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The origins of children's metamemory: The role of theory of mind

Serena Lecce *, Patrizia Demicheli, Silvia Zocchi, Paola Palladino

Department of Brain and Behavioral Sciences, University of Pavia, 27100 Pavia, Italy

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A B S T R A C T

The relation between preschoolers' theory of mind (ToM) and declarative metamemory (DM) was investigated in two studies. The first study focused on 4-year-old children's ($N = 106$) cognitive and affective ToM and their DM. The data showed a significant association between cognitive (but not affective) ToM and DM, independent of verbal ability, non-verbal ability, and working memory. The second study involved 83 children tested at 4 years 6 months of age (and 6 months later) for cognitive ToM and DM. Here, results showed that early cognitive ToM, in particular false-belief understanding, predicts later DM independent of early verbal ability. These data support a view considering cognitive ToM as a precursor of children's DM.

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Introduction

Declarative metamemory (DM) refers to individuals' knowledge and beliefs about the functioning of their own memory (Flavell & Wellman, 1977; Schneider, 1999). It is conscious explicit knowledge about factors that affect memory performance and includes not only knowing that a range of variables affect memory but also knowing why they affect memory. DM comprises knowledge about memory tasks, memory-relevant variables, and potential applicable memory strategies as well as beliefs about the capacities, functioning, and limitations of the memory system. It can be assessed using off-line tasks such as questionnaires.

* Corresponding author. Fax: +39 0382 986272.
E-mail address: slecce@unipv.it (S. Lecce).

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Overall, existing studies show substantial improvements in DM between kindergarten and early school years (e.g., Cavanaugh & Borkowski, 1980; Fritz, Howie, & Kleitman, 2010; Sodian, Schneider, & Perlmutter, 1986), with preschool children showing a basic understanding of metamemory-relevant variables (Kreutzer, Leonard, & Flavell, 1975; Lockl & Schneider, 2007; Wellman, 1977). Given the effects of metamemory on children's learning (Schneider, 2008), it is striking that very few studies have investigated the origins of children's knowledge about memory. An approach that seems fruitful in addressing this issue is one that links children's emerging DM to individual differences in theory of mind (ToM).

ToM is defined as the ability to attribute mental states such as beliefs, emotions, and intentions to self and others in order to predict, influence, and manipulate social behavior (Wellman, Phillips, & Rodriguez, 2000). After many years of research in this area, we now know that children acquire important milestones during preschool years (Wellman, Cross, & Watson, 2001), following a predictable developmental trajectory (Pons & Harris, 2000; Wellman & Liu, 2004). Crucially, research has shown the existence of strong individual differences between children of the same age (Cutting & Dunn, 1999), with important consequences for children's social and cognitive development (Hughes, 2011; Lecce, Caputi, & Pagnin, 2014).

In studying the connections between ToM and DM, great emphasis has been placed on the theoretical model developed by Kuhn (2000), which positions the acquisition of ToM understanding in the larger context of metacognitive development. According to this framework, ToM appears early and as a basic metaknowing of the content of the mind and the nature of mental states. Metacognition is considered a subsequent (and more mature) ability encompassing knowledge about cognitive processes and the links between these cognitive processes and cognitive performance. In addition, it involves procedural knowledge, that is, the application of metamemory during memory performance. Kuhn's model is extremely pertinent for the purpose of the current study because it claims that ToM serves as a base for the development of metacognition. Indeed, Kuhn posited that having a concept of mental states, such as beliefs, is a necessary initial step for thinking about the strategies to solve a cognitive task.

Despite Kuhn's (2000) model being an innovative approach, very few studies have empirically tested this model. To date, the most comprehensive research on the relation between ToM and DM was conducted by Lockl and Schneider (2007), who focused on children's false-belief understanding, that is, the understanding that beliefs are separate and distinct from reality (Perner, 1991). Lockl and Schneider (2007) followed a sample of German preschoolers longitudinally for 3 years: from 3, 4, and finally 5 years of age. Participants were tested for verbal ability and false-belief understanding at all ages and for DM at 5 years. Findings showed strong relations between false-belief understanding and DM, with false-belief understanding at 3 and 4 years of age significantly predicting DM (independent of verbal ability) at 5 years.

The results of Lockl and Schneider's (2007) study are original and have contributed considerably to increasing interest in this area of research. However, they leave a number of questions open. First, on the basis of Lockl and Schneider's work, we do not know whether the relation between ToM and DM is specific for cognitive ToM, such as false-belief understanding, or rather generalized to other domains of ToM, such as emotion understanding. Second, given that Lockl and Schneider (2007) measured DM only at 5 years of age, they were unable to test the relation between early DM and later ToM. Thus, the question of whether the relation between ToM and DM is unidirectional or bidirectional remains open for investigation. Answering these questions is relevant both theoretically and empirically (see the final Discussion for more comments on this issue).

In the current research, we conducted two separate studies to answer these questions. Both focused on 4- and 5-year-olds because during this developmental period individual differences in ToM are shown clearly (Wellman et al., 2001) and DM begins to emerge (Wellman, 1977). Study 1 was designed to examine the specificity of the relation between ToM and DM by comparing cognitive and affective ToM and by taking into consideration a number of control variables. Study 2 expanded on the findings of Study 1 by using a longitudinal design to examine the direction of the relation between ToM and DM.

Specificity of the relation between ToM and DM

As mentioned above, ToM is a complex developmental phenomenon that encompasses a wide range of mental states (see Astington, 2001; Wellman, 2012). One important distinction is that between the cognitive and affective ToM. Cognitive ToM concerns children's ability to understand cognitive states and requires an appreciation of the differences between the speaker's knowledge/belief and that of the listener. During the preschool years, children acquire a critical ability in this domain, namely false-belief understanding. As we might expect, this acquisition marks children's understanding that one acts based on one's beliefs even when these can differ from reality (Wellman et al., 2001). Affective ToM concerns children's ability to infer emotions and feelings, and it requires empathic appreciation of the listener's emotional state. At preschool age, children become able to name different emotional expressions (e.g., happy, sad, angry, neutral) and come to understand that external events cause emotions (Pons & Harris, 2000). Recent studies on typically developing children encourage consideration of cognitive and affective ToM separately from one another because they do not correlate significantly when language and family socioeconomic status are taken into account (Cutting & Dunn, 1999; Hughes, Lecce, & Wilson, 2007) and may show different consequences (Dunn, 1995). Similar conclusions can be drawn from neuropsychological studies on populations with typical development (Kalbe et al., 2010) and psychiatric disorders (Shamay-Tsoory, Aharon-Peretz, & Levkovitz, 2007).

