate effect sizes. Moreover, the direction of the association was asymmetric. Specifically, longitudinal studies showed that early individual differences in EF predict later variation in explicit ToM, but early individual differences in explicit ToM did not predict later variation in EF.

Taken together, the literature points to a reliable link between EF and explicit ToM (but see Devine et al., 2016, for null longitudinal results in middle childhood). Overall, the weight of the evidence seems to support the hypothesis that EF are necessary for explicit ToM development, even though some degree of bidirectional interdependence cannot be completely ruled out (Perner & Lang, 2000).

3.2.2.2.2 Brain associations

Data from the neuroscience field, and in both clinical and typical individuals is also revealing (Perner & Lang, 2000). Considering the first theoretical account, it is hypothesized that if EF are a prerequisite for explicit ToM, then developing explicit ToM should not be possible if EF are impaired. There is evidence that impaired EF is associated with impaired explicit ToM in adolescents and adults (Gökçen et al., 2016). Moreover, training EF in children with autism aged 6 to 15 was shown to improve their explicit ToM abilities (Fisher et al., 2005). In addition, conversation-based training studies showing that improvements in explicit ToM are predicted by initial level of EF (Gao et al., 2020). However, there is also evidence that EF can be impaired, for instance in children with ADHD while their second-order explicit ToM is not (e.g., Perner et al., 2002).

Considering the second view, according to which explicit ToM supports the development of EF, the amount of evidence is sparser. While shared impairments have been evidenced in autistic population, as already suggested (Joseph & Tager–Flusberg, 2004), there is also evidence showing that explicit ToM can be impaired without EF impairments in autism (Pellicano, 2007). However, while behavioral longitudinal data seems to contradict this view (Devine & Hughes, 2014), recent resting-state fMRI data from a longitudinal study from birth to 2 years old showed that the functional brain network associated with ToM (namely, the default mode network) matured faster than the networks associated with EF (namely the frontoparietal and salience networks) (Gao et al., 2015). This finding could indicate that explicit ToM supports the development of EF, but as the authors suggest, this requires further investigation (Wade et al., 2018). Finally, the fifth view is supported by fMRI data showing that while EF and explicit ToM show specialized networks, there is also partial overlap between these networks (e.g., the mPFC and the left TPJ, Saxe, 2006).

To conclude, behavioral and neural studies indicate that the first account (EF as a prerequisite for explicit ToM) has received substantial support. Task demands may modulate the strength

of the observed link, but they cannot fully account for it. At the same time, neuroimaging findings suggest some degree of bidirectionality, with overlapping networks involved in both domains. Overall, the evidence highlights the fundamental role of EF in explicit ToM development, with contributions from multiple EF components rather than a single one.

3.3 EF and language influences on implicit ToM

While previous research has largely focused on explicit ToM, much less attention has been given to the possible associations between implicit ToM and domain-general abilities such as language and EF. In children, this relationship remains underexplored and highly debated. Indeed, although the factors contributing to individual differences in explicit ToM are well documented, it is still unclear whether these factors also play a role in implicit ToM (Roby & Scott, 2018).

One reason for this lack of investigation is that implicit ToM has been demonstrated in infants, who have not yet fully developed their language or EF skills. Thus, implicit ToM should not depend on these capacities. Supporting this view, the two-system account (Apperly & Butterfill, 2009) suggests that the implicit system operates automatically, unconsciously, and with limited flexibility, and is thought to function independently of language and executive processes. In fact, implicit ToM tasks were specifically designed to demonstrate mental state understanding in populations without fully developed language or EF abilities, such as infants.

In addition, in everyday social interactions, particularly in conversations, adults often interpret others' mental states quickly and without conscious effort. For instance, we resolve linguistic ambiguities to understand intended meaning in conversations almost instantly. This efficiency suggests that such processing might occur without the need for deliberate attention or cognitive control (Stone et al., 1998).

However, alternative perspectives challenge this view, with regard to EF and language, although the arguments differ for each domain. For EF, it has been proposed that online belief tracking may involve effortful processing and thus draw on some EF resources. Since our own perspective tends to dominate, adopting another person's point of view may require both time and cognitive effort (Lin et al., 2010). Additionally, monitoring others' beliefs in conversation has been shown to require attentional resources (Apperly et al., 2006). Therefore, even if spontaneous, mental state processing might still be cognitively demanding.

In contrast, the argument for language is more about experience and exposure. It has been suggested that participating in or observing conversations that involve mental state terms can increase children's attention to agents and their mental states. This exposure could make them more motivated to track such states, even when it is not strictly necessary. Furthermore, language may help children form associations between mental states and observable behaviors, thus supporting a deeper understanding of how internal states relate to actions (Meristo et al., 2012).

In the sections that follow, I review studies that have examined the relations between both language and EF and implicit ToM**.**

3.3.1 Language and implicit ToM

The first study to examine this link was conducted by Low (2010) with 3- to 4-year-old children. The study aimed to assess whether complex syntax (specifically complement clauses) was related to both implicit and explicit ToM. Results showed that performance in the implicit task was unrelated to language abilities, unlike both types of explicit ToM tasks, which were correlated with language. Moreover, a low-verbal explicit ToM task also correlated with language. This suggests that the relation between language and explicit ToM is not solely due to the verbal demands of the tasks, a conclusion supported by later studies (e.g., Šimleša et al., 2021).

A similar pattern was found by Grosse Wiesmann et al. (2017), who also used AL task and traditional explicit ToM tasks. Their results showed that language was significantly associated with explicit ToM, but not with implicit ToM. A replication of this study using a longitudinal design with children from 3 to 4 led to the same result (Kaltefleiter et al., 2022). In line with this, Kloo et al. (2020), also using a longitudinal design, found no correlation between early verbal abilities and implicit ToM.

However, studies including deaf children offer a different perspective. Meristo and colleagues (2012) examined whether early language access is necessary for developing implicit ToM. The study included deaf children of hearing parents, aged 17 to 26 months, and hearing controls. Both groups performed similarly in the true belief condition, but only hearing children correctly anticipated the agent's behavior in the false belief condition. Deaf children looked in the incorrect direction, suggesting that early access to language and communication is crucial for implicit ToM development. These results were replicated in children aged 4 to 8, showing

impairments in implicit ToM (Meristo et al., 2016). Interestingly, when pooling data from both studies, a developmental trend emerged. Among deaf children, younger participants consistently looked in the wrong direction, while older ones looked at both locations, suggesting a transitional phase in implicit ToM development. Moreover, vocabulary was significantly correlated with both implicit and explicit ToM across the full sample, suggesting that early communicative experience supports both systems.

Further evidence for a causal role of language in implicit ToM was provided by a training study by San Juan & Astington (2017). Three-year-old children who failed explicit false belief tasks were assigned to one of three training groups: 1) a control group with no epistemic language, 2) a group exposed to common epistemic verbs (e.g., "think"), and 3) a group using contrasting invented verbs to highlight belief contrasts. After training, only the two epistemic groups showed significant improvements in implicit ToM, as measured by looking behavior. Importantly, language abilities were associated with better post-training performance in implicit ToM. However, training on epistemic language was not sufficient to improve explicit ToM, thus the results might be taken with caution.

In addition, language may help children cope with cognitive demands in ToM tasks. When belief reasoning requires resolving ambiguity, only children with higher verbal abilities succeed in implicit ToM tasks (Scott & Roby, 2015). Under high cognitive load, performance in implicit ToM decreased, suggesting that language may serve as a resource to support implicit belief tracking in demanding contexts.

Finally, Roby & Scott (2018), found that children aged 2.5 years whose parents used more cognitive mental state terms (e.g., "think", "know") were more likely to anticipate agents' behavior based on false beliefs in spontaneous looking tasks. Having an older sibling was also linked to better performance, suggesting the importance of social learning contexts.

In sum, although implicit ToM can emerge early and operate automatically, these studies suggest that language plays a facilitative role in its development and flexibility, particularly when tasks are ambiguous or when early language access and communication are limited.

3.3.2 EF and implicit ToM

The three studies described at the beginning of the previous section also included measures of EF. For instance, while cognitive flexibility was correlated with explicit ToM, no association

was found with implicit ToM in 3 to 4 years old children (Low, 2010). Similarly, no link was found between implicit ToM and either cognitive flexibility or inhibitory control in the same age range (Grosse Wiesmann et al., 2017). This was further confirmed by longitudinal data, showing that early implicit ToM was not related to either early or later EF abilities, whereas a clear correlation was found with explicit ToM performance (Kloo et al., 2020).

In contrast, in a study with 18-month-old infants, Yott & Poulin-Dubois (2012) used a VOE task to assess implicit ToM and a detour retrieval task to measure inhibitory control. In this task, children first observed the experimenter retrieving a toy from a box by using a knob on the side. When given the opportunity themselves, children were scored based on whether they used the same strategy, which required inhibiting the impulse to reach directly through a transparent window. Results showed that infants with better inhibitory control scores were also those who showed more surprise when the agent acted inconsistently with their belief in the VOE task. This suggests that children may use domain-general cognitive skills to overcome the reality bias and consider the agent's mental state.

A similar conclusion was reached in adults (Schneider et al., 2012). Participants completed a standard AL task involving true and false belief trials. To test the role of EF, the authors manipulated cognitive load. Participants were assigned to one of three groups: no load, low load, or high load. In the no load condition, participants simply watched classic videos used to assess implicit ToM. In the low load condition, they heard a stream of spoken letters but were not required to respond. This was designed to mildly engage executive resources by requiring participants to resist distraction. In the high load condition, participants performed a 2-back task with the same auditory stream, requiring active working memory engagement. Results showed that only participants in the no load condition successfully tracked both the object's location and the agent's belief. The low load group tracked only the object, and the high load group tracked neither. These results suggest that implicit ToM processing can be disrupted by executive demands, particularly those involving working memory.

Importantly, however, in both studies showing a link between EF and implicit ToM (Schneider et al., 2012; Yott & Poulin-Dubois, 2012), the target object remained hidden behind the last location. Thus, participants had to overcome a reality bias (the presence of the object interferes with their ability to take the perspective of the agent), which might have required participants to inhibit their own knowledge in order to consider the agent's belief (Grosse Wiesmann al., 2017). In contrast, studies that failed to find a link between EF and implicit ToM (Grosse

Wiesmann et al., 2017; Kloo et al., 2020; Low, 2010) typically removed the object from the scene at the end of the trial, possibly reducing the inhibitory demand. This suggests that the EF-ToM link may depend in part on the specific design features of the task, such as the presence or absence of conflicting reality cues.

Yet, as in the case of language, some researchers argue that the relation between EF and ToM is not simply due to task features. Carlson et al. (2015), for example, found that both high-demand and low-demand false belief tasks showed similar correlations with EF, suggesting a functional association between EF and belief reasoning, regardless of the task's executive load.

Overall, these findings support the idea that spontaneous belief reasoning, while not fully conscious or deliberate, could still requires cognitive effort and attentional resources. Beyond perspective taking, altercentric biased in adults has been shown to be sensitive to cognitive demand, can be quite flexible and rapidly updated in adults (Fogd et al., 2024, 2025).

In summary, although implicit ToM is often described as automatic and independent of language and EF, current evidence seems to be not sufficient to fully rule out the influence of such variables on implicit mentalizing. Moreover, most studies on typically developing children have been investigated either until age 4 (with the exception of one study which included deaf children aged until 8, Meristo et al., 2012), or in adults. Hence, how these variables interact beyond the preschool years remains largely unexplored.

4. Contextual influences on ToM

Another wave of studies examined the factors that might explain interindividual differences in ToM development (Hughes & Devine, 2015). Researchers have asked whether culture could influence ToM, which provides insights into its universal nature, but also whether the family environment plays a role. Within the family, factors such as parenting style, the presence of siblings, and the way parents interact and use mental state language have all been investigated. In addition, the social and economic resources available to the family have been identified as important predictors of ToM. These environmental and contextual influences are described in the following section. As with research on language and EF, studies of ToM almost always focus on its explicit dimension. Thus, the findings reviewed below concern explicit ToM (with few but some exceptions).

4.1 Culture and ToM

The role of cultural context in ToM development has been the focus of much research in recent years. Most studies distinguish between individualist and collectivist cultures, which differ in the values, social norms, and interaction styles that children are exposed to in daily life (Peterson & Slaughter, 2016). These cultural differences, such as how parents talk to children, which behaviors are encouraged, or how emotions are expressed, can shape both the timing and the way children begin to understand other people's thoughts and beliefs (Selcuk et al., 2023). Although some studies found little or no difference across cultures (Avis & Harris, 1991; Callaghan et al., 2005), later research revealed more complexity.

In their seminal meta-analysis about false belief development (Wellman et al., 2001), authors found a significant difference in the age at which children develop false belief depending on the country (Figure 8). Even though the different countries showed the same developmental trajectories, some countries performed better or worse in the false belief tasks (e.g., Canadian children performed better than Japan children), with Australian children being 69% correct against 40% for children from Japan at 44 months. This result was further confirmed by meta-analytic findings showing that despite the same developmental trajectories, significant differences in the age at which children pass false belief tasks can be observed between for instance children from Hong Kong and Canada, with Canadian children succeeding much earlier than those in Hong Kong (Liu et al., 2008).

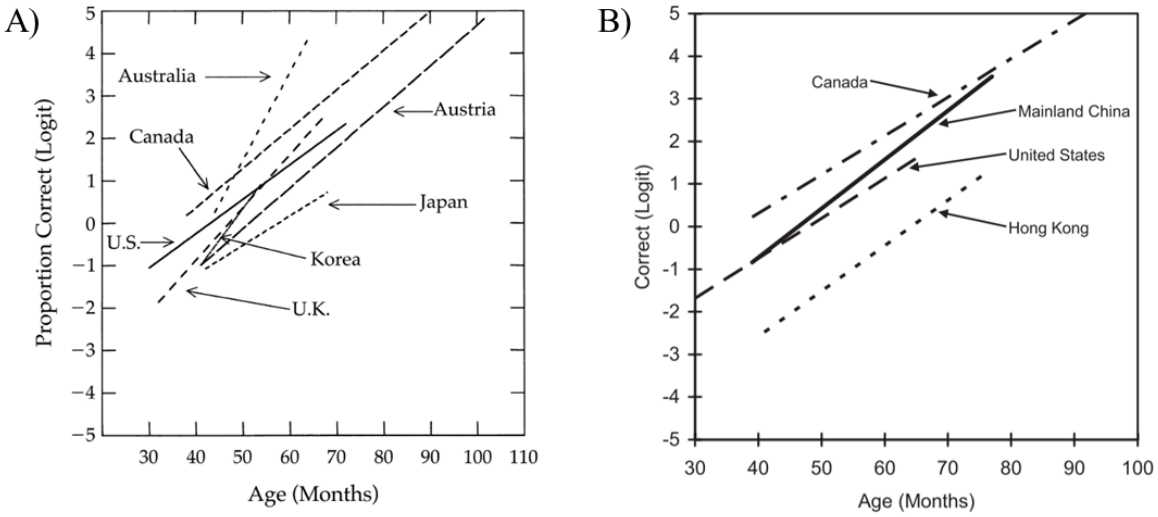


Figure 8. Developmental trajectory of false belief depending on the country. Figures from A) Wellman et al., 2001 ; B) Liu et al., 2008.

This difference is often compared in terms of individualist versus collectivist countries, which lead to slight differences in ToM (Selcuk et al., 2023).

To illustrating this, and to better capture the progressive development of ToM, authors proposed a broader scale with seven tasks, each representing a key step in ToM development (Wellman & Liu, 2004). These include understanding that a) people can have different desires, b) different beliefs, or c) that seeing leads to knowing (knowledge access), as well as d) recognizing false beliefs, e) predict behaviors accordingly, and finally, f) understanding that people can display an emotion that is different from what they really feel. Their study showed that 80% of children of the sample followed the same fixed order when acquiring these skills, in the order described (Wellman & Liu, 2004). However, follow-up studies using this scale found that while American and Chinese children followed similar developmental sequences, the order of some steps differed slightly (Wellman et al., 2006). Results showed that Chinese children tended to understand knowledge access earlier than diverse belief, while it was the reverse for American children. This pattern was replicated between children from Iran and Australia, with Iranian children showing the same developmental sequence as Chinese children, and Australian children showing the same developmental sequence as American children. This suggests that cultural values may shape the way children develop ToM. For instance, in Western countries, a strong emphasis is put on the expression of personal opinions, and children are encouraged to develop in this direction (Liu et al., 2008).

Altogether, these findings suggest that while the structure of ToM development may be universal, the timeline is shaped by both cultural values and children's everyday experiences. While cultural contexts shape the timeline of ToM, variations within families provide further explanations for individual differences. This will be further discussed in the following section.

4.2 Family influences

4.2.1 Siblings, parenting style, and mind-mindedness

4.2.1.1 Sibling effect

The first evidence linking siblings to ToM showed that children who engaged in more cooperative play with an older sibling were more successful on false belief tasks, a finding later referred to as the *sibling effect* (Devine et al., 2016; Dunn et al., 1991; Ruffman et al., 1998). This association may be explained by the fact that these relationships provide children with more opportunities for talk and play, but also offer more conflicting situations, giving them the chance to think about others' mental states and to recognize that people can hold different views of the same situation (Devine & Hughes, 2018; Perner et al., 1994). Research has further suggested that older siblings are especially helpful for preschoolers, since younger children can learn from those who are more experienced (Peterson, 2000; Ruffman et al., 1998). Longitudinal studies showed that having more siblings predicts stronger ToM skills, and that being the youngest child in a family is linked to more advanced ToM (Mcalister & Peterson, 2013), further confirmed by a meta-analysis (Devine & Hughes, 2018). Moreover, this effect was strongest in studies that considered the number of child-aged siblings, compared to those that only counted the total number of siblings or just older siblings. This suggests that having siblings close in age provides more benefit for ToM development than simply having older siblings. Beyond the number of siblings, the quality of their relationships also matters. Positive relationships and low levels of conflict are linked with better ToM (Cutting & Dunn, 2006; Devine & Hughes, 2018; Hou et al., 2022; Hughes & Ensor, 2005). For instance, children who use arguments that take into account a sibling's perspective during disagreements also perform better on ToM tasks (Foote & Holmes-Lonergan, 2003).

Interestingly, one of the only studies investigating individual differences in implicit ToM found that having an older sibling was linked to better performance in an AL task (Roby & Scott, 2018), suggesting the importance of social learning contexts both for implicit and explicit ToM.

4.2.1.2 Parenting style

Beyond family size, parenting style has also been shown to play an important role in the development of ToM (Miller, 2016). Parenting is usually described through three broad categories: authoritative, authoritarian, and permissive (Baumrind, 1996; O'Reilly & Peterson, 2014). Authoritative parents tend to support children's autonomy, encourage reflection, and allow open discussions of different perspectives, often including negotiation of family rules. In contrast, authoritarian parents focus more on strict obedience and expect children to follow rules without questioning them, often using punishment when these are not respected. Finally, permissive parents are more indulgent but at the same time less involved, showing little control and leaving children to regulate themselves. While authoritative and authoritarian styles are often described as equal in terms of involvement from parents, parents that are permissive are usually considered much less engaged in children's education (O'Reilly & Peterson, 2014; Rinaldi & Howe, 2012).

A consistent finding is that authoritarian parenting is linked to lower ToM performance. Several studies reported a negative relation between authoritarian parenting and ToM in children aged 3 to 6 (Kuntoro et al., 2017; Villalobos et al., 2010; Vinden, 2001), meaning that the more parents adopt an authoritarian style, the lower children's ToM performance. By contrast, authoritative parenting has been associated with better outcomes. Children aged 5 to 12 show stronger ToM when raised with an authoritative style (O'Reilly & Peterson, 2014), and children aged 5 to 6 demonstrate more advanced higher-order ToM under this parenting style (Khanipour & Nezafatbakhsh, 2021). One explanation is that authoritative parenting creates more opportunities for children to take part in open discussions about beliefs, desires, intentions, and emotions with their families. These conversations, which often involve mental state terms and open-ended questions, help children to develop their perspective taking abilities (O'Reilly & Peterson, 2014). On the other hand, authoritarian parenting limits such discussions, reducing children's chances to think about different viewpoints, and engage in discussion about mental states (Wang et al., 2016).

4.2.1.3 Mind-mindedness

Parental mind-mindedness has been identified as an important factor in children's development. It refers to the caregiver's ability to see and treat the child as an independent thinker (Meins, 1997). This can be observed in behaviors such as the use of mental-state language when parents

describe their child, or when they interpret infants' vocalizations in mentalistic terms (Meins, 1997; Meins et al., 2013). It is also reflected in the frequency and appropriateness of parents' mind-related comments in everyday interactions (Devine & Hughes, 2018; Meins et al., 2001). For instance, parents who show higher mind-mindedness tend to use more mentalistic descriptions of their child rather than focusing only on observable behaviors (Meins et al., 1998). Mind-mindedness predicts a range of different outcomes in children. For instance, maternal mind-mindedness predicted school readiness through its effects on language abilities at age 2 and effortful control at age 3, which together contributed to school readiness at age 4 (Bernier et al., 2017).

Higher levels of parental mind-mindedness are also associated with better emotional regulation in infants (Zeegers et al., 2018) and are considered a key factor in the development of ToM (Devine & Hughes, 2018). A large body of evidence shows that parental mind-mindedness strongly predicts children's ToM, a finding also supported by meta-analytic results (Devine & Hughes, 2018; Kirk et al., 2015). The reason for this association might be because mind-mindedness likely reflects both stronger parent–child relationships and greater use of mental-state talk, which, as highlighted in previous sections, has been shown to foster ToM abilities in children (Devine & Hughes, 2018). Interestingly, one study found that cultural differences in false belief acquisition between children in the UK and Hong Kong were fully explained by variations in parental mind-mindedness (Hughes et al., 2018), which show the strong relation between this parental behavior and children's ToM development.

In sum, the family environment plays a central role in ToM development, mainly through the quality and type of interactions that take place at home. Beyond these factors, socioeconomic status has also been linked to ToM. The next section reviews evidence on how SES shapes linguistic, cognitive, and social outcomes relevant to ToM development.

4.2.2 Socioeconomic status

Socioeconomic status (SES) reflects the degree of access individuals have to economic, cultural and social resources, along with the social position, privileges, and prestige that accompany them (Duncan & Magnuson, 2012). SES is not limited to income but also includes educational attainment, occupational prestige, and subjective perceptions of social class (APA, 2023). It is therefore a multidimensional construct that covers both material and non-material resources (Adler et al., 1994; Bukodi & Goldthorpe, 2013). SES has been consistently associated with a

broad range of outcomes, including health, cognitive development, and socioemotional well-being. In the following section, I first review SES measurements, then I provide explanations that have been given for SES influences, and finally I describe evidence of socioeconomic influences on children's development.

4.2.2.1 Measuring SES

From a theoretical perspective, three main approaches to SES have been described: the materialist, gradient, and class-based perspectives (APA, 2023). The materialist approach emphasizes objective resources such as income or wealth, often expressed in terms like poverty thresholds. The gradient approach focuses on relative social position, treating SES as a continuous scale that may also include subjective perceptions of status. Finally, the class-based approach, grounded in theories of social stratification (e.g., Piketty, 2018; Weber, 1922), highlights hierarchies of power and privilege within society (Avvisati, 2020).

Despite these distinctions, SES is now most often measured through the "big three": education, occupation, and income (Avvisati, 2020; Duncan & Magnuson, 2012; Ensminger et al., 2014; Sirin, 2005; Willms & Tramonte, 2019). Each dimension may influence individuals differently, and their impact often depends on broader social and policy contexts. Education refers to the highest degree completed (e.g., bachelor's degree), occupation reflects employment status (e.g., teacher), and income corresponds to financial resources (e.g., monthly salary).

Building on this three-part approach, large-scale international assessments such as the OECD's Programme for International Student Assessment (PISA) assess SES using a composite index of cultural, social, and economic status (OECD, 2020). Cultural status (educational level) is measured through parents' highest level of education, converted into years of schooling. Social status (occupational status) is measured using the highest parental occupation, coded according to the International Standard Classification of Occupations (ISCO-08; ILO, 2012) and converted into International Socio-Economic Index scores (ISEI-08; Ganzeboom, 1992, 2010). Following the "dominance method" (Bukodi & Goldthorpe, 2013; Erikson, 1984), the higher status of either parent is retained, the idea being that the lower status of one parent does not reduce the other's status. Finally, economic status is estimated through home possessions, such as the number of books or household items, adapted to each country's context as a proxy for family wealth. Together, this OECD method captures students' access to financial, social and cultural capital, which define a family's social position (Avvisati et al., 2020).

4.2.2.2 Influence of SES on health, brain and cognition

SES has been consistently linked to health, cognitive, and socioemotional outcomes from early childhood to adulthood (Bradley & Corwyn, 2002). Lower SES is associated with higher risks of physical and mental health problems, including multimorbidity (Pathirana & Jackson, 2018), obesity (McLaren, 2007), cardiovascular disease (de Mestral & Stringhini, 2017), higher mortality rates (Anderson et al., 1997) but also depression (Miech & Shanahan, 2000) and more generally higher rates of mental disorders in adulthood (Kivimäki et al., 2020). Moreover, in children, SES predicts birth issues such as preterm delivery (Smith et al., 2007) as well as later health difficulties (Pawlinska-Chmara & Wronka, 2007).

Beyond health, SES also shapes cognitive and academic trajectories. Children from lower SES families tend to show lower school achievement (Harwell et al., 2017), higher school absence (Klein et al., 2020), and delays in language and executive abilities (Letourneau et al., 2013), with maternal education identified as a strong predictor of cognitive development (Harding et al., 2015; Mercy & Steelman, 1982). SES further influences socioemotional outcomes, being linked to more internalizing and externalizing problems (Letourneau et al., 2013; Reiss, 2013; Vukojević et al., 2017).

4.2.2.2.1 SES impacts children development: common and specific path influences

Income, parental education, and occupation each have both common and specific effects on children's cognitive development. These indicators of SES influence development through a variety of proximal factors (see Figure 9), which can act separately but also overlap.

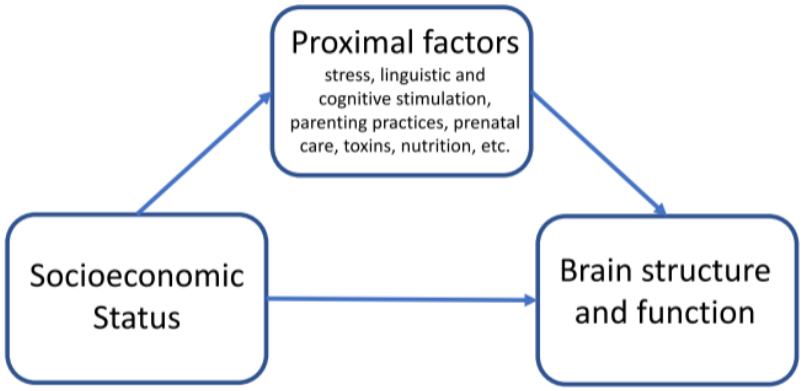


Figure 9. Mediating proximal factors of the relation between socioeconomic status and brain structure and function. Figure from Farah, 2017.

Income mainly affects the material and economic resources available to the families. For instance, low-income families are more exposed to environmental toxins (e.g., cadmium; Brailsford et al., 2018) and poorer nutrition (Hatløy et al., 2000). They also face reduced access to health care, childcare, and extracurricular activities such as sports programs (Eime et al., 2013; Heck & Parker, 2002; Hofferth & Wissoker, 1992). Economical resources are also associated with the neighbor environment, and more generally to environmental risk exposure (Evans & Kantrowitz, 2002). Moreover, lower SES is linked to higher parental stress, possibly due to, amongst other things, financial concerns (Cohen et al., 2006; Hackman & Farah, 2009; Steptoe et al., 2003). In turn, stress has strong effects on children's development (Lupien et al., 2000). For instance, depending on the time of the month, if parents face financial concerns, child-directed speech is reduced, showing an influence on financial stress on parent-child interactions (Roby & Scott, 2022). In addition, unhealthy behaviors, such as alcohol consumption, has more harmful effects for low-SES individuals than for high-SES individuals with similar consumption levels (Collins, 2016).

Parental education is linked to a wide range of family processes. More educated parents tend to engage in different forms of parent–child interaction (Chang et al., 2024). Some research indicate that SES influences both the quality and time spent together (see Monna & Gauthier, 2008 for a review). It is worth noting, however, that more recent findings suggest that differences between SES groups may lie more in how time is organized than in how much time is spent together (Delès, 2022). High SES families may be better positioned to provide more stimulating environments, whether linguistic, through differences in child-directed speech (Hoff, 2014), or cognitive, by better access to cognitively stimulating materials (Bradley & Corwyn, 2002; Kishiyama et al., 2009). High-SES parents also seem to, on average, set higher educational expectations for their children (Stull, 2013). Research suggests that education is further associated with quality of family and home environments (Hackman et al., 2015; Sarsour et al., 2011). In addition, parenting style also differs across SES. For instance, higher SES parents are more likely to be authoritative, while lower SES parents tend to be more authoritarian (Bornstein & Bradley, 2014).

Parental work conditions also shape children's development. For instance, low-SES parents are less likely to benefit from paid leave or flexible work schedules, which makes it harder for them to support children facing academic or behavioral problems (Heymann & Earle, 2000). In addition, precarious jobs are often characterized by less control and lower prestige (Duncan & Magnuson, 2012). Low-autonomy jobs, which involve routine tasks with little decision-

making, might limit the skills parents practice and later use in parenting (Duncan & Magnuson, 2012; Menaghan & Parcel, 1991). For instance, mothers working in cognitively complex jobs may be more likely to provide cognitively stimulating environments to their children (Menaghan & Parcel, 1991; Monna & Gauthier, 2008).

In sum, income, education, and occupation each influence children's development through both unique and overlapping pathways. While some factors might be uniquely related to one indicator of SES, it is more likely that all factors are influenced by each other's, and that the different links and mediators are interdependent. Moreover, it has been argued that including multiple indices of SES is better to assess the multidimensionality and complexity of its effects (Duncan & Magnuson, 2012; Farah, 2017). Below I review evidence of SES effects on language, cognitive, and social development.

4.2.2.2.2 SES, EF and language

A growing body of evidence shows that SES has a strong impact on children's cognitive and brain development. These effects are observed in both behavioral and neuroimaging studies and appear from the very first months of life.

Brain studies provide converging evidence for these behavioral differences. Low SES has been associated with delayed maturation of the prefrontal cortex in children and reduced frontal activity in adolescents, which aligns with behavioral delays (Lawson et al., 2018). Event-Related Potential studies also show that children of mothers with lower education have more difficulties suppressing distracting stimuli (D'Angiulli et al., 2008). SES is further linked to both functional and structural brain differences, including reduced hemispheric specialization of the left inferior frontal gyrus during language tasks and lower volumes in this region among low-SES children. More broadly, SES has been associated with differences in cortical volume, surface area, and thickness (Noble et al., 2015).

Importantly, these disparities appear very early in development. Differences in frontal electroencephalographic activity can already be seen at six months of age (Tomalski et al., 2013), and differences in cortical and subcortical grey matter have been reported as early as 4–6 weeks (Gao et al., 2015). Early alterations have also been identified in functional networks such as the sensorimotor and default mode networks (Farah, 2017).

These findings are consistent with behavioral findings observed in children. Low-SES children tend to show lower performance in both language and EF (Noble et al., 2005). Differences in language development are visible early in life (Fernald et al., 2013; Hoff, 2003; Ma et al., 2024), while EF deficits are also well documented (Lawson et al., 2018; Hackman & Farah, 2009; Raver et al., 2013). In a seminal study, Noble et al., (2005) assessed five neurocognitive systems (visual cognition, spatial cognition, memory, language, and EF) and found that SES had its strongest effects on language and EF, with large effect sizes. Parental education alone explained 27% of the variance in children's language skills and 12% in EF performance. Importantly, SES-related disparities in EF appear early and remain stable across development, without widening or diminishing over (Hackman et al., 2015).

Together, these findings suggest that SES influences both language and executive systems through early and persistent effects on brain structure and function, which in turn shape children's cognitive abilities.

4.2.2.2.3 SES and social cognition

The link between SES and social cognition is less consistent than for general cognitive abilities. Some studies suggest that individuals from lower SES backgrounds show advantages in social cognition. For example, adults with lower social status have been found to display stronger neural activity in ToM-related regions such as the precuneus and mPFC (Muscatell & Eisenberger, 2012), and to adopt more prosocial behaviors (Piff et al., 2010). A long tradition of social psychology research supports this view, reporting that lower-class individuals are more accurate in recognizing emotions (Bjornsdottir et al., 2017; Dietze & Knowles, 2021; Fendinger et al., 2023; Kraus et al., 2011; Piff et al., 2010; Stellar et al., 2012). This has been explained by a greater need for interdependence, which makes individuals with lower status more attentive to others' emotions and thoughts. In contrast, high-SES individuals would be more independent and therefore less motivated to attend to such cues (Kraus et al., 2010; Kraus & Keltner, 2009). However, these findings are contested. Some studies failed to replicate the low-SES advantage and even reported better emotion recognition in high-SES participants (Deveney et al., 2018). More recent neuroimaging studies also suggest a more complex picture, with higher subjective SES linked to stronger prosocial behavior and differentiated activation of the mentalizing network, particularly the TPJ, during prosocial decisions (Schulreich et al., 2023). Other evidence shows that higher SES is associated with earlier maturation of the default

mode network in infants (Gao et al., 2015) and with better ToM abilities in adults (Quesque et al., 2022).

In children, it has been shown that higher SES was predictive of better social cognitive skills, such as better moral reasoning abilities or prosocial behavior (Parker et al., 2023; Suryadi et al., 2025). In addition, research in toddlers reports that SES modulates patterns of joint attention (Abels & Hutman, 2015; Reilly et al., 2021). Low SES has also been associated with fewer gestures to communicate (Rowe & Goldin-Meadow, 2009) and less face-to-face interaction (Keller et al., 2005). The effect of SES on joint attention is actually mediated by maternal sensitivity and stimulation (Koşkulu et al., 2021). Further evidence confirms the importance of caregiver input, as maternal availability predicts infants' ability to encode goal-directed actions (Licata et al., 2014). Moreover, low-SES mothers tend to show a decline in appropriate mind-related comments (mind-mindedness) during the first year of life, a decline not observed in high-SES mothers (Silletti et al., 2022).

Beyond these general aspects of social cognition, a large number of studies have examined the link between SES and explicit ToM. Most findings indicate that children from higher SES families perform better on false belief tasks (Cole & Mitchell, 1998; Cutting & Dunn, 1999; Ebert et al., 2020; Farhadian et al., 2010a; Hughes et al., 1999; Pears & Moses, 2003; Ruffman et al., 2006; Shatz et al., 2003; Weimer & Guajardo, 2005) and in emotion understanding (Cutting & Dunn, 1999; Meins & Fernyhough, 1999). Evidence is sparser beyond preschool years, but some studies also point to SES-related differences in older children and adolescents (Babu, 2011; Ebert et al., 2020; Pluck et al., 2021). However, findings are not always consistent, with studies reporting no link (Adrián et al., 2007; Dunn et al., 1991) or an advantage for low-SES children at age two (McEwen et al., 2007). A meta-analysis of more than 7000 children confirmed a modest but reliable link between SES and false belief understanding, even after controlling for language skills (Devine & Hughes, 2018). In addition, longitudinal studies confirm SES as a predictor of later ToM (Devine & Hughes, 2018). Importantly, the factors responsible for this association are not yet clarified, with language and EF identified as potential mediators of this association (Devine & Hughes, 2018). Importantly, no study investigated whether SES could impact implicit ToM in children.

To conclude, while numerous studies have identified the factors responsible for individual differences in explicit ToM (Hughes & Devine, 2015), the mechanisms underlying spontaneous, implicit ToM remain unknown (Roby & Scott, 2018). This gap is crucial, as it

raises the question of whether SES or related contextual influences, as well as cognitive factors shape not only explicit reasoning about mental states but also the early, automatic processes of social understanding.

5. Thesis objectives

The literature review allowed us to identify several gaps in the field. First, while most studies have investigated whether SES affects explicit ToM in preschoolers, far fewer have examined whether SES continues to influence explicit ToM beyond this age range. Moreover, language and EF have consistently been shown to be linked to explicit ToM and have been identified as potential mediators of the relation between SES and explicit ToM. However, to date, no study has tested their contributions within a mediation model in preschool- and school-aged children. Second, implicit ToM has rarely been assessed beyond preschool years. The few studies that have done so report contrasting findings concerning its relation to explicit ToM in preschool and school-aged children. In addition, little is known about the developmental trajectory of implicit ToM across this age range. Finally, very few studies have addressed the individual variability observed in implicit ToM. The contrasting results reported in the literature suggest such variability, but the factors underlying it have not yet been identified.

Thus, this thesis aims to examine how linguistic, cognitive, and environmental factors influence both implicit and explicit ToM. More specifically, the objectives are threefold: (a) to clarify the role of EF and language in mediating the relation between SES and explicit ToM in preschool- and school-aged children; (b) to investigate the relation between implicit and explicit ToM beyond the preschool years; and (c) to determine whether predictors of explicit ToM also predict implicit ToM abilities over time.

In **Study 1**, we focus on the mediating role of language and EF in explaining the association between SES and explicit ToM in preschool- and school-aged children. To address this question, we conducted a cross-sectional study with children aged 3 to 8, assessing explicit false belief, EF (inhibition and flexibility), language (vocabulary, syntax, and novel word learning), as well as family SES (education and occupation).

In **Study 2**, we examine the relation between implicit ToM and explicit ToM using the same cross-sectional sample. To assess implicit ToM in children, we adapted the ball detection task (el Kaddouri et al., 2020) which has provided reliable results in adults and enables testing of both implicit and explicit ToM. In addition, we investigate whether EF, language, and SES are associated with individual differences in implicit ToM.

Finally, in **Study 3**, we investigate the developmental trajectories of implicit and explicit ToM. More specifically, we analyze the effect of age on these two dimensions and test the role of different predictors in their development in preschool- and school-aged children. To do so, we conducted a longitudinal study with children aged 3 to 7, collecting the same set of variables as in Study 1 and 2.

PART II.

Experimental contributions

General method

We collected data from children between October 2022 and June 2024. The analyses are presented in three studies, two using cross-sectional data and one examining longitudinal associations. This section presents the general methodology used across studies, including participant characteristics, measures, and experimental design.

1 Participants

1.1 Cross sectional (T0)

A total of 391 preschool and school-aged children were recruited at baseline (T0) across four age groups: 102 aged 3 to 4 years, 108 aged 4 to 5 years, 114 aged 5 to 6 years, 67 aged 6 to 7 years. Recruitment took place in public preschools and elementary schools in Paris, France (urban setting). The participating schools served highly diverse populations, reflecting a wide range of ethnic, cultural, and migration backgrounds.

1.2 Longitudinal follow-up (T1 & T2)

A subsample of the initial cohort (specifically children aged 3 to 6 years at T0) was invited to participate in a longitudinal follow-up. Children aged 6–7 years at T0 were not included in the longitudinal data collection. This follow-up included two additional time points: T1 and T2. A total of 354 children (189 boys, 165 girls) participated in at least one wave. The average interval between T0 and T1 was 0.45 years (SD = 0.08), and between T1 and T2 was 0.78 years (SD = 0.07). Sample characteristics by session are reported in Table 2, with detailed descriptive statistics by age group provided in the Study 3.

All parents provided written informed consent for their child's participation, either in the cross-sectional design (for older children) or in the longitudinal protocol (for younger children). The study was approved by the local ethics committee (IRB: 00012024-63, CER-Paris Cité) and conducted in accordance with national and international ethical standards for research with human participants.

Variable	*N*
Total sample (M/F)	354 (189 / 165)
Repartition per session	1: *N* = 308
	2: *N* = 303
	3: *N* = 252
Mean age in months (SD)	4.49 (0.85)
Mean time interval T0 – T1 (SD)	0.45 (0.08)
Mean time interval T1 – T2 (SD)	0.78 (0.07)

Table 2. Main descriptive characteristics of the longitudinal sample. M = male; F = female; SD = standard deviation. Intervals are expressed in years.

2 Procedure

It included the three measurement points (T0, T1, and T2), each consisting of two to three experimental sessions. All testing sessions were conducted individually in quiet rooms within participating schools. During each session, children completed a series of tasks on tablet or computer. Each full assessment lasted approximately one hour, split into two or three blocks of about 20 minutes each. At least two trained experimenters were present during all sessions.

3 Measures

A full description of all measures assessed in the cross-sectional and longitudinal studies is presented here. Brief summaries of each task will be provided again in the relevant study sections.

3.1 ToM assessments

ToM was assessed using three versions of an adapted change-of-location false-belief task based on the Ball Detection Task (El Kaddouri et al., 2020): an implicit and explicit first-order version (Figure 10), and an explicit second-order version (Figure 12). Each of them is described below.

3.1.1 Implicit

Children completed an implicit version of the *Ball Detection Task*, presented on a tablet. The original version of this task was designed for adults and consisted of 80 trials. To ensure feasibility for young children, the number of trials was significantly reduced to 14 trials. While the timing of events was adapted, the overall event structure remained unchanged. Additionally, the original object (a yellow ball) was replaced with an animated target (a ladybug) to minimize potential confusion or surprise related to an inanimate object moving on its own.

The final version included short animated videos (approximately 10 seconds each), featuring *Buzz Lightyear* (from the cartoon Toy Story) and the ladybug. Each video comprised two phases: a belief formation phase and an outcome phase. During the belief formation phase, the beliefs of both Buzz, the agent (A) and the participant (P) regarding the presence of the ladybug behind a green occluder were manipulated. Belief states about the ladybug's presence were noted as '+' (positive belief) or '–' (negative belief).

Each video began with Buzz and the ladybug in the room. The ladybug then moved along the table, and depending on the condition, one of four scenarios followed:

1. **True belief – positive belief (P+A+):** The ladybug walks halfway from behind the occluder and then returns. Buzz leaves the room with the belief that the ladybug is behind the occluder (A+). In his absence, the ladybug walks out and returns to the same location, so the child shares Buzz's belief (P+).

2. **False belief – negative belief (P+A-):** The ladybug walks halfway out and exits the scene. Buzz leaves the room with the belief that the ladybug is not behind the occluder (A–). In his absence, the ladybug re-enters and stops behind the occluder. The child then holds a different belief from Buzz (P+).

3. **False belief – positive belief (P-A+):** The ladybug walks halfway out and then returns behind the occluder. Buzz leaves with the belief that the ladybug is behind it (A+). While he is gone, the ladybug exits the scene completely. The child therefore holds a belief that differs from Buzz (P–).

4. **True belief – negative belief (P–A–):** The ladybug walks halfway out and exits. Buzz leaves with the belief that the ladybug is no longer behind the occluder (A–). In his

absence, the ladybug briefly reappears and then exits again. The child ends up holding the same belief as Buzz (P–).

In the outcome phase**,** Buzz returns to the room and the occluder falls, revealing whether or not the ladybug is behind it. The outcome (presence or absence of the ladybug) was independent from previous events: each of the four conditions described above included one negative-outcome trial (L-) and two positive-outcome trials (L+), presented in a pseudo-randomized order.

Children were instructed to press a button with a ladybug only when the occluder felt and the ladybug was present. Before each trial, a blank screen with a fixation cross appeared for 2000 ms. Timings of the sequence were kept constant across all trials and conditions and are described in detail in Figure 11. Prior to the task, children viewed two example videos (one P+A+ and one P–A–), during which the experimenter explained the task instructions.

Reaction times (RTs) were recorded for all trials. Due to a programming error, only 12 trials per participant were retained for analysis, consisting of one negative-outcome and two positive-outcome trials for each of the four conditions.

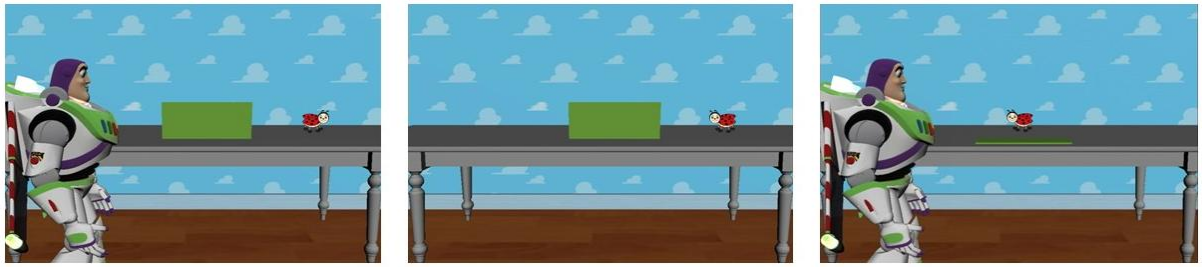


Figure 10. Illustration of the tasks assessing implicit and explicit theory of mind. The first two panels show the initial stages, which are identical across both versions of the task. The third panel represents the outcome phase specific to the implicit theory of mind condition.

3.1.2 Explicit first order (T0, T1, T2)

This task focused on the belief-incongruent conditions from the implicit version (P+A− and P−A+). Children watched two slowed-down videos (about 15 seconds), with the experimenter narrating the key events of the videos. After each video, children had to answer one control question ("Where is the ladybug now?") and a false-belief question ("Where does Buzz think

the ladybug is?"). One point was given only if both answers were correct, ensuring accurate attribution of first-order false belief. Total scores ranged from 0 to 2.

3.1.3 Explicit second-order (T1, T2)

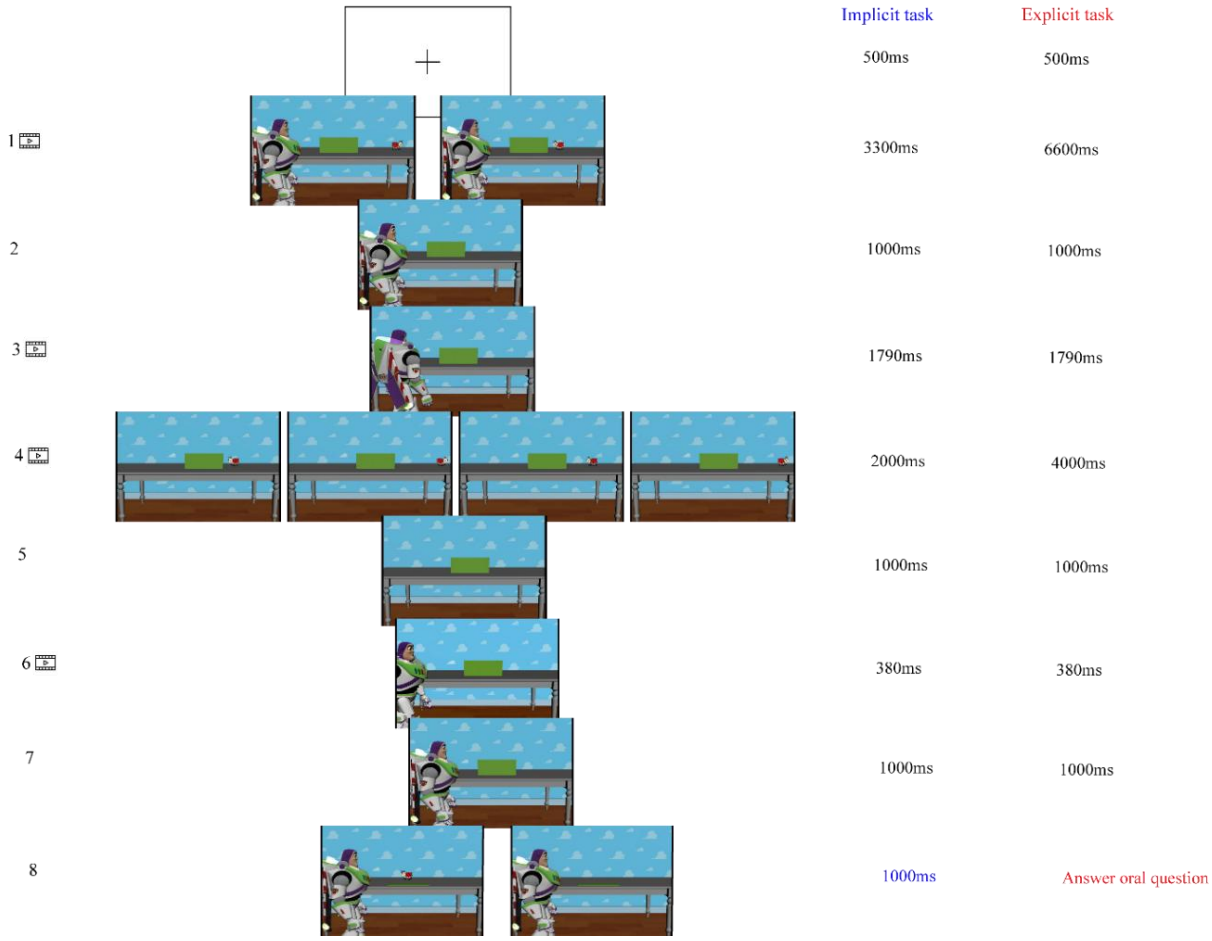


Figure 11. Detailed sequence of the videos used for the implicit and explicit theory of mind tasks. Timings for the implicit version are shown in the left column, while timings for the explicit first-order version are shown in the right column. Ms = milliseconds.

This task was introduced at T1 for children aged 4 to 5 years, given their success rates on the first-order false-belief task at T0. The task closely followed the structure of the explicit first-order task, with the main difference being the introduction of a third character, Woody, in addition to Buzz and the ladybug. In this version, Buzz remained in the room throughout the sequence, while Woody left the room but continued to observe the scene by looking through a window. Crucially, Buzz was unaware that Woody could see what was happening, including

the movement of the ladybug. This created a situation in which Buzz held a false belief about Woody's belief regarding the ladybug's location.

Before the test trials, children watched an introductory sequence in which Woody left the room and looked through the window. The experimenter used this moment to ensure that the child understood two critical aspects of the scene: that Woody could still see the events in the room, and that Buzz could not see Woody. Following this familiarization phase, children watched the two false belief videos corresponding to the same belief conditions as in the explicit first-order task. After each video, they were asked two questions: "Where is the ladybug now?" and "Where does Buzz think Woody will look for the ladybug?". A score of one point was awarded only if all three answers were correct within a trial, resulting in a total score ranging from 0 to 2.

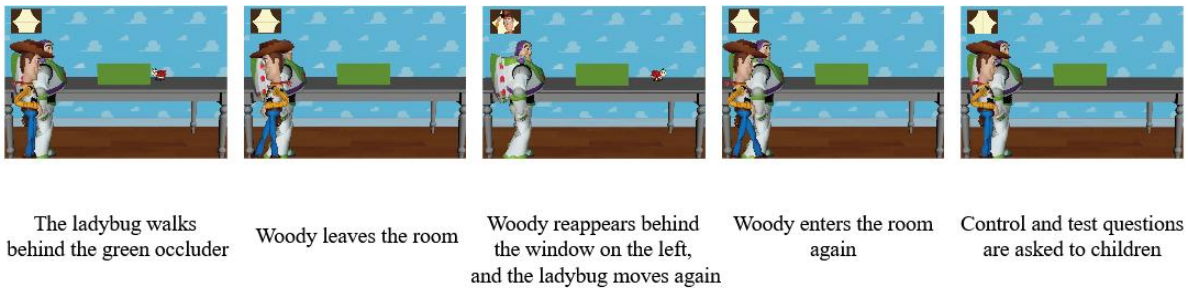


Figure 12. Description of the second-order theory of mind task.

3.2 Language assessments (T0, T1, T2)

Language skills were evaluated using a French adaptation of the *Quick Interactive Language Screener* (QUILS, Golinkoff et al., 2017; Levine et al., 2020), currently being standardized for French-speaking populations (de Carvalho et al., in prep). This computerized test assessed children's vocabulary knowledge (i.e., What words do children already know in French, e.g., asking them to select the correct image for "a coat rack" among distractors), syntax (i.e., what do children understand about how words go together in sentences, e.g., responding to questions that begin with where, when and how, like in "How is the man making crêpes?" in a narrative context), and language-learning processes (i.e., How good are children at learning new language items, e.g., learning a novel verb "bamouling" in a sentence like "Someone is bamouling something to someone"). Figure 13 displays an example of each component. Children

independently followed instructions and responded via a touchscreen, earning one point per correct response. The task consisted of 48 trials, including 16 vocabulary trials, 16 syntax trials, and 16 language-learning processing trials. A score for each component (vocabulary, syntax and process) was computed based on the 16 corresponding trials. The use of a multi-component task, which does not rely on vocabulary alone, is supported by meta-analytic evidence suggesting that different facets of language are related to false belief understanding (Milligan et al., 2007). While the strongest difference in predictive power was found between receptive vocabulary and general language measures, the overall analysis revealed that multiple aspects of language (e.g., semantics, syntax, memory for complements) are relevant in understanding ToM performance (Milligan et al., 2007).

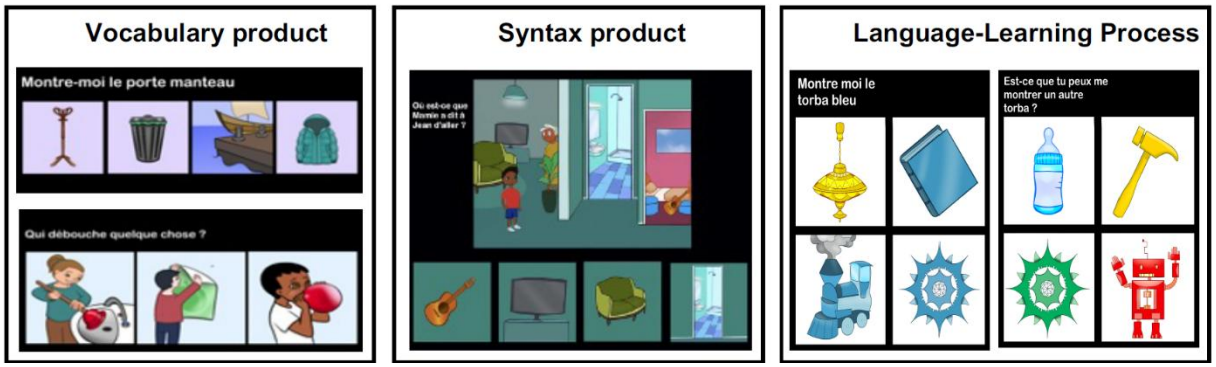


Figure 13. Illustration of the three components of the language assessment.

3.3 EF assessments (T0, T1, T2)

EF were assessed using the Hearts and Flowers (H&F) task (Davidson et al., 2006), which included three blocks of trials. In the congruent block, a heart appeared on the right or left side of the screen and children were instructed to press the response button located on the same side of the screen. In the incongruent block, a flower was displayed on the right or left side of the screen and children were asked to press on the response button located on the opposite side of the screen. In the mixed block, on each trial, a heart or a flower was displayed on one side of the screen and participants responded according to the instructions of the heart or flower stimuli, requiring children to alternate between rules (see Figure 14). Each stimulus appeared for 2500ms, with a 500ms inter-trial fixation cross. Practice trials preceded each block (4 trials for congruent/incongruent, 6 for mixed).

Performance was scored using the two-vector (TV) method (Zelazo et al., 2013), which assigns 0-5 points for accuracy and 0-5 points for reaction time (RT). RT is included only for participants achieving ≥75% accuracy, while others receive an accuracy-only score (0-5). Importantly, the TV method integrates accuracy and RT into a single score to capture individual differences in speed–accuracy tradeoff, a key aspect of EF performance (Camerota et al., 2019). This method has also shown stronger associations with other EF measures than alternative scoring methods (Wu et al., 2024). A TV score was computed for each block. Participants scoring < 50% on the hearts block were excluded, following established practice (Wu et al., 2024).

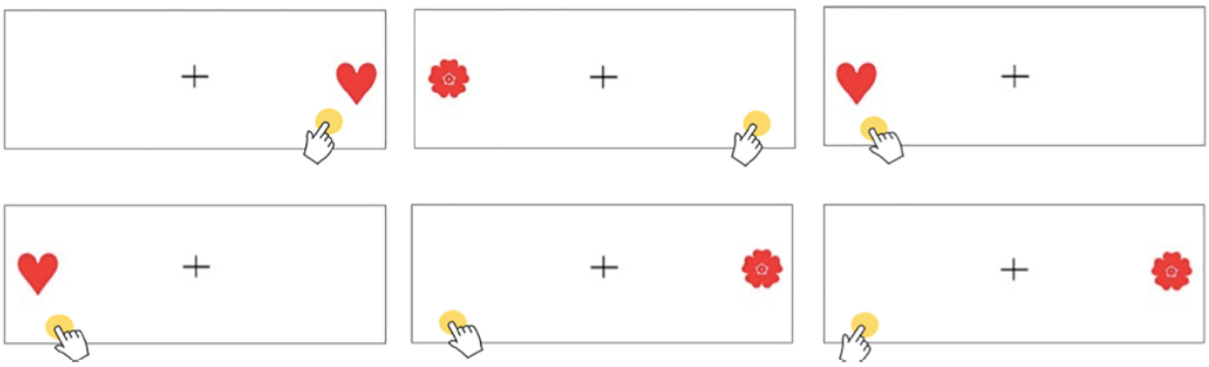


Figure 14. Illustration of the hearts and flowers task. The congruent bloc is on the left, the incongruent bloc is in the middle and the mixed block is on the right.

