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Authors
Lagattuta, Kristin Hansen
Elrod, Noel M
Kramer, Hannah J

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How Do Thoughts, Emotions, and Decisions Align? A New Way to Examine Theory of Mind in Middle Childhood and Beyond

Kristin Hansen Lagattuta, **Noel M. Elrod**[#], and **Hannah J. Kramer**[#]
Department of Psychology and Center for Mind and Brain, University of California, Davis

[#] These authors contributed equally to this work.

Abstract

The current study examined 4- to 10-year-olds' and adults' (*N* = 280) tendency to connect people's thoughts, emotions, and decisions into *valence-matched mental state triads* (thought valence = emotion valence = decision valence; such as, anticipate something bad + feel worried + avoid) and *valence-matched mental state dyads* (thought-emotion, thought-decision, and emotion-decision). Participants heard vignettes about focal characters who re-encountered individuals who had previously harmed them twice, helped them twice, or both harmed and helped them. Baseline trials involved no past experience. Children and adults predicted the focal characters' thoughts (anticipate something good or bad), emotions (feel happy or worried), and decisions (go near or stay away). Results showed significant increases between 4 and 10 years in the formation of valence-matched mental state triads and dyads, with thoughts and emotions most often aligned by valence. We also documented age-related improvement in awareness that uncertain situations elicit less valence-consistent mental states than more certain situations, with females expecting weaker coherence among characters' thoughts, emotions, and decisions than males. Controlling for age and sex, individuals with stronger executive function (working memory and inhibitory control) predicted more valence-aligned mental states. These findings add to the emerging literature on development and individual differences in children's reasoning about mental states and emotions during middle childhood and beyond.

Keywords

theory of mind; emotion understanding; executive function; middle childhood; individual differences; sex differences

Children's understanding of mental states and emotions, theory of mind (ToM), has been a core topic in cognitive development research for the past 30 years. Despite a rich foundation of studies on infants' and preschoolers' concepts about desires, emotions, and beliefs (see Wellman, 2014), less attention has been directed towards ToM improvements after age 6, including sources of variability during middle childhood and beyond (Hughes & Devine, 2015; Lagattuta et al., 2015; Miller, 2012; Pillow, 2012). As reviewed in Lagattuta (2014), one such advance involves more complex reasoning about causal connections between

Correspondence concerning this article should be addressed to Kristin H. Lagattuta, Department of Psychology and Center for Mind and Brain, University of California, Davis, 1 Shields Avenue, Davis, CA 95616. Electronic mail may be sent to khlaga@ucdavis.edu.

mental states (e.g., how thoughts cause emotions). The current research expands this inquiry to consider development and individual differences in 4- to 10-year-olds' and adults' beliefs about *triadic* interrelations among thoughts, emotions, and decisions—for example, how thoughts elicit emotions as well as shape decisions. We focus on the thought-emotion-decision triad because it figures prominently in scientific theories of emotion, decision making, and clinical disorders, with interventions often aimed at helping individuals recognize and change maladaptive relations among how they think, feel, and act (Baumeister, Vohs, DeWall, & Zhang, 2007; Borkovec, Ray, & Stober, 1998; Coricelli et al., 2005; Dolan, 2002; Ellis, 1991; Ehlers & Clark, 2000; Fredrickson, 2001; Lazarus, 1982; Wood, Quinn, & Kashy, 2002). Thus, this study informs basic research on ToM development during middle childhood, and it has implications for clinical practice.

