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Correlates and antecedents of theory of mind development during middle childhood and adolescence: An integrated model

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A B S T R A C T

Theory of Mind (ToM) is one of the core abilities that allows children to connect socially with others and to consider others' perspectives. Historically, most research on ToM development has focused on early childhood, but recent years have seen an increased focus on how children build this critical social understanding beyond the preschool timeframe. Given this burgeoning literature, we have identified and organized findings across a variety of domains of development to provide a cohesive theoretical framework depicting the correlates and antecedents of ToM development throughout middle childhood and adolescence. Thus, the present paper provides a synthesis and narrative review of the research to yield insights into important ways in which often-disparate lines of study (e.g., brain specialization, relational aggression, reading comprehension) relate to ToM and bidirectionally influence one another in the developing child. Specifically, we focused our analysis of the literature on identifying neural networks underlying ToM, the roles of executive function and emotional self-regulation on ToM, the socioemotional correlates of ToM, and relations between ToM and academic performance. We also provide a brief discussion of studies recognizing sociocultural, linguistic, and contextual influences on ToM. Our review provides evidence for both common and distinct processes and corollaries with age across these disparate literatures, with significant research indicating the important role of mediating and moderating processes when considering how advanced ToM impacts development. We end by proposing a theoretical, integrative framework and discussing the future directions for the field, including testable predictions generated by the framework that span often-disparate domains of inquiry.

Introduction

Theory of mind (ToM) is the ability to understand and take into account one's own and others' mental states (Premack & Woodruff, 1978). ToM is one of the core abilities that allows children to get along with others and to see others' perspectives. Traditionally, most research on ToM development focused on when children acquire explicit ToM in early childhood (e.g., when children pass tests of false belief understanding), but recent years have seen an increasing number of studies examining ToM throughout middle childhood and adolescence (Apperly, Warren, Andrews, Grant, & Todd, 2011; Banerjee, Watling, & Caputi, 2011; Devine & Hughes, 2013; Hughes, 2016). This body of work indicates that ToM continues to develop beyond the preschool years as children advance in their understanding of the constructivist nature of knowledge and learn to comprehend nuanced aspects of social cognition such as irony, sarcasm, and humor (e.g., Dumontheil, Apperly, & Blakemore, 2010; Weimer, Perault Dowds, Fabricius, Schwanenflugel, & Suh, 2017). Alongside research mapping out the development of these advanced social cognitive processes, there has been increased attention on understanding the mechanisms by which these new abilities emerge (e.g., associated neural and cognitive processes; Astington &

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Hughes, 2013; Hughes, 2016) and how the emergence of advanced ToM relates to other domains of development (e.g., social, academic; Dore, Amendum, Golinkoff, & Hirsh-Pasek, 2018). A synthesis of the research on the antecedents, correlates, and consequences of ToM development throughout middle childhood and adolescence is needed to spur both basic developmental science and applied policy interventions aiming to improve academic and social outcomes. Thus, the present paper provides a conceptual review of the growing body of research on ToM development beyond the preschool years, culminating in a dynamic developmental framework of advanced ToM integrating neural, social, and cognitive domains (see Fig. 1). The goal of this paper and the framework is not a comprehensive list of every potential individual or group-level variable that could intersect with ToM. Instead, we offer a synthesis and narrative review of the research to yield insights into important ways in which these often-disparate lines of study (e.g., brain specialization, relational aggression, reading comprehension) relate to ToM and influence one another in the developing child. We end by discussing future directions for the field, including testable predictions generated by our proposed, integrative framework.

Overarchingly, an important consideration of the current review is whether and how relations between other processes and ToM are different throughout middle childhood and adolescence as compared to older and younger age periods. Importantly, there might be relations among domains of development that are unique during this timeframe as compared to prior developmental timepoints, potentially influenced by a variety of factors including differences in language ability (e.g., Im-Bolter, Agostino, & Owens-Jaffray, 2016), the complexity and saliency of interpersonal relationships (Carr, 2011; Somerville et al., 2013), and the neural processes underlying social cognitive processes (Blakemore, 2012; Dai & Scherf, 2019). Throughout the paper, we emphasize the bidirectionality of proposed relations in the framework to highlight the mutual influences among the constructs described and discuss the potential developmental changes throughout the review.

Alongside conceptual questions of developmental change are the more practical questions of operationalizing and measuring advanced forms of ToM beyond assessments typically used in early childhood. Several recent papers have tackled this question theoretically and psychometrically (e.g., Devine, White, Ensor, & Hughes, 2016; Hayward & Homer, 2017; Osterhaus, Koerber, & Sodian, 2016), and a variety of new advanced ToM measures have been proposed (e.g., Devine & Hughes, 2013; Hayward & Homer, 2017; Rice & Redcay, 2015). In reviewing existing research, we are necessarily limited by the measures employed by past work, but we acknowledge the ways in which measurement might influence results, particularly given studies on how varied ToM measures do not cohere in this age range (Schaafsma, Pfaff, Spunt, & Adolphs, 2015; Warnell & Redcay, 2019). In our discussion of future directions, we also describe ways in which issues of measurement might be confronted in order to advance the field.

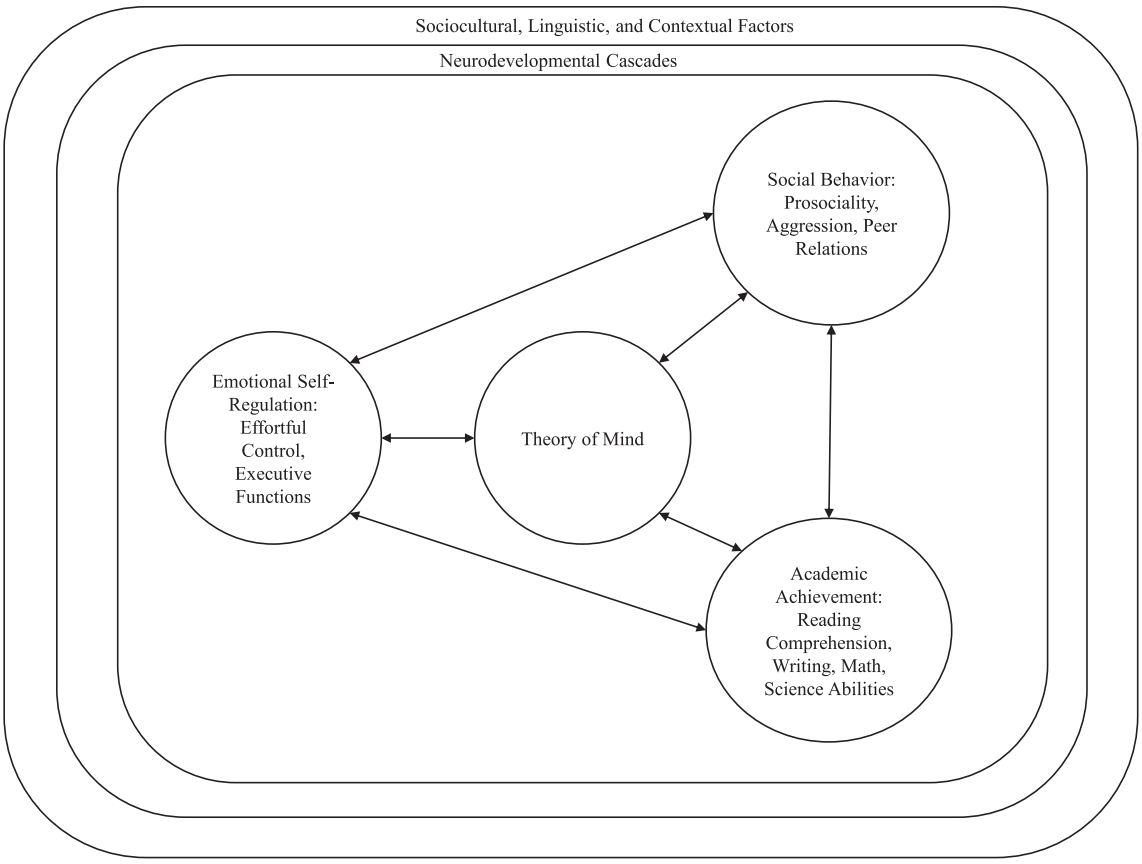

Fig. 1. Interrelations among emotional self-regulation, theory of mind, social behavior, and academic achievement with sociocultural, linguistic, and contextual factors and neurodevelopmental cascades shown as influences.

We begin this review by addressing the neurodevelopmental processes underlying ToM development throughout middle childhood and adolescence, with particular attention to bidirectional brain-behavior relations. There are numerous neurodevelopmental pathways underlying both ToM and ToM-related predictors, antecedents, and outcomes that we detail in the review. We next review research highlighting the links among self-regulatory processes and ToM, considering both traditional executive function measures (e.g., working memory) and measures focused on children's ability to regulate their own emotional experiences (e.g., effortful control). We argue that this interplay between ToM and self-regulation influences links between ToM and other complex social and academic outcomes. We next review how developing ToM influences children's social development, including both positive and negative social outcomes. We follow this section with discussion of how ToM influences children's academic performance as they move through middle and high school. Finally, based on this review, we synthesize across these sections and propose our integrated framework of advanced ToM, ending with a discussion of future directions for the field.