To date, only one study has compared children's cognitive and affective ToM in relation to metacognition. This research, conducted by Lecce and colleagues (Lecce, Zocchi, Pagnin, Palladino, & Taumoepeau, 2010), involved a sample of Italian primary school children. It focused on children's metaknowledge about reading comprehension and showed that whereas cognitive ToM (indexed by cognitive mental state language and the Strange Stories task) was significantly associated with metaknowledge about reading, affective ToM (indexed by emotion mental state language and the Test of Emotion Comprehension) was not. Importantly, the relation between cognitive ToM and metacomprehension was independent of expressive and receptive language and of reading comprehension skills.

Although Lecce, Zocchi, Pagnin, Palladino, and Taumoepeau (2010) work focused on children older than those considered in the current study, and on metacognition applied to a reading comprehension task, we expected to find similar results with respect to DM. There are three main reasons for expecting DM to be more closely related to cognitive ToM than to affective ToM. First, children's DM presupposes a familiarity with cognitive mental state terms (e.g., remembering, forgetting) rather than affective state terms (e.g., happy, sad) (Wellman & Johnson, 1979), which seem to be more closely related to positive dimensions of social behavior such as prosocial behavior (Denham, 1986; Iannotti, 1985). Second, a central step in children's awareness of their own memory functioning is the understanding that knowledge states depend on informative experience (see Welch-Ross, 2000). Importantly, this recognition, as argued by Lockl and Schneider (2007), is also a crucial component for passing the false-belief task that forms a critical component of cognitive ToM. For example, to understand that the presence of noise, or the number of items to remember, affects the memorization process, children need to understand the links between experience and knowledge state and that knowledge of an event depends strictly on the experience concerning that event. In line with this view, Bright-Paul, Jarrold, and Wright (2008) showed that children's understanding of the origins of knowledge is linked significantly with false-belief understanding in preschoolers. Finally, in examining the links between cognitive ToM and DM, it is important to consider that awareness of the processes underlying acquisition of new knowledge (e.g., acquiring new memories) becomes possible only when children address the concept of representational change, typically assessed through false-belief tasks (Gopnik & Astington, 1988). Overall, then, these considerations, together with existing findings, lead us to expect DM to be more closely related to cognitive ToM than to affective ToM. However, it is important to note that affective ToM is itself a component of ToM and that it is possible that commonalities between the two types of ToM might play a role in the development of DM. To examine this issue, we designed Study 1.

Direction of the relation between ToM and DM

The second main goal of the current study was to investigate the direction of the relation between ToM and DM. As cited above, Kuhn's (2000) theoretical model and data from Lockl and Schneider (2007) suggest that ToM, and in particular false-belief understanding, is a precursor of metacognition and that the acquisition of mental state reasoning is a necessary initial step in the development of metacognition. However, existing data did not test this prediction fully because they did not measure both false-belief understanding and DM at two time points. More stringent tests are needed to demonstrate a clear direction between ToM and DM.

New studies are especially needed to understand the developmental process from ToM to metacognition better and, in particular, to metamemory. Despite the fact that existing research and theoretical models lead us to expect that individual differences in children's ToM may prepare the way for their later DM, we still know very little about the nature of conceptual changes. One possibility is that there is a general continuity between ToM, as the sum of the various sub-components (see Wellman & Liu, 2004), and metamemory; if so, we should find an association between children's progression in ToM understanding (as a global index) and later DM. Alternatively, it is possible that some components of ToM would be more closely linked to later DM than others. Here, we acknowledge that individual differences in children's ToM in general may prepare the way for their later DM. It is indeed evident that unless children are aware of the existence of mental states and their subjective nature, they cannot think about how these mental states work in a memory task. This position was emphasized by Bartsch and Estes (1996), according to whom ToM understanding provides a foundation for thinking about mental states and their relation to cognitive tasks. Given this, we argue that ToM is a complex ability made up of different components and concepts that develop at different ages (Wellman & Liu, 2004), and these sub-components are likely to have differential impact on later metamemory. More precisely, we expect early false-belief understanding, more than other basic aspects of ToM understanding such as perspective taking and comprehension of ignorance, to predict later DM. There are at least three main reasons (in addition to the ones outlined above) for such a prediction. First, as noted by Flavell, Green, and Flavell (1998, 2000), early mastery in false-belief understanding helps the development of metacognition because it brings mental activity to the attention of children. Passing a false-belief task is indeed the first clear evidence of an understanding that mental representations do not necessarily correspond to reality and, thus, can themselves become objects of consideration. This discovery prompts children to reflect on their cognitive activity, paving the way for the development of explicit metacognition that would be impossible in the absence of this "mind-reading" (Efklides, 2008; Kuhn, 2000). Second, children's DM requires an acquaintance with terms indicating cognitive activities and the ability to infer and reflect on cognitions. Importantly, individual differences in children's use and understanding of mental state terms are associated with false-belief understanding (Grazzani & Ornaghi, 2012; Hughes & Dunn, 1998) and mark full understanding of specific mnemonic conceptions (Wellman & Johnson, 1979). Here, it is important to note that a basic understanding of memory-related verbs seems to follow a mastery of the classic false-belief task. More precisely, Lyon and Flavell (1994) showed that it is only at around 4 years of age, when most children pass first-order false-belief tasks, that children understand that it is possible to remember or forget something only if they have previously known it. Third, mastery of first-order false-belief tasks requires an understanding of the concepts of knowledge and beliefs, and this understanding is also involved in some aspects of metamemory. Indeed, as Lockl and Schneider (2007) argued, a crucial component for passing first-order false-belief tasks is the understanding that beliefs derive from experiences in the world. These acknowledgments are likely to play a role in children's knowledge of memory processes and, more precisely, in their awareness of the variables that affect memory performance. Overall, these considerations fit the view of considering false-belief understanding, rather than earlier ToM acquisitions, as a crucial precursor for helping children to understand the link between mental representation and memory. To test this hypothesis, in Study 2 we compared the association between early pre-false-belief and false-belief understanding with later DM.

