Theory of mind: The state of the art*

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ABSTRACT
In this article, I reflect on theory of mind as a field (ToM), how it has developed over the years, and focally on the state of current research and theory. Having begun with preschoolers’ understanding of beliefs and desires, the field now includes research from infancy through late life, contributions and contributors from around the world, research on behavior, conversation, neural correlates, gene-environment contributions, evolution, and the social-behavioral antecedents and consequences of the unfolding trajectories of ToM understanding. Several topics in particular portray the current state of the art and my sense of where theory-of-mind research is likely to head in the near future: progressions of theory of mind achievement; cultural experiences plus experiential influences that shape developmental trajectories; developmental cognitive neuroscience; infant ToM insights; research on ToM developments beyond preschool, including children’s increasing interest in and wrestling with extraordinary minds, such as those of God and super-heroes.

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Introduction

I have studied theory of mind for more than 30 years. I still find it fascinating, so I am pleased to be invited to write about the state of the art of the field. As to be expected from my 30-year involvement, my own insider appraisals inevitably color anything I’ll say: Mine is not an unbiased perspective.

Given the limitations of any one person’s perspective, it’s important to say that theory of mind research has been blessed by the efforts of a number of unusually bright and insightful scholars, like those listed in Table 1.

Because this is the European Journal of Developmental Psychology, that table highlights many who are from Europe, which has been a hotbed of theory of mind (ToM) research and theorizing. Those involved are not only older contributors, like

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myself, many are younger scholars and many of these are also from Europe, such as Marek Meristo, Serena Lecce, Hannes Rakoczy, Victoria Southgate, Carolien Rieffe, Ian Apperly, and Gisa Ascherleben.

Historical framing

Developmental scientists know you cannot understand the current state of anything without knowing what went before, so I begin with some historical background. The question of how people come to understand their own and others’ minds has a long history in philosophy, of course, but two thrusts launched the field within developmental science.

Some researchers, like me, began with an earlier interest in and research on metacognition. In principle, metacognition refers to our wide-ranging human knowledge about cognition, but research on metacognitive development was and still is especially focused on children’s knowledge of cognitive difficulties plus their knowledge and use of strategies for memory and learning.

My interest in metacognition morphed into a more basic one involving what children think about the mind more generally, not just their ideas about memory and learning. I was not alone in making this shift. For many others, however, interest began with Premack and Woodruff’s seminal 1978 article, ‘Does the chimpanzee have a theory of mind?’. Their article is where the phrase theory of mind originated for designating the field, a phrase borrowed from philosophy of mind (e.g. Churchland, 1984; Fodor, 1987).

The label ‘theory of mind’ caught on quickly, in part because it was a catchy phrase. But also for some of us, the phrase aptly fit an emerging theory theory: the theoretical claim that children’s conceptual development constitutes naïve theory development (Gopnik & Wellman, 1992, 1994, 2012; Wellman, 1990).

Two conferences in 1986 further incubated the field, one in north America organized by Janet Astington and Alison Gopnik at Toronto, and one in Europe organized by Paul Harris at Oxford. The volume of papers resulting from those talks (Aastington, Harris, & Olson, 1988) helped inspire increasingly widespread interest in ToM and still provides a useful historical look at the state of the field.

Table 1. List of researchers who have regularly contributed to our understanding of theory of mind and its development.

<table>
<thead>
<tr>
<th>Researchers</th>
<th>Scholars from European countries.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alison Gopnik</td>
<td>György Gergley*</td>
</tr>
<tr>
<td>Janet Astington</td>
<td>Mike Tomasello</td>
</tr>
<tr>
<td>Josef Perner*</td>
<td>Lou Moses</td>
</tr>
<tr>
<td>Beate Sodian*</td>
<td>Alan Leslie*</td>
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<tr>
<td>Paul Harris*</td>
<td>Mark Sabbagh</td>
</tr>
<tr>
<td>Karen Bartsch</td>
<td>Daniela O’Neill</td>
</tr>
<tr>
<td>Andy Whiten*</td>
<td>Claire Hughes*</td>
</tr>
<tr>
<td>Charlie Lewis*</td>
<td>Simon Baron-Cohen*</td>
</tr>
<tr>
<td>Amanda Woodward</td>
<td>Candida Peterson</td>
</tr>
</tbody>
</table>

*Scholars from European countries.
in those early days. And finally, two early books, one by me (Wellman, 1990), one by Josef Perner (1991), helped stoke further early interest.

**Development**

Early on, many researchers studying theory of mind became obsessed with false belief understanding, although the larger question always was children’s understanding of mental states more generally. This was studied in two ways still with us today: (1) Assessing children’s – at first essentially preschoolers – appreciation of how agents’ beliefs and desires work together to produce intentional behavior, including actions driven by false beliefs. And (2) assessing children’s understanding that thoughts and physical objects are two very different sorts of ontological things, nonmaterial and mental things versus physical, tangible, and real things (e.g. a thought about a dog versus a dog). Contradicting Piaget’s claims about childhood realism, young children proved surprisingly good at both of these nonobvious and abstract understandings (see Perner, 1991; and Wellman, 1990).

Development includes origins and change, and so over the years, research expanded in breadth and depth. We now have studies on the development of theory of mind in infancy, childhood, adolescence, adulthood, and even late life. This more inclusive age-related research also encouraged a broader focus on progressions of understanding. Research foci broadened to include, for example, children’s developing emotion understanding, engagement in pretend play, lying and more. Children’s understanding was studied not only via controlled experimental tasks but also via its more ‘real life’ expression in, for example, children’s everyday conversations about people and minds through the use of terms like think, want, feel, and guess.

Researchers have also examined underpinnings of theory of mind understandings in evolutionary processes, neural processes, and developmental learning (including computational models of constructivist learning). Development in typical and atypical populations (e.g. individuals with autism or deafness) has been studied, as have individual differences in theory-of-mind development.