Measuring theory of mind beyond early childhood

Theory of mind development during early childhood has been the focus of extensive study. Using tasks that require participants to consider their own mental states as well as those of others (i.e., first-order beliefs, differential desires) researchers have revealed that ToM development during early childhood represents an extended and progressive set of conceptual acquisitions (e.g., Wellman & Liu, 2004). Though less-studied, there are several important advances in mental state understanding that occur in later childhood (Devine & Hughes, 2013). Advanced ToM tasks have been used to demonstrate that during middle childhood, children advance in their understanding of mental states, including intentions and perspectives (e.g., Happé, 1994). Using tasks that assess advanced ToM developments, such as those that require social reasoning about others' intentions (Filippova & Astington, 2008), perspectives (Dumontheil et al., 2010), and social thinking (sometimes termed second-order false beliefs, Miller, 2009, 2012; Perner & Wimmer, 1985), researchers have documented developments in higher order ToM (Dumontheil et al., 2010; Vetter, Altgassen, Phillips, Mahy, & Kliegel, 2013). While some research has focused on the social side of ToM development, revealing that adolescents' reasoning about ambiguous social interactions and social understanding improves (e.g., empathy; Bosacki, 2000), others have shown that children improve in the cognitive components of ToM across middle and late childhood, such as in the ability to understand how mental processes affect knowledge construction (i.e., Constructivist ToM development; Weimer et al., 2017). As there is no single gold standard advanced ToM assessment, this review examines a diverse array of ToM measures employed in middle childhood and adolescence. We first consider how the brain might support ToM processing in these ages.

Neural networks underlying ToM

Researchers have studied extensively the brain bases of ToM in adulthood, identifying a set of regions known as the 'mentalizing network.' Although the exact regions engaged vary by task, recent meta-analyses have identified medial prefrontal cortex (MPFC) and bilateral temporal parietal junction (TPJ) as core areas involved when thinking about the thoughts of others (Molenberghs, Johnson, Henry, & Mattingley, 2016; Schurz, Radua, Aichhorn, Richlan, & Perner, 2014). Depending on the specific ToM assessment, other structures commonly engaged during mentalizing include additional cortical midline regions (precuneus; dorsal anterior cingulate cortex, dACC) as well as additional frontal and temporal regions (temporal poles; posterior superior temporal sulcus, pSTS; inferior frontal gyrus, IFG; Mahy, Moses, & Pfeifer, 2014). Importantly, although the majority of neural research on ToM examines adults, the bulk of behavioral ToM research examines younger age groups, resulting in comparatively less knowledge about how these behavioral developments are reflected in the brain.

The limited neuroimaging research examining ToM in preschoolers has found activation in similar regions to those activated in adult ToM studies. For example, Richardson, Lisandrelli, Riobueno-Naylor, and Saxe (2018) measured neural activation while both adults and children aged 3–12 years watched a naturalistic movie clip involving mental and physical states. They found that the brain's mentalizing and pain-processing networks were in place and distinct from age 3 onwards, becoming increasingly specialized with age.

Early differences in the mentalizing network also relate to ToM ability. In an EEG study of 4-year-olds, differences in alpha activity in dMPFC and right TPJ were related to performance on explicit ToM items (Sabbagh, Bowman, Evraire, & Ito, 2009) and, between ages 4 and 8 years, functional connectivity between nodes of the mentalizing network also related to advanced ToM (Xiao, Geng, Riggins, Chen, & Redcay, 2019). Additionally, white matter structural maturity in the mentalizing network was found to correlate positively with false belief reasoning in preschoolers (Grosse Wiesmann et al., 2017). This developmental continuity in the mentalizing network is consistent with infant studies indicating that frontal and temporal regions, similar to those engaged in adult mentalizing, are activated when infants process social information (e.g., eye contact, emotion, biological motion; reviewed in Grossmann, 2015).

While the basic network for processing ToM is in place early, this network undergoes specialization for processing mental states between early and middle childhood. Gweon and colleagues (2012) scanned adults and children aged 5–12 years while they listened to stories involving mental state information, social but non-mental state information, and physical information. In general, children recruited similar regions as adults when listening to mental state information versus physical information (i.e., MPFC, TPJ, and precuneus). Neural selectivity for mental versus social stories increased in both left and right TPJ as children aged and specialization for mental states in right TPJ was related to ToM performance outside of the scanner. Similarly, research involving naturalistic videos found that neural responses were more variable in children than adults, with increased adult-like responding in left TPJ as children aged (Moraczewski, Chen, & Redcay, 2018). Much is still unknown, however, about the mechanisms by which these neural changes support improved ToM processing from early to middle childhood.

Although ToM improves throughout middle childhood (e.g., Devine & Hughes, 2013), the heightened social sensitivity of

adolescence makes it an especially important period for understanding the brain bases of ToM (see Blakemore, 2018; Blakemore & Mills, 2014; and Somerville et al., 2013 for reviews). As with children, the core regions of the adult mentalizing network are active when adolescents complete ToM tasks (e.g., Blakemore, den Ouden, Choudhury, & Frith, 2007; Sebastian et al., 2011; Vetter et al., 2013; see Kilford, Garrett, & Blakemore, 2016 for review). There is evidence, however, that MPFC shows peak activation in adolescence. Within MPFC, dorsal regions (dMPFC) have been linked to self-related processing and canonical ToM tasks, whereas ventral regions (vMPFC) might be more involved in processing rewards and affective states (Bzdok et al., 2013). Several investigations of affective ToM have found higher vMPFC activity for adolescents than adults (e.g., Moore et al., 2012; Sebastian et al., 2011; Vetter et al., 2013), with evidence that peak activation might occur toward the beginning of adolescence (Moore et al., 2012; Rosen et al., 2018). Outside of affective ToM, vMPFC activity also peaks in adolescence when engaging in self-evaluation (Pfeifer & Peake, 2012; Pfeifer et al., 2013) and when winning rewards for disliked social partners (Braams, Peters, Peper, Güroğlu, & Crone, 2014). Adolescents similarly show heightened dMPFC activity compared to adults when considering social versus basic emotions (Burnett, Bird, Moll, Frith, & Blakemore, 2009) and when donating money while being observed (Van Hoorn, Van Dijk, Güroğlu, & Crone, 2016). This heightened dMPFC activity that occurs when adolescents are being observed might be due to reflecting on what the observer is thinking about their choice to donate.

Adolescents even show increased prefrontal recruitment for tasks and conditions that lack explicit ToM demands. For example, in an interactive game, adults only recruited dMPFC on trials that required perspective taking, whereas adolescents engaged dMPFC on all trials with any social information (Dumontheil, Hillebrandt, Apperly, & Blakemore, 2012). This over-recruitment of dMPFC is consistent with evidence for adolescent dMPFC activation even when individuals are not given a specific mentalizing task. When individuals aged 8–22 years believed they were being observed, dorsal MPFC activation showed a curvilinear pattern, increasing into adolescence before decreasing again (Sommerville et al., 2013). That is, even when simply lying in a scanner, feeling that one is the object of social observation increases activity in a core region of the mentalizing network, potentially due to increased adolescent focus on what others are thinking. Additionally, whereas adults recruit dMPFC more for live versus recorded speech, older children recruit the region equally in both contexts (Rice & Redcay, 2016; Rice, Moraczewski, & Redcay, 2016). Although the exact mechanisms underlying these neural changes are unknown, they might reflect the increased salience of social situations and stimuli in adolescence, consistent with a bidirectional interplay between brain and behavior.

Unfortunately, systematic assessments of single samples spanning childhood through adulthood are rare, making it difficult to pinpoint exactly when MPFC activity peaks and whether this peak varies across ToM tasks. In particular, although there is some evidence for increases from childhood to adolescence in MPFC activity (e.g., Sommerville et al., 2013; Warnell, Sadikova, & Redcay, 2018), most existing research compares adolescents to adults. Further, in contrast to a peak in frontal activity in adolescence, there is some evidence that activation in temporal mentalizing regions (e.g., TPJ, pSTS) continues to increase from adolescence to adulthood, although this is less robustly documented (e.g., van den Bos, Dijk, Westenberg, Rombouts, & Crone, 2010; see Blakemore, 2012 for discussion and review).

Overall, these results suggest that the mentalizing network undergoes development through adolescence, but the specific neural mechanisms underlying these developments are less clear. Two potential mechanisms explaining how neural changes support behavioral changes are the timing of responses and the connectivity between regions. Evidence supporting the role of timing includes findings that anticipatory responding to mental state information increases from early to middle childhood (Richardson et al., 2018) and that typical children and children with autism spectrum disorder show different temporal brain responses when processing mental state information (Yuk et al., 2018). Given limitations of fMRI in measuring precise timing, future research combining fMRI with more temporally sensitive neuroimaging measures may offer more insight into these processes. In addition to changes in timing, patterns of connectivity between regions, both within and across networks, also might change with age (Richardson & Saxe, 2019; but see Mccormick, Hoorn, Cohen, & Telzer, 2018). Although the exact impact of these changes on behavior is unknown, researchers have found that stronger connectivity between nodes of the mentalizing network is related to advanced ToM abilities in childhood (Xiao et al., 2019). Functional specialization also might be supported by neuroanatomical changes in ToM regions that extend into late adolescence (Mills, Lalonde, Clasen, Giedd, & Blakemore, 2012). Future research should continue to use fine-grained analyses to better map neural changes onto the ToM abilities that are acquired from middle childhood into adolescence.

Although understanding how the mentalizing network subserves development on classic ToM tasks is important, this network also is recruited for a broader set of processes across development, including several of the domains discussed in this review. For example, research has identified a coupling between the mentalizing network and regions activated during narrative processing (see Mar, 2011 for review), even for language without social content (Jacoby & Fedorenko, 2018). Additionally, increased adolescent academic self-concept has been linked to increased activation in mentalizing regions during self-evaluation (van der Aar, Peters, van der Cruijsen, & Crone, 2019). These overlaps could have implications for links between ToM and academic performance. Additionally, although the mentalizing network is distinct from the executive functioning network, some studies have found areas of overlap, although the spatial precision and developmental progression of this overlap is debated (see Wade et al., 2018 for review). For example, the mentalizing network might be involved in self-referential components of emotional self-regulation, with evidence for developmental changes in how frontal and temporal mentalizing regions support cognitive reappraisals (McRae et al., 2012). Thus, the mentalizing network plays a role in a variety of cognitive processes throughout middle childhood and adolescence, with the extent of its contribution dependent on the exact domain.