Study 1

Study 1 addressed our first goal, the specificity of the relation between ToM and DM, in two ways. First, it compared cognitive and emotion understanding to investigate whether the association between ToM and DM is specific for some, but not other, categories of mental states. Second, it examined whether the relation between ToM and DM is independent of children's verbal ability, non-verbal ability, and working memory. This is a crucial issue given that previous studies have shown that declarative knowledge and cognitive understanding are facilitated by verbal and non-verbal abilities (Lockl & Schneider, 2007; Milligan, Astington, & Dack, 2007; Schneider, Korkel, & Weinert, 1987) as well as working memory (Demetriou, 2009; Gordon & Olson, 1998). Therefore, we considered these as control variables.

Method

Participants

A total of 106 preschoolers (M_{age} = 4.5 years, SD = 6.5 months), 46 boys and 60 girls, took part in this study. Children were recruited from four kindergartens in Northern Italy and were all Caucasian. Family backgrounds ranged from lower to middle class. Criteria for inclusion were informed consent from parents, Italian as native language, and no developmental delay.

Measures

Verbal ability. This was assessed via the Test for Reception of Grammar (TROG; Bishop, 1982; Italian adaptation: M. Cendron et al., personal communication, 1995), which evaluates semantic and syntactic skills. Children were required to match a picture to a word (or a sentence), choosing among four alternatives. One point was given for each correct item (range = 0–80, α = .83).

Non-verbal ability. This was assessed via the Coloured Progressive Matrices (Raven, Court, & Raven, 1986). Scores on the three series of matrices (A, B, and AB) were summed (range = 0–36, α = .74).

Working memory. This was assessed using a dual request word recall task (Lanfranchi, Cornoldi, & Vianello, 2004). Children were read eight lists of two to five two-syllable words and were asked to repeat the first word of the list while simultaneously tapping on the table every time the word *ball* was presented. One point was assigned for each list correctly responded to (range = 0–8, α = .81).

Cognitive theory of mind. This was assessed via the Theory of Mind Test (TMT; Pons & Harris, 2002), which examines cognitive (and not emotion) understanding. It evaluates the following 10 components of cognitive understanding (Flavell, 2004): (a) Level 1 of perspective taking, (b) Level 2 of perspective taking, (c) comprehension of intentionality, (d) comprehension of ignorance, (e) comprehension of false belief, (f) comprehension of the distinction between appearance and reality, (g) comprehension of lies, (h) comprehension of jokes, (i) comprehension of second-order false belief, and (j) comprehension of double bluff. While showing a cartoon scenario, the experimenter read an accompanying story about the depicted character(s) or the content of the picture. After hearing each story, children were asked to attribute a cognition to the main character by pointing to one of two alternative outcomes depicted below the scenario. Each component was evaluated via two items, and children were given one point for each category in which they passed both items (range = 0–10, α = .69).

Affective theory of mind. This was measured through the Test of Emotion Comprehension (TEC; Albanese & Molina, 2008; Pons & Harris, 2000). The TEC gives an overall score of emotion understanding by evaluating nine components with a hierarchical organization: (a) emotion understanding based on facial expression, (b) understanding of external causes of emotion, (c) emotion understanding based on desires, (d) emotion understanding based on beliefs, (e) understanding of the influence of a reminder on the current emotional state, (f) understanding of the capacity to control a felt emotion, (g) understanding of the capacity to hide an emotion, (h) understanding of mixed emotions, and (i) understanding of moral emotions. The task consisted of a picture book with a simple scenario on each page. While showing each picture scenario, the experimenter read the accompanying story with a neutral tone of voice. After hearing each story, children were asked to attribute an emotion to the main character (whose face was blank) by pointing to one of four alternative emotional outcomes depicted below the scenario. Two items per component were administered, and children were given one point for each category in which they passed both items (range = 0–9, α = .74).

Declarative metamemory. This aspect was evaluated via two measures: the DM–vignette task (Cornoldi & Orlando, 1988) and the DM–story task (Cornoldi, Gobbo, & Mazzoni, 1991).

The DM–vignette task (Cornoldi & Orlando, 1988) is based on items originally developed by Kreutzer (Kreutzer et al., 1975) and Wellman (1977). It evaluates children's knowledge of the following four memory-relevant variables: (a) presence or absence of noise, (b) number of items to remember, (c) random versus categorized order of the items to remember, and (d) memory strategies (e.g., drawing). Children were shown four pairs of illustrated vignettes that were identical except for the memory variable tested in that specific item. The following is a description of the scenarios depicted for each pair of vignettes: (a) for noise, a vignette of a child in a room with a lot of noise (e.g., a radio playing and a barking dog) versus a vignette of a child in a quiet room; (b) for number of items, a vignette of a child with a lot of objects to remember versus a vignette of a child with few objects to remember; (c) for classification, a vignette of a child with a list of objects to remember placed randomly versus a vignette of a child with a list of objects to remember ordered by category (e.g., vehicles, toys); and (d) for drawing, a vignette of a child trying to remember by looking at the objects versus a vignette of a child drawing pictures of the objects that need to be remembered.

For each pair of vignettes, the experimenter briefly described the drawings before asking children a test question (e.g., "Which girl will remember all the items?"). One point was given for each vignette (range = 0–4, α = .74).

The DM–story task (Cornoldi et al., 1991) examined children's knowledge about memory strategies using a narrative format. It was chosen because narratives offer children an important opportunity to organize social experience (Bruner, 1986) and reflect on mental states (Dyer, Shatz, & Wellman, 2000). The story was titled "The Captive Princess" and was divided into two sections, each followed by a group of questions. It comprised a story of a prince who must meet a wise man in order to discover how to undo a spell and free a princess. Children are told that once the antidote for the spell has been revealed (i.e., a sequence of actions), the prince must make a very long journey to return to the castle where the princess has been imprisoned. The first section of the story ends with the prince in front of the castle and is followed by three questions. The first two questions assess children's knowledge of forgetting: "Will the prince remember what to do to free his princess?" and "In fact, the prince did not remember, so why does he not remember?" The third question evaluates children's knowledge of retrieval: "What can the prince do in order to remember the antidote?" When the children have answered these questions, the second section of the story starts. Children are told that the prince decides to go back to the wise man. Once there, the wise man repeats to the prince what he must do in order to break the spell, and the prince returns again to the castle. At this point of the story, children are asked the final question (i.e., "What can the prince do in order to be sure to recall what to do?") assessing their knowledge of memory maintenance strategies. In this last question, children are encouraged to give as many answers as possible.