Individual differences are no more or less important than these other topics, but individual variation in reaching theory-of-mind milestones has helped us address antecedents of theory-of-mind competence, which we now know includes such things as engagement in social-pretend play, having siblings, frequency of engagement in explanatory conversations, and growing up bilingual. The sort of variation that is assessed in these studies is essentially a child’s coming somewhat earlier versus somewhat later to a ToM milestone that most preschoolers normatively achieve in the preschool years, such as an understanding of false beliefs.

This same sort of variation allowed investigators to show that theory of mind developments have wide-ranging consequences. ToM has significant impacts
on children’s friendships and popularity, their engagement in lying and deception, game-playing skills, strategies for persuading or arguing with others, and transition to school.

This individual-differences research has been concurrent and correlational but also prospective and longitudinal. Moreover, there is also experimental research, including intensive microgenetic studies designed to accelerate the everyday experiences that arguably propel ordinary theory-of-mind acquisition. It is through such microgenetic studies, for example, that we know of the formative power for advancing ToM understanding of engagement in explanatory conversations about why people do things.

The list of current state-of-the-art ToM research topics does not end here: research shows not only that theory-of-mind advances predict children's social skills and interactions, but also their cognitive skills and actions. Children's achievement of ToM insights predicts their use of metacognitive learning strategies, harkening back to the earlier study of metacognition. Further, it predicts their learning of reading and mathematics content in school, and their acceptance or resistance to feedback from teachers.

Thinking evolutionarily and comparatively, contemporary research with monkeys and chimpanzees has shed light on the nature of distinctively human theory of mind, harkening back to Premack and Woodruff (1978). Surprisingly, so too has research on dogs and birds.

In terms of social and cultural factors, researchers have looked at variations in upbringing to identify both universal and culture-specific aspects of theory-of-mind conceptions and trajectories. They similarly have examined ToM acquisitions as impacted by the native language children are acquiring.

Researchers are also busy going beyond behavior to study the neural correlates of, and neural substrates supporting, theory of mind judgments and attributions. Further, there is research on genetic versus environmental contributions to ToM skills and development, including the related question of whether theory of mind acquisition evidences a critical period similar to the well-documented critical period that constrains language acquisition.

These expansions I have just reviewed outline the current state of theory-of-mind research as I see it. They map a very far-flung and impressive research enterprise, showing the increases in scope and breadth of ToM research over its original research foci and methods. (For fuller coverage of some of the topics just spotlighted, see Hare & Tomasello, 2005; Wellman, 2014).

Given this overview, from here on I will touch more deeply on a few of those points just mentioned: First, I’ll address current false-belief research, but then quickly move to emphasize investigations of extended progressions in ToM achievements. A focus on current research on ToM progressions allows me to address several additional topics like the cultural experiences plus experiential influences that help shape developmental trajectories. Then moving away from early childhood, I cover contemporary research on infant ToM insights,
and then current research on ToM developments beyond preschool. One of the most intriguing set of post-preschool developments, I propose, is children’s increasing interest in and wrestling with extraordinary minds, such as minds of God and super-heroes.

I end with a brief review of contemporary cognitive neuroscience research on theory of mind. Here I emphasize the sparser but important research not with adults but on the neural manifestations of and neural contributions to ToM development in childhood.

To be clear I cannot do justice to all these topics in depth, and I cover these particular topics because they seem to me to be parts of the present that will be still more active in the future as well.

**Developmental progressions in understanding theory of mind**

A brief look at children’s understanding of false beliefs paves a way to address more extended progressions of understanding. Figure 1 shows a schematic of a standard preschool false belief task dealing with a change of locations. Correct answers on such tasks – saying that Jill will look for her candy in the drawer – show an understanding that people live their lives not so much in the world itself, but in the world of mental states: because really the candy she wants is in the cupboard, but Jill will look in the drawer.

Theory of mind encompasses many understandings beyond false belief, and I will consider them shortly, but false belief has proven to be a good initial focus, because false belief tasks can be made very natural for use with children in a variety of everyday situations. As a result, there is a wealth of false belief data to inform us, and from children in many different cultural communities. These data have been aggregated and summarized in several comprehensive meta-analyses (Liu, Wellman, Tardif, & Sabbagh, 2004; Milligan, Astington, & Dack, 2007; Slaughter, Imuta, Peterson, & Henry, 2015; Wellman, Cross, & Watson, 2001).

To illustrate, consider the first meta-analysis conducted, that conducted by me, Cross and Watson (2001). Even as early as 2001 we were able to include more than 200 studies, and because studies typically include more than one false-belief condition (e.g. including separate groups of 3-, 4-, and 5-year-olds, or comparing tasks that ask children to judge behavior or thoughts – where will Jill look? What does she think?) we were able include almost 600 false-belief conditions encompassing data from more than 7,000 children. The tasks were verbal and nonverbal, asked children to judge real life humans, videotaped humans, toy figurines, story characters, and more.

The bottom portion of Figure 1 shows one view of the overall findings. Each of those lines depicts the developmental trajectory summarized over all children in a country. The trajectories are actually curvilinear (progress on false-belief understanding is rapid between 2 ½ and 5 ½ years and slows down after that). But the data in Figure 1 are transformed to show the trajectories as straight lines.
so they are easier to compare. With this transformation 0 is random chance, 50/50 performance.

Clearly, there is early achievement and developmental change. By 4½ and 5 years, on a vast array of false belief situations, many children judge and explain correctly. But going backward to 2 and 3 there is consistent change, moving from below- to above-chance performance as children get older.

Such meta-analyses address several questions, but the graph at the bottom of Figure 1 shows one important one: how the aggregated data look across countries and cultures. In that graph, there are some differences in timetables—some children are a bit faster, some slower. This is true not only across country/community sites (as shown in the graph) but also across individuals within a
country or study (not shown in the graph). It is this normal variation in coming to understand false belief on these standard preschool false-belief tasks that has been the richest source of our current understanding of the real-life impact of ToM on children’s lives, such as its influence on children’s friendships and popularity, engagement in lying and deception, game-playing skills, and so on, as I talked of earlier.