There also is increasing evidence for overlap between the mentalizing network and brain systems supporting social interaction more broadly, including peer interaction. Even for tasks without explicit ToM demands, children and adults recruit the mentalizing network during live interaction (see Redcay & Warnell, 2018 for review). For example, children aged 7–13 years show increased TPJ activation for speech perceived to be live versus recorded, even when such speech contains no mental state content (Rice et al., 2016).

The mentalizing network also is activated when children believe they are interacting with a real-life peer, and the magnitude of this activation increases from ages 8–12 years (Alkire, Levitas, Warnell, & Redcay, 2018; Warnell et al., 2018). Attesting to a broader role for mentalizing in social behavior, mentalizing network activation also has been linked to both aggressive (Decety, Michalska, Akitsuki, & Lahey, 2009) and prosocial (van den Bos et al., 2010; Van Hoorn et al., 2016) behaviors throughout development, with different patterns in early versus late adolescence. Thus, the neural mechanisms underpinning conventional ToM tasks also might broadly support real-world social outcomes throughout development.

In sum, the basic components of the mentalizing network are in place by early childhood, but patterns of activation and connectivity continue to undergo refinement as children age, with a particular social sensitivity manifesting in adolescence. The activation in this network likely supports a variety of other components of cognitive and social development, which in turn affect children's social motivation and experiences, creating a developmental cascade that further shapes brain activation (cf. Masten & Cicchetti, 2010). Investigating these neurodevelopmental cascades requires large scale, multi-modal, longitudinal studies that include multiple mentalizing tasks. Given changes in activation even from early to late adolescence, researchers should target narrow age ranges and also assess pubertal status in order to closely identify how brain changes relate to ToM performance during this timeframe (Goddings, Burnett Heyes, Bird, Viner, & Blakemore, 2012). Such neuroimaging studies will be complemented by the development of new behavioral assays to better capture ToM change and variability throughout middle childhood and adolescence. While there is some evidence that age and puberty might each play a role, depending on task and region (Goddings et al., 2012; Moore et al., 2012), further research is needed to identify specifically how pubertal changes affect development in the mentalizing network. One theory is that hormonal changes associated with puberty spur increased social motivation and social sensitivity (Forbes & Dahl, 2010), which also might influence neural development in regions associated with ToM. Overall, the field should continue to investigate how the neural and behavioral correlates of ToM intertwine.

Executive function, emotional self-regulation, and ToM

Self-regulation is a broad construct that includes both executive functions (EFs) and emotional self-regulation (Eisenberg, Hofer, & Vaughan, 2007). EFs are higher-order cognitive and neurological processes, such as inhibitory control, cognitive flexibility (also called shifting), and working memory, which allow for reflective or deliberate, goal-directed thought and action (Diamond, 2013). Emotion-related or emotional self-regulation (often termed emotion regulation or ER for brevity in the literature) refers to "processes used to manage and change if, when, and how (e.g., how intensely) one experiences emotions and emotion-related motivational and physiological states, as well as how emotions are expressed behaviorally" (Eisenberg et al., 2007, p. 288). Henceforth, we use ER to refer to emotional self-regulation given that emotional self-regulation is often synonymous with emotion regulation in the literature (Liew & Spinrad, in press). ER often is measured using assessments of such abilities and traits as effortful control, emotionality, and reactivity. Following Eisenberg et al. (2007), we use the term emotional *self*-regulation rather than emotion regulation to include the broader processes involved in ER rather than on the amount of emotion experienced or expressed and also to emphasize the *self*-regulatory (rather than external or interpersonal) processes involved in ER. Given that effortful control includes inhibitory control, activation control (Evans & Rothbart, 2007), and some EF skills, there is overlap in the constructs of EF and ER. While many ToM studies often evaluate EFs from a purely cognitive point of view, without including them in the macro concept of self-regulation, given the interrelatedness of these two constructs, it is important to draw from the literature on ER as well as EF to understand ToM development. The two constructs are related throughout development, but as they often are studied separately in terms of ToM development, we address them separately here.

Executive functions

EF is a non-unitary, multi-faceted construct including skills that improve rapidly in early childhood and continue to develop across middle childhood, into adolescence, and into young adulthood (Davidson, Amso, Anderson, & Diamond, 2006; Huizinga, Dolan, & van der Molen, 2006). EF consists of cool cognitive processes (e.g., inhibition, working memory, planning), which involve making judgements in emotionally-neutral situations, and hot affective processes (e.g., ability to delay gratification, affective decision making), which involve reasoning about emotionally-laden situations (Zelazo & Müller, 2002). These abilities have unique developmental timelines. Some evidence, for example, suggests that whereas shifting reaches maturity by about 15 years of age, working memory and some aspects of inhibitory control develop into young adulthood (Huizinga et al., 2006). Developmental performance differences vary, though, depending upon the task used (see Davidson et al., 2006).

During preschool, EF skills measured at 24 months predict later ToM understanding at 39 months, suggesting that EF development could enable children to attend to, process, and learn about mental states (e.g., Carlson, Mandell, & Williams, 2004). ToM understanding requires individuals to hold information in mind while continuing to process new information (working memory), suppress their own knowledge to consider that of others (inhibition), and switch between what they know and what someone else may be thinking (cognitive flexibility). EFs also correlate with ToM performance throughout middle childhood both concurrently (Austin, Groppe, & Elsner, 2014; Devine et al., 2016; Wilson, Andrews, Hogan, Wang, & Shum, 2018) and longitudinally (Austin et al., 2014), though findings are mixed regarding which domain of EF is most predictive of ToM. Whereas some have found that working memory uniquely predicts ToM performance (Lecce & Bianco, 2018; Lecce, Bianco, Devine, & Hughes, 2017), others have indicated inhibitory control and perhaps set-shifting are more important than working memory (Bock, Gallaway, & Hund, 2015; Cassetta, Pexman, & Goghari, 2018; Vetter et al., 2013), though it is likely that multiple facets of EF are needed for "online" processing of others' perspectives (Dumontheil et al., 2010). For example, Dumontheil et al. (2010) examined changes in ToM understanding across middle

childhood into young adulthood using a computerized version of the Director Task, based upon Keysar, Barr, Balin, and Brauner (2000) original task. Performance on this task involves being able to hold directions in mind and suppress one's own perspective. Thus, Dumontheil et al. (2010) propose that participants' improved perspective taking into young adulthood suggests that EF is important for ToM across middle childhood, adolescence, and young adulthood.

One reason for mixed findings could be that advanced ToM measures differ across studies [e.g, second-order false belief, Strange Stories (Happé, 1994), Silent Films (Devine & Hughes, 2013)], and it is possible that the demands of these tasks vary such that different subcomponents of EF are required. In fact, Valle, Massaro, Castelli, and Marchetti (2015) examined ToM development in adolescence and early adulthood by examining correlates of participants' abilities a) to recognize the mental states of story characters at different levels of recursive complexity (Imposing Memory Task), and b) to explain how a character would predict others' behaviors based on that character's understanding of mental states (higher-order false belief). They found support for differential relationships between EF and ToM performance depending upon the abilities required in ToM tasks: working memory correlated with performance on the Imposing Memory Task, but not to performance on a third-order false belief task.

Yet, it also is plausible that different components of EF underlie ToM understanding at a conceptual level, beyond task demands. The positive association between EF and ToM has been explained using two main types of theories, the "expression" account and the "emergence" account (Devine & Hughes, 2014; Moses, 2001; Wang, Devine, Wong, & Hughes, 2016). The expression account of ToM development posits that the executive or higher-order cognitive demands of ToM tasks mask children's true understanding of others' mental states. Thus, the relationship between EF and ToM is a consequence of task demands. By contrast, the emergence account of ToM development suggests that EF is a developmental precursor to ToM that enables people to process and reflect upon the mental states of themselves and others (see Devine & Hughes, 2014).

Results in early childhood (Devine & Hughes, 2014) as well as middle childhood (Lecce & Bianco, 2018) support the emergence account. For example, Lecce and Bianco (2018) conducted a training study with 9- to 11-year-old children. Working memory moderated the effect of training such that children with higher working memory scores benefited most from training; more specifically, working memory enabled children to benefit from conversations focused on mental states. These data suggest that EF is necessary, but not sufficient for ToM understanding (see also Perner & Lang, 2000). Additionally, EF predicts ToM throughout middle childhood even when ToM is assessed with complex, second-order false belief tasks; specifically, cognitive flexibility predicts ToM performance beyond working memory, age, vocabulary, and inhibitory control (Bock et al., 2015). There also are likely bidirectional influences between EF and ToM across development throughout middle childhood and adolescence (Austin et al., 2014) so that gains in one domain contribute to developments in the other. However, further research is needed to understand the bidirectional influences of EF and ToM on development of these skills.

Research also has proposed relations among mental attentional capacity, attentional inhibition, language, executive processes (shifting and updating), and ToM (Im-Bolter et al., 2016). Im-Bolter et al. (2016) suggested that higher order ToM performance throughout middle childhood might be more cognitively demanding, drawing more so on cognitive resources, perhaps due to a novice level of understanding. Language and EF interact to support ToM performance in this age group, which fits with earlier findings that children from Hong Kong perform less well on ToM tasks despite stronger EF abilities (Wang et al., 2016). In early adolescence, however, capacity itself becomes less important for ToM performance, perhaps given increases in capacity and greater familiarity with ToM concepts. Capacity, however, continues to relate to language and shifting, which are both important for ToM performance. Switching, in particular, is important for ToM performance in early adolescence (Im-Bolter et al., 2016). These results indicate the importance of examining components of EF separately and for understanding how the relationships among aspects of EF and ToM can vary with age.