Prior studies have used block-specific scores to model distinct EF components (e.g., Camerota et al., 2020). Following this approach, and in order to differentiate the predictive power of each component, we used the incongruent block to index inhibition and the mixed block to index cognitive flexibility (Liu et al., 2022).

Although the H&F task is most often used with children aged 4 and above, research shows that EF can be assessed from age 3 with age-appropriate tasks (Willoughby et al., 2010). In our sample, children aged 3 to 4 years performed above chance in the congruent block, suggesting they understood the task demands.

The overall timeline is described in Figure 15.

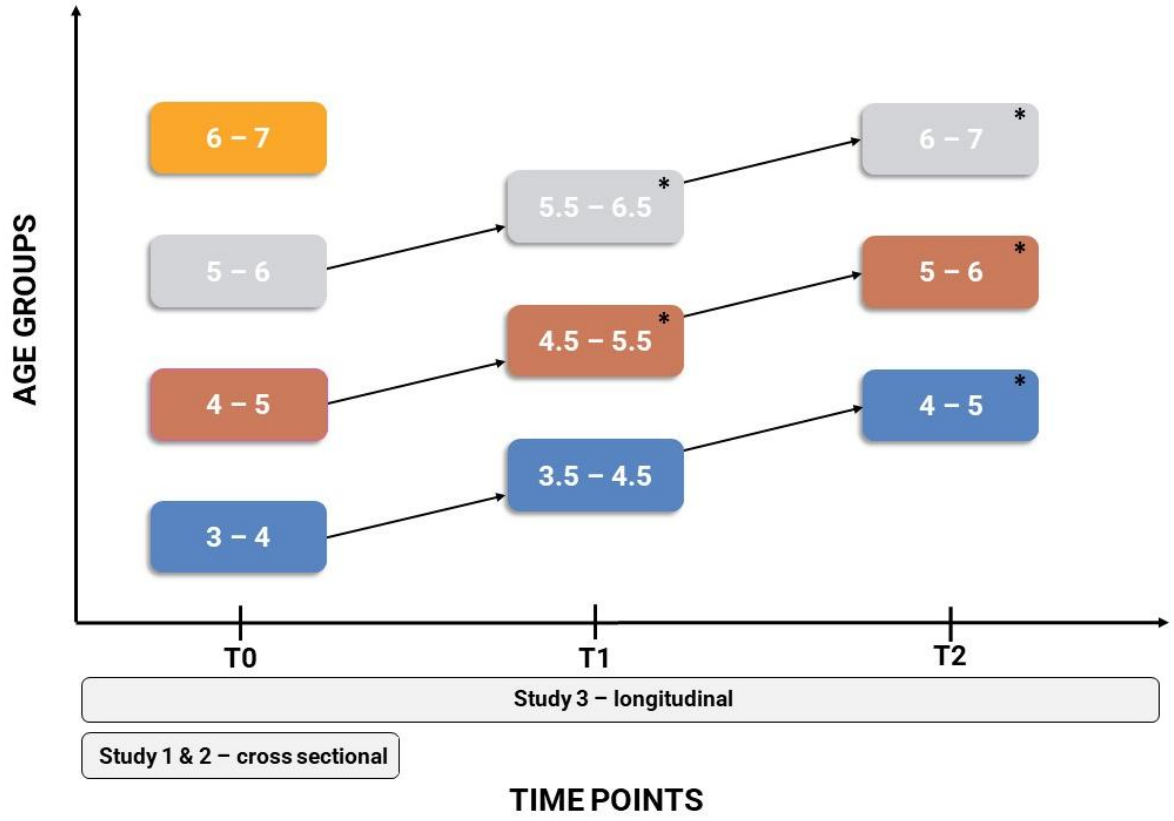


Figure 15. Overview of age group participation across timepoints. Age categories are expressed in years. All children completed all tasks at each session, except for the 2nd order theory of mind task, which was administered only at specific time points (indicated by * on the graph).

3.4 Family SES

A composite score was calculated by selecting the highest education level and the highest occupational status between both parents (see Maximino-Pinheiro et al., 2024 for a similar procedure), consistent with findings showing that relation between ToM and family SES is stronger when SES is measured through multiple variables (Devine & Hughes, 2018). We followed the standardized procedure recommended by the OECD for international assessments such as PISA, in which family SES is typically assessed through three dimensions: parental education, occupational status, and household possessions used as a proxy for income (Avvisati, 2020). However, we did not include an income-related indicator in our study. In light of evidence that questions related to income often lead to higher rates of item non-response and participant dropout due to reluctance to disclose such information (Mariel et al., 2020), we limited our assessment of family SES to parental education and occupational status. Furthermore, in European countries, family income tends to show weaker correlations with

parental education compared to contexts such as the United States (Walhovd et al., 2022), which further supports the decision to exclude this indicator from the present measure.

Initially, each parent's education level was converted into the number of years of education, ranging from 0 (no degree) to 20 (Doctoral degree). Subsequently, the occupations of both parents were coded according to the International Standard Classification of Occupations (ISCO-08) (ILO, 2012) at the 3-digit level. These ISCO-08 codes were then mapped to their corresponding values in the International Socio-Economic Index of occupational status (ISEI-08) (Ganzeboom, 2010; Ganzeboom et al., 1992) using the R software package *occupar* (Ferrari, 2019). The ISEI-08 categorizes occupations based on the average education and earnings of workers (e.g., 17 for cleaners and helpers, 37 for client information workers, and 68 for finance managers). For homemakers, students, and unemployed individuals, an ISEI-08 value of 17, which corresponds to the category of 'elementary workers', was assigned, in line with previous studies (e.g., Maximino-Pinheiro et al., 2024). This method is comparable to the one adopted by the OECD for its PISA surveys (OECD, 2020; Avvisati, 2020).

Study 1

Association between family socioeconomic status and explicit theory of mind: language and executive functions as mediators

In the first study, we investigated whether language and EF would mediate the relation between SES and explicit ToM in children aged 3 to 7 using structural equation modelling. In this study, every mention of "ToM" abilities refers to explicit first-order ToM.

This study led to a manuscript: Houdayer, J., Le Stanc, L., Rémeau, M., de Carvalho, A., Houdé, O., Bardi, L., & Borst, G. (submitted). Language, not executive functions, mediate the relation between family socioeconomic status and theory of mind.

1. Introduction

As described in the General introduction, ToM (Premack & Woodruff, 1978) enables individuals to perceive both themselves and others as psychological beings with distinct mental states, namely belief, desires, intentions, and emotions (Astington & Dack, 2000). ToM allows one to infer these mental states and to understand that they can differ between individuals, even when faced with identical situations (de Villiers & de Villiers, 2014). Beyond its importance in understanding social interactions, allowing individuals to adapt their behaviors in society and in fostering peer relations (Ronchi et al., 2020), ToM also contributes more generally to life outcomes such as academic achievement (Lecce et al., 2011,Lecce et al., 2014).

The traditional view is that children develop first-order ToM, i.e., the ability to represent another person's mental states, from age 4 or 5, as demonstrated by their performance in the false belief tasks (Wimmer & Perner, 1983; Wellman et al., 2001). A complete description of Max and the chocolate task is provided in the General introduction (section 1.2.4). However, more recent research challenged the universality of this developmental milestone, highlighting substantial variability in the timing and expression of ToM across individuals (Slaughter & De Rosnay, 2017).

As mentioned in the General introduction, one factor accounting for this variability is the family SES, which has been shown to further affect ToM development. The family SES refers to a combination of economic and social resources that shape various family characteristics. It is typically measured through family income, education, and occupation (Bornstein, 2019; Duncan & Magnuson, 2012; Haft & Hoeft, 2017; Lawson et al., 2018; Lupien et al., 2000; Matthews & Gallo, 2011). Education reflects the highest degree completed by caregivers, occupation refers to their employment status, and income corresponds to financial resources available to the family. Each dimension may affect children in different ways, through both shared and distinct mechanisms. For instance, parental education seems to impact both the time and quality of parent-child interactions (Chang et al., 2024; Monna & Gauthier, 2008), which is linked to various cognitive outcome in children (Hughes & Devine, 2019; Pavarini et al., 2013; Tamis-LeMonda et al., 2019). In addition, parental occupation can influence parenting behaviors. For instance, mothers working in cognitively complex jobs may be more likely to provide cognitively stimulating environments to their children (Menaghan & Parcel, 1991; Monna & Gauthier, 2008). Finally, lower income is associated with higher parental stress, possibly due to financial concerns (Baum et al., 1999; Cohen et al., 2006; Hackman & Farah,

2009; Steptoe et al., 2003). In turn, stress has strong effects on children's development (Lupien et al., 2000).

The relation between ToM and family SES is complex, and the underlying variables contributing to this association are not yet fully understood. One hypothesis is that SES influences ToM indirectly via its effect on children's language development. First, SES influences the amount and quality of language input in the home environment, which directly shapes children's language development (Letourneau et al., 2013; Ma et al., 2024; Levine et al., 2020). Indeed, SES-related disparities in vocabulary, syntactic development, and language processing, core components of the language system that develop significantly between ages 3 and 8 (Shiel et al., 2012), can already be observed by age three (Levine et al., 2020). One explanation for this association is that parents with higher education levels tend to engage more frequently in rich verbal interactions with their children, using complex structures such as wh-questions or relative clauses (Hoff, 2003; Huttenlocher et al., 2010; Levine et al., 2020). These differences in both the quantity and complexity of input could foster the development of children's expressive language and syntactic skills. Conversely, children from lower-SES backgrounds are typically exposed to less frequent and less complex child-directed speech, especially when caregivers experience financial stress (Roby & Scott, 2022). In turn, reduced exposure to child-directed speech has been linked to slower vocabulary growth and less efficient real-time language processing (Weisleder & Fernald, 2013).

In addition, language ability is itself a robust predictor of ToM performance (Ebert, 2020; Milligan et al., 2007). Several explanations have been proposed for how language supports ToM development. For instance, mastery of mental state vocabulary is essential for understanding what terms like *think*, *want*, or *like* actually mean, and has been linked to children's performance on false belief tasks (Shatz, 1994). Moreover, syntactic competence, particularly the ability to interpret complement clauses (e.g., *She thinks that the ball is in the basket)*, has been closely associated with ToM, as such structures allow children to represent beliefs that may differ from reality (de Villiers & de Villiers, 2025).

Taken together, these findings suggest that lower language abilities may partly explain the ToM delays observed in children from low-SES backgrounds. Consistent with this hypothesis, the relation between family SES and ToM tends to be smaller when difference in language abilities is accounted for across different ages (Hughes et al., 1999; Pluck et al., 2021; Weimer & Guajardo, 2005). Furthermore, one study showed that language abilities mediate the relation

between family SES and ToM in preschoolers (Tompkins et al., 2017), and between maternal education and children's false belief understanding (Bulgarelli & Molina, 2016).

However, not all findings align. Some studies reported an association between the family SES and ToM, independently of children's language abilities (Cutting & Dunn, 1999; Pears & Moses, 2003; Farhadian et al., 2010) and some even no association between language, family income and ToM (Miller et al., 2018; Doenyas et al., 2018). Taken together, these inconsistent findings suggest that language alone is insufficient to fully account for the family SES-ToM relation.

Beyond language, domain-general factors such as EF skills could also contribute to the difference observed in the development of ToM between children from high and low family SES. EF are a set of high-level cognitive functions that allow one to intentionally regulate their thinking and act to achieve goals. As mentioned in the general introduction (section 3.2.1), three core EF are commonly distinguished: inhibitory control, working memory, and cognitive flexibility (Diamond, 2013), which undergo rapid development during the preschool years (Hughes, 1998).

Family SES has been shown to influence EF development (Lawson et al., 2018), which could be explained by the fact that children from low-SES backgrounds are often exposed to chronic stress, which can affect prefrontal cortex development (one of the main brain regions supporting EF; Friedman & Robbins, 2022) through mechanisms such as elevated cortisol levels (Blair & Raver, 2016; Haft & Hoeft, 2017). In addition, limited access to cognitively enriching materials may further hinder EF development (Kishiyama et al., 2009), as suggested by the fact that enriched home environments mediate the SES–EF relation (Dilworth-Bart et al., 2007). EF, in turn, play a well-documented role in ToM development (Devine & Hughes, 2014). Although several models have been proposed to explain this association (Wade et al., 2018), one influential account highlights the importance of self-monitoring and inhibitory control for understanding mental states. Self-monitoring is thought to support self-awareness, a foundational component of ToM (Russell, 1996), while inhibitory control and cognitive flexibility enable children to suppress their own perspective and adopt others' viewpoints (Carlson & Moses, 2001; Hughes & Ensor, 2005b; Russell et al., 1991; Wade et al., 2018). Accordingly, SES may influence ToM indirectly by shaping the development of EF. Notably, EF remain robust predictors of ToM even when controlling for age, language ability, and SES (Chasiotis et al., 2006; Shahaeian et al., 2015; Hughes & Ensor, 2005, Hughes & Ensor, 2006;

Henning et al., 2011; Devine et al., 2016). While some studies indicate that language often accounts for more variance in ToM during early childhood (Burnel et al., 2021; Shahaeian et al., 2023), others report that EF may be more critical than language for ToM development in children aged 2 to 4 (Hughes & Ensor, 2007) and 6 to 10 years (Miller et al., 2018). In addition, EF and language are closely associated during development, with strong relations found between the two from early to late childhood (Kaushanskaya et al., 2017; Müller et al., 2009; Spiegel et al., 2021). Accordingly, the pathways from SES to ToM may involve language and EF, either through independent routes or via shared processes.

While studies examined the impact of both EF and language on the relation between ToM and family SES, they typically do so by investigating such impacts separately in different groups of participants. In addition, none investigated whether these two factors mediate similarly the relation between family SES and ToM. The present study aimed to do so. We recruited 391 preschoolers aged 3 to 7 and assessed their family SES (based on parents' level of education and occupational status), their ToM skills (using a first-order change-of-location false-belief task), their language knowledge (vocabulary, syntax, and novel word learning), and their EF skills (inhibition and cognitive flexibility). While children over age five typically succeed on first-order false belief tasks (Wellman & Liu, 2004), we included this measure across the full age range because more recent research shows that performance may vary across socioeconomical and cultural contexts. For instance, children from rural Vanuatu and Samoa have been found to show significant delays on such tasks, with some seven-year-olds still failing to succeed, compared to the standard developmental timeline (Dixson et al., 2018; Mayer & Träuble, 2015). Since most of the existing literature is based on U.S. and U.K. samples, which may not reflect broader cultural or linguistic contexts, and given that our sample was both French and included a substantial proportion of children from low-SES backgrounds, we sought to account for potential variability in ToM development by including children over 5 years of age.

Moreover, while income, education, and occupation are closely linked, their interdependence and effects on children also vary by country. For example, in European countries, family income tends to correlate less strongly with parental education than in the United States (Walhovd et al., 2022). Additionally, the impact of income on cognitive outcomes and brain volume appears stronger in U.S. samples compared to European ones. This may reflect broader access to education and healthcare in some European countries, with social policies likely buffering developmental disparities more effectively than in the U.S., where access depends

more heavily on private resources (Walhovd et al., 2022). Finally, questions related to income often lead to higher rates of item non-response and participant dropout due to reluctance to disclose such information (Mariel et al., 2020).Accordingly, the present study focuses on the effects of parental education and occupation.

Previous studies have reported effects of both parental occupation and education on children's ToM, with sometimes inconsistent findings across studies. For example, some evidence suggests effects of maternal occupation and education, and paternal occupation but not paternal education (Cutting & Dunn, 1999), whereas other work found that only maternal occupation predicted ToM (Farhadian et al., 2010). In addition, maternal education has often been highlighted as one of the strongest predictors of children's development more broadly (Harding et al., 2015). By including both parents' education and occupation in the same model, the present study allows for a direct comparison of their relative contributions.

We conducted a parallel mediation analysis, with EF and language abilities as mediators of the relation between family SES and ToM. These two variables were selected because they have been most consistently associated with ToM development and are commonly used to account for individual differences in ToM performance in children (de Villiers & de Villiers, 2025). We examined language and EF as distinct mediators of the SES–ToM association, allowing us to assess their unique contributions while controlling for overlap, considering their interdependence and shared mechanisms (Gooch et al., 2016).

Consistent with previous findings, we hypothesized that family SES would influence language, EF, and ToM abilities. Furthermore, if language and EF abilities account in part for the relation between SES and ToM, then both variables should significantly mediate this association. Prior research suggests that the associations between language and ToM (up to 7 years old; Milligan et al., 2007), EF and ToM (up to 6 years old; Devine & Hughes, 2014), family SES and children's language knowledge (Ma et al., 2024) and family SES and children's EF skills (up to late childhood; Lawson et al., 2018) are relatively stable. Conversely, the association between family SES and children's ToM skills appears to increase with age (Devine & Hughes, 2018). Therefore, a further objective of this study was to examine the extent to which age moderated the mediation of language and/or EF on the association between family SES and ToM.

2. Method

2.1 Participants

A total of 391 preschool and school-aged children were recruited (102 3- to 4-year-olds, 108 4- to 5-year-olds, 114 5- to 6-year-olds, 67 6- to 7-year-olds). Sixteen children were excluded from the analysis due to excessive distraction during testing, resulting in a final sample of 375 participants (176 girls; *Mean age* = 4.9 ± 1.1 years). Descriptive statistics by age group are summarized in Table 1.1. The study was conducted in public preschools and elementary schools located in Paris, France (urban setting). Due to local legal and ethical restrictions, individual-level data on participants' community of descent were not collected. However, the schools from which participants were recruited serve diverse populations, with children from a wide range of ethnic, cultural, and migration backgrounds, reflecting the multiethnic composition of our sample. Details regarding the sample's family SES are provided in the Results section.

Age group	*M*	*SD*	*N* (Number of girls)
3-to-4-year-olds	3.45	0.28	95 (34)
4-to-5-year-olds	4.46	0.27	105 (51)
5-to-6-year-olds	5.42	0.26	108 (58)
6-to-7-year-olds	6.57	0.24	67 (33)

Table 1.1. Descriptive statistics of the study sample by age group. M = Mean, SD = Standard Deviation, N = Number of participants.

2.2 Materials and procedure

While full task descriptions can be found in the General method, below we provide brief summaries for each task.

2.2.1 ToM assessments

Children viewed two narrated false-belief videos and answered a control question ("Where is the ladybug now?") and a false-belief question ("Where does Buzz think the ladybug is?"). One point was awarded only if both answers were correct.

2.2.2 Language assessments

A French adaptation of the Quick Interactive Language Screener (QUILS) assessed vocabulary, syntax, and language-learning processes. The task included 48 trials (16 per component). One point was awarded per correct response.

2.2.3 EF assessments

EFs were measured with the three blocks of the H&F task (congruent, incongruent, mixed). Performance was scored with the two-vector (TV) method, attributing 0–5 points for accuracy, and an additional 0–5 points for RT per block (RT points only if accuracy ≥ 75%), yielding a block-level score that integrates speed–accuracy trade-offs. The incongruent block indexes inhibition, the mixed block cognitive flexibility.

Prior studies have used block-specific scores to model distinct EF components (e.g., Camerota et al., 2020). Following this approach, and in order to differentiate the predictive power of each component, we used the incongruent block to index inhibition and the mixed block to index cognitive flexibility (Liu et al., 2022). However, we chose to retain all three blocks in our analysis for several reasons. First, although the task is primarily associated with inhibition and flexibility, the three blocks also engage working memory by requiring participants to retain and apply rules (Diamond, 2013). Second, all three blocks have been used collectively to assess the three core EF components (inhibition, flexibility, and working memory) (Chung et al., 2018; Gold et al., 2021). Third, the mean TV score across blocks has been shown to provide a valid global EF index (Wu et al., 2024). Finally, in our data, including the congruent block in the EF latent variable improved model fit compared to models using only the incongruent and mixed blocks.

Twelve children were excluded from EF analyses due to <50% accuracy in the congruent block, indicating failure to grasp task instructions, in line with Wu et al. (2024).

2.2.4 Family SES

Family SES was computed from the highest parental education and the highest parental occupational status across caregivers.

2.3 Statistical analysis

We first examined the descriptive statistics for each variable across age groups. For a preliminary comparison of ToM developmental trajectories, the sample was divided into low- and high-SES groups using a median split. SES was treated as a continuous variable in all other analyses.

Then, we examined associations among all variables using partial correlations controlling for age, with false discovery rate (FDR) correction for multiple comparisons (Benjaminit & Hochberg, 1995). To identify underlying latent constructs, we conducted an Additional Factor Analysis (EFA) on the language and EF measures, followed by a Confirmatory Factor Analysis (CFA) to validate the factor structure. Results supported a two-factor model. The first factor, labeled *LANG*, included the three components from the language battery: processing, vocabulary, and syntax. The second factor, labeled *EF*, comprised the three components from the H&F task: congruent, inhibition, and cognitive flexibility. These two latent variables were then extracted using the *lavaan* package (Rosseel, 2012) for use in subsequent analyses.

We examined two main distinct models. In the first model, we investigated whether language and EF mediated the relation between family SES and ToM while controlling for age with a parallel mediation. To further explore whether age moderated this mediation, we then performed a second model using a moderated mediation analysis, in which age was included as a moderator. In this analysis, we calculated an index of moderated mediation allowing to quantify the moderation (Hayes, 2022) and perform simple slope analyses to assess the indirect effect across different ages. Specifically, we estimated the conditional indirect effects at various age levels, typically the mean and one standard deviation above and below the mean (Hayes, 2015), to determine whether they differed.

To account for non-normality in our data we used Robust Maximum Likelihood Estimation (MLR) for model estimation and performed 1000 percentile bootstrap resamples to estimate the indirect effects, the index of moderated mediation, and simple slopes. Missing data were handled using a Full Information Maximum Likelihood (FIML) approach.

Model fits were assessed using established guidelines (Schermelleh-Engel et al., 2003), with the following thresholds indicating good fit: Tucker-Lewis Index (TLI) and Comparative Fit Index (CFI) ≥ 0.95, Standardized Root Mean Square Residual (SRMR) ≤ 0.08, and Root Mean Square Error of Approximation (RMSEA) ≤ 0.06.

We report standardized estimates to reduce the influence of measurement scales. Latent variables and mediations were conducted in Structural Equation Modeling (SEM; Bollen, 1989) framework using the *lavaan* package (Rosseel, 2012). The data handling and data analysis were performed using R version 4.3.1 (R Core Team, 2023).

Although the ToM score is an ordinal variable with three levels (0, 1, 2), we treated it as continuous and used MLR estimation with FIML for two main reasons. First, Weighted Least Squares Means and Variance adjusted (WLSMV), commonly recommended for ordinal outcomes, relies on listwise deletion for missing data. This method has been shown to reduce power and yield biased parameter estimates, whereas MLR with FIML retains all available data and provides more efficient estimates (Enders, 2001). Second, simulation studies (e.g., Robitzsch, 2020) showed that treating ordinal variables with at least three categories as continuous can yield robust and unbiased estimates, provided the model is well specified. To assess robustness, we also ran the model using WLSMV. The results were consistent with those obtained with MLR. Finally, we conducted a series of additional models to examine the effects of specific subcomponents in greater detail. Full analyses and results are available in the Appendix A1.

3. Results

With regard to the two indices of family SES, descriptive statistics indicated that 22.8% of children' mothers (parent 1) had completed high school or less, 20.6% held a postsecondary qualification equivalent to two or three years of college, and 56.6% had attained a master's or doctoral degree (M = 14.91, SD = 3.90). Among fathers (parent 2), 28.9% had a high school diploma or less, 15.7% had completed two or three years of college, and 55.4% held a graduate-level degree (M = 14.52, SD = 4.42). Regarding occupational status, 31.4% of mothers and 30.9% of fathers held positions with an ISEI-08 score of 50 or below, a range associated with intermediate-level occupations. The mean ISEI-08 score was 56.19 (SD = 23.20) for mothers and 57.93 (SD = 21.73) for fathers.

Table 1.2 presents descriptive statistics for each variable in children, organized by age group. Table 1.3 presents the partial correlations, controlling for age, along with the overall descriptive statistics for all variables. The family SES index (including separate indices for education and occupation) showed significant correlations with language, and EF measures. Additionally,

ToM was significantly correlated with language, EF measures, and the family SES index, and parental education (see Table 1.3).

Age range	Variable	*M*	*SD*	*Min*	*Max*
3 - 4	ToM	0.35	0.60	0.00	2.00
	Process of learning new words	0.35	0.23	0.00	0.94
	Syntax	0.43	0.19	0.00	0.88
	Vocabulary	0.48	0.22	0.12	1.00
	Congruent - H&F	4.46	1.85	0.16	7.11
	Incongruent - H&F (inhibition)	3.60	1.85	0.00	6.57
	Mixed - H&F (cognitive flexibility)	2.73	1.40	0.00	6.13
4 - 5	ToM	0.95	0.83	0.00	2.00
	Process of learning new words	0.65	0.27	0.00	1.00
	Syntax	0.68	0.20	0.19	1.00
	Vocabulary	0.70	0.23	0.19	1.00
	Congruent - H&F	6.23	1.27	0.62	8.18
	Incongruent - H&F (inhibition)	5.36	1.68	0.31	7.64
	Mixed - H&F (cognitive flexibility)	4.33	1.69	0.78	7.16
5 - 6	ToM	1.11	0.85	0.00	2.00
	Process of learning new words	0.78	0.20	0.06	1.00
	Syntax	0.78	0.16	0.31	1.00
	Vocabulary	0.81	0.18	0.25	1.00
	Congruent - H&F	7.08	0.62	5.63	8.59
	Incongruent - H&F (inhibition)	6.51	1.11	1.72	8.13
	Mixed - H&F (cognitive flexibility)	5.50	1.37	1.09	7.87
6 - 7	ToM	1.30	0.78	0.00	2.00
	Process of learning new words	0.88	0.14	0.31	1.00
	Syntax	0.87	0.15	0.19	1.00
	Vocabulary	0.92	0.13	0.25	1.00
	Congruent - H&F	7.90	0.62	6.44	9.22
	Incongruent - H&F (inhibition)	7.41	0.90	2.97	9.14
	Mixed - H&F (cognitive flexibility)	6.73	1.11	1.72	8.61

Table 1.2. Descriptive Statistics by age group for each variable assessed in children. ToM = Theory of Mind, H&F = Hearts and Flowers task. N = Number of observations, M = Mean, SD = Standard Deviation, Min = Minimum, Max = Maximum. Possible score ranges for each measure are as follows: ToM = 0–2; Process = 0–1; Syntax = 0–1; Vocabulary = 0–1; H&F Congruent, Incongruent, and Mixed = 0–10.

	1.	**2.**	**3.**	**4.**	**5.**	**6.**	**7.**	**8.**	**9.**	**10.**
1. SES	__									
2. Education	.93***	__								
3. Occupation	.93***	.74***	__							
4. ToM	.14*	.15*	.1	__						
5. Process	.35***	.33***	.32***	.23***	__					
6. Syntax	.3***	.26***	.28***	.26***	.6***	__				
7. Vocabulary	.42***	.39***	.41***	.25***	.66***	.63***	__			
8. Congruent	.17**	.15*	.17**	.16**	.3***	.27***	.31***	__		
9. Inhibition	.19**	.16**	.19**	.19**	.39***	.26***	.32***	.62***	__	
10. Flexibility	.15**	.13*	.15**	.18**	.36***	.23***	.28***	.44***	.59***	__
N	338	330	330	310	355	355	355	343	338	332
M	.01	15.59	62.7	.95	.65	.68	.72	6.37	5.69	4.79
SD	1	3.58	2.91	.85	.29	.24	.25	1.7	1.96	1.97
Min	-3.66	0	14.64	0	0	0	.12	.16	0	0
Max	1.37	20	88.7	2	1	1	1	9.22	9.14	8.61

Table 1.3. Partial correlations controlling for age and general descriptive statistics. SES = Socioeconomic status; Education = highest parental education; Occupation = highest parental occupation; ToM = Theory of Mind, H&F = Hearts and Flowers task. N = Number of observations, M = Mean, SD = Standard Deviation, Min = Minimum, Max = Maximum. Significance levels for p-values of correlation coefficients are denoted as follows: *p < .05, **p<.01, ***p < .001.

3.1 Measurement model

The two-factor latent measurement model showed good fit to the data, $\chi^2(8) = 14.71$, p = .07, RMSEA = .05, SRMR = .01, CFI = 1, TLI = .99. An inspection of parameter estimates revealed that all items had strong factor loadings (Appendix A2, Table A1).

3.2 Parallel mediation analysis

3.2.1 Main model

The main model (Figure 1.1) demonstrated good fit: $\chi^2(20) = 33.55$, $p = .03$, RMSEA = .04, SRMR = .02, CFI = .99, TLI = .99. The total effect of family SES on ToM was significant (β = .13, $p = .02$). However, once the mediators were included, the direct effect became non-significant (β = –.02, $p = .79$), indicating full mediation.

SES had significant direct effects on language (β = .32, $p < .001$) and EF (β = .14, $p < .001$). Of the two mediators, only language significantly predicted ToM (β = .38, $p = .001$); EF did not (β = .16, $p = .17$). Results are presented in Table 1.4. The model accounted for 64% of the variance in language, 65% in EF, and 25% in ToM.

The indirect effect of SES on ToM through language was significant (β = .12, $p = .002$, 95% CI [0.05, 0.22]), while the indirect effect through EF was not (β = .02, $p = .26$, 95% CI [–0.01, 0.07]). These findings support a unique mediation through language. A Wald test confirmed that the difference between the two mediators was significant ($p = .048$).

	β	***SE***	***z***	***p***	**95% Boot CI**
Indirect effect of language	.12	.04	2.96	.01	.05, .22
Indirect effect of EF	.02	.02	1.13	.26	-.01, .07

Table 1.4. Indirect effects of language and EF on the family SES - ToM relation. SE = Standard Error; 95% Boot CI = bootstrapped 95% upper and lower confidence intervals. Confidence intervals that do not include 0 are considered significant.

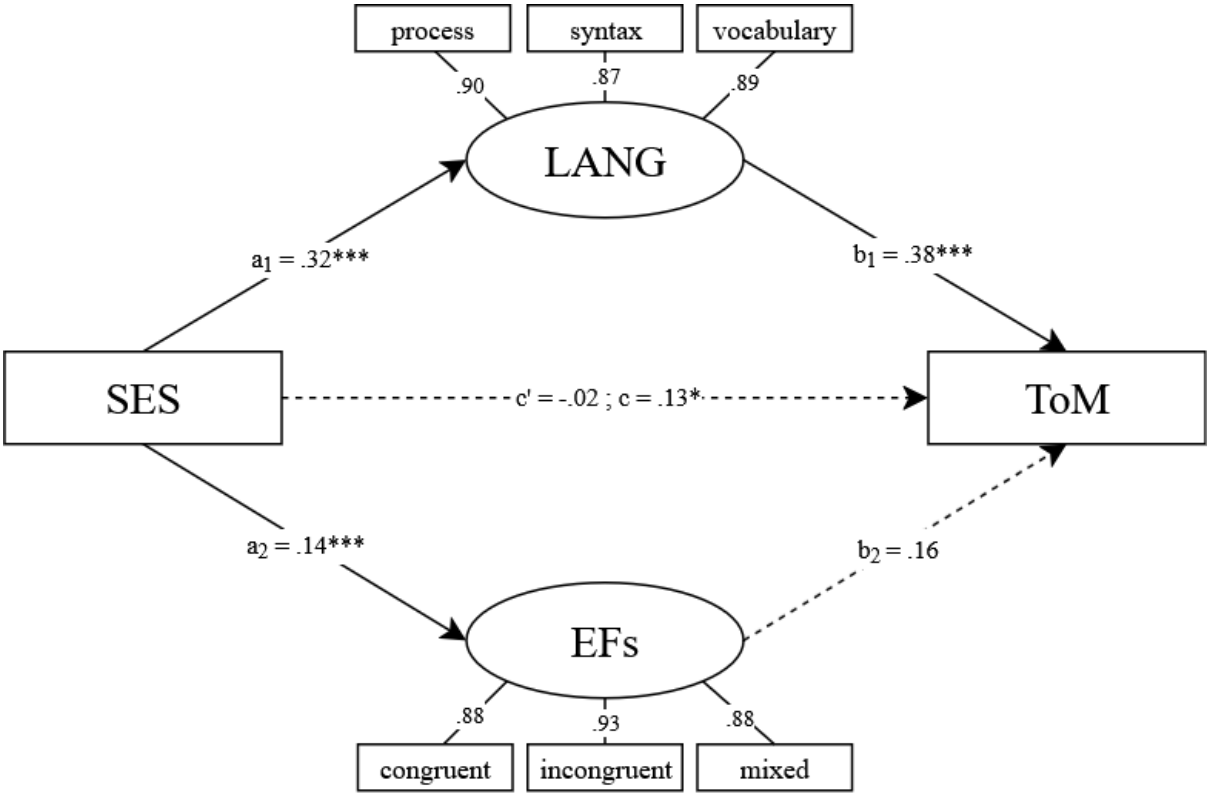


Figure 1.1. Parallel mediation analysis examining the relations between SES and ToM, with language and EF as mediators with age as covariate. Paths a_1, a_2, b_1, b_2, c, and c' represent the beta coefficients for the corresponding direct effects. Significance levels for p-values of direct and total effects are denoted as follows: *p < .05, **p < .01, ***p < .001. Dotted lines represent non-significant paths.

3.2.2 Additional analysis

Additional analyses were conducted to further disentangle the respective contributions of different SES indicators and language components to the SES–ToM relation.

3.2.2.1 Mother education vs. occupation

A model including both mother's education and occupation showed significant indirect effects via language for mother education (β = .09, *p* = .01, CI [0.03, 0.18]) and occupation (β = .07, *p* = .03, CI [0.02, 0.14]). A Wald test revealed no significant difference between the two (*p* = .63), suggesting comparable predictive strength. Neither mother's education (β = .02, *p* = .41) nor occupation (β = .02, *p* = .32) showed significant indirect effects via EF.

3.2.2.2 Parental education vs. occupation

Similarly, parental education had a significant indirect effect on ToM via language (β = .07, *p* = .03, CI [0.02, 0.16]), while the effect of parental occupation did not reach significance (β = .06, *p* = .07, CI [0.02, 0.16]). The difference between the two effects was not significant (*p* = .76). Neither education (β = .01, *p* = .53) nor occupation (β = .06, *p* = .43) showed significant indirect effects via EF.

3.2.2.3 Vocabulary, syntax and process of learning new words

A model including vocabulary, syntax, and word-learning processes indicated no significant indirect effects via vocabulary (β = .04, *p* = .31) or process (β = .01, *p* = .72). Syntax showed a significant direct effect on ToM (β = .18, *p* = .04), and its indirect effect approached significance (β = .04, *p* = .07). Wald tests revealed no significant differences between these components (Vocabulary vs. Syntax: *p* = .86; Syntax vs. Process: *p* = .40; Vocabulary vs. Process: *p* = .63). Embedded clauses score, previously identified as one of the strongest predictors of ToM among language components (de Villiers & de Villiers, 2014), was considered in an additional model. However, it did not show any unique direct (β = .04, p = .60) or indirect (β = .01, p = .64) contribution to ToM.

3.3 Moderated mediation analysis

3.3.1 Main model

The moderated mediation model showed good fit: $\chi^2(8) = 12.37$, *p* = .14, RMSEA = .04, SRMR = .01, CFI = 1, TLI = .99. Age significantly moderated the relationship between SES and language (β = –.09, *p* = .01), but not between SES and ToM (β = –.02, *p* = .72).

The index of moderated mediation was significant (β = –.04, *p* = .02), indicating that the mediating role of language weakened with age. However, the indirect effect remained significant at all age levels: one standard deviation below the mean (around 3 years and 11 months; β = .19, *p* < .001), at the mean (around 5 years and 6 months; β = .15, *p* < .001), and one standard deviation above (around 7 years; β = .11, *p* < .001).

	Corresponding Age	*β*	BootSE	*z*	*p*	95% Boot CI
Age – 1 SD below the mean	3 years 11 months	.19	.05	3.53	.001	.10, .29
Mean age	5 years 6 months	.15	.04	3.77	.001	.08, .22
Age + 1 SD above the mean	7 years	.11	.03	2.55	.001	.05, .19
Index of moderated mediation		-.04	.02	-2.12	.03	-.08, -.01

Table 1.5. Bootstrap results for the conditional effect of language on the SES - ToM link. BootSE = bootstrap standard error; 95% Boot CI = bootstrapped 95% upper and lower confidence intervals. Confidence intervals that do not include 0 are considered significant.

3.3.2 Additional analysis: ceiling effects.

Despite the task being standardized and normed up to 6 years and 11 months, children aged 6 to 7 years exhibited near-ceiling scores on the language task in our sample. To examine whether this could account for the decline in the indirect effect with age, we re-ran the moderated mediation model including only children under 72 months of age (Figure 3). In this restricted sample, the index of moderated mediation was not significant (β = –.01, p = .69), suggesting that the previously observed age-related decline may reflect ceiling effects in older children.

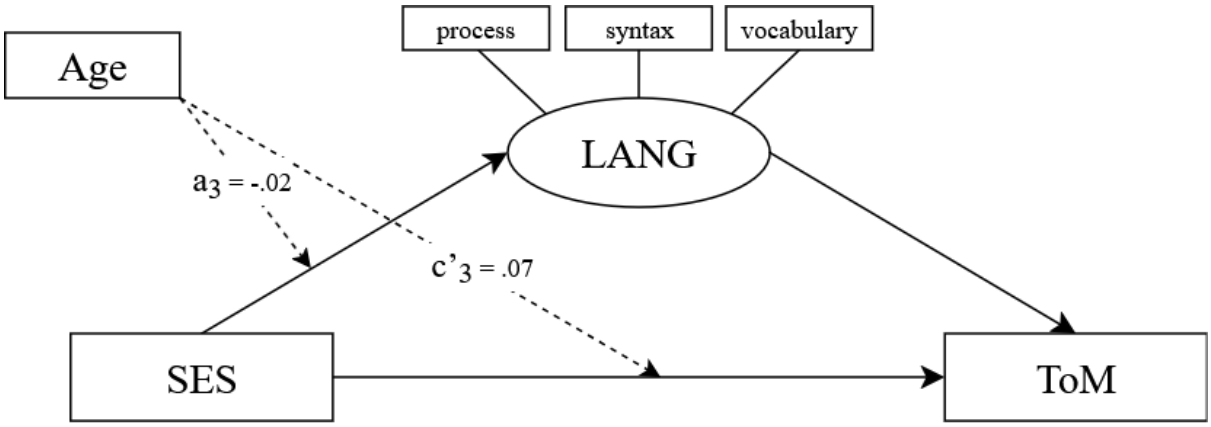


Figure 1.2. Moderated mediation analysis of the relations between SES and ToM, with language as mediator, and age as moderator. Paths a_3 and c'_3 represent the beta coefficients for the corresponding direct effects. Dotted lines represent non-significant paths.

4. Discussion

This study investigated whether language and EF mediate the relation between family SES and ToM, and whether their roles vary with age in preschool and school-aged children. Our findings revealed that family SES is associated with ToM, language, and EF. Furthermore, language mediated the SES-ToM relation, emerging as the sole significant mediator when controlling for age and EF. Finally, the indirect effect of language on the SES-ToM link varied with age, with significant mediation observed only in younger children.

First, children's performance on the ToM task aligned with expectations, with scores gradually improving between ages 3 and 7, reflecting the typical developmental trajectory observed in first-order false belief tasks. Despite the trajectory being similar, the proportion of correct response appears to be lower than in previous studies (Wellman et al., 2001). This delay may reflect the socioeconomic composition of our sample, with descriptive statistics showing that high-SES children reached above-chance accuracy earlier than their low-SES peers. This pattern is consistent with prior research showing delayed acquisition of first-order false belief in more socioeconomically diverse samples (Dixson et al., 2018; Mayer & Träuble, 2015).

Consistent with prior research, partial correlations indicated that family SES is linked to ToM (Cole & Mitchell, 1998; Cutting & Dunn, 1999; Devine & Hughes, 2018), language (Hart & Risley, 1995; Ma et al., 2024) and EF development (Kishiyama et al., 2009; Lawson et al.,

2018). Moreover, ToM was significantly associated with EF and language measures. However, when language was included, the association between EF and ToM disappeared, leaving language as the sole predictor of ToM. This is in line with previous studies highlighting the foundational role of language in ToM development (de Villiers & de Villiers, 2025; de Villiers & de Villiers, 2014; Ebert, 2020; Jenkins & Astington, 1996; Milligan et al., 2007). Beyond the shared demands of false-belief tasks and linguistic processing (Bloom & German, 2000), our findings may reflect the role of pragmatic and semantic skills, such as tracking speakers' beliefs or understanding mental state terms (Fernández, 2013; Hughes & Dunn, 1998), in facilitating ToM processing in social and conversational contexts (De Rosnay et al., 2014). Intervention studies reinforce this link, showing that engaging children in mental-state discourse or narrative contexts can improve ToM (Hale & Tager-Flusberg, 2003; for a meta-analysis on training programs, see Hofmann et al., 2016). For a detailed review of language's role in ToM development, see de Villiers & de Villiers (2014).

In our sample, language fully mediated the SES–ToM relation, echoing prior findings (Bulgarelli & Molina, 2016; Tompkins et al., 2017), and emphasizing language as a central mechanism underlying SES-related disparities in ToM development. This also aligns with research showing strong SES-related disparities in language development (Noble et al., 2005). These findings are particularly notable given the context of our sample. Our study offers a novel contribution by examining these relations within a French cohort, whereas most prior studies have focused on U.S. samples, often analyzing EF, language, and ToM separately rather than integrating them into a unified mediation model. Incorporating all variables into a single model allowed us to better understand the SES–ToM relation.

Additional analyses further suggested that syntactic skills were more closely linked to ToM than vocabulary or word learning, consistent with the role of complement syntax in representing beliefs (Kaltefleiter et al., 2021). While differences between components did not reach significance, the trend aligns with the literature highlighting syntax's important contribution to ToM (de Villiers & de Villiers, 2025).

Analyzing SES components separately revealed that both mother education and mother occupation showed similar strength in predicting ToM through language. However, when considering both parents, parental education, but not parental occupation, predicted ToM through language. This pattern mirrors prior work highlighting the specific influence of education on cognitive and language outcomes (Davis-Kean, 2005; Reardon, 2011). This could

be explained by the fact that parents with higher education levels tend to engage more frequently in interactions with their children (Sayer et al., 2004). This increased engagement may reflect a greater awareness of the developmental benefits of such interactions (see Monna & Gauthier, 2008 for a review). These interactions, in turn, likely support both social and cognitive development (Bulgarelli & Molina, 2016), further contributing to SES-related differences in ToM.

The lack of a unique contribution from EF to ToM contrasts with prior findings identifying EF as predictors of ToM (Doenyas et al., 2018; Henning et al., 2011; Hughes & Ensor, 2005; Marcovitch et al., 2015) and perspective taking abilities (Frick & Baumeler, 2017) when verbal abilities are accounted for (see Devine & Hughes, 2014 for a meta-analysis). Several factors may account for the discrepancies between our findings and the ones reported in these previous studies. First, studies that have found an effect of EF while controlling for language have typically assessed only one or a limited number of aspects of language, most of the time vocabulary. Our broader battery, assessing vocabulary, syntax, and novel word learning, may have captured variance that would otherwise be attributed to EF. Indeed, language and EF are strongly interrelated in early childhood (Doebel & Zelazo, 2016; Gooch et al., 2016; Shokrkon & Nicoladis, 2022), and syntax, in particular, has been shown to correlate more closely with EF than vocabulary (Spiegel et al., 2021). Finally, one possible explanation lies in the cultural context of our sample. Most prior studies examining the links between SES, ToM, EF, and language have been conducted in the United States, whereas our study was conducted in France. As studies suggest that SES-brain-cognition relations are stronger in U.S. than in European samples (Walhovd et al., 2022), this difference may partly explain the discrepancies between our findings and previous research. Recent research has also challenged the deficit-oriented view often applied to SES-related differences in child development, particularly in U.S.-based research. For instance, Miller et al. (2024) argued that framing children from marginalized backgrounds as linguistically deficient reflects a narrow understanding of language competence, one that overlooks culturally diverse communicative practices. These critiques underscore the need to interpret SES-related disparities within broader sociocultural contexts.

A first moderated mediation analysis revealed that both the SES-language relation and the SES-language-ToM pathway vary with age. A notable limitation, however, is the potential ceiling effect in our language measures. Many children aged 6 to 7 scored near the maximum, reducing variability. When we reran the moderated mediation model on children under 72 months, the age-related decline in the indirect effect disappeared. Reducing our sample might have limited

our power to detect subtle moderation effects. However, the absence of consistent age-related moderation in previous research (Ma et al., 2024; Milligan et al., 2007) lends further support to the ceiling-effect explanation. This suggests that the apparent moderation by age may reflect limited measurement sensitivity rather than a true developmental shift. Future studies should employ more challenging or age-appropriate language assessments to better capture developmental change in older children.

Moreover, the use of a single ToM task may have restricted our ability to capture the complexity of ToM abilities. For instance, meta-analytic evidence indicates that studies employing composite scores for both EF and ToM report stronger EF-ToM associations, whereas reliance on a single ToM task tends to yield smaller effect sizes (Devine & Hughes, 2014; Hughes et al., 2000). Our choice to use the same task across all ages was guided by the need for comparability, and the expectation that low-SES children might develop first-order ToM later than their middle- or high-SES peers (Ebert et al., 2017). Future research would benefit from employing a broader range of ToM measures, including advanced and composite tasks, to better capture age-related variations and notably the EF-ToM relation.

Although we confirmed the unique role of language in mediating the SES-ToM relation, other factors related to both language and ToM might be interesting to consider. Another pathway through which SES may influence ToM is parental mind-mindedness, the caregiver's ability to view and treat their child as an independent thinker (Meins, 1997). Mind-mindedness, reflected in behaviors such as mental-state descriptions and interpreting infants' vocalizations (Meins, 1997; Meins et al., 2013) is linked to parental SES (Meins et al., 2013), and robustly predicts ToM development (Kirk et al., 2015). Devine & Hughes (2018) found that mind-mindedness and mental-state talk reduced the SES-ToM association but could not fully explain it. Integrating measures of mind-mindedness, language, and EF could provide a more comprehensive understanding of how SES influences ToM development across age.

In conclusion, our findings suggest that disparities in ToM are partly driven by the influence of family SES on language development in children aged 3 to 7 years. This underscores the need for targeted interventions to foster ToM development in children from disadvantaged backgrounds. For instance, intervention programs could include activities specifically designed to help children understand that others may have thoughts and feelings different from their own. Such programs could leverage the use of children's books, which often depict characters experiencing differing emotions or perspectives that lead to misunderstandings. These

narratives offer a valuable and accessible resource for fostering ToM skills by immersing children in scenarios that encourage perspective-taking and emotional understanding (Beazidou et al., 2013; Kumschick et al., 2014). By incorporating guided discussions, children's books can serve as a powerful tool to support the development of ToM abilities. Prioritizing both language and social cognition in early interventions may allow to play a pivotal role in fostering equity in ToM skills among children from diverse socioeconomic backgrounds.

Study 2

Implicit theory of mind: cross-sectional associations with explicit theory of mind, language, executive functions and socioeconomic status

After showing that explicit ToM was associated with SES in children from age 3 to 7, and that this association was mediated by language, we will now consider the contribution of language, EF, SES, and explicit ToM to implicit ToM in children within the same age range.

1. Introduction

As described in the General introduction (see section 2), infants' behavior in adapted false belief tasks challenged the traditional view that ToM develops around age 4 (Onishi & Baillargeon, 2005). While explicit ToM is typically assessed with traditional false belief tasks, which require children to explicitly reason about mental states (Baron-Cohen et al., 1985; Wellman et al., 2001; Wimmer & Perner, 1983), implicit ToM is usually assessed through more indirect measures, such as adapted false belief tasks that record infants' looking behaviors (e.g., He et al., 2011, 2012; Southgate et al., 2007). This reflects a so-called developmental paradox, namely that children under age 2 appear to understand others' beliefs, while they succeed at the classic false belief tasks only from age 4-5 (Wellman et al., 2001). This inconsistency has received considerable attention, and many studies have since found signs of early belief processing in very young children (e.g., Buttelmann et al., 2009; He et al., 2012; Knudsen & Liszkowski, 2012; Scott & Baillargeon, 2009; Senju et al., 2011; Southgate et al., 2007, 2010).

Following this discovery, several theoretical accounts have been proposed to explain this developmental paradox, and thus the nature of explicit and implicit ToM (see section 2.1.2 of the General introduction). Three main accounts are most widely discussed in the ToM field: the continuity (Baillargeon et al., 2010; Carruthers, 2016), the dual-process (e.g., Apperly & Butterfill, 2009), and the submentalizing (Heyes, 2014; Phillips et al., 2015) accounts. As mentioned, continuity accounts propose that implicit and explicit ToM rely on the same abilities, with failures in explicit tasks explained by the executive or linguistic demands of such tasks (Bloom & German, 2000). More recently, Carruthers (2016) argued for a single mindreading system that undergoes *gradual conceptual enrichment* from early childhood to adulthood. In contrast, the dual-process account posits two distinct systems: one automatic, fast, and unconscious, the other deliberate, slow, and conscious (Apperly & Butterfill, 2009). Finally, the submentalizing account claims that performance on implicit ToM tasks reflects low-level processes, such as sensitivity to statistical regularities, rather than genuine ToM abilities (Heyes, 2014).

Therefore, these competing views also differ in their predictions regarding the relation between implicit and explicit ToM. Continuity accounts predict associations between the two, at both behavioral and neural levels (e.g., some overlap would be expected). In contrast, dual-process and submentalizing accounts predict no such associations: either because they rely on distinct systems, or because implicit tasks do not measure social processing at all (although the

submentalizing account has since been challenged by several findings, e.g., Furlanetto et al., 2016). Both continuity and dual-process accounts, which posit that implicit ToM involves mentalizing are supported by empirical findings. Continuity accounts are supported by evidence that implicit ToM in infancy predicts later explicit ToM (e.g., Thoermer et al., 2012), and by studies showing consistent associations between implicit and explicit ToM in preschoolers (e.g., Kaltefleiter et al., 2022; Low, 2010). In addition, recent findings indicate that preschoolers who have acquired explicit ToM also display implicit ToM, whereas those who have not, do not, supporting the idea of a mutual influence between the two (Speiger, Rothmaler, Bravo, et al., 2025). Neuroimaging studies further point to partial overlap, with both implicit and explicit ToM recruiting common brain areas in adults (Boccadoro et al., 2019; Naughtin et al., 2017; Nijhof et al., 2018). Conversely, supporting the dual-system accounts, other studies report no correlation between implicit and explicit ToM (Grosse Wiesmann et al., 2017). Supporting this distinction, differences in the type of belief tracked between implicit and explicit ToM have been documented. For instance, implicit ToM seems to enable children to track beliefs about object location but not identity, whereas explicit ToM enables processing of both (Low & Watts, 2013; Schneider et al., 2014). In line with this, a recent study showed that in 3- to 4-year-olds, implicit and explicit ToM are associated with distinct neural correlates (cortical thickness and surface area) and revealed no behavioral correlation (Grosse Wiesmann et al., 2020).

While this debate is still ongoing, the literature on implicit ToM faces several challenges. It has been shown that implicit ToM is present from infancy (Senju et al., 2011), continues to develop in preschool (Grosse Wiesmann et al., 2017), school-aged children (Senju et al., 2010), and through adulthood (El Kaddouri et al., 2020; Kovács et al., 2010; Kulke & Rakoczy, 2018). However, most studies have assessed this capacity in children until age 3 or 4, leaving preschool and school-aged children relatively understudied. This lack of evidence limits our understanding of implicit ToM development during these years, as well as the factors contributing to its development. Among the few studies that did so, implicit ToM has been confirmed in children aged 3 to 7 (Schuwerk et al., 2018; Senju et al., 2010), while no replication in 2-years-old was found (Grosse Wiesmann et al., 2018; Kulke et al., 2018). These results highlight the second challenge, which is the replicability of implicit ToM findings (see section 2.1.3 of the General Introduction). Results in young children have proven inconsistent, raising concerns about the reliability of implicit ToM measures in young children (Barone et al., 2019; Barone & Gomila, 2021; Kulke & Rakoczy, 2018). As described earlier, three main

paradigms have been used to assess implicit ToM in infants: AL (Southgate et al., 2007), VOE (He et al., 2011), and helping behaviors (Buttelmann et al., 2009). Meta-analytic findings indicate that all three paradigms suffer from poor reliability in children (Barone et al., 2019). A recent review reinforced this conclusion, showing that VOE findings were successfully replicated in only about two-thirds of attempts. Similar inconsistencies were observed for AL tasks, with more than half of replication attempts yielding mixed or negative results, and for helping behaviors, with about half of studies failing to reproduce the original effects (Barone & Gomila, 2021). Overall, the VOE paradigm appears to be the most reliable among the three (Barone et al., 2019).

Interestingly, this lack of replication in 2 (or 3, Grosse Wiesmann et al., 2018) years old children, but not in older children, echoes findings on altercentric bias (Southgate, 2020). This bias reflects the influence of others' perspectives on our cognitive processes and has been argued to reflect implicit ToM (see section 2.2.2 of the General introduction). It has been suggested that the altercentric bias may follow a U-shaped developmental trajectory: emerging in infancy, diminishing during early childhood, and re-emerging later in development (Manea et al., 2023). This pattern is further supported by recent data indicating that, among children aged 3 to 5, the presence of an altercentric bias is observed only in children who have already developed explicit ToM (Speiger, Rothmaler, Bravo, et al., 2025). Additional support comes from perspective-taking research involving the Dot task (Samson et al., 2010). In this paradigm, participants are asked to judge whether a number of dots painted on a wall corresponds to a previously indicated number, with an avatar present who either shares or does not share the participant's perspective. Evidence of both egocentric and altercentric biases have been reported in children aged 6 to 10 and in adults, and broadly consistent across age groups (Surtees & Apperly, 2012). More recent results reported contrasting results, however, with no altercentric bias found in children from age 5 to 10, and a strong egocentric bias (i.e., interference from their own point of view when asked to consider the agent's), which disappeared after age 10 (Rubio-Fernandez et al., 2022). Specifically, while children aged 5 to 10 struggled to adopt the agent's perspective, children from age 10 onward were able to do so as efficiently as when reasoning from their own point of view.

It is important to note, however, that altercentric effects observed in such perspective-taking involve, in some trials to take the perspective of the agent, thus making the mental states or visual perspective of the agent salient. In contrast, implicit ToM tasks are typically designed to

measure spontaneous belief attribution when these beliefs are not mentioned or relevant to the task (Kovács et al., 2010).

A substantially replicated paradigm assessing spontaneous ToM in these conditions is the ball detection task (Kovács et al., 2010). Adults performance in this task reveals that the speed of object detection is affected by the agent's perspective, even though participants are not asked to attend to that perspective (see a complete description of the ball detection task in the General introduction) (Bardi et al., 2019; Bardi, et al., 2017; Boccadoro et al., 2019; Bardi, et al., 2017 ; Deschrijver et al., 2016; Kovács et al., 2014; Kovács et al., 2010; Nijhof et al., 2016, 2018). This paradigm showed one specific ToM index, based on the difference between two conditions that differed only in the agent's perspective. Importantly, this index was shown to correlate with autistic traits (Nijhof et al., 2017), which makes it a good candidate to assess individual differences.

As suggested in the General introduction, however, relatively little is known about the factors that contribute to individual differences in implicit ToM. Results from Study 1 indicated that family SES predicts explicit ToM primarily through its influence on language development. In contrast, it is still unclear whether family SES, EF or language abilities are associated with implicit ToM across development. As previously noted, studies examining the link between EF and implicit ToM have produced mixed results. Some report significant associations (Schneider et al., 2012; Yott & Poulin-Dubois, 2012), whereas others do not (Grosse Wiesmann et al., 2017; Low, 2010). Language-related findings are similarly inconsistent, with some studies reporting no relations (Grosse Wiesmann et al., 2017; Low, 2010), while others identify significant links (Meristo et al., 2012, 2016; San Juan & Astington, 2012). A more detailed review of these findings is provided in the General Introduction (see section 3.3). Concerning the family environment, evidence suggests that parental use of mental state language is influenced by SES and is associated with both explicit (Ebert et al., 2017) and implicit ToM (Roby & Scott, 2018). Additionally, SES appears to affect early social cognition, such as joint attention (Reilly et al., 2021). Recent research also highlights the potential role of broader sociocultural factors, particularly those related to cultural background, in the altercentrism bias. A recent preregistered study has begun to investigate how characteristics associated with WEIRD (Western Educated Industrialized Rich and Democratic; Henrich et al., 2010a, 2010b) populations could influence this bias (Padberg et al., 2022). However, no study to date has directly investigated whether family SES could impact implicit ToM in children.