Nonetheless, granting this sort of variation, there is very similar conceptual development in all countries. Young children everywhere come to explicitly understand that a person’s actions are importantly controlled by what he thinks, not just reality itself.

While false belief represents, in hindsight, an impressively informative ToM measure, focus on a single task (even in aggregated batteries) is misleading. As the editor of this journal, Willem Koops, once told me, it is ‘not very developmental’ (Wellman, 2012). A wider developmental perspective was clearly needed.

Consider, in this regard, the scope of our everyday theory of mind understandings. At a minimum, philosophers and psychologists agree our everyday understanding of people revolves around three main categories of mind and behavior: beliefs, desires and intentional actions. Beliefs and desires together shape and cause our actions. Or, in our everyday reasoning we construe people as engaging in actions they believe will get them what they want. Think about Romeo and Juliet. Because they wanted to get together, but thought their families would violently disapprove, they try to meet in secret.

ToM reasoning is certainly more complicated than this alone, and in a bit more detail must include at least several other sets of related constructs and connections. For example, a person’s perceptions and basic emotions (among other things) ground their beliefs and desires. Moreover, beliefs and desires not only shape actions, they shape actors’ reactions to what their acts produce.

Anything like this way of thinking about ordinary social-cognitive reasoning highlights the centrality not only of beliefs in our everyday theory of mind but of desires as well. And in terms of progressions, one thing researchers discovered early on was that children understood certain things about desires before achieving parallel insights about beliefs. For example, consider just the top two rows of Figure 2. As schematized there, via cartoon depictions of children’s understanding of characters’ states, on simple experimental tasks, children understand early on that different people can have different desires for the very same thing: the person on the top left wants that apple, the person on the right does not and instead dislikes it. This understanding of diverse desires precedes an understanding of diverse beliefs. When the child does not know what is actually in a container, for example, he could nonetheless understand one person might think it contains one thing – an apple – but someone else may think instead it has something very different—a banana.

A progression from reasoning about desires to reasoning about beliefs characterizes children’s performance on experimental tasks (see, e.g. the
meta-analysis in Wellman & Liu, 2004) but it also characterizes children’s everyday conversations about people’s actions and minds (e.g. Bartsch & Wellman, 1995; Ruffman, Slade, & Crowe, 2002; Tardif & Wellman, 2000a).

More extended progressions of understanding further characterize theory-of-mind development and have been useful in illuminating the origins and mechanisms of development and change. One set of progressions I’m particularly pleased with is that captured in our Theory-of-Mind Scale (Wellman & Liu, 2004) that encompasses carefully constructed tasks assessing children’s understanding of all the constructs listed in Figure 2.

In short, a child might understand that: (a) people can have different desires, even different desires for the same things (Diverse Desires, or DD), (b) people can have different beliefs, even different beliefs about the exact same situation (Diverse Beliefs, DB), (c) something can be true, but someone might not know that (Knowledge-Access, KA), (d) something can be true, but someone might falsely believe something different (False Belief, FB), (e) someone can feel one way but display a different emotion (Hidden Emotion, HE).

Using such a battery of tasks, studies encompassing hundreds of preschoolers in the U.S., Canada, Australia, and Germany evidence a clear and consistent order of difficulty (e.g. Kristen, Thoermer, Hofer, Aschersleben, & Sodian, 2006; Peterson, Wellman, & Liu, 2005; Wellman & Liu, 2004). It is the order listed above and in Figure 2, with diverse desires easiest and hidden emotions hardest. For shorthand: DD>DB>KA>FB>HE. Thus, this ToM Scale establishes a progression of conceptual achievements that pace theory-of-mind understanding in normally developing children, as well as a method for measuring that development (a

Figure 2. Graphical depiction of a child’s understanding of five different mental-state contrasts.
method validated with longitudinal data as well; Peterson & Wellman, in press; Wellman, Fang, & Peterson, 2011).

Validated progressions like this allow deeper examination of crucial questions such as, to what extent are the timetables and sequences of Tom acquisition consistent or varied across children growing up in different circumstances? Which additionally allows consideration of the extent to which theory-of-mind developments are culturally universal or specific, and do or do not depend on various childhood experiences.

**Theory of mind timetables**

The false-belief data in Figure 1 already show us something about timetables. There is some variation in when children achieve an understanding of false beliefs. But at the same time there is consistency in that all the change seems to be happening sometime in or near the preschool years. From these data alone it is conceivable either (a) that early theory-of-mind achievements represent maturational unfolding of some theory-of-mind module or device. Because then timetables for theory-of-mind developments should be consistent—not identical but closely similar because they are maturationally constrained – and perhaps that is what the false-belief data are showing us.

Alternatively, (b) it is conceivable that those data show us substantial variation. The timing differences are significant, for example, across countries within these meta-analyses.

So, are ToM understandings just constrained to be modestly sped up or delayed? Or are they more seriously plastic? A compelling test-case concerns deaf children.

**Deafness**

Importantly, there are two informative groups of deaf children to consider. Deaf children of deaf parents grow up with ordinary conversational, language experiences – albeit in sign language – and so grow up with others who communicate and interact with them profusely. But most deaf children – about 90–95%–are born to hearing parents. They grow up with very different early experiences. For example, despite sometimes valiant efforts to learn sign language, hearing parents rarely achieve real proficiency. Especially when their child is young, hearing parents mostly communicate with their deaf child using simple signs or gestures to refer to here-and-now objects (Lederberg & Everhart, 1998; Moeller & Schick, 2006). Also, often only one person in the family – typically the mother – is the designated primary communicator and interactor for the child. The deaf child in a hearing family begins life with little discourse about persons’ inner states, thoughts and ideas, is likely to have restricted play with others, and generally
has less access to the free-flowing, turn-taking, perspective-shifting interchange of social interactions and communication.