Emotional self-regulation (ER)

Although links between EF and ToM have been extensively studied, less attention has been given to the links between ER and ToM development. ER is required for self-determined or goal-directed behaviors and goal attainment (Deci & Ryan, 2000; Gross, 2015). ER processes often have been conceptualized as consisting of two modes or dual systems. A dual systems model of emotional self-regulation can be represented as consisting of reflexive and reflective systems (Carver, Johnson, & Joormann, 2009; Hofmann, Friese, & Strack, 2009), although researchers sometimes use different terms to refer to each of the systems. Terms that refer to the reflexive and reflective systems involved in ER include reactivity and self-regulation (Rothbart & Derryberry, 1981), social-emotional and cognitive self-regulation (Bodrova & Leong, 2006), and implicit and explicit ER (Gyurak, Gross, & Etkin, 2011). While both reflexive and reflective systems are involved in ER, reflective processes and higher-order cognition (Evans & Stanovich, 2013) are of particular interest to the study of ToM because ToM requires the inhibition of automatic or reflexive response tendencies to take one's own perspective (i.e., executive inhibition) in order to reflect on others' mental states (Perner, Lang, & Kloo, 2002; van de Meer, Groenewold, Nolen, Pijnenborg, & Aleman, 2011).

In preschoolers, Jahromi and Stifter (2008) have indicated that EFs, but not ER, predict false belief understanding. In contrast, Lane et al. (2013) found that children who experienced greater physiological reactivity (indicative of emotional reactivity) demonstrated better ToM. There are theoretical reasons to suspect links between ER and ToM during middle childhood, given the links between ER and social competence (e.g., Eisenberg et al., 2009; McKown, Gumbiner, Russo, & Lipton, 2009; Shields, Cicchetti, & Ryan, 1994), but studies investigating these links directly during middle childhood are surprisingly sparse.

In one study of adults, Kalbe et al. (2007) examined whether the cognitive and emotional subcomponents of ToM correspond to different levels in skin conductance responses in adults, who listened to ten cognitive ToM stories, ten affective ToM stories, and ten non-ToM (control) stories. Results demonstrated significantly elevated responses for affective ToM (i.e., ToM involving emotional

components) but not with cognitive ToM and control stories, suggesting the possibility that different facets of ToM might be differentially supported by ER. Links between ER and ToM also could change throughout development. One possibility is that as children engage in more complex and socially demanding situations, the ways in which socioemotional and behavioral development directly influence each other becomes increasingly evident. McKown et al. (2009) have shown that 4- to 14-year-old children with greater socioemotional skills (e.g., awareness of nonverbal cues, ToM understanding, empathy, and social problem reasoning) and highly rated ER abilities are more competent in their social interactions. Thus, in addition to research examining direct links between ER and advanced ToM, it is important to consider feedback loops and bidirectionality.

Another important future direction is to examine effortful control. Effortful control and EF are distinct but related constructs involved in inhibition of automatic or reflexive response tendencies (Liew, 2012; Lin, Liew, & Perez, 2019; Nigg, 2016). One core distinction between effortful control and EF is that working memory is a part of EF but not of effortful control. Working memory is not typically considered a part of temperament or personality processes (e.g., effortful control), but it is for EF (Eisenberg & Zhou, 2016). Effortful control (i.e., constraint or inhibition) can contribute to ER (e.g., when a child inhibits emotional expression), but ER involves more than effortful control as it includes the ability to activate behavior and shift attention (Eisenberg et al., 2004). While studies on ToM in early childhood often include measures of effortful control and/or executive functioning, studies on middle childhood or adolescence typically focus on measures of EF (e.g., Vetter et al., 2013) but not effortful control (e.g., Pérez-Edgar, 2015). The focus on EF rather than on effortful control throughout middle childhood or adolescence might be because effortful control is a dimension of temperament that emerges early in life and matures in early and middle childhood but tends to remain relatively stable across development, while EF develops most rapidly during early childhood and continues to mature throughout adolescence, in line with frontal maturation in the brain (Blakemore & Choudhury, 2006; Zelazo & Carlson, 2012). Without more research, however, it is unknown if effortful control continues to impact children's sophisticated social understanding as they become older.

Further, while the two components of self-regulation reviewed above, EFs and ER, have been linked in recent work with adolescents (Effeney, Carroll, & Bahr, 2013; Follmer & Sperling, 2016), direct links among ToM, EFs, and ER are underexplored. Interestingly, increasing evidence suggests that both variables play a role in academic achievement (e.g., Blair & Raver, 2015; Duckworth, Taxer, Eskreis-Winkler, Galla, & Gross, 2019; Lockl, Ebert, & Weinert, 2017). Researchers have integrated both ToM and self-regulation in the study of developmental and academic outcomes (e.g., Jahromi & Stifter, 2008; Olson, Lopez-Duran, Lunkenheimer, Chang, & Sameroff, 2011). Despite these findings, very few have differentiated the cognitive, motivational/emotional, and behavioral aspects of regulation (e.g., effortful control, executive functioning) to examine relations with ToM, and how these self-regulatory and socio-cognitive abilities uniquely or jointly contribute to social and academic success. Future work should address these relations.

Socioemotional correlates of ToM

Researchers increasingly have focused attention on identifying the extent to which ToM is associated with children's social behaviors and peer relationships. Given the particular salience and influence of peer relationships in adolescence (Suleiman & Deardorff, 2015), we have focused our review on a discussion of ToM and social relationships outside the family. In spite of this focus, we note that family relations are foundational to later social development and that ToM has been found to relate to interactions with parents (Meins et al., 2003) and siblings (e.g., McAlister & Peterson, 2007), and we encourage longitudinal studies examining how early links between ToM and family relations are related to later peer outcomes.

Research on the socioemotional correlates of advanced ToM has focused on both adaptive and maladaptive behavioral outcomes such as prosocial behavior and aggression, as well as indicators of children's social status within their larger peer group (e.g., peer group acceptance and rejection). In general, researchers have proposed that more advanced understanding of mental states should have a positive effect on children's behavioral adjustment and social status (Hughes & Devine, 2015; Hughes & Leekam, 2004).

Consistent with this proposition, several researchers have found positive associations between more advanced mentalizing skills and indicators of social competence, prosocial behavior, and peer acceptance (Banerjee et al., 2011; Bosacki & Astington, 2001; Caputi, Lecce, Pagnin, & Banerjee, 2012; Cassidy, Werner, Rourke, Zubernis, & Balaraman, 2003; Fink, Begeer, Hunt, & de Rosnay, 2014; Imuta, Henry, Slaughter, Selcuk, & Ruffman, 2016; Lalonde & Chandler, 1995; Slaughter, Imuta, Peterson, & Henry, 2015; Weimer et al., 2017). Extending this proposition, children with less advanced understanding of mental states, compared to peers, are at greater risk for behavioral and relational problems. More specifically, one line of investigation has examined the associations between ToM and children's aggressive and bullying behaviors. Applying a social information processing perspective, investigators have evaluated a social skills deficit hypothesis, according to which aggressive behaviors are largely the result of deficient and maladaptive social cognitive biases (Crick & Dodge, 1994). Consistent with this viewpoint are findings from several studies that have reported negative associations between ToM and aggression, such that less advanced ToM skills are associated with greater rates of aggression among children and adolescents from 10 to 15 years old (Bosacki & Astington, 2001; Gomez-Garibello & Talwar, 2015; Kokkinos, Voulgaridou, Mandrali, & Parousidou, 2016; Shakoor et al., 2012; Weimer et al., 2017).

Contrary to these findings that indicate an inverse association between ToM and aggression, some researchers have posited that there may be a positive association between ToM and aggression, such that children who display more advanced ToM skills may be at greater risk for engaging in aggressive and bullying behaviors (Caravita, Di Blasio, & Salmivalli, 2010; Gini, 2006; Sutton et al., 1999a, 1999b). More specifically, having more advanced ToM and perspective taking skills may facilitate the use of more sophisticated forms of aggression such as indirect and relational aggression. That is, children and adolescents might be able to engage more effectively in behaviors such as social exclusion, rumor spreading, gossiping and friendship manipulation if they are more competent at understanding others' mental states (Gomez-Garibello & Talwar, 2015; Renouf et al., 2009). In addition to research linking ToM with different forms of aggression, researchers have posited that ToM might be positively linked with different functions of aggression, in

particular proactive and instrumental aggression, including bullying behaviors (Gasser & Keller, 2009; Renouf et al., 2010; Sutton et al., 1999a, 1999b).

Attempts to explain these divergent findings point to several considerations, each of which reflect fruitful areas for further investigation. First, there is a need to better account for potential developmental differences in the associations between ToM and children's behavioral adjustment in early versus middle childhood. Accordingly, Hughes and Devine (2015) propose two alternative hypotheses. According to the developmental lag hypothesis, there are individual differences in the age at which children attain certain mentalizing skills. One implication of this hypothesis is that mentalizing skills in early childhood (e.g., false-belief) will have a stronger association with concurrent social adjustment, but are less likely to be longitudinally associated with children's social adjustment throughout middle childhood (since most children will have attained these skills by that period). According to the genuine variation hypothesis, individual differences in early mentalizing skills are indicative of the ease and fluency with which children attain mentalizing skills and reflect more sustained and persistent variations in mental reasoning. Thus, early individual differences might have long-term effects on children's social adjustment (Fink et al., 2014; Shakoor et al., 2012). It is important to note that one potential limitation of these hypotheses is that they point to individual differences in when children attain mentalizing abilities, and thus, they speak less directly to how children use or apply them (Caputi et al., 2012; Hughes, 2011).