Although children's reasoning about triadic coherence among thoughts, emotions, and decisions has not been systematically investigated, researchers have done substantial work examining children's understanding of each dyadic component: thought-emotion, emotion-decision, and thought-decision. Considering first thought-emotion relations, Lagattuta and colleagues (Lagattuta, 2007; Lagattuta, 2014; Lagattuta & Wellman, 2001; Lagattuta, Wellman, & Flavell, 1997) found that between the ages of 3 and 6 years children exhibit greater awareness that thinking or being reminded about the past or the future can change current emotions. In addition, although 5- to 6-year-olds recognize that two people in the same situation will feel differently depending upon the focus of their thoughts, older children better appreciate the power of positive thinking to improve emotions during negative events (Bamford & Lagattuta, 2012). Moreover, while children pass false belief tasks around 4 or 5 years of age, they continue to struggle with understanding emotions caused by false beliefs until 6 or 7 (see Harris, de Rosnay, & Ronfard, 2014). More generally, studies have documented improvement between 3 and 10 years of age in children's understanding that thoughts shape emotional wellbeing as well as how emotional states affect how a person thinks (Altshuler & Ruble, 1989; Amsterlaw, Lagattuta, & Meltzoff, 2009; Bender, Pons, Harris, & de Rosnay, 2011; Flavell, Flavell, & Green, 2001; Harris, Johnson, Hutton, Andrews, & Cooke, 1989; Sayfan & Lagattuta, 2008, 2009).

Researchers have examined children's understanding of emotion-decision relations in the context of morality, coping, and post-decision regret. For example, Lagattuta (2005) found that children 7 years and older better understand than younger children that willpower decisions (inhibiting desires to abide by rules) can be emotionally satisfying and that fulfilling desires by breaking rules can cause negative feelings (see also Arsenio, Gold, & Adams, 2006; Lagattuta, Nucci, & Bosacki, 2010; Lagattuta & Weller, 2014). There are also significant improvements between 5 and 7 years of age in recognizing that deciding to forgo personal desires to help others can have emotional benefits (Weller & Lagattuta, 2013, 2014). Relevant to how emotions affect coping decisions, Sayfan and Lagattuta (2009) demonstrated that children as young as 4 years of age understand that behavior choices, such as fight or flight, can be effective in reducing fear, with advances between 4 and 7 years in understanding more complex causal links between emotion and behavior (see also Bamford & Lagattuta, 2010; Harris, 1989). Children begin to report feeling regret around 6 to 9 years of age (Beck & Riggs, 2014; O'Connor, McCormack, & Feeney, 2012; Rafetseder & Perner, 2012), and this emotion aids them in making more adaptive future decisions (O'Connor, McCormack, Beck, & Feeney, 2015; O'Connor, McCormack, & Feeney, 2014). Still, children exhibit more difficulty reasoning about another's regret than reporting their own experience of it (Weisberg & Beck, 2010), further indicating that knowledge about emotion-decision connections continues to develop through middle childhood.

Finally, researchers have also investigated children's reasoning about thought-decision relations. This has predominantly been tested using the classic false belief paradigm (Wimmer & Perner, 1983). In this task, one character places an object in a certain location and leaves, and then a second character moves that object. Participants are asked where the first character will look for the object. Individuals older than 4 or 5 demonstrate understanding that a character will act on his or her beliefs even if they contrast with reality (see Wellman, Cross, & Watson, 2001). Lagattuta and colleagues (Lagattuta, 2007; Lagattuta & Wellman, 2001) took a different approach by examining children's knowledge that people's actions can be caused by thinking about the past or anticipating the future. Findings revealed improvements between 3 and 7 years of age in explaining decisions (e.g., quickly putting away a small pet) as caused by the content of people's thoughts (e.g., thinking a dog will repeat its chasing behavior from the past).

Based on the extant research, then, it appears that from 3 to 10 years of age children develop more sophisticated reasoning about relations between thoughts and emotions, emotions and decisions, and thoughts and decisions. To our knowledge, no previous work has explored how children combine *all three* mental states. Thus, to broaden the scope of ToM investigations in early and middle childhood, we investigate development and individual differences in 4- to 10-year-olds' and adults' reasoning about these triadic interconnections. To do so, the current study takes advantage of a dataset created by Lagattuta and Sayfan (2013). They presented children and adults with scenarios each featuring target characters who encounter someone who previously harmed them (two negative events, NN), helped them (two positive events, PP), both harmed and helped them (NP, PN), or who was unfamiliar (no past experience). Participants predicted whether the focal character would think something good or bad would happen next (thought), would feel happy or worried (emotion), and would approach or avoid the perpetrator (decision). Although all age groups made significant distinctions among trial types—for example, even 4- to 5-year-olds judged that characters would anticipate a higher likelihood of harm, feel more worried, and make more avoidant decisions in NN > PN > NP > PP trials—there were improvements between 4 and 10 years and between childhood and adulthood in the ability to integrate different kinds of past event information to predict future-oriented mental states.