Deaf children of hearing parents (but not deaf children of deaf parents) are substantially delayed in understanding false belief, often as delayed as high-functioning children with autism (see the review by Peterson, 2009). Again, however, a focus on false belief understanding alone is limiting. More informatively, when deaf children (of hearing parents) receive the ToM Scale they too evidence a consistent sequence of progression, but one that is delayed at every step along the way. Table 2 shows some aggregated scaling data for deaf children of hearing parents.

It is clear that it takes deaf children of hearing parents 12 or more years to progressively achieve what hearing children (and deaf children of deaf parents) achieve in 4 to 6 years. Thus, it is only at around 11 and 12 years or older that they understand false belief. These are not just modest delays, but serious, consistent, delays that accumulate sequentially.

Other data show that theory of mind acquisition can be substantially and significantly sped up. These data come from a very different approach, microgenetic training studies which attempt to accelerate the everyday experiences that children receive in explaining human behavior, by requiring such explanations in multiple bi- or tri-weekly sessions over the course of 8–12 weeks. Such systematic training improves children’s false-belief understanding and advances children along the ToM Scale of progressive understandings (Amsterlaw & Wellman, 2006; Rhodes & Wellman, 2013). In these studies, children who are pre-tested to include only those who consistently fail a large battery of false-belief tasks, achieve in a matter of weeks ToM progress that ordinarily requires a year or more of development.

In total, theory-of-mind timetables are seriously not just modestly plastic. Relatedly, theory of mind also is not hobbled by a maturational, critical-period constraint.

According to a critical period account, deprivation of some crucial input or experience at some specified early age (e.g. the preschool years: Morgan & Kegal, 2006; Siegal & Varley, 2002) will result in a permanent deficit in theory-of-mind development. It is difficult to fully rule out such hypotheses, yet these scaling data, by revealing steady progress by deaf children on the theory of mind scale understandings through primary school and into high school are inconsistent.

Table 2. Average ages (in years) of children for increasing scores on the ToM Scale.

<table>
<thead>
<tr>
<th>ToM Scale Scores</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>U.S. and Australian preschoolers: (N = 280)</td>
<td>3.22</td>
<td>3.66</td>
<td>3.84</td>
<td>4.45</td>
<td>4.77</td>
<td>5.15</td>
</tr>
<tr>
<td>Deaf children of hearing parents: (N = 66)</td>
<td>8.77</td>
<td>7.83</td>
<td>7.92</td>
<td>9.88</td>
<td>11.31</td>
<td>12.40</td>
</tr>
</tbody>
</table>

*Data for U.S. and Australian preschoolers were obtained from Wellman and Liu (2004); Wellman et al. (2004); Peterson et al. (2005); Wellman et al. (2008); and Peterson and Wellman (2009). Data for deaf children of hearing parents are from Peterson et al. (2005) and Peterson and Wellman (2009).

*Scores range from 0 to 5 where 0 means the child fails all 5 tasks, 1 means they pass DD, 2 means they pass DD and DB, and so on.
with this critical period view, as are longitudinal data using the theory of mind scale (e.g. Wellman et al., 2011).

Furthermore, a provocative study of a unique group of Nicaraguan deaf adults (Pyers & Senghas, 2009) supports a similar conclusion. Pyers and Senghas longitudinally followed two cohorts. The first had been limited to using a pidgin form of signing that had no terms for thinking or other cognitive states. Unsurprisingly given the other deaf data I’ve outlined, they continued to fail false belief tests even in adulthood. But then, while in their late twenties, they began to interact at a local deaf club with adults from later cohorts. who had, through interacting together in primary and high school, created a sign language equipped with cognitive terms (and more complex syntax). The first-cohort adults eventually learned and used cognitive-state terms from interacting and communicating with later cohorts in adulthood. After two years of this informal conversational contact, follow-up data revealed dramatic theory of mind gains for the older, language-deprived cohort who now equaled the good false-belief mastery of the second cohort. Together with our evidence from older late-signing deaf children, these results demonstrate that first-time mastery of ‘preschool’ theory of mind understanding is possible well beyond the bounds of any postulated critical periods and, indeed, well into adulthood (for research with deaf adults see O’Reilly, Peterson, & Wellman, 2014).

Theory of mind sequences

So far, the theory-of-mind sequences I’ve described have been the same—DD>DB>KA>FB>HE – even for deaf children. But ToM sequences vary as well, as is clear in various recent cross-cultural studies comparing, for example, English-speaking Western children to those growing up in mainland China.

Assume that theory-of-mind understandings are the products of social and conversational experiences (as seems clear from the deaf data). By hypothesis those could easily vary from one community to another and Western and Chinese childhood experiences could be crucially different. Various authors have described an Asian focus on persons as sharing group commonalities and interdependence and a contrasting Western focus on persons as distinctively individual and independent (e.g. Markus & Kitayama, 1991; Nisbett, 2003). These differences include differing emphases on common knowledge and perspectives versus diversity of individual beliefs and perspectives. Indeed, in conversation with young children, Chinese parents comment predominantly on ‘knowing’, whereas U.S. parents comment more on ‘thinking’ (Bartsch & Wellman, 1995; Tardif & Wellman, 2000b).

In accord with such conversational-cultural preferences for emphasizing knowledge acquisition versus belief differences, Chinese preschoolers evidence a consistent but different theory of mind sequence where KA and DB are reversed: DD>KA>DB>FB>HE (Wellman, et al., 2006, 2011). Both Western and
Chinese children first understand basic aspects of desire (DD). But the cultures diverge at the next step. Most Western children first appreciate belief differences (DB) and then acquisition of knowledge (KA). For Chinese children in Beijing, the ordering of these two steps is reversed. Most of them pass KA before DB.