Consequently, a second consideration that relates more directly to applications or performance of mentalizing abilities is the proposition that ToM is a neutral tool or skill that can be applied in positive or negative ways (Astington, 2004; Hughes & Devine, 2015). As a corollary to this premise, it would be expected that the effects of ToM are moderated by other social-cognitive or emotion processes. For instance, there is evidence that children (ages 5–6 years old) who exhibit more prosocial tendencies are less inclined to engage in relational aggression, even when they exhibit the ToM skills to effectively engage in these behaviors (Renouf et al., 2009). Research on emotional processes indicates that among children who were either 6 or 10 years old, those with less advanced ToM were at greater risk for engaging in aggressive behaviors if they also exhibited higher levels of callous-unemotional traits (Song, Waller, Hyde, & Olson, 2016). In addition to social-cognitive and emotion processes, the effects of ToM also might be moderated by salient contextual processes. For instance, investigators have examined whether children's peer relationships could alter the associations between ToM and aggression. For example, Renouf et al. (2010) found that ToM was negatively associated with reactive aggression, and positively associated with proactive aggression when children were making the transition to kindergarten (i.e., about 6 years old), but only among children who experienced high levels of peer victimization.

In addition to potential moderating processes, a third consideration relates to potential mediating mechanisms that provide insights into how ToM is primarily indirectly associated with children's social adjustment. Support for this premise has been garnered from several studies that have investigated how children's social-cognitions and behavioral styles might have a more proximal association with their social adjustment. With respect to social cognitions, ToM has been found to facilitate the use of social problem-solving skills, which in turn, reduced the risks for aggressive behaviors among adolescents who were about 14–15 years old (Weimer et al., 2017). Furthermore, lower ToM increased the risks for moral disengagement, which in turn, was associated with more frequent aggressive behaviors among children who were 10–12 years old (Kokkinos et al., 2016). With respect to behavioral styles, there is evidence that prosocial behavior functions as a mediator between ToM and peer acceptance and rejection in the early grade school years (Caputi et al., 2012).

Taken together, one implication of these findings is that the association between ToM and children's peer relationships is dependent on the application or usage of mentalizing abilities to promote the use of cooperation or helping behaviors, which in turn foster more harmonious social interactions. As previously noted, however, there might be important social-cognitive, emotional or contextual processes that moderate the extent to which children use their mentalizing skills in order to engage in prosocial behaviors (Caputi et al., 2012; Imuta et al., 2016). Although there is evidence that ToM is positively associated with children's peer relationships in early childhood (Slaughter et al., 2015), a second implication of these findings is that these associations might have an even more pronounced effect in middle childhood, after children have transitioned to formal schooling and must successfully integrate themselves into a more diverse, complex, and larger peer group (see Imuta et al., 2016).

Expanding on the viewpoint that there are individual differences in the attainment and use of mentalizing skills, a fourth consideration relates to how specific tasks used to measure different components of ToM might have differential associations with children's behavioral adjustment and peer relationships. For instance, Banerjee and colleagues (2011) have proposed that traditional ToM tasks utilized in early childhood (e.g., false-belief understanding) might not capture the forms of mentalizing abilities that relate most directly to children's social adjustment. These investigators contend that more advanced tasks typically used in middle childhood, such as "faux pas," more accurately reflect aspects of mentalizing abilities that are directly pertinent for children's social interactions, and consequently are more strongly associated with their social adjustment. Consistent with this viewpoint, they have found that performance on faux pas tasks was positively associated with children's sociability (Banerjee & Henderson, 2001) and peer acceptance (Banerjee et al., 2011; Caputi et al., 2012), and negatively associated with peer rejection (Banerjee & Watling, 2005; Banerjee et al., 2011), particularly among older children (ages 9–11 years old) than younger children (ages 6–8 years old).

These findings imply that faux pas tasks, or other socially-relevant tasks, more directly assess aspects of emotion understanding that are important determinants of children's social adjustment, and which are not assessed by more traditional ToM tasks that focus on beliefs and cognitive representations (Banerjee et al., 2011). Moreover, these findings suggest potential developmental variations in the associations between ToM and children's social adjustment (Hughes & Devine, 2015). More specifically, findings from Banerjee and colleagues (2011) support the viewpoint that the effects of faux pas are more pronounced in middle and late childhood (as opposed to early childhood), when these forms of mentalizing abilities become more normative. That is, older children who continue to exhibit difficulties in these forms of understanding appear to lack important prerequisite or foundational skills in order to engage in positive social interactions, which in turn, would increase their risks for peer rejection.

Although much of the research described has considered the role of ToM in impacting children's peer relationships, it is important to recognize that peer relationships also might function as an important socialization context for the development of ToM (Hughes & Leekam, 2004; Hughes & Devine, 2015). This premise is consistent with social constructivist perspectives, according to which the development of children's mental states occurs in the context of their social interactions (Caputi et al., 2012; Carpendale & Lewis, 2004). Although the family context and parent-child and sibling interactions are also important influences on ToM development in early childhood (Devine & Hughes, 2018), several researchers have evaluated how children's friendships and social status among peers (e.g., peer acceptance and rejection) are associated with their mentalizing abilities (Badenes, Estevan, & Bacete, 2000; Banerjee et al., 2011; Peterson & Siegal, 2002; Slaughter, Dennis, & Pritchard, 2002). From a conceptual standpoint, it is plausible that peer socialization effects are more likely to be pronounced after children have made the transition to formal schooling and spend a considerable amount of time with classmates.

Longitudinal studies, however, have found mixed empirical evidence for links between early peer status and later ToM. Bosacki (2013) found that children whose drawings were of cooperative activities at age 8 later scored more highly on ToM than children who drew competitive activities, suggesting that prosocial interactions might relate positively with ToM. By contrast, Banerjee and colleagues (2011) found that peer rejection, but not peer acceptance, was prospectively associated with children's ToM. These findings suggest that children who are actively disliked and excluded from their peer group are deprived of more adaptive socialization experiences, which could undermine the development of ToM. These findings are also consistent with research on children's social information processing, such that peer rejection has been found to be predictive of biases in encoding social cues and hostile attributions (Lansford, Malone, Dodge, Pettit, & Bates, 2010). In contrast to the findings reported by Banerjee et al., Caputi and colleagues (2012) reported that peer acceptance and rejection were not prospectively associated with ToM. Similarly, using a measure of social preference to assess children's social status, Fink and colleagues (2014) reported that social preference was not significantly predictive of ToM. Although the reasons for these discrepancies are unclear, it is possible that they are due to differences in the ages of the samples assessed or to the forms of ToM that were measured (as previously noted, Banerjee et al. assessed faux pas). With respect to age-related or developmental differences, Caputi et al. and Fink et al. examined longitudinal samples who were followed from roughly ages 5–7 years old. Notably, Banerjee et al. examined a longitudinal sample from ages 6–11, but the effects of peer rejection on ToM emerged between the ages of 7–10. Taken together, these findings suggest that there may be specific developmental periods in middle childhood, but not necessarily in early childhood, in which peer socialization effects are most pronounced.

In sum, the relations between ToM and peer relations are complex and dynamic throughout middle childhood, particularly as ToM becomes more advanced. Links between social outcomes and social cognition remain a primary question of interest in the field, particularly as these relations between ToM and social behavior are unfolding alongside children's developing cognitive abilities, which include dynamic couplings among ToM, executive functions, and academic skills.

ToM and academics

In addition to impacts on social development in childhood and adolescence, ToM also has been linked to academic achievement. For example, in a longitudinal study, Lecce, Caputi, Pagnin, & Banerjee (2017) found that social competence mediates the relationship between early ToM and later school achievement (a latent factor of reading, math, and teacher rated academic competence), independently of verbal abilities and current ToM. Further, Lockl et al. (2017) found that ToM in first graders significantly predicts teachers' ratings of children's reading and mathematical competencies, even controlling for socioeconomic status, gender, nonverbal abilities, working memory, and language abilities. Additionally, Weimer et al. (2017) have found that adolescent academic achievement (as measured via grade point average) relates significantly with constructivist ToM, an advanced form of ToM that involves understanding the interpretive processes embedded in knowledge construction.

Although these findings suggest relations between ToM and general academic abilities across childhood and adolescence, other findings point more specifically to links between ToM and developing reading skills. For example, Blair and Razza (2007) demonstrated preschool ToM was predictive of kindergarten literacy skills, but not math skills. Similarly, in a path analytic study of 7- to 10-year-old children, Cantin, Gnaedinger, Gallaway, Hesson-Mcinnis, and Hund (2016) found reading comprehension contributed to ToM (suggesting a bidirectional relation that we expand on below), but no significant relations emerged between ToM and mathematics achievement. These findings suggest reading seems to hold a special status in relation of academic abilities to ToM. This is not surprising for two reasons. First, neurobiological evidence indicates considerable overlap between the core mentalizing network underlying ToM and networks involved in processing of story comprehension (Gweon et al., 2012; Mar, 2011). Additionally, reading comprehension skill underlies academic achievement in other areas, such as science (Reed, Petscher, & Truckenmiller, 2016) and mathematics (Vilenius-Tuohimaa, Aunola, & Nurmi, 2008) in middle childhood and adolescence, pointing to reading's special status among academic skills more generally.