Hence, there is limited knowledge about a) the relation between implicit and explicit ToM beyond preschool, and b) whether the factors that predict explicit ToM abilities also predict implicit ToM abilities. The ball detection paradigm presents three main advantages in testing ToM. First, the task has been replicated multiple times (Bardi et al., 2017a; Bardi et al., 2019; Bardi et al., 2017b; Hudson et al., 2021; Kovács et al., 2014; Low et al., 2020; Nijhof et al., 2016, 2018) and appears to be more robust than other implicit ToM paradigms used in young children (Barone et al., 2019). Second, the task allows, with the same material, the assessment of both implicit and explicit ToM (Nijhof et al., 2018). Finally, a ToM index extracted from the task has been linked to the severity of autistic traits, allowing to capture individual variability. In addition, altercentric bias measures appear to offer a promising way to assess implicit ToM in children, with recent evidence showing a close link to explicit ToM (Speiger, Rothmaler, Bravo, et al., 2025). However, no study has investigated whether the ball detection task could be used in preschool and school-aged children. Thus, the aims of the present study are threefold: a) adapt the ball-detection paradigm to assess implicit ToM in children aged 3 to 7, b) examine the relation between implicit and explicit ToM using this paradigm in children, and c) explore whether implicit ToM is associated with the same factors as explicit ToM, namely EF, language, and family SES. To do so, we tested the presence of egocentric and altercentric bias the same sample of Study 1, and tested relation between potential index of implicit ToM and explicit ToM (first order false-belief), language (vocabulary, syntax, and learning new words), EF (inhibition and flexibility) and family SES (parental education and occupation).

We expected explicit ToM to correlate with implicit ToM (Kloo et al., 2020), language (Milligan et al., 2007), EFs (Devine & Hughes, 2014), and SES (Devine & Hughes, 2018). Given the mixed findings in the literature, we did not formulate strong hypotheses regarding the relation of implicit ToM with EF, language, and family SES, as previous studies have yielded inconsistent results (Grosse Wiesmann et al., 2017; Low, 2010; Meristo et al., 2016; Roby & Scott, 2018; Schneider et al., 2012; Yott et al., 2011), and in some cases very little evidence is available (Roby & Scott, 2018). Finding correlations between implicit ToM and broader cognitive or environmental factors would directly challenge the two-systems account, which posits that implicit ToM is spontaneous, inflexible, and largely independent of executive or linguistic abilities. Such findings would also be difficult to reconcile with continuity accounts that assume that implicit ToM is independent of these domains.

2. Method

2.1 Participants

The final sample was identical to that of Study 1 and comprised 375 children (176 girls; *Mean age* = 4.9 ± 1.1 years). Descriptive statistics by age group are reported in the method section of Study 1.

2.2 Materials

This study examined the contributions of explicit ToM**,** language**,** EFs and family SES to implicit ToM. While full task descriptions can be found in the General method, below we provide brief summaries and specify the cleaning procedure for the implicit ToM measure.

2.2.1 ToM assessments

2.2.1.1 Implicit ToM

Children completed an adapted version of the Ball Detection task with short animations that manipulated the participant's belief (P) and the agent's belief (A) about a ladybug's presence behind an occluder (+ = present, − = absent). The four belief combinations were: P+A+, P+A−, P−A+, P−A−. At the end of each video, the ladybug could be present (L+) or absent (L-), and this was independent from previous events. On each trial, children pressed a ladybug button only when the occluder fell and the ladybug was present. Accuracy and RT were recorded. Twelve trials were analyzed in total: 4 L− trials (one per belief combination) and 8 L+ trials **(**two per belief combination).

2.2.1.2 Explicit first-order ToM

Children viewed two narrated false-belief videos (P+A- and P-A+) and answered a control question ("Where is the ladybug now?") and a false-belief question ("Where does Buzz think the ladybug is?"). One point was awarded only if both answers were correct.

2.2.2 Language assessments

A French adaptation of the Quick Interactive Language Screener (QUILS) assessed vocabulary, syntax, and language-learning processes. The task included 48 trials (16 per component). One point was awarded per correct response.

2.2.3 EF assessments

EFs were measured with the three blocks of the Hearts & Flowers task (congruent, incongruent, mixed). Performance was scored with the two-vector (TV) method, attributing 0–5 points for accuracy, and an additional 0–5 points for RT per block (RT points only if accuracy ≥ 75%), yielding a block-level score that integrates speed–accuracy trade-offs. The incongruent block indexes inhibition, the mixed block cognitive flexibility.

2.2.4 Family SES

Family SES was computed from the highest parental education and the highest parental occupational status across caregivers.

2.3 Data cleaning

To ensure data quality, 28 children (8.02%) were excluded for clear inattention during the implicit task**.** We then removed cases whose response patterns indicated poor or no understanding of instructions: 24 children (6.88%) who pressed the ladybug's button 0 or 1 time across all trials, and 12 children (3.44%) who responded on 13 or 14 of 14 trials (therefore not retaining response when the ladybug was absent). In total, 66 children (18.91%) were excluded, yielding a final implicit-ToM sample of 285 participants. No further exclusions were applied based on accuracy.

For RT analyses, to ensure interpretable data, we further restricted the sample to children with ≥ 50% accuracy in both present (L+) and absent (L−) outcome trials, resulting in a subsample of 219 participants.

2.4 Statistical analysis

All analyses were conducted in R (version 4.3.1; R Core Team, 2023) using the following packages: *tidyverse* (Wickham et al., 2025), *emmeans* (Lenth, 2017), *ordinal* (Christensen, 2010), *car* (Fox et al., 2001), and *ppcor* (Kim, 2015).

2.4.1 Overview

Because the implicit ToM task has not previously been used with children under age 10 (El Kaddouri, 2020), and because we substantially adapted the original adult version (the original target was replaced by a ladybug in our version), we began by characterizing task performance.

We first ran models predicting accuracy and RT to test the effects of (a) the participant's own belief and (b) the agent's belief (each coded as positive vs. negative), and their interactions with age, in order to detect age-related changes in task performance. In a second step, we derived individual indices of implicit ToM and examined their associations with explicit ToM, language, EFs, and SES using partial correlations (age-controlled).

2.4.2 Accuracy models

Both present-outcome (L+) and absent-outcome (L−) trials were analyzed. For L− (one trial per condition, accuracy coded 0/1), we fitted binomial GLMs with fixed effects of participant belief, agent belief, age, and their interactions. For L+ (two trials per condition), responses were summed per participant and condition (possible scores between 0 and 2) and analyzed with a cumulative link model (CLM) using the same fixed-effects structure. Age was z-scored, and sum contrasts were applied to participant and agent belief. An analysis of deviance was used to test for main effects (Christensen, 2018). In post-hoc tests of interaction effects, we applied FDR correction for multiple comparisons. To report the magnitude and direction of the effects, we include effect estimates (β) and their standard errors.

2.4.3 RT model

RTs were standardized prior to analysis and then averaged per participant × condition (P+A+, P+A-, P-A+, P-A-) for L+ trials. We fitted a linear model with fixed effects of participant belief, agent belief, age, and their interactions. Main effects and interactions were assessed using Type III ANOVA. Age was z-scored, and participant and agent belief were sum-coded, consistent with the accuracy analyses.

Details of the RT and accuracy models (including fit statistics) are presented in the Appendix A2.

2.4.4 Individual indices

In prior work, the RT difference between P–A– and P–A+ (called the *ToM index*) has been used as an adult marker of implicit ToM because these two conditions differ only in the agent's belief, with the participant's belief and the outcome held constant (Deschrijver et al., 2016; El Kaddouri et al., 2020; Kovács et al., 2014; Kovács et al., 2010; Nijhof et al., 2016, 2018; Phillips et al., 2015). By contrast, the P+A+ vs P+A− contrast has typically not been retained, as RT differences are usually nonsignificant in adults. Because the task has not been used with young

children and we could expect differences from adults patterns, we targeted three effects: agent belief, participant belief, and belief congruency, and summarized performance using a) RT difference scores, b) accuracy indices, and c) composite indices. These composite scores were calculated by standardizing both RT and accuracy across participants and conditions, and then combining them into a single metric where higher values indicate both faster and more accurate responses. We then ran partial correlations (controlling for age) between all candidate implicit indices and explicit ToM. P-values were adjusted using the FDR correction. Although previous studies have reported no association (e.g., Grosse Wiesmann et al., 2017), we expected implicit ToM to correlate with explicit ToM, based on prior evidence suggesting a developmental association between the two (e.g., Grosse Wiesmann et al., 2018; Low, 2010; Thoermer et al., 2012). We focused on this association because, if implicit and explicit ToM are indeed related, a significant correlation would suggest that the implicit index captures some form of ToM-related processing. Indices showing associations with explicit ToM were retained and entered into a final age-controlled correlation matrix along with language**,** EF, and family SES. Descriptive statistics for explicit ToM, language, EFs, and family SES are reported in the Method section of Study 1.

2.4.5 Composite predictors

We created an index score for language, EFs and SES by running a principal component analysis (PCA) including the standardized observed variables (Berni et al., 2011). The advantages of PCA are that it reduces dimensionality while minimizing information loss (Jollife & Cadima, 2016). For the index of language, we ran the PCA with the scores of process, syntax, and vocabulary. For the index of EF, the PCA was performed with the scores of inhibition and flexibility. Finally, for the index of SES, the PCA included the highest parental occupational status and the highest parental level of education. These index scores were then derived by extracting the first principal component (PC1). The relevance of this method was confirmed by checking the proportion of variance explained by PC1 and the correlations (loadings) between the observed variables and PC1.

3 Results

3.1 Accuracy

3.1.1 Descriptive statistics

Prior to cleaning based on accuracy (described in the data cleaning section), we summarized accuracy by age group (Table 2.1). Performance was low in the 3 to 4 age range and rapidly increased, with most older children showing high accuracy.

Accuracy	**3 – 4**	**4 – 5**	**5 – 6**	**6 – 7**
0 – 25%	1	0	1	0
25 – 50%	21	14	6	2
50 – 75%	19	26	13	3
75 – 1%	8	46	69	56
Mean (SD)	0.56 (.17)	0.75 (.18)	0.84 (.18)	0.89 (.12)

Table 2.1. Accuracy in the implicit ToM task for each age group. Age categories are reported in years. Values indicate number of participants per accuracy bracket.

3.1.2 Binomial models

We tested effects of participant belief and agent belief on accuracy using age as continuous (Figure 2.1).

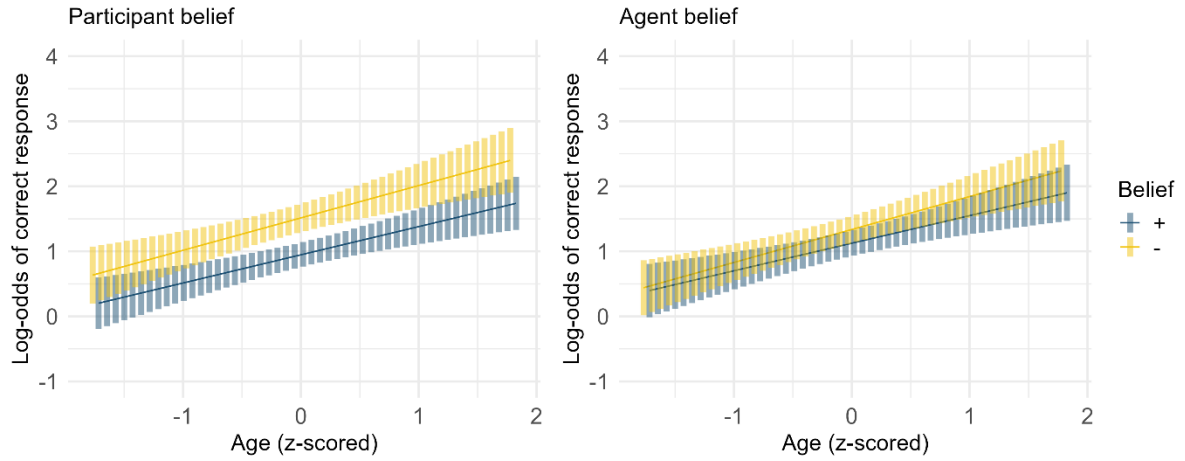


Figure 2.1. Predicted accuracy from logistic regression. Belief + = Belief that the ladybug will be present; belief - = belief that the ladybug will be absent. In this model, the yellow line matches the outcome.

There was a significant main effect of participant belief ($\chi^2(1) = 5.74$, p=.02), and of age (z-scored) ($\chi^2(1) = 26.04$, $p < .001$). The participant belief × age interaction was not significant ($\chi^2(1) = 0.18$, $p = .67$). Agent belief showed no main effect ($\chi^2(1) = 1.46$, $p = .23$) and no interaction with age ($\chi^2(1) = 0.20$, $p = .66$).

3.1.3 Ordinal model

We applied the same strategy to L+ trials (two trials aggregated per condition).

There was a significant main effect of age ($\chi^2(1) = 61.12$, $p < .001$). Participant belief alone was not significant ($\chi^2(1) = .04$, $p = .83$), but interacted with age ($\chi^2(1) = 12.35$, $p < .001$). Post-hoc analyses showed that the effect was positive and significant at −1 SD of age, but negative and significant at +1 SD (Table 2.2). This suggests that younger participants were less accurate when their belief aligned with the outcome, whereas older participants were more accurate in such cases. Agent belief ($\chi^2(1) = .17$, $p = .68$) and its interaction with age ($\chi^2(1) = .07$, $p = .79$)

were not significant. Figure 2.2 displays the predicted accuracy for both participant and agent belief.

Contrast (Participant belief)	Age level	Estimate	SE	Z-ratio	p-value
(-) vs. (+)	-1	0.60	0.25	2.38	.017
	0	-0.03	0.15	-0.21	.833
	1	-0.66	0.22	-3.01	.003

Table 2.2. Estimated effects of participant belief at varying age levels. - = Belief that the ladybug will be absent; + = belief that the ladybug will be present; SE = standard error.

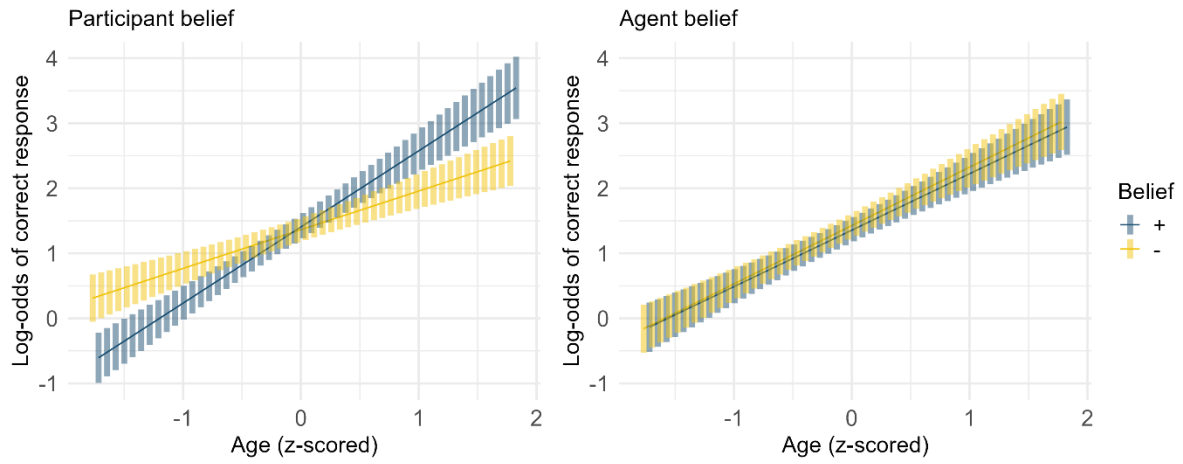


Figure 2.2. Precited accuracy from ordinal logistic regression. *Note*. - = Belief that the ladybug will be absent; + = belief that the ladybug will be present. In this model, the blue line matches

Overall, we observe a progressive increase in the participant-belief effect with age across accuracy analyses, while the agent-belief effect remains absent.

3.2 RT

3.2.1 Descriptive statistics

As noted in the Statistical Analyses section, additional exclusions were applied for the RT analyses. Table 2.3 reports descriptive statistics for the final sample. Descriptive statistics by condition and age group are presented in the Appendix A2 (Table A16).

Age Group	N	Mean age (SD)	Mean accuracy (SD)	Min	Max
3 – 4	21	41.86 (3.47)	0.69 (0.13)	0.50	1
4 - 5	64	53.77 (3.08)	0.83 (0.13)	0.50	1
5 - 6	76	65.14 (3.14)	0.90 (0.11)	0.50	1
6 - 7	58	78.83 (2.77)	0.91 (0.09)	0.57	1

Table 2.3. Descriptive statistics of the final sample. SD = Standard deviation; Min = Minimum score; Max = Maximum score.

3.2.2 Linear model

As for accuracy, we tested the effects of age (z-scored), participant belief and agent belief on RT (L+ trials), as well as their interactions.

There was a significant main effect of participant belief ($\chi^2(1) = 5.57$, p=.004), and of age ($\chi^2(1) = 66.27$, $p < .001$). The participant belief × age interaction was not significant ($\chi^2(1) = 0.41$, $p = .43$). Agent belief showed no main effect ($\chi^2(1) = 0.25$, $p = .54$) and no interaction with age ($\chi^2(1) = 0.08$, $p = .74$).



Figure 2.3. Predicted standardized RT from linear regression. *Note*. - = Belief that the ladybug will be absent; + = belief that the ladybug will be present. In this model, the blue line matches the outcome.

Overall, we observe a progressive increase in the participant-belief effect with age across RT analyses, while the agent-belief effect shows no effect (see Figure 2.3 for model estimates).

3.3 Implicit ToM indices

3.3.1 Selection of indices

We examined age-controlled partial correlations between implicit ToM indices (RT-, accuracy-, and composite-based) and children's explicit ToM performance. To ensure comparability, only positive outcome trials were included (two trials per condition).

For each "Agent" index, we computed the mean difference between conditions in which the agent's belief was false (A−) and conditions in which it was true (A+). Composite scores were calculated by standardizing both RT and accuracy across participants and conditions, and then combining them into a single metric where higher values indicate both faster and more accurate

responses. Table 2.4 summarizes all indices, their formulas, and interpretations. Given the absence of pre-registration, the indices are reported as exploratory measures.

Label	**Measure**	**Compared conditions**	**Participant belief**	**Interpretation**
RT_P+	RT	P+A− – P+A+	P+ (fixed)	Effect of agent's belief when participant's belief is positive. Positive = slower RT when agent's belief is negative.
RT_P-	RT	P−A− − P−A+	P- (fixed)	Effect of agent's belief; participant's belief is negative in both conditions.
RT_Agent	RT	(P+A−, P−A−) - (P+A+, P−A+)	Varies	Overall effect of agent's belief on RT. Positive = slower RT when agent's belief is negative.
ACC_P+	Accuracy	P+A+ − P+A−	P+ (fixed)	Effect of agent's belief when participant's belief and outcome are positive. Positive = higher accuracy when agent's belief is positive.
ACC_P-	Accuracy	P−A+ − P−A−	P- (fixed)	Effect of agent's belief when participant's belief is negative and outcome positive. Positive = higher accuracy when agent's belief is positive.
ACC_Agent	Accuracy	(P+A+, P−A+) − (P+A−, P−A−)	Varies	Overall effect of agent's belief on accuracy (positive outcomes). Positive = higher accuracy when agent's belief is positive.

COMP_P+	Accuracy and RT	P+A+ − P+A−	P+ (fixed)	Composite effect of agent's belief when participant's belief is positive. Positive = better performance when agent's belief is positive.
COMP_P-	Accuracy and RT	P−A− − P−A+	P- (fixed)	Composite effect of agent's belief when participant's belief is negative. Positive = better performance when agent's belief is positive.
COMP_Agent	Accuracy and RT	(P+A+, P−A+) − (P+A−, P−A−)	Varies	Overall composite effect of agent's belief. Positive = better performance when agent's belief is positive.

Table 2.4. List of implicit theory of mind indices across RT and accuracy scores derived from the implicit ToM task. Each index corresponds to a specific belief manipulation of the agent. All condition are derived from the positive outcomes, with 2 trials per condition.

3.3.3 Partial correlations

Only one index (reflecting the effect of the agent's belief on RT) was positively associated with explicit ToM. All other indices showed no reliable association with explicit ToM. All correlations are presented in Table 2.5. Importantly, children in our sample displayed the same RT pattern reported in adults for the P+A− versus P+A+ contrast (slower responses in P+A− than P+A+). While this difference is only descriptively present in adults (i.e., not statistically significant), it reached significance in children. We therefore retained this difference as a theoretically motivated implicit ToM index capturing the agent-belief effect when the child's own belief is positive (P+), even though it did not correlate significantly with explicit ToM in the current study. Both indices were thus retained for subsequent analyses**:** ToMI1 indexes the agent-belief effect on RT across conditions, and ToMI2 indexes the agent-belief effect on RT when the child's belief is positive (P+).

	1.	**2.**	**3.**	**4.**	**5.**	**6.**	**7.**	**8.**	**9.**	**10.**
1. RT_P+	__									
2. RT_P-	.09	__								
3. RT_Agent	.81***	.66***	__							
4. ACC_P+	-.05	-.07	-.12	__						
5. ACC_P-	.01	-.15	-.04	-.07	__					
6. ACC_Agent	-.03	-.15	-.12	.68***	.68***	__				
7. COMP_P+	.73***	-.02	.54***	.65***	-.08	.35***	__			
8. COMP_P-	-.05	-.57***	-.4***	.12	-.73***	-.41***	.07	__		
9. COMP_Agent	.59***	.42***	.69***	.37***	.48***	.64***	.71***	-.66***	__	
10. ToM_E	.16	.15	.22**	.07	-.11	-.03	.1	.02	.07	__

Table 2.5. Partial correlation (age-controlled) between all implicit ToM indices and explicit ToM. ToM_E = explicit theory of mind. All other indices are described in table 9. P-values are reported as follow: **p<.01; ***p<.001.

3.4 Predictors indices

3.4.1 PCA

Before computing the full correlation matrix, we derived composite indices for SES, language, and EF via PCA on standardized variables, retaining PC1 as the index for each domain. PC1 accounted for 86–90% of the variance across domains. Eigenvalues, variance explained, and factor loadings are reported in Table 2.6**.**

Index	Eigenvalue	Proportion of variance explained	Factor loading	
SES	1.74	0.87	Education	0.93
			Occupation	0.93
Language	2.57	0.86	Vocabulary	0.93
			Syntax	0.91
			Process	0.93
EF	1.78	0.89	Inhibition	0.94
			Flexibility	0.94

Table 2.6. Eigenvalues of the PC1 for each composite score computed by PCA.

3.4.2 Partial correlations

We then examined how implicit and explicit ToM relate to language, EFs, and SES using age-controlled partial correlations (Table 2.7). Explicit ToM was positively associated with language, EF, and SES. By contrast, one index of implicit ToM (agent belief in general conditions) correlated with explicit ToM but not with language, EF, or SES. We used FDR adjustment.

	1.	2.	3.	4.	5.	6.
1. ToMI1	__					
2. ToMI2	.66***	__				
3. ToME	.22**	.15	__			
4. Language	.08	.04	.26***	__		
5. EF	-.03	.00	.19**	.37***	__	
6. SES	.05	.04	.15*	.34***	.13	__

Table 2.7. Partial correlations (controlling for age) between implicit ToM, explicit ToM, language, EF and SES. ToMI1 = First index of implicit theory of mind (agent belief); ToMI2 = Second index of implicit theory of mind (agent belief when the belief of the child is positive); ToME = Explicit theory of mind; EFs = Executive functions; SES = Socioeconomic status. P-values are reported as follow: *p<.05; ***p<.001.

Finally, we examined whether overall accuracy in the implicit ToM task was associated with EF, language abilities, and SES. We computed partial correlations controlling for age and adjusted p-values using the FDR correction. Accuracy was positively correlated with EF and language, but not with SES. These findings indicate that EF and language abilities are associated with better overall performance on the implicit ToM task (Table 2.8). An assessment of differences between excluded and included children for RT analysis revealed significant group differences in SES, EF, and language (see Appendix A2, Table A15).

	1. Acc	2. Lang.	3. EF	4. SES
1. Accuracy	__			
2. Language	.27***	__		
3. EF	.34***	.36***	__	
4. SES	.004	.3***	.11	__

Table 2.8. Partial correlations (controlling for age) between accuracy in the implicit ToM task, language, EF and SES. Accuracy = accuracy in the implicit ToM task; EFs = executive functions; SES = socioeconomic status. P-values are reported as follow: **p<.01; ***p<.001.

4 Discussion

The aims of this study were to a) adapt the ball-detection paradigm to assess implicit ToM in children aged 3 to 7, b) examine the relation between implicit and explicit ToM using this paradigm in children, and c) explore whether implicit ToM is associated with the same factors as explicit ToM, namely EF, language, and fam

ily SES.

First, we found that general performance in the ball-detection task improved with age. Children gradually became more accurate, consistent with the development of attentional and inhibitory abilities during this period (Cragg & Nation, 2008; Frye et al., 1995), which are needed for completing the task successfully (e.g., withdraw responses when the ladybug is absent).

We also observed a consistent participant belief effect across both accuracy and RT models. This finding aligns with previous work showing an egocentric bias in both children and adults during automatic perspective-taking tasks (Piaget & Inhelder, 1956; Surtees & Apperly, 2012). This result is also consistent with more recent findings indicating a persistent egocentric bias until age 10 (Rubio-Fernandez et al., 2022). In addition, this aligns with a recent theoretical account suggesting that egocentrism develops during childhood, not in infancy as originally proposed (Piaget & Inhelder, 1956), as children begin to form a self-perspective (which is therefore conflicting with others' perspective). This, according to this theoretical account,

would explain why infants may display an altercentric bias, which is gradually replaced by a dominant egocentric bias later in early childhood (Southgate, 2020).

In contrast, we did not find agent belief effects in our sample. One explanation could be that the egocentric bias is still too dominant in early childhood for an altercentric effect to emerge (Rubio-Fernandez et al., 2022). This would be in line with findings suggesting that the altercentric bias observed in infancy tends to disappear during childhood and reappear later in adulthood (Manea et al., 2023). Another possibility is that the absence of agent belief effects is related to the executive demands of the task. Given that the ball detection task requires some level of EF, which are still developing during this age range, children may have lacked the resources to reliably process the agent's perspective (as maintaining attention to their task is already demanding for them). This interpretation would echo findings in adults showing that cognitive load interferes with implicit mentalizing (Schneider et al., 2012).

Notably, the classical ToM index commonly reported in adult studies was not replicated. In fact, we observed a reversed pattern, with faster responses in P–A– trials compared to P–A+ trials (even though examining age groups individually, none showed a significant difference between these two conditions). This result, in addition to the lack of agent belief effect, may also be due to specific characteristics of the task used.

Several methodological adaptations may have influenced the results. First, to make the paradigm more child-friendly, we replaced the target object (a ball, in the original adult version) with a ladybug. It is possible that children were more likely to attribute mental states to a ladybug than to a non-living object, which may have influenced their attribution of mental states to the agent (Buzz lightyear). Indeed, children may have focused more on the ladybug and its location, and less on the agent. This interpretation would be in line with research showing that children frequently attribute mental states to animals (Meints et al., 2010), that animals are the category most strongly associated with anthropomorphism (Urquiza-Haas & Kotrschal, 2015), and that infants show a natural attentional bias toward animals over objects (DeLoache et al., 2011). Additionally, children are regularly exposed to anthropomorphized animals in books and cartoons (Marriott, 2002), which may further encourage this tendency.

Second, in earlier versions of the task, adults were asked to press a key when the agent left the scene, the so-called attention-check (Kovács et al., 2010). The attention-check was removed in our version of the task. This was done because combining the detection of the target and the

attention check proved too demanding for younger children. Its absence in our version may have reduced the salience of the agent's mental state, thereby limiting the emergence of agent belief effects. Indeed, this was argued to be necessary in helping participants encode the agent's belief, as it marks the precise moment when the agent forms a belief about the object's location (El Kaddouri et al., 2020).

We also made adjustments to the task structure to better suit young children's attentional capacities. The number of trials was significantly reduced, and all participants were shown trials in a fixed order to minimize repetition and maintain engagement. While this design choice aligns with recent recommendations favoring fewer trials and larger samples (Miller, 2024), it may have affected the reliability of the measure. Additionally, since our main focus was on positive outcome trials, we deliberately included fewer negative outcome trials, following, for instance, Go No-Go paradigms (Hayashi et al., 2018). This design limits the interpretability of the results involving negative outcomes (i.e., binomial models) and calls for caution in their interpretation.

Taken together, the absence of expected ToM effects in this version of the task likely reflects a combination of developmental factors, particularly the persistence of egocentric bias, and specific task-related limitations. Future research could aim to manipulate these elements in order to better isolate their effects and refine the measurement of implicit ToM in children.

Concerning the relation between implicit and explicit ToM, we found that only the agent belief effect on reaction times was significantly associated with performance on the explicit ToM task. This result is consistent with previous studies showing that implicit and explicit ToM are associated during development (Grosse Wiesmann et al., 2018; Kaltefleiter et al., 2022; Low, 2010; Thoermer et al., 2012). Interestingly, since the agent belief effect did not emerge at the group level, its specific association with explicit ToM could suggest that only children with a certain level of explicit understanding may have been sensitive to the agent's belief in this context. This interpretation would be in line with recent findings indicating that only children who succeed on classic false-belief tasks also show an altercentric bias (Speiger, Rothmaler, Bravo, et al., 2025). These results challenge the dual-process account of ToM (Apperly & Butterfill, 2009), which assumes separate and independent systems for implicit and explicit ToM, but support the continuity hypothesis, which posits a gradual developmental integration between the two (Carruthers, 2016).

Finally, we found no correlation between implicit ToM and EF, language skills, or family SES. This is consistent with prior work suggesting that these factors are only linked to explicit ToM (Grosse Wiesmann et al., 2017; Low, 2010), and do not appear to play a significant role in implicit ToM abilities. In addition, implicit ToM abilities might not be related, or at least less, to family factors as this is the case for explicit ToM (Devine & Hughes, 2018). It is worth noting that participants excluded from the final analyses based on the 50% accuracy threshold had significantly lower EF and language abilities and came from lower-SES backgrounds. Importantly, however, running additional analyses without applying this exclusion criterion did not change the main results. Nonetheless, future research could benefit from finding a balance between ensuring data quality and preserving individual variability, particularly among children with lower resources.

While cross-sectional designs provide valuable insights into age-related differences, they cannot capture how individual trajectories develop. To address this, our third study adopts a longitudinal design to investigate the developmental trajectories of implicit and explicit ToM between ages 3 and 7. By following the same children over time, we aim to better characterize the development of implicit and explicit ToM and how factors such as EF, language, and family SES contribute to these developmental pathways. This approach aims to offer a more nuanced understanding of how ToM evolves during a period of cognitive and social development.

Study 3

Trajectories of implicit and explicit theory of mind: effects of language, executive functions and family SES in an accelerated longitudinal design

In the two previous studies, we examined the factors associated with implicit and explicit ToM. First, we found that explicit ToM was linked to SES, and that this association was mediated by children's language abilities. We then showed that implicit ToM was partially related to explicit ToM, but not to language, executive functions, or family SES. Building on these findings, the present study investigates the developmental trajectories of implicit and explicit ToM in children between ages 3 and 7.

This study led to a manuscript: Houdayer, J., Le Stanc, L., de Carvalho, A., Houdé, O., Bardi, L., & Borst, G. (in prep). Trajectories of implicit and explicit theory of mind: effects of language, executive functions and family SES in an accelerated longitudinal design.

1. Introduction

The first study of this thesis showed that explicit ToM was linked to family SES, language, and EF in children aged 3 to 7. When all variables were included into a single model, only language remained a significant predictor of explicit ToM. Moreover, the association between family SES and ToM was fully explained by language, with no moderating role of age. These results suggest that the relations between SES and both language and ToM remain stable across the preschool and early school years. The second study focused on implicit ToM between ages 3 and 7 and its relation to explicit ToM. Adapting a widely used adult paradigm (Kovács et al., 2010), we found that children in this age range were influenced only by their own perspective, not by that of an agent, indicating a strong egocentric bias. Altercentric bias, defined as the influence, positive or negative, of others' mental states on cognitive processes even when those states are irrelevant to the task (Kovács et al., 2010; Southgate, 2020), was therefore not observed at a general level. Nevertheless, we did find that the cost of the agent's beliefs on reaction times, an index of implicit ToM, correlated with explicit first order ToM performance in children. Furthermore, neither language, EF, nor family SES were related to implicit ToM, pointing to the relative independence of this ability from broader cognitive and environmental influences. While the first and second study used a cross-sectional design, this third study adopts an accelerated longitudinal design to focus on the developmental trajectories of implicit and explicit ToM, including advanced explicit ToM, and the role of EF, language, and SES as predictors of these trajectories.

As noted in Study 2, and in the General introduction, little is known about the developmental trajectory of implicit ToM in preschool and school-aged children. Recent evidence suggests a U-shaped trajectory for altercentric bias, with early signs in infancy, an absence of this bias in later childhood, and a reemergence in adulthood (Manea et al., 2023). Yet, except studies from the perspective taking field (Rubio-Fernandez et al., 2022), only one study has investigated this bias in children (Speiger et al., 2025). Moreover, no study has examined how this bias develops within the same individuals during the preschool and school years. Given that a non-linear trajectory is expected for this bias, especially as it seems to change between infancy and adulthood, more studies are necessary to better understand how this bias evolves in individuals. Furthermore, little is known about the predictors that may contribute to developmental change in implicit ToM (Roby & Scott, 2018).

In contrast, the development of explicit ToM, has been studied more extensively. Language is consistently identified as a strong predictor, whether by means of training interventions (Guajardo & Watson, 2002; Hale & Tager-Flusberg, 2003; Lecce, Bianco, et al., 2014; Lohmann & Tomasello, 2003), longitudinal studies (Astington & Jenkins, 1999; de Villiers & Pyers, 2002; Ruffman et al., 2003) or meta-analyses (Milligan et al., 2007). EF are also a strong predictor of explicit ToM during development, with longitudinal studies pointing to a supporting role of EF between ages 2 and 5 (Carlson et al., 2004; Doenyas et al., 2018; Flynn, 2007; Marcovitch et al., 2015; Müller et al., 2009) as well as between ages 6 and 10 (Miller et al., 2018). Some studies have attempted to determine whether EF or language play a more central role in ToM development. However, findings have been inconsistent. Several studies report that when both language and EF are considered, the relation between EF and ToM disappears once language is controlled for (Hughes & Ensor, 2007; Shahaeian et al., 2023). In contrast, other work indicates that both EF and language matter for ToM. For instance, it has been reported that both cognitive flexibility and sentential complements sentences (e.g., she thinks that it will rain today) are associated with ToM in 3- to 4-year-olds (Low, 2010). As noted in Study 1, while evidence suggests that both language and EF are involved in ToM development, relatively few studies have directly compared their contribution within the same sample (de Villiers & de Villiers, 2025). Most often, one variable is tested as a main predictor, while the other is included as a control. In addition, and even fewer studies have done so within a longitudinal design.

Among studies adopting such design, language has been found to explain the longitudinal relation between EF and ToM between ages 3 and 6 (Andre & Maintenant, 2025). Similarly, in children aged 3 to 5, inhibition predicted false-belief performance in early assessments but not later on, when complement comprehension became the strongest predictor (de Villiers & de Villiers, 2025). Other longitudinal work also reports mixed findings, with cognitive flexibility mediating the link between memory for false complements (e.g., “The child thought it was sugar. But look, it was really salt. What did the child think it was?”) and ToM in 4- to 6-year-olds (Farrant et al., 2012), while complement clauses predicted ToM more strongly than EF in 2- to 3-year-olds (Boeg Thomsen et al., 2021). Overall, these studies highlight the central role of language in ToM development, though the specific contribution of EF remains more ambiguous.

However, an important limitation of these studies in their lack of attention to socioeconomic diversity. Despite evidence showing that ToM is linked to family SES (Devine & Hughes, 2018;

see also the General introduction), longitudinal studies previously mentioned do not report SES information (Andre & Maintenant, 2025; de Villiers & de Villiers, 2025; Farrant et al., 2012), or focus on high-SES participants (Boeg Thomsen et al., 2021). This raises the question of whether the strength of the associations between ToM, language, and EF would differ in more socioeconomically diverse populations.

Recent findings suggest that this may be the case, in ways that would suggest an even more pronounced role of language in lower SES samples. For instance, the relation between language and ToM seems to be stronger for low-SES children than for their high-SES peers (Ebert et al., 2020) although this difference was not directly tested statistically. In contrast, previous studies indicate that the relation between EF and ToM is absent in a context of poverty (Huang et al., 2022), or does not differ between low and high SES children (Shahaeian et al., 2015), even though cultural differences have been identified in the strength and significance of this relation (Oh & Lewis, 2008; Sabbagh et al., 2006) suggesting that contextual factors may moderate these associations.

Another key factor in understanding ToM is age. In Study 1, we found no moderating effect of age in the relation between SES, language and first order ToM. This is consistent with previous findings which indicate that the association between language and ToM is stable between ages 3 and 7 (Milligan et al., 2007), as well as between children's vocabulary and SES which persist from 16 months to almost 13 years (Ma et al., 2024). However, a meta-analysis showed an age-moderation between family SES and ToM, suggesting stronger effect sizes in older children (Devine & Hughes, 2018). This might indicate that more advanced ToM, such as second order ToM, may be more sensitive to family SES.

Yet, the majority of studies on ToM are restricted to preschoolers. This reflects another gap in the literature, which concerns the strong focus on first order ToM, while less has been evidenced about second order ToM, whether concerning its relation to language, EF, or family SES. While first order ToM involves attributing a mental state to someone (e.g., "He thinks the box contains a candy"), second order ToM requires reasoning about someone's mental states about another person's mental states (e.g., "She thinks that he believes the box contains a candy") (Perner & Wimmer, 1985). This level of embedded reasoning makes second order ToM more complex and requires greater linguistic and cognitive resources (Miller, 2009).

First order ToM usually develops around age four (Wellman et al., 2001), whereas second order ToM emerges more gradually from age 6 to 9 (Perner & Wimmer, 1985). However, performance varies considerably depending on tasks and methods employed (Hayward & Homer, 2017; Miller, 2009), and some children perform at chance on second order tasks until age ten (Flobbe et al., 2008).

A major difference between first and second order ToM is the population studied. Indeed, while recent studies assessed ToM in various sociocultural samples (Devine & Hughes, 2018; Liu et al., 2008), second order ToM literature mostly focuses on WEIRD samples (Miller, 2009). When contextual influences have been considered, however, the associations identified appear similar to those observed for first order ToM. Links have been reported between family SES and second order ToM, with parental language input and literacy environments partly explaining this relation (Ebert, 2020; Galende et al., 2012; Kara & Selcuk, 2023). Specific parental behaviors, such as linguistic scaffolding, decontextualized talk (i.e., mentioning previous events), and contingent responding (i.e., adapting feedback based on children's performance), also predict second order ToM (Galende et al., 2012), as do family factors like having a younger sibling (Paine et al., 2018).

In addition, despite this imbalance between first and second order ToM studies, links between second order ToM and EF (Austin et al., 2014; Kloo et al., 2020; Osterhaus et al., 2022), as well as between ToM and language (Astington et al., 2002; Ebert, 2020; Kloo et al., 2020; Osterhaus et al., 2022; Paine et al., 2018) have been evidenced. However, age (Arslan et al., 2020) and first order ToM (Osterhaus & Koerber, 2021) seems to be the two strongest predictors of second order ToM. Indeed, correlations between second order ToM, EF, and syntax disappear once age is controlled for, suggesting that maturation drives much of this development (Arslan et al., 2012). In addition, a longitudinal study found that first order ToM was the only significant predictor of second order ToM from ages 5 to 8 (Osterhaus & Koerber, 2021).

While Studies 1 and 2 were cross-sectional, the present study adopts an accelerated longitudinal design, which allows data collection over a wide age range in a limited time, reduces dropout, and captures both inter- and intra-individual differences while limiting cohort effects (Galbraith et al., 2017). To our knowledge, no previous work has examined the joint role of language and EF in predicting implicit, and explicit first and second order ToM in a socioeconomically diverse sample using this design. In this study, EF, language, and family SES were used as

predictors of implicit, explicit first order and explicit second order ToM. In addition, we included interactions with age for each of the predictors (family SES, language, and EF) to assess the possible age-related variations in the relation between ToM, language, EF, and SES in children aged 3 to 7 years.

Thus, the aims of the present study are to: (a) confirm the established effect of age on first and second order ToM, and estimate age effects on implicit ToM between ages 3 and 7, (b) investigate the predictive roles of language, EF, and SES in the development of implicit and explicit first and second order ToM in children aged 3 to 7 using an accelerated longitudinal design. We collected longitudinal data on 354 children aged 3 to 7, assessed at three time points on implicit ToM, explicit first order ToM, explicit second order ToM, language, EF, and family SES.

2. Method

2.1 Participants

A total of 354 children (165 girls) completed at least one of the three assessments (T0, T1 or T2). Full descriptive statistics for the sample, stratified by cohort, session, and sex, are presented in Table 3.1. Distribution of participants across cohorts and sessions is described in Figure 3.1.

Cohort	Session	Sex	*N*	*M* (months)	*SD* (months)	*M* (years)	*SD* (years)
Preschool1	T0	F	63	40.75	3.36	3.4	0.28
Preschool1	T0	M	38	41.71	3.39	3.48	0.28
Preschool1	T1	F	63	46.62	3.28	3.88	0.27
Preschool1	T1	M	42	47.36	3.2	3.95	0.27
Preschool1	T2	F	54	55.76	3.38	4.65	0.28
Preschool1	T2	M	37	56.76	3.24	4.73	0.27
Preschool2	T0	F	54	53.07	3.13	4.42	0.26
Preschool2	T0	M	50	52.9	3.36	4.41	0.28
Preschool2	T1	F	49	58.71	2.84	4.89	0.24
Preschool2	T1	M	48	58.6	3.26	4.88	0.27

Preschool2	T2	F	44	67.82	3.01	5.65	0.25
Preschool2	T2	M	43	67.86	3.3	5.66	0.27
Preschool3	T0	F	57	64.58	3.54	5.38	0.3
Preschool3	T0	M	63	65.14	3.46	5.43	0.29
Preschool3	T1	F	47	70.4	3.43	5.87	0.29
Preschool3	T1	M	53	70.58	3.47	5.88	0.29
Preschool3	T2	F	37	79.41	4	6.62	0.33
Preschool3	T2	M	39	81	3.71	6.75	0.31

Table 3.1. Descriptive statistics of the study sample by cohort, session and sex. *N* = Number of observations, *M* = Mean, *SD* = Standard Deviation; M = Male; F = Female. Preschool1 = children aged 3–4 years at T0; Preschool2 = children aged 4–5 years at T0; Preschool3 = children aged 5–6 years at T0.

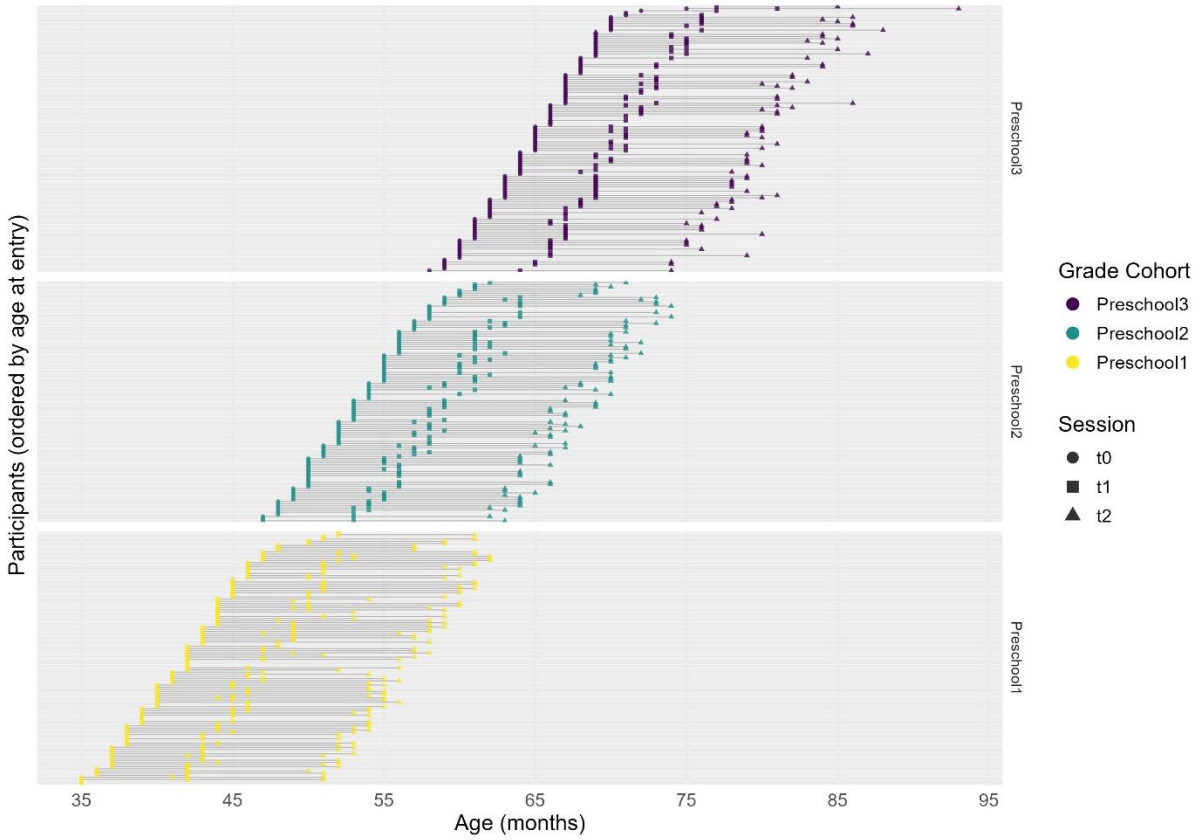


Figure 3.1. Longitudinal design: age distribution of participants across cohorts and sessions. Each line represents one participant, ordered by age at entry. Preschool1 = children aged 3–4 years at T0; Preschool2 = children aged 4–5 years at T0; Preschool3 = children aged 5–6 years at T0.

2.2 Materials

2.2.1 ToM assessments

2.2.1.1 Implicit ToM

Children completed an adapted version of the ball detection task (El Kaddouri et al., 2020) featuring short animations. This task included four conditions that manipulated the child's and an agent's beliefs (four belief combinations). Children pressed a ladybug button when the occluder fell and the target was present. Based on the results of Study 2, two RT-based indices were computed: ToMI1, indexing the agent-belief effect across conditions, and ToMI2, indexing the agent-belief effect when the child's belief is positive (P+).

2.2.1.2 Explicit first-order ToM

Two narrated videos (classic false belief scenarios) were followed by a control question ("Where is the ladybug now?") and a false-belief question ("Where does Buzz think the ladybug is?"). One point was awarded only if both answers were correct.

2.2.1.3 Explicit second-order ToM

Two narrated videos introduced a third character (Woody) to elicit second order beliefs (what one character thinks about another's belief). After a brief familiarization, children answered two questions (control and second order belief question). One point was awarded only if the two answers were correct.

2.2.2 Language assessments

A French adaptation of the Quick Interactive Language Screener (QUILS) assessed vocabulary, syntax, and language-learning processes via touchscreen responses. The task comprised 48 trials (16 per component), with one point per correct response.

2.2.3 EF assessments

EF were measured with the H&F task, which included three blocks: congruent, incongruent, and mixed blocks. The incongruent block indexes inhibition, and the mixed block indexes cognitive flexibility. Performance was scored with the two-vector (TV) method, assigning 0–5 points for accuracy and 0–5 for RT per block (RT points were added only if accuracy ≥75%), yielding a block level score that integrates speed–accuracy trade-offs.

2.2.4 Family SES

Family SES was derived from the highest parental education and the highest parental occupational status from both parents. Higher values reflect higher socioeconomic status.

2.3 Statistical analysis

Statistical analyses were performed in RStudio (version 4.3.3, R Core Team, 2023) using the following packages: *tidyverse* (Wickham et al., 2025), *lme4* (Bates et al., 2015) *lmerTest* (Kuznetsova et al., 2017), *partR2* (Stoffel et al., 2021), *psych* (Revelle, 2024), *broom* (Robinson et al., 2024), *ordinal* (Christensen, 2010), *ppcor* (Kim, 2015) and *emmeans* (Lenth, 2017). The

procedures for estimating developmental trajectories and assessing the effects of predictors on those trajectories were inspired by studies using accelerated longitudinal designs (Mills et al., 2021).

Developmental trajectories were estimated separately for the four variables of interest: first order ToM**,** second order ToM, and the two implicit ToM indices. Because the first and second order outcomes were ordinal, we fitted cumulative link mixed-effects models (CLMM, Christensen, 2018). For each implicit ToM index, based on reaction times, we fitted a linear mixed-effects model (LMM). For each variable, two models were compared: (1) a linear model including an age-centered linear term (centered on the sample mean), and (2) a quadratic model including both the age-centered term and its square (age^2). In each model, a random intercept was specified for each participant to account for the longitudinal structure of the data. Model comparisons were conducted using likelihood ratio tests, and the best-fitting model was retained.

In a second step, we fitted mixed-effects models to test whether language, EF and family SES predicted the previously identified developmental trajectories. For each predictor domain, we derived an index (PC1) from a PCA on z-scored observed variables (which is the same procedure as the one used in Study 2), resulting in three indexes: language index, EF index and SES index. This PCA approach for constructing composite indices in longitudinal models follows prior applications in developmental research (Giorgio et al., 2020).

For each predictor, we computed a participant-level mean across available sessions. All predictors were included in the mixed models for each dependent variable, with a random intercept for each participant. The interaction with the age-centered term (centered on the sample mean) and each predictor was included, allowing estimation of both the main effect and its change with age (interaction term). All variables were standardized (z-scores) to reduce the risk of multicollinearity among predictors. Standardized betas were reported for these models. Diagnostics on the final models (generalized variance inflation factors, GVIFs) indicated no multicollinearity issues (maximum adjusted value = 2.77). For each model, complete results (fixed and random effects, and fit indices) are presented in the Appendix A3.

3. Results

Descriptive statistics for all variables (explicit/implicit ToM scores, language and EF components), sorted by cohort and time point, are reported in the Appendix A23.

3.1 Associations between implicit and explicit ToM across age

To examine potential longitudinal associations between the different levels of ToM, we first computed a partial correlation matrix. P-values were adjusted for multiple comparisons using the FDR correction. Results are presented in Table 3.2. The two implicit ToM indices were correlated within the same timepoints but showed no cross-time associations (e.g., T0 with T1), suggesting substantial variability both between children at each session and across sessions. First order ToM was associated with one implicit ToM index (ToMI1) at T0 and T1, but this relation was no longer observed at T2. Finally, second order ToM was quite consistently associated with first order ToM across sessions.

	1.	**2.**	**3.**	**4.**	**5.**	**6.**	**7.**	**8.**	**9.**	**10.**	**11.**
1.ToMI1 T0	__										
2.ToMI1 T1	.16	__									
3.ToMI1 T2	.09	-.04	__								
4.ToMI2 T0	.79***	.06	-.06	__							
5.ToMI2 T1	.05	.67***	-.04	.02	__						
6.ToMI2 T2	.13	.03	.72***	.04	-.03	__					
7.ToM1 T0	.3**	.02	.2	.21	.03	.14	__				
8.ToM1 T1	.16	.07	.21*	.16	-.02	.18	.23**	__			
9.ToM1 T2	.03	.1	.12	-.07	.06	.08	.15	.24**	__		
10.ToM2 T1	.12	-.14	.22	.05	-.12	.06	.23*	.21*	.22*	__	
11.ToM2 T2	.16	.13	-.02	.21	0	0	.18	.28***	.25**	.07	__

Table 3.2. Age-adjusted partial correlations among ToM measures across time points. *ToMI1* = Agent belief effect on RT; *ToMI2* = Agent belief effect on RT when the belief of the child is positive; *ToM1* = Explicit first order theory of mind; *ToM2* = Explicit second order theory of mind; *T0* = First session of the longitudinal design; *T1* = Second session; *T2* = Third session. Significance levels for the correlation coefficients are indicated as follows: $p < .05$, p < .01, *p

3.2 Developmental trajectories

3.2.1 Developmental trajectories of implicit ToM

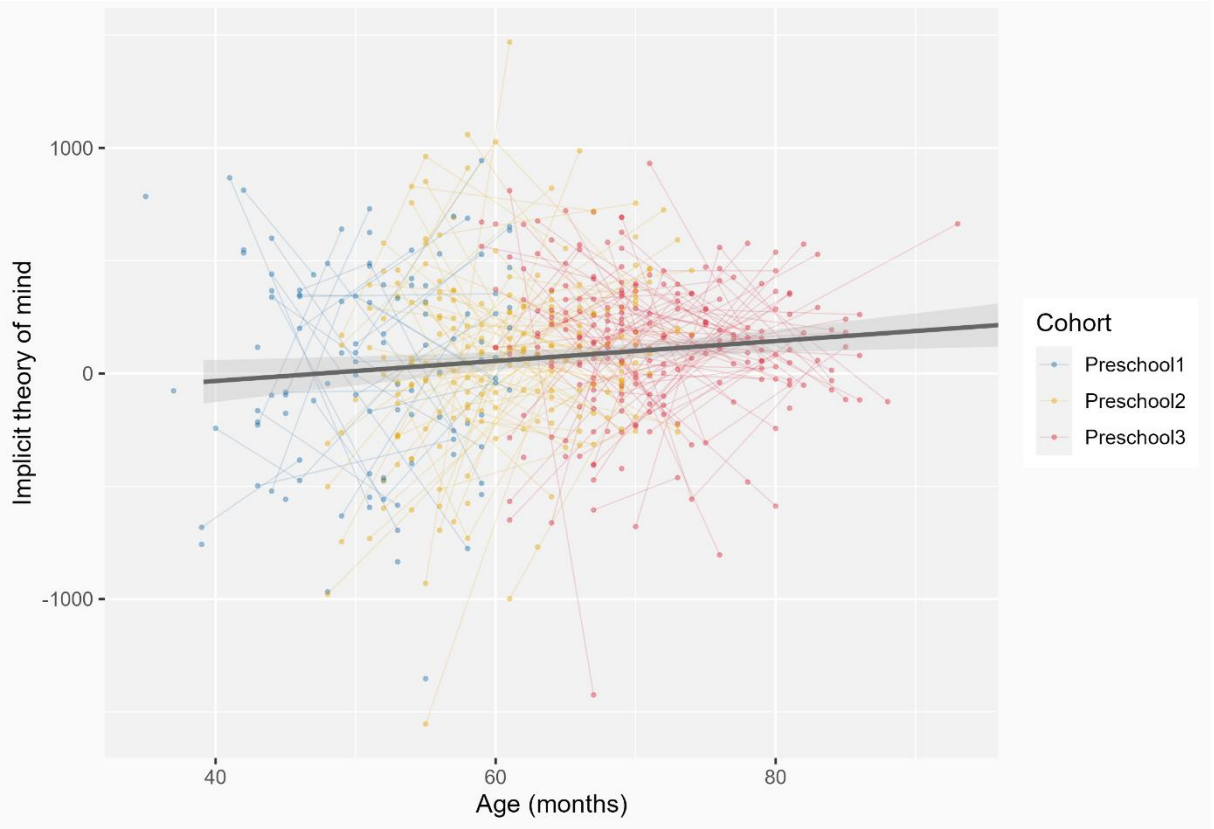


Figure 3.2. Estimated developmental trend in implicit ToM (agent belief cost in positive conditions). Each line represents one participant, with color indicating age at the first measurement. The grey line shows the linear trend predicted by the mixed model, and the shaded grey area represents the 95% confidence interval. Cohort = indicates group based on the first testing session.