This is not some singular peculiarity of Chinese mind and development; the same alternative sequence appears in Iranian preschool children (Shahaeian, Peterson, Slaughter, & Wellman, 2011) and in Turkish children as well (Selcuk, Brink, Ekerim, & Wellman, in press). Despite profound differences in Iran’s Muslim traditions and beliefs in contrast to Chinese Confucian/Communist ones, both China and Iran share collectivist family values emphasizing consensual learning, knowledge acquisition, respect for the wisdom of elders and low tolerance for children’s assertions of disagreement or independent belief. As a consequence, parents in both Iran and China often resemble each other and differ from Western parents in placing stronger emphasis on children’s conformity to tradition and their emulating knowledgeable adults to overcome their ignorance. Western parents are correspondingly apt to more strongly encourage their children’s thinking independently, and free and assertive expression of their own opinions. Data on children’s progressive development through the ToM scale are in line with these cultural variations in parental beliefs and practices.

**Infants’ theory of mind**

Theory-of-mind research began with older children and scrolled backwards toward infancy. The earliest examples of psychological construals of people (both in infants and in research on infants) appear in infants’ understandings of intentional action and experience: By the end of the first year, children treat themselves and others as intentional agents that have internal experiences – notably desires and goals. This is clear from infant, looking-time research with infants as young as 6- and 8-months (e.g. Brandone & Wellman, 2009; Woodward, 1998) but also from findings using active-interactive paradigms where infants accept objects from or imitate adults’ actions on objects (e.g. Behne, Carpenter, Call, & Tomasello, 2005; Meltzoff, 1995).

In the last 10 years, however, researchers have claimed that infants go beyond an understanding of intentional actions and experiences. By 12 to 18 months, it is claimed, infants recognize that people act on the basis of their beliefs and false beliefs.

Figure 3 outlines an initial influential task by Onishi and Baillargeon (2005). In this looking-time, violation-of expectation paradigm Onishi and Baillargeon found that indeed 15-month-old infants apparently had formed some sort of implicit expectation that the agent’s action would be constrained by her false belief. From this initial demonstration, other demonstrations have accumulated, using looking-time methods and paradigms similar to the one used by Onishi and Baillargeon (e.g. Scott & Baillargeon, 2009; Southgate, Chevallier, &
Csibra, 2010; Surian, Caldi, & Sperber, 2007) but others using active-interactive paradigms (e.g. Buttelmann, Carpenter, & Tomasello, 2009; Southgate, Senju, & Csibra, 2007).

While these studies are clever and revealing, how their findings should best be interpreted remains controversial, prompting, for example, further research and research summaries (for critical reviews, see e.g. Heyes, 2014; Sodian, 2011; Wellman, 2014). As one example, Kulke and Rakoczy (2018) recently compiled a summary of published and unpublished replications of implicit false belief attempts. Additionally, a forthcoming issue of the journal Cognitive Development looks in more detail at the current studies tackling implicit-explicit false-belief data and accounts (see the special issue called, ‘Understanding theory of mind in infancy and toddlerhood’).

From these reviews and additional research, it is clear that there is not as yet a straightforward story. Thus, in the Kulke and Rakoczy’s (2018) summary about half of the attempts to find an understanding of false beliefs using violation-of-expectation looking measures, failed. These fifty-fifty results occurred for studies testing infants and 2- and 3-year-olds. Even many studies with adults using these methods failed to find violation of expectations to false-belief scenarios. This is hard to square with a conclusion that violation-of expectation methods tap a clearcut, implicit, human understanding of actions driven by false beliefs.

In short, the state of the art of empirical research on infants’ possible implicit understanding of agents in terms of their false beliefs (as opposed to their well-replicated understanding of agents’ intentions and desires) is one

**Figure 3.** Diagram of infant looking-time task used in an initial study of infant false-belief understanding.

Legend: Fifteen-month-old infants view a person interact with an object. A smiley face indicates that person is present and can see, a crossed-out face indicates the person has gone away and cannot see. So, in familiarization infants see a change-of-location scenario where the person puts their toy in one of two locations, the gray box. But then she goes away and while she can’t see the toy is moved to the white box. The infants are divided into two groups who see different test events: the person comes back and either (for half the infants) searches directly in the gray box (and her reach is frozen when her hand enters the box without showing the objects again) or reaches into the white box. If infants understand that the familiarization events set up a false belief in the person then they should expect the actor to reach in the grey box. And if she reaches in the white box that should be unexpected and lead to increased looking. That is why these methods are also called Violation of Expectation methods. And Onishi and Baillargeon (2005) found that indeed the infants looked at this test event a lot, much longer than they looked at this event.
of uncertainty. Moreover, it’s important to remember that preschool ToM tellingly relates to children’s social interactions (e.g. their popularity with peers, their engaging in social actions such as pretend play, lying, etc.). As yet there is no evidence that infant implicit ‘false-belief’ responses predict anything about infants’ social actions and interactions.

We do know that infant ToM understandings are related to later ones. For example, Thoermer and colleagues (2012) conducted a study showing that infants with more robust ‘correct’ responses on an infant looking-time false-belief task did better as 4-year-olds on standard preschool false-belief tasks.

To be clear, however, these prospective longitudinal data do not validate the earlier infant data as indeed measuring false-belief understanding. They do not because early looking time data on other infant social-cognition tasks, and in particular infant understanding of intentional action and desires, also longitudinally predict preschool theory of mind performances. This is a consistently replicated and validated finding (e.g. Aschersleben, Hofer, & Jovanovic, 2008; Wellman, Phillips, Dunphy-Lelii, & LaLonde, 2004; Wellman, Lopez-Duran, LaBounty, & Hamilton, 2008). So, it is infants’ understanding of persons as intentional actors more generally that robustly predicts children’s later ToM understandings, and of course the infant ‘false belief’ scenarios present infants with actors who are engaged in intentional goal-driven actions (as in Figure 3).

Notably, those that firmly believe the infant FB positive findings often interpret them in deeply nativist fashions as revealing evolved, innate initial understandings that emerge without learning. Thus, according to Leslie (2005), ‘mental state concepts (“theory of mind”) emerge from a specialized neurocognitive mechanism that matures in the second year of life’ (p. 459). This is an ‘automatic, modular, “instinctual” mechanism’ (Leslie, 2005, p. 462). (See also Baillargeon, Scott, & He, 2010).