Why might ToM be related to reading development? One possibility involves the development of EF skills. EFs contribute significantly and directly to the development of ToM, as we noted above. Reading comprehension is inherently complex, involving simultaneous integration of multiple processes, features, and perspectives in text (e.g., Cartwright & Duke, 2019; Duke & Cartwright, 2019; Kintsch, 1988; RAND, 2002); thus, it necessarily recruits EFs (e.g., Locascio, Mahone, Eason, & Cutting, 2010). Readers must shift flexibly among word-level features and text meaning (cognitive flexibility; Cartwright et al., 2017), suppress attention to information not relevant to the ongoing comprehension of text (inhibitory control; Borella, Carretti, & Pelegrina, 2010), and update a continually evolving model of text meaning in mind while reading a text (working memory; Garcia-Madruga et al., 2013). The relation of ToM to developing reading comprehension may therefore be related to shared relations of reading and ToM to EF skills. However, studies consistently indicate significant relations between ToM and reading skills beyond contributions of EF in preschool (e.g., Blair &

Razza, 2007) and middle childhood (e.g., Cantin et al., 2016; Guajardo & Cartwright, 2016).

A second possibility is that reading comprehension involves ToM abilities directly. Indeed, reading comprehension not only requires reasoning about events and actions in texts, but also reasoning about authors' and characters' perspectives and internal mental states to facilitate social inferences about text meaning (Cartwright, 2015; Dore et al., 2018). Neurobiological, correlational, and experimental evidence converge to support this possibility. For example, ToM and narrative comprehension are aligned at a neurobiological level, as well, pointing to the tight relation between the two processes, which recruit the same neural networks (see Gweon, Dodell-Feder, Bedny, & Saxe, 2012; Mar, 2011). In correlational work, ToM contributes directly and longitudinally to successful reading comprehension. For example, Kim (2017) found ToM contributed significantly to reading comprehension in 7-year-olds beyond vocabulary, working memory, inference, grammar, and monitoring abilities. Similarly, Boerma and colleagues (2017) found ToM contributes uniquely to reading comprehension in 8- to 11-year-olds, beyond home literacy environment, print exposure, and verbal ability. Furthermore, preschool ToM predicts reading comprehension throughout middle childhood (Atkinson, Slade, Powell, & Levy, 2017; Guajardo & Cartwright, 2016), and school-age children's social-emotional comprehension of mental processes used in social situations relates to their reading performance (McKown, Russo-Ponsaran, Allen, Johnson, & Warren-Khot, 2016).

However, as Bruner noted (1988, 1990), application of ToM abilities to reading tasks is difficult for children. For example, in one study, 7- to 11-year-olds had difficulty inferring characters' internal motivations unless they were stated explicitly in text (Shannon, Kameenui, & Baumann, 1988). Similarly, 9- to 11-year-olds rarely include characters' internal motivations in retellings of stories, focusing instead on characters' actions (McConaughy, 1985), suggesting that physical (i.e., non-mental) inferences about characters are easier for children than mental state inferences about characters. Restrictions in EFs may make it more difficult for children to focus on both mental and physical content simultaneously, or children may not yet be able to apply developing ToM abilities in a complex reading task.

Promising lines of work suggest training ToM improves reading comprehension for students who struggle to understand characters' perspectives throughout middle childhood (Lysaker, Tonge, Gauson, & Miller, 2011; Shanahan & Shanahan, 1997). Other work suggests bidirectional relations between ToM and reading ability, such that reading comprehension also might contribute to the development of ToM throughout middle childhood (Cantin et al., 2016). The findings of Cantin et al. (2016) suggest developing reading comprehension skill may facilitate the development of ToM because inferential comprehension of characters' mental states in texts may provide practice with increasingly sophisticated ToM abilities. Indeed, Boerma, Mol, and Jolles (2017) provided evidence for reciprocal relations between ToM and reading in middle childhood. Home literacy environment, an indicator of exposure to books and reading experiences, contributed directly to children's ToM, which, in turn, contributed directly to reading comprehension. The reciprocal, mutually facilitative relations between ToM and reading likely persist into late adolescence and adulthood, as evidenced by findings that fiction reading improves ToM abilities in 18- to 75-year-olds (Kidd & Castano, 2013). Being better able to take the perspective of others can facilitate reading comprehension, and through reading, people learn the degree to which perspectives can vary. Further research is warranted to clarify the exact mechanisms linking reading ability, ToM, and EFs.

Sociocultural, linguistic, and contextual influences

Sociocultural, linguistic, and contextual variables also exert bidirectional influences on ToM development. Although a full review of these factors is outside the scope of this manuscript, we note their importance in understanding ToM in middle childhood and adolescence. Research focused on cross-cultural comparisons in preschoolers has found that children in Anglo-Western cultures (e.g., Australia, Canada, USA) follow similar trajectories, but that children in non-Western cultures (e.g., China, Singapore, Iran) develop ToM understanding in an alternative sequence (Peterson & Slaughter, 2017; Shahaeian, Peterson, Slaughter, & Wellman, 2011; Wellman & Liu, 2004; Wellman, Fang, Liu, Zhu, & Liu, 2006; Zhang, Shao, & Zhang, 2016). Similarly, cross-cultural research on ToM development in young children has shown that in cultural contexts that discourage mental state talk, children show developmental lags in ToM development (Mayer & Träuble, 2014). Kuntoro, Saraswati, Peterson, and Slaughter (2013) also found a significant link between authoritarian parenting and slower rates of ToM development among young children in non-Western cultural contexts. A recent systematic review of studies focused on cultural variations in ToM and related constructs (e.g., empathy, perspective-taking) suggests that development in these areas might differ cross-culturally due to differences in linguistic factors, value preferences, and parenting characteristics (Aival-Naveh, Rothschild-Yakar, & Kurman, 2019). Further, researchers have identified links between sociodemographic factors and ToM (Devine et al., 2016; Renouf et al., 2010), and suggested that relations between these might differ during middle childhood (Miller, Reavis, & Avila, 2018). Other studies have found different processes among ToM and social variables (e.g., self-concept) when comparing adolescents in different cultural contexts (e.g., Canadian and Polish adolescents; Bosacki, Bialecka-Pikul, & Szpak, 2013). Furthermore, Antonietti, Liverta-Sempio, Marchetti, and Astington (2006) and Olson, Antonietti, Liverta-Sempio, and Marchetti (2006) have examined relations among ToM constructs such as mental language across cultures. Their research reveals that mental language and understanding of epistemic and emotional mental states continues to develop into early adulthood and varies across cultural contexts (e.g., Canada, Italy, Serbia, Tanzania). Thus, it is important to consider the role of culture in ToM research focused on children in middle childhood and adolescence.

Relations between language competence and ToM development have been well-established (e.g., Milligan, Astington, & Dack, 2007) and longitudinal studies focused on children in early childhood have indicated that language skills predict ToM development (Astington & Jenkins, 1999; de Villiers & Pyers, 2002). Recent research also has focused on relations among language proficiency and ToM. Some researchers have suggested that bilingualism enhances ToM (Berguno & Bowler, 2004; Farhadian et al., 2010; Goetz, 2003; Javor, 2016; Kovács, 2012), although associations between bilingualism and ToM overlap with broader language skills (Diaz & Farrar, 2018; Nguyen & Astington, 2014) and sociocultural factors (Weimer & Gasquoine, 2016). Bilingual language development is likely

influenced by a number of factors such as age and process of language acquisition, proficiency level attained in languages, amount of exposure, motivation, type of learning experience, and the degree of similarity between the two languages (Costa & Sebastián-Gallés, 2014). To understand how language proficiency relates to ToM, these variables, and other social cognitive factors should be explored further. Some research has offered promising insight. For example, Diaz and Farrar (2018) have found that while language predicted ToM in both monolingual and bilingual children, EF was only associated with ToM in monolingual children (not bilingual children). Similarly, Buac and Kaushanskaya (2020) found that language ability, not EF skills, predicted ToM in simultaneous bilinguals (those acquiring English and Spanish at the same time). They also indicated that different patterns of relations among the variables occurred in bilinguals with English as a first language and monolinguals when compared to simultaneous bilinguals, suggesting that language acquisition histories influence ToM development. Further research is needed to advance our understanding of the relations among correlates of ToM (e.g., sociocultural factors, language competence, EF) and ToM development among bilinguals and children with unique language histories.

It also is important to consider broader sociocontextual factors in investigations of ToM and language proficiency. Pelletier (2006) found that vocabulary predicted performance on reading and story comprehension tasks among monolingual and high-achieving students, but ToM predicted reading and story comprehension in lower-achieving second-language learners in middle childhood and in younger lower language learners. Thus, to understand relations among correlates of ToM development, children from diverse sociocultural, linguistic, and contextual backgrounds should be included in investigations.

A guiding framework for future research

Although some research has identified links among advanced ToM and other components of neural, social, and cognitive development, a conceptual framework to describe relations among these constructs would serve as a useful guide for future research. To date, models of school-aged children and adolescents have been evaluated to assess the socioemotional and sociocognitive mechanisms underlying ToM development. Across studies, models have considered mediating (indirect) and moderating (interactive) mechanisms but are limited in how they integrate different factors. For example, while some examined relations among ToM and social behavior during this developmental time frame, they have failed to include measures of language proficiency, or socioeconomic status, which should be accounted for as important sociocultural factors. Further, few scholars have offered models that integrate the possible neurodevelopmental components underlying ToM with other behavioral factors.