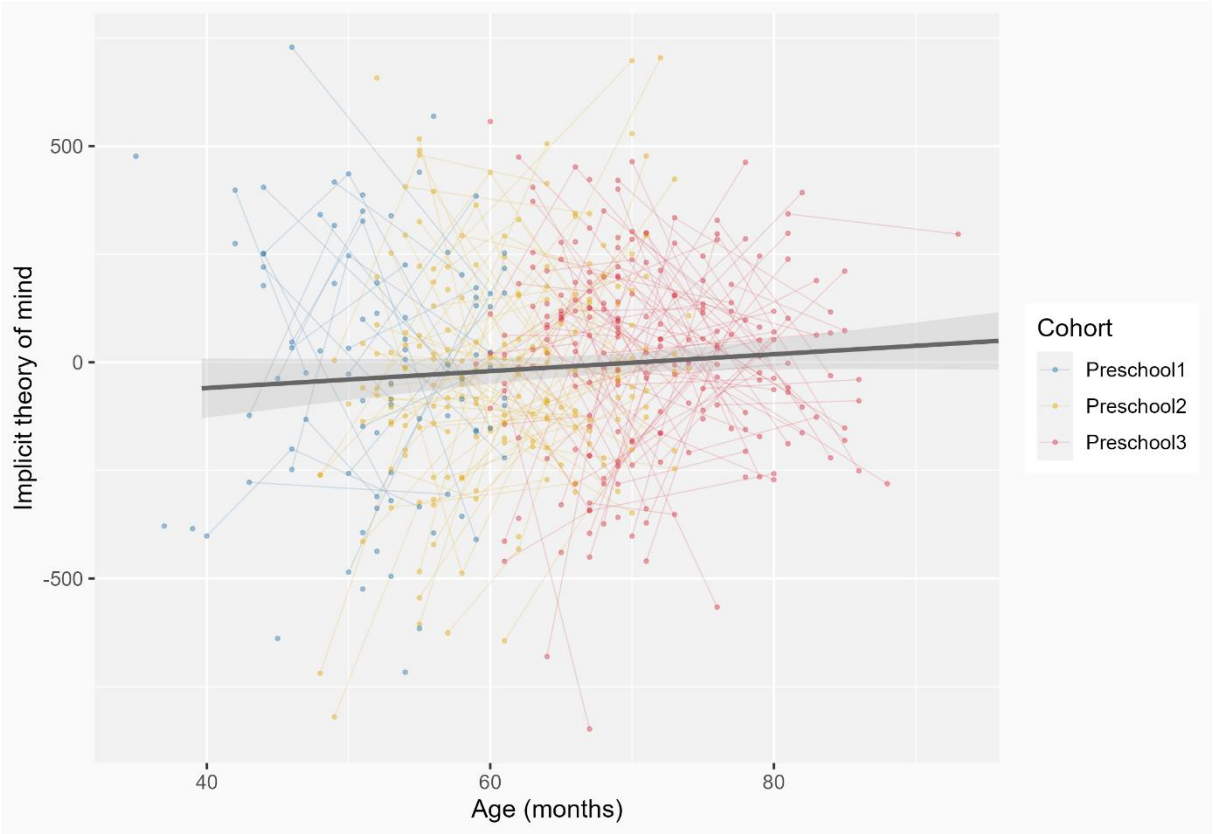


Figure 3.3. Estimated developmental trend in implicit ToM (general agent belief cost). Each line represents one participant, with color indicating age at the first measurement. The grey line shows the linear trend predicted by the mixed model, and the shaded grey area represents the 95% confidence interval. Cohort = indicates group based on the first testing session.

Table 3.3 summarizes the developmental trajectories for implicit ToM. A linear trajectory emerged for ToMI2, showing a progressive increase ($b = 4.43$, $p = .006$; Figure 3.2), consistent with a growing impact of the agent's perspective on RT and, thus, greater consideration of the agent's beliefs. By contrast, ToMI1 did not vary with age ($b = 1.95$, $p = .090$; Figure 3.3). Semi-partial R^2 indicated that age explained approximately 1% of the variance in both implicit ToM indices.

Dependant variable	Best model	Intercept (b ± SE, p)	Age (b ± SE, p)	LRT $\chi^2(1)$, p-value
Implicit ToM – ToMI1	Linear	-12.75 (12.76), p = .319	1.95 (1.15), p = .090	.03, p = .853
Implicit ToM – ToMI2	Linear	70.22 (17.76), p <.001	4.43 (1.61), p =.006	.34, p = .559

Table 3.3. Estimated parameters of the developmental trajectories for both implicit ToM index. Coefficients are not standardized. SE = Standard error; LRT = Likelihood Ratio Test.

3.2.2 Developmental trajectories of explicit ToM

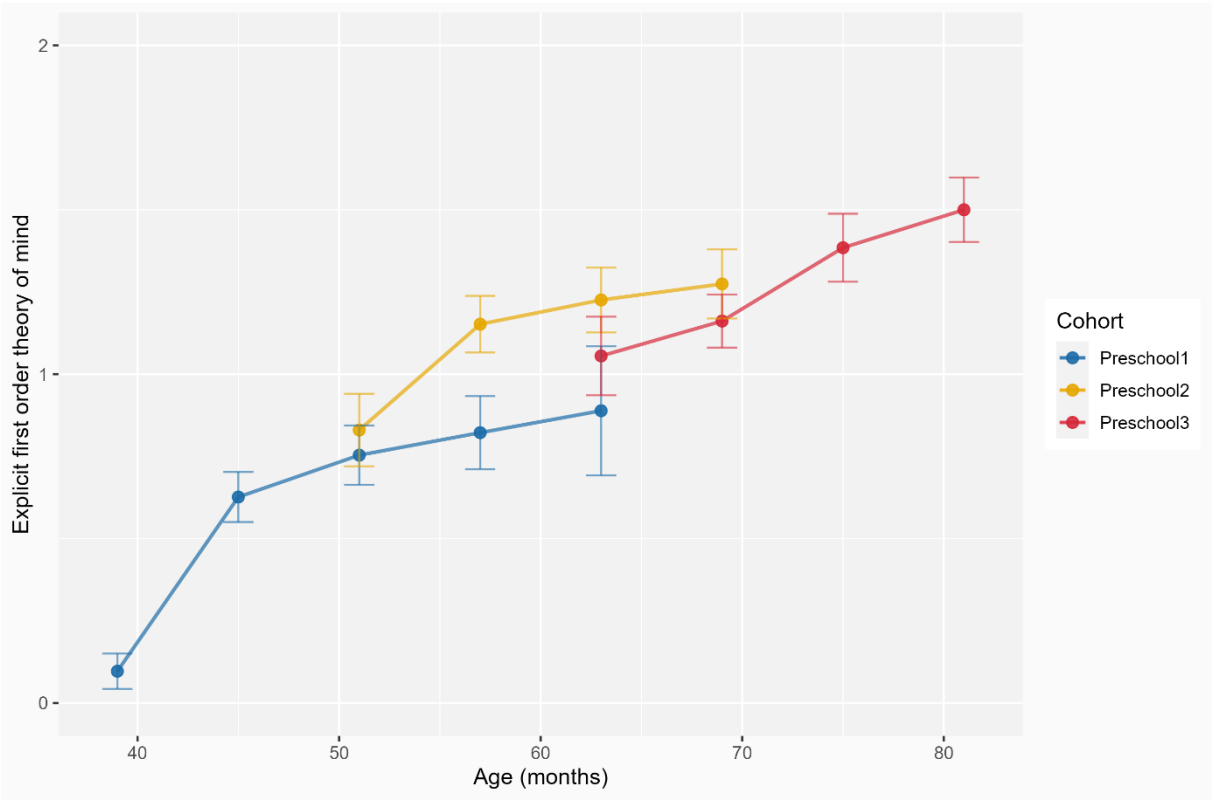


Figure 3.4. Estimated developmental trend in explicit first-order ToM. Predicted means and standard errors are plotted for 6-month age intervals.

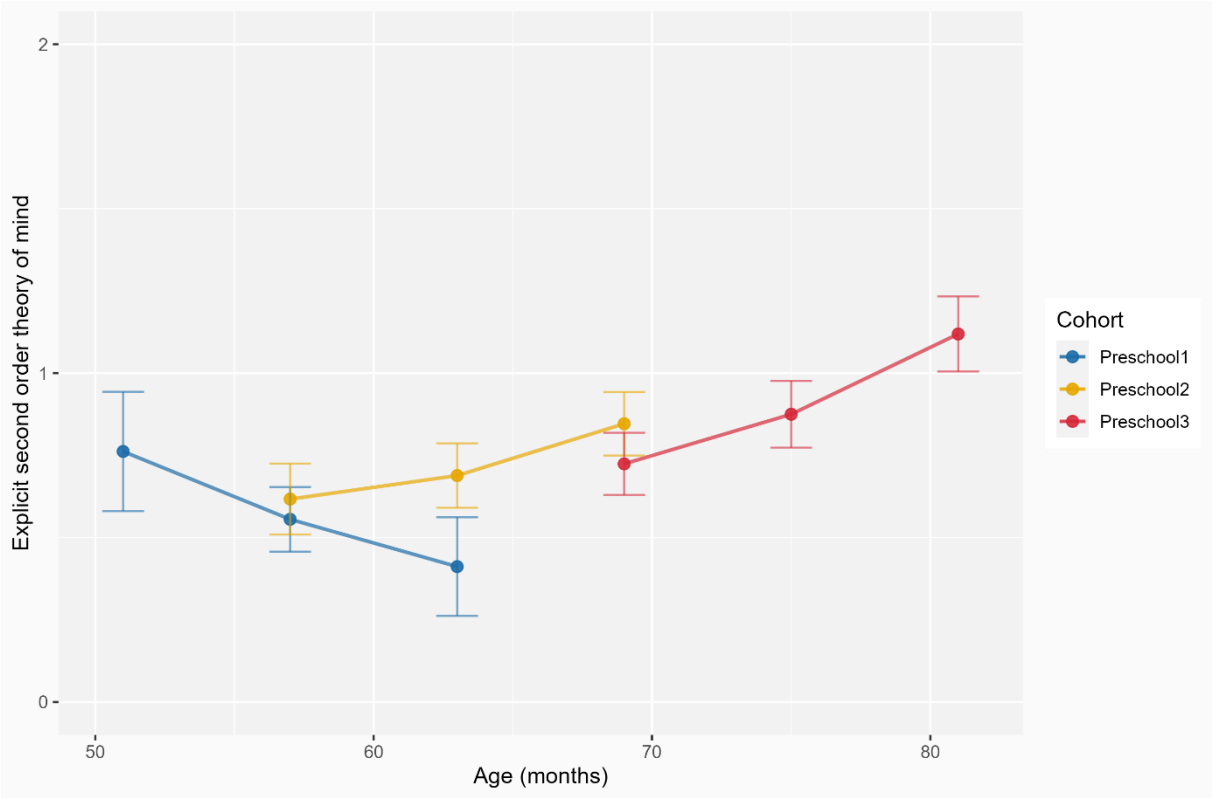


Figure 3.5. Estimated developmental trend in explicit second-order ToM. Predicted means and standard errors are plotted for 6-month age intervals.

Table 3.4 summarizes the developmental trajectories for explicit ToM (first and second order). Accuracy increased with age for both first order ($b = .08$, $p < .001$) and second order ToM ($b = .04$, $p < .001$), with older children showing higher performance on both tasks. The ordinal models explained approximately 6% of the variance for first order ToM and 2% for second order.

Dependant variable	Best model	Age (b ± SE, p)	LRT $\chi^2(1)$, p-value
First order ToM	Linear	.08 (.01), p<.001	1.7, p = .193
Second order ToM	Linear	.04 (.01), p<.001	.14, p = .707

Table 3.4. Estimated parameters of the developmental trajectories for both explicit ToM indexes. *C*oefficients are not standardized. ToM = Theory of mind; SE = Standard error; LRT

3.3 Developmental trajectories predictors

3.3.1 PCA

Before including the predictors in the models, we first derived composite predictor indices for SES, EF, and language via PCA on standardized variables, retaining PC1 as the index for each domain. The PC1 in this sample explained the vast majority of variance for SES, EF, and language (all > .85). Eigenvalues, variance explained, and factor loadings for the three predictor indices are reported in Table 3.5.

Index	Eigenvalue	Proportion of variance explained	Factor loading	
SES	1.71	.86	Education	.92
			Occupation	.92
Language	2.58	.86	Vocabulary	.94
			Syntax	.92
			Process	.92
EF	1.77	.88	Inhibition	.94
			Flexibility	.94

Table 3.5. Eigenvalues of the PC1 for each composite score computed by PCA.

3.3.2 Predictive models of implicit ToM

Two linear mixed-effects models (one for each implicit ToM index) were fitted. For ToMI1, the model including age, language, EF, and SES (including their interactions with age) explained about 2% of the variance (marginal $R^2 = .019$). No significant main effects or age interactions were observed for language, EF, or SES, and the age effect was not significant. Results are reported in Table 5.

For ToMI2, the analogous model explained about 2% of the variance (marginal $R^2 = .020$). Age was a significant positive predictor of this implicit ToM index ($\beta = .17$, $p = .014$), whereas neither the main effects nor the age interactions of language, EF, or SES were significant. Results are reported in Table 3.6.

Dependant variable	**Term**	**β (SE)**	***p***
Implicit ToM – ToMI1	Intercept	-.06 (.06)	.273
	Age	.13 (.08)	.079
	Language	.01 (.10)	.958
	EF	.04 (.11)	.738
	SES	.10 (.07)	.116
	Age x Language	-.03 (.10)	.771
	Age x EF	-.04 (.11)	.703
	Age x SES	-.09 (.07)	.177
Implicit ToM – ToMI2	Intercept	-.06 (.06)	.321
	Age	.17 (.07)	.014
	Language	-.07 (.09)	.462
	EF	.05 (.10)	.649

SES	.06 (.06)	.364
Age x Language	.02 (.09)	.838
Age x EF	-.07 (.10)	.490
Age x EF	-.07 (.10)	.490

Table 3.6. Standardized coefficients predicting implicit ToM trajectories (both indexes). Coefficients are standardized. ToM = theory of mind; EF = executive functions; SES = socioeconomic status; SE = Standard error.

These results suggest that, beyond developmental change with age, individual differences in language, EF, and SES do not account for variability in implicit ToM.

3.3.3 Predictive models of explicit ToM

Coefficients of the CLMMs are reported as standardized logit-scale estimates. For first order ToM, the CLMM including age, language, EF, and SES (and their interactions with age) revealed significant effects of age (β = .49, $p < .001$), language (β = .53, $p < .001$), EF (β = 0.32, $p = .041$), and SES (β = .28, $p = .007$). This model explained about 17% of the variance (adjusted McFadden $R^2 = .166$). None of the age × predictor interactions reached significance (see Table 3.7). These results indicate that, controlling for age and the other predictors, language, EF, and SES were significant positive predictors of first order ToM.

For second order ToM, the CLMM revealed a significant main effect of language (β = .50, $p = .026$) and a significant age × SES interaction (β = .31, $p = .049$). This model explained 11% of the variance (adjusted McFadden $R^2 = .107$). Post hoc comparisons of estimated marginal means showed that second order ToM increased with age for high SES children (β = .75, $p<.001$), as well as middle SES children (β = .46, $p = .005$) but not low SES children (β =.16, $p = .41$). Other effects and interactions were non-significant (see Table 3.8 and Figure 3.6). These findings suggest that SES moderates the developmental trajectory of second order ToM.

Dependant variable	Term	Estimate	*p*
First order ToM	Age	.49 (.12)	<.001
	Language	.53 (.15)	<.001
	EF	.32 (.16)	.041
	SES	.28 (.10)	.007
	Age x Language	-.10 (.15)	.502
	Age x EF	.16 (.16)	.317
	Age x SES	.13 (.10)	.203
Second order ToM	Age	.13 (.18)	.492
	Language	.50 (.22)	.026
	EF	-.03 (.22)	.907
	SES	.10 (.16)	.519
	Age x Language	-.16 (.23)	.474
	Age x EF	.40 (.26)	.119
	Age x SES	.31 (.16)	.049

Table 3.7. Standardized coefficients predicting explicit ToM trajectories (first and second order). Coefficients are standardized. SE = standard error; ToM = theory of mind; EF = executive functions; SES = socioeconomic status.

Value of SES	Est	SE	z	*p*
Low (-1 SD SES)	.16	.20	-.83	.41
Medium (mean SES)	.46	.13	3.49	.005
High (+1 SD SES)	.75	.12	2.59	<.001

Table 3.8. Estimated age effects on second-order ToM across SES levels. SE = standard error.

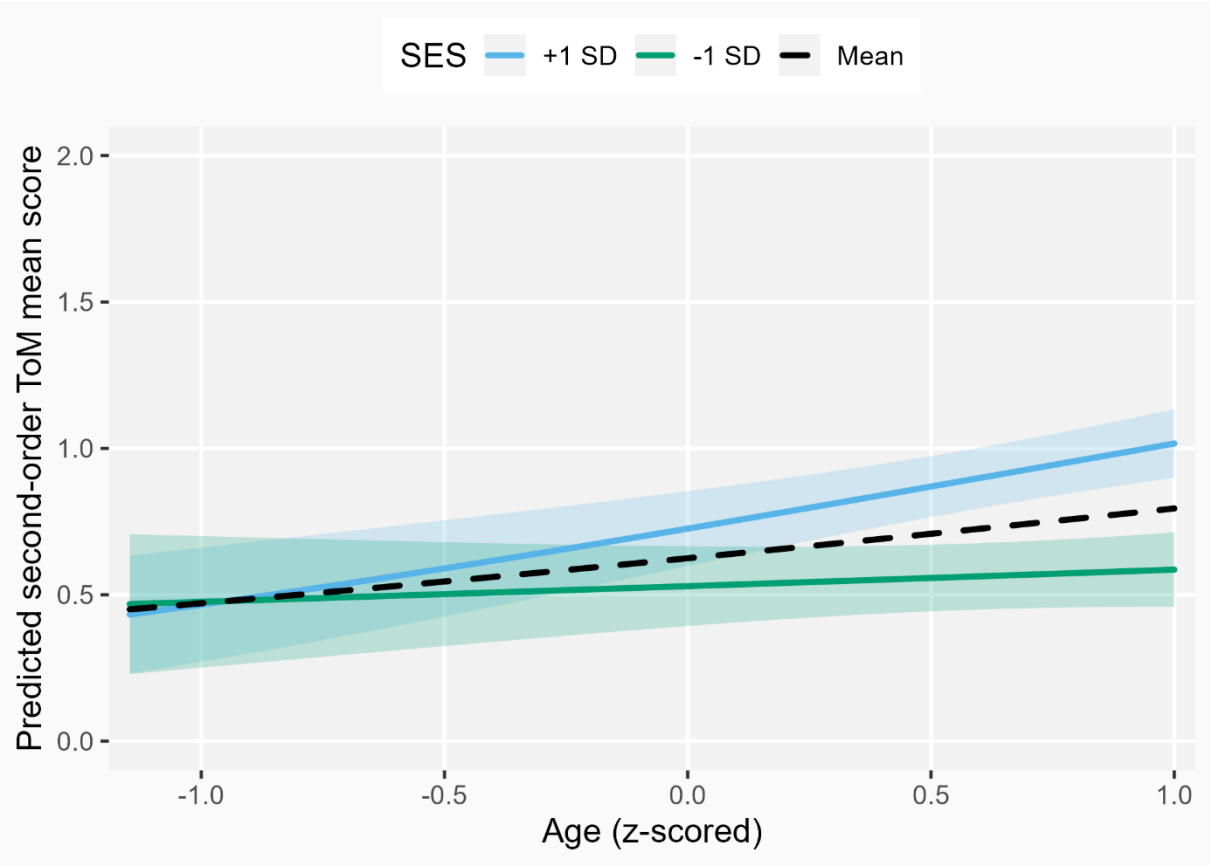


Figure 3.6. Interactions of SES and age in predicting second order ToM score. ToM = theory of mind; SES = socioeconomic status; SD = standard deviation; +1 SD = one standard deviation above the mean; −1 SD = one standard deviation below the mean. The lighter colored bands indicate 95% confidence intervals.

4. Discussion

The aims of the present study were to: (a) confirm the established effect of age on first and second order ToM, and estimate age effects on implicit ToM between ages 3 and 7, (b) investigate the predictive roles of language, EF, and SES in the development of implicit and explicit first and second order ToM in children aged 3 to 7 using an accelerated longitudinal design. We first assessed relations between all ToM measures across testing sessions. Then, we estimated age effects on each ToM variable. Finally, we assessed how the different predictors influenced the developmental trajectories of each ToM measure.

Regarding the relations between the different components of ToM, we first observed a correlation between first order explicit ToM and one index of implicit ToM (i.e., the agent belief

cost on reaction time) across development. This result is consistent with findings from Study 2, as well as with previous findings reporting links between explicit and implicit ToM in children (Grosse Wiesmann et al., 2018; Kaltefleiter et al., 2022; Kloo et al., 2020; Speiger et al., 2025). This suggests that both abilities continue to interact during the developmental period of explicit ToM. However, at the third measurement point, explicit ToM did not correlate with any of the implicit ToM indices. One possible explanation could be ceiling effects due to both age and repeated testing in first order explicit ToM (Slade et al., 2008), which may have reduced variability and thereby limited the detection of correlations (Hammers et al., 2024). Yet, since associations between first order explicit ToM and other tasks were still observed, this explanation cannot fully account for the absence of associations at this point. These discrepancies seem to indicate that the associations between implicit and explicit ToM are fragile, much like implicit ToM itself (Cheema et al., 2024).

Consistent with this idea, while explicit first order ToM scores were correlated across testing sessions, the two implicit ToM indices did not show stability over time. This fragility of implicit ToM echoes previous findings suggesting the poor reliability of implicit ToM measures in children (Barone et al., 2019; Kulke et al., 2018; Kulke & Rakoczy, 2018). Among the few studies assessing the same implicit ToM measure longitudinally, few have tested whether performance on the task is stable across time points. Still, studies often highlight a lack of internal consistency in implicit ToM measures, whether through missing correlations between tasks over time (Poulin-Dubois et al., 2020), inconsistent replication across false-belief conditions, or divergent results depending on scoring methods between ages 2 and 4 (Grosse Wiesmann et al., 2018; Kaltefleiter et al., 2022).

Moreover, we observed consistent correlations between first and second order ToM over time. This is in line with papers showing an association between first and second order ToM in children in preschool (Kloo et al., 2020; Lockl & Schneider, 2007) and elementary school (Osterhaus & Koerber, 2021; Peskin et al., 2016). Beyond this association, it has been argued that first order ToM may be a prerequisite for second order ToM, since first order false belief is embedded in the second order question (e.g., “Where does Paul thinks Chloe thinks the object is?”) (Miller, 2009).

Overall, our results indicate that there might be a continuity in ToM between age 3 and 7, from implicit ToM to more advanced and complex forms of ToM. Our findings are consistent with recent findings showing a relation between implicit ToM and first order ToM, and first order

ToM and second order ToM, but no link between implicit and second order ToM (Kloo et al., 2020).

Regarding age effects, as expected, age predicted performance in explicit first and second order ToM, consistent with the significant increase of these capacities between ages 3 and 7. The development of second order ToM was less important than first order ToM, likely because children start developing second order ToM from age 6 (Fu et al., 2023; Miller, 2009). We also observed an age effect in one of the index of implicit ToM (i.e., the agent belief cost on reaction time when the belief of the participant is positive). Longitudinal studies assessing the developmental trajectory of implicit ToM are rare, but seems to indicate a developmental change in implicit ToM between 3 and 4 years old, with only 4-years-old anticipating actions resulting from false beliefs above chance (Grosse Wiesmann et al., 2018). Our finding could also be consistent with the hypothesis that the altercentric bias evolves over time (Manea et al., 2023), but is hindered during the preschool years by the emergence of a self-perspective (Southgate, 2020). In addition, developmental changes have also been reported in the altercentric interference in the dot task (for a description of the dot task, see the General introduction, section 2.1.2), which was found to increase between ages 12 and 14 (Weidema et al., 2023), suggesting that this bias continues to develop in adolescence.

Consistent with results of Study 2, we found that both implicit ToM indices were independent of language, EF, and family SES. With respect to cognitive and language measures, our results align with previous studies reporting no association between implicit ToM, language, and EF in children (Grosse Wiesmann et al., 2017; Kloo et al., 2020; Low, 2010). Yet, as noted in the General Introduction, other studies have identified links between these domains (Meristo et al., 2012; San Juan & Astington, 2017; Schneider et al., 2012; Yott & Poulin-Dubois, 2012), suggesting that evidence remains mixed. Several factors may account for these discrepancies. For instance, San Juan & Astington (2017) reported that language-based training improved implicit ToM but not explicit ToM, a surprising finding given the robust association between language and explicit ToM (Milligan et al., 2007), which calls for cautious interpretation. Likewise, Schneider et al. (2012) observed a relation between EF and implicit ToM, but in adults, which raises the possibility that contributing factors may change from childhood to adulthood. An additional caveat concerns our exclusion criteria. As mentioned in Study 2, to ensure data quality, we removed participants with an accuracy below 50%. However, these excluded children also had lower EF and language abilities than those retained. This suggests

that the task may have been too demanding to reliably assess implicit ToM in young children and, thus, not optimal for capturing individual variability.

Turning to SES, results from Study 2, as well as this study, indicated no predictive association with implicit ToM. Our results from Study 1 indicated that the association between family SES and ToM is fully explained by language, consistent with a mediation study reporting similar patterns (Tompkins et al., 2017). The absence of association between SES and implicit ToM, along with an indirect link to explicit ToM suggest that SES may not influence mentalizing abilities per se, but instead affect peripheral abilities needed to succeed in the traditional false belief tasks (i.e., language and EF, Bloom & German, 2000). This hypothesis would echo findings in adults (for a review on social cognition and SES, see section 4.2.2 of the General introduction), where low-SES individuals have been found to outperform their high-SES peers in social cognition tasks (Bjornsdottir et al., 2017; Dietze & Knowles, 2021; Kraus et al., 2011; Stellar et al., 2012).

Yet, in this study, family SES did predict the development of first-order ToM, even after controlling for language and EF. This is consistent with meta-analytic findings showing that the relation between the two variables is reduced when verbal abilities are accounted for but does not completely disappear (Devine & Hughes, 2018). Still, as this study did not include mediation analyses, it remains possible that the link between SES and explicit ToM operates indirectly, through language.

We also found a strong association between first order ToM and language, in line with both Study 1 and Study 2. This consistent relation confirms the importance of this variable in the developmental trajectory of ToM (Ebert, 2020). In addition, among all predictors, the estimate for language was the strongest, which echoes the strong and robust relation found between the two in meta-analysis (Milligan et al., 2007). For a review of the relation between language and first order explicit ToM, see section 3.1.1 the General introduction. Interestingly, while we found a unique relation to language in Study 1, here all other relations remained significant. Specifically, we found a significant relation between EF and ToM. The absence of such a relation in Study 1 was somewhat surprising given the well-documented link between these two variables (Devine & Hughes, 2014). Our results suggest that EF, in addition to language, contribute to the developmental trajectory of first order ToM, in line with previous longitudinal findings (Carlson et al., 2004; Doenyas et al., 2018; Flynn, 2007; Marcovitch et al., 2015; Miller et al., 2018; Müller et al., 2009).

The differences that we observe from Study 1 can be explained in different manners. It has been demonstrated that longitudinal and cross-sectional designs can yield to very different results with the same participants and the same variables (Farran et al., 2024). These discrepancies arise because longitudinal data allow for the analysis of intra-individual differences and developmental trajectories, which cross-sectional data cannot do (O'Laughlin et al., 2018). In addition, in this study, we used CLMMs for estimating trajectories of first and second order ToM. CLMM, which is designed for ordinal variables, is more robust and less sensitive to ceiling effects than LMM (Taylor et al., 2023).

We found that among all predictors, only language significantly predicted second order ToM. This is consistent with studies showing the importance of language in developing second order ToM development. For instance, longitudinal studies have shown that when both first and second order ToM are included in a composite score, language significantly predicts ToM development, and this relation tends to increase with age (Lockl & Schneider, 2007). Research on atypical populations further supports this association. Indeed, some studies showed that better language abilities can reduce second order ToM difficulties in autistic children (Milligan et al., 2007; Peristeri et al., 2024). These children may also rely on compensatory linguistic strategies, such as the use of recursive sentence complements and general linguistic abilities, to succeed in false belief second order tasks (Polyanskaya et al., 2022). Training in recursive complements has even been shown to improve second order ToM performance. Similarly, in children with hearing impairments, success in second order ToM tasks depends heavily on general language abilities, including expressive syntax, vocabulary, and mastery of recursive structures (Serrat et al., 2024).

Further support for the role of language in second order ToM comes from studies comparing standard and low verbal task formats. Seven years old children succeeded in the classical task, but not in the low verbal one, which was not observed for the first order ToM (Hollebrandse et al., 2014). The authors interpret this result as evidence that linguistic abilities help children process the recursive structure of second order beliefs. They further argue that understanding second order ToM benefits from linguistic scaffolding. This interpretation is in line with findings showing that parental linguistic scaffolding is one of the strongest predictors of second order ToM in children explaining its association with SES (Galende et al., 2012).

Finally, we found a significant interaction between age and family SES in predicting second order ToM. While no SES-related differences were observed at younger ages, the gap became

apparent at the mean age and increased at one standard deviation above the mean. Specifically, within our age range, children from middle- and high-SES backgrounds showed improvements in second order ToM as they grew older, whereas children from low-SES backgrounds did not. In other words, only children from more advantaged backgrounds demonstrated developmental gains in second-order ToM across age. This result may be explained by several factors. For instance, low-SES children, who often show delays in language and EF (Merz et al., 2019; Noble et al., 2005), may have not yet fully develop the necessary resources to succeed in advanced ToM tasks, which requires more complex information processing (Miller, 2009). Moreover, studies suggest that the association between SES and second order ToM is mediated by parental language input and the literacy environment (Ebert, 2020; Galende et al., 2012; Kara & Selcuk, 2023). Since SES is linked to the linguistic environments within the family (Hoff, 2003; Huttenlocher et al., 2010; Levine et al., 2020), these findings might indicate that socioeconomic factors do not directly shape second order ToM. Rather, it might be the quality of children's language environment that plays the central role (Galende et al., 2012), consistent with our finding that only language predicted second order ToM.

Another explanation is that, since SES impacts first order ToM, and given that children must typically master first order ToM before succeeding in second order ToM (Miller, 2009), low-SES children may first need to overcome delays in first order ToM before advancing to second order reasoning. However, this is not incompatible with the previous explanation, since language fully mediates the relation between first order ToM and SES, as we have seen in Study 1.

Taken together, our study provides evidence for some developmental continuity from implicit ToM to explicit first and second order ToM. Explicit and one implicit measure of ToM abilities improved with age, suggesting that implicit ToM might continue to develop during the school years, consistent with findings of perspective-taking improvements into adolescence (Dumontheil et al., 2010; Weidema et al., 2023). Language, EF, and SES predicted explicit ToM, with language emerging as the strongest predictor, and the only unique predictor of second order ToM, underscoring its central role in ToM development. By contrast, none of these factors predicted performance on implicit ToM tasks, which may point to an independence from these domains, or alternatively reflect methodological limitations in reliably capturing implicit ToM in preschool and school-aged children. This underscores the need for improved measurement tools, especially for use across diverse populations. To date, most ToM studies focus on WEIRD samples (Mayer & Träuble, 2015; Padberg et al., 2022; Sanches de Oliveira

& Baggs, 2023), which limits the generalizability of findings. Finally, exploring how the relative contributions of cognitive, linguistic, and environmental factors change across the lifespan, alongside the development of executive and language abilities, could improve our understanding of the factors contributing to spontaneous ToM in individuals.

PART III.

General discussion

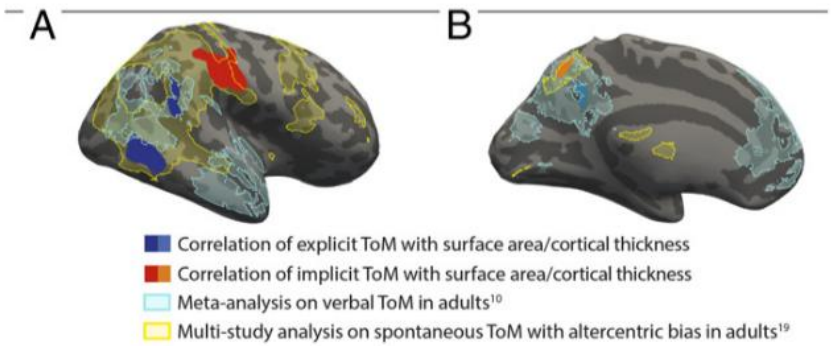
This thesis had several goals. First, we aimed to better characterize the relation between SES and explicit ToM in children. Specifically, we sought to examine whether children's language abilities and EF could explain this association. Second, given the lack of tasks designed to assess implicit ToM in children older than 2 to 3 years, we aimed to adapt a well-documented paradigm used with adults (i.e., the ball-detection task), in order to measure this capacity in older children. Having a suitable task for assessing implicit ToM in this age group was necessary for our third objective, which was to better characterize the relation between implicit and explicit ToM in older children, particularly given the lack of studies investigating this capacity in preschool and school-aged children. Fourth, we aimed to examine the developmental trajectories of both implicit and explicit ToM by assessing age-related effects in a longitudinal design, as well as the predictive roles of EF, language, and SES. In the first section of this general discussion, I review the main findings of this thesis in light of existing literature. The second section addresses general implications related to the deficit view of SES, with methodological considerations and limitations of the current work. Finally, the third section explores future directions, including the need for appropriate ToM assessments, addressing the replication crisis in implicit ToM research, and improving sample representativeness by conducting studies within school environments.

1. Review of findings

1.1 Implicit and explicit ToM associations

The relation between implicit and explicit ToM has been highly debated since the discovery that young children could attribute false belief to agents way before they can answer explicit false belief questions (Clements & Perner, 1994; Onishi & Baillargeon, 2005). Infants' early and spontaneous understanding of false belief (i.e., implicit ToM) have since been evidenced in children using a variety of paradigms (Buttelmann et al., 2009; He et al., 2011, 2012; Southgate et al., 2007) This phenomenon led to several theoretical accounts that aimed at explaining the discrepancies that we could observe between children's failure in traditional false beliefs task (Wellman et al., 2001) and implicit ToM. Following these theoretical debates, studies have provided mixed findings, with discrepancies observed in both brain and behavioral data. For instance, recent studies indicated that the two abilities rely on distinct neural networks in infants, with implicit ToM associated with parietal networks, and explicit ToM associated

with frontal networks (Li et al., 2025). Other neuroimaging studies have confirmed independence between implicit and explicit ToM (see Figure 16), both at the behavioral and



neural level (Grosse Wiesmann et al., 2020; 2017).

Figure 16. Brain correlates for explicit and implicit ToM, as well as the altercentric bias. Figure from Grosse Wiesmann et al., 2020 adapted from Schurz et al., 2014 and Boccadoro et al., 2019.

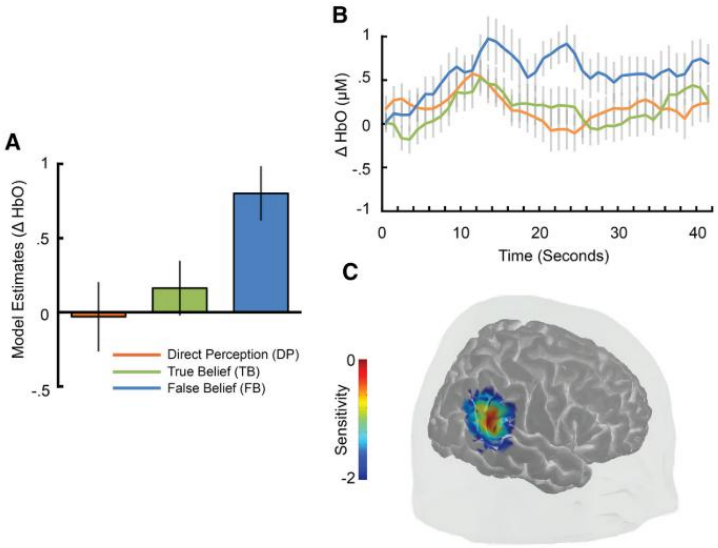


Figure 17. Neural activity in the TPJ channel in response to others' beliefs in 7 months old. A) Brain response in the TPJ channel depending on belief condition. B) Activity over time during the test videos. C) Sensitivity values (log scale) in the TPJ channel. Figures from Hyde et al., 2018.

In contrast, others have shown that both abilities rely on similar brain networks (Ma et al., 2023). For instance, activation of the TPJ was associated with implicit false belief in 7 months

children (see Figure 17, Hyde et al., 2018), a region that has strongly been associated with explicit ToM between children aged 5 to 11 (Gweon et al., 2012), as well as implicit ToM in adults (Kovács et al., 2014). In addition, overlap between implicit and explicit neural networks have been observed in adults (Bardi et al., 2017; Hyde et al., 2015). Interestingly, other findings suggest that children who succeed in explicit false belief tests show earlier TPJ activations when the belief of a character becomes false, whereas those who fail show later activation, during the agent's search for the object (Bowman & Brandone, 2024). This suggests that both keep interacting during development.

Divergent results have been observed in behavioral studies as well. For instance, some reported longitudinal associations between infants' implicit ToM and their later explicit ToM abilities (Kloo et al., 2020; Sodian et al., 2016; Thoermer et al., 2012), while others report no such associations (Poulin-Dubois, 2020; Poulin-Dubois et al., 2023). Similar inconsistencies have been reported without the use of longitudinal designs, with some finding a link between the two (Low, 2010), while other do not (Grosse Wiesmann et al., 2017). Despite inconsistencies in the findings, a recent review of evidence argued in favor of a single system account (Sodian et al., 2020), given the large amount of evidence showing continuity between the two (Scott et al., 2022).

Our results support this hypothesis. First, we found an association between explicit and one implicit ToM index in a cross-sectional sample of 371 children aged 3 to 7. We then confirmed this link using an accelerated longitudinal design with 354 children, covering a four-year developmental span (ages 3 to 7), showing that the two abilities are related over time. This study contributes to the existing literature by testing this association in a large sample of preschool and school-aged children, an age range that has received relatively little attention compared the early preschool. Importantly, we assessed implicit ToM using a task that assesses bias toward others' perspectives. This is the first time this bias has been measured in children using this task. More broadly, an altercentric bias measure has recently been used in preschoolers (Speiger et al., 2025), highlighting its potential as a novel way to assess implicit ToM in this age group.

1.2 Developmental trajectories

Developmental trajectories (see Figure 18) of explicit ToM are well documented (Wellman et al., 2001), with a gradual improvement between age 3 to 5 in children for first order ToM, and

6 to 9 for second order (Perner & Wimmer, 1985), despite discrepancies have been observed between studies (Miller et al., 2009).

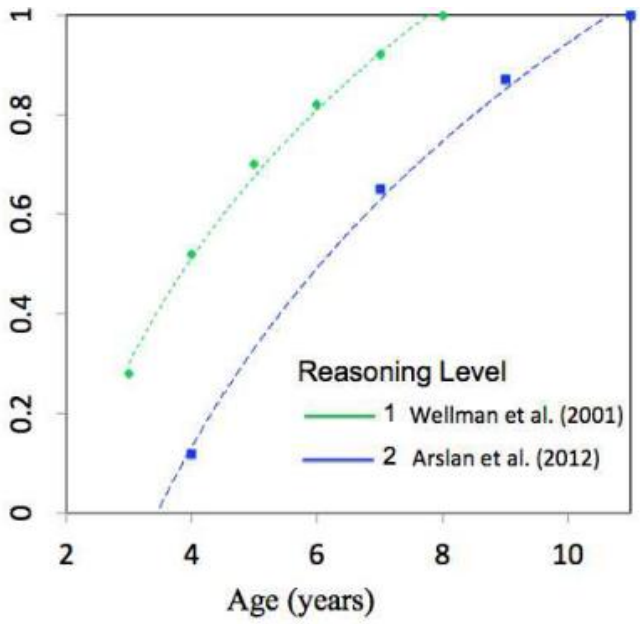


Figure 18. Developmental trajectories of first and second order ToM. Figure from Arslan et al., 2012.

The developmental trajectory of implicit ToM is however less clear. This capacity have been observed in children between 7 months and about 3 years old (He et al., 2011, 2012; Király et al., 2023; Knudsen & Liszkowski, 2012; Kovács et al., 2010; Southgate et al., 2007), in preschoolers (Grosse Wiesmann et al., 2017; Kaltefleiter et al., 2022; Low & Watts, 2013; Sodian et al., 2024), in school-aged children (Senju et al., 2010), as well as in adults (El Kaddouri et al., 2020; Fogd et al., 2025; Grainger et al., 2018; Kovács et al., 2010; Schneider et al., 2017).

The AL literature presents a different view of developmental trajectories compared to studies on the altercentric bias. Grosse Wiesmann et al. (2018) evidenced that only 4 years old children correctly anticipated actions based on false beliefs, whereas 2 and 3 years old children did not. In contrast, using a similar task, others found that 2 to 4 years old children did anticipate the actions based on erroneous beliefs (Kaltefleiter et al., 2022), although they did so only in one of the two false belief conditions, the other one mostly leading to non-replications (Kulke et al., 2019). The same pattern was observed from preschool to late adulthood (Kulke et al., 2018),

with one false belief condition leading to correct anticipation in the different age groups (children, adults, elder adults).

A different pattern has been observed for the altercentric bias. Its development appears non-linear, with 9-month-old infants showing an altercentric bias, whereas 18-month-olds did not (Tebbe et al., 2025), in line with the U-shaped trajectory that was proposed (Manea et al., 2023; Southgate, 2020). Altercentric bias was observed in preschoolers, but only when the belief of the agent was made salient first (Speiger, Rothmaler, Bravo, et al., 2025), and the same pattern was evidenced in adult (Speiger, Rothmaler, Liszkowski, et al., 2025). However, studies using the ball detection task, which also measure sensitivity to others' perspectives, have shown implicit ToM effects in adults even without any mention of the agent's belief (Bardi et al., 2017a, 2017b; El Kaddouri et al., 2020; Nijhof et al., 2016, 2017, 2018), indicating variability between the tasks used to measure implicit ToM.

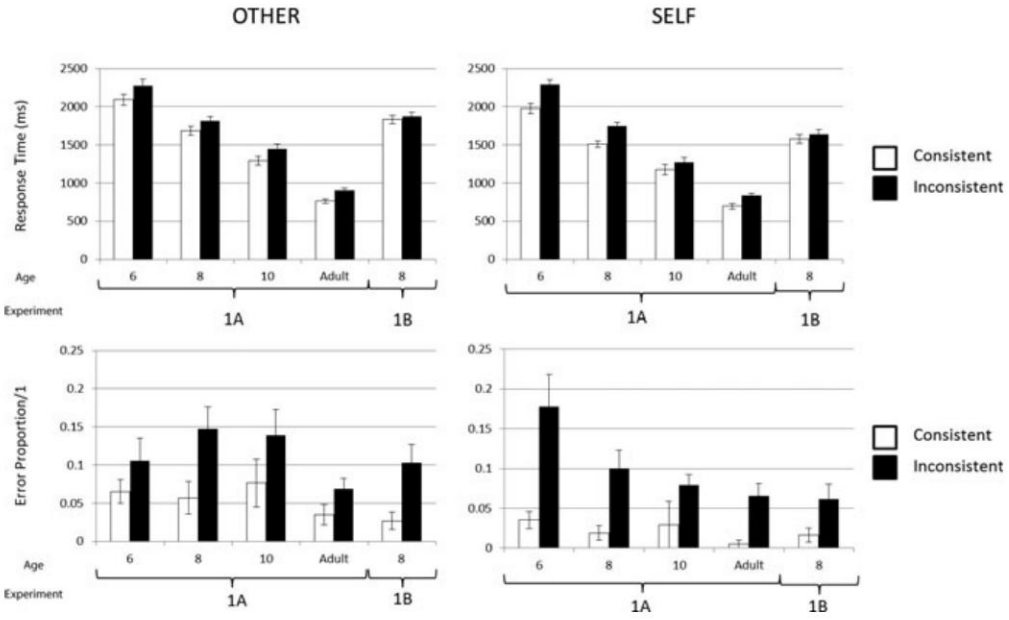


Figure 19. Mean response time and error proportion in the dot task for different age group, both from the other (egocentric) and the self (altercentric) perspective. Figures from Surtees et al., 2012.

Finally, while distinct from the implicit ToM literature, the perspective-taking field has also explored the developmental trajectory of the altercentric bias using the dot task. This bias has been observed in children aged 6 to 10 (see Figure 19, Surtees & Apperly, 2012) and shown to continue developing into adolescence (Weidema et al., 2023).

Our results align with existing findings. We first observed strong age effect on both first and second order ToM. In addition, we observed age-related development in one index of implicit ToM, with increasing costs of taking the agent's perspective, even when it was irrelevant to the task. However, this effect emerged only in one of the two implicit ToM indexes (specifically, when the child held a true belief). Interestingly, we found a general egocentric bias in our sample, but no altercentric bias, suggesting that children were only influenced by their own perspective. To our knowledge, this is the first longitudinal assessment of this specific bias. These findings suggest that implicit ToM continues to evolve during childhood.

1.3 Influence of linguistic and cognitive domains

Language has consistently been linked to explicit ToM (de Villiers & de Villiers, 2014; Milligan et al., 2007). Across all studies in this thesis, we found a robust association between language and both first and second-order explicit ToM. These findings confirm the strong predictive role of language in the development of explicit ToM, including its more advanced forms (Milligan et al., 2007).

We found limited evidence for a link between EF and explicit ToM (Devine & Hughes, 2014). In Study 1, EF did not predict explicit ToM. In contrast, in Study 3, using a longitudinal design, results showed that EF predicted first-order ToM. However, across our sample, linguistic factors remained more predictive of explicit ToM than EF abilities. Notably, EF did not predict second-order ToM. As suggested in Study 3, this result is consistent with recent longitudinal findings showing that language is a stronger predictor of explicit ToM than EF (André & Maintenant, 2025; De Villiers & De Villiers, 2025).

The associations of EF and language with implicit ToM are however less consistent, with studies reporting mixed findings in preschoolers. Some report significant associations (Meristo et al., 2012; San Juan & Astington, 2017; Schneider et al., 2012; Yott & Poulin-Dubois, 2012), while others do not (Grosse Wiesmann et al., 2017; Low, 2010). In both Study 2 and Study 3, we found that implicit ToM was independent from language and EF between ages 3 and 7. This may suggest that this ability operates without relying on linguistic or executive resources, consistent with two-system accounts that view implicit ToM as automatic, inflexible, and independent of general cognitive capacities (Apperly & Butterfill, 2009). However, we also found that overall performance on our implicit ToM task was associated with children's language and executive abilities. Specifically, children excluded from the sample showed lower

EF and language scores than those retained. This sampling bias therefore limits the conclusions that can be drawn from these results and calls for the development of suitable measures of implicit ToM for this age range.

1.4 Influence of environmental factors

In developmental literature, higher SES has consistently been associated with better performance on explicit ToM tasks in children (Carlson & Moses, 2001; Cutting & Dunn, 1999; Devine & Hughes, 2018; Ebert et al., 2020; Hughes & Ensor, 2005; Pluck et al., 2021). One common explanation for this link is that SES is strongly related to both EF and language abilities, two cognitive domains that are themselves closely tied to ToM performance (Devine & Hughes, 2014; Milligan et al., 2007) and show robust associations with SES (Lawson et al., 2018; Merz et al., 2019; Noble et al., 2005).

Building on this literature, we investigated whether SES influences ToM indirectly, through its effects on language and EF. In Study 1, we found that the relation between SES and explicit ToM was fully mediated by children's language abilities, suggesting that SES-related differences in ToM performance may reflect differences in language development rather than differences in mentalizing ability itself.

In Study 2 and 3, we explored whether implicit ToM would also be linked to SES. Indeed, while the effects of environmental factors on explicit ToM have been well documented (Devine & Hughes, 2018; Liu et al., 2008; Peterson & Slaughter, 2016), much less is known about how these same factors influence implicit ToM. In both studies, we found that implicit ToM appeared to be independent of socioeconomic background.

These findings can be compared to those from the adult literature, where studies have suggested that low-SES individuals outperform their high-SES peers on social cognition tasks. One explanation is that individuals from higher-status backgrounds, being more socially independent, may pay less attention to others' mental states (Kraus et al., 2010). This advantage among low-SES adults has been reported in several studies (Muscatell et al., 2012; Piff et al., 2010; Kraus et al., 2011; Stellar et al., 2012; Dietze & Knowles, 2021; Dietze et al., 2022; Bjornsdottir et al., 2017), although some recent findings suggest more mixed or contradictory patterns (Gao et al., 2015; Quesque et al., 2022).

In sum, we found partial evidence of an effect of SES on explicit ToM, and no effect on implicit ToM. Taken together, our results may suggest that SES not affect ToM abilities per se, but rather impacts external skills, such as language and EF, which are more strongly involved in traditional ToM false belief tasks (Bloom & German, 2000).

Concerning these external skills, language and EF have consistently been linked to SES in childhood (Merz et al., 2019). However, much of the research in this area has been conducted within a deficit-based framework (Taylor et al., 2023), which tends to depict low-SES individuals as lacking or impaired in comparison to their high-SES peers. This perspective has important methodological, educational, and ethical implications, which will be addressed in the following section.

2. Reflections and methodological limitations

In this section, I will first discuss implication of adopting a deficit view of SES for research and education. In a following section, I will discuss methodological limitations of this present work.

2.1 The deficit view and the WEIRD sampling bias

2.1.1 The dominant deficit-view

The dominant framework for explaining SES-related differences in cognitive development is through the social causation view, according to which the economical and social resources of an individual impacts its performances (Conger & Donnellan, 2007; Taylor et al., 2023). Two models have been proposed within this view (Conger & Donnellan, 2007). The first model, called the family investment model, claims that families with higher SES can invest more in their children's cognitive development by providing learning materials or enriched environments. The second model, the family stress model, claims that economic stress influences parenting behaviors, such as emotional support and responsiveness, which in turn affect children's cognitive and emotional development (Duncan & Magnuson, 2012).

There is now substantial evidence that SES affects brain development, which is in turn associated with academic achievement, language, and EF development (Aikens & Barbarin, 2008; Hackman et al., 2010; Merz et al., 2019; Noble et al., 2005; Sirin, 2005). Relations to language have been explained rather in terms of linguistic environments, suggesting that lower SES children would be exposed to less qualitative linguistic inputs than high-SES children (Hoff, 2006), which would impact their language development (Ferjan Ramírez, Lytle,

National, et al., 2020). EF would be impacted, for instance, by the elevated cortisol levels associated with chronic stress experienced by parents, which can negatively impact the prefrontal cortex, a brain region critical for EF (Arnsten, 2009; Feola et al., 2020; Sheridan et al., 2012; Taylor et al., 2023).

2.1.2 Implications for children

Researchers, however, have highlighted the limits of this framework. Systematically describing low-SES individuals as impaired (the so-called deficit view) carries several implications (Taylor et al., 2023). First, it reveals a lack of awareness within neuroscience and psychology regarding the representativeness of research samples. Indeed, given that research is almost always limited to WEIRD participants, these are treated as the default reference group (Henrich et al., 2010b, 2010a). Consequently, individuals from non-WEIRD contexts are compared to this unrepresentative baseline and perceived as deficient (Taylor et al., 2023). This illustrates not only a neglect of alternative developmental pathways but also a broader failure to acknowledge sampling bias within the field (Taylor et al., 2023).

When differences are framed as deficits, interventions often aim to "fix" the individual, placing the responsibility on parents instead of addressing the broader systemic inequalities that influence development (Figueroa, 2024; Garcini et al., 2022; Taylor et al., 2023). For example, several studies have proposed parenting programs for low-SES families to improve children's cognitive or language skills (Hatcher & Page, 2020; Neville et al., 2013). The problem with this kind of approach is that it often assumes that some forms of language are inherently better than others (Figueroa, 2024). Describing children from marginalized backgrounds as linguistically deficient reflects a narrow view of language competence, which overlooks culturally diverse ways of speaking and communicating (Miller et al., 2024).

These assumptions have real consequences for children, particularly in educational systems (Sheehy-Skeffington et al., 2024), where educators often justify certain practices and perceptions of students based on the deficit view, built on ideas such as the "word gap" (Adair et al., 2017; Hart & Risley, 1995). This perspective can directly reduce learning opportunities for children by shaping expectations and interactions in the classroom. Moreover, the education system itself may contribute to these disparities. Research has shown that teachers tend to offer fewer opportunities for classroom participation to low-SES children (Doyle et al., 2025), and thus reinforce inequities in the classrooms, which directly affects academic success (Goudeau

et al., 2023). These findings suggest that school environments and educational systems not only reflect but also reinforce social inequalities. They also highlight how deficit-based views of SES can have concrete consequences for institutions and public policies and point to the importance of conducting SES-related research in a careful way.

2.1.3 Adaptative as opposed to deficit frameworks

Rather than focusing on deficit, some researchers have proposed adaptive frameworks of adversity (Pepper & Nettle, 2017) to better capture the diversity of cognitive outcomes observed across contexts (Mittal et al., 2015). SES-related differences in cognition may therefore be understood as contextually adaptive rather than deficient (Frankenhuis & de Weerth, 2013; Pepper & Nettle, 2017). For instance, individuals living in unpredictable environments may develop cognitive strategies that prioritize immediate rewards over long-term planning (Brezina et al., 2009), which is often considered dysfunctional but can be advantageous in unstable conditions (Mittal et al., 2015). For instance, it has been suggested that individuals from low-SES backgrounds exposed to frequent adversity may show greater cognitive flexibility, which would reflect the need to adjust rapidly in unstable environments (Mittal et al., 2015). Interestingly, low-SES adults indeed show enhanced cognitive flexibility, but only under uncertain conditions (Figure 20, Mittal et al., 2015). This highlights the critical role of context in eliciting such adaptations, and that the allocation of resources might also differ between context and individuals.

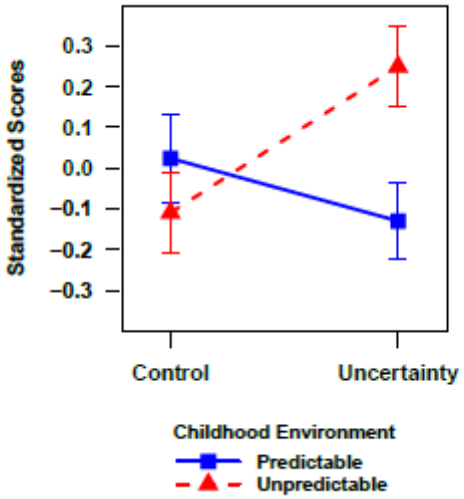


Figure 20. Scores in a cognitive flexibility task in uncertain and control context, in individual who grew up in predictable and unpredictable childhood environments. Figure from Mittal et al., 2015.

2.2 Methodological limitations

2.2.1 Adaptation from an adult paradigm

In this thesis, we aimed to adapt a well-documented paradigm used in adults (i.e., the ball detection task) to assess implicit ToM in children between ages 3 and 7. This task presents several advantages for studying implicit ToM. First, its effects have been replicated multiple times in adults. Second, unlike AL or VOE tasks that rely on passive observation (Schneider et al., 2014), it requires an active response from children, who are asked to press a button when they detect the target, which makes the task more engaging. This feature also makes it more suitable for older children, as motivation for the same task tends to vary with age (Buttelmann, 2017). In addition, the task can easily be implemented on tablets, which facilitates data collection in schools, enabling the testing of more representative samples (Garavan et al., 2018) and therefore reducing sampling bias, as will be discussed further.

However, adapting this paradigm for preschool and school-aged children presented several challenges. First, even though children are more active than in classic implicit ToM tasks, the task remains quite long, monotonous, and repetitive, which can lead to a rapid loss of interest. By reducing the number of trials to two per condition, we aimed to make the task more suitable for children. However, recent evidence using a similar task suggests that performance evolves

across trials, where differences between conditions diminished over time (Rothmaler & Grosse Wiesmann, 2023). It is therefore necessary to find the right balance between a limited number of trials, which is more suitable for children (Brooker et al., 2019), and a sufficient number to ensure reliability.

Furthermore, the removal of the attention check (response to the departure of the agent) was also an issue. This was done to facilitate the task, as it appeared too demanding for children aged 3–4, who already struggled to follow the main instruction (detecting the presence of the target). However, the task soon became too easy for older children, leading to less engagement. This highlights the difficulty of designing (implicit ToM) measures that are both cognitively accessible and sufficiently stimulating. The length of the sequence (about 15 seconds) also requires consideration. Shorter sequences would more easily maintain attention but might also hinder agent belief processing, as sufficient length is required for participants to have time to process and encode beliefs (Baillargeon et al., 2018). Finally, replacing the ball with a ladybug may have increased engagement in children, but requires caution. As mentioned in Study 2, animals are often anthropomorphized (Urquiza-Haas & Kotrschal, 2015), which may have diverted their attention away from the agent and thus reduce mental state attribution.

2.2.2 Narrow focus on false beliefs

In addition, the large majority of studies assessing ToM focus on false belief tasks (Wellman et al., 2001). This focus, however, can create confusion between the task and the ability it is meant to measure (Quesque & Rossetti, 2020). Our use of a single false belief task to assess explicit ToM (one for first-order, one for second-order) is therefore a limitation of this work. ToM can be assessed through a variety of tasks beyond false belief (Fu et al., 2023), each targeting different developmental steps. For instance, Wellman & Liu (2004) developed a widely used battery designed to capture distinct stages of ToM development in preschoolers, including both cognitive and emotional components. More recently, authors have created and validated a broader battery of explicit ToM tasks (with one implicit ToM item) suitable for children aged 3 to 12. This tool includes a wide range of tasks assessing different aspects of ToM, is interactive, age-adapted, and available in open access (Sotomayor-Enriquez et al., 2024).

2.2.3 Use of the same tasks across age groups

Finally, having the same tasks for all ages is also a limitation of this work. Indeed, this was done to ensure comparability between children and better assess the developmental trajectory

for each capacity (Weber et al., 2023). However, this approach may also reduce the reliability of the tasks across ages. A single task does not represent the same level of difficulty for a 4-year-old and for a 7-year-old, potentially leading to ceiling or floor effects (Willoughby et al., 2023). In line with this, we observed ceiling effects in one of our tasks, the language task, which limits age-related analyses, as variability tends to decrease with age. For instance, the inclusion of both reaction times and accuracy could allow for more precision in the scores and help overcome ceiling effects components (Willoughby et al., 2023; Camerota et al., 2020). In addition to floor effects, a task that is too difficult or too easy can also impact children's motivation during testing, and thus affect the reliability of the results, as motivation has been shown to influence cognitive performance in children (Worthy et al., 2011).