Children's answers were coded according to the criteria presented by the authors (Cornoldi et al., 1991), including an evaluation of the maturity of children's knowledge of memory strategies (for more details, see Cornoldi et al., 1991). More precisely, children's knowledge of forgetting (the first two questions) was evaluated on a scale of 0 (e.g., "don't know" response or "Yes the prince will remember" without any justification) to 7 (e.g., "The prince will not remember because he did not think about the instructions and got distracted by the trip"). This scale assesses children's knowledge that (a) information decays from memory and that (b) information is sensitive to time delay between coding and retrieval as well as on how such time is used to strategically rehearse memory information. Children's knowledge of retrieval was evaluated on a scale of 0 (e.g., "don't know") to 5 (e.g., "He can think carefully about those three things in his head"). This scale assesses children's knowledge of the necessity of doing something before information decays from memory and of the role of mental activity in contrasting decay. Children's knowledge of storage was evaluated, coding the maturity of each strategy mentioned on a scale of 1 (e.g., magic retrieval) to 3 (e.g., rehearse information in memory so that it can be fixed in the head) and then summing these. Scores on this scale reflect the efficacy of metamemory strategies to contrast decay. Although the alpha was modest (.55), the three scales were all significantly associated with cognitive ToM ($r \geqslant .29$, $p = .003$). Therefore, as suggested by the authors of this task, we computed an overall score of children's knowledge of memory strategies by summing raw scores of each answer.

Procedure

All tasks were administered individually in the children's kindergartens. At each time point, children participated in three testing sessions of approximately 20 to 30 min each. During the first session, children were administered the verbal ability, non-verbal ability, and working memory tasks. During the second session, they completed the DM–story and affective ToM tasks. During the last session, they undertook the DM–vignette and cognitive ToM tasks.

Results

First, we present descriptive statistics for each study measure and data reduction strategies for constructing DM knowledge indexes. Next, we report findings concerning associations between control and key variables and associations between cognitive and affective ToM. Finally, we consider links between children's ToM and DM.

Table 1 provides a summary of the descriptive statistics for metamemory tasks. Results showed that children had difficulties in identifying categorization as an efficient memory strategy but that children understand that remembering fewer items is easier than remembering many items. With reference to the metamemory story task, results on percentage of success showed that children's knowledge of forgetting was better than their knowledge of retrieval, $t(105) = 2.55$, $p = .012$, and of storage, $t(105) = 3.35$, $p = .001$.

Descriptive statistics for all study tasks are shown in Table 2.

Inspection of correlations showed that individual differences in the DM–vignette and DM–story tasks were significantly associated with one another, $r(106) = .48$, $p < .001$; therefore, we created an aggregate index of DM by summing z scores on each task.

Table 3 shows the pattern of correlations between the study variables. As expected, individual differences in cognitive ToM, affective ToM, and DM were all significantly associated with individual differences in control variables: verbal ability, non-verbal ability, and working memory. The only exception was a lack of association between working memory and affective ToM. Given these results, children's scores in verbal and non-verbal abilities as well as in working memory were treated as control variables in the following analyses. Table 3 also shows that children's cognitive and affective ToM were significantly associated. Nevertheless, when we computed partial correlation analyses controlling for verbal ability, non-verbal ability, and working memory, the value of this correlation fell below the significance level, $r(101) = .09$, $p = .34$. This finding supports our decision to consider them separately.

Table 1
Descriptive statistics for items in declarative metamemory tasks.

Task		*M* (*SD*)	Actual range
Vignette task	Noise	0.64 (0.48)	0–1
	Number	0.70 (0.46)	0–1
	Category	0.49 (0.50)	0–1
	Drawing	0.54 (0.50)	0–1
Story task	Knowledge of forgetting	2.64 (1.19)	0–6
	Knowledge of retrieval	1.59 (0.88)	0–4
	Knowledge of storage	1.16 (0.95)	0–4

Table 2
Means (and standard deviations) of scores for Study 1 key variables.

Variable	Task	*M* (*SD*)	Actual range
Verbal ability	TROG	55.42 (16.40)	0–78
Non-verbal ability	Raven's matrices	17.24 (3.95)	0–27
Working memory	Dual request word recall task	4.10 (1.81)	0–8
Cognitive ToM	TMT	6.64 (1.50)	0–10
Affective ToM	TEC	5.16 (1.53)	0–8
Declarative metamemory	Vignette task	2.37 (1.08)	0–4
	Story task	5.40 (2.05)	0–10

Note. TROG, Test for Reception of Grammar; TMT, Theory of Mind Test; TEC, Test of Emotion Comprehension.

Table 3
Correlations between Study 1 variables.

	NVA	WM	C_ToM	A_ToM	DM
Verbal ability (VA)	.51***	.41***	.54***	.57***	.58***
Non-verbal ability (NVA)	–	.17	.33**	.38***	.41***
Working memory (WM)		–	.28**	.05	.21*
Cognitive ToM (C_ToM)			–	.36***	.51***
Affective ToM (A_ToM)				–	.37***
Declarative metamemory (DM)					–

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

The main goal of Study 1 was to examine whether children's cognitive and affective ToM were related to DM differently. Our results showed that individual differences in DM were significantly correlated with both cognitive and affective ToM. However, when we controlled for verbal ability, non-verbal ability, and working memory, the relation between DM and cognitive ToM remained significant, $r(101) = .29$, $p = .003$, but not that between DM and affective ToM, $r(101) = .08$, $p = .34$. Crucially, the difference between these two indexes of partial correlations was marginally significant, $Z = 1.615$, $p = .05$, one-tailed.

Discussion

The main aim of Study 1 was to investigate the relation between preschoolers' ToM and DM. We were particularly interested in examining whether this association (a) was independent of verbal ability, non-verbal ability, and working memory and (b) differed depending on whether we considered children's cognitive or affective ToM.