One illustration of the complicated relation between ToM and other aspects of behavior comes from the social-emotional literature. Rather than a straightforward relation (i.e., main effect) between ToM and aggression throughout middle childhood and adolescence, the direction of effect varies depending on the form of aggression assessed (e.g., proactive vs reactive) and the social context, implying the need to assess for potential (person by environment) interaction effects (Renouf et al., 2010). To add to this complexity, these associations might be further mediated or moderated by additional person-level factors (e.g., social cognitive and emotion processes) that could alter how children utilize ToM in their behavioral responses (Song et al., 2016; Weimer et al., 2017). Collectively, these studies suggest that a new conceptual framework for understanding and testing the linkages among these constructs is needed. In particular, the mixed findings could suggest that main-effects models, which assess the direct effects of ToM on aggression, might be limited in their predictive utility (Arsenio & Lemerise, 2001). Future research should examine the hypothesis that ToM mediates relations between aspects of ER (e.g., effortful control, EFs) and social and academic outcomes.

Consequently, we propose a conceptual framework that includes many feedback loops and depicts multiple possible mechanisms underlying ToM development during middle childhood and early adolescence, a timeframe in which there are many neurodevelopmental, socioemotional, and cognitive advances. Fig. 1 shows that self-regulation, comprised of effortful control and executive functions, relates to ToM development, which relates to prosocial and negative social outcomes, all critical domains of academic achievement. We chose to use the term emotional self-regulation to emphasize that both the reflexive (emotionality/reactivity) and reflective (effortful control and executive functioning) processes are important factors for ToM, interpersonal and social outcomes, and academic achievement. The feedback loops are illustrative of the bidirectional nature of these relationships. In addition to examining relations between behavioral assays, the proposed framework also considers bidirectional brain-behavior links, embedding the developing child within a series of neurodevelopmental cascades. The basic neural components necessary for ToM during middle childhood and early adolescence are in place by early childhood, but patterns of activation and connectivity continue to undergo refinement as children age and are influenced by a variety of other changing components of social and cognitive developmental processes (e.g., language processing, prosocial behavior).

There are many applications of the framework proposed herein that will guide future research. Below we discuss in more detail specific hypotheses, but first we review some broad principles of the framework. The framework underscores the importance of examining the directionality among these proposed transactional relationships, including via longitudinal and experimental studies. Relations between ToM correlates should also be explored, with investigators examining paths that might be indirect, or conditional on (i.e., moderated by) other social and emotional factors. For example, given the findings on relations among negative social behavior and ToM (Song et al., 2016), researchers could examine if preadolescents' ER moderates associations between ToM and aggression. It also would be of interest to explore how internal motivations and aspects of personality (e.g., temperament, emotion perception, motivation) mediate ToM and academic/social outcomes.

Similarly, it is hoped that our framework inspires researchers to take an integrative approach that encompasses variables at multiple levels of analysis and use this framework to clarify further how the neurodevelopmental, cognitive, sociocultural, and contextual factors underlie ToM development and how ToM relates to broader domains of development. For example, researchers should examine how sociocultural and linguistic factors (e.g., parenting practices, family constellation, language proficiency,

bilingualism) relate to ToM, social, and academic outcomes in children of diverse backgrounds. Given that bilingual children have been shown to have unique language developmental profiles, sociolinguistic factors might interrelate with cognitive components in predicting ToM development. For example, in global regions in which bilingualism is valued and common, ToM might be enhanced, whereas, in cultural contexts that perceive bilingualism negatively (e.g., immigrants suppressing their native tongue due to discrimination), there might be relatively little effect of bilingualism on ToM development.

Moreover, the framework could guide work that addresses current limitations in ToM measurement. Given that there are inconsistent findings across studies relying on disparate measures (e.g., more cognitive vs. more affective ToM tasks) and methodologies, in order to increase the ecological validity of investigations of ToM, researchers should measure development in naturalistic settings as much as possible and assess not only ToM capacity but also the motivation and ability to apply ToM. Currently, much research on ToM capacity is conducted in the laboratory using decontextualized assays (e.g., predicting what story characters will do next), whereas peer relations and classroom behavior are unfolding in real-time and often involve multiple interacting individuals. Bridging these methodological disconnects could better capture variability in the real-world correlates depicted in our framework. However, naturalistic research should avoid confounding factors simply because they are confounded in the real world. Thus, naturalistic research need not superficially imitate reality but, instead, should explain it.

We hope our framework also brings together conventionally disparate domains of developmental research (e.g., *social* and *cognitive* development) and guides interdisciplinary investigations and interventions (e.g., among educators, school counselors, and psychologists collectively seeking to improve social outcomes for children). For example, while research has shown that children's poor effortful regulation skills predict later behavioral problems (Morris et al., 2013), it is possible that adolescents in school contexts that emphasize socioemotional learning (e.g., that include curricular approaches focused on increasing ToM, empathy, and related skills) will nevertheless develop *prosocial* behavior patterns and correspondingly experience academic success. Ultimately, there is a need for studies that incorporate not only multiple predictors and antecedents of ToM, but also those that measure these constructs from multiple lenses. We need increased investigations that examine how the links among naturalistic neuroimaging, facets of emotional regulation, and social behavior (i.e., prosocial and aggression) interrelate and predict academic outcomes.

Specific hypotheses for future research

Based on this review and the proposed framework, we have developed several viable directions for future researchers and proposed hypotheses. This is not an exhaustive list, but rather a set of suggestions to guide thinking. We hypothesize that ToM and other socioemotional processes might affect relations between emotional self-regulation (i.e., effortful control, EFs) and social behavior (prosociality, aggression, peer status), as well as between emotional self-regulation and academic variables, especially reading comprehension. Further we expect that pathways between these factors will differ when comparing frameworks of children across diverse sociocultural, linguistic, and contextual backgrounds.

Our review of the literature on the neurodevelopmental underpinnings of ToM reveals several directions for future research. Studies should continue to examine age-related changes in mentalizing network activity from early childhood through adolescence, ideally using longitudinal designs, given inconsistencies in past work as to whether linear, quadratic, or null changes in network recruitment are expected. Potentially, age-related changes could be dependent on the regions studied (e.g., frontal versus temporal) and the tasks used, such that adolescent mentalizing network activity would peak for tasks that involved direct social interaction and appraisal but not for more conventional false belief tasks. Such research could also use behavioral assays to more directly target proposed links between heightened MPFC activity and heightened subjective salience of social information, including others' mental states. This research should also more clearly dissociate relative contributions of age versus pubertal status to frontal region activity given previous mixed findings about developmental changes in social processing (see Dai & Scherf, 2019 for a meta-analysis). One concern of many prior studies of brain-behavior relations is that results may be hampered by small sample sizes (Cremers et al., 2017). Thus, studies with larger samples are essential. Indeed, one recent study examining self-evaluation in girls aged 10–13 found no relation between MPFC activity and age or puberty (Barendse et al., 2020), but different results may be found in studies of how dMPFC activity developmentally changes when more directly reflecting on others' mental states.

Future neuroimaging work should also continue to incorporate naturalistic and spontaneous ToM measures, given evidence that interactive contexts alter neural processing (see Redcay & Schilbach, 2019 for review). The incorporation of new tasks, on which children and adolescents are not at ceiling, will also allow for better understanding of how individual differences in ToM performance relate to neural variability. One hypothesis is that links between neural activation and real-world social outcomes (e.g., sociometric status) will be stronger for more realistic, socially-interactive tasks than conventional false belief reasoning or even reasoning about faux pas of characters in stories. Similarly, studies should examine the neural bases of a variety of ToM tasks in a single sample, akin to studies which have administered a suite of tasks to assay the role of pSTS (e.g., Deen et al., 2015; Dasgupta et al., 2018). This research should also include different ages, as one possibility is that increased neural specialization could lead to less neural overlap among tasks as children move from early childhood through adolescence.

Studies using naturalistic ToM tasks could also further explore the hypothesis that adolescence corresponds to increased engagement of mentalizing regions, even in contexts in which mentalizing is not required (Redcay & Warnell, 2018). Although there are a handful of suggestive studies finding such heightened activation, researchers could systematically manipulate the perception of social presence and judgement while measuring activity in ToM regions. For example, researchers could examine the influence of being observed by a peer versus an adult, or being recorded to being observed later versus being observed in real-time. Importantly, regions of the mentalizing network are active during a variety of tasks, even those which do not involve mental state reasoning. To help isolate the role of mentalizing network regions in social interaction, researchers could incorporate ToM localizers, use more sophisticated

analytical techniques, and develop more precise tasks, such as paradigms that systematically increase mentalizing demands in interactive contexts (e.g., Alkire et al., 2018).

Our specific proposed framework also suggests several directions for future work combining neuroimaging research with studies of self-regulation, social behavior, and academic achievement. Longitudinal research could help disentangle questions of causality in relations between social behavior and neural activity. For example, researchers could test whether sustained positive or negative experiences with peers precede changes in mentalizing network activity when anticipating peer feedback or handling peer pressure (e.g., Falk et al., 2014). Similarly, researchers could develop assessments of emotional self-regulation that systematically vary in their ToM demands, to determine how activation in regulatory and ToM networks interplays throughout development. Finally, although there is evidence for neural overlap in narrative processing and ToM networks (Mar, 2011), most of this work has been done in adults. Expanding this work to younger ages, and adding in explicit assessments of academic reading ability, might help explain individual differences in academic achievement.

The results of our review also indicate several future directions in the study of self-regulation and ToM. First, that there is a need to examine EF abilities separately to better understand relations among the components of EF and ToM and how these vary with age. It is hypothesized that disparate components of EF will relate to ToM uniquely at various time points across early childhood to adolescence. For example, working memory, inhibitory control, and cognitive flexibility might become more important in adolescence as ToM tasks grow more complex. It also is proposed that these aspects of EF will account for more variability in applied task performance and everyday application of ToM concepts compared to explicit, laboratory task performance. Indeed, performance and task demands also may vary with the context and nature of social interaction. Differential relations also may arise as researchers explore meaningful differences between cognitive and affective ToM or between naturalistic and non-naturalistic ToM measures. For example, EF might be more related to canonical false belief tasks, as compared to ER, which might relate with naturalistic or spontaneous measures integrated into real-world interaction.