3. Perspectives

3.1 Towards suitable implicit ToM measures

As mentioned throughout this thesis, future research is warranted to design tasks that reliably measure implicit ToM in children. Adapting an adult paradigm to children was a first step. While doing so, we identified several ways of improving the task that we adapted. First, it seems that the instructions became really clear for children from age 5. Therefore, reintroducing the attention checks halfway through the sequence could both improve the attention to the agent (as it was introduced for), and thus the attribution of beliefs, as well as enhance engagement in children. Indeed, having two responses to give within the sequence could make the task less monotonous and more engaging for children.

In addition, in order to increase the number of trials for better reliability, dividing trials into several blocks and allowing breaks in between may be an efficient compromise (Rollins & Riggins, 2021). However, further investigation is needed to find the exact number of trials required to assess implicit ToM within this paradigm. Furthermore, including sounds (e.g., footsteps, door closing, or object sounds) could make the task more engaging for children and elicit greater attention, as typically done in children ToM paradigms (e.g., Grosse Wiesmann et al., 2017). This could also make clearer what the agent can and cannot witness. For instance, a door sound could signal that the agent is no longer present in the room, clarifying that the agent cannot see or hear the displacements of the target. Finally, as the task is not inherently rewarding, incorporating simple rewards could enhance children's motivation.

Developing more engaging and appropriately demanding paradigms would therefore not only improve data quality but also help clarify the sources of variability in both implicit and explicit ToM (Devine & Apperly, 2022). In addition, directly comparing the altercentric bias to more classic implicit ToM measures (e.g., AL and VOE) in longitudinal settings could allow a direct comparison of the developmental trajectories of each of these measures (Poulin-Dubois et al., 2020). It would also allow to assess the reliability and stability of altercentric bias within the same individuals and help clarify what the different measures of implicit ToM actually measure.

3.2 Against the replication crisis

As discussed in the General Introduction, as well as in Studies 2 and 3, assessing implicit ToM presents several methodological challenges, with a major one being the replication crisis. Reviews and meta-analysis indicated that a large proportion of findings fail to replicate, highlighting the fragility of implicit ToM measure (Barone et al., 2019; Kulke & Rakoczy, 2018). Baillargeon et al. (2018) have recently identified several hypotheses to explain the discrepancies in the results (e.g., timing of the sequences too short for children to build expectations, ambiguous scenarios, low statistical power). Among the identified factors was also the fact that high number of participants are excluded from the sample for errors in the familiarization trials. Indeed, in non-replication studies, success rates during familiarization often range between 25% and 65%, suggesting that failure in the test phase may not reflect a lack of ToM ability per se (Baillargeon et al., 2018). This raises concerns about the suitability of these tasks for reliably measuring implicit ToM. Also, authors have suggest that different results can be expected from different age groups, as preschoolers will not behave in the same ways as 18 months old children and might not be motivated by the task in the same ways (Buttelmann, 2017).

In light of these challenges, researchers developed the ManyBabies project, which was created as a large-scale collaborative initiative aimed at promoting open science, transparency, and methodological consistency (Schuwerk et al., 2021). One subproject, ManyBabies2, specifically focuses on implicit ToM in both children and adults. By bringing together multiple laboratories across different countries and cultures, the project aims to address the replication crisis in developmental research, with the idea to use the same standardized methodology across different laboratories to evaluate the robustness, reliability, and generalizability of social-cognitive measures in infancy and early childhood. Importantly, this initiative also aims to

reduce sampling bias and to account for individual and cultural differences that may influence performance in social tasks during early development (Tsui et al., 2022).

3.3 School settings for better representativeness

In light of the different aspects discussed in this general discussion, findings of a link between SES and explicit ToM in children can be viewed differently. Building on the sampling bias evoked in the previous section, findings that low SES children lag behind their high-SES peers in ToM must indeed be considered in the broader context of research critiques that challenge the universality of the developmental milestone around age 4 (Wellman et al., 2001). Even if explicit ToM have now been assessed in diverse sociocultural backgrounds, much of what we know about ToM development, such as the ability to pass a standard false belief task around age four, still comes from WEIRD samples (Mayer & Träuble, 2015). Therefore, the delays observed in explicit ToM in low SES are drawn from comparisons to WEIRD samples, that is considered the baseline in psychology (Sanches de Oliveira & Baggs, 2023). Recent work shows that the 4 years old developmental milestone is not universal, but rather vary significantly across cultures (Mayer & Träuble, 2015).

This lack of representativeness in samples might be even more true in implicit ToM studies (Padberg et al., 2022). As a result, important questions remain about whether the tools that are used to assess ToM are valid in more diverse sociocultural contexts, and whether the patterns observed in WEIRD samples generalize to other populations. It underscores the need to broaden ToM research beyond WEIRD samples and to carefully evaluate whether our current measures capture what we assume they do.

Assessing children's abilities within schools is an effective way to increase the representativeness of samples (Alibali & Nathan, 2010). By conducting testing sessions directly in schools, we aimed to include participants from a broader range of sociocultural backgrounds. This is particularly important given the strong focus on WEIRD samples in the ToM field (Mayer & Träuble, 2015). In addition, recruiting families through schools enables direct interaction between researchers and families (Garavan et al., 2018), and may reduce the hesitation some families feel about participating in research. In addition, it facilitates participation, as families do not need to travel to a lab, since the testing takes place during school hours, within the school itself. This approach also encourages collaboration between

schools and research teams, and supports the development of joint projects involving families, educators, and researchers.

Conclusion

Throughout this thesis, we aimed to better understand the development of explicit and implicit ToM in preschool and school-aged children, as well as the roles of language, EF and SES in these developmental trajectories.

Across studies, we found a link between implicit and explicit ToM, both cross-sectionally and longitudinally, in children aged 3 to 7. This relation suggests that implicit and explicit ToM are interconnected during development, supporting theoretical accounts that propose continuity between the two abilities.

Regarding developmental trajectories, explicit ToM followed the expected progression between ages 3 and 7. In addition, one index of implicit ToM also showed age-related change, indicating an increasing attention to others' perspectives. However, children overall displayed an egocentric rather than altercentric bias, meaning they were more influenced by their own perspective than by the agent's. Further studies, with careful attention to task parameters, are needed to better understand the development of this bias in childhood.

Language consistently emerged as the strongest predictor of explicit ToM, while EF showed a significant but more limited contribution. In contrast, implicit ToM appeared independent from both language and EF, supporting the view that it operates automatically and separately from higher cognitive resources. However, since excluded children tended to have lower EF and language abilities, future adaptations of the task are needed to minimize this selection bias.

Finally, we found that the effect of SES on explicit ToM was fully explained by language, although the association between SES and ToM remained in the longitudinal study. In contrast, implicit ToM showed no relation with SES, suggesting that environmental factors may influence ToM performance indirectly, through their effects on language and EF, rather than mentalizing ability itself.

Together, this work provides some evidence for a continuous developmental link between implicit and explicit ToM and highlights the central role of language in explicit ToM, as well as the limited influence of EF abilities and SES. It also stresses the need for more reliable, engaging, and age-appropriate measures of implicit ToM, along with more diverse and representative samples. Such methodological advances are essential to better capture variability

of ToM development and move toward a more inclusive understanding of children's social cognition.

References

Abels, M., & Hutman, T. (2015). Infants' behavioral styles in joint attention situations and parents' socio-economic status. *Infant Behavior and Development*, *40*, 139-150. https://doi.org/10.1016/j.infbeh.2015.05.004

Adair, J. K., Colegrove, K. S.-S., & McManus, M. E. (2017). How the Word Gap Argument Negatively Impacts Young Children of Latinx Immigrants' Conceptualizations of Learning. *Harvard Educational Review*, *87*(3), 309–334. https://doi.org/10.17763/1943-5045-87.3.309

Adler, N. E., Boyce, T., Chesney, M. A., Cohen, S., Folkman, S., Kahn, R. L., & Syme, S. L. (1994). Socioeconomic status and health: The challenge of the gradient. *American Psychologist, 49*(1), 15–24. https://doi.org/10.1037/0003-066X.49.1.15

Adolphs, R. (1999). Social cognition and the human brain. *Trends in cognitive sciences*, 3(12), 469-479.Adrián, J. E., Clemente, R. A., & Villanueva, L. (2007). Mothers' Use of Cognitive State Verbs in Picture-Book Reading and the Development of Children's Understanding of Mind: A Longitudinal Study. *Child Development*, *78*(4), 1052–1067. https://doi.org/10.1111/J.1467-8624.2007.01052.X

Aikens, N. L., & Barbarin, O. (2008). Socioeconomic Differences in Reading Trajectories: The Contribution of Family, Neighborhood, and School Contexts. *Journal of Educational Psychology*, *100*(2), 235–251. https://doi.org/10.1037/0022-0663.100.2.235

Alibali, M., & Nathan, M. (2010). Conducting research in schools: A practical guide. *Journal of Cognition and Development, 11*(4), 397–407. https://doi:10.1080/15248372.2010.516417

Allen, K. A. (2020). *The Psychology of Belonging* (1st ed.). Routledge. https://doi.org/10.4324/9780429327681

Allen, K., Kern, M. L., Vella-Brodrick, D., Hattie, J., & Waters, L. (2018). What Schools Need to Know About Fostering School Belonging: a Meta-analysis. *Educational Psychology Review*, *30*(1), 1–34. https://doi.org/10.1007/s10648-016-9389-8

Allen, Kern, M. L., Rozek, C. S., McInerney, D. M., & Slavich, G. M. (2021). Belonging: a review of conceptual issues, an integrative framework, and directions for future research. *Australian Journal of Psychology*, *73*(1), 87–102. https://doi.org/10.1080/00049530.2021.1883409

Amodio, D., & Frith, C. (2006). Meeting of minds: the medial frontal cortex and social cognition. *Nature Reviews Neuroscience 2006 7:4*, *7*(4), 268–277. https://doi.org/10.1038/nrn1884

Anderson, R. T., Sorlie, P., Backlund, E., Johnson, N., & Kaplan, G. A. (1997). Mortality effects of community socioeconomic status. *Epidemiology*, *8*(1), 42-47. https://doi.org/10.1097/00001648-199701000-00007

Andre, M. L., & Maintenant, C. (2025). The role of executive function and language abilities in explaining theory of mind development in preschool-age children. *Journal of Clinical and Experimental Neuropsychology*, *47*(3), 205–217. https://doi.org/10.1080/13803395.2025.2498712

APA. (2023). https://dictionary.apa.org/socioeconomic-statusApperly, I. A., & Butterfill, S. A. (2009). Do humans have two systems to track beliefs and belief-like states?. *Psychological review*, *116*(4), 953.

Apperly, I. A., Riggs, K. J., Simpson, A., Chiavarino, C., & Samson, D. (2006). Is belief reasoning automatic? *Psychological Science*, *17*(10), 841–844. https://doi.org/10.1111/J.1467-9280.2006.01791.X

Apperly, I. A., Samson, D., & Humphreys, G. W. (2009). Studies of Adults Can Inform Accounts of Theory of Mind Development. *Developmental Psychology*, *45*(1), 190–201. https://doi.org/10.1037/a0014098

Apperly, I. A., & Wang, J. J. (2021). Mindreading in Adults. In *The Cognitive Basis of Social Interaction Across the Lifespan* (pp. 96–116). Oxford University PressOxford. https://doi.org/10.1093/oso/9780198843290.003.0005

Arnsten A. F. (2009). Stress signalling pathways that impair prefrontal cortex structure and function. *Nature reviews. Neuroscience*, *10*(6), 410–422. https://doi.org/10.1038/nrn2648

Arslan, B., Hohenberger, A., & Verbrugge, R. (2012). The development of second-order social cognition and its relation with complex language understanding and memory. In *Proceedings of the annual meeting of the cognitive science society* (Vol. 34, No. 34).

Arslan, B., Verbrugge, R., Taatgen, N., & Hollebrandse, B. (2020). Accelerating the Development of Second-Order False Belief Reasoning: A Training Study With Different Feedback Methods. *Child Development*, *91*(1), 249–270. https://doi.org/10.1111/CDEV.13186

Astington, J. W., & Baird, J. A. (Eds.). (2005). *Why language matters for theory of mind*. Oxford University Press.

Astington, J. W., & Dack, L. A. (2000). Necessary but not Sufficient: The Respective Roles of Single and Multiple Influences on Individual Development. *Theory of Mind*.

Astington, J. W., & Jenkins, J. M. (1999). A Longitudinal Study of the Relation Between Language and Theory-of-Mind Development. In *Developmental Psychology* (Vol. 35, Issue 5).

References

Astington, J. W., Pelletier, J., & Homer, B. (2002). Theory of mind and epistemological development: The relation between children's second-order false-belief understanding and their ability to reason about evidence. *Elsevier*. https://doi.org/10.1016/S0732-118X(02)00005-3

Austin, G., Groppe, K., & Elsner, B. (2014). The reciprocal relationship between executive function and theory of mind in middle childhood: A 1-year longitudinal perspective. *Frontiers in psychology*, *5*, 655. https://doi.org/10.3389/fpsyg.2014.00655

Avis, J., & Harris, P. L. (1991). Belief-Desire Reasoning among Baka Children: Evidence for a Universal Conception of Mind. *Child Development*, *62*(3), 460–467. https://doi.org/10.1111/j.1467-8624.1991.tb01544.x

Avvisati, F. (2020). The measure of socio-economic status in PISA: a review and some suggested improvements. In *Large-Scale Assessments in Education* (Vol. 8, Issue 1). Springer. https://doi.org/10.1186/s40536-020-00086-x

Baayen, H., & Linke, M. (2021). Generalized Additive Mixed Models. *A Practical Handbook of Corpus Linguistics*, 563–591. https://doi.org/10.1007/978-3-030-46216-1_23

Babu, N. (2011). *Theory of mind understanding in narration: A study among children from different socioeconomic backgrounds in India*. https://doi.org/10.4087/ZMFM1057

Baillargeon, R., Scott, R. M., & He, Z. (2010). False-belief understanding in infants. *Trends in cognitive sciences*, *14*(3), 110-118. https://doi.org/10.1016/j.tics.2009.12.006

Baillargeon, R., Spelke, E. S., & Wasserman, S. (1985). Object permanence in five-month-old infants. *Cognition*, *20*(3), 191-208. https://doi.org/10.1016/0010-0277(85)90008-3

Baldwin, D. A., & Baird, J. A. (2001). Discerning intentions in dynamic human action. *Trends in Cognitive Sciences*, *5*(4), 171–178. https://doi.org/10.1016/S1364-6613(00)01615-6

Bardi, L., Desmet, C., & Brass, M. (2019). Spontaneous Theory of Mind is reduced for nonhuman-like agents as compared to human-like agents. *Psychological Research*, *83*(7), 1571–1580. https://doi.org/10.1007/s00426-018-1000-0

Bardi, L., Desmet, C., Nijhof, A., Wiersema, J. R., & Brass, M. (2017a). Brain activation for spontaneous and explicit false belief tasks overlaps: New fMRI evidence on belief processing and violation of expectation. *Social Cognitive and Affective Neuroscience*, *12*(3), 391–400. https://doi.org/10.1093/scan/nsw143

Bardi, L., Six, P., & Brass, M. (2017b). Repetitive TMS of the temporo-parietal junction disrupts participant's expectations in a spontaneous Theory of Mind task. *Social Cognitive and Affective Neuroscience*, *12*(11), 1775–1782. https://doi.org/10.1093/scan/nsx109

Barnes-Holmes, Y., McHugh, L., & Barnes-Holmes, D. (2004). Perspective-taking and Theory of Mind: A relational frame account. *The Behavior Analyst Today*, *5*(1), 15. https://doi.org/10.1037/h0100133

Baron-Cohen, S. (2005). The Empathizing System: A Revision of the 1994 Model of the Mindreading System. In B. J. Ellis & D. F. Bjorklund (Eds.), Origins of the social mind: Evolutionary psychology and child development (pp. 468–492). The Guilford Press.

Baron-Cohen, S., Leslie, A. M., & Frith, U. (1985). Does the autistic child have a "theory of mind"?. *Cognition*, *21*(1), 37-46. https://doi.org/10.1016/0010-0277(85)90022-8

Barone, P., Corradi, G., & Gomila, A. (2019). Infants' performance in spontaneous-response false belief tasks: A review and meta-analysis. In *Infant Behavior and Development* (Vol. 57). Elsevier Ltd. https://doi.org/10.1016/j.infbeh.2019.101350

Barone, P., & Gomila, A. (2021). Infants' performance in the indirect false belief tasks: A second-person interpretation. In *Wiley Interdisciplinary Reviews: Cognitive Science* (Vol. 12, Issue 3). John Wiley and Sons Inc. https://doi.org/10.1002/wcs.1551

Bates, D., Mächler, M., Bolker, B., & Walker, S. (2015). Fitting Linear Mixed-Effects Models Using lme4. *Journal of Statistical Software*, *67*(1). https://doi.org/10.18637/jss.v067.i01

Baum, A., Garofalo, J. P., & Yali, A. M. (1999). Socioeconomic status and chronic stress. Does stress account for SES effects on health? *Annals of the New York Academy of Sciences*, *896*, 131–144. https://doi.org/10.1111/J.1749-6632.1999.TB08111.X

Baumeister, R. F., & Leary, M. R. (1995). The Need to Belong: Desire for Interpersonal Attachments as a Fundamental Human Motivation. In *Psychological Bulletin* (Vol. 117, Issue 3).

Baumrind, D. (1996). The discipline controversy revisited. *Family Relations: An Interdisciplinary Journal of Applied Family Studies, 45*(4), 405–414. https://doi.org/10.2307/585170

Beaudoin, C., & Beauchamp, M. H. (2020). Social cognition. In *Handbook of clinical neurology* (Vol. 173, pp. 255-264). Elsevier. https://doi.org/10.1016/B978-0-444-64150-2.00022-8

Beazidou, E., Botsoglou, K., & Vlachou, M. (2013). Promoting emotional knowledge: strategies that Greek preschool teachers employ during book reading. *Early Child Development and Care*, *183*(5), 613–626. https://doi.org/10.1080/03004430.2012.678490

Benjamini, Y., & Hochberg, Y. (1995). Controlling the False Discovery Rate - a Practical and Powerful Approach to Multiple Testing. *Journal of the Royal Statistical Society. Series B: Statistical Methodology*, *57*(1), 289-300. https://doi.org/10.1111/j.2517-6161.1995.tb02031.x

Berni, A., Giuliani, A., Tartaglia, F., Tromba, L., Sgueglia, M., Blasi, S., & Russo, G. (2011). Effect of vascular risk factors on increase in carotid and femoral intima-media thickness. Identification

of a risk scale. *Atherosclerosis*, *216*(1), 109–114. https://doi.org/10.1016/j.atherosclerosis.2011.01.034

Bernier, A., McMahon, C. A., & Perrier, R. (2017). Maternal mind-mindedness and children's school readiness: A longitudinal study of developmental processes. *Developmental Psychology, 53*(2), 210–221. https://doi.org/10.1037/dev0000225

Bertenthal, B. I., Boyer, T. W., & Harding, S. (2014). When do infants begin to follow a point?. *Developmental Psychology*, *50*(8), 2036. https://doi.org/10.1037/a0037152

Bianco, F., Lecce, S., & Banerjee, R. (2016). Conversations about mental states and theory of mind development during middle childhood: A training study. *Journal of Experimental Child Psychology*, *149*, 41–61. https://doi.org/10.1016/j.jecp.2015.11.006

Bjornsdottir, R. T., Alaei, R., & Rule, N. O. (2017). The Perceptive Proletarian: Subjective Social Class Predicts Interpersonal Accuracy. *Journal of Nonverbal Behavior*, *41*(2), 185–201. https://doi.org/10.1007/S10919-016-0248-6/

Blair, C., & Raver, C. C. (2016). Poverty, Stress, and Brain Development: New Directions for Prevention and Intervention. In *Academic Pediatrics* (Vol. 16, Issue 3, pp. S30–S36). Elsevier Inc. https://doi.org/10.1016/j.acap.2016.01.010

Blasi, A., Mercure, E., Lloyd-Fox, S., Thomson, A., Brammer, M., Sauter, D., Deeley, Q., Barker, G. J., Renvall, V., Deoni, S., Gasston, D., Williams, S. C. R., Johnson, M. H., Simmons, A., & Murphy, D. G. M. (2011). Early specialization for voice and emotion processing in the infant brain. *Current Biology*, *21*(14), 1220–1224. https://doi.org/10.1016/j.cub.2011.06.009

Bloom, P., & German, T. P. (2000). Two reasons to abandon the false belief task as a test of theory of mind. *Cognition*, *77*(1), B25–B31. https://doi.org/10.1016/S0010-0277(00)00096-2

Boccadoro, S., Cracco, E., Hudson, A. R., Bardi, L., Nijhof, A. D., Wiersema, J. R., Brass, M., & Mueller, S. C. (2019). Defining the neural correlates of spontaneous theory of mind (ToM): An fMRI multi-study investigation. *NeuroImage*, *203*. https://doi.org/10.1016/j.neuroimage.2019.116193

Boeg Thomsen, D., Theakston, A., Kandemirci, B., & Brandt, S. (2021). Do complement clauses really support false-belief reasoning? A longitudinal study with English-speaking 2- to 3-year-olds. *Developmental Psychology*, *57*(8), 1210–1227. https://doi.org/10.1037/dev0001012

Bollen, K. A. (1989). Structural equations with latent variables. *Vol. 210*. John Wiley & Sons.

Bornstein, M. H. (2019). Handbook of Parenting Volume 2.

Bornstein, M. H., & Bradley, R. H. (2014). Socioeconomic status, parenting, and child development. *Socioeconomic Status, Parenting, and Child Development*, 1–287. https://doi.org/10.4324/9781410607027

Bower, T. G. R. (1974). Development in infancy. San Francisco: Freeman Press.

Bowman, L. C., & Brandone, A. C. (2024). Neural correlates of preschoolers' passive-viewing false belief: Insights into continuity and change and the function of right temporoparietal activity in theory of mind development. *Developmental Science*, *27*(6). https://doi.org/10.1111/desc.13530

Bradley, R. H., & Corwyn, R. F. (2002). Socioeconomic status and child development. *Annual Review of Psychology*, *53*, 371–399. 10.1146/annurev.psych.53.100901.135233

Brailsford, J. M., Hill, T. D., Burdette, A. M., & Jorgenson, A. K. (2018). Are socioeconomic inequalities in physical health mediated by embodied environmental toxins?. *Socius*. https://doi.org/10.1177/23780 23118771462

Brandone, A. C., & Wellman, H. (2009). You can't always get what you want: Infants understand failed goal-directed actions. *Psychological Science*, *20*(1), 85–91. https://doi.org/10.1111/j.1467-9280.2008.02246.x

Bretherton, I., & Beeghly, M. (1982). Talking About Internal States: The Acquisition of an Explicit Theory of Mind. In *Developmental Psychology* (Vol. 18, Issue 6). https://doi.org/10.1037/0012-1649.18.6.906

Brezina, T., Tekin, E., & Topalli, V. (2009). "might not be a tomorrow": A multimethods approach to anticipated early death and youth crime. *Criminology*, *47*(4), 1091–1129. https://doi.org/10.1111/J.1745-9125.2009.00170.X

Brooker, R. J., Bates, J. E., Buss, K. A., Canen, M. J., Dennis-Tiwary, T. A., Gatzke-Kopp, L. M., Hoyniak, C., Klein, D. N., Kujawa, A., Lahat, A., Lamm, C., Moser, J. S., Petersen, I. T., Tang, A., Woltering, S., & Schmidt, L. A. (2019). Conducting Event-Related Potential (ERP) Research With Young Children. https://doi.org/10.1027/0269-8803/A000243

Brownell, H., Griffin, R., Winner, E., Friedman, O., & Happé, F. (2000). Cerebral lateralization and theory of mind. *Understanding other minds: Perspectives from developmental cognitive neuroscience, 2*, 306–333. https://doi.org/10.7717/peerj.3929

Bukodi, E., & Goldthorpe, J. H. (2013). Decomposing 'social origins': The effects of parents' class, status, and education on the educational attainment of their children. *European sociological review*, *29*(5), 1024-1039. https://doi.org/10.1093/esr/jcs079

Bulgarelli, D., & Molina, P. (2016). Social Cognition in Preschoolers: Effects of Early Experience and Individual Differences. *Frontiers in Psychology*, *7*. https://doi.org/10.3389/fpsyg.2016.01762

References

Bull, R., Phillips, L. H., & Conway, C. A. (2008). The role of control functions in mentalizing: Dual-task studies of theory of mind and executive function. *Cognition*, *107*(2), 663-672. https://doi.org/10.1016/j.cognition.2007.07.015

Burnel, M., Durrleman, S., Reboul, A., Carré, A., Baciu, M., & Perrone-Bertolotti, M. (2021). Theory-of-mind during childhood: Investigating syntactic and executive contributions. *Social Development*, *30*(1), 73–94. https://doi.org/10.1111/sode.12471

Buttelmann, D. (2017). Calling for careful designs for the evaluation of interactive behavioral measures on early false-belief reasoning. In *Frontiers in Psychology* (Vol. 8, Issue AUG). Frontiers Media S.A. https://doi.org/10.3389/fpsyg.2017.01302

Buttelmann, D., Carpenter, M., & Tomasello, M. (2009). Eighteen-month-old infants show false belief understanding in an active helping paradigm. *Cognition*, *112*(2), 337–342. https://doi.org/10.1016/j.cognition.2009.05.006

Butterfill, S. A., & Apperly, I. A. (2013). How to construct a minimal theory of mind. *Mind and Language*, *28*(5), 606–637. https://doi.org/10.1111/MILA.12036

Butterworth, G., & Jarrett, N. (1991). What minds have in common is space: Spatial mechanisms serving joint visual attention in infancy. *British Journal of Developmental Psychology*, *9*(1), 55–72. https://doi.org/10.1111/j.2044-835x.1991.tb00862.x

Call, J., & Tomasello, M. (2008). Does the chimpanzee have a theory of mind? 30 years later. *Cell.Com*. https://doi.org/10.1016/j.tics.2008.02.010

Callaghan, T., Rochat, P., Lillard, A., Claux, M. L., Odden, H., Itakura, S., Tapanya, S., & Singh, S. (2005). Synchrony in the onset of mental-state reasoning: Evidence from five cultures. *Psychological Science*, *16*(5), 378–384. https://doi.org/10.1111/J.0956-7976.2005.01544.X

Cameron-Faulkner, T., Theakston, A., Lieven, E., & Tomasello, M. (2015). The relationship between infant holdout and gives, and pointing. *Infancy*, *20*(5), 576–586. https://doi.org/10.1111/infa.12085

Camerota, M., Willoughby, M. T., & Blair, C. B. (2019). Speed and accuracy on the hearts and flowers task interact to predict child outcomes. *Psychological Assessment*, *31*(8), 995–1005. https://doi.org/10.1037/pas0000725

Camerota, M., Willoughby, M. T., & Blair, C. B. (2020). Measurement models for studying child executive functioning: Questioning the status quo. *Developmental Psychology*, *56*(12), 2236–2245. https://doi.org/10.1037/dev0001127

Cannon, E. N., & Woodward, A. L. (2012). Infants generate goal-based action predictions. *Developmental Science*, *15*(2), 292–298. https://doi.org/10.1111/j.1467-7687.2011.01127.x

Carey, S., & Spelke, E. (1996). Science and core knowledge. *Philosophy of science*, *63*(4), 515-533. https://doi.org/10.1086/289971

Carlson, S. M., Claxton, L. J., & Moses, L. J. (2015). The Relation Between Executive Function and Theory of Mind is More Than Skin Deep. *Journal of Cognition and Development*, *16*(1), 186–197. https://doi.org/10.1080/15248372.2013.824883

Carlson, S. M., Mandell, D. J., & Williams, L. (2004). Executive function and theory of mind: Stability and prediction from ages 2 to 3. *Developmental Psychology*, *40*(6), 1105–1122. https://doi.org/10.1037/0012-1649.40.6.1105

Carlson, S. M., & Moses, L. J. (2001). Individual Differences in Inhibitory Control and Children's Theory of Mind. *Child Development*, *72*(4), 1032–1053. https://doi.org/10.1111/1467-8624.00333

Carlson, S. M., Moses, L. J., & Breton, C. (2002). How Specific is the Relation between Executive Function and Theory of Mind? Contributions of Inhibitory Control and Working Memory. *Infant and Child Development*, *11*(2), 73–92. https://doi.org/10.1002/icd.298

Carpenter, M., Nagell, K., Tomasello, M., Butterworth, G., & Moore, C. (1998). Social cognition, joint attention, and communicative competence from 9 to 15 months of age. *Monographs of the society for research in child development*, i-174. https://doi.org/10.2307/1166214

Carruthers, P. (2002). The cognitive functions of language. *Behavioral and brain sciences*, *25*(6), 657-674. https://doi.org/10.1017/S0140525X02000122

Carruthers, P. (2013). Mindreading in infancy. *Wiley Online Library*, *28*(2), 141–172. https://doi.org/10.1111/mila.12014

Carruthers, P. (2016). Two Systems for Mindreading? *Review of Philosophy and Psychology*, *7*(1), 141–162. https://doi.org/10.1007/s13164-015-0259-y

Carruthers, P., & Smith, P. K. (Eds.). (1996). *Theories of theories of mind*. Cambridge university press.

Chang, R., Li, C., Wei, M., Jiang, Y., Health, J. Z.-B. P., & 2024, undefined. (2024). Roles of caregiver-child interaction on the association of socioeconomic status with early childhood development: a population-based study in rural China. *Springer*, *24*(1). https://doi.org/10.1186/s12889-024-18803-4

Chasiotis, A., Kiessling, F., Campos, D., & Hofer, J. (2006). Theory of mind and inhibitory control in three cultures: Conflict inhibition predicts false belief understanding in Germany, Costa Rica and Cameroon. *International Journal of Behavioral Development*, *30*(3), 249–260. https://doi.org/10.1177/0165025406066759

References

Cheema, S., Augustin, C., Göttlich, M., Krämer, U. M., & Beyer, F. (2024). Fragile Mentalizing: Lack of Behavioral and Neural Markers of Social Cognition in an Established Social Perspective Taking Task when Combined with Stress Induction. *ENeuro*, *11*(11). https://doi.org/10.1523/ENEURO.0084-24.2024

Christensen, R. (2010). ordinal: Regression Models for Ordinal Data. In *CRAN: Contributed Packages*. https://doi.org/10.32614/CRAN.package.ordinal

Christensen, R. H. B. (2018). Cumulative link models for ordinal regression with the R package ordinal. *Submitted in J. Stat. Software*, *35*, 1-46. http://cran.uni-muenster.de/web/packages/ordinal/vignettes/clm_article.pdf

Chung, K. K. H., Lam, C. B., & Cheung, K. C. (2018). Visuomotor integration and executive functioning are uniquely linked to Chinese word reading and writing in kindergarten children. *Reading and Writing*, *31*(1), 155–171. https://doi.org/10.1007/s11145-017-9779-4

Clements, W. A., & Perner, J. (1994). Implicit Understanding of Belief. In *Cognitive Development* (Vol. 9). https://doi.org/10.1016/0885-2014(94)90012-4

Cohen, S., Doyle, W. J., & Baum, A. (2006). Socioeconomic status is associated with stress hormones. *Psychosomatic Medicine*, *68*(3), 414–420. https://doi.org/10.1097/01.PSY.0000221236.37158.B9

Cole, K., & Mitchell, P. (1998). Family Background in Relation to Deceptive Ability and Understanding of the Mind. *Social Development*, *7*(2), 181–197. https://doi.org/10.1111/1467-9507.00061

Collins S. E. (2016). Associations Between Socioeconomic Factors and Alcohol Outcomes. *Alcohol research : current reviews*, *38*(1), 83–94. https://doi.org/10.35946/arcr.v38.1.11

Conger, R. D., & Donnellan, M. B. (2007). An interactionist perspective on the socioeconomic context of human development. *Annual Review of Psychology*, *58*, 175–199. https://doi.org/10.1146/ANNUREV.PSYCH.58.110405.085551

Cragg, L., & Nation, K. (2008). Go or no-go? Developmental improvements in the efficiency of response inhibition in mid-childhood. *Developmental Science*, *11*(6), 819–827. https://doi.org/10.1111/J.1467-7687.2008.00730.X

Cutting, A. L., & Dunn, J. (1999). Theory of Mind, emotion understanding, language, and family background: Individual differences and interrelations. *Child Development*, *70*(4), 853–865. https://doi.org/10.1111/1467-8624.00061

Cutting, A. L., & Dunn, J. (2006). Conversations with siblings and with friends: Links between relationship quality and social understanding. *British Journal of Developmental Psychology*, *24*(1), 73–87. https://doi.org/10.1348/026151005X70337

D'Angiulli, A., Weinberg, J., Grunau, R., Hertzman, C., & Grebenkov, P. (2008). Towards a cognitive science of social inequality: children's attention-related ERPs and salivary cortisol vary with their socioeconomic status. In *Proceedings of the 30th Cognitive Science Society Annual Meeting* (pp. 211-216). Wahington, DC: Cognitive Science Society.

Davidson, M. C., Amso, D., Anderson, L. C., & Diamond, A. (2006). Development of cognitive control and executive functions from 4 to 13 years: Evidence from manipulations of memory, inhibition, and task switching. *Neuropsychologia*, *44*(11), 2037–2078. https://doi.org/10.1016/j.neuropsychologia.2006.02.006

Davis-Kean, P. E. (2005). The influence of parent education and family income on child achievement: The indirect role of parental expectations and the home environment. *Journal of Family Psychology*, *19*(2), 294–304. https://doi.org/10.1037/0893-3200.19.2.294

De Bruin, L. C., & Newen, A. (2014). The developmental paradox of false belief understanding: a dual-system solution. *Synthese*, *191*(3), 297–320. https://doi.org/10.1007/S11229-012-0127-6

de Carvalho, A., Bijeljac-Babic, R., Picaud, A., Golinkoff, R., de Villiers, J., Hirsh-Pasek, K., Iglesias, A., Christophe, A., Granjon, L., Huet, V., & Nazzi, T. (n.d.). Introducing the TICOALA: a computerized and interactive language assessment for French learning preschoolers.

de Mestral, C., & Stringhini, S. (2017). Socioeconomic Status and Cardiovascular Disease: an Update. *Current Cardiology Reports*, *19*(11). https://doi.org/10.1007/S11886-017-0917-Z

De Rosnay, M., Fink, E., Begeer, S., Slaughter, V., & Peterson, C. (2014). Talking theory of mind talk: Young school-aged children's everyday conversation and understanding of mind and emotion. *Journal of Child Language*, *41*(5), 1179–1193. https://doi.org/10.1017/S0305000913000433

de Villiers, J. G., & de Villiers, P. (2025). The contributions of language and inhibitory control to false belief reasoning over time. *Frontiers in Psychology*, *15*. https://doi.org/10.3389/fpsyg.2024.1455941

de Villiers, J. G., & de Villiers, P. A. (2009). Complements Enable Representation of the Contents of False Beliefs: The Evolution of a Theory of Theory of Mind. *Language Acquisition*, 169–195. https://doi.org/10.1057/9780230240780_8

De Villiers, J. G., & De Villiers, P. A. (2014). The role of language in theory of mind development. *Topics in Language Disorders*, *34*(4), 313–328. https://doi.org/10.1097/

De Villiers, J. G., & Pyers, J. E. (2002). Complements to cognition: A longitudinal study of the relationship between complex syntax and false-belief-understanding. *Cognitive development*, *17*(1), 1037-1060. https://www.sciencedirect.com/science/article/pii/S0885201402000734

References

Delès R. (2022). Educational inequalities in France: A survey on parenting practices during the first COVID-19 lockdown. *Revue internationale de pedagogie*, *68*(4), 539–549. https://doi.org/10.1007/s11159-022-09965-7

DeLoache, J. S., Pickard, M. B., & LoBue, V. (2011). How very young children think about animals. In P. McCardle, S. McCune, J. A. Griffin, & V. Maholmes (Eds.), *How animals affect us: Examining the influences of human–animal interaction on child development and human health* (pp. 85–99). American Psychological Association. https://doi.org/10.1037/12301-004

Demanet, J., & van Houtte, M. (2012). School Belonging and School Misconduct: The Differing Role of Teacher and Peer Attachment. *Journal of Youth and Adolescence*, *41*(4), 499–514. https://doi.org/10.1007/s10964-011-9674-2

Dennett, D. C. (1979). *Brainstorms Series: Philosophical Essays on Mind and Psychology.* Harvester Press.

D'Entremont, B., Hains, S. M., & Muir, D. W. (1997). A demonstration of gaze following in 3-to 6-month-olds. *Infant Behavior and Development*, *20*(4), 569-572. https://doi.org/10.1016/S0163-6383(97)90048-5

Deschrijver, E., Bardi, L., Wiersema, J. R., & Brass, M. (2016). Behavioral measures of implicit theory of mind in adults with high functioning autism. *Cognitive Neuroscience*, *7*(1–4), 192–202. https://doi.org/10.1080/17588928.2015.1085375

Desgranges, B., Laisney, M., Bon, L., Duval, C., Mondou, A., Bejanin, A., ... & Muckle, G. (2012). TOM-15: Une épreuve de fausses croyances pour évaluer la théorie de l'esprit cognitive. *Revue de neuropsychologie*, *4*(3), 216-220. https://doi.org/10.1684/nrp.2012.0232

Deveney, C. M., Chen, S. H., Wilmer, J. B., Zhao, V., Schmidt, H. B., & Germine, L. (2018). How generalizable is the inverse relationship between social class and emotion perception? *PLoS ONE*, *13*(10). https://doi.org/10.1371/JOURNAL.PONE.0205949

Devine, R. T., & Apperly, I. A. (2022). Willing and able? Theory of mind, social motivation, and social competence in middle childhood and early adolescence. *Developmental Science*, *25*(1). https://doi.org/10.1111/desc.13137

Devine, R. T., & Hughes, C. (2014). Relations between false belief understanding and executive function in early childhood: A meta-analysis. *Child Development*, *85*(5), 1777–1794. https://doi.org/10.1111/CDEV.12237

Devine, R. T., & Hughes, C. (2018). Family Correlates of False Belief Understanding in Early Childhood: A Meta-Analysis. *Child Development*, *89*(3), 971–987. https://doi.org/10.1111/cdev.12682

Devine, R. T., White, N., Ensor, R., & Hughes, C. (2016). Theory of mind in middle childhood: Longitudinal associations with executive function and social competence. *Developmental Psychology*, *52*(5), 758–771. https://doi.org/10.1037/dev0000105

Diamond, A. (2013). Executive functions. In *Annual Review of Psychology* (Vol. 64, pp. 135–168). Annual Reviews Inc. https://doi.org/10.1146/annurev-psych-113011-143750

Dietze, P., & Knowles, E. D. (2021). Social Class Predicts Emotion Perception and Perspective-Taking Performance in Adults. *Personality and Social Psychology Bulletin*, *47*(1), 42–56. https://doi.org/10.1177/0146167220914116

Dilworth-Bart, J. E., Khurshid, A., & Vandell, D. L. (2007). Do maternal stress and home environment mediate the relation between early income-to-need and 54-months attentional abilities? *Infant and Child Development*, *16*(5), 525–552. https://doi.org/10.1002/ICD.528

Dixson, H. G. W., Komugabe-Dixson, A. F., Dixson, B. J., & Low, J. (2018). Scaling Theory of Mind in a Small-Scale Society: A Case Study From Vanuatu. *Child Development*, *89*(6), 2157–2175. https://doi.org/10.1111/cdev.12919

Doebel, S., & Zelazo, P. D. (2016). Seeing conflict and engaging control: Experience with contrastive language benefits executive function in preschoolers. *Cognition*, *157*, 219–226. https://doi.org/10.1016/j.cognition.2016.09.010

Doenyas, C., Yavuz, H. M., & Selcuk, B. (2018). Not just a sum of its parts: How tasks of the theory of mind scale relate to executive function across time. *Journal of Experimental Child Psychology*, *166*, 485–501. https://doi.org/10.1016/j.jecp.2017.09.014

Doyle, L., Cimpian, A., Goupil, L., National, S. G.-P. of the, & 2025, undefined. (2025). Preschool teachers provide fewer participation opportunities to working-class students than those from more privileged backgrounds. *Pnas.Org*, *122*(36), 2515833122. https://doi.org/10.1073/pnas.2515833122

Dumontheil, I., Apperly, I. A., & Blakemore, S. J. (2010). Online usage of theory of mind continues to develop in late adolescence. *Developmental Science*, *13*(2), 331–338. https://doi.org/10.1111/J.1467-7687.2009.00888.X

Duncan, G. J., & Magnuson, K. (2012). Socioeconomic status and cognitive functioning: Moving from correlation to causation. In *Wiley Interdisciplinary Reviews: Cognitive Science* (Vol. 3, Issue 3, pp. 377–386). https://doi.org/10.1002/wcs.1176

Dunn, J., & Brophy, M. (2005). Communication, Relationships, and Individual Differences in Children's Understanding of Mind. https://psycnet.apa.org/record/2005-12116-003

Dunn, J., Brown, J., Slomkowski, C., Tesla, C., & Youngblade, L. (1991). Young Children's Understanding of Other People's Feelings and Beliefs: Individual Differences and Their

Antecedents. *Child Development*, *62*(6), 1352–1366. https://doi.org/10.1111/J.1467-8624.1991.TB01610.X

Ebert, S. (2020). Theory of mind, language, and reading: Developmental relations from early childhood to early adolescence. *Journal of Experimental Child Psychology*, *191*, 104739. https://doi.org/10.1016/j.jecp.2019.104739

Ebert, S., Lehrl, S., & Weinert, S. (2020). Differential Effects of the Home Language and Literacy Environment on Child Language and Theory of Mind and Their Relation to Socioeconomic Background. *Frontiers in Psychology*, *11*, 555654. https://doi.org/10.3389/fpsyg.2020.555654

Ebert, S., Peterson, C., Slaughter, V., & Weinert, S. (2017). Links among parents' mental state language, family socioeconomic status, and preschoolers' theory of mind development. *Cognitive Development*, *44*, 32–48. https://doi.org/10.1016/j.cogdev.2017.08.005

Eggebrecht, A. T., Elison, J. T., Feczko, E., Todorov, A., Wolff, J. J., Kandala, S., Adams, C. M., Snyder, A. Z., Lewis, J. D., Estes, A. M., Zwaigenbaum, L., Botteron, K. N., McKinstry, R. C., Constantino, J. N., Evans, A., Hazlett, H. C., Dager, S., Paterson, S. J., Schultz, R. T., … Pruett, J. R. (2017). Joint Attention and Brain Functional Connectivity in Infants and Toddlers. *Cerebral Cortex*, *27*, 1709–1720. https://doi.org/10.1093/cercor/bhw403

Eime, R. M., Harvey, J. T., Craike, M. J., Symons, C. M., & Payne, W. R. (2013). Family support and ease of access link socio-economic status and sports club membership in adolescent girls: A mediation study. *International Journal of Behavioral Nutrition and Physical Activity*, *10*. https://doi.org/10.1186/1479-5868-10-50

Eisenberger, N. I., Lieberman, M. D., & Williams, K. D. (2003). Does Rejection Hurt? An fMRI Study of Social Exclusion. In *New Series* (Vol. 302, Issue 5643). https://doi.org/10.1126/science.1089134

El Kaddouri, R. (2020). *Me, myself and others: representations of self and other in children with autism spectrum disorder*. [Doctoral dissertation, Ghent University]

El Kaddouri, R., Bardi, L., De Bremaeker, D., Brass, M., & Wiersema, J. R. (2020). Measuring spontaneous mentalizing with a ball detection task: putting the attention-check hypothesis by Phillips and colleagues (2015) to the test. *Psychological Research*, *84*(6), 1749–1757. https://doi.org/10.1007/s00426-019-01181-7

Ellsworth, P. C., Carlsmith, J. M., & Henson, A. (1972). The stare as a stimulus to flight in human subjects: a series of field experiments. *Journal of personality and social psychology*, *21*(3), 302. https://doi.org/10.1037/h0032323

Enders, C. K. (2001). The performance of the full information maximum likelihood estimator in multiple regression models with missing data. Educational and Psychological Measurement, 61(5), 713-740. https://doi.org/10.1177/001316440161500

Ensminger, M. E., & Fothergill, K. E. (2014). A decade of measuring SES: What it tells us and where to go from here. In *Socioeconomic status, parenting, and child development* (pp. 13-27). Routledge.

Erikson, R. (1984). Social class of men, women and families. *Sociology*, *18*(4), 500–514. https://doi.org/10.1177/0038038584018004003

Evans, G. W., & Kantrowitz, E. (2002). Socioeconomic status and health: the potential role of environmental risk exposure. *Annual review of public health*, *23*(1), 303-331. https://doi.org/10.1146/annurev.publhealth.23.112001.112349

Farah, M. J. (2017). The Neuroscience of Socioeconomic Status: Correlates, Causes, and Consequences. In *Neuron* (Vol. 96, Issue 1, pp. 56–71). Cell Press. https://doi.org/10.1016/j.neuron.2017.08.034

Farhadian, M., Abdullah, R., Mansor, M., Redzuan, M., & Kumar, V. (2010). Parental Demographics and Preschool Children's Theory of Mind. *Journal of Human Ecology*, *29*(2), 121–128. https://doi.org/10.1080/09709274.2010.11906254

Farran, E. K., Purser, H. R. M., Jarrold, C., Thomas, M. S. C., Scerif, G., Stojanovik, V., & Van Herwegen, J. (2024). Cross-sectional and longitudinal assessment of cognitive development in Williams syndrome. *Developmental Science*, *27*(1). https://doi.org/10.1111/desc.13421

Farrant, B. M., Maybery, M. T., & Fletcher, J. (2012). Language, cognitive flexibility, and explicit false belief understanding: Longitudinal analysis in typical development and specific language impairment. *Child Development*, *83*(1), 223–235. https://doi.org/10.1111/j.1467-8624.2011.01681.x

Feinman, S. (1982). Social referencing in infancy. *Merrill-Palmer Quarterly (1982-)*, 445-470.

Fendinger, N. J., Dietze, P., & Knowles, E. D. (2023). Beyond cognitive deficits: how social class shapes social cognition. *Trends in Cognitive Sciences*, *27*(6), 528-538. https://doi.org/10.1016/j.tics.2023.03.004

Feola, B., Dougherty, L. R., Riggins, T., & Bolger, D. J. (2020). Prefrontal cortical thickness mediates the association between cortisol reactivity and executive function in childhood. Neuropsychologia, 148, 107636. https://doi.org/10.1016/j.neuropsychologia.2020.107636

Ferjan Ramírez, N., Lytle, S. R., & Kuhl, P. K. (2020). Parent coaching increases conversational turns and advances infant language development. *Proceedings of the National Academy of*

Sciences of the United States of America, *117*(7), 3484–3491. https://doi.org/10.1073/pnas.1921653117

Fernald, A., Marchman, V. A., & Weisleder, A. (2013). SES differences in language processing skill and vocabulary are evident at 18 months. *Developmental Science*, *16*(2), 234–248. https://doi.org/10.1111/desc.12019

Fernández, C. (2013). Mindful storytellers: Emerging pragmatics and theory of mind development. *First Language*, *33*(1), 20–46. https://doi.org/10.1177/0142723711422633

Ferrari, D. (2019). Occupar package.

Figueroa, M. (2024). Language development, linguistic input, and linguistic racism. *Wiley Interdisciplinary Reviews: Cognitive Science*, *15*(3). https://doi.org/10.1002/wcs.1673

Fisher, N., Happé, F., & Dunn, J. (2005). The relationship between vocabulary, grammar, and false belief task performance in children with autistic spectrum disorders and children with moderate learning difficulties. *Journal of Child Psychology and Psychiatry and Allied Disciplines*, *46*(4), 409–419. https://doi.org/10.1111/J.1469-7610.2004.00371.X

Flavell, J. H., Flavell, E. R., Green, F. L., & Wilcox, S. A. (1981). The Development of Three Spatial Perspective-Taking Rules. Child Development, 52(1), 356–358. https://doi.org/10.2307/1129250

Flobbe, L., Verbrugge, R., Hendriks, P., Krämer, I., Flobbe, L., Verbrugge, R., Hendriks, P., & Krämer, I. (2008). Learning to apply theory of mind. *Springer*, *17*(4), 417–442. https://doi.org/10.1007/s10849-008-9064-7

Flynn, E. (2007). The role of inhibitory control in false belief understanding. *Infant and Child Development*, *16*(1), 53–69. https://doi.org/10.1002/icd.500

Fodor, J. A. (1975). *The language of thought* (Vol. 5). Harvard university press.

Fodor, J. A. (1983). The modularity of mind. MIT press.

Fogd, D., Sebanz, N., & Kovács, Á. M. (2024). Flexible social monitoring as revealed by eye movements: Spontaneous mental state updating triggered by others' unexpected actions. *Cognition*, *249*, 105812. https://doi.org/10.1016/J.COGNITION.2024.105812

Fogd, D., Téglás, E., & Kovács, Á. M. (2025). Adults Represent Others' Logical Inferences Even When It Is Unnecessary. *Cognitive Science*, *49*(6). https://doi.org/10.1111/cogs.70076

Foote, R. C., & Holmes-Lonergan, H. A. (2003). Sibling conflict and theory of mind. *British Journal of Developmental Psychology*, *21*(1), 45–58. https://doi.org/10.1348/026151003321164618

Fox, J., Weisberg, S., & Price, B. (2001). car: Companion to Applied Regression. In *CRAN: Contributed Packages*. https://doi.org/10.32614/CRAN.package.car

Frankenhuis, W. E., & de Weerth, C. (2013). Does Early-Life Exposure to Stress Shape or Impair Cognition? *Current Directions in Psychological Science*, *22*(5), 407–412. https://doi.org/10.1177/0963721413484324

Frick, A., & Baumeler, D. (2017). The relation between spatial perspective taking and inhibitory control in 6-year-old children. *Psychological Research*, *81*(4), 730–739. https://doi.org/10.1007/s00426-016-0785-y

Friedman, N. P., & Robbins, T. W. (2022). The role of prefrontal cortex in cognitive control and executive function. In *Neuropsychopharmacology* (Vol. 47, Issue 1, pp. 72–89). Springer Nature. https://doi.org/10.1038/s41386-021-01132-0

Frischen, A., Bayliss, A. P., & Tipper, S. P. (2007). Gaze Cueing of Attention: Visual Attention, Social Cognition, and Individual Differences. *Psychological Bulletin*, *133*(4), 694–724. https://doi.org/10.1037/0033-2909.133.4.694

Frith, C., & Frith, U. (2003). Development and neurophysiology of mentalizing. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *358*(1431), 459–473. https://doi.org/10.1098/RSTB.2002.1218

Frith, C., & Frith, U. (2007). Social Cognition in Humans. In *Current Biology* (Vol. 17, Issue 16). https://doi.org/10.1016/j.cub.2007.05.068

Frith, C., & Frith, U. (2008). Implicit and Explicit Processes in Social Cognition. In *Neuron* (Vol. 60, Issue 3, pp. 503–510). https://doi.org/10.1016/j.neuron.2008.10.032

Frye, D., Zelazo, P., & Palfai, T. (1995). Theory of mind and rule-based reasoning. *Elsevier*. https://www.sciencedirect.com/science/article/pii/0885201495900241

Fu, I. N., Chen, K. L., Liu, M. R., Jiang, D. R., Hsieh, C. L., & Lee, S. C. (2023). A systematic review of measures of theory of mind for children. In *Developmental Review* (Vol. 67). Elsevier Inc. https://doi.org/10.1016/j.dr.2022.101061

Furlanetto, T., Becchio, C., Samson, D., & Apperly, I. (2016). Altercentric interference in level 1 visual perspective taking reflects the ascription of mental states, not submentalizing. *Journal of Experimental Psychology: Human Perception and Performance*, *42*(2), 158–163. https://doi.org/10.1037/xhp0000138

Galbraith, S., Bowden, J., & Mander, A. (2017). Accelerated longitudinal designs: An overview of modelling, power, costs and handling missing data. *Statistical Methods in Medical Research*, *26*(1), 374–398. https://doi.org/10.1177/0962280214547150

Galende, N., de Migúl, M. Ś., & Arranz, E. (2012). The role of parents' distancing strategies in the development of five-year-old children's Theory of Mind. *Early Child Development and Care*, *182*(2), 207–220. https://doi.org/10.1080/03004430.2011.553676

Gallese, V. (2005). Embodied simulation: From neurons to phenomenal experience. *Phenomenology and the Cognitive Sciences*, *4*(1), 23–48. https://doi.org/10.1007/S11097-005-4737-Z

Gallese, V., & Sinigaglia, C. (2011). What is so special about embodied simulation?. *Trends in cognitive sciences*, *15*(11), 512-519. https://doi.org/10.1016/j.tics.2011.09.003

Ganglmayer, K., Attig, M., Daum, M. M., & Paulus, M. (2019). Infants' perception of goal-directed actions: A multi-lab replication reveals that infants anticipate paths and not goals. *Infant Behavior and Development*, *57*. https://doi.org/10.1016/J.INFBEH.2019.101340

Ganzeboom, H. B. G. (2010). A new international socio-economic index (ISEI) of occupational status for the International Standard Classification of Occupation 2008 (ISCO-08) constructed with data from the ISSP 2002–2007 *In ISSP Research Session, 2010*

Ganzeboom, H. B. G., De Graaf, P. M., & Treiman, D. J. (1992). A standard international socio-economic index of occupational status. *Social Science Research*, *21*(1), 1–56. https://doi.org/10.1016/0049-089X(92)90017-B

Gao, Q., Huang, Q., Zhang, Q., & Chen, W. (2020). Does executive function influence the development of theory of mind in elementary students? *Current Psychology*, *39*(2), 389–396. https://doi.org/10.1007/S12144-018-0107-1

Gao, W., Alcauter, S., Smith, J. K., Gilmore, J. H., & Lin, W. (2015). Development of human brain cortical network architecture during infancy. *Brain Structure and Function*, *220*(2), 1173–1186. https://doi.org/10.1007/s00429-014-0710-3

Garavan, T., Wang, J., Matthews-Smith, G., Nagarathnam, B., & Lai, Y. (2018). Advancing national human resource development research: suggestions for multilevel investigations. *Human Resource Development International*, *21*(4), 288–318. https://doi.org/10.1080/13678868.2018.1429171

Garcini, L. M., Arredondo, M. M., Berry, O., Church, J. A., Fryberg, S., Thomason, M. E., & McLaughlin, K. A. (2022). Increasing diversity in developmental cognitive neuroscience: A roadmap for increasing representation in pediatric neuroimaging research. *Developmental Cognitive Neuroscience*, *58*, 101167. https://doi.org/10.1016/j.dcn.2022.101167

Gergely, G., Nádasdy, Z., Csibra, G., & Bíró, S. (1995). Taking the intentional stance at 12 months of age. *Cognition*, *56*(2), 165-193. https://doi.org/10.1016/0010-0277(95)00661-H

Giorgio, J., Tanna, A., Jagust, W. J., Baker, S. L., Landau, S. M., Tanaka, T., Chen, C. P., Reilhac, A., Malpetti, M., Rowe, J. B., O'Brien, J. T., & Kourtzi, Z. (2020). A cross-cohort cognitive composite for tracking changes in pre-clinical and prodromal Alzheimer's disease. *Alzheimer's & Dementia*, *16*(S6). https://doi.org/10.1002/alz.037928

Gökçen, E., Frederickson, N., and, K. P.-J. of autism, & 2016, undefined. (2016). Theory of mind and executive control deficits in typically developing adults and adolescents with high levels of autism traits. *Springer*, *46*(6), 2072–2087. https://doi.org/10.1007/s10803-016-2735-3

Gold, K. I., Kopelman-Rubin, D., Mufson, L., & Klomek, A. B. (2021). I Can Succeed for Preschools: A Randomized Control Trial of a New Social-emotional Learning Program. *Early Education and Development*, *32*(3), 343–359. https://doi.org/10.1080/10409289.2020.1755777

Golec-Staśkiewicz, K., Wojciechowski, J., Haman, M., Wolak, T., Wysocka, J., & Pluta, A. (2024). Unveiling the neural dynamics of the theory of mind: a fMRI study on belief processing phases. *Social Cognitive and Affective Neuroscience*, *19*(1). https://doi.org/10.1093/scan/nsae095

Golinkoff, R. M., De Villiers, J. G., Hirsh-Pasek, K., Iglesias, A., Wilson, M. S., Morini, G., & Brezack, N. (2017). *User's manual for the Quick Interactive Language Screener (QUILS): A measure of vocabulary, syntax, and language acquisition skills in young children*. Paul H. Brookes Publishing Company.

Gooch, D., Thompson, P., Nash, H. M., Snowling, M. J., & Hulme, C. (2016). The development of executive function and language skills in the early school years. *Journal of Child Psychology and Psychiatry and Allied Disciplines*, *57*(2), 180–187. https://doi.org/10.1111/jcpp.12458

Gopnik A. (2010). How babies think. *Scientific American*, *303*(1), 76–81. https://doi.org/10.1038/scientificamerican0710-76

Gopnik, A., & Meltzoff, A. N. (1997). *Words, thoughts, and theories*. Mit Press.