The most important finding of Study 1 was that the association between preschoolers' ToM and DM was significant when we controlled for verbal ability, non-verbal ability, and working memory and was specific for cognitive (but not affective) ToM understanding. Crucially, the correlation between cognitive ToM and DM was significantly stronger than the one between affective ToM and DM. These results confirm our predictions and are also consistent with the claim that acquisition of an understanding of mental representation promotes the development of DM as proposed by Kuhn (2000). Our results also fit with empirical findings on German children (Lockl & Schneider, 2007) and Cypriot children (Demetriou, 2009). In addition to confirming existing findings, our study also expands them by adopting new measures of both ToM (TMT by Pons & Harris, 2002) and metamemory (story task by Cornoldi et al., 1991) and involving younger children.

Study 1 represents the first clear demonstration that the relation between ToM and DM during preschool years does not generalize across domains of mental state understanding but rather is specific to cognitive ToM. However, although Study 1 yielded interesting findings, its correlational nature did not allow us to investigate the direction of the relation between children's cognitive ToM and DM fully. To address this issue, we designed a second study (outlined below).

Study 2

Study 2 was designed to expand on the findings of Study 1 and to investigate the direction of the relation between ToM and DM. Given the results of the first study, in Study 2 we only considered children's understanding of beliefs (cognitive ToM). Notably, to make our study more sensitive to individual differences, we also expanded the tasks to measure cognitive ToM (see the Method section for more details) in two ways. First, we administered two tasks for each component of the TMT. Second, we included four classic first-order false-belief tasks. The addition of these tasks provides an extended, genuinely progressive developmental assessment of children's ToM competence and allowed us to investigate which components of cognitive ToM are more closely related to DM. More precisely, in addition to considering ToM as a general index comprising different components, we examined pre-false-belief versus false-belief understanding in relation to DM.

To achieve these goals, Study 2 adopted a longitudinal design in which we followed a group of children between 4 years 6 months and 5 years of age. This design allowed us to compare two models: one in which early cognitive understanding predicts later DM (Model A) and one in which early DM predicts subsequent cognitive understanding (Model B). In this second study, we considered language as a control variable (as in Study 1). For reasons of testing constraints, we did not include children's non-verbal ability and working memory. However, Study 1 showed that these play a minor role in the association between cognitive understanding and DM.

Method

Participants

A total of 83 children (40 girls and 43 boys), all Caucasian, took part in the study. They had a mean age of 4.6 years (SD = 3.55 months, range = 48–63 months) at Time 1 (T1) and of 5.2 years (SD = 3.56 months, range = 54–69 months) at Time 2 (T2). Participants were recruited through kindergartens in a small university town in Northern Italy. Kindergartens were located in areas with mixed socioeconomic backgrounds. Children with language or developmental difficulties were excluded from the sample.

Measures

Children were tested longitudinally at two time points separated by a testing interval of approximately 6 months. At each time point, they were evaluated for verbal ability, cognitive ToM, and DM.

Verbal ability. Language skills were assessed with the Vocabulary subtest of the Wechsler Preschool and Primary Scale of Intelligence–III (WPPSI; Wechsler, 2008). The subtest consists of 38 items of increasing difficulty. For each item, children were required to indicate the picture depicting a word spoken by the experimenter by choosing one of four alternatives (range = 0–38, α_{T1} = .85 and α_{T2} = .81).

Cognitive theory of mind. This was assessed via four first-order false-belief tasks and the TMT used in Study 1 (Pons & Harris, 2002).

The first two first-order tasks were presented using puppet scenarios, as previously undertaken in studies on British and Italian children (Lecce & Hughes, 2010). The first one was an unexpected content task (Bartsch & Wellman, 1989) where children were shown a plain container and a prototypical container (a miniature cereal box). They were asked to guess what was inside the prototypical container. Children were then shown that the prototypical content (i.e., cereal) was actually in the plain container. A puppet was introduced, and children were asked the test question (i.e., "Which box will the puppet think has cereal in it?") and the control question (i.e., "What is in this box?"). The second first-order task was based on the standard "Sally Ann" task (Wimmer & Perner, 1983) and was enacted using a toy kitchen. The third and fourth first-order false-belief tasks were presented using storybooks and were based on the first part of the second-order tasks developed by Sullivan and colleagues (Sullivan, Zaitchik, & Tager-Flusberg, 1994). In the first of these, a mother tells her son Peter that she has bought him a toy for his birthday when in fact she has bought him a puppy. Children were asked a test question (i.e., "What did Peter think he was getting for his birthday?") and a reality control question (i.e., "What was his Mum giving him really?"). The second task involved a similar scenario but with two siblings (i.e., Mary and John) and a bar of chocolate. The same set of test questions (first order) and control reality questions were asked. In each task, children were coded as being successful only if they passed both the test and control questions (range = 0–4, α_{T1} = .58 and α_{T2} = .68).

For the TMT (Pons & Harris, 2002), in this study we administered two items for each of the following components: (a) Level 1 of perspective taking, (b) Level 2 of perspective taking, (c) comprehension of intentionality, (d) comprehension of ignorance, (e) comprehension of false belief, (f) comprehension of the distinction between appearance and reality, (g) comprehension of lies, and (h) comprehension of jokes. One point was given for each correct answer (range = 0–16, α_{T1} = .65 and α_{T2} = .64). For additional comments on the TMT, see Study 1.

Declarative metamemory. This was assessed using the same tasks used in Study 1: the DM–vignette task (Cornoldi & Orlando, 1988) and the DM–story task (Cornoldi et al., 1991).

For the DM–vignette task (Cornoldi & Orlando, 1988), in Study 2 we administered seven items rather than four items (i.e., pairs of vignettes). These three additional items evaluated children's knowledge of the following memory variables: the age of the person performing the memory task, the presence/absence of external help, and the amount of time to study the items to remember. For each item, the experimenter asked children a test question (i.e., "Which girl will remember all the items?") as well as a justification question (i.e., "Why?"). The addition of a justification question was important because it served to check whether children who correctly answered the forced-choice question were simply guessing (Lockl & Schneider, 2007). A justification was considered as appropriate (e.g., meriting one point) when the child referred in any way to the critical aspect in which the memory task conditions differed (e.g., "because the dog makes too much noise," "because she has more pictures"). In contrast, a justification was coded as inappropriate when the child (a) referred to an aspect of the picture that was memory irrelevant (e.g., "because this dog is too big"), (b) provided an irrelevant answer (e.g., "because I like girls more than boys," "because her jacket is nicer"), or (c) provided no answer (range = 0–14, α_{T1} = .67 and α_{T2} = .76).