Whereas Lagattuta and Sayfan (2013) analyzed predictions for characters' thoughts, emotions, and decisions as separate dependent variables, we explore the extent to which participants *aligned* their three mental state judgments by valence. In doing so, the current project provides new insight into children's and adults' beliefs about causal interconnectedness or coherence among mental states. Thus, to be credited with providing a *valence-matched mental state triad*, a participant would have to predict either (1) that the character anticipates a negative future (negative thought), feels worried (negative emotion), and will avoid the perpetrator (negative decision), or (2) that the character anticipates a positive future (positive thought), feels happy (positive emotion), and will approach the perpetrator (positive decision). Given age-related improvements in reasoning about causal connections between different kinds of mental states, we predicted that the provision of valence-matched mental state triads would increase between 4 and 10 years of age as well as between childhood and adulthood.

Because a mental state triad is comprised of three interlocking dyads (thought-emotion, emotion-decision, thought-decision), we further investigate which of these combinations children and adults expect to align most by valence. Although few studies have systematically compared children's proficiency with different kinds of mental state dyads, evidence from Lagattuta and Wellman (2001) and Bartsch, Campbell, and Troseth (2007) suggest that thoughts and emotions may be viewed as more interconnected than decisions and thoughts or decisions and emotions. Moreover, although people's thoughts and emotions typically align (Lazarus, 1982), it is not always straightforward how individuals will behave when experiencing certain thoughts and emotions—different people could reasonably decide to take different actions (e.g., fight versus flight when experiencing stress, see Taylor et al., 2000). Thus, we expected participants across age to provide more valence-matched connections between thoughts and emotions compared to thought-decision or emotion-decision dyads.

As an additional layer, we examine whether the cohesion of children's and adults' triadic mental state judgments vary by the characters' prior experiences. We hypothesized that trials featuring perpetrators who changed how they treated the focal character in the past (PN, NP) should elicit fewer valence-matched mental state triads and dyads than trials where perpetrators acted in consistent ways (NN, PP). That is, because the future is more uncertain in *inconsistent-past* versus *consistent-past trials*, participants should expect less alignment by valence in how characters will think, feel, and act. Given age-related improvements in identifying uncertain situations (Lagattuta & Sayfan, 2011, 2013; Lyons & Ghetti, 2011; Robinson, Rowley, Beck, Carroll, & Apperly, 2006), we anticipated that this distinction by trial type would widen with age. Two potential patterns for *baseline trials* (no past events) were equally plausible. On the one hand, this could be the easiest condition for forming valence-matched connections among thoughts, emotions, and decisions. With no past event information to integrate, children and adults could reasonably pick a valence (e.g., anticipate positive future) and stick with it for their other judgments (e.g., feel happy, approach). Alternatively, because there is no past information from which to draw, baseline trials are also uncertain (see Lagattuta & Sayfan, 2011). If uncertainty is the driving factor, then the valence-consistency of mental state judgments for baseline trials should not differ from the inconsistent-past trials (NP, PN).

We include gender in our analyses because previous studies have found that girls outperform boys in some tasks involving reasoning about connections between mind and emotion starting as young as 3 to 4 years of age (see Lagattuta, 2014 for a review). During early childhood girls also participate in more frequent mental state talk than boys , and they exhibit higher emotion understanding (Bosacki & Astington, 1999; Dunn, Brown, Slomkowski, Tesla, & Youngblade, 1991). Studies have also shown a female advantage in interpreting emotions and mental states during middle childhood (Banerjee, Watling, & Caputi, 2011; Calero, Salles, Semelman, & Sigman, 2013; Devine & Hughes, 2013). Given