Such strict nativist interpretations are encouraged by a paucity of findings about how infant social cognition develops and changes in response to experience. But a recent set of studies by Meristo and colleagues (2016, 2012) in Sweden and Estonia with deaf infants of hearing parents shows that they do not show the same false-belief responses that hearing infants do.

Meristo and colleagues (2012) used looking-time methods to test the implicit false-belief inferences of both hearing infants (19- to 20-month-olds) and, crucially, deaf infants of hearing parents (17- to 26-month-olds). Hearing infants in that study expected agents’ search-actions to be guided by their false beliefs, just as in earlier research for 15-month-old (e.g. Onishi & Baillargeon, 2005), and equally in 18-month-old (Neumann, Thoermer, & Sodian, 2008) and 25-month-old infants (Southgate et al., 2010) in research using anticipatory-looking methods very similar to the one used by Meristo et al. (2016). Deaf infants, however, tested with the same implicit and nonverbal anticipatory-looking methods, displayed impairment in their responses – they did not anticipate agents’ search actions to be guided by their false beliefs. They didn’t do so until about 4 years
of age (Meristo et al., 2016). Such findings for deaf infants are in sharp contrast to nativists predictions.

To account for their findings, Meristo and colleagues straightforwardly refer to the differences in communicative and interactive experience that characterize the deaf and hearing infants. Their findings attest to the impact of experience-dependent learning even on infants’ implicit, understandings of mental-state driven action.

This infant research with deaf of hearing children highlights a final concern about infant ‘false-belief’ findings: Like the preschool false-belief findings before them, they are not very developmental. Studies on infant false-belief typically report on 15-month-olds alone on one task, or 18-month-olds (or 25-month-olds, etc.) alone on some very different task. We need a much more progressive developmental picture. Even cross-sectional research where 10-, 12-, 15-month-olds are all tested on the exact same task (of the sort we do have for infant understanding of agents’ intentions and desires, as summarized in Woodward, 2013) would be an advance. More direct research on infants’ social-cognitive learning would also be helpful. These deaf data, along with emerging studies of infants’ statistical learning within the social-cognitive domain (e.g. Wellman, Kushnir, Xu, & Brink, 2016), suggest more broadly that infant implicit understandings can reflect learning as much as preschool ones do. I hope that the future brings more infant research on social-cognitive development and learning.

Developments beyond preschool

What about children’s theory-of-mind developments post-preschool? Research on this topic has had two primary foci: Assessment of ToM development in older children where false-belief tasks often ceiling out. And, examining ToM’s role in children’s transition to school.

Assessment

Increasingly, researchers have created ways to hopefully measure theory-of-mind advances beyond the preschool years. These began with Perner and Wimmer’s (1985) second-order false belief task, but also now include Happe’s (Happé, 1994) Strange Stories tasks, and the Reading the Mind in the Eyes tasks plus Faux Pas tasks of Baron-Cohen and his colleagues (Baron-Cohen, Wheelwright, Hill, Raste, & Plumb, 2001; Baron-Cohen, Wheelwright, & Joliffe, 1997). My colleagues and I developed an extended 6-Step Theory of Mind Scale that goes beyond the 5-step version I outlined earlier and is suitable for children up to 10–14 years (Peterson, Wellman, & Slaughter, 2012). And Hughes and colleagues have developed their Silent Films Task (Devine & Hughes, 2013).

Their titles alone suggest that these tests could measure quite different post-preschool theory-of-mind understandings. Contemporary empirical
research shows that indeed they do. A recent large-scale study by Osterhaus, Koerber, and Sodian (2016), for example, both nicely reviews quite a few of these ToM assessment measures for older individuals and empirically demonstrates their deep differences. The tasks they tested empirically (including second-order false belief, strange stories, faux pas, and the reading the mind in the eyes) did not correlate well with each other, and they correlated with different sets of other factors. Their study and report provides a better summary than I can briefly provide.

**Theory of mind and education**

In what ways might and do ToM understandings impact children in their transition to and performance in elementary school. Thinking about the concept of school readiness is helpful here. School readiness encompasses the cognitive and social skills that children need to use and learn when they enter school, including all the topics listed in Table 3: Children’s social circumstances at school, their academic performance, and their academic motivation. Theory of mind does matter for school readiness and school learning and in all three of these general ways.

**Impact of theory of mind on children’s classroom social circumstances.**

Several studies address the influence of theory of mind on children’s positive social relationships with their peers and with their teachers. In a recent meta-analysis, Slaughter and colleagues (Slaughter et al., 2015) reviewed the research on ToM’s relation to peer acceptance and popularity. They find that, summing over many studies and controlling for numerous background factors, better ToM consistently and significantly predicts better peer acceptance, and does so if peer acceptance is measured by soliciting ratings from children themselves or ratings from children’s teachers.

In recent research my colleagues and I (Peterson, Slaughter, Moore, & Wellman, 2016) looked beyond children’s peer acceptance alone to address their ‘peer

<table>
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<th>Table 3. Outline of potential influences of theory of mind on children in school.</th>
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<td>1. School Social Circumstances</td>
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<td>• popularity/rejection</td>
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<td>• leadership, joining in</td>
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<tr>
<td>2. Academic Performance and Strategies</td>
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<tr>
<td>• reading, writing, math</td>
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<tr>
<td>• history, social studies</td>
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<td>• metacognition</td>
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<td>3. Academic Motivation</td>
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<td>• persistence, overcoming failure</td>
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<td>• sensitivity to teacher feedback</td>
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social maturity’ more broadly, including their leadership and skills for joining in. We did this by using a recently created Peer Social Maturity Scale (PSMAT; first validated in Peterson, Slaughter, & Paynter, 2007) which had children's teachers rate them on different social skills such as skills for standing up for one's own opinions, leadership skills with peers, skills for joining groups of peers, and overall maturity of their peer skills. More than 100 children aged 6–13 years received ratings on the PSMAT and were tested on a variety of theory-of-mind tasks that included a false-belief battery (3 tasks) plus the 6-item Extended ToM Scale. For control purposes, language competence and several other factors were also assessed.