The DM–story task (Cornoldi et al., 1991) and its coding system were identical to those used in Study 1.

Procedure

All tasks were administered individually in the children's kindergartens. At each time point, children participated in two testing sessions of approximately 20 to 30 min each. The order of the tasks was fixed. During the first session, children were administered the vocabulary task and the false-belief tasks; during the second session, they were asked to complete the TMT and the DM task.

Results

We begin by reporting descriptive statistics for each measure and preliminary results concerning (a) descriptive statistics for the metamemory tasks, (b) developmental changes, and (c) stability of individual differences across time. Next, we present relations between conceptually overlapping measures and data reduction strategies for constructing aggregate measures of cognitive ToM and DM. Finally, we report analyses concerning relations between cognitive understanding and DM (within and across time).

Preliminary analyses

We started by examining, in detail, the results of the metamemory tasks (see Table 4). As in Study 1, the most difficult item on the DM–vignette task was the categorization item. The easiest vignettes were the number item at Time 1 and the drawing item at Time 2. Regarding the DM–story task, our results showed that children had good knowledge of forgetting but limited knowledge of memory strategies.

Table 4
Descriptive statistics for various items of the declarative metamemory tests.

		Time 1		Time 2	
		Actual range	*M* (*SD*)	Actual range	*M* (*SD*)
Vignette task	Category	0–2	0.51 (0.55)	0–2	0.46 (0.57)
	Number	0–2	1.13 (0.85)	0–2	1.52 (0.85)
	Time	0–2	0.96 (0.86)	0–2	1.24 (0.92)
	Noise	0–2	0.72 (0.83)	0–2	1.34 (0.86)
	Help	0–2	0.77 (0.72)	0–2	0.98 (0.74)
	Drawing	0–2	1.02 (0.84)	0–2	1.61 (0.64)
	Age	0–2	1.08 (0.84)	0–2	1.23 (0.84)
Story task	Knowledge of forgetting	0–6	2.53 (1.20)	0–6	3.07 (1.33)
	Knowledge of retrieval	0–5	1.47 (1.03)	0–5	1.49 (0.97)
	Knowledge of storage	0–6	0.76 (1.31)	0–4	0.95 (1.09)

Children significantly increased or improved their performance on all tasks (see Table 5). Given these developmental changes, individual differences in the following variables were also significantly stable across time: verbal ability, $r(83) = .56$, $p < .001$; first-order false belief, $r(83) = .31$, $p = .005$; TMT, $r(83) = .67$, $p < .001$, DM–vignette task, $r(83) = .44$, $p < .001$; and DM–story task, $r(83) = .44$, $p < .001$.

With respect to associations between conceptually overlapping measures, our analyses showed that individual differences on the first-order false-belief tasks and the TMT were correlated at Time 1, $r(83) = .50$, $p < .001$, and Time 2, $r(83) = .31$, $p = .063$. Therefore, we computed an overall index of cognitive ToM at Time 1 ($\alpha = .66$) and Time 2 ($\alpha = .72$) by summing z scores. Within DM, children's performance on the vignette task was significantly associated with that on the story task at Time 1, $r(83) = .26$, $p = .016$, and Time 2, $r(83) = .55$, $p < .001$. Therefore, we again computed aggregate scores of children's DM at Time 1 ($\alpha = .67$) and Time 2 ($\alpha = .77$) by summing z scores. Table 6 shows the pattern of associations between the study variables. As can be seen, at Time 1 and Time 2, children's verbal ability was significantly correlated with concurrent level of cognitive ToM and DM. Therefore, we adopted verbal ability as a control variable in examining the association between cognitive ToM and DM.

Concurrent and longitudinal relations between cognitive ToM and DM

As can be seen in Table 6, our data showed that individual differences in cognitive ToM were significantly associated with those in DM, at both Time 1 and Time 2, even when we controlled for concurrent verbal ability, $r_{T1}(80) = .22$, $p = .05$, and $r_{T2}(80) = .25$, $p = .02$. We were also interested in

Table 5
Children's scores on the key variables of Study 2.

Variable	Task	Time 1	Time 2	$t(81)$	p	95% CI		Cohen's d
		M (*SD*) Actual range	*M* (*SD*) Actual range			*LL*	*UL*	
Verbal ability	WPPSI	22.66 (5.63) 0–32	25.14 (4.62) 0–33	−4.96	.000	−3.47	−1.48	−0.48
Cognitive ToM	First-order FB	2.05 (0.99) 0–4	2.39 (0.80) 0–4	−2.83	.006	−0.58	−0.10	−0.38
	TMT	12.69 (2.38) 6–16	14.03 (2.09) 7–16	−6.52	.000	−1.75	−0.93	−0.60
Declarative metamemory	Vignette task	6.55 (2.57) 1–13	8.66 (2.92) 3–14	−6.46	.000	−2.76	−1.46	−0.77
	Story task	5.15 (2.80) 1–15	5.78 (2.55) 1–12	−2.54	.013	−1.12	−0.14	−0.24

Note. CI = confidence interval; LL = lower limit; UL = upper limit; FB = false belief.

Table 6
Correlations between Study 2 variables within and across time.

	T1 C_ToM	T1 PRE_FB	T1 FB	T1 DM	T2 VA	T2 C_ToM	T2 PRE_FB	T2 FB	T2 DM
T1 VA	.38***	.32**	.37**	.45***	.56***	.35**	.22*	.32**	.53***
T1 C_ToM	–	.62***	.80***	.35**	.53***	.56***	.51***	.28*	.50***
T1 PRE_FB		–	.37**	.25**	.42***	.48***	.15	.51***	.27*
T1 FB			–	.34**	.48***	.51***	.15	.51***	.50***
T1 DM				–	.38***	.39***	.27*	.34**	.65***
T2 VA					–	.47***	.31**	.40***	.52***
T2 C_ToM						–	.46***	.80***	.43***
T2 PRE_FB							–	.16	.18
T2 FB								–	.43***
T2 DM									–

Note. T1, Time 1; T2, Time 2; VA, verbal ability; C_ToM, cognitive ToM; PRE_FB, pre-false-belief understanding; FB, false-belief understanding; DM, declarative metamemory.
* $p < .05$.
** $p < .01$.
*** $p < .001$.

examining whether task demands affected our results. Therefore, we restricted these correlational analyses to the TMT and DM–vignette tasks that were more similar in procedure, language, and format and found that results did not change. More precisely, the correlation between individual differences in early TMT and later DM, $r(80) = .68$, $p = .00$, was significantly stronger than the correlation between early DM and later TMT, $r(80) = .36$, $p = .001$, $z = 2.92$, $p = .001$.