Gopnik, A., & Wellman, H. M. (1992). Why the child's theory of mind really *is* a theory. *Mind & Language, 7*(1-2), 145–171. https://doi.org/10.1111/j.1468-0017.1992.tb00202.x

Goudeau, S., Sanrey, C., Autin, F., Stephens, N. M., Markus, H. R., Croizet, J. C., & Cimpian, A. (2023). Unequal opportunities from the start: Socioeconomic disparities in classroom participation in preschool. Journal of Experimental Psychology: General, 152(11), 3135. https://doi.org/10.1037/xge0001437

Grainger, S. A., Henry, J. D., Naughtin, C. K., Comino, M. S., & Dux, P. E. (2018). Implicit false belief tracking is preserved in late adulthood. *Quarterly Journal of Experimental Psychology*, *71*(9), 1980–1987. https://doi.org/10.1177/1747021817734690

Grosse Wiesmann, C., Friederici, A. D., Disla, D., Steinbeis, N., & Singer, T. (2018). Longitudinal evidence for 4-year-olds' but not 2- and 3-year-olds' false belief-related action anticipation. *Cognitive Development*, *46*, 58–68. https://doi.org/10.1016/j.cogdev.2017.08.007

Grosse Wiesmann, C., Friederici, A. D., Singer, T., & Steinbeis, N. (2017). Implicit and explicit false belief development in preschool children. *Developmental Science*, *20*(5). https://doi.org/10.1111/desc.12445

References

Grosse Wiesmann, C., Friederici, A. D., Singer, T., & Steinbeis, N. (2020). Two systems for thinking about others' thoughts in the developing brain. *Proceedings of the National Academy of Sciences of the United States of America*, *117*(12), 6928–6935. https://doi.org/10.1073/pnas.1916725117

Grosse Wiesmann, C., Schreiber, J., Singer, T., Steinbeis, N., & Friederici, A. D. (2017). White matter maturation is associated with the emergence of Theory of Mind in early childhood. *Nature Communications*, *8*. https://doi.org/10.1038/ncomms14692

Grossmann, T. (2010). The development of emotion perception in face and voice during infancy. In *Restorative Neurology and Neuroscience* (Vol. 28, Issue 2, pp. 219–236). https://doi.org/10.3233/RNN-2010-0499

Guajardo, N. R., & Watson, A. C. (2002). Narrative discourse and theory of mind development. *Journal of Genetic Psychology*, *163*(3), 305–325. https://doi.org/10.1080/00221320209598686

Gweon, H., Dodell-Feder, D., Bedny, M., & Saxe, R. (2012). Theory of Mind Performance in Children Correlates With Functional Specialization of a Brain Region for Thinking About Thoughts. *Child Development*, *83*(6), 1853–1868. https://doi.org/10.1111/J.1467-8624.2012.01829.X

Hackman, D. A., & Farah, M. J. (2009). Socioeconomic status and the developing brain. In *Trends in Cognitive Sciences* (Vol. 13, Issue 2, pp. 65–73). https://doi.org/10.1016/j.tics.2008.11.003

Hackman, D. A., Farah, M. J., & Meaney, M. J. (2010). Socioeconomic status and the brain: Mechanistic insights from human and animal research. In *Nature Reviews Neuroscience* (Vol. 11, Issue 9, pp. 651–659). https://doi.org/10.1038/nrn2897

Hackman, D. A., Gallop, R., Evans, G. W., & Farah, M. J. (2015). Socioeconomic status and executive function: Developmental trajectories and mediation. *Developmental Science*, *18*(5), 686–702. https://doi.org/10.1111/DESC.12246

Haft, S. L., & Hoeft, F. (2017). Poverty's Impact on Children's Executive Functions: Global Considerations. *New Directions for Child and Adolescent Development*, *2017*(158), 69–79. https://doi.org/10.1002/cad.20220

Hagerty, B. M., Lynch-Sauer, J., Patusky, K. L., Bouwsema, M., & Collier, P. (1992). Sense of belonging: a vital mental health concept. *Archives of psychiatric nursing*, *6*(3), 172–177. https://doi.org/10.1016/0883-9417(92)90028-h

Hale, C. M., & Tager-Flusberg, H. (2003). The influence of language on theory of mind: A training study. *Developmental Science*, *6*(3), 346–359. https://doi.org/10.1111/1467-7687.00289

Hamilton. (2016). Gazing at me: The importance of social meaning in understanding direct-gaze cues. In *Philosophical Transactions of the Royal Society B: Biological Sciences* (Vol. 371, Issue 1686). Royal Society of London. https://doi.org/10.1098/rstb.2015.0080

Hammers, D. B., Bothra, S., Polsinelli, A., Apostolova, L. G., & Duff, K. (2024). Evaluating Practice Effects Across Learning Trials – Ceiling Effects, or Something More? *Journal of Clinical and Experimental Neuropsychology*, *46*(7), 630. https://doi.org/10.1080/13803395.2024.2400107

Happé, F. (2005). *Autism: An introduction to psychological theory*. Psychology Press.

Harding, J. F., Morris, P. A., & Hughes, D. (2015). The Relationship Between Maternal Education and Children's Academic Outcomes: A Theoretical Framework. *Journal of Marriage and Family*, *77*(1), 60–76. https://doi.org/10.1111/jomf.12156

Harris, P. L. (2005). Conversation, Pretense, and Theory of Mind. In J. W. Astington & J. A. Baird (Eds.), *Why language matters for theory of mind* (pp. 70–83). Oxford University Press. https://doi.org/10.1093/acprof:oso/9780195159912.003.0004

Harris, P. L., Johnson, C. N., Hutton, D., Andrews, G., & Cooke, T. (1989). Young Children's Theory of Mind and Emotion. *Cognition and Emotion*, *3*(4), 379–400. https://doi.org/10.1080/02699938908412713

Harris, P. L., Koenig, M. A., Corriveau, K. H., & Jaswal, V. K. (2018). Cognitive foundations of learning from testimony. *Annual Review of Psychology*, *69*(1), 251-273. https://doi.org/10.1146/annurev-psych-122216-011710

Hart, B., & Risley, T. R. (1995). Meaningful differences in the everyday life of

America's children. Baltimore, MD: Paul Brookes.Harwell, M., Maeda, Y., Bishop, K., & Xie, A. (2017). The Surprisingly Modest Relationship Between SES and Educational Achievement. *Journal of Experimental Education*, *85*(2), 197–214. https://doi.org/10.1080/00220973.2015.1123668

Haslam, S. A., Jetten, J., Postmes, T., & Haslam, C. (2009). Social identity, health and well-being: An emerging agenda for applied psychology. *Applied Psychology*, *58*(1), 1–23. https://doi.org/10.1111/j.1464-0597.2008.00379.x

Hatcher, A., & Page, J. (2020). Parent-Implemented Language Intervention for Teaching Enhanced Milieu Teaching Strategies to Parents of Low-Socioeconomic Status. *Journal of Early Intervention*, *42*(2), 122–142. https://doi.org/10.1177/1053815119873085

Hatløy, A., Hallund, J., Diarra, M. M., & Oshaug, A. (2000). Food variety, socioeconomic status and nutritional status in urban and rural areas in Koutiala (Mali). *Public Health Nutrition*, *3*(1), 57–65. https://doi.org/10.1017/S1368980000000628

Hawkley, L. C., & Capitanio, J. P. (2015). Perceived social isolation, evolutionary fitness and health outcomes: a lifespan approach. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *370*(1669). https://doi.org/10.1098/RSTB.2014.0114

Hayashi, S., Wada, H., Kim, S. P., Motomura, Y., Higuchi, S., & Kim, Y. K. (2018). Enhanced Nogo-P3 amplitudes of mothers compared with non-mother women during an emotional Go/Nogo task. *Journal of Physiological Anthropology*, *37*(1), 1–8. https://doi.org/10.1186/s40101-018-0167-9

Hayes, A. F. (2015). An Index and Test of Linear Moderated Mediation. *Multivariate Behavioral Research*, *50*(1), 1–22. https://doi.org/10.1080/00273171.2014.962683

Hayes, A. F. (2022). *Introduction to Mediation, Moderation, and Conditional Process Analysis: A Regression-Based Approach.: Vol. 3*. The Guilford Press.

Hayward, E. O., & Homer, B. D. (2017). Reliability and validity of advanced theory-of-mind measures in middle childhood and adolescence. *The British journal of developmental psychology*, *35*(3), 454–462. https://doi.org/10.1111/bjdp.12186

He, Z., Bolz, M., & Baillargeon, R. (2011). False-belief understanding in 2.5-year-olds: evidence from violation-of-expectation change-of-location and unexpected-contents tasks. *Developmental Science*, *14*(2), 292. https://doi.org/10.1111/J.1467-7687.2010.00980.X

He, Z., Bolz, M., & Baillargeon, R. (2012). 2.5-year-olds succeed at a verbal anticipatory-looking false-belief task. *British Journal of Developmental Psychology*, *30*(1), 14–29. https://doi.org/10.1111/j.2044-835X.2011.02070.x

Heck, K. E., & Parker, J. D. (2002). Family structure, socioeconomic status, and access to health care for children. *Health services research, 37*(1), 173–186. https://doi.org/10.1111/1475-6773.99190

Henning, A., Spinath, F. M., & Aschersleben, G. (2011). The link between preschoolers' executive function and theory of mind and the role of epistemic states. *Journal of Experimental Child Psychology*, *108*(3), 513–531. https://doi.org/10.1016/j.jecp.2010.10.006

Henrich, J., Heine, S. J., & Norenzayan, A. (2010a). Beyond WEIRD: Towards a broad-based behavioral science. *Behavioral and Brain Sciences*, *33*(2–3), 111–135. https://doi.org/10.1017/S0140525X10000725

Henrich, J., Heine, S. J., & Norenzayan, A. (2010b). The weirdest people in the world? *Behavioral and Brain Sciences*, *33*(2–3), 61–83. https://doi.org/10.1017/S0140525X0999152X

Heyes, C. (2014). Submentalizing: I Am Not Really Reading Your Mind. *Perspectives on Psychological Science*, *9*(2), 131–143. https://doi.org/10.1177/1745691613518076

Heymann, S. J., & Earle, A. (2000). Low-Income Parents: How Do Working Conditions Affect Their Opportunity to Help School-Age Children At Risk? *American Educational Research Journal*, *37*(4), 833–848. https://doi.org/10.3102/00028312037004833

Hickok, G. (2014). *The myth of mirror neurons: The real neuroscience of communication and cognition*. WW Norton & Company.

Hoff, E. (2003). The Specificity of Environmental Influence: Socioeconomic Status Affects Early Vocabulary Development Via Maternal Speech. *Child Development*, *74*(5), 1368–1378. https://doi.org/10.1111/1467-8624.00612

Hoff, E. (2014). Causes and consequences of SES-related differences in parent-to-child speech. In *Socioeconomic status, parenting, and child development* (pp. 147-160). Routledge.

Hofferth, S. L., & Wissoker, D. A. (1992). Price, quality, and income in child care choice. *Journal of Human Resources*, 70-111. https://doi.org/10.2307/145913

Hofmann, S. G., Doan, S. N., Sprung, M., Wilson, A., Ebesutani, C., Andrews, L. A., ... & Harris, P. L. (2016). Training children's theory-of-mind: A meta-analysis of controlled studies. *Cognition*, *150*, 200-212. https://doi.org/10.1016/j.cognition.2016.01.006

Hollebrandse, B., van Hout, A., & Hendriks, P. (2014). Children's first and second-order false-belief reasoning in a verbal and a low-verbal task. *Synthese*, *191*(3), 321–333. https://doi.org/10.1007/s11229-012-0169-9

Holt-Lunstad, J., Smith, T. B., Baker, M., Harris, T., & Stephenson, D. (2015). Loneliness and Social Isolation as Risk Factors for Mortality: A Meta-Analytic Review. *Perspectives on Psychological Science*, *10*(2), 227–237. https://doi.org/10.1177/1745691614568352

Hou, X. H., Wang, L. J., Li, M., Qin, Q. Z., Li, Y., & Chen, B. B. (2022). The roles of sibling status and sibling relationship quality on theory of mind among Chinese preschool children. *Personality and Individual Differences*, *185*, 111273. https://doi.org/10.1016/j.paid.2021.111273

Huang, R., Baker, E. R., Battista, C., & Liu, Q. (2022). Executive Function and Theory of Mind in Children Living in Poverty: A Short-term Longitudinal Study. *Journal of Cognition and Development*, *23*(5), 751–775. https://doi.org/10.1080/15248372.2022.2110873

Hudson, A. R., De Coster, L., Spoormans, H., Verbeke, S., Van der Jeught, K., Brass, M., & Mueller, S. C. (2021). Childhood Abuse and Adult Sociocognitive Skills: Distinguishing Between Self and Other Following Early Trauma. *Journal of Interpersonal Violence*, *36*(23–24), NP13254–NP13274. https://doi.org/10.1177/0886260520906190

Hugenberg, K., & Wilson, J. P. (2013). Faces are central to social cognition. *The Oxford handbook of social cognition*, 167-193.

Hughes, C. (1998). Executive function in preschoolers: Links with theory of mind and verbal ability. *British Journal of Developmental Psychology*, *16*(2), 233–253. https://doi.org/10.1111/j.2044-835X.1998.tb00921.x

Hughes, C., Adlam, A., Happé, F., Jackson, J., Taylor, A., & Caspi, A. (2000). Good Test-Retest Reliability for Standard and Advanced False-Belief Tasks across a Wide Range of Abilities. *Journal of Child Psychology and Psychiatry*, *41*(4), 483–490. https://doi.org/10.1111/1469-7610.00633

Hughes, C., Deater-Deckard, K., & Cutting, A. L. (1999). 'Speak roughly to your little boy'? Sex Differences in the Relations Between Parenting and Preschoolers' Understanding of Mind. *Social Development*, *8*(2), 143–160. https://doi.org/10.1111/1467-9507.00088

Hughes, C., & Devine, R. T. (2015). A Social Perspective on Theory of Mind. *Handbook of child psychology and developmental science, socioemotional processes*, *3*, 564.

Hughes, C., & Devine, R. T. (2019). For Better or for Worse? Positive and Negative Parental Influences on Young Children's Executive Function. *Child Development*, *90*(2), 593–609. https://doi.org/10.1111/CDEV.12915

Hughes, C., Devine, R. T., & Wang, Z. (2018). Does Parental Mind-Mindedness Account for Cross-Cultural Differences in Preschoolers' Theory of Mind? *Child Development*, *89*(4), 1296–1310. https://doi.org/10.1111/cdev.12746

Hughes, C., & Dunn, J. (1998). Understanding mind and emotion: Longitudinal associations with mental-state talk between young friends. *Developmental Psychology*, *34*(5), 1026–1037. https://doi.org/10.1037/0012-1649.34.5.1026

Hughes, C., & Ensor, R. (2005). Executive function and theory of mind in 2 year olds: A family affair?. *Developmental neuropsychology*, *28*(2), 645-668. https://doi.org/10.1207/s15326942dn2802_5

Hughes, C., & Ensor, R. (2006). Behavioural problems in 2-year-olds: Links with individual differences in theory of mind, executive function and harsh parenting. *Journal of Child Psychology and Psychiatry and Allied Disciplines*, *47*(5), 488–497. https://doi.org/10.1111/j.1469-7610.2005.01519.x

Hughes, C., & Ensor, R. (2007). Executive Function and Theory of Mind: Predictive Relations From Ages 2 to 4. *Developmental Psychology*, *43*(6), 1447–1459. https://doi.org/10.1037/0012-1649.43.6.1447

Huttenlocher, J., Waterfall, H., Vasilyeva, M., Vevea, J., & Hedges, L. V. (2010). Sources of variability in children's language growth. *Cognitive Psychology*, *61*(4), 343–365. https://doi.org/10.1016/J.COGPSYCH.2010.08.002

Hyde, D. C., Aparicio Betancourt, M., & Simon, C. E. (2015). Human temporal-parietal junction spontaneously tracks others' beliefs: A functional near-infrared spectroscopy study. *Human Brain Mapping*, *36*(12), 4831–4846. https://doi.org/10.1002/hbm.22953

Hyde, D. C., Simon, C. E., Ting, F., & Nikolaeva, J. I. (2018). Functional organization of the temporal–parietal junction for theory of mind in preverbal infants: A near-infrared spectroscopy study. *Journal of Neuroscience*, *38*(18), 4264–4274. https://doi.org/10.1523/JNEUROSCI.0264-17.2018

Iacoboni, M. (2008). Mesial frontal cortex and super mirror neurons. *Behavioral and Brain Sciences*, *31*(1), 30-30. https://doi.org/10.1017/S0140525X07003214

ILO. (2012). International Standard Classification of Occupations 2008 (ISCO-08): Structure, group definitions and correspondence tables.

Jenkins, J. M., & Astington, J. W. (1996). Cognitive factors and family structure associated with theory of mind development in young children. *Developmental psychology*, *32*(1), 70.

Johnson, M. H., Dziurawiec, S., Ellis, H., & Morton, J. (1991). Newborns' preferential tracking of face-like stimuli and its subsequent decline. *Cognition*, *40*(1-2), 1-19. https://doi.org/10.1016/0010-0277(91)90045-6

Jollife, I. T., & Cadima, J. (2016). Principal component analysis: A review and recent developments. In *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences* (Vol. 374, Issue 2065). Royal Society of London. https://doi.org/10.1098/rsta.2015.0202

Joseph, R., & Tager–Flusberg, H. (2004). The relationship of theory of mind and executive functions to symptom type and severity in children with autism. *Development and Psychopathology*, *16*(1), 137–155. https://doi.org/10.1017/S095457940404444X

Kahneman, D. (2011). Thinking, fast and slow. New York, NY: Farrar, Straus and Giroux.

Kaltefleiter, L. J., Schuwerk, T., Grosse Wiesmann, C., Kristen-Antonow, S., Jarvers, I., & Sodian, B. (2022). Evidence for goal- and mixed evidence for false belief-based action prediction in 2- to 4-year-old children: A large-scale longitudinal anticipatory looking replication study. *Developmental Science*, *25*(4). https://doi.org/10.1111/desc.13224

Kaltefleiter, L. J., Sodian, B., Kristen-Antonow, S., Grosse Wiesmann, C., & Schuwerk, T. (2021). Does syntax play a role in Theory of Mind development before the age of 3 years? *Infant Behavior and Development*, *64*, 101575. https://doi.org/10.1016/J.INFBEH.2021.101575

Kampis, D., & Southgate, V. (2020). Altercentric cognition: How others influence our cognitive processing. *Trends in Cognitive Sciences*, *24*(11), 945-959. https://doi.org/10.1016/j.tics.2020.09.003

References

Kara, B., & Selcuk, B. (2023). The Role of Socioeconomic Adversity and Armed Conflict in Executive Function, Theory of Mind and Empathy in Children. *Child Psychiatry and Human Development*, *54*(2), 533–545. https://doi.org/10.1007/s10578-021-01270-y

Kaushanskaya, M., Park, J. S., Gangopadhyay, I., Davidson, M. M., & Weismer, S. E. (2017). The relationship between executive functions and language abilities in children: A latent variables approach. *Journal of Speech, Language, and Hearing Research*, *60*(4), 912–923. https://doi.org/10.1044/2016_JSLHR-L-15-0310

Keller, H., Abels, M., Lamm, B., Yovsi, R. D., Voelker, S., & Lakhani, A. (2005). Ecocultural effects on early infant care: A study in Cameroon, India, and Germany. *Ethos*, *33*(4), 512-541. https://doi.org/10.1525/eth.2005.33.4.512

Kellerman, J., Lewis, J., & Laird, J. D. (1989). Looking and loving: The effects of mutual gaze on feelings of romantic love. *Journal of Research in Personality*, *23*(2), 145–161. https://doi.org/10.1016/0092-6566(89)90020-2

Keysers, C. (2011). *The Empathic Brain: How the discovery of mirror neurons changes our understanding of human nature*. Chicago: Social Brain Press.Khanipour, H., Nezafatbakhsh, S., Aghababaei, N., & Zand, S. (2021). Predicting the theory of mind precursors based on parenting styles and language skills in preschool children. *Iranian Journal of Child Neurology*, *15*(3), 85. https://doi.org/10.22037/ijcn.v15i2.23235

Kim, S. (2015). ppcor: An R Package for a Fast Calculation to Semi-partial Correlation Coefficients. *Communications for Statistical Applications and Methods*, *22*(6), 665–674. https://doi.org/10.5351/CSAM.2015.22.6.665

Király, I., Oláh, K., & Kovács, Á. M. (2023). Can 18-Month-Olds Revise Attributed Beliefs? *Open Mind*, *7*, 435–444. https://doi.org/10.1162/opmi_a_00087

Kirk, E., Pine, K., Wheatley, L., Howlett, N., Schulz, J., & Fletcher, B. (C). (2015). A longitudinal investigation of the relationship between maternal mind-mindedness and theory of mind. *British Journal of Developmental Psychology*, *33*(4), 434–445. https://doi.org/10.1111/bjdp.12104

Kishiyama, M. M., Boyce, W. T., Jimenez, A. M., Perry, L. M., & Knight, R. T. (2009). Socioeconomic Disparities Affect Prefrontal Function in Children. *Journal of Cognitive Neuroscience*, *21*(6), 1106–1115. https://doi.org/10.1162/jocn.2009.21101

Kissgen, R., & Schleiffer, R. (2002). Specificity hypothesis of a theory of mind deficit in early childhood autism. *Zeitschrift fur Kinder-und Jugendpsychiatrie und Psychotherapie*, *30*(1), 29-40. https://doi.org/10.1024//1422-4917.30.1.29

Kivimäki, M., Batty, G. D., Pentti, J., Shipley, M. J., Sipilä, P. N., Nyberg, S. T., ... & Vahtera, J. (2020). Association between socioeconomic status and the development of mental and physical health conditions in adulthood: a multi-cohort study. *The Lancet Public Health*, *5*(3), e140-e149. https://doi.org/10.1016/S2468-2667(19)30248-8

Klein, M., Sosu, E., & Dare, S. (2020). Mapping inequalities in school attendance: The relationship between dimensions of socioeconomic status and forms of school absence. *Elsevier*. https://doi.org/10.1016/j.childyouth.2020.105432

Kloo, D., Kristen-Antonow, S., & Sodian, B. (2020). Progressing from an implicit to an explicit false belief understanding: A matter of executive control? *International Journal of Behavioral Development*, *44*(2), 107–115. https://doi.org/10.1177/0165025419850901

Kloo, D., & Perner, J. (2003). Training Transfer Between Card Sorting and False Belief Understanding: Helping Children Apply Conflicting Descriptions. *Child Development*, *74*(6), 1823–1839. https://doi.org/10.1046/J.1467-8624.2003.00640.X

Knudsen, B., & Liszkowski, U. (2012). 18-Month-Olds Predict Specific Action Mistakes Through Attribution of False Belief, Not Ignorance, and Intervene Accordingly. *Infancy*, *17*(6), 672–691. https://doi.org/10.1111/j.1532-7078.2011.00105.x

Koşkulu, S., Küntay, A. C., & Uzundag, B. A. (2021). Maternal behaviors mediate the relationship between socioeconomic status and joint attention. *Journal of Applied Developmental Psychology*, *75*, 101291. https://doi.org/10.1016/j.appdev.2021.101291

Kovács, Á. M., Kühn, S., Gergely, G., Csibra, G., & Brass, M. (2014). Are all beliefs equal? Implicit belief attributions recruiting core brain regions of theory of mind. *PLoS ONE*, *9*(9). https://doi.org/10.1371/journal.pone.0106558

Kovács, Á. M., Téglás, E., & Endress, A. D. (2010). The social sense: susceptibility to others' beliefs in human infants and adults. *Science (New York, N.Y.), 330*(6012), 1830–1834. https://doi.org/10.1126/science.1190792

Kraus, M. W., Côté, S., & Keltner, D. (2010). Social Class, Contextualism, and Empathic Accuracy. *Psychological Science*, *21*(11), 1716–1723. https://doi.org/10.1177/0956797610387613

Kraus, M. W., & Keltner, D. (2009). Signs of Socioeconomic Status. *Psychological Science*, *20*(1), 99–106. https://doi.org/10.1111/j.1467-9280.2008.02251.x

Kraus, M. W., Piff, P. K., & Keltner, D. (2011). Social class as culture: The convergence of resources and rank in the social realm. *Current Directions in Psychological Science*, *20*(4), 246–250. https://doi.org/10.1177/0963721411414654

Kulke, L., Johannsen, J., & Rakoczy, H. (2019). Why can some implicit Theory of Mind tasks be replicated and others cannot? A test of mentalizing versus submentalizing accounts. *PLoS ONE*, *14*(3). https://doi.org/10.1371/journal.pone.0213772

Kulke, L., & Rakoczy, H. (2018). Implicit Theory of Mind – An overview of current replications and non-replications. *Data in Brief*, *16*, 101–104. https://doi.org/10.1016/J.DIB.2017.11.016

Kulke, L., Reiß, M., Krist, H., & Rakoczy, H. (2018). How robust are anticipatory looking measures of Theory of Mind? Replication attempts across the life span. *Cognitive Development*, *46*, 97–111. https://doi.org/10.1016/j.cogdev.2017.09.001

Kumschick, I. R., Beck, L., Eid, M., Witte, G., Klann-Delius, G., Heuser, I., Steinlein, R., & Menninghaus, W. (2014). Reading and feeling: The effects of a literature-based intervention designed to increase emotional competence in second and third graders. *Frontiers in Psychology*, *5*(DEC). https://doi.org/10.3389/fpsyg.2014.01448

Kuntoro, I. A., Peterson, C. C., & Slaughter, V. (2017). Culture, Parenting, and Children's Theory of Mind Development in Indonesia. *Journal of Cross-Cultural Psychology*, *48*(9), 1389–1409. https://doi.org/10.1177/0022022117725404

Kushnir, T., Xu, F., & Wellman, H. (2010). Young Children Use Statistical Sampling to Infer the Preferences of Other People. *Psychological Science*, *21*(8), 1134–1140. https://doi.org/10.1177/0956797610376652

Kuznetsova, A., Brockhoff, P. B., & Christensen, R. H. B. (2017). lmerTest Package: Tests in Linear Mixed Effects Models. *Journal of Statistical Software*, *82*(13), 1–26. https://doi.org/10.18637/JSS.V082.I13

Lagattuta, K. H., Sayfan, L., & Blattman, A. J. (2010). Forgetting common ground: Six- to seven-year-olds have an overinterpretive theory of mind. *Developmental Psychology, 46*(6), 1417–1432. https://doi.org/10.1037/a0021062

Lambert, N. M., Stillman, T. F., Hicks, J. A., Kamble, S., Baumeister, R. F., & Fincham, F. D. (2013). To Belong Is to Matter: Sense of Belonging Enhances Meaning in Life. *Personality and Social Psychology Bulletin*, *39*(11), 1418–1427. https://doi.org/10.1177/0146167213499186

Lang, B., & Perner, J. (2002). Understanding of intention and false belief and the development of self-control. *British Journal of Developmental Psychology*, *20*(1), 67–76. https://doi.org/10.1348/026151002166325

Lawson, G. M., Hook, C. J., & Farah, M. J. (2018). A meta-analysis of the relationship between socioeconomic status and executive function performance among children. *Developmental Science*, *21*(2). https://doi.org/10.1111/desc.12529

Lecce, S., Bianco, F., Devine, R., child, C. H.-J. of experimental, & 2017, undefined. (2017). Relations between theory of mind and executive function in middle childhood: A short-term longitudinal study. *Elsevier*. https://doi.org/10.1016/j.jecp.2017.06.011

Lecce, S., Bianco, F., Devine, R. T., Hughes, C., & Banerjee, R. (2014). Promoting theory of mind during middle childhood: A training program. Journal of experimental child psychology, 126, 52-67. https://doi.org/10.1016/j.jecp.2014.03.002

Lecce, S., Caputi, M., & Hughes, C. (2011). Does sensitivity to criticism mediate the relationship between theory of mind and academic achievement?. *Journal of experimental child psychology*, *110*(3), 313-331.. https://doi.org/10.1016/j.jecp.2011.04.011

Lecce, S., Caputi, M., & Pagnin, A. (2014). Long-term effect of theory of mind on school achievement: The role of sensitivity to criticism. *European Journal of Developmental Psychology*, *11*(3), 305–318. https://doi.org/10.1080/17405629.2013.821944

Lenth, R. V. (2017). emmeans: Estimated Marginal Means, aka Least-Squares Means. In *CRAN: Contributed Packages*. https://doi.org/10.32614/CRAN.package.emmeans

Leppänen, J. M., Moulson, M. C., Vogel-Farley, V. K., & Nelson, C. A. (2007). An ERP study of emotional face processing in the adult and infant brain. *Child Development*, *78*(1), 232–245. https://doi.org/10.1111/j.1467-8624.2007.00994.x

Leslie, A. (1991). The theory of mind impairment in autism: Evidence for a modular mechanism of development? https://psycnet.apa.org/record/1991-97348-004

Letourneau, N. L., Duffett-Leger, L., Levac, L., Watson, B., & Young-Morris, C. (2013). Socioeconomic Status and Child Development: A Meta-Analysis. *Journal of Emotional and Behavioral Disorders*, *21*(3), 211–224. https://doi.org/10.1177/1063426611421007

Levine, D., Pace, A., Luo, R., Hirsh-Pasek, K., Michnick Golinkoff, R., de Villiers, J., Iglesias, A., & Sweig Wilson, M. (2020). Evaluating socioeconomic gaps in preschoolers' vocabulary, syntax and language process skills with the Quick Interactive Language Screener (QUILS). *Early Childhood Research Quarterly*, *50*, 114–128. https://doi.org/10.1016/j.ecresq.2018.11.006

Li, S., Müller, B. C. N., Meinhardt, J., & Sodian, B. (2025). Resting-state EEG alpha asymmetry predicts false belief understanding during early childhood: An exploratory longitudinal study. *Brain Research*, *1853*, 149523. https://doi.org/10.1016/J.BRAINRES.2025.149523

Licata, M., Paulus, M., Thoermer, C., Kristen, S., Woodward, A. L., & Sodian, B. (2014). Mother-infant Interaction Quality and Infants' Ability to Encode Actions as Goal-directed. *Social Development*, *23*(2), 340–356. https://doi.org/10.1111/sode.12057

Lin, S., Keysar, B., & Epley, N. (2010). Reflexively mindblind: Using theory of mind to interpret behavior requires effortful attention. *Journal of Experimental Social Psychology*, *46*(3), 551–556. https://doi.org/10.1016/j.jesp.2009.12.019

Liszkowski, U., Carpenter, M., Henning, A., Striano, T., & Tomasello, M. (2004). Twelve-month-olds point to share attention and interest. In *Developmental Science* (Vol. 7).

Liu, A. S., Rutherford, T., & Karamarkovich, S. M. (2022). Numeracy, Cognitive, and Motivational Predictors of Elementary Mathematics Achievement. *Journal of Educational Psychology*, *114*(7), 1589–1607. https://doi.org/10.1037/edu0000772

Liu, D., Wellman, H. M., Tardif, T., & Sabbagh, M. A. (2008). Theory of Mind Development in Chinese Children: A Meta-Analysis of False-Belief Understanding Across Cultures and Languages. *Developmental Psychology*, *44*(2), 523–531. https://doi.org/10.1037/0012-1649.44.2.523

Lockl, K., & Schneider, W. (2007). Knowledge About the Mind: Links Between Theory of Mind and Later Metamemory. *Child Development, 78*(1), 148–167. https://doi.org/10.1111/j.1467-8624.2007.00990.x

Lohmann, H., & Tomasello, M. (2003). The Role of Language in the Development of False Belief Understanding: A Training Study. *Child Development*, *74*(4), 1130–1144. https://doi.org/10.1111/1467-8624.00597

Lord, C., Elsabbagh, M., Baird, G., & Veenstra-Vanderweele, J. (2018). Autism spectrum disorder. *The lancet*, *392*(10146), 508-520. https://doi.org/10.1016/S0140-6736(18)31129-2

Low, J. (2010). Preschoolers' implicit and explicit false-belief understanding: Relations with complex syntactical mastery. *Child development*, *81*(2), 597-615. https://doi.org/10.1111/j.1467-8624.2009.01418.x

Low, J., Edwards, K., & Butterfill, S. A. (2020). Visibly constraining an agent modulates observers' automatic false-belief tracking. *Scientific Reports*, *10*(1). https://doi.org/10.1111/j.1467-8624.2009.01418.x

Low, J., & Perner, J. (2012). Implicit and explicit theory of MD: State of the art. In *British Journal of Developmental Psychology* (Vol. 30, Issue 1, pp. 1–13). https://doi.org/10.1111/j.2044-835X.2011.02074.x

Low, J., & Watts, J. (2013). Attributing False Beliefs About Object Identity Reveals a Signature Blind Spot in Humans' Efficient Mind-Reading System. *Psychological Science*, *24*(3), 305–311. https://doi.org/10.1177/0956797612451469

Luo, Y., & Baillargeon, R. (2010). Toward a mentalistic account of early psychological reasoning. *Current Directions in Psychological Science, 19*(5), 301–307. https://doi.org/10.1177/0963721410386679

Lupien, S. J., King, S., Meaney, M. J., & McEwen, B. S. (2000). Child's stress hormone levels correlate with mother's socioeconomic status and depressive state. *Biological Psychiatry*, *48*(10), 976–980. https://doi.org/10.1016/S0006-3223(00)00965-3

Ma, Q., Pu, M., Haihambo, N., Baetens, K., Heleven, E., Deroost, N., ... & Van Overwalle, F. (2023). Effective cerebello–cerebral connectivity during implicit and explicit social belief sequence learning using dynamic causal modeling. *Social Cognitive and Affective Neuroscience*, *18*(1), nsac044. https://doi.org/10.1093/scan/nsac044

Ma, Y., Fan, H., & Chen, Q. (2024). Socioeconomic status and vocabulary development among children: a meta-analysis. *Current Psychology*, *43*(39), 30736–30747. https://doi.org/10.1007/s12144-024-06666-2

Manea, V., Kampis, D., Grosse Wiesmann, C., Revencu, B., & Southgate, V. (2023). An initial but receding altercentric bias in preverbal infants' memory. *Proceedings of the Royal Society B: Biological Sciences*, *290*(2000). https://doi.org/10.1098/rspb.2023.0738

Maner, J. K., DeWall, C. N., Baumeister, R. F., & Schaller, M. (2007). Does social exclusion motivate interpersonal reconnection? Resolving the "porcupine problem." *Journal of Personality and Social Psychology*, *92*(1), 42–55. https://doi.org/10.1037/0022-3514.92.1.42

Marcovitch, S., O'Brien, M., Calkins, S. D., Leerkes, E. M., Weaver, J. M., & Levine, D. W. (2015). A longitudinal assessment of the relation between executive function and theory of mind at 3, 4, and 5 years. *Cognitive Development*, *33*, 40–55. https://doi.org/10.1016/j.cogdev.2014.07.001

Margoni, F., Surian, L., & Baillargeon, R. (2023). The Violation-of-Expectation Paradigm: A Conceptual Overview. In *Psychological Review* (Vol. 131, Issue 3, pp. 716–748). American Psychological Association. https://doi.org/10.1037/rev0000450

Mariel, P., Hoyos, D., Meyerhoff, J., Czajkowski, M., Dekker, T., Glenk, K., ... & Thiene, M. (2021). *Environmental valuation with discrete choice experiments: Guidance on design, implementation and data analysis* (p. 129). Springer Nature.

Marriott, S. Red in Tooth and Claw? Images of Nature in Modern Picture Books. *Children's Literature in Education* 33, 175–183 (2002). https://doi.org/10.1023/A:1019677931406

Mascaro, O., & Kovács, Á. M. (2022). The origins of trust: Humans' reliance on communicative cues supersedes firsthand experience during the second year of life. Developmental Science, 25(4), e13223. https://doi.org/10.1111/desc.13223

Mascaro, O., & Sperber, D. (2009). The moral, epistemic, and mindreading components of children's vigilance towards deception. *Cognition*, *112*(3), 367–380. https://doi.org/10.1016/j.cognition.2009.05.012

Matthews, K. A., & Gallo, L. C. (2011). Psychological Perspectives on Pathways Linking Socioeconomic Status and Physical Health. *Annual Review of Psychology*, *62*(1), 501–530. https://doi.org/10.1146/annurev.psych.031809.130711

Maximino-Pinheiro, M., Menu, I., Boissin, E., Brunet, L. A., Barone, C., & Borst, G. (2024). Metacognition as a mediator of the relation between family SES and language and mathematical abilities in preschoolers. *Scientific Reports*, *14*(1). https://doi.org/10.1038/s41598-024-60972-0

Mayer, A., & Träuble, B. (2015). The Weird World of Cross-Cultural False-Belief Research: A True- and False-Belief Study Among Samoan Children Based on Commands. *Journal of Cognition and Development*, *16*(4), 650–665. https://doi.org/10.1080/15248372.2014.926273

Mcalister, A. R., & Peterson, C. C. (2013). Siblings, Theory of Mind, and Executive Functioning in Children Aged 3–6 Years: New Longitudinal Evidence. *Child Development*, *84*(4), 1442–1458. https://doi.org/10.1111/CDEV.12043

McEwen, F., Happé, F., Bolton, P., Ronald, A., Rijsdijk, F., & Plomin, R. (2007). Origins of individual differences in imitation: links with language, pretend play, and rudimentary theory of mind in two-year-old twins. *Child Development*, *78*(2), 474-492. https://doi.org/10.1111/j.1467-8624.2007.01010.x

McLaren, L. (2007). Socioeconomic Status and Obesity. *Epidemiologic Reviews*, *29*(1), 29–48. https://doi.org/10.1093/EPIREV/MXM001

Meins, E. (1997). *Security of Attachment and the Social Development of Cognition*. Hove, UK: Psychology Press. https://doi.org/10.4324/9780203775912

Meins, E., & Fernyhough, C. (1999). Linguistic acquisitional style and mentalising development: The role of maternal mind-mindedness. Cognitive Development, 14(3), 363-380. https://doi.org/10.1016/S0885-2014(99)00010-6

Meins, E., Fernyhough, C., Arnott, B., Leekam, S. R., & De Rosnay, M. (2013). Mind-mindedness and theory of mind: Mediating roles of language and perspectival symbolic play. *Child Development*, *84*(5), 1777–1790. https://doi.org/10.1111/cdev.12061

Meins, E., Fernyhough, C., Fradley, E., & Tuckey, M. (2001). Rethinking Maternal Sensitivity: Mothers' Comments on Infants' Mental Processes Predict Security of Attachment at 12 Months. *Journal of Child Psychology and Psychiatry*, *42*(5), 637–648. https://doi.org/10.1111/1469-7610.00759

Meins, E., Fernyhough, C., Russell, J., & Clark-Carter, D. (1998). Security of attachment as a predictor of symbolic and mentalising abilities: A longitudinal study. *Social Development*, *7*(1), 1–24. https://doi.org/10.1111/1467-9507.00047

Meints, K., Racca, A., & Hickey, N. (2010). How to prevent dog bite injuries? Children misinterpret dogs facial expressions. *Injury Prevention*, *16*(Suppl 1), A68-A68.

Mellor, D., Stokes, M., Firth, L., Hayashi, Y., & Cummins, R. (2008). Need for belonging, relationship satisfaction, loneliness, and life satisfaction. *Personality and Individual Differences*, *45*(3), 213–218. https://doi.org/10.1016/j.paid.2008.03.020

Meltzoff, A. N. (2007). "Like me": A foundation for social cognition. *Developmental Science*, *10*(1), 126–134. https://doi.org/10.1111/J.1467-7687.2007.00574.X

Menaghan, E. G., & Parcel, T. L. (1991). Determining children's home environments: The impact of maternal characteristics and current occupational and family conditions. *Journal of Marriage and the Family*, 417-431. https://doi.org/10.2307/352909

Mercier, H. (2020). *Not Born Yesterday*. Princeton University Press. https://doi.org/10.1515/9780691198842

Mercy, J. A., & Steelman, L. C. (1982). Familial influence on the intellectual attainment of children. *American Sociological Review*, 532-542. https://doi.org/10.2307/2095197

Meristo, M., Morgan, G., Geraci, A., Iozzi, L., Hjelmquist, E., Surian, L., & Siegal, M. (2012). Belief attribution in deaf and hearing infants. *Developmental Science*, *15*(5), 633–640. https://doi.org/10.1111/j.1467-7687.2012.01155.x

Meristo, M., Strid, K., & Hjelmquist, E. (2016). Early conversational environment enables spontaneous belief attribution in deaf children. *Cognition*, *157*, 139–145. https://doi.org/10.1016/j.cognition.2016.08.023

Merz, E. C., Wiltshire, C. A., & Noble, K. G. (2019). Socioeconomic Inequality and the Developing Brain: Spotlight on Language and Executive Function. *Child Development Perspectives*, *13*(1), 15–20. https://doi.org/10.1111/cdep.12305

Miech, R. A., & Shanahan, M. J. (2000). Socioeconomic Status and Depression over the Life Course. *Journal of Health and Social Behavior, 41*(2), 162–176. https://doi.org/10.2307/2676303

Miller, J. (2024). How Many Participants? How Many Trials? Maximizing the Power of Reaction Time Studies. *Behavior Research Methods*, *56*(3), 2398–2421. https://doi.org/10.3758/s13428-023-02155-9

Miller, P. J., Sperry, D. E., & Sperry, L. L. (2024). A deficit story in motion: How marginalized youngsters are defined out of the educational game before they enter school. *Journal of Social Issues*, *80*(4), 1218–1237. https://doi.org/10.1111/josi.12647

Miller, S. A. (2016). *Parenting and theory of mind*. Oxford University Press.

Miller, S. A. (2009). Children's Understanding of Second-Order Mental States. *Psychological Bulletin*, *135*(5), 749–773. https://doi.org/10.1037/a0016854

Miller, S. E., Reavis, R. E., Reavis, R. D., & Avila, B. N. (2018). *Associations Between Theory of Mind, Executive Function, and Friendship Quality in Middle Childhood*. *64*(3), 397–426. https://doi.org/10.13110/merrpalmquar

Milligan, K., Astington, J. W., & Dack, L. A. (2007). Language and theory of mind: Meta-analysis of the relation between language ability and false-belief understanding. *Child development*, *78*(2), 622-646. https://doi.org/10.1111/j.1467-8624.2007.01018.x

Mills, K. L., Siegmund, K. D., Tamnes, C. K., Ferschmann, L., Wierenga, L. M., Bos, M. G. N., Luna, B., Li, C., & Herting, M. M. (2021). Inter-individual variability in structural brain development from late childhood to young adulthood. *NeuroImage*, *242*, 118450. https://doi.org/10.1016/j.neuroimage.2021.118450

Mitchell, P., & Lacohée, H. (1991). Children's early understanding of false belief. *Cognition*, *39*(2), 107-127. https://doi.org/10.1016/0010-0277(91)90040-B

Mittal, C., Griskevicius, V., Simpson, J. A., Sung, S., & Young, E. S. (2015). Cognitive adaptations to stressful environments: When childhood adversity enhances adult executive function. *Psycnet.Apa.Org*. https://doi.org/10.1037/pspi0000028

Miyake, A., Friedman, N. P., Emerson, M. J., Witzki, A. H., Howerter, A., & Wager, T. D. (2000). The Unity and Diversity of Executive Functions and Their Contributions to Complex "Frontal Lobe" Tasks: A Latent Variable Analysis. *Cognitive Psychology*, *41*(1), 49–100. https://doi.org/10.1006/cogp.1999.0734

Monna, B., & Gauthier, A. H. (2008). A review of the literature on the social and economic determinants of parental time. *Journal of Family and Economic Issues*, *29*(4), 634–653. https://doi.org/10.1007/s10834-008-9121-z

Moore, C., Dunham, P. J., & Bruner, J. S. (2014). *Understanding the Link Between Joint Attention and Language*. 131–158. https://doi.org/10.4324/9781315806617-7

Moses, L. J., & Tahiroglu, D. (2010). Clarifying the relation between executive function and children's theories of mind. In B. W. Sokol, U. Muller, & J. I. M. Carpendale (Eds.), Self and social regulation: Social interaction and the development of social understanding and executive functions (pp. 218–233). Oxford, UK: Oxford University Press. https://doi.org/10.1093/acprof:oso/9780195327694.003.0009

Müller, U., Jacques, S., Brocki, K., & Zelazo, P. D. (2009). The executive functions of language in preschool children. *Private Speech, Executive Functioning, and the Development of Verbal Self-Regulation*, 53–68. https://doi.org/10.1017/CBO9780511581533.005

Mundy, P., Block, J., Delgado, C., Pomares, Y., Van Hecke, A. V., & Parlade, M. V. (2007). Individual differences and the development of joint attention in infancy. *Child Development*, *78*(3), 938–954. https://doi.org/10.1111/j.1467-8624.2007.01042.x

Mundy, P., & Newell, L. (2007). Attention, joint attention, and social cognition. *Current Directions in Psychological Science*, *16*(5), 269–274. https://doi.org/10.1111/j.1467-8721.2007.00518.x

Muscatell, K. A., & Eisenberger, N. I. (2012). A Social Neuroscience Perspective on Stress and Health. *Social and Personality Psychology Compass*, *6*(12), 890–904. https://doi.org/10.1111/J.1751-9004.2012.00467.X

Nagai, Y., Hosoda, K., Morita, A., & Asada, M. (2003). A constructive model for the development of joint attention. *Connection Science*, *15*(4), 211–229. https://doi.org/10.1080/09540090310001655101

Nash, H. M. (2001). *Social skills training, training to task, and theory of mind performance among young children*. [Doctoral dissertation, Idaho State University].

Naughtin, C. K., Horne, K., Schneider, D., Venini, D., York, A., & Dux, P. E. (2017). Do implicit and explicit belief processing share neural substrates? *Human Brain Mapping*, *38*(9), 4760–4772. https://doi.org/10.1002/hbm.23700

Neville, H. J., Stevens, C., Pakulak, E., Bell, T. A., Fanning, J., Klein, S., & Isbell, E. (2013). Family-based training program improves brain function, cognition, and behavior in lower socioeconomic status preschoolers. *Pnas.Org*, *110*(29), 12138–12143. https://doi.org/10.1073/pnas.1304437110

Newton, A. M., & De Villiers, J. G. (2007). Thinking while talking: Adults fail nonverbal false-belief reasoning. *Psychological Science*, *18*(7), 574–579. https://doi.org/10.1111/J.1467-9280.2007.01942.X

Nijhof, A. D., Bardi, L., Brass, M., & Wiersema, J. R. (2018). Brain activity for spontaneous and explicit mentalizing in adults with autism spectrum disorder: An fMRI study. *NeuroImage: Clinical*, *18*, 475–484. https://doi.org/10.1016/J.NICL.2018.02.016

Nijhof, A. D., Brass, M., Bardi, L., & Wiersema, J. R. (2016). Measuring mentalizing ability: A within-subject comparison between an explicit and implicit version of a ball detection task. *PLoS ONE*, *11*(10). https://doi.org/10.1371/journal.pone.0164373

Nijhof, A. D., Brass, M., & Wiersema, J. R. (2017). Spontaneous mentalizing in neurotypicals scoring high versus low on symptomatology of autism spectrum disorder. *Psychiatry Research*, *258*, 15–20. https://doi.org/10.1016/J.PSYCHRES.2017.09.060

Noble, K. G., Engelhardt, L. E., Brito, N. H., Mack, L. J., Nail, E. J., Angal, J., Barr, R., Fifer, W. P., & Elliott, A. J. (2015). Socioeconomic disparities in neurocognitive development in the first two years of life. *Developmental Psychobiology*, *57*(5), 535–551. https://doi.org/10.1002/DEV.21303

Noble, K. G., Norman, M. F., & Farah, M. J. (2005). Neurocognitive correlates of socioeconomic status in kindergarten children. *Developmental Science*, *8*(1), 74–87. https://doi.org/10.1111/J.1467-7687.2005.00394.X

OECD. (2020). *Construction of indices. In PISA 2018 Results (Volume III): What School Life Means for Students' Lives*. OECD Pusblishing.

Oh, S., & Lewis, C. (2008). Korean preschoolers' advanced inhibitory control and its relation to other executive skills and mental state understanding. *Child Development*, *79*(1), 80–99. https://doi.org/10.1111/J.1467-8624.2007.01112.X

O'Laughlin, K. D., Martin, M. J., & Ferrer, E. (2018). Cross-Sectional Analysis of Longitudinal Mediation Processes. *Multivariate Behavioral Research*, *53*(3), 375–402. https://doi.org/10.1080/00273171.2018.1454822

Onishi, K. K., & Baillargeon, R. (2005). Do 15-month-old infants understand false beliefs? *Science*, *308*(5719), 255–258. https://doi.org/10.1126/science.1107621

O'Reilly, J., & Peterson, C. C. (2014). Theory of mind at home: linking authoritative and authoritarian parenting styles to children's social understanding. *Early Child Development and Care*, *184*(12), 1934–1947. https://doi.org/10.1080/03004430.2014.894034 Ornaghi, V., Brockmeier, J., & Gavazzi, I. G. (2011). The role of language games in children's understanding of mental states: A training study. *Journal of Cognition and Development*, *12*(2), 239–259. https://doi.org/10.1080/15248372.2011.563487

Osterhaus, C., & Koerber, S. (2021). The Development of Advanced Theory of Mind in Middle Childhood: A Longitudinal Study From Age 5 to 10 Years. *Child Development*, *92*(5), 1872–1888. https://doi.org/10.1111/cdev.13627

Osterhaus, C., Kristen-Antonow, S., Kloo, D., & Sodian, B. (2022). Advanced scaling and modeling of children's theory of mind competencies: Longitudinal findings in 4- to 6-year-olds. *International Journal of Behavioral Development*, *46*(3), 251–259. https://doi.org/10.1177/01650254221077334

Padberg, M., Eckert, J., Grosse Wiesmann, C., & Pope-Caldwell, S. (2022). *Is altercentrism WEIRD? A cross-cultural comparison on the susceptibility to other's beliefs*. https://osf.io/rcgfv/resources

Paine, A. L., Pearce, H., van Goozen, S. H. M., de Sonneville, L. M. J., & Hay, D. F. (2018). Late, but not early, arriving younger siblings foster firstborns' understanding of second-order false belief. *Journal of Experimental Child Psychology*, *166*, 251–265. https://doi.org/10.1016/j.jecp.2017.08.007

Parker, P., Sanders, T., Anders, J., Shure, N., Jerrim, J., Noetel, M., Parker, R., Ciarrochi, J., & Marsh, H. (2023). School socioeconomic status context and social adjustment in children. *Developmental Psychology*, *59*(1), 15–29. https://doi.org/10.1037/DEV0001463

Pathirana, T. I., & Jackson, C. A. (2018). Socioeconomic status and multimorbidity: a systematic review and meta-analysis. *Australian and New Zealand Journal of Public Health*, *42*(2), 186–194. https://doi.org/10.1111/1753-6405.12762

Pavarini, G., de Hollanda Souza, D., & Hawk, C. K. (2013). Parental Practices and Theory of Mind Development. *Journal of Child and Family Studies*, *22*(6), 844–853. https://doi.org/10.1007/S10826-012-9643-8/

Pawlinska-Chmara, R., & Wronka, I. (2007). Assessment of the effect of socioeconomic factors on the prevalence of respiratory disorders in children. Journal of Physiology and Pharmacology, 58(5), 523-529.

Pears, K. C., & Moses, L. J. (2003). Demographics, Parenting, and Theory of Mind in Preschool Children. *Social Development*, *12*(1), 1–20. https://doi.org/10.1111/1467-9507.00219

Pellicano E. (2007). Links between theory of mind and executive function in young children with autism: clues to developmental primacy. *Developmental psychology*, *43*(4), 974–990. https://doi.org/10.1037/0012-1649.43.4.974

Pepper, G. V., & Nettle, D. (2017). The behavioural constellation of deprivation: Causes and consequences. *Behavioral and Brain Sciences*, *40*. https://doi.org/10.1017/S0140525X1600234X

Peristeri, E., Vogelzang, M., Tsimpli, I. M., & Durrleman, S. (2024). Bilingualism and second-order theory of mind development in autistic children over time: Longitudinal relations with language, executive functions, and intelligence. *Autism Research*, *17*(9), 1818–1829. https://doi.org/10.1002/aur.3214

Perner, J. (1991). Understanding the representational mind. MIT Press.

Perner, J. (2010) Who took the cog out of cognitive science? Mentalism in an era of anti cognitivism. In Cognition and neuropsychology: International perspectives on psychological science

(Frensch, P.A. and Schwarzer, R. eds), pp. 241-261, Psychology PressPerner, J., & Clements, W. A. (2003). From an implicit to an explicit "Theory of Mind". In *Beyond dissociation: Interaction between dissociated implicit and explicit processing* (pp. 273-294). John Benjamins Publishing Company. https://doi.org/10.1075/aicr.22.14per

Perner, J., Kain, W., & Barchfeld, P. (2002). Executive Control and Higher-Order Theory of Mind in Children at Risk of ADHD. *Infant and Child Development*, *11*(2), 141–158. https://doi.org/10.1002/icd.302

Perner, J., & Lang, B. (1999). Development of theory of mind and executive control. *Trends in cognitive sciences*, *3*(9), 337-344. https://doi.org/10.1016/S1364-6613(99)01362-5

Perner, J., & Lang, B. (2000). Theory of mind and executive function: Is there a developmental relationship?.

Perner, J., Leekam, S. R., & Wimmer, H. (1987). Three-year-olds' difficulty with false belief: The case for a conceptual deficit. *British Journal of Developmental Psychology*, *5*(2), 125–137. https://doi.org/10.1111/j.2044-835x.1987.tb01048.x

Perner, J., & Roessler, J. (2012). From infants' to children's appreciation of belief. In *Trends in Cognitive Sciences* (Vol. 16, Issue 10, pp. 519–525). https://doi.org/10.1016/j.tics.2012.08.004

Perner, J., Ruffman, T., & Leekam, S. R. (1994). Theory of Mind Is Contagious: You Catch It from Your Sibs. *Child Development*, *65*(4), 1228–1238. https://doi.org/10.1111/J.1467-8624.1994.TB00814.X

Perner, J., & Wimmer, H. (1985). "John thinks that Mary thinks that…" attribution of second-order beliefs by 5-to 10-year-old children. Journal of experimental child psychology, 39(3), 437-471. https://doi.org/10.1016/0022-0965(85)90051-7

Peskin, J., Comay, J., Chen, X., & Prusky, C. (2016). Does Theory of Mind in Pre-kindergarten Predict the Ability to Think About a Reader's Mind in Elementary School Compositions? A Longitudinal Study. *Journal of Cognition and Development*, *17*(3), 396–417. https://doi.org/10.1080/15248372.2015.1049697

Peterson, C. C. (2000). Kindred spirits: Influences of siblings' perspectives on theory of mind. Cognitive Development, 15(4), 435-455. https://doi.org/10.1016/S0885-2014(01)00040-5

Peterson, C. C., & Slaughter, V. (2016). Culture and the sequence of developmental milestones toward theory of mind mastery. In Theory of mind development in context (pp. 47-62). Routledge.

Phillips, J., Ong, D. C., Surtees, A. D. R., Xin, Y., Williams, S., Saxe, R., & Frank, M. C. (2015). A second look at automatic theory of mind: Reconsidering kovács, téglás, and endress (2010). *Psychological Science*, *26*(9), 1353–1367. https://doi.org/10.1177/0956797614558717

Piaget, J., & Inhelder, B. (1956). *The child's concept of space.* Routledge & Paul.

Piff, P. K., Kraus, M. W., Côté, S., Cheng, B. H., & Keltner, D. (2010). Having less, giving more: the influence of social class on prosocial behavior. *Journal of personality and social psychology*, *99*(5), 771. https://doi.org/10.1037/a0020092

Piketty, T. (2018). *Top incomes in France in the twentieth century: Inequality and redistribution, 1901–1998.* Harvard University Press.

Pluck, G., Córdova, M. A., Bock, C., Chalen, I., & Trueba, A. F. (2021). Socio-economic status, executive functions, and theory of mind ability in adolescents: Relationships with language ability and cortisol. *British Journal of Developmental Psychology*, *39*(1), 19–38. https://doi.org/10.1111/bjdp.12354

Polyanskaya, I., Eigsti, I. M., Brauner, T., & Blackburn, P. (2022). Second-Order False Beliefs and Linguistic Recursion in Autism Spectrum Disorder. *Journal of Autism and Developmental Disorders*, *52*(9), 3991–4006. https://doi.org/10.1007/s10803-021-05277-1

Poulin-Dubois, D. (2020). Theory of mind development: State of the science and future directions. In *Progress in Brain Research* (Vol. 254, pp. 141–166). Elsevier B.V. https://doi.org/10.1016/bs.pbr.2020.05.021

Poulin-Dubois, D., Azar, N., Elkaim, B., & Burnside, K. (2020). Testing the stability of theory of mind: A longitudinal approach. Plos one, 15(11), e0241721. https://doi.org/10.1371/journal.pone.0241721

Poulin-Dubois, D., Goldman, E. J., Meltzer, A., & Psaradellis, E. (2023). Discontinuity from implicit to explicit theory of mind from infancy to preschool age. *Cognitive Development*, *65*, 101273. https://doi.org/10.1016/J.COGDEV.2022.101273

Pourtois, G., Schettino, A., & Vuilleumier, P. (2013). Brain mechanisms for emotional influences on perception and attention: What is magic and what is not. In *Biological Psychology* (Vol. 92, Issue 3, pp. 492–512). https://doi.org/10.1016/j.biopsycho.2012.02.007

Povinelli, D. J., & Vonk, J. (2004). We don't need a microscope to explore the chimpanzee's mind. Mind & Language, 19(1), 1-28. https://doi.org/10.1111/j.1468-0017.2004.00244.x

Premack, D., & Woodruff, G. (1978). Does the chimpanzee have a theory of mind?. *Behavioral and brain sciences, 1*(4), 515-526.