For typically-developing children, ToM predicted social maturity ($r = .40, p < .01$) even with age and language competence partialled out. In this study then, as well as in others (Garner & Waajid, 2008), ToM helps children develop positive relationships with their peers and moreover with their teachers. These positive relationships in turn, foster academic progress (Buhs & Ladd, 2001; Rubin, Bukowski, & Parker, 2006; Wentzel, 2003). Lagattuta, Hjortsvang, and Kennedy (2014) provide a good, recent review of the relationship between positive school-based social relations (with peers and with teachers) and enhanced academic performance at school.

School readiness in this social sense is not only important for children with typical development but also for those with atypical development, children with delay. In the Peterson, et al. (2016) research, for deaf children of hearing parents ToM also predicted social maturity ($r = .27, p < .05$), and again did so even with age and language competence partialled out. Theory of mind helps children develop positive relationships with their school peers and their teachers; it does so even when ToM itself is delayed.

**Academic performance and strategies**

Do theory-of-mind understandings also impact children's academic performances more directly? The rationale for thinking that ToM may do so is that ToM targets children's understanding of minds including their own minds. Conceptually, theory of mind includes notions about learning and memory as well as about beliefs and desires more specifically. Thus, it arguably includes knowledge about how to use one's mind to enhance learning and memory, that is, metacognition.

When children go to school they face increased demands for learning and memory and thus their metacognitive knowledge about knowledge of strategies for enhancing cognition and learning can become increasingly relevant (see e.g. Schneider, 2015). In seminal research, Schneider and colleagues (Lockl & Schneider, 2007) assessed a longitudinal sample of almost 200 German children beginning the transition to school. At 5 ½, at the end of kindergarten, children’s metacognition was assessed – specifically, their knowledge of learning and learning strategies in the sense of remembering information that is
presented, or metamemory. Earlier, at ages 3 ½ and 4 ½ their theory of mind was assessed by several false belief tasks and some other ToM items suitable for younger children like those used in the Wellman and Liu ToM Scale. And for control purposes several background factors, such as language competence, were assessed as well.

Better ToM at 3 ½ and 4 ½ years longitudinally predicted better metamemory at age 5 ½, that is at end of the kindergarten year, when children would transition to first grade the following year. This was true even when language competence was controlled ($betas = .20–.40$, $ps < .01$). Moreover, this relation between ToM and metamemory holds in other studies of young children too (e.g. Lecce, Demicheli, Zocchi, & Palladino, 2015).

What about research more directly related to academic performance, such as children’s reading and math or their overall school achievement? In several overlapping articles Serena Lecce and her colleagues (Lecce, Caputi, & Hughes, 2011; Lecce, Caputi, & Pagnin, 2014) have reported results from a longitudinal study of children tested at 5 ½ years, and again at fifth grade – i.e. at 10 years of age – that helps address this question.

Theory of mind at 5 ½ years was measured by a composite of false-belief tasks and other tasks taken from the 5-step ToM Scale. Academic performance at fifth grade was assessed straightforwardly by tests of reading comprehension and math ability as well as a teacher rating of the child’s overall academic achievement. Several background factors were included as control variables, for example, verbal ability measured by children’s scores on the Peabody Picture Vocabulary Test at 5 ½ years.

In a regression model, ToM at 5 ½ years predicted 10-year-old academic performance ($\beta = .55, p < .00$) and did so after age, verbal ability at 5 ½ years, and ToM at 10 years (controlling for concurrent ToM) were entered first. Thus, early ToM competence directly predicted later academic performance.

To be fair, not all research shows such tight connections between ToM and academic outcomes. For example, Strasser and del Río (2014) tested Chilean kindergarteners on their comprehension and recall of child-appropriate wordless storybooks (a task arguably related to later reading comprehension). Theory of mind (measured by a Spanish version of the 6-step Extended ToM Scale) did significantly predict children’s story comprehension. But in a regression analysis including a variety of overlapping predictors, theory of mind no longer surfaced as a significant independent predictor of story comprehension, whereas vocabulary and working memory did. Thus, in this study the influence of theory of mind on early reading-related comprehension, was subsumed under language and memory measures.

**Academic motivation**

The Lecce et al. (2014) research that showed longitudinal impact of ToM on school children’s reading and math also provided data about children’s academic motivation and, specifically children’s sensitivity to teacher feedback.
Sensitivity to feedback was measured using scenarios acted out with a teacher puppet and a child puppet (as done initially by Heyman, Dweck, & Cain, 1992). Enhanced theory-of-mind understanding at age 5 years significantly predicted sensitivity to teacher feedback at 10 years and sensitivity to teacher feedback in turn significantly predicted school achievement. So, ToM at age 5½ not only predicted academic performance at age 10 more directly, it additionally predicted academic performance through its significant influence on sensitivity to teacher feedback which also predicted children’s academic performance.

In the Lecce et al. (2014) study, receptivity to teacher feedback as I have labelled it, predicted improved academic performance over time. However, children's receptivity to their teachers’ comments can be seen as having both negative and positive influences and, Lecce and her colleagues called this measure ‘sensitivity to criticism,’ because some earlier longitudinal research (Cutting & Dunn, 2002; Dunn, 1995) found that better, earlier ToM predicted deleterious reactions to teacher criticism. And in other research, person-oriented criticism (where an adult criticizes the child, e.g. ‘You're not very good at math’) as opposed to process-oriented criticism (‘You failed to carry from the 10s place’) appears to increase children’s learned helpfulness and so decreases their effective, persistent performance (e.g. Elliot & Dweck, 2005; Kamins & Dweck, 1999). Thus, the influence of teacher feedback to students is complex, depending on the type of feedback provided (praise vs. criticism, person-oriented vs. process-oriented). But, the influence of teacher feedback also depends, as the Lecce et al. (2014) research shows, on children’s theory of mind.