The main aim of Study 2 was to examine the direction of the relation between children's cognitive ToM and their declarative metamemory. This was undertaken by comparing two opposing models: Model A, in which early cognitive ToM predicts subsequent DM, and Model B, in which the reverse is presented. To investigate this issue, we conducted correlations and hierarchical regression analyses.

Model A. Analyses of correlations (see Table 5) indicated that children's cognitive ToM at Time 1 was significantly associated with DM at Time 2. When we controlled for verbal ability, the association between cognitive ToM at Time 1 and DM at Time 2 remained significant, $r(79) = .37$, $p = .001$. To better understand the effect of early cognitive ToM on later DM, we performed a hierarchical regression analysis in which we entered Time 1 verbal ability and DM at Step 1 and Time 1 cognitive ToM at Step 2. This allowed us to establish whether Time 1 cognitive ToM made a significant independent contribution in predicting variance in Time 2 DM. Step 1 explained 50% of the variance in Time 2 DM, $F(2,79) = 39.24$, $p < .001$. The addition of Time 1 cognitive ToM at Step 2 significantly improved the amount of variance explained, $\Delta R^2 = .06$, $\Delta F(1,78) = 8.90$, $p = .004$. Notably, the effect of Time 1 cognitive ToM on Time 2 DM was still significant when Time 2 cognitive ToM was added to Step 1, $\Delta R^2 = .04$, $\Delta F(1,77) = 5.59$, $p = .02$.

Model B. Concerning the relations between early DM and later cognitive ToM, Table 4 showed that Time 2 cognitive ToM was significantly correlated with Time 1 DM. Importantly, the association between early DM and later cognitive ToM remained significant even when we controlled for verbal ability, $r(79) = .28$, $p = .01$. To understand this relation more fully, we performed a hierarchical regression in which we entered Time 1 verbal ability, memory performance, and cognitive ToM in Step 1 as control variables and entered Time 1 DM in Step 2 as an independent variable. Results showed that Step 1 explained a significant 36% of the variance, $F(2,79) = 19.90$, $p < .001$, in Time 2 cognitive ToM, with Time 1 cognitive ToM being the only significant predictor, $\beta = .50$, $p < .001$. The addition of Time 1 DM at Step 2 did not significantly improve the amount of variance explained, $\Delta R^2 = .03$, $\Delta F(1,78) = 3.50$, $p = .08$. This suggested that early DM did not play a unique role in predicting the development of cognitive ToM.

Concurrent and longitudinal relations between sub-components of cognitive ToM and DM

To investigate the relation between ToM and DM more fully, we computed two new indexes of ToM. First, we calculated a pre-false-belief index that reflected how close or far children were from false-belief understanding. To do this, we scored children on the following four components of the TMT, investigating those conceptual steps held to precede false belief developmentally on a regular basis (e.g., Wellman et al., 2001): (a) Level 1 of perspective taking, (b) Level 2 of perspective taking, (c) comprehension of intentionality, and (d) comprehension of ignorance. Because each component had a score range of 0 to 2, the pre-false-belief index had a possible range of 0 to 8. Second, we computed a false-belief index that reflected how well children performed on first-order false-belief tasks. To obtain this index, we summed children's raw scores on the two false-belief items of the TMT and on the four first-order false-belief tasks (range = 0–6). Analyses showed that, as expected, children's scores on pre-false-belief understanding (Time 1: $M = 6.91$, $SD = 1.20$; Time 2: $M = 7.36$, $SD = 0.91$) were significantly higher than scores on false-belief understanding (Time 1: $M = 3.11$, $SD = 1.50$; Time 2: $M = 3.97$, $SD = 1.30$) at both time points, $t(82) \geqslant 20.91$, $p = .00$.

Results (see Table 6) showed significant concurrent correlations between false-belief understanding and DM at both Time 1 and Time 2. Conversely, the association between pre-false-belief understanding and DM was significant only at Time 1. These associations remained significant when we controlled for concurrent verbal ability and age in both cases, $r \geqslant .22$, $p = .05$. Building on our results showing that early cognitive ToM predicted later DM, we explored the relations between pre-false-belief and false-belief understanding at Time 1 and DM at Time 2. Results showed that both indexes significantly correlated with later DM. However, the association between Time 1 false-belief understanding and Time 2 DM was significantly stronger than the corresponding association for Time 1 pre-false-belief understanding, $z = 2.07$, $p = .04$. In addition, when we controlled for individual differences in children's verbal ability, only the association between Time 1 false-belief understanding and Time 2 DM remained significant, $r = .38$, $p = .001$.

To better understand the relation between early false-belief understanding and Time 2 DM, we conducted two analyses. First, we ran a hierarchical regression analysis showing that Time 1 false-belief understanding made a significant contribution in predicting variance in Time 2 DM, $\Delta R^2 = .05$, $\Delta F(1,78) = 9.34$, $p = .003$, independent of Time 1 verbal ability and Time 1 DM, $R^2 = .50$, $F(1,79) = 9.34$, $p = .003$. Notably, the effect of Time 1 false-belief understanding on Time 2 DM was still significant when Time 2 false-belief understanding was added to Step 1, $\Delta R^2 = .03$, $\Delta F(1,77) = 5.50$, $p = .02$. Second, we compared Time 2 DM in children with low performance (i.e., those who scored less than three points) and high performance (i.e., those who scored four to six points) on false-belief understanding. Results showed that, as expected, children who mastered false-belief tasks had better performance in DM than those who did not, $t(61) = 4.09$, $p = .00$, even when we controlled for language and memory performance, $F(1,58) = 7.872$, $p = .007$.