Given that research has indicated both positive association between ToM and prosocial behavior and negative associations between ToM and aggression (i.e., less advanced ToM skills are associated with greater rates of aggression) there are several hypotheses to be tested around ToM and social development, many of which involve ER. Using the proposed framework, researchers could examine the interrelations among ER, ToM, and social behavior at multiple time points from early childhood into late adolescence. For example, using latent growth curve modeling, research could model individual developmental trajectories from culturally and linguistically diverse groups of children to map changeover time. Such analyses could help determine the effect of the predictors over and above SES, parental strategies, or other covariates. We hypothesize potential developmental variations in the associations between ToM and children's social behavior across language and cultural groups, above and beyond SES.

Additional hypotheses generated from our proposed framework might help to explain inconsistencies in prior studies that indicate that ToM is both positively and negatively associated with children's aggressive behaviors. More specifically, by integrating children's ER, we hypothesize that the effects of ToM on children's aggression are moderated by ER processes. That is, considering the viewpoint that ToM is a neutral tool that can be applied in both positive and negative ways, we expect that ToM is more likely to be positively associated with aggression among children who exhibit emotion and self-regulatory difficulties (e.g., low effortful or inhibitory control; high emotional reactivity). In contrast, when children have higher levels of ER, ToM is hypothesized to be negatively associated with aggression.

We also expect that there might be important contextual (e.g., peer relational) moderators. More specifically, in the context of maladaptive peer relationships (e.g., peer rejection or peer victimization), we hypothesize that children could be more inclined to use their ToM to facilitate the use of more sophisticated forms of relational aggression. In contrast, when children experience social contexts that are more harmonious (e.g., a child is well accepted; peer group norms do not support the use of aggression), we hypothesize that more advanced ToM would be more strongly associated with prosocial behaviors. Finally, we expect that these associations would be more pronounced in adolescence, compared to childhood, when peer groups become more salient and influential.

In the realm of academic achievement, our review also generates several suggestions for future research. As we noted previously, ToM is related to general academic achievement (Lecce et al., 2017; Lockl et al., 2017; Weimer et al., 2017). However, research disaggregating the various types of achievement domains (e.g. reading and math) shows significant relations of ToM to reading but not to mathematics skill (Blair & Razza, 2007; Cantin et al., 2016), suggesting a unique relation between ToM and reading. More research is needed, however, to further explore relations of ToM to subcomponents of these domains of academic achievement, such as various types of reading (e.g., literal vs. inferential reading comprehension, or narrative vs. expository text comprehension) and mathematics (e.g., computational vs. applied problems) tasks. Mentalizing may be more important for some academic task types, such as inferential narrative texts or mathematical word problem comprehension, than for others. Further, given these positive relations, ToM could offer a unique target of intervention for reading comprehension difficulties, which has been tested in small studies (i.e., Lysaker et al., 2011), but should be further explored in more extensive training work.

In addition to ToM contributing directly to reading comprehension (e.g., Kim, 2017), research has suggested possible bidirectional relations between ToM and reading, such that reading may facilitate ToM abilities (Cantin et al., 2016). Reading fictional texts (i.e., those with social content) might provide the opportunity to practice applying ToM skills to make social inferences, which might facilitate ToM skills as well as improve reading. Boerma et al. (2017) provided preliminary evidence to support this hypothesis, finding that home literacy environment, an indicator of exposure to books and reading experiences, contributed directly to ToM in middle childhood, which, in turn, contributed directly to reading comprehension. Kidd and Castano (2013) provided similar correlational evidence with adults, finding that adults who read fiction (i.e., texts that offer opportunities to consider characters' perspectives) more frequently had better ToM abilities. These findings are promising, but randomized controlled trials are necessary to determine whether reading directly influences ToM abilities. Guajardo and Watson (2002) presented promising evidence from a training study with

preschoolers for whom a narrative comprehension intervention improved ToM. These findings suggest text-based interventions might improve ToM in middle childhood, a direction that should be explored in future work.

Why might reading comprehension be tied to ToM development? Our review revealed several reasons why this may be the case. First, research has revealed a coupling between the mentalizing network and regions activated during narrative processing (Gweon et al., 2012; Mar, 2011). Mentalizing network development enables new abilities, which in turn affect academic performance. That academic practice may then feed back into brain development, a hypothesis that should be tested in future work.

Behaviorally, development of EF skills occurs alongside the development of ToM and of reading. The relation of ToM to developing reading comprehension may therefore be influenced by shared relations of reading and ToM to EF skills. However, studies consistently indicate significant relations between ToM and reading skills beyond contributions of EF in preschool (e.g., Blair & Razza, 2007) and middle childhood (e.g., Cantin et al., 2016; Guajardo & Cartwright, 2016). These findings suggest reading comprehension may involve ToM abilities directly. During middle childhood, children advance in their understanding of mental states, including intentions, perspectives, and social thinking (Dumontheil et al., 2010; Filippova & Astington, 2008; Happé, 1994; Vetter et al., 2013). At the same time, children's reading comprehension development shifts, such that inferential and language comprehension processes come to dominate their processing of the meanings of texts, in contrast to early childhood when word decoding processes are the dominant contributors to reading comprehension (Gough, Hoover, & Peterson, 1996; Lonigan, Burgess, & Schatschneider, 2018). Comparable studies of the relative contributions of ToM to reading comprehension across development, from early to middle childhood – and beyond – are scarce. Longitudinal evidence is necessary to understand how changes in ToM skill interact with, and support, improvements in inferential reading comprehension skill across development.

Finally, bidirectional relations between self-regulatory abilities, such as emotion regulation (ER) and executive functioning (EF), and reading comprehension may partially account for relations of ToM to reading comprehension and other types of academic achievement. Few studies have examined all of these variables, however, within the same sample. Recently, Kim (2017) used structural equation modeling to examine contributions of a number of variables, including ToM and working memory (one of the three core EFs) in a sample of 2nd grade students, finding that both variables contributed significant variance to reading comprehension. Themodel precluded examination of whether ToM mediated relations between reading and working memory and did not examine potential reciprocal relations between these variables, a direction that should be explored in future work that includes both EF and ER variables. Finally, longitudinal research using our framework could explore which components of mentalizing predict various academic abilities; for example, mental state vocabulary - an indicator of ToM knowledge - may contribute differently to reading comprehension than the social inferential ability involved in belief-desire reasoning assessed in false belief tasks. These should be explored in future work.

Although this review focuses on neurotypical development, there are many applications of the framework to work in ToM and psychopathology including autism and social anxiety. Recent research throughout middle childhood has suggested a curvilinear relation between ToM ability and social anxiety, such that both very high and very low levels of ToM can link to greater social anxiety (Nikolić et al., 2019), with increased self-consciousness mediating links between social anxiety and high ToM. Similarly, different components of ToM show different patterns of performance in autism, including in late childhood and adolescence (e.g., Fitzpatrick et al., 2018; Schaller & Rauh, 2017; Sodian, Schuwerk, & Kristen, 2015). One potential explanation for the lack of straightforward ToM findings in psychopathology is that early differences in motivation or basic social processing might differentially affect components of ToM as children age, which in turn affects other social processes (e.g., Chevallier, Kohls, Troiani, Brodkin, & Schultz, 2012). Thus, the complex, transactional framework proposed here is also relevant to understanding atypical developmental processes, including in other disorders linked to altered ToM such as schizophrenia, bipolar disorder, borderline personality disorder, and depression. Future work should directly compare ToM-relevant developmental pathways (e.g., links between ToM and social success) among clinical and non-clinical groups and also examine severity of clinical traits as potential moderators.

Conclusion

After decades of focus on ToM in early childhood, developmental scientists are increasingly focusing on how ToM continues to develop through middle childhood and adolescence. Here, we synthesized this growing literature, focusing on brain bases, the roles of executive function and emotional self-regulation, how developing social cognitive capacities affect the child's social world, and how ToM relates to academic performance. Across these areas, there is evidence for both common and distinct processes and corollaries with age, with significant literature indicating the important role of mediating and moderating processes when considering how advanced ToM impacts development. Thus, while the rudimentary components of the mentalizing network emerge in early childhood, patterns of activation and neural connectivity particularly in areas of social sensitivity undergo further development across childhood. These developmental changes likely facilitate children's abilities to regulate their own emotions and engage in increased degrees of both positive and negative social interaction, which may in turn enhance social cognitive and academic abilities. Correspondingly, improved self-regulation enables ToM, empathy, perspective-taking, and related social cognitive abilities not only because it leads to social interactions that provide data-gathering opportunities for children to consider how their peers' mental states might differ from their own, but also enables children to engage in prosocial behavior when they are motivated to do so. Further research is needed to investigate the acquisition versus application of ToM. Such research focused on understanding how social outcomes could be both positively and negatively linked to ToM in this age range should continue to explore moderators (e.g., gender, role models, temperament). Further, while research has suggested that ToM is an important aspect of children's social and academic success, it is difficult to disentangle the underlying developmental mechanisms.

In sum, by synthesizing studies from across these disparate areas of research, we have proposed an integrated transactional framework, explaining how neural and behavioral changes in the child's ToM influence, and are influenced by, other cognitive

processes, emotional capacities, peer relations, and school contexts. We hope that future research on advanced ToM continues to bridge multiple domains of study in order to explain how this core cognitive capacity influences children across development.

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