Quesque, F., Coutrot, A., Cox, S., de Souza, L. C., Baez, S., Cardona, J. F., Mulet-Perreault, H., Flanagan, E., Neely-Prado, A., Clarens, M. F., Cassimiro, L., Musa, G., Kemp, J., Botzung, A., Philippi, N., Cosseddu, M., Trujillo-Llano, C., Grisales-Cardenas, J. S., Fittipaldi, S., … Bertoux, M. (2022). Does Culture Shape Our Understanding of Others' Thoughts and

Emotions? An Investigation Across 12 Countries. *Neuropsychology*, *36*(7), 664–682. https://doi.org/10.1037/neu0000817

Quesque, F., & Rossetti, Y. (2020). What Do Theory-of-Mind Tasks Actually Measure? Theory and Practice. *Perspectives on Psychological Science*, *15*(2), 384–396. https://doi.org/10.1177/1745691619896607

R Core Team. (2023). *R: A Language and Environment for Statistical Computing. R Foundation for Statistical Computing, Vienna. https://www.R-project.org/*

Reardon, S. F. (2018). The widening academic achievement gap between the rich and the poor. In *Social stratification* (pp. 536-550). Routledge.

Reilly, E. B., Stallworthy, I. C., Mliner, S. B., Troy, M. F., Elison, J. T., & Gunnar, M. R. (2021). Infants' abilities to respond to cues for joint attention vary by family socioeconomic status. *Infancy*, *26*(2), 204–222. https://doi.org/10.1111/INFA.12380

Reiss, F. (2013). Socioeconomic inequalities and mental health problems in children and adolescents: a systematic review. Social science & medicine, 90, 24-31. https://doi.org/10.1016/j.socscimed.2013.04.026

Repacholi, B. M. (1998). Infants' use of attentional cues to identify the referent of another person's emotional expression. Developmental psychology, 34(5), 1017. https://doi.org/10.1037/0012-1649.34.5.1017

Revelle, W. (2024). *psych: Procedures for Psychological, Psychometric, and Personality Research*. https://CRAN.R-project.org/package=psych

Rinaldi, C. M., & Howe, N. (2012). Mothers' and fathers' parenting styles and associations with toddlers' externalizing, internalizing, and adaptive behaviors. Early Childhood Research Quarterly, 27(2), 266-273. https://doi.org/10.1016/j.ecresq.2011.08.001

Rizzolatti, G. (2005). The mirror neuron system and its function in humans. *Anatomy and Embryology*, *210*(5–6), 419–421. https://doi.org/10.1007/S00429-005-0039-Z

Rizzolatti, G., Fadiga, L., Gallese, V., & Fogassi, L. (1996). Premotor cortex and the recognition of motor actions. *Elsevier*. https://www.sciencedirect.com/science/article/pii/0926641095000380

Robinson, D., Hayes, A., & Couch, S. (2024). *broom: Convert Statistical Objects into Tidy Tibbles*. https://CRAN.R-project.org/package=broom

Robitzsch, A. (2020). Why Ordinal Variables Can (Almost) Always Be Treated as Continuous Variables: Clarifying Assumptions of Robust Continuous and Ordinal Factor Analysis Estimation Methods. *Frontiers in Education*, *5*. https://doi.org/10.3389/feduc.2020.589965

Roby, E., & Scott, R. M. (2018a). The relationship between parental mental-state language and 2.5-year-olds' performance on a nontraditional false-belief task. *Cognition*, *180*, 10–23. https://doi.org/10.1016/j.cognition.2018.06.017

Roby, E., & Scott, R. M. (2018b). The relationship between parental mental-state language and 2.5-year-olds' performance on a nontraditional false-belief task. *Cognition*, *180*, 10–23. https://doi.org/10.1016/J.COGNITION.2018.06.017

Roby, E., & Scott, R. M. (2022). Financial concern reduces child directed speech in a socioeconomically diverse sample. *Scientific Reports*, *12*(1). https://doi.org/10.1038/s41598-022-13177-2

Rollins, L., & Riggins, T. (2021). Adapting event-related potential research paradigms for children: Considerations from research on the development of recognition memory. *Developmental Psychobiology*, *63*(6). https://doi.org/10.1002/dev.22159

Ronchi, L., Banerjee, R., & Lecce, S. (2020). Theory of mind and peer relationships: The role of social anxiety. *Social Development*, *29*(2), 478–493. https://doi.org/10.1111/sode.12417

Rosseel, Y. (2012). lavaan : An R Package for Structural Equation Modeling. *Journal of Statistical Software*, *48*(2). https://doi.org/10.18637/jss.v048.i02

Rothbart, M. K., Posner, M. I., & Rosicky, J. (1994). Orienting in normal and pathological development. Development and Psychopathology, 6(4), 635-652. https://doi.org/10.1017/S0954579400004715

Rothmaler, K., & Grosse Wiesmann, C. (2023). Evidence against implicit belief processing in a blindfold task. *PLoS ONE*, *18*(11 November). https://doi.org/10.1371/journal.pone.0294136

Rouchy, J. C. (2002). Cultural Identity and Groups of Belonging. *Group*, *26*(3), 205–217. https://doi.org/10.1023/A:1021009126881

Rowe, M. L., & Goldin-Meadow, S. (2009). Differences in early gesture explain SES disparities in child vocabulary size at school entry. *Science*, *323*(5916), 951–953. https://doi.org/10.1126/SCIENCE.1167025

Ruba, A. L., Meltzoff, A. N., & Repacholi, B. M. (2019). How do you feel? Preverbal infants match negative emotions to events. *Developmental Psychology*, *55*(6), 1138–1149. https://doi.org/10.1037/dev0000711

Rubio-Fernandez, P., Long, M., Shukla, V., Bhatia, V., & Sinha, P. (2022). Visual perspective taking is not automatic in a simplified Dot task: Evidence from newly sighted children, primary school children and adults. *Neuropsychologia*, 172, 108256. https://doi.org/10.1016/j.neuropsychologia.2022.108256

References

Ruffman, T., Perner, J., Naito, M., Parkin, L., & Clements, W. A. (1998). Older (but not younger) siblings facilitate false belief understanding. *Developmental psychology*, *34*(1), 161. https://doi.org/10.1037/0012-1649.34.1.161

Ruffman, T., Slade, L., Devitt, K., & Crowe, E. (2006). What mothers say and what they do: The relation between parenting, theory of mind, language and conflict/cooperation. *British Journal of Developmental Psychology*, *24*(1), 105–124. https://doi.org/10.1348/026151005X82848

Ruffman, T., Slade, L., Rowlandson, K., Rumsey, C., & Garnham, A. (2003). How language relates to belief, desire, and emotion understanding. Cognitive Development, 18(2), 139-158. https://doi.org/10.1016/S0885-2014(03)00002-9

Russell, J. (1996). *Agency: Its Role In Mental Development* (1st ed.). Psychology Press. https://doi.org/10.4324/9780203775691

Russell, J., Mauthner, N., Sharpe, S., & Tidswell, T. (1991). The 'windows task' as a measure of strategic deception in preschoolers and autistic subjects. *British Journal of Developmental Psychology*, *9*(2), 331–349. https://doi.org/10.1111/j.2044-835x.1991.tb00881.x

Sabbagh, M. A., Xu, F., Carlson, S. M., Moses, L. J., & Lee, K. (2006). The development of executive functioning and theory of mind: A comparison of Chinese and U.S. preschoolers. *Psychological Science*, *17*(1), 74–81. https://doi.org/10.1111/J.1467-9280.2005.01667.X

Saffran, J. R., Johnson, E. K., Aslin, R. N., & Newport, E. L. (1999). Statistical learning of tone sequences by human infants and adults. Cognition, 70(1), 27-52. https://doi.org/10.1016/s0010-0277(98)00075-4

Samson, D., Apperly, I. A., Braithwaite, J. J., Andrews, B. J., & Bodley Scott, S. E. (2010). Seeing it their Way: Evidence for rapid and involuntary computation of what other people see. *Journal of Experimental Psychology: Human Perception and Performance*, *36*(5), 1255–1266. https://doi.org/10.1037/a0018729

San Juan, V., & Astington, J. W. (2012). Bridging the gap between implicit and explicit understanding: How language development promotes the processing and representation of false belief. *British Journal of Developmental Psychology*, *30*(1), 105–122. https://doi.org/10.1111/J.2044-835X.2011.02051.X

San Juan, V., & Astington, J. W. (2017). Does language matter for implicit theory of mind? The effects of epistemic verb training on implicit and explicit false-belief understanding. *Cognitive Development*, *41*, 19–32. https://doi.org/10.1016/j.cogdev.2016.12.003

Sanches de Oliveira, G., & Baggs, E. (2023). Psychology's WEIRD Problems. In *Psychology's WEIRD Problems*. Cambridge University Press. https://doi.org/10.1017/9781009303538

Santiesteban, I., Catmur, C., Hopkins, S. C., Bird, G., & Heyes, C. (2014). Avatars and arrows: Implicit mentalizing or domain-general processing?. Journal of Experimental Psychology: Human Perception and Performance, 40(3), 929. https://doi.org/10.1037/a0035175

Sari, M. (2012). Sense of school belonging among elementary students.

Sarsour, K., Sheridan, M., Jutte, D., Nuru-Jeter, A., Hinshaw, S., & Boyce, W. T. (2011). Family socioeconomic status and child executive functions: the roles of language, home environment, and single parenthood. *Journal of the International Neuropsychological Society : JINS, 17*(1), 120–132. https://doi.org/10.1017/S1355617710001335

Sartori, L., Becchio, C., & Castiello, U. (2011). Cues to intention: The role of movement information. *Cognition*, *119*(2), 242–252. https://doi.org/10.1016/j.cognition.2011.01.014

Saxe, R. (2006). Uniquely human social cognition. In *Current Opinion in Neurobiology* (Vol. 16, Issue 2, pp. 235–239). https://doi.org/10.1016/j.conb.2006.03.001

Saxe, R. (2009). The neural evidence for simulation is weaker than i think you think it is. *Philosophical Studies*, *144*(3), 447–456. https://doi.org/10.1007/s11098-009-9353-2

Saxe, R. (2010). The right temporo-parietal junction: a specific brain region for thinking about thoughts. Handbook of theory of mind, 1-35.

Saxe, R., & Kanwisher, N. (2003). People thinking about thinking people: The role of the temporo-parietal junction in "theory of mind." *NeuroImage*, *19*(4), 1835–1842. https://doi.org/10.1016/S1053-8119(03)00230-1

Sayer, L. C., Gauthier, A. H., & Furstenberg, F. F. (2004). Educational differences in parents' time with children: Cross-national variations. *Journal of Marriage and Family*, *66*(5), 1152–1169. https://doi.org/10.1111/j.0022-2445.2004.00084.x

Scaife, M., & Bruner, J. S. (1975). The capacity for joint visual attention in the infant. Nature, 253(5489), 265-266. https://doi.org/10.1038/253265a0

Schermelleh-Engel, K., Moosbrugger, H., & Müller, H. (2003). Evaluating the fit of structural equation models: Tests of significance and descriptive goodness-of-fit measures. *Methods of psychological research online, 8*(2), 23-74. https://doi.org/10.23668/psycharchives.12784

Schlicht, T. (2023). Philosophy of social cognition. Cham: Palgrave Macmillan.

Schneider, D., Lam, R., Bayliss, A. P., & Dux, P. E. (2012). Cognitive Load Disrupts Implicit Theory-of-Mind Processing. *Psychological Science*, *23*(8), 842–847. https://doi.org/10.1177/0956797612439070

Schneider, D., Slaughter, V. P., & Dux, P. E. (2014). What do we know about implicit false-belief tracking? In *Psychonomic Bulletin and Review* (Vol. 22, Issue 1). Springer New York LLC. https://doi.org/10.3758/s13423-014-0644-z

Schneider, D., Slaughter, V. P., & Dux, P. E. (2017). Current evidence for automatic Theory of Mind processing in adults. In *Cognition* (Vol. 162, pp. 27–31). Elsevier B.V. https://doi.org/10.1016/j.cognition.2017.01.018

Schulreich, S., Tusche, A., Kanske, P., & Schwabe, L. (2023). Higher subjective socioeconomic status is linked to increased charitable giving and mentalizing-related neural value coding. *NeuroImage*, *279*, 120315. https://doi.org/10.1016/j.neuroimage.2023.120315

Schuwerk, T., Jarvers, I., Vuori, M., & Sodian, B. (2016). Implicit mentalizing persists beyond early childhood and is profoundly impaired in children with autism spectrum condition. *Frontiers in Psychology*, *7*(OCT). https://doi.org/10.3389/fpsyg.2016.01696

Schuwerk, T., Kampis, D., Bohn, M., Fisher, C., Grosse Wiesmann, C., Hyde, D. C., Kulke Friedrich-Alexander, L., Mahowald, K., Mascaro, O., Prein, J., Raz, G., Saxe Dana Schneider Friedrich-Schiller, R., Southgate, V., Yuen, F., Rose Yuile, A., Zimmer, L., & Frank, M. C. (2021). Action Anticipation Based on an Agent's Epistemic State in Toddlers and Adults.

Schuwerk, T., Priewasser, B., Sodian, B., & Perner, J. (2018). The robustness and generalizability of findings on spontaneous false belief sensitivity: A replication attempt. *Royal Society Open Science*, *5*(5). https://doi.org/10.1098/rsos.172273

Scott, R. M., & Baillargeon, R. (2009). Which penguin is this? attributing false beliefs about object identity at 18 months. *Child Development*, *80*(4), 1172–1196. https://doi.org/10.1111/j.1467-8624.2009.01324.x

Scott, R. M., & Roby, E. (2015). Processing demands impact 3-year-olds' performance in a spontaneous-response task: New evidence for the processing-load account of early false-belief understanding. *PLoS ONE*, *10*(11). https://doi.org/10.1371/journal.pone.0142405

Scott, R. M., Roby, E., & Baillargeon, R. (2022). 11 How Sophisticated Is Infants Theory of Mind?. The cambridge handbook of cognitive development, 242.

Sehlstedt, I., Hansson, I., & Hjelmquist, E. (2024). The longitudinal relations between mental state talk and theory of mind. *BMC Psychology*, *12*(1). https://doi.org/10.1186/s40359-024-01692-y

Selcuk, B., Gonultas, S., & Ekerim-Akbulut, M. (2023). Development and use of theory of mind in social and cultural context. *Child Development Perspectives*, *17*(1), 39–45. https://doi.org/10.1111/cdep.12473

Sellabona, E. S., Sánchez, C. R., Majoral, E. V., Guitart, M. E., Caballero, F. S., & Ortiz, J. S. (2013). Labelling improves false belief understanding. A training study. The Spanish Journal of Psychology, 16, E6. https://doi.org/10.1017/sjp.2013.8

Senju, A., Southgate, V., Miura, Y., Matsui, T., Hasegawa, T., Tojo, Y., Osanai, H., & Csibra, G. (2010). Absence of spontaneous action anticipation by false belief attribution in children with

autism spectrum disorder. *Development and Psychopathology*, *22*(2), 353–360. https://doi.org/10.1017/S0954579410000106

Senju, A., Southgate, V., Snape, C., Leonard, M., & Csibra, G. (2011). Do 18-month-olds really attribute mental states to others?: A critical test. *Psychological Science*, *22*(7), 878–880. https://doi.org/10.1177/0956797611411584

Senju, A., Southgate, V., White, S., & Frith, U. (2009). Mindblind eyes: An absence of spontaneous theory of mind in Asperger syndrome. *Science*, *325*(5942), 883–885. https://doi.org/10.1126/SCIENCE.1176170

Serrat, E., Amadó, A., Durrleman, S., Intxaustegi, A., & Sidera, F. (2024). Expressive syntax matters for second-order false belief: a study with hearing-impaired children. *Frontiers in Communication*, *9*. https://doi.org/10.3389/fcomm.2024.1401576

Shahaeian, A., Haynes, M., & Frick, P. J. (2023). The role of language in the association between theory of mind and executive functioning in early childhood: New longitudinal evidence. *Early Childhood Research Quarterly*, *62*, 251–258. https://doi.org/10.1016/J.ECRESQ.2022.09.003

Shahaeian, A., Henry, J. D., Razmjoee, M., Teymoori, A., & Wang, C. (2015). Towards a better understanding of the relationship between executive control and theory of mind: An intra-cultural comparison of three diverse samples. *Developmental Science*, *18*(5), 671–685. https://doi.org/10.1111/desc.12243

Shatz, M. (1994). Theory of mind and the development of social-linguistic intelligence in early childhood. In C. Lewis & P. Mitchell (Eds.), *Children's early understanding of mind: Origins and development.* NJ: Erlbaum.

Shatz, M., Diesendruck, G., Martinez-Beck, I., & Akar, D. (2003). The influence of language and socioeconomic status on children's understanding of false belief. Developmental Psychology, 39(4), 717. https://doi.org/10.1037/0012-1649.39.4.717

Sheehy-Skeffington, J., Covarrubias, R. G., Croizet, J.-C., & Goudeau, S. (2024). Society in the classroom: Introduction to the special issue. *Wiley Online Library*, *80*(4), 1211–1217. https://doi.org/10.1111/josi.12659

Shepherd, S. V. (2010). Following gaze: gaze-following behavior as a window into social cognition. Frontiers in integrative neuroscience, 4, 5.https://doi.org/10.3389/fnint.2010.00005

Sheridan, M. A., Sarsour, K., Jutte, D., D'Esposito, M., & Boyce, W. T. (2012). The impact of social disparity on prefrontal function in childhood. *PLoS ONE*, *7*(4). https://doi.org/10.1371/JOURNAL.PONE.0035744

Shiel, G., Cregan, Á., McGough, A., & Archer, P. (2012). Oral language in early childhood and primary education (3-8 years). Dublin: National Council for Curriculum and Assessment.

Shokrkon, A., & Nicoladis, E. (2022). The Directionality of the Relationship Between Executive Functions and Language Skills: A Literature Review. In *Frontiers in Psychology* (Vol. 13). Frontiers Media S.A. https://doi.org/10.3389/fpsyg.2022.848696

Silletti, F., Salvadori, E. A., Presaghi, F., Fasolo, M., Aureli, T., & Coppola, G. (2022). Maternal mind-mindedness during the first year of life: Developmental trajectories and moderators. Developmental Psychology, 58(9), 1615. https://doi.org/10.1037/dev0001389

Šimleša, S., Hacin, K., Cepanec, M., & Pavliša, J. I. (2021). Importance of Language for Children's Theory of Mind:Comparison of Verbal and Nonverbal Theory of Mind Tasks. *Psihologija*, *54*(2), 123–135. https://doi.org/10.2298/PSI190924023S

Sirin, S. R. (2005). Socioeconomic Status and Academic Achievement: A Meta-Analytic Review of Research. *Review of Educational Research*, *75*(3), 417–453. https://doi.org/10.3102/00346543075003417

Skerry, A. E., & Spelke, E. S. (2014). Preverbal infants identify emotional reactions that are incongruent with goal outcomes. *Cognition*, *130*(2), 204–216. https://doi.org/10.1016/j.cognition.2013.11.002

Slade, L., & Ruffman, T. (2005). How language does (and does not) relate to theory of mind: A longitudinal study of syntax, semantics, working memory and false belief. *British Journal of Developmental Psychology*, *23*(1), 117–141. https://doi.org/10.1348/026151004X21332

Slade, P. D., Townes, B. D., Rosenbaum, G., Martins, I. P., Luis, H., Bernardo, M., Martin, M. D., & DeRouen, T. A. (2008). The Serial Use of Child Neurocognitive Tests: Development Versus Practice Effects. *Psychological Assessment*, *20*(4), 361–369. https://doi.org/10.1037/a0012950

Slaughter, V., & Gopnik, A. (1996). Conceptual Coherence in the Child's Theory of Mind: Training Children to Understand Belief. *Child Development*, *67*(6), 2967–2988. https://doi.org/10.1111/J.1467-8624.1996.TB01898.X

Slaughter, Virginia., & De Rosnay, Marc. (2017). Theory of mind development in context. Routledge.

Slavich, G. M. (2020). Social Safety Theory: A Biologically Based Evolutionary Perspective on Life Stress, Health, and Behavior. https://doi.org/10.1146/annurev-clinpsy-032816

Slavich, G. M., Roos, L. G., Mengelkoch, S., Webb, C. A., Shattuck, E. C., Moriarity, D. P., & Alley, J. C. (2023). Social Safety Theory: Conceptual foundation, underlying mechanisms, and future directions. *Health Psychology Review*, *17*(1), 5–59. https://doi.org/10.1080/17437199.2023.2171900

Smith, L. K., Draper, E. S., Manktelow, B. N., Dorling, J. S., & Field, D. J. (2007). Socioeconomic inequalities in very preterm birth rates. Archives of disease in childhood. Fetal and neonatal edition, 92(1), F11–F14. https://doi.org/10.1136/adc.2005.090308

Sodian, B. (2023). Reply to Poulin-Dubois et al. (2023): Replication problems concerning both implicit and explicit false belief reasoning greatly reduced the chance of finding longitudinal correlations. *Cognitive Development*, *65*. https://doi.org/10.1016/J.COGDEV.2022.101294

Sodian, B., Kaltefleiter, L. J., Schuwerk, T., & Kloo, D. (2024). Continuity in false belief understanding from 33 to 52 months of age. *Journal of Experimental Child Psychology*, *247*. https://doi.org/10.1016/j.jecp.2024.106039

Sodian, B., Kristen-Antonow, S., & Kloo, D. (2020). How Does Children's Theory of Mind Become Explicit? A Review of Longitudinal Findings. *Child Development Perspectives*, *14*(3), 171–177. https://doi.org/10.1111/cdep.12381

Sodian, B., Licata, M., Kristen-Antonow, S., Paulus, M., Killen, M., & Woodward, A. (2016). Understanding of Goals, Beliefs, and Desires Predicts Morally Relevant Theory of Mind: A Longitudinal Investigation. *Child Development*, *87*(4), 1221–1232. https://doi.org/10.1111/cdev.12533

Sodian, B., & Thoermer, C. (2004). Infants' understanding of looking, pointing, and reaching as cues to goal-directed action. In *Journal of Cognition and Development* (Vol. 5, Issue 3, pp. 289–316). https://doi.org/10.1207/s15327647jcd0503_1

Sotomayor-Enriquez, K., Gweon, H., Saxe, R., & Richardson, H. (2024). Open dataset of theory of mind reasoning in early to middle childhood. Data in brief, 52, 109905. https://doi.org/10.1016/j.dib.2023.109905

Southgate, V. (2020). Are Infants Altercentric? The Other and the Self in Early Social Cognition. *Psychological Review*, *127*(4), 505–523. https://doi.org/10.1037/rev0000182

Southgate, V., Chevallier, C., & Csibra, G. (2010). Seventeen-month-olds appeal to false beliefs to interpret others' referential communication. Developmental science, 13(6), 907-912. https://doi.org/10.1111/j.1467-7687.2009.00946.x

Southgate, V., Senju, A., & Csibra, G. (2007). Action Anticipation through Attribution of False Belief by 2-Year-Olds. In *Science* (Vol. 18, Issue 7). https://doi.org/10.1111/j.1467-9280.2007.01944.x

Speiger, M. L., Rothmaler, K., Bravo, A., Liszkowski, U., Rakoczy, H., & Wiesmann, C. G. (2024). Explicitly attributing false beliefs leads to altercentric biases in preschool children's search for objects. PsyArXiv Preprints, 10.

Speiger, M. L., Rothmaler, K., Liszkowski, U., Rakoczy, H., & Wiesmann, C. G. (2025). Evidence that altercentric biases in a continuous false belief task depend on highlighting the agent's belief. *Cognition*, *256*. https://doi.org/10.1016/j.cognition.2024.106055

Sperber, D., & Wilson, D. (1986). *Relevance: Communication and cognition. Harvard University Press.*

Spiegel, J. A., Goodrich, J. M., Morris, B. M., Osborne, C. M., & Lonigan, C. J. (2021). Relations between executive functions and academic outcomes in elementary school children: A meta-analysis. *Psychological Bulletin*, *147*(4), 329–351. https://doi.org/10.1037/bul0000322

Stein, M., Auerswald, M., & Ebersbach, M. (2017). Relationships between Motor and Executive Functions and the Effect of an Acute Coordinative Intervention on Executive Functions in Kindergartners. *Frontiers in psychology*, *8*, 859. https://doi.org/10.3389/fpsyg.2017.00859

Stellar, J. E., Manzo, V. M., Kraus, M. W., & Keltner, D. (2012). Class and compassion: socioeconomic factors predict responses to suffering. *Emotion (Washington, D.C.)*, *12*(3), 449–459. https://doi.org/10.1037/a0026508

Stenberg, G. (2013). Do 12-month-old infants trust a competent adult? *Infancy*, *18*(5), 873–904. https://doi.org/10.1111/infa.12011

Stephenson, L. J., Edwards, S. G., & Bayliss, A. P. (2021). From Gaze Perception to Social Cognition: The Shared-Attention System. *Perspectives on Psychological Science*, *16*(3), 553–576. https://doi.org/10.1177/1745691620953773

Steptoe, A., Kunz-Ebrecht, S., Owen, N., Feldman, P. J., Willemsen, G., Kirschbaum, C., & Marmot, M. (2003). Socioeconomic status and stress-related biological responses over the working day. *Biopsychosocial Science and Medicine*, *65*(3), 461-470. https://10.1097/01.PSY.0000035717.78650.A1

Stillman, T. F., Baumeister, R. F., Lambert, N. M., Crescioni, A. W., DeWall, C. N., & Fincham, F. D. (2009). Alone and without purpose: Life loses meaning following social exclusion. *Journal of Experimental Social Psychology*, *45*(4), 686–694. https://doi.org/10.1016/j.jesp.2009.03.007

Stoffel M.A, Nakagawa S., Schielzeth H. (2021). partR2: partitioning R^2 in generalized linear mixed models. https://doi.org/10.7717/peerj.11414

Stone, V. E., Baron-Cohen, S., & Knight, R. T. (1998). Frontal lobe contributions to theory of mind. Journal of cognitive neuroscience, 10(5), 640-656. https://doi.org/10.1162/089892998562942

Striano, T., Brennan, P. A., & Vanman, E. J. (2002). Maternal Depressive Symptoms and 6-Month-Old Infants' Sensitivity to Facial Expressions. *Infancy*, *3*(1), 115–126. https://doi.org/10.1207/S15327078IN0301_6

Stull, J. (2013). Family socioeconomic status, parent expectations, and a child's achievement. *Research in Education*, *90*(1), 53–67. https://doi.org/10.7227/RIE.90.1.4

Surian, L., & Geraci, A. (2012). Where will the triangle look for it? Attributing false beliefs to a geometric shape at 17 months. *British Journal of Developmental Psychology*, *30*(1), 30–44. https://doi.org/10.1111/j.2044-835X.2011.02046.x

Surtees, A. D. R., & Apperly, I. A. (2012a). Egocentrism and Automatic Perspective Taking in Children and Adults. *Child Development*, *83*(2), 452–460. https://doi.org/10.1111/j.1467-8624.2011.01730.x

Surtees, A. D. R., & Apperly, I. A. (2012b). Egocentrism and Automatic Perspective Taking in Children and Adults. *Child Development*, *83*(2), 452–460. https://doi.org/10.1111/J.1467-8624.2011.01730.X

Suryadi, S., Dhieni, N., & Edwita, E. (2025). The Influence of Socio-Economic Status, Parenting Style, and Self-Control on Children's Prosocial Behavior. *Islamic Guidance and Counseling Journal*, *8*(1). https://doi.org/10.25217/0020258545800

Tamis-LeMonda, C. S., Adolph, K. E., Lobo, S. A., Karasik, L. B., Ishak, S., & Dimitropoulou, K. A. (2008). When infants take mothers' advice: 18-month-olds integrate perceptual and social information to guide motor action. *Developmental Psychology*, *44*(3), 734–746. https://doi.org/10.1037/0012-1649.44.3.734

Tamis-LeMonda, C. S., Kuchirko, Y. A., Escobar, K., & Bornstein, M. H. (2019). Language and Play in Parent–Child Interactions. *Handbook of Parenting*, 189–213. https://doi.org/10.4324/9780429401695-7

Tanti, C., Stukas, A. A., Halloran, M. J., & Foddy, M. (2011). Social identity change: Shifts in social identity during adolescence. *Journal of Adolescence*, *34*(3), 555–567. https://doi.org/10.1016/j.adolescence.2010.05.012

Taylor, E. K., Abdurokhmonova, G., & Romeo, R. R. (2023). Socioeconomic Status and Reading Development: Moving from "Deficit" to "Adaptation" in Neurobiological Models of Experience-Dependent Learning. In *Mind, Brain, and Education* (Vol. 17, Issue 4, pp. 324–333). John Wiley and Sons Inc. https://doi.org/10.1111/mbe.12351

Taylor, J. E., Rousselet, G. A., Scheepers, C., & Sereno, S. C. (2023). Rating norms should be calculated from cumulative link mixed effects models. *Behavior Research Methods*, *55*(5), 2175–2196. https://doi.org/10.3758/s13428-022-01814-7

Tebbe, A. L., Rothmaler, K., Zielke, H. E., Hepach, R., & Wiesmann, C. G. (2025). Altercentric Memory Error at 9 Months But Correct Object Memory by 18 Months Revealed in Infants' Pupil. *Developmental Science*, *28*(3). https://doi.org/10.1111/desc.70016

Thoermer, C., Sodian, B., Vuori, M., Perst, H., & Kristen, S. (2012). Continuity from an implicit to an explicit understanding of false belief from infancy to preschool age. *British Journal of Developmental Psychology*, *30*(1), 172–187. https://doi.org/10.1111/j.2044-835X.2011.02067.x

Tomalski, P., Moore, D. G., Ribeiro, H., Axelsson, E. L., Murphy, E., Karmiloff-Smith, A., Johnson, M. H., & Kushnerenko, E. (2013). Socioeconomic status and functional brain development - associations in early infancy. *Developmental Science*, *16*(5), 676–687. https://doi.org/10.1111/DESC.12079

Tomasello, M., Carpenter, M., Call, J., Behne, T., & Moll, H. (2005). Understanding and sharing intentions: The origins of cultural cognition. *Behavioral and Brain Sciences*, *28*(5), 675–691. https://doi.org/10.1017/S0140525X05000129

Tompkins, V., Logan, J. A. R., Blosser, D. F., & Duffy, K. (2017). Child language and parent discipline mediate the relation between family income and false belief understanding. *Journal of Experimental Child Psychology*, *158*, 1–18. https://doi.org/10.1016/j.jecp.2017.01.001

Tong, Y., Wang, F., & Danovitch, J. (2020). The role of epistemic and social characteristics in children's selective trust: Three meta-analyses. *Developmental Science*, *23*(2). https://doi.org/10.1111/desc.12895

Tsui, A., Kachergis, G., Carstensen, A., Frank, M., Lew-Williams, C., Mathur, M., Bergmann, C., & Baumgartner, H. (2022). *MB1_Africa_RR_Stage1_accepted.pdf*. https://doi.org/10.17605/OSF.IO/JGR79

Urquiza-Haas, E. G., & Kotrschal, K. (2015). The mind behind anthropomorphic thinking: Attribution of mental states to other species. Animal behaviour, 109, 167-176. https://doi.org/10.1016/j.anbehav.2015.08.011

Villalobos, A. R., Padilla-Mora, M., & Trías, J. F. (2010). Authoritarian parenting received from mothers reveals individual differences in preschooler's false-belief, but not in advanced theory of mind. World Academy of Science, *Engineering and Technology, 66*, 132-137. https://doi.org/10.5281/zenodo.1332224

Vinden, P. G. (2001). Parenting attitudes and children's understanding of mind: A comparison of Korean American and Anglo-American families. *Cognitive development*, *16*(3), 793-809. https://doi.org/10.1016/S0885-2014(01)00059-4

Vukojević, M., Zovko, A., Talić, I., Tanović, M., Rešić, B., Vrdoljak, I., & Splavski, B. (2017). Parental socioeconomic status as a predictor of physical and mental health outcomes in children–literature review. Acta Clinica Croatica, 56(4.), 742-748. https://doi.org/10.20471/acc.2017.56.04.23

Wade, M., Browne, D. T., Plamondon, A., Daniel, E., & Jenkins, J. M. (2016). Cumulative risk disparities in children's neurocognitive functioning: A developmental cascade model. *Developmental Science*, *19*(2), 179–194. https://doi.org/10.1111/DESC.12302

Wade, M., Prime, H., Jenkins, J. M., Yeates, K. O., Williams, T., & Lee, K. (2018). On the relation between theory of mind and executive functioning: A developmental cognitive neuroscience perspective. In *Psychonomic Bulletin and Review* (Vol. 25, Issue 6, pp. 2119–2140). Springer Science and Business Media, LLC. https://doi.org/10.3758/s13423-018-1459-0

Walden, T. A., & Ogan, T. A. (1988). *The Development of Social Referencing* (Vol. 59, Issue 5).

Walhovd, K. B., Fjell, A. M., Wang, Y., Amlien, I. K., Mowinckel, A. M., Lindenberger, U., Duzel, S., Bartrés-Faz, D., Ebmeier, K. P., Drevon, C. A., Baaré, W. F. C., Ghisletta, P., Johansen, L. B., Kievit, R. A., Henson, R. N., Madsen, K. S., Nyberg, L., Harris, J. R., Solé-Padullés, C., … Brandmaier, A. M. (2022). Education and Income Show Heterogeneous Relationships to Lifespan Brain and Cognitive Differences Across European and US Cohorts. *Cerebral Cortex*, *32*(4), 839–854. https://doi.org/10.1093/cercor/bhab248

Wang, Z., Devine, R. T., Wong, K. K., & Hughes, C. (2016). Theory of mind and executive function during middle childhood across cultures. *Journal of Experimental Child Psychology*, *149*, 6–22. https://doi.org/10.1016/j.jecp.2015.09.028

Weber, A. M., Greiff, S., & Iliescu, D. (2023). Assessing Children in Developmental Research. European Journal of Psychological Assessment. https://doi.org/10.1027/1015-5759/A000808

Weber, M. (1922). *Wirtschaft und Gesellschaft*. Tübingen: Mohr. Weidema, A., Hollarek, M., Sijtsma, H., Lee, N. C., Walsh, R. J., van Buuren, M., & Krabbendam, L. (2023). Increased interference from conflicting perspectives and gender differences: A longitudinal study during adolescence. *Journal of Experimental Child Psychology*, *235*. https://doi.org/10.1016/j.jecp.2023.105717

Weimer, A. A., & Guajardo, N. R. (2005). False Belief, Emotion Understanding, and Social Skills Among Head Start and Non-Head Start Children. *Early Education & Development*, *16*(3), 341–366. https://doi.org/10.1207/s15566935eed1603_3

Weisleder, A., & Fernald, A. (2013). Talking to Children Matters: Early Language Experience Strengthens Processing and Builds Vocabulary. *Psychological Science*, *24*(11), 2143–2152. https://doi.org/10.1177/0956797613488145

Wellman, H. (2014). *Making minds: How theory of mind develops*. New York, NY: Oxford University Press.

Wellman, H. (2017). The Development of Theory of Mind: Historical Reflections. *Child Development Perspectives*, *11*(3), 207–214. https://doi.org/10.1111/cdep.12236

Wellman, H. M. (1990). The Child's Theory of Mind. Cambridge, MA: MIT Press.Wellman, H. M., Cross, D., & Watson, J. (2001). Meta-analysis of theory-of-mind development: The truth about false belief. Child development, 72(3), 655-684. https://doi.org/10.1111/1467-8624.00304

Wellman, H., & Liu, D. (2004). Scaling of Theory-of-Mind Tasks. *Child Development*, *75*(2), 523–541. https://doi.org/10.1111/J.1467-8624.2004.00691.X

Wellman, H. M., Fang, F., Liu, D., Zhu, L., & Liu, G. (2006). Scaling of theory-of-mind understandings in Chinese children. Psychological science, 17(12), 1075-1081. https://doi.org/10.1111/j.1467-9280.2006.01830.x

Wicker, B., Keysers, C., Plailly, J., Royet, J. P., Gallese, V., & Rizzolatti, G. (2003). Both of us disgusted in My insula: the common neural basis of seeing and feeling disgust. Neuron, 40(3), 655-664. https://doi.org/10.1016/S0896-6273(03)00679-2

Wickham, H., Vaughan, D., & Girlich, M. (2025). *tidyr: Tidy Messy Data. R package version 1.3.1*. https://tidyr.tidyverse.org

Williams, K. D. (2009). *Chapter 6 Ostracism* (pp. 275–314). https://doi.org/10.1016/S0065-2601(08)00406-1

Willms, J. D., & Tramonte, L. (2019). *The measurement and use of socioeconomic status in educational research*. In L. E. Suter, B. Denman, & E. Smith (eds), The SAGE Handbook of Comparative Studies in Education. London: Sage.

Willoughby, M. T., Blair, C. B., Wirth, R. J., & Greenberg, M. (2010). The Measurement of Executive Function at Age 3 Years: Psychometric Properties and Criterion Validity of a New Battery of Tasks. *Psychological Assessment*, *22*(2), 306–317. https://doi.org/10.1037/a0018708.supp

Willoughby, M. T., Camerota, M., King, K. M., Nduku, T., & Piper, B. (2023). Leveraging item-level accuracy and reaction time to address ceiling effects in the measurement of inhibitory control in preschool-aged children. Frontiers in Psychology, 14, 861441. https://doi.org/10.3389/fpsyg.2023.861441

Wilson, D., & Sperber, D. (2002). Truthfulness and relevance. Mind, 111(443), 583-632.

Wimmer, H. (1989). Common-Sense Mentalismus und Emotion: Einige entwicklungspsychologische Implikationen. In: Roth, E. (eds) Denken und Fühlen. Lehr- und Forschungstexte Psychologie, vol 32. Springer, Berlin, Heidelberg. https://doi.org/10.1007/978-3-642-75304-6_5

Wimmer, H., & Perner, J. (1983). Beliefs about beliefs: Representation and constraining function of wrong beliefs in young children's understanding of deception. *Cognition, 13*(1), 103–128. https://doi.org/10.1016/0010-0277(83)90004-5

Wirth, J. H., Sacco, D. F., Hugenberg, K., & Williams, K. D. (2010). Eye gaze as relational evaluation: Averted eye gaze leads to feelings of ostracism and relational devaluation. Personality and social psychology bulletin, 36(7), 869-882. https://doi.org/10.1177/0146167210370032

Woo, B. M., Liu, S., & Spelke, E. S. (2024). Infants rationally infer the goals of other people's reaches in the absence of first-person experience with reaching actions. *Developmental Science*, *27*(3). https://doi.org/10.1111/desc.13453

Woodward, A. L. (1998). Infants selectively encode the goal object of an actor's reach. *Cognition*, *69*(1), 1-34. https://doi.org/10.1016/S0010-0277(98)00058-4

Worthy, D., Brez, C., & Markman, A. (2011). Motivational influences on cognitive performance in children: Focus over fit. *Taylor & Francis*, *12*(1), 103–119. https://doi.org/10.1080/15248372.2010.535229

Wu, T., Weiland, C., McCormick, M., Hsueh, J. A., Snow, C., & Sachs, J. (2024). One Score to Rule Them All? Comparing the Predictive and Concurrent Validity of 30 Hearts and Flowers Scoring Approaches. *Assessment*. https://doi.org/10.1177/10731911241229566

Yott, J., & Poulin-Dubois, D. (2012). Breaking the rules: Do infants have a true understanding of false belief? *British Journal of Developmental Psychology*, *30*(1), 156–171. https://doi.org/10.1111/j.2044-835X.2011.02060.x

Zarbatany, L., & Lamb, M. E. (1985). Social referencing as a function of information source: Mothers versus strangers. Infant behavior and Development, 8(1), 25-33. https://doi.org/10.1016/S0163-6383(85)80014-X

Zeegers, M., Vente, W. de, & Nikolić, M. (2018). Mothers' and fathers' mind-mindedness influences physiological emotion regulation of infants across the first year of life. *Wiley Online Library*, *21*(6). https://doi.org/10.1111/desc.12689

Zelazo, P. D. (2006). The Dimensional Change Card Sort (DCCS): a method of assessing executive function in children. *Nature Protocols 2006 1:1*, *1*(1), 297–301. https://doi.org/10.1038/nprot.2006.46

Zelazo, P. D., Anderson, J. E., Richler, J., Wallner-Allen, K., Beaumont, J. L., & Weintraub, S. (2013). II. NIH Toolbox Cognition Battery (CB): Measuring executive function and attention. *Monographs of the Society for Research in Child Development*, *78*(4), 16–33. https://doi.org/10.1111/mono.12032

Zelazo, P. David., Astington, J. W., & Olson, D. R. (2009). Developing theories of intention: social understanding and self-control. Psychology Press.

Appendices

A1. Study 1

			b	*β*	SE	*z*	*p*
Loadings	Language	Process	1.00	.90	.00		
	Language	Syntax	.96	.87	.04	25.11	.00
	Language	Vocabulary	.99	.89	.04	25.13	.00
	EF	Congruent	1.00	.88	.00		
	EF	Inhibition	1.10	.93	.05	20.92	.00
	EF	Flexibility	1.07	.88	.06	17.53	.00
Covariances	EF	Language	.66	.81	.07	9.81	.00
Residual variances	Process		.19	.18	.03	7.38	.00
	Syntax		.26	.25	.02	10.31	.00
	Vocabulary		.20	.20	.03	8.15	.00
	Congruent		.23	.22	.03	7.43	.00
	Inhibition		.15	.14	.03	5.88	.00
	Flexibility		.27	.23	.04	7.81	.00
Latent factors variances	Language		.84	1.00	.06	12.99	.00
	EF		.80	1.00	.10	7.71	.00
Intercepts	Process		-.02	-.02	.05	-.42	.67
	Syntax		-.02	-.02	.05	-.41	.68
	Vocabulary		-.02	-.02	.05	-.42	.67
	Congruent		-.03	-.03	.05	-.61	.54
	Inhibition		-.07	-.07	.06	-1.29	.20
	Flexibility		-.11	-.10	.06	-1.94	.05
R^2	Process		.82				
	Syntax		.75				
	Vocabulary		.80				
	Congruent		.78				
	Inhibition		.86				

	b	*β*	SE	*z*	*p*
Flexibility	.77				

Table A1. Summary of confirmatory factor analysis for the two-factor model (Language and Executive Functions).

			b	*β*	SE	*z*	*p*	*95% CI*
Regressions	Language	SES	.53	.32	.07	7.76	.00	[.40, .67]
	Language	Age	1.18	.71	.08	14.59	.00	[1.02, 1.34]
	EF	SES	.23	.14	.07	3.54	.00	[.10, .36]
	EF	Age	1.32	.78	.09	14.48	.00	[1.14, 1.50]
	ToM	Language	.23	.38	.07	3.31	.00	[.09, .37]
	ToM	EF	.10	.16	.07	1.38	.17	[-.04, .23]
	ToM	SES	-.02	-.02	.06	-.27	.79	[-.14, .11]
	ToM	Age	-.01	-.01	.09	-.06	.96	[-.19, .18]
Indirect effects	Language		.12	.12	.04	3.07	.00	[.04, .20]
	EF		.02	.02	.02	1.26	.21	[-.01, .06]
Total effect			.13	.13	.05	2.38	.02	[.02, .23]

Table A2. Structural equation model estimated with MLR: regression paths and indirect effects among language, executive functions, and theory of mind.

			b	*β*	SE	*z*	*p*	95% CI
Regressions	Language	SES	.53	.32	.07	7.66	.00	[.40, .66]
	Language	Age	1.18	.71	.08	15.01	.00	[1.04, 1.35]
	EF	SES	.23	.14	.07	3.33	.00	[.10, .37]
	EF	Age	1.32	.78	.09	14.61	.00	[1.15, 1.50]
	ToM	Language	.23	.38	.07	3.22	.00	[.09, .37]
	ToM	EF	.10	.16	.07	1.30	.19	[-.05, .23]
	ToM	SES	-.02	-.02	.07	-.26	.79	[-.15, .11]
	ToM	Age	-.01	-.01	.09	-.05	.96	[-.21, .17]
Indirect effects	Language		.12	.12	.04	2.96	.00	[.05, .22]
	EF		.02	.02	.02	1.13	.26	[-.01, .07]
Total effect			.13	.13	.05	2.38	.02	[.02, .23]

Table A3. Structural equation model estimated with 1000 bootstrap samples: regression paths and indirect effects among language, executive functions, and theory of mind.

				b	*β*	SE	*z*	*p*	95% CI
Regressions	Language	SES		.54	.32	.07	8.04	.00	[.41, .68]
	Language	Age		1.19	.71	.08	14.21	.00	[1.03, 1.36]
	Language	SES x Age		-.14	-.09	.06	-2.44	.01	[-.26, -.03]
	ToM	SES		-.02	-.02	.06	-.36	.72	[-.15, .10]
	ToM	Age		.06	.06	.09	.68	.50	[-.11, .23]
	ToM	SES x Age		.02	.02	.06	.36	.72	[-.09, .13]
	ToM	Language		.27	.45	.06	4.73	.00	[.16, .38]
Indirect effect	Language			.15	.15	.03	4.28	.00	[.08, .22]
Total effect	Total			.13	.12	.05	2.35	.02	[.02, .23]
IMM				-.04	-.04	.02	-2.29	.02	[-.07, -.01]
Moderated effects	Low			.69	.41	.10	6.91	.00	[.49, .88]
	Mean			.54	.32	.07	8.04	.00	[.41, .68]
	High			.40	.23	.08	5.08	.00	[.25, .55]
Conditional moderated effects	Low			.19	.19	.04	4.21	.00	[.10, .27]
	Mean			.15	.15	.03	4.28	.00	[.08, .22]
	High			.11	.11	.03	3.46	.00	[.05, .17]

Table A4. Moderated mediation model (SEM) estimated with MLR: effects of SES and age on language and theory of mind. IMM = index of moderated mediation.

			b	*β*	SE	*z*	*p*	95% CI
Regressions	Language	SES	.54	.32	.07	7.78	.00	[.40, .68]
	Language	Age	1.19	.71	.08	14.09	.00	[1.04, 1.37]
	Language	SES x Age	-.14	-.09	.06	-2.33	.02	[-.27, -.03]
	ToM	SES	-.02	-.02	.06	-.35	.73	[-.14, .11]
	ToM	Age	.06	.06	.09	.68	.50	[-.10, .23]
	ToM	SES x Age	.02	.02	.06	.35	.73	[-.10, .13]
	ToM	Language	.27	.45	.06	4.62	.00	[.14, .38]
Indirect effect	Language		.15	.15	.04	4.02	.00	[.08, .22]
Total effect	Total		.13	.12	.05	2.33	.02	[.02, .23]
IMM			-.04	-.04	.02	-2.12	.03	[-.08, -.01]
Moderated effects	Low		.69	.41	.10	6.65	.00	[.50, .89]
	Mean		.54	.32	.07	7.78	.00	[.40, .68]
	High		.40	.23	.08	4.90	.00	[.26, .57]
Conditional moderated effects	Low		.19	.19	.05	3.94	.00	[.10, .29]
	Mean		.15	.15	.04	4.02	.00	[.08, .22]
	High		.11	.11	.03	3.22	.00	[.05, .19]

Table A5. Moderated mediation model (SEM) estimated with 1000 bootstrap samples: effects of SES and age on language and theory of mind. IMM = index of moderated mediation.

			b	*β*	SE	*z*	*p*	95% CI
Regressions	Language	Mother ed.	.34	.21	.10	3.39	.00	[.14, .54]
	Language	Mother oc.	.26	.16	.09	2.95	.00	[.09, .43]
	Language	Age	1.20	.72	.08	14.30	.00	[1.03, 1.36]
	EF	Mother ed.	.16	.09	.11	1.40	.16	[-.06, .37]
	EF	Mother oc.	.20	.12	.11	1.82	.07	[-.02, .41]
	EF	Age	1.35	.79	.09	14.49	.00	[1.16, 1.53]
	ToM	Language	.25	.41	.07	3.73	.00	[.12, .38]
	ToM	EF	.10	.17	.07	1.46	.14	[-.03, .23]
	ToM	Mother ed.	-.01	-.01	.08	-.12	.90	[-.17, .15]
	ToM	Mother oc.	-.07	-.07	.07	-.95	.34	[-.21, .07]
	ToM	Age	-.04	-.04	.10	-.39	.69	[-.22, .15]
Indirect effects	ToM (through language)	Mother ed.	.09	.09	.03	2.62	.01	[.02, .15]
	ToM (through language)	Mother oc.	.07	.07	.03	2.30	.02	[.01, .12]
	ToM (through EF)	Mother ed.	.02	.02	.02	.98	.33	[-.02, .05]
	ToM (through EF)	Mother oc.	.02	.02	.02	1.14	.26	[-.01, .05]
Total effect		Mother ed.	.10	.10	.04	2.88	.00	[.03, .17]
		Mother oc.	.09	.08	.03	2.73	.01	[.02, .15]

Table A6. Parallel mediation model (SEM) estimated with MLR: indirect effects of mother's education and occupation on theory of mind through language and executive functions

			b	*β*	SE	*z*	*p*	95% CI
Regressions	Language	Mother ed.	.34	.21	.11	3.21	.00	[.15, .58]
	Language	Mother oc.	.26	.16	.09	2.83	.00	[.08, .45]
	Language	Age	1.20	.72	.08	14.59	.00	[1.04, 1.35]
	EF	Mother ed.	.16	.09	.12	1.35	.18	[-.08, .37]
	EF	Mother oc.	.20	.12	.11	1.77	.08	[-.03, .42]
	EF	Age	1.35	.79	.09	14.63	.00	[1.18, 1.52]
	ToM	Language	.25	.41	.07	3.61	.00	[.12, .40]
	ToM	EF	.10	.17	.07	1.37	.17	[-.05, .23]
	ToM	Mother ed.	-.01	-.01	.08	-.12	.91	[-.17, .15]
	ToM	Mother oc.	-.07	-.07	.08	-.93	.35	[-.24, .06]
	ToM	Age	-.04	-.04	.10	-.38	.70	[-.25, .14]
Indirect effects	ToM (through language)	Mother ed.	.09	.09	.04	2.45	.01	[.03, .18]
	ToM (through language)	Mother oc.	.07	.07	.03	2.15	.03	[.02, .14]
	ToM (through EF)	Mother ed.	.02	.02	.02	.82	.41	[-.01, .07]
	ToM (through EF)	Mother oc.	.02	.02	.02	.99	.32	[.00, .07]
Total effect		Mother ed.	.10	.10	.04	2.64	.01	[.04, .19]
		Mother oc.	.09	.08	.03	2.54	.01	[.03, .16]

Table A7. Parallel mediation model (SEM) estimated with 1000 bootstrap samples: indirect effects of mother's education and occupation on theory of mind through language and executive function

			b	*β*	SE	*z*	*p*	95% CI
Regressions	Language	Education	.31	.19	.10	3.00	.00	[.11, .51]
	Language	Occupation	.25	.16	.10	2.49	.01	[.05, .45]
	Language	Age	1.20	.72	.08	14.63	.00	[1.04, 1.36]
	EF	Education	.11	.06	.11	.96	.34	[-.11, .32]
	EF	Occupation	.15	.09	.12	1.30	.19	[-.08, .38]
	EF	Age	1.33	.79	.09	14.45	.00	[1.15, 1.50]
	ToM	Language	.24	.39	.07	3.37	.00	[.10, .38]
	ToM	EF	.10	.16	.07	1.42	.16	[-.04, .23]
	ToM	Education	.09	.09	.08	1.06	.29	[-.07, .25]
	ToM	Occupation	-.12	-.12	.08	-1.46	.14	[-.28, .04]
	ToM	Age	-.01	-.01	.09	-.13	.89	[-.20, .17]
Indirect effects	ToM (through language)	Education	.07	.07	.03	2.38	.02	[.01, .13]
	ToM (through language)	Occupation	.06	.06	.03	1.94	.05	[.00, .12]
	ToM (through EF)	Education	.01	.01	.01	.79	.43	[-.02, .04]
	ToM (through EF)	Occupation	.01	.01	.02	.95	.34	[-.02, .05]
Total effect		Education	.08	.08	.04	2.41	.02	[.02, .15]
		Occupation	.08	.08	.03	2.16	.03	[.01, .14]

Table A8. Parallel mediation model (SEM) estimated with MLR: indirect effects of parental education and occupation on theory of mind through language and executive functions

			b	*β*	SE	*z*	*p*	95% CI
Regressions	Language	Education	.31	.19	.11	2.91	.00	[.10, .53]
	Language	Occupation	.25	.16	.11	2.39	.02	[.05, .49]
	Language	Age	1.20	.72	.08	15.01	.00	[1.05, 1.36]
	EF	Education	.11	.06	.11	.92	.36	[-.13, .33]
	EF	Occupation	.15	.09	.12	1.25	.21	[-.08, .40]
	EF	Age	1.33	.79	.09	14.49	.00	[1.15, 1.50]
	ToM	Language	.24	.39	.07	3.27	.00	[.09, .38]
	ToM	EF	.10	.16	.07	1.33	.18	[-.05, .23]
	ToM	Education	.09	.09	.08	1.04	.30	[-.08, .25]
	ToM	Occupation	-.12	-.12	.08	-1.45	.15	[-.29, .04]
	ToM	Age	-.01	-.01	.10	-.13	.89	[-.22, .16]
Indirect effects	ToM (through language)	Education	.07	.07	.03	2.22	.03	[.02, .16]
	ToM (through language)	Occupation	.06	.06	.03	1.79	.07	[.02, .16]
	ToM (through EF)	Education	.01	.01	.02	.63	.53	[-.01, .07]
	ToM (through EF)	Occupation	.01	.01	.02	.79	.43	[.00, .08]
Total effect		Education	.08	.08	.04	2.22	.03	[.02, .18]
		Occupation	.08	.08	.04	2.01	.04	[.01, .17]

Table A9. Parallel mediation model (SEM) estimated with 1000 bootstrap samples: indirect effects of parental education and occupation on theory of mind through language and executive functio

			b	*β*	SE	*z*	*p*	95% CI
Regressions	Vocabulary	SES	.34	.34	.04	8.96	.00	[.27, .42]
	Vocabulary	Age	.63	.62	.04	17.55	.00	[.56, .70]
	Syntax	SES	.24	.24	.04	5.85	.00	[.16, .32]
	Syntax	Age	.65	.64	.04	17.58	.00	[.58, .72]
	Process	SES	.27	.27	.04	6.51	.00	[.19, .35]
	Process	Age	.66	.65	.03	19.85	.00	[.59, .72]
	EF	SES	.23	.14	.07	3.43	.00	[.10, .36]
	EF	Age	1.31	.78	.09	14.46	.00	[1.14, 1.49]
	ToM	Vocabulary	.11	.11	.10	1.07	.29	[-.09, .31]
	ToM	Syntax	.18	.17	.09	2.02	.04	[.01, .35]
	ToM	Process	.04	.04	.10	.36	.72	[-.16, .23]
	ToM	EF	.13	.22	.06	2.05	.04	[.01, .26]
	ToM	SES	.01	.01	.06	.16	.88	[-.11, .13]
	ToM	Age	.02	.02	.09	.17	.86	[-.16, .19]
Indirect effects	ToM (through vocabulary)	SES	.04	.04	.04	1.06	.29	[-.03, .11]
	ToM (through syntax)	SES	.04	.04	.02	1.91	.06	[.00, .09]
	ToM (through process)	SES	.01	.01	.03	.36	.72	[-.04, .06]
	ToM (through EF)	SES	.03	.03	.02	1.73	.08	[.00, .06]
Total effect			.12	.12	.03	3.95	.00	[.06, .18]

Table A10. Parallel mediation model (SEM) estimated with MLR: indirect effects of socioeconomic status on theory of mind through vocabulary, syntax, process of learning new words, and executive functions

			b	*β*	SE	*z*	*p*	95% CI
Regressions	Vocabulary	SES	.34	.34	.04	9.08	.00	[.28, .42]
	Vocabulary	Age	.63	.62	.04	17.52	.00	[.56, .70]
	Syntax	SES	.24	.24	.04	6.07	.00	[.16, .32]
	Syntax	Age	.65	.64	.04	17.49	.00	[.58, .72]
	Process	SES	.27	.27	.04	6.40	.00	[.19, .36]
	Process	Age	.66	.65	.03	20.51	.00	[.60, .72]
	EF	SES	.23	.14	.07	3.24	.00	[.10, .37]
	EF	Age	1.31	.78	.09	14.59	.00	[1.15, 1.50]
	ToM	Vocabulary	.11	.11	.10	1.04	.30	[-.11, .31]
	ToM	Syntax	.18	.17	.09	1.98	.05	[.00, .35]
	ToM	Process	.04	.04	.10	.36	.72	[-.15, .23]
	ToM	EF	.13	.22	.07	1.92	.05	[.00, .27]
	ToM	SES	.01	.01	.06	.15	.88	[-.12, .13]
	ToM	Age	.02	.02	.09	.17	.86	[-.18, .18]
Indirect effects	ToM (through vocabulary)	SES	.04	.04	.04	1.02	.31	[-.04, .10]
	ToM (through syntax)	SES	.04	.04	.02	1.85	.06	[.00, .09]
	ToM (through process)	SES	.01	.01	.03	.36	.72	[-.04, .07]
	ToM (through EF)	SES	.03	.03	.02	1.54	.12	[.00, .08]
Total effect			.12	.12	.03	3.87	.00	[.06, .19]

Table A11. Parallel mediation model (SEM) estimated with 1000 bootstrap samples: indirect effects of socioeconomic status on theory of mind through vocabulary, syntax, process of learning new words, and executive functions.

			b	*β*	SE	*z*	*p*	95% CI
Regressions	Language	SES	.56	.33	.08	7.18	.00	[.40, .71]
	Language	Age	1.18	.71	.10	11.70	.00	[.98, 1.37]
	EF	SES	.25	.15	.07	3.71	.00	[.12, .39]
	EF	Age	1.35	.79	.09	14.52	.00	[1.17, 1.54]
	ToM	Language	.25	.37	.09	2.72	.01	[.07, .43]
	ToM	EF	.14	.22	.09	1.53	.13	[-.04, .33]
	ToM	SES	-.01	-.01	.08	-.17	.87	[-.17, .15]
	ToM	Age	-.08	-.07	.13	-.60	.55	[-.32, .17]
Indirect effects	Language		.14	.13	.06	2.53	.01	[.03, .25]
	EF		.04	.03	.03	1.43	.15	[-.01, .09]
Total effect			.16	.15	.07	2.26	.02	[.02, .30]

Table A12. Ordinal mediation model estimated with MLR: regression paths and indirect effects among language, executive functions, and theory of mind.

				b	*β*	SE	*z*	*p*	95% CI
Regressions	Language	SES		.60	.37	.08	7.84	.00	[.45, .76]
	Language	Age		1.07	.66	.09	11.29	.00	[.88, 1.25]
	Language	SES x Age		-.03	-.02	.06	-.45	.66	[-.14, .09]
	ToM	SES		.01	.01	.07	.08	.94	[-.14, .15]
	ToM	Age		.10	.10	.10	1.06	.29	[-.09, .29]
	ToM	SES x Age		.07	.07	.06	1.16	.25	[-.05, .19]
	ToM	Language		.25	.39	.07	3.70	.00	[.12, .38]
Indirect effect	Language			.15	.15	.04	3.59	.00	[.07, .23]
Total effect	Total			.16	.15	.06	2.64	.01	[.04, .27]
IMM				-.01	-.01	.02	-.44	.66	[-.04, .02]
Moderated effects	Low			.63	.39	.10	6.46	.00	[.44, .82]
	Mean			.60	.37	.08	7.84	.00	[.45, .76]
	High			.58	.35	.10	5.92	.00	[.39, .77]
Conditional moderated effects	Low			.16	.15	.05	3.34	.00	[.06, .25]
	Mean			.15	.15	.04	3.59	.00	[.07, .23]
	High			.14	.14	.04	3.42	.00	[.06, .22]

Table A13. Restricted sample - moderated mediation model (SEM) estimated with MLR: effects of SES and age on language and theory of mind. IMM = index of moderated mediation.

			b	*β*	SE	*z*	*p*	95% CI
Regressions	Language	SES	.60	.37	.08	7.66	.00	[.46, .77]
	Language	Age	1.07	.66	.10	11.10	.00	[.89, 1.27]
	Language	SES x Age	-.03	-.02	.06	-.42	.67	[-.16, .09]
	ToM	SES	.01	.01	.07	.08	.93	[-.13, .15]
	ToM	Age	.10	.10	.10	1.01	.31	[-.10, .31]
	ToM	SES x Age	.07	.07	.06	1.11	.27	[-.05, .20]
	ToM	Language	.25	.39	.07	3.64	.00	[.11, .37]
Indirect effect	Language		.15	.15	.04	3.52	.00	[.07, .24]
Total effect	Total		.16	.15	.06	2.61	.01	[.04, .27]
IMM			-.01	-.01	.02	-.39	.69	[-.04, .02]
Moderated effects	Low		.63	.39	.10	6.24	.00	[.45, .84]
	Mean		.60	.37	.08	7.65	.00	[.46, .77]
	High		.58	.35	.10	5.72	.00	[.38, .79]
Conditional moderated effects	Low		.16	.15	.05	3.24	.00	[.07, .26]
	Mean		.15	.15	.04	3.52	.00	[.07, .24]
	High		.14	.14	.04	3.32	.00	[.07, .23]

Table A14. Restricted sample – moderated mediation model (SEM) estimated with 1000 bootstrap samples: effects of SES and age on language and theory of mind. IMM = index of moderated mediation.