Discussion

Study 2 was designed to more deeply explore the relationship between cognitive ToM and DM in preschoolers. It had a cross-lagged longitudinal design in which the key study variables were measured at two time points separated by a time interval of 6 months.

The main finding was that children's ability to reason about cognitive states significantly predicts their later DM independent of verbal ability and earlier DM (Model A). In contrast, early DM did not uniquely explain a significant percentage of variance in later cognitive ToM when we controlled for verbal ability and earlier cognitive ToM (Model B). In other words, children who scored higher in the cognitive understanding tasks were more likely to have better knowledge about variables that may influence memory performance and the existence of memory strategies 6 months later.

These findings support the existence of a predictive relation between ToM and DM knowledge and fits with Kuhn's (2000) model. Our results confirm and complement those of Lockl and Schneider (2007), which support consideration of cognitive ToM as a prerequisite for the development of DM and the acquisition of cognitive mental state concepts as a necessary initial step for the development of the other components of metacognition. Children appear to take advantage of their ability to reason about cognitive mental states and social behaviors when asked to reflect on their own cognitive activity (Perner, 2000). Therefore, their ability to infer cognitive mental states from social behaviors seems to be intuitive knowledge that opens the gateway to more mature reasoning about mental phenomena. We argue that ToM understanding provides children with the conceptual underpinnings needed to develop metacognitive knowledge. Notably, our data showed that false-belief understanding, rather than mastery of those conceptual steps that precede false beliefs, is crucial for the development of DM. We acknowledge that children's scores on pre-false-belief understanding were relatively high and that further studies should compare pre-false-belief versus false-belief understanding in relation to DM. Having said this, our results are consistent with the view that false-belief understanding is a necessary condition for the development of DM (Lecce, Bianco, Demicheli, & Cavallini, 2014). Moreover, it is worth considering how prior false-belief understanding helps the acquisition of metamemory, and we argue that an important role is played by the ability to metarepresent. This is defined as the ability to represent a representation of reality, that is, to consciously represent the content of another's belief. Passing false-belief tasks is the first clear evidence that children are able to metarepresent and reason explicitly about beliefs (Perner, 1991; Wellman et al., 2001). Indeed, to pass a typical change-of-location false-belief task, children not only need to distinguish between belief and reality but also must be able to represent the protagonist's belief—hence, *meta*represent. Metarepresentation is also crucial for metacognitive knowledge such as that investigated in the current study. Notably, the concept of metarepresentation is particularly relevant for DM because memories are not a copy of reality but rather a mental representation of it. As recently argued by San Juan and Astington (2012), cognitive mental state terms (which, as predicted, are a robust correlate of false-belief understanding) can help children to abstract and remember the content of these representations and, critically, cultivate metarepresentational understanding.

Findings of the current study have both theoretical and practical implications. Theoretically, they support Kuhn's (2000) model and encourage us to view ToM understanding as part of a more general metarepresentational ability. Such a view is also consistent with a growing body of research showing significant relations between ToM and other aspects of metacognitive knowledge such as metareading (Lecce et al., 2010), metacognitive vocabulary (Antonietti, Liverta-Sempio, Marchetti, & Astington, 2006), and epistemological beliefs about learning (Lecce, Caputi, & Pagnin, 2009, 2015). Empirically, the results reported above speak to the cognitive consequences of ToM and, together with the data that show an association with school achievement (Blair & Razza, 2007; Lecce, Caputi, & Hughes, 2011; Lecce, Caputi, et al., 2014), prompt researchers to design intervention studies for preschoolers and school-aged children (Lecce, Bianco, Devine, Hughes, & Banerjee, 2014).

Given these strengths, it should also be noted that the current study focused on children's DM knowledge, leaving aside other components of DM such as procedural DM. Therefore, an important goal for future research would be to also investigate the links between cognitive ToM and procedural DM. This issue is particularly interesting because procedural and DM skills show differences in developmental timing, with declarative knowledge of strategies preceding procedural application of that knowledge (Bjorklund, Miller, Coyle, & Slawinski, 1997; Grammer et al., 2011; Schlagmüller & Schneider, 2002). In addition, these forms of DM skills involve different processes (Fritz et al., 2010), with DM being affected by domain-general abilities (Schneider, 1993), and procedural DM by more specific processes such as executive abilities (Isingrini, Perrotin, & Souchay, 2008; Nelson & Narens, 1994). Another limitation of the current study is that the tasks used for assessing cognitive ToM and DM differ in structure and, partially, in cognitive demands. However, although we cannot exclude the possibility that the difference in format between tasks affected our results, we believe that this aspect had a minor role. Two pieces of evidence support this argument. First, the correlation between cognitive ToM and DM remained significant, albeit considerably reduced, after we controlled for verbal ability. Second, our results did not change when we restricted our analyses to the ToM and metamemory tasks that were more similar: the TMT and the DM–vignette task. However, clearly more work is needed to examine this issue. Finally, although in this second study we were able to compare pre-false-belief and false-belief understanding with respect to their developmental relation with DM, we were not able to conduct finer analyses on the individual components of ToM. Future research should address this issue, paying attention to the role of knowledge access that is likely to have a strong relation with metamemory.

Summary and conclusions

In this article, we have reported two studies on the specificity and direction of the relation between ToM and DM. Our results indicate that (a) there is a significant relation between children's ToM and DM, (b) this relation is specific to cognitive (but not affective) ToM, (c) the relation between cognitive ToM and DM is independent of children's verbal ability, non-verbal ability, and working memory, (d) the link between cognitive ToM and DM goes from earlier cognitive ToM to later DM, and (e) this developmental link is due to false-belief understanding rather than early pre-false-belief conceptual acquisitions. These findings are original yet consistent with previous empirical studies and theoretical models.

Although innovative, our studies have a number of limitations that should be acknowledged. The first is that the sample size is relatively small, and so more work is needed before generalizing our findings. Second, despite using more than one control variable, we did not include a comprehensive measure of children's executive functions that are likely to be related to both ToM and DM. Therefore, an important goal for future research would also be to investigate the role of planning, inhibition, and shifting in the relation between ToM and DM. Third, with only two time points, we were unable to adopt a more dynamic approach assessing whether progression in cognitive ToM matters for the development of DM.

Despite these limitations, our findings provide a valuable foundation for future research and encourage interventions to promote children's cognitive understanding during preschool years.

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