To summarize, state-of-the art research shows that theory of mind influences school outcomes indirectly – via their peer popularity, joining in, metacognition, academic motivation—and influences school outcomes directly including reading math achievements. More such research would certainly be welcome.

**Extraordinary minds**

For me, one of the most intriguing later, post-preschool developments concerns children’s increasing willingness to entertain ideas of extraordinary minds and capacities. Initially, Barrett and colleagues (2001) demonstrated that as children come to appreciate the constraints of ordinary human knowledge and belief – for example, that people can have false beliefs – they recognize that God could have more extraordinary power.

Many findings have followed from this, charting children's further understanding of not only of God (Giménez-Dasí, Guerrero, & Harris, 2005; Makris & Pnevmatikos, 2007) but also omniscience (Lane, Wellman, & Evans, 2014) and afterlife (Bering & Bjorklund, 2004; Harris & Giménez, 2005). Research on extraordinary minds has also extended to consider extraordinary mental communications as well, such as prayer (Lane, Evans, Brink, & Wellman, 2016; Woolley, Phelps, Davis, & Mandell, 1999).
Cumulatively, these studies show that the school-age years are pivotal for children’s understanding of such extraordinary experiences, even for those children in devout homes who receive instruction and exposure to these ideas very early in life (Lane, Wellman, & Evans, 2012). These studies thus show additional advances in children’s theory-of-mind saturated conceptions that extend beyond preschool. Further, they show how children’s later ToM understandings are built on earlier preschool understandings that provide the foundation for children’s construction of later ideas, including their receptivity to and assimilation of sociocultural teachings, doctrines, and ideas about God, superheroes, Santa Claus, and more.

Understanding extraordinary minds goes beyond agents like God and superheroes. Consider robots and personified smart technological devices (e.g. Siri, Echo, Alexa). Children live in a world that increasingly includes such devices. How do they think and feel about such devices and how does this affect their interactions with and learning from them? We review the sparse emerging data on these questions and outline additional questions for future research in a recent review paper (Brink & Wellman, in press). But going forward, these are state of the art questions in need of state of the art research.

**Cognitive neuroscience**

One further important topic deserves some coverage because it certainly is part of research that characterizes the current state of the art: Research on the neural correlates of theory of mind and theory of mind development.

Investigations with adults demonstrate that theory-of-mind reasoning involves a network of neural regions, most consistently the medial prefrontal cortex, and the left and right temporoparietal junction, but also several temporal lobe sites. Figure 4 graphically shows the localization of these sites. These regions are recruited when adults engage in mental-reasoning tasks and they are impaired in autistic adults (for reviews see (Gallagher & Frith, 2003; Saxe, Carey, & Kanwisher, 2004)).

However, even if findings from studies with adults were crystal clear – and they are not – they could not provide an understanding of brain and cognition earlier in development. For example, it is completely possible that while adult data reveal the mature ToM network, that children, especially young children, have nothing like it. Thus, direct neurocognitive examinations of younger children are needed – especially in children from 2 to 6 or 7 years, when developmental ToM changes are pronounced. Such developmental neuroscience is just beginning (for a recent review, see Bowman & Wellman, 2014).

Although this developmental cognitive neuroscience work is still very much in progress, there are three things to be said as of now.
(1) Many of the same sites activated for adult theory-of-mind reasoning are activated for such reasoning earlier in life as well (see e.g. Bowman, Liu, Meltzoff, & Wellman, 2012; Sabbagh, Bowman, Evraire, & Ito, 2009). Although the activations and sites also differ in childhood from those in adulthood (see point 2 below), this overlap is nonetheless an intriguing and important finding, because, as just mentioned, in advance of these data it was perfectly possible that the neural resources young children recruit to engage in ToM tasks and reasoning are vastly different from the adult network.

(2) However, emerging research has also begun to show profound differences between adults and children and substantial developmental changes in the regions recruited for the theory-of-mind across childhood development. Activations start off much more diffuse early in life, and additionally functions shift as development proceeds (Bowman & Wellman, 2014). Developmental changes like these, even if not yet fully mapped or understood, are important because they would be unlikely if the ToM network was mature from the start and if theory of mind after infancy merely reflected changes in executive functions or language, as some propose (e.g. Baillargeon et al., 2010).

(3) Changes in the theory-of-mind network have also been found in older children, post-preschool and into adolescence (e.g. Saxe, Whitfield-Gabrieli, Scholz, & Pelphrey, 2009). Better understanding of these changes have the potential for more effectively illuminating theory-of-mind changes after the preschool years.
Concluding remarks

Over 30 years, the field of theory of mind has emerged, developed, and changed, creating the current field and its ‘art.’ We began in the 1980s focusing on preschoolers, but now chart theory-of-mind achievements from infancy through adulthood, from the nursery to the schoolyard to the classroom, and into the highways and byways of social life. We began with behaviors and now probe neural networks, genes, and social networks. We began looking at children in a few Western locales – the U.S., Canada, Europe—and now look worldwide. Similarly, interest in theory of mind began as the province of handful of researchers, now a legion of researchers study theory of mind across the world, only a few of which I’ve been able to cite in this article.

In the early days of theory of mind research, we advanced arguments for why theory of mind and its development were important topics for research, but the research on offer was very sparse. Now research shows that, and how widely, theory of mind proclivities impact human life. If you want more than research evidence for this widespread impact simply Google the topic ‘theory of mind.’ When I did so recently there were more than 35 million hits, encompassing references to theory of mind not only by developmental scientists, but also anthropologists, religious scholars, clinicians, educators, legal scholars, primatologists, philosophers, journalists and even novelists. In a great many different ways ‘theory of mind’ is an integral part of human life and contemporary human discussion.

As clear from these concluding remarks, while the field began with nothing but questions; now we have many answers. But of course, answers provoke new questions. So, one key ‘state of the art’ accomplishment is a firmer sense of how much remains to be known.

Disclosure statement

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