A2. Study 2

	t	*df*	*p*
EF	10.027	309.304	<.001
Language	11.595	314.131	<.001
SES	3.926	307.875	<.001

Table A15. Group comparisons between children excluded from RT analyses and those included on EF, Language, and SES. Entries report Welch's t statistic (*t*), degrees of freedom (*df*), and FDR-corrected p-values. Positive *t* values indicate higher scores in the included group.

	P+A+	P+A-	P-A+	P-A-
3 - 4	1596 (381)	1978 (291)	1839 (374)	1780 (295)
4 - 5	1548 (390)	1569 (285)	1673 (374)	1611 (357)
5 - 6	1281 (295)	1430 (377)	1530 (333)	1448 (323)
6 - 7	1098 (451)	1312 (411)	1402 (435)	1268 (352)
Overall	1317 (417)	1458 (388)	1545 (395)	1462 (369)

Table A16. Mean reaction times (ms) with standard deviations (Mean (SD)) for each condition (P+A+, P+A−, P−A+, P−A−) across age groups (3–4, 4–5, 5–6, 6–7). Overall aggregates all age groups.

	Estimate	**SE**	***z***	***p***
Intercept	1.20	0.09	13.72	*<.001*
Age	0.49	0.10	4.98	<.001
Agent (+)	0.21	0.17	1.21	.23
Participant (+)	0.42	0.17	2.38	.02
Participant (+) x Age	0.08	0.20	0.43	.67
Agent (+) x Age	0.09	0.20	0.45	.66

Table A17. Binomial logistic regression (logit) predicting accuracy. Estimates are log-odds. SE = standard errors. Age is z-scored. Factors are effect-coded (−½, +½): *Agent (+)* / *Participant (+)* corresponds to the + vs − contrasts at mean age.

Dispersion	**Null deviance (df = 839)**	**Residual deviance (df = 834)**	**AIC**	**Fisher scoring iterations**
1	875.49	841.86	853.86	4

Table A18. Model fit indices for the same binomial logit model: dispersion parameter (fixed at 1), null and residual deviances with degrees of freedom, Akaike Information Criterion (AIC), and number of Fisher scoring iterations.

	Estimate	**SE**	***z***	***p***
Age	0.71	0.09	7.82	0.00
Agent (+)	0.06	0.15	0.41	0.68
Participant (+)	-0.03	0.15	-0.21	0.83
Participant (+) x Age	-0.63	0.18	-3.52	0.00
Agent (+) x Age	0.05	0.18	0.27	0.79

Table A19. Proportional-odds (cumulative logit) model predicting accuracy. Estimates are on the latent logit scale; SE = standard errors. Age is z-scored. Factors are effect-coded (−½, +½): *Agent (+)* / *Participant (+)* corresponds to the + vs − contrasts at mean age.

Threshold	**Estimate**	**SE**	***z***
0|1	-2.38	0.13	-18.39
1|2	-0.60	0.08	-7.58

Table A20. Model thresholds for the proportional-odds logit linking ordinal response categories: 0|1 and 1|2. Logit estimates, standard errors, and Wald z statistics are reported.

	Estimate	**SE**	***t***	***p***
Intercept	0.22	0.04	5.83	*<.001*
Age	-0.38	0.04	-9.95	<.001
Agent (+)	-0.05	0.08	-0.62	.538
Participant (+)	-0.22	0.08	-2.89	.004
Participant (+) x Age	-0.06	0.08	-0.79	.433
Agent (+) x Age	-0.03	0.08	-0.34	.736

Table A21. Linear model predicting standardized reaction time. Standardized coefficients (Estimate), standard errors (SE), *t* statistics, and two-sided *p* values. RT and Age are z-scored. Agent and Participant were effect-coded (−½, +½).

Residual SE	Residual *df*	Adjusted R^2	*F*	*p*
0.82	645	0.15	23.36	<.001

Table A22. Model fit for the same linear model: residual standard error (Residual SE) with residual degrees of freedom, adjusted R^2, omnibus *F* test and *p* value.

A3. Study 3

Cohort	Session	Variable	*N*	*M*	SD
Preschool1	T0	ToM1	64	1.34	0.6
Preschool1	T0	ToM2			
Preschool1	T0	ToMI1	14	22.98	368.21
Preschool1	T0	ToMI2	18	44.61	497.98
Preschool1	T0	Process	96	0.34	0.23
Preschool1	T0	Syntax	96	0.41	0.2
Preschool1	T0	Vocabulary	94	0.46	0.21
Preschool1	T0	Inhibition	79	3.44	1.86
Preschool1	T0	Flexibility	72	2.66	1.43
Preschool1	T1	ToM1	94	1.68	0.71
Preschool1	T1	ToM2			
Preschool1	T1	ToMI1	27	36.68	301.3
Preschool1	T1	ToMI2	35	28.57	443.24
Preschool1	T1	Process	99	0.51	0.28
Preschool1	T1	Syntax	100	0.6	0.22
Preschool1	T1	Vocabulary	96	0.62	0.23
Preschool1	T1	Inhibition	100	4.43	1.81
Preschool1	T1	Flexibility	97	3.31	1.73
Preschool1	T2	ToM1	87	1.85	0.76
Preschool1	T2	ToM2	83	1.58	0.7
Preschool1	T2	ToMI1	53	-43.86	271.37
Preschool1	T2	ToMI2	57	37.2	448.8
Preschool1	T2	Process	87	0.69	0.26
Preschool1	T2	Syntax	88	0.69	0.22
Preschool1	T2	Vocabulary	88	0.74	0.21
Preschool1	T2	Inhibition	87	6.41	1.33
Preschool1	T2	Flexibility	87	5.3	1.77
Preschool2	T0	ToM1	94	1.97	0.82
Preschool2	T0	ToM2			
Preschool2	T0	ToMI1	52	-61.52	299.2
Preschool2	T0	ToMI2	57	-9.21	454.17

Preschool2	T0	Process	97	0.63	0.28
Preschool2	T0	Syntax	97	0.67	0.21
Preschool2	T0	Vocabulary	95	0.7	0.24
Preschool2	T0	Inhibition	101	5.33	1.69
Preschool2	T0	Flexibility	100	4.37	1.74
Preschool2	T1	ToM1	95	2.17	0.79
Preschool2	T1	ToM2	90	1.66	0.74
Preschool2	T1	ToMI1	66	-38.46	228.25
Preschool2	T1	ToMI2	70	89.76	447.29
Preschool2	T1	Process	94	0.75	0.24
Preschool2	T1	Syntax	95	0.79	0.2
Preschool2	T1	Vocabulary	93	0.79	0.2
Preschool2	T1	Inhibition	95	6.39	1.32
Preschool2	T1	Flexibility	95	5.44	1.67
Preschool2	T2	ToM1	83	2.3	0.74
Preschool2	T2	ToM2	85	1.8	0.72
Preschool2	T2	ToMI1	75	25.87	239.65
Preschool2	T2	ToMI2	76	127.22	316.58
Preschool2	T2	Process	84	0.86	0.13
Preschool2	T2	Syntax	84	0.87	0.14
Preschool2	T2	Vocabulary	84	0.88	0.15
Preschool2	T2	Inhibition	83	7.52	1.57
Preschool2	T2	Flexibility	83	6.97	1.27
Preschool3	T0	ToM1	96	2.09	0.86
Preschool3	T0	ToM2			
Preschool3	T0	ToMI1	73	9.46	262.81
Preschool3	T0	ToMI2	79	128.64	364.97
Preschool3	T0	Process	118	0.77	0.19
Preschool3	T0	Syntax	118	0.77	0.17
Preschool3	T0	Vocabulary	117	0.81	0.18
Preschool3	T0	Inhibition	109	6.25	1.56
Preschool3	T0	Flexibility	109	5.44	1.63
Preschool3	T1	ToM1	98	2.22	0.77

Preschool3	T1	ToM2	94	1.76	0.73
Preschool3	T1	ToMI1	85	19.49	221.61
Preschool3	T1	ToMI2	86	118.25	317.58
Preschool3	T1	Process	97	0.87	0.16
Preschool3	T1	Syntax	97	0.85	0.14
Preschool3	T1	Vocabulary	97	0.86	0.18
Preschool3	T1	Inhibition	98	7.07	0.92
Preschool3	T1	Flexibility	98	6.35	1.33
Preschool3	T2	ToM1	72	2.53	0.67
Preschool3	T2	ToM2	72	2.06	0.71
Preschool3	T2	ToMI1	62	6.55	192.4
Preschool3	T2	ToMI2	65	133.82	267.71
Preschool3	T2	Process	70	0.93	0.08
Preschool3	T2	Syntax	70	0.91	0.11
Preschool3	T2	Vocabulary	70	0.94	0.08
Preschool3	T2	Inhibition	66	7.87	0.9
Preschool3	T2	Flexibility	66	7.28	1.21

Table A23. Descriptive statistics by cohort and session for explicit ToM (first and second order), implicit ToM (both indices), all language components, and all EF components.

Estimated parameters of the cumulative link mixed models for first-order ToM (ToM1) and second-order ToM (ToM2).

	N	R^2 McFadden	R^2 McFadden adjusted	AIC	BIC
ToM1	779	0.06	0.06	1586.5	1605.1
ToM2	422	0.02	0.01	868.2	884.4

Table A24. Global fit indices of the unstandardized model.

Variable	Term	*b*	SE	*z*	*p*	*95% CI*	*β*
ToM1	0|1	-0.957	0.11	-8.705	<.001	[-1.17, -0.74]	
ToM1	1|2	0.913	0.11	8.316	<.001	[0.7, 1.13]	
ToM1	Age	0.076	0.008	8.95	<.001	[0.06, 0.09]	0.88
ToM2	0|1	-0.066	0.124	-0.535	.593	[-0.31, 0.18]	
ToM2	1|2	1.879	0.185	10.182	<.001	[1.52, 2.24]	
ToM2	Age	0.04	0.01	3.627	<.001	[0.02, 0.06]	0.46

Table A25. Fixed effects. Standardized estimates are on the logit scale.

Variable	Group	Variance	SD
ToMI1	Participant ID	0.931	0.965
ToMI2	Participant ID	0.057	0.238

Table A26. Unstandardized random effects.

Estimated parameters of the cumulative link mixed models with all predictors (ToM1 and ToM2).

	N	R² McFadden	R² McFadden adjusted	AIC	BIC
ToM1	715	0.18	0.166	1403.2	1448.9
ToM2	390	0.13	0.11	785.5	825.2

Table A27. Global fit indices of the unstandardized model.

Variable	Term	*β*	SE	*z*	*p*	95% CI
ToM1	0|1	-0.93	0.121	-7.67	<.001	[-1.17, -0.69]
	1|2	0.938	0.12	7.824	<.001	[0.7, 1.17]
	Age	0.492	0.115	4.278	<.001	[0.27, 0.72]
	Language	0.526	0.154	3.416	<.001	[0.22, 0.83]
	EF	0.324	0.159	2.043	.041	[0.01, 0.64]
	SES	0.279	0.104	2.678	.007	[0.08, 0.48]
	Age x Language	-0.102	0.151	-0.672	.502	[-0.40, 0.2]
	Age x EF	0.156	0.156	1.002	.317	[-0,15, 0.46]
	Age x SES	0.129	0.102	1.273	.203	[-0.07, 0.33]
ToM2	0|1	-0.061	0.142	-0.428	.669	[-0.34, 0.22]
	1|2	1.978	0.208	9.501	<.001	[1.57, 2.39]
	Age	0.126	0.184	0.687	.492	[-0.23, 0.49]
	Language	0.496	0.223	2.22	.026	[0.06, 0.93]
	EF	-0.026	0.224	-0.117	.907	[-0.47, 0.41]
	SES	0.101	0.157	0.644	.519	[-0.21, 0.41]
	Age x Language	-0.167	0.233	-0.717	.474	[-0.62, 0.29]
	Age x EF	0.399	0.256	1.56	.119	[-0.10, 0.90]
	Age x SES	0.31	0.158	1.966	.049	[0.001, 0.62]

Table A28. Fixed effects for the standardized models with all predictors. Estimates are on the logit scale.

Variable	Group	Variance	SD
ToMI1	Participant ID	0.452	0.672
ToMI2	Participant ID	0.072	0.268

Table A29. Unstandardized random effects.

Estimated parameters of the linear mixed models examining the effect of the agent's belief on RT (ToMI1) and on RT when the child's belief is positive (ToMI2).

	N	R^2 marginal	R^2 conditional	AIC	BIC
ToMI1	506	0.01	0.08	7024.6	7041.5
ToMI2	542	0.01	0.02	7978.2	7995.4

Table A30. Global fit indices of the unstandardized model.

Variable	Term	*b*	SE	*t*	*p*	*95% CI*	*β*
ToMI1	Intercept	-12.75	12.76	-0.999	.319	[-37.88, 12.39]	-0.04
	Age	1.95	1.15	1.699	.090	[-0.307, 4.207]	0.09
ToMI2	Intercept	70.22	17.76	3.953	<.001	[35.24, 105.21]	-0.05
	Age	4.43	1.613	2.747	.006	[1.26, 7.60]	0.14

Table A31. Fixed effects.

Variable	Group	Variance	SD
ToMI1	Participant ID	4636.3	68.1
	Residuals	58540.3	242
ToMI2	Participant ID	977.86	31.3
	Residuals	144799.4	380.5

Table A32. Unstandardized random effects.

Estimated parameters of the linear mixed models with all predictors (ToMI1 and ToMI2).

	N	R² marginal	R² conditional	AIC	BIC
ToMI1	466	0.02	0.08	6436.37	6477.8
ToMI2	501	0.02	0.04	7351	7393.2

Table A33. Global fit indices of the unstandardized model.

Variable	Term	*β*	SE	*t*	*p*	95% CI
ToMI1	Intercept	-0.066	0.06	-1.099	.273	[-0.18, 0.05]
	Age	0.128	0.073	1.761	.079	[-0.02, 0.27]
	Language	-0.005	0.098	-0.053	.958	[-0.20, 0.19]
	EF	0.035	0.106	0.335	.738	[-0.17, 0.24]
	SES	0.102	0.065	1.576	.116	[-0.03, 0.23]
	Age x Language	-0.029	0.101	-0.291	.771	[-0.23, 0.17]
	Age x EF	-0.042	0.11	-0.381	.703	[-0.26, 0.18]
	Age x SES	-0.094	0.069	-1.354	.177	[-0.23, 0.04]
ToMI2	Intercept	-0.057	0.058	-0.994	.321	[-0.17, 0.06]
	Age	0.168	0.068	2.467	.014	[0.03, 0.30]
	Language	-0.068	0.092	-0.737	.462	[-0.25, 0.11]
	EF	0.045	0.098	0.456	.649	[-0.15, 0.24]
	SES	0.056	0.061	0.909	.364	[-0.07, 0.18]
	Age x Language	0.019	0.094	0.204	.838	[-0.17, 0.20]
	Age x EF	-0.071	0.102	-0.691	.490	[-0.27, 0.13]
	Age x SES	0.016	0.065	0.24	.811	[-0.11, 0.14]

Table A34. Fixed effects for the standardized models with all predictors.

Variable	Group	Variance	SD
ToMI1	Participant ID	3481.3	59
	Residuals	58744.4	242.4
ToMI2	Participant ID	3209.4	56.65
	Residuals	144774.4	380.49

Table A35. Unstandardized random effects.

Publications

Articles dans des revues à comité de lecture

Houdayer, J., Le Stanc, L., Rémeau, M., de Carvalho, A., Houdé, O., Bardi, L., & Borst, G. (n.d.). Language, not executive functions, mediate the relation between family socioeconomic status and theory of mind [Manuscript submitted for publication].

Houdayer, J., Le Stanc, L., de Carvalho, A., Houdé, O., Bardi, L., & Borst, G. (n.d.). Developmental trajectories of implicit and explicit theory of mind: effects of language, executive functions and family SES in an accelerated longitudinal design [Manuscript in preparation].

Article de vulgarisation scientifique

Houdayer, J., & Borst, G. (2023). La théorie de l'esprit chez les enfants : développement, implications éducatives et contexte social. *Le 21 du LaPsyDÉ.*

Communications affichées

Houdayer, J., De Carvalho, A., Le Stanc, L., Houdé, O., Bardi, L., & Borst, G. (2023, March). Effect of family SES on the development of implicit and explicit theories of mind in preschool and school-aged children [Poster presentation]. Society for Research in Child Development, Salt Lake City, UT, United States.

Houdayer, J., Le Stanc, L., De Carvalho, A., Houdé, O., Bardi, L., & Borst, G. (2024, January). Effect of family SES on implicit and explicit theories of mind in preschool and school-aged children [Poster presentation]. Budapest CEU Conference on Cognitive Development, Budapest, Hungary.

Houdayer, J., Le Stanc, L., De Carvalho, A., Houdé, O., Bardi, L., & Borst, G. (2025, October). Developmental trajectories of implicit and explicit theory of mind: executive functions, language, and socioeconomic contributions [Poster presentation]. Social and moral brain seminar, Ghent, Belgium.

Communications orales

Houdayer, J. (2024, May). Statut socio-économique et développement des théories de l'esprit chez les enfants d'âges préscolaires et scolaires [Oral presentation]. Les inégalités dans le système éducatif et le rôle des interventions des scientifiques dans les classes. Laboratoire Astroparticule et Cosmologie, Paris, France.

Houdayer, J. (2024, October). Exploring the links between socio-economic status, implicit and explicit theory of mind in 5- to 6-year-old children [Oral presentation]. Journée des Babylabs 2024, Aix-Marseille Université, Marseille, France.

Houdayer, J. (2025, March). Effect of socioeconomic status on theory of mind development in preschool and school-aged children [Oral presentation]. NeuroSpin, Paris-Saclay, France.

Houdayer, J. (2025, March). Effect of socioeconomic status on theory of mind development in preschool and school-aged children [Oral presentation]. Ghent University, Ghent, Belgium.

Résumé de la thèse

Contexte

La cognition sociale désigne l'ensemble des processus mentaux permettant de percevoir, interpréter et répondre aux stimuli sociaux (Adolphs, 1999 ; Frith & Frith, 2007). Elle comprend, entre autres, la reconnaissance des émotions, mais également l'interprétation de signaux tels que les regards ou la posture, facilitant ainsi les interactions sociales (Frith & Frith, 2007). Elle se développe progressivement chez les enfants, avec plusieurs mécanismes présents dès la première année de vie. Par exemple, les enfants développent avec l'âge leurs capacités d'attention conjointe (i.e., la capacité à coordonner son attention avec celle d'une autre personne vers un même objet ou évènement ; Mundy & Newell, 2007), ou encore deviennent de plus en plus experts dans l'évaluation des individus, préférant apprendre auprès de personnes perçues comme compétentes ou familières (Stenberg, 2013 ; Tong et al., 2020). Ces compétences sociales constituent le fondement du développement de la théorie de l'esprit.

La théorie de l'esprit (TdE, Premack & Woodruff, 1978) désigne la capacité à se percevoir et à percevoir les autres comme des êtres psychologiques dotés d'états mentaux (croyances, désirs, intentions et émotions, Astington & Dack, 2000). La TdE est généralement évaluée par les tâches de fausse croyance (Wellman et al., 2001 ; Wimmer & Perner, 1983 ; Baron-Cohen et al., 1985). Dans la version originale de cette tâche, appelée Max et le chocolat (Wimmer & Perner, 1983), l'expérimentateur raconte à l'enfant une histoire dans laquelle Max place une tablette de chocolat dans un placard vert. Pendant que Max est sorti, sa mère déplace le chocolat dans un placard bleu. Lorsque Max revient, l'expérimentateur demande à l'enfant d'indiquer où Max ira chercher le chocolat. L'objectif est d'évaluer si les enfants sont en mesure de prédire les actions d'un personnage compte tenu de sa fausse croyance (i.e., Maxi ira chercher la tablette de chocolat dans le placard vert car il n'a pas été témoin de son déplacement dans le placard bleu).

La réussite à ces tâches reflète la capacité de l'enfant à reconnaître qu'une personne peut avoir une croyance différente de la réalité, que cette croyance peut être différente de la sienne, et que les croyances influencent nos comportements. Les enfants de moins de 4 ans échouent souvent à ces tâches, en répondant selon leur propre connaissance de la situation (i.e., Max ira chercher

la tablette dans le placard vert, où il l'a vue pour la dernière fois) plutôt qu'en adoptant le point de vue du personnage (Max ira chercher la tablette dans le placard bleu, car c'est là où il l'a vue pour la dernière fois). Cette capacité correspond à la TdE de premier ordre (attribuer des états mentaux à autrui), mais cette capacité continue de se développer jusqu'à l'âge adulte vers des formes plus complexes, telles que les croyances de second ordre (attribuer des états mentaux à autrui vis-à-vis des états mentaux d'une troisième personne), l'ironie, ou le sarcasme (Perner & Wimmer, 1985 ; Osterhaus & Koerber, 2021).

Des travaux ultérieurs ont en revanche montré que lorsque l'on adapte les tâches de fausses croyances au répertoire comportemental des jeunes enfants, ils sont en mesure d'attribuer des fausses croyances de façon très précoce, bien avant l'âge de 4 ans (Onishi & Baillargeon, 2005 ; Clements & Perner, 1994). Ce résultat a ensuite été confirmé de nombreuses fois chez les enfants à l'aide de divers paradigmes expérimentaux (e.g., Southgate et al., 2007 ; Buttelmann et al., 2009), permettant de mettre en avant un type de tâche dite implicite, traitée différemment par les jeunes enfants. Ce paradoxe développemental (i.e., les jeunes enfants semblent montrer une sensibilité aux fausses croyances dans les tâches implicites, tandis que les enfants de moins de 5 ans échouent généralement dans les tâches explicites classiques) a donné lieu à la distinction entre une forme implicite de TdE, présente très tôt chez les enfants, et une forme explicite de TdE, plus tardive (Clements & Perner, 1994).

Plusieurs hypothèses ont été avancées pour tenter d'expliquer ce paradoxe développemental. Selon certains chercheurs, la TdE explicite et implicite relèveraient d'une même compétence (Baillargeon et al., 2010). Les difficultés rencontrées dans les tâches explicites seraient alors dues aux fortes exigences langagières et exécutives qu'elles imposent (Carruthers et al., 2016). D'autres auteurs défendent l'idée de deux systèmes distincts, un système rapide, inflexible et automatique, et un autre plus lent, conscient et délibéré (Apperly & Butterfill, 2009). D'autres encore estiment que les performances observées dans les tâches de TdE implicite ne reflètent pas de véritables capacités de TdE, mais résultent plutôt de simples réactions attentionnelles automatiques reflétant des processus de bas niveau (Heyes, 2014). Malgré des arguments empiriques en faveur de chaque position, aucune explication théorique ne fait encore consensus. Par ailleurs, les résultats issus des paradigmes implicites ont été remis en question par la crise de la réplicabilité (Kulke & Rakoczy, 2018), plusieurs études ayant mis en évidence des difficultés à reproduire les effets observés dans les trois types de paradigmes expérimentaux chez les enfants (Barone et al., 2019 ; 2021).

L'évaluation de la TdE implicite ne se limite pas aux jeunes enfants. Chez l'adulte, elle a été plusieurs fois mise en évidence par le biais de la *ball detection task* (Kovács et al., 2010). Cette tâche a montré que les individus attribuent spontanément des états mentaux à autrui même lorsque la prise en compte de ces états mentaux n'est pas pertinente pour la tâche en cours. Dans cette tâche, les participants doivent détecter la présence d'une balle le plus rapidement possible. La croyance du participant et celle d'un agent quant à la localisation de la balle sont manipulées. Il a été montré que les participants sont plus rapides pour détecter un objet lorsque l'agent croit que l'objet sera présent, même lorsqu'eux-mêmes pensent que la balle ne sera pas présente. Ces résultats indiquent que les individus prennent en compte les états mentaux de façon spontanée, et que cela impacte leurs processus cognitifs. Cet effet a été largement répliqué par la suite (Deschrijver et al., 2016 ; Nijhof et al., 2016, 2018 ; Bardi et al., 2017a, 2017b, 2019 ; Boccadoro et al., 2019 ; El Kaddouri et al., 2020 ; Hudson et al., 2021 ; Low et al., 2020). Cette tendance correspond à un biais altérocentrique (i.e., lorsque la perspective d'autrui interfère avec nos propres processus cognitifs ; Kampis & Southgate, 2020), mis en évidence par la suite à travers d'autres tâches, notamment chez les enfants de maternelle (Speiger et al., 2025).

De nombreuses études ont tenté de savoir si un lien existait entre la TdE explicite et implicite. Par exemple, une version adaptée de la *ball detection task*, incluant à la fois une version explicite et une version implicite a mis en évidence des activations cérébrales communes aux deux types de TdE (la jonction temporo-pariétale et le cortex préfrontal médian ; Kovács et al., 2014 ; Bardi et al., 2017a ; Nijhof et al., 2018). Ces résultats soutiennent l'idée que des processus implicites persistent à l'âge adulte et partagent certaines des activations cérébrales associées à la TdE explicite.

Afin d'investiguer ces liens chez les enfants, plusieurs études longitudinales ont testé si la TdE implicite précoce prédisait les capacités de TdE explicite ultérieures. Les résultats de ces études sont contrastés. Des associations positives ont été rapportées (Thoermer et al., 2012 ; Sodian et al., 2016 ; Kloo et al., 2020), mais d'autres études ne répliquent pas ces liens (Poulin-Dubois et al., 2020, 2023 ; Grosse Wiesmann et al., 2017). Dans l'ensemble, les résultats suggèrent une continuité possible entre les deux capacités (Sodian et al., 2020), sans apporter de réponse précise au débat théorique en cours. Les mêmes disparités dans les résultats ont été identifiées chez les enfants d'âge préscolaire. Certaines études montrent un lien entre TdE explicite et implicite chez les enfants de 3 à 4 ans (Low, 2010 ; Kaltefleiter et al., 2022), tandis que d'autres montrent une absence de corrélation entre les deux (Grosse Wiesmann et al., 2017), ainsi que des marqueurs cérébraux distincts (Grosse Wiesmann et al., 2020). Par ailleurs, certains auteurs

ont récemment montré un lien entre le biais altérocentrique et la TdE explicite, indiquant que seuls les enfants ayant développé leur TdE explicite montraient ce biais (Speiger et al., 2025).

La trajectoire développementale de la TdE implicite après 3 - 4 ans reste peu documentée. Une fragilité a été identifiée par certaines études qui montrent notamment une prise en compte spontanée des états mentaux d'autrui à 4 ans, mais pas à 2 et 3 ans (Grosse Wiesmann et al., 2018), contrairement à ce qui a été montré auparavant (e.g., Southgate et al., 2007 ; He et al., 2011). Concernant le biais altérocentrique, les données suggèrent une trajectoire développementale en U pour cette capacité, qui serait présente chez le nourrisson, atténuée ou absente plus tardivement dans l'enfance, et qui réémergerait à l'âge adulte (Southgate, 2020 ; Fogd et al., 2024, 2025 ; Manea et al., 2023 ; Tebbe et al., 2025).

Par ailleurs, le rôle du langage dans le développement de la TdE explicite est désormais bien établi. Par exemple, les compétences syntaxiques et lexicales, la compréhension des phrases complétives, ou encore la compréhension des termes se référant aux états mentaux (e.g., penser, croire, savoir) prédisent la réussite aux tâches de fausse croyance explicite (Astington & Jenkins, 1999 ; Milligan et al., 2007). Les fonctions exécutives (FE), composées de la mémoire de travail, de l'inhibition et de la flexibilité cognitive, correspondent aux capacités de haut niveau qui permettent aux individus de réguler intentionnellement leurs pensées et leurs actions afin d'atteindre leurs objectifs (Diamond, 2013). De nombreuses études ont montré un lien entre les FE et la TdE explicite (Devine & Hughes, 2014). Les deux capacités seraient fortement liées au cours du développement. Par exemple, les FE nous permettraient d'inhiber notre propre connaissance de la réalité pour adopter la perspective d'autrui (Carlson et al., 2002).

Enfin, certains facteurs environnementaux, tels que le statut socio-économique (SES), sont liés à la TdE explicite (Devine & Hughes, 2018). Le SES, généralement composé du niveau d'étude, du métier, ou des revenus des parents, est un prédicteur du développement cognitif des enfants (Hackman et al., 2010). Le SES pourrait notamment impacter la TdE par l'effet qu'il produit sur les capacités langagières et exécutives (Noble et al., 2005). En effet, de nombreuses études ont montré que les enfants issus de milieux socio-économiques favorisés présentent, en moyenne, de meilleures compétences langagières et exécutives, qui, à leur tour, influenceraient le développement de la TdE explicite (Devine & Hughes, 2018).

Si de nombreuses études ont identifié les prédicteurs de la TdE explicite, les mécanismes qui sous-tendent la TdE implicite restent méconnus (Roby & Scott, 2017). Certaines études

suggèrent un lien entre la TdE implicite et le langage (San Juan & Astington, 2017 ; Meristo et al., 2012) et entre la TdE implicite et les FE (Poulin-Dubois et al., 2012 ; Schneider et al., 2012), tandis que d'autres montrent que la TdE implicite est indépendante de ces capacités générales (Grosse Wiesmann et al., 2017 ; Low, 2010). De plus, aucune étude n'a évalué l'impact des facteurs environnementaux dans le développement de la TdE implicite (Roby & Scott, 2017). Cela soulève la question de savoir si le statut socio-économique ainsi que les facteurs cognitifs et langagiers, influencent non seulement le raisonnement explicite autour des états mentaux, mais également les processus automatiques et spontanés de compréhension sociale.

Les objectifs de cette thèse sont les suivants :

- Clarifier le rôle des FE et du langage dans la relation entre le SES et la TdE explicite
- Evaluer la relation entre la TdE explicite et implicite chez les enfants d'âges préscolaires
- Déterminer les prédicteurs des trajectoires développementales de TdE explicite, et déterminer si ces prédicteurs sont les mêmes pour la TdE implicite au cours du développement

Méthode générale

L'ensemble des analyses est présenté en trois chapitres, comprenant une étude transversale (étude 1 et 2) et une étude longitudinale accélérée (étude 3).

Pour l'étude transversale, 391 enfants âgés de 3 à 7 ans ont été recrutés dans des écoles maternelles et élémentaires publiques de Paris. Les 4 groupes d'âge comprenaient respectivement 102 enfants de 3 à 4 ans, 108 de 4 à 5 ans, 114 de 5 à 6 ans, 67 de 6 à 7 ans.

Une sous-cohorte longitudinale (enfants âgés de 3 à 6 ans) a été suivie pour deux points de mesure supplémentaires (T1 et T2). Parmi ce sous-échantillon, 354 enfants (189 garçons, 165 filles) ont participé à au moins un point de mesure. L'intervalle moyen était de 0,45 an entre T0 et T1, et de 0,78 an entre T1 et T2. L'ensemble du protocole a été approuvé par le comité d'éthique de l'Université Paris Cité (IRB 00012024-63).

L'étude longitudinale accélérée comprenait trois temps de mesure (T0, T1, T2), chacun composé de deux à trois sessions individuelles d'environ une heure au total. Tous les enfants participaient à l'évaluation transversale à T0, et seuls les élèves de maternelle étaient suivis pour les sessions longitudinales.

Les mesures suivantes ont été collectées :

La TdE a été mesurée à l'aide de versions adaptées de la *ball detection task* (El Kaddouri et al., 2020). Les versions implicites et explicites étaient évaluées grâce au même matériel, à savoir des vidéos mettant en scène Buzz l'Éclair (Toy Story) et une coccinelle. Dans la version implicite, les enfants doivent détecter la présence d'une coccinelle le plus rapidement possible. La croyance du participant et celle d'un agent quant à la localisation de la coccinelle sont manipulées et peuvent être vraies ou fausses. Les temps de réaction et les réponses correctes des participants sont mesurés. Dans les versions explicites, de premier et de second ordre, les enfants devaient répondre à des questions sur les croyances des personnages après visionnage des vidéos. Le second ordre, introduit à T1, ajoutait un troisième personnage, Woody.

Les compétences langagières ont été évaluées à l'aide de la version française du *Quick Interactive Language Screener* (QUILS), mesurant le vocabulaire réceptif, la syntaxe et l'apprentissage de nouveaux mots (de Carvalho et al., in prep).

Les fonctions exécutives ont été évaluées grâce à la tâche des Cœurs et Fleurs (*Hearts & Flowers*, Davidson et al., 2006**)**, composée de blocs congruents, incongruents et mixtes. Les performances étaient calculées selon la méthode à deux vecteurs (Zelazo et al., 2013), intégrant la proportion de réponses correctes et le temps de réaction. Les blocs incongruent et mixte évaluaient respectivement l'inhibition et la flexibilité cognitive.

Enfin, le SES familial a été évalué à partir du niveau d'étude et du métier le plus élevé des deux parents, en suivant la classification internationale des professions ISCO-08 (ILO, 2012) et les indices socio-économiques ISEI-08 (Ganzeboom, 2010).

Étude 1

Parmi les médiateurs possibles de la relation entre le SES et la TdE explicite, le langage occupe une place centrale. Il est à la fois fortement influencé par le SES (Noble et al., 2005 ; Ma et al., 2024) et constitue un important prédicteur de la TdE explicite (Milligan et al., 2007). Les études suggèrent que le SES impacte l'environnement langagier dans lequel les enfants évoluent (Hoff et al., 2003). Par ailleurs, un environnement favorisant l'acquisition du vocabulaire relatif aux états mentaux et des structures syntaxiques serait nécessaire à la compréhension des fausses croyances (de Villiers & de Villiers, 2025). Toutefois, certaines études suggèrent que le langage ne suffit pas à expliquer l'effet du SES sur la TdE.

Les FE constituent un autre médiateur potentiel. Également influencées par le SES, notamment via le stress fréquent vécu par les parents (Friedman & Robbins, 2022), ou le manque d'accès à du matériel favorisant la stimulation cognitive (Kishiyama et al., 2009), les FE sont fortement liées à la TdE (Devine & Hughes, 2014). Langage et FE sont par ailleurs étroitement liés, suggérant que leurs effets sur la TdE pourraient être indépendants mais également conjoints (Gooch et al., 2016a).

En revanche, aucune étude n'a évalué la contribution simultanée de ces deux facteurs dans un modèle de médiation parallèle. Cette étude vise donc à examiner simultanément le rôle médiateur du langage et des FE dans la relation entre SES familial et TdE explicite. Un échantillon de 391 enfants français âgés de 3 à 7 ans a été évalué sur leurs compétences en TdE explicite (tâche de fausse croyance), leurs capacités langagières (vocabulaire, syntaxe, apprentissage de nouveaux mots) et leurs FE (inhibition, flexibilité). Le SES (diplôme et métier le plus élevé entre les deux parents) était également collecté. Cette étude vise également à explorer l'effet modérateur de l'âge, compte tenu des changements développementaux connus dans ces relations (Devine & Hughes, 2018).

Une analyse factorielle exploratoire puis confirmatoire a permis d'identifier un modèle à deux facteurs latents : un facteur langagier, regroupant le vocabulaire, la syntaxe et l'apprentissage de nouveaux mots, et un facteur FE, regroupant les trois composantes de la tâche des Cœurs et des Fleurs (congruence, inhibition et flexibilité cognitive). Ces variables latentes ont ensuite été intégrées dans des modèles d'équation structurelle (SEM).

Les résultats ont montré que le SES exerçait des effets directs significatifs sur le langage et les FE, mais seul le langage prédisait significativement la TdE. Par ailleurs, l'effet du SES sur la TdE était entièrement médié par le langage, mais pas par les FE. Des analyses complémentaires ont révélé que seul le niveau d'étude parental influençait la TdE par le langage. Parmi les composantes linguistiques, la syntaxe montrait la contribution la plus forte, bien que marginale, tandis que le vocabulaire et l'apprentissage de nouveaux mots n'avaient pas d'effet distinct. En tenant compte des effets plafonds potentiels de la tâche de langage, les résultats ont montré que l'âge ne modérait pas l'effet médiateur du langage sur l'association entre le SES et la TdE explicite.

Dans l'ensemble, les résultats ont montré que le SES est associé à la TdE, au langage et aux FE ; que le langage permet d'expliquer la relation SES–TdE lorsque l'âge et les FE sont pris en

compte ; et qu'une fois les effets plafonds pris en compte, l'effet indirect du langage ne variait pas avec l'âge.

Ces résultats montrent le rôle fondamental du langage dans la réussite aux tâches de fausse croyance (Tompkins et al., 2017). Parmi les différentes dimensions du langage, la syntaxe semble montrer le lien le plus fort, bien que les différences entre les trois composantes langagières ne soient pas significativement différentes. Parmi les différents aspects du SES, seul le niveau d'étude parental montre un effet via le langage. Cet effet pourrait être expliqué par l'effet du niveau d'étude sur les interactions parents-enfants (Monna & Gauthier, 2008), soulignant l'importance des interactions précoces dans le développement de la TdE.

Étude 2

Depuis les résultats mis en évidence par Onishi & Baillargeon (2005), les comportements des jeunes enfants dans les tâches de fausse croyance adaptées ont remis en cause l'idée que la TdE n'émerge qu'à partir de 4 ans (Southgate et al., 2007 ; Buttelmann et al., 2009). Cette découverte a conduit à distinguer une TdE implicite, évaluée grâce à des mesures indirectes, et une TdE explicite, évaluée par des tâches verbales de fausse croyance (Clements & Perner, 1994).

Les résultats de la littérature restent cependant contradictoires vis-à-vis de la relation entre ces deux formes de TdE. Certaines études montrent des corrélations comportementales entre TdE implicite et explicite (Kloo et al., 2020 ; Low, 2010), soutenant l'idée d'un continuum (Baillargeon et al., 2010). D'autres, en revanche montrent que les deux compétences ne sont pas corrélées, et qu'elles reposent sur des structures cérébrales distinctes (Grosse Wiesmann et al., 2017 ; 2020), dans le sens de la théorie des deux systèmes (Apperly & Butterfill, 2009). Par ailleurs, la recherche sur la TdE implicite présente plusieurs défis, tels que les difficultés de réplication des paradigmes majoritairement utilisés (AL, VOE, comportements d'aide), et rareté des études sur les enfants d'âge préscolaire et scolaire, pourtant essentiels pour comprendre son développement.

Enfin, les facteurs explicatifs de la variabilité en TdE implicite demeurent mal connus. Alors que le SES familial influence la TdE explicite via le langage, son rôle sur la TdE implicite n'a jamais été évalué. De même, les liens entre langage, FE et TdE implicite restent contradictoires (Grosse Wiesmann et al., 2017 ; Poulin-Dubois et al., 2012).

Cette étude vise donc à évaluer les relations entre la TdE implicite et explicite chez les enfants d'âge préscolaire et scolaire, ainsi que les associations avec le langage, les FE et le SES. Nous avons repris exactement le même échantillon et les mêmes tâches que dans l'étude 1 (391 enfants français, 3–7 ans) en incluant la TdE implicite dans les analyses. Les enfants ont ainsi été évalués en TdE explicite (fausse croyance) et TdE implicite (fausse croyance spontanée), ainsi que sur le langage (vocabulaire, syntaxe, apprentissage de nouveaux mots), les FE (inhibition, flexibilité) et le SES (diplôme et métier le plus élevé entre les deux parents).

Pour évaluer la capacité de TdE implicite des enfants, nous avons adapté la *ball detection task* (El Kaddouri et al., 2020). Parmi les changements, nous avons remplacé la balle par une coccinelle, pour adapter le matériel aux enfants et réduire l'effet inhabituel lié au mouvement autonome d'un objet inanimé. Les essais étaient présentés dans un ordre fixe et leur nombre était réduit à deux par conditions, afin de correspondre aux capacités attentionnelles des jeunes enfants (Brooker et al., 2019). Enfin, afin de réduire la demande cognitive associée à la tâche, la seconde consigne, qui consiste à appuyer sur un bouton lorsque l'agent quitte la pièce (correspondant à la vérification de l'attention), a été retirée.

Des modèles binomiaux, ordinaux et linéaires ont été utilisés pour évaluer l'effet de la croyance du participant et de la croyance de l'agent, ainsi que leur interaction avec l'âge, sur la proportion de réponses correctes et les temps de réaction. Les prédicteurs (langage, FE, SES) ont été résumés par des indices composites à l'aide d'une analyse en composante principale.

Les analyses relatives à la proportion de réponses correctes montrent un effet significatif de la croyance du participant et de l'âge, mais aucun effet de la croyance de l'agent. Les enfants les plus âgés étaient globalement plus précis, et les effets liés à leur propre croyance augmentaient avec l'âge. De même, les analyses de temps de réaction indiquent des temps de réponse plus rapides avec l'âge et un effet robuste de la croyance du participant, sans influence de celle de l'agent. Ces résultats suggèrent une augmentation progressive de l'influence de la croyance du participant avec l'âge, révélant un biais égocentrique chez les enfants, et une absence de prise en compte de la perspective de l'agent.

Des indices individuels de TdE implicite ont ensuite été calculés à partir des différences de temps de réaction et de précision, ainsi que des scores composites intégrant la vitesse et l'exactitude. Parmi eux, un seul indice, reflétant l'effet de la croyance de l'agent sur les temps de réaction a montré une corrélation significative et positive avec la TdE explicite, bien que

faible. Les indices de TdE implicite n'étaient pas associés au langage, aux FE ni au SES, contrairement à la TdE explicite, significativement corrélée à ces trois domaines en contrôlant pour l'âge.

Les résultats indiquent que les performances à la tâche s'améliorent avec l'âge. Un effet robuste de la croyance du participant (biais égocentrique) sur l'exactitude et les temps de réaction a été mis en évidence, en lien avec l'idée qu'un biais égocentrique persiste jusqu'à l'âge de 10 ans (Rubio-Fernandez et al., 2022). À l'inverse, les enfants n'étaient pas influencés par la croyance de l'agent, possiblement parce qu'un biais égocentrique domine encore à ces âges. Ce résultat pourrait également être expliqué par la demande exécutive associée à la tâche, qui empêcherait l'attribution d'états mentaux, en lien avec l'idée que la charge cognitive entrave la TdE implicite chez les adultes (Schneider et al., 2012). Par ailleurs, l'indice de TdE implicite mis en évidence chez les adultes (Kovács et al., 2010) n'était pas répliqué dans notre échantillon.

Plusieurs adaptations méthodologiques peuvent aussi avoir atténué les effets liés à la croyance de l'agent. Parmi ces ajustements, le remplacement de la balle par une coccinelle (susceptible d'induire de l'anthropomorphisme, et pouvant rendre la coccinelle plus saillante et réduire l'attention portée à l'agent), la suppression de la vérification de l'attention (indiquer le départ de l'agent, qui sert normalement à accentuer l'attention portée à la croyance de l'agent), ou encore la réduction et l'ordre fixe des essais peuvent avoir joué un rôle.

Concernant le lien implicite–explicite**,** seul l'effet de la croyance de l'agent sur les temps de réaction est corrélé à la TdE explicite, suggérant une plus grande prise en compte des états mentaux de l'agent chez les enfants ayant développé leur TdE explicite. Enfin, aucune corrélation n'a été observée entre TdE implicite et les FE**,** le langage ou le SES (contrairement à la TdE explicite), suggérant une indépendance de la TdE implicite vis-à-vis de ces facteurs.

Étude 3

La trajectoire développementale de la TdE implicite entre 3 et 7 ans demeure mal comprise. Des données suggèrent un développement non linéaire du biais altérocentrique, qui serait présent chez le nourrisson, absent chez l'enfant plus âgé, et qui apparaît de nouveau à l'âge adulte (Manea et al., 2023 ; Southgate et al., 2020 ; Tebbe et al., 2025). De plus, les prédicteurs qui contribuent à la trajectoire développementale de la TdE implicite demeurent largement inconnus (Roby & Scott, 2017). À l'inverse, la littérature sur la TdE explicite confirme l'influence du langage et des FE, mais les comparaisons directes de ces deux variables sur les

trajectoires développementales de la TdE explicite dans un même échantillon, et a fortiori avec une approche longitudinale, restent rares (de Villiers & de Villiers, 2025 ; Andre & Maintenant, 2025). Additionnellement, la diversité socio-économique est peu prise en compte, alors que le SES pourrait moduler les relations entre la TdE explicite, le langage et les FE. Enfin, la TdE de second ordre reste moins étudiée, et l'est souvent dans des échantillons non représentatifs (occidental, éduqué, industrialisé, riche, démocratique, WEIRD, Henrich, 2010).

Pour combler ces lacunes, la troisième étude adopte une approche longitudinale accélérée en incluant 354 enfants âgés de 3 à 7 ans (trois temps de mesure) et examine : (a) l'effet de l'âge sur la TdE implicite ; (b) les rôles prédictifs du langage, des FE et du SES dans le développement de la TdE explicite de premier et second ordre ; (c) le rôle de ces mêmes prédicteurs dans le développement de la TdE implicite, y compris leurs interactions avec l'âge afin de déterminer si ces relations sont stables au cours du développement. Les enfants ont été évalués sur leurs compétences en TdE explicite de premier et de second ordre (tâche de fausse croyance de changement de lieu) et implicite (tâche de fausse croyance spontanée) leurs capacités langagières (vocabulaire, syntaxe, apprentissage de nouveaux mots) et leurs FE (inhibition, flexibilité). Le SES (diplôme et métier le plus élevé entre les deux parents) a également été collecté lors du premier point de mesure (études 1 et 2).

Nous avons estimé les trajectoires développementales de quatre variables : la TdE explicite de premier et de second ordre, ainsi que deux indices de TdE implicite (reflétant l'influence de la croyance de l'agent sur les temps de réaction), à l'aide de modèles mixtes. Pour les variables de TdE, de nature ordinale, nous avons utilisé des modèles mixtes à lien cumulatif (CLMM)**,** et pour les indices implicites, de nature continue, des modèles linéaires mixtes (LMM). Pour chaque variable, un modèle linéaire a été comparé à un modèle quadratique. Un intercept aléatoire par participant a été inclus afin de tenir compte de la structure longitudinale des données**.** Les prédicteurs (langage, FE, SES) ont été résumés par des indices composites à l'aide d'une analyse en composante principale, et introduits, avec leurs interactions avec l'âge, dans les modèles finaux.

Les analyses de corrélations partielles ont montré que les deux indices implicites sont liés au sein d'un même temps de mesure, mais ne montrent pas de stabilité d'une session à l'autre. La TdE explicite de premier ordre était associée à l'un des indices implicites au début du suivi, tandis que la TdE de second ordre était corrélée à la TdE de premier ordre. Concernant les trajectoires, un indice de TdE implicite augmentait linéairement avec l'âge (impact croissant de

la perspective de l'agent sur les temps de réaction), et les TdE explicites de premier et de second ordre progressaient également avec l'âge.

Enfin, les modèles prédictifs indiquent que ni le langage, ni les FE, ni le SES (ni leurs interactions avec l'âge) ne prédisaient la TdE implicite. À l'inverse, la TdE explicite de premier ordre était positivement associée au langage, aux FE et au SES. Enfin, la TdE de second ordre était prédite par le langage, et une interaction entre l'âge et le SES a été mise en évidence, indiquant que la progression avec l'âge pour cette variable n'était observée que chez les enfants de SES moyen ou élevé.

Dans l'ensemble, ces résultats indiquent un lien entre la TdE explicite de premier ordre et un indice de TdE implicite, en lien avec les résultats de l'étude 2. En revanche, ce lien semble fragile, dans la mesure où l'indice impliqué n'est pas le même que lors de l'étude 2, et qu'aucune corrélation n'a été retrouvée au troisième temps de mesure, indiquant une faible stabilité des tâches implicites, ce qui est cohérent avec les limites de fiabilité souvent rapportées (Poulin-Dubois et al., 2020). A l'inverse, des corrélations ont été observées entre la TdE de premier et de second ordre à travers les différents points de mesure. Ces résultats soutiennent l'idée d'une continuité entre les différentes composantes de la TdE au cours du développement (Kloo et al., 2020 ; Sodian et al., 2020).

Concernant les effets de l'âge, les performances augmentaient pour la TdE explicite (1er et 2e ordre). Un effet d'âge apparaît aussi pour l'indice implicite reflétant le coût de la croyance de l'agent lorsque la croyance de l'enfant est positive, cohérent avec l'hypothèse d'un biais altérocentrique qui est présent chez les très jeunes enfants mais disparaît ensuite, possiblement dû au développement de la perspective de soi (Southgate et al., 2020). Ni le langage, ni les FE, ni SES ne prédisaient la TdE implicite, tandis que la TdE explicite de premier ordre était liée au langage, aux FE et au SES. Pour la TdE de second ordre, seul le langage émerge comme prédicteur unique. En revanche, une interaction entre l'âge et le SES révèle une progression avec l'âge chez les enfants SES moyen et élevé, mais pas les enfants de bas SES, possiblement dû au délai observé dans l'acquisition de la TdE de premier ordre.

Finalement, les résultats suggèrent une continuité développementale allant de la TdE implicite vers des formes explicites plus complexes, avec un rôle central du langage, un apport, bien que plus faible, des FE pour la TdE de premier ordre, et des trajectoires développementales

distinctes en fonction du SES (notamment pour le second ordre), tandis que la TdE implicite ne semble pas liée à ces facteurs, ou insuffisamment captée par les outils actuels.

Conclusion

Cette thèse comprenait plusieurs objectifs :

- Préciser le lien entre SES et TdE explicite chez l'enfant en testant le rôle explicatif du langage et des FE
- Caractériser le lien entre TdE implicite et TdE explicite chez les enfants d'âge préscolaire et scolaire, en adaptant un paradigme adulte de TdE implicite (la *ball detection task*) aux enfants afin de mesurer la TdE implicite chez les enfants de cette tranche d'âge
- Décrire les trajectoires développementales de la TdE implicite et explicite avec une approche longitudinale accélérée, et tester la contribution prédictive du langage, des FE et du SES sur les deux types de TdE.

Les résultats des différentes études ont montré un lien, bien que fragile, entre la TdE implicite et explicite chez des enfants âgés de 3 à 7 ans, tant en adoptant une approche transversale que longitudinale. Cette relation suggère que les TdE implicite et explicite interagissent au cours du développement, allant dans le sens d'une hypothèse de continuité entre ces deux capacités (Kloo et al., 2020).

Concernant les trajectoires développementales, la TdE explicite a suivi la progression attendue entre 3 et 7 ans. De plus, un indice de TdE implicite était également influencé par l'âge, indiquant une attention croissante aux perspectives d'autrui. Cependant, les enfants présentaient globalement un biais égocentrique plutôt qu'altérocentrique, et étaient donc davantage influencés par leur propre perspective que par celle de l'agent. Des études supplémentaires, accordant une attention particulière aux paramètres de la tâche, sont nécessaires pour mieux comprendre le développement de la prise en compte spontanée de la perspective d'autrui durant l'enfance.

Le langage est ressorti de façon constante comme le prédicteur le plus fort de la TdE explicite, tandis que les FE ont montré une contribution significative mais plus limitée. À l'inverse, la TdE implicite est apparue indépendante à la fois du langage et des FE, ce qui confirme l'idée qu'elle fonctionne de manière automatique et séparément des ressources cognitives supérieures

(Grosse Wiesmann et al., 2017). Toutefois, étant donné que les enfants exclus des analyses (dû à un score de précision trop faible) avaient tendance à présenter des capacités langagières et exécutives plus faibles, de futures adaptations de la tâche sont nécessaires pour minimiser ce biais de sélection.

Enfin, nous avons constaté que l'effet du SES sur la TdE explicite était entièrement expliqué par le langage dans la première étude, bien que l'association entre le SES et la TdE subsiste dans l'étude longitudinale. À l'inverse, la TdE implicite n'a montré aucune relation avec le SES. Ces résultats suggèrent que les facteurs environnementaux pourraient influencer la TdE de manière indirecte, via leurs effets sur le langage, plutôt que sur la capacité de mentalisation elle-même.

De façon générale, ces travaux apportent des éléments en faveur d'un lien développemental continu entre la TdE implicite et explicite et soulignent le rôle central du langage dans la TdE explicite, ainsi que l'influence limitée des capacités de FE et du SES. Ils soulignent également la nécessité de développer des mesures de TdE implicite plus fiables, plus engageantes et adaptées à l'âge des enfants, ainsi que d'inclure des échantillons plus diversifiés et représentatifs. Ces progrès méthodologiques sont essentiels pour mieux comprendre la variabilité développementale associée à la TdE et avancer vers une compréhension plus inclusive de la cognition sociale des enfants.