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these findings, one might hypothesize that females will form more valence-matched mental state triads and dyads than males. Alternatively, prior research also indicates that female children and adults perceive the future as more uncertain than do males (Lagattuta, 2007; Lagattuta & Sayfan, 2011). Thus, across age, females could predict future-oriented mental states to be less aligned than males because they view these relations in different ways. For example, even though a person might anticipate a positive future and feel happy, because there is room for doubt, he or she may choose to avoid (a broken triad). Although Lagattuta and Sayfan (2013) found no sex differences when they analyzed thought, emotion, and decision judgments separately (see also Charman, Ruffman, & Clements, 2002; Wellman et al., 2001 for no sex differences in ToM); potentially, sex differences may emerge in how females versus males expect mental states to align. Therefore, gender was examined because the literature predicts several possible outcomes: females providing more valence-matched mental state judgments, males providing more valence-matched mental state judgments, or no sex differences.

Aside from examining the influence of age and sex on the ability to form valence-matched mental state triads and dyads, we also aimed to contribute to the small, but growing literature on individual differences in ToM in middle childhood and older age groups. We focus on connections between ToM and executive function (EF, a number of interconnected higher-order cognitive processes, Miyake et al., 2000), because inhibitory control (IC, the ability to stop automatic responses, Best & Miller, 2010) and working memory (WM, the ability to consider and manipulate pieces of information, Baddeley, 1992) predict variability in ToM in early childhood (see Devine & Hughes, 2014; Marcovitch et al., 2015). Much less is known about these relations in older children (see Hughes & Devine, 2015; Lagattuta et al., 2015). Lagattuta and colleagues recently demonstrated that even when controlling for age, individual differences in WM and IC predict more advanced ToM in 4- to 10-year-olds and adults (Kennedy, Lagattuta, & Sayfan, 2015; Lagattuta, Sayfan, & Blattman, 2010; Lagattuta, Sayfan, & Harvey, 2014). The current study aims to test EF-ToM links across a wide age range using a different ToM task; this time, examining the valence alignment of thought-emotion-decision judgments. We reasoned that participants would need to recruit EF skills to evaluate the impact of past event information as well as to track and coordinate the valence consistency of their mental state judgments.

In summary, the current study investigates 4- to 10-year-olds' and adults' reasoning about connections among future-oriented thoughts, emotions, and decisions; in particular, their formation of valence-matched mental state triads (anticipate positive future + feel happy + approach; anticipate negative future + feel worried + avoid) as well as dyads (thought-emotion, thought-decision, and emotion-decision). We further analyze the impact of different kinds of past event information (consistent-past, inconsistent-past, no past) on the valence alignment of children's and adults' mental state judgments. We expected age-related increases in connecting people's thoughts, emotions, and decisions, with consistent-past trials (NN, PP) eliciting more coherent triads and dyads than inconsistent-past (PN, NP) and potentially baseline (no past event) trials. We explored relations between gender and performance. Finally, we expanded inquiry of ToM-EF links to examine whether children and adults with higher WM and IC provide more valence-coherent predictions about how people will think, feel, and act.

Method

Participants

Participants, taken from the dataset of Lagattuta and Sayfan (2013), included 280 individuals separated into 4 age groups: (1) 63 4- to 5-year olds (*M* = 4 years 10 months; *SD* = 7 months; 34 females), (2) 66 6- to 7-year-olds (*M* = 6;11; *SD* = 7; range = 6; 35 f), (3) 87 8- to 10-year-olds (*M* = 9;4; *SD* = 9; 42 f), and (4) 64 adults (*M* = 20; *SD* = 6; 34 f). Children were recruited from a pool of previous research participants, fliers, and parent referrals from primarily middle to upper-middle class, educated families: 81% were Caucasian, 6.5% Hispanic, 4.6% Asian American, 2.8% African American, and 5.1% other or of multi-ethnic or -racial heritage. The adult sample was comprised of undergraduate students recruited from psychology classes: 43.8% were Caucasian, 12.5% Hispanic, 25% Asian American, 4.7 African American, and 14.1% other or of multi-ethnic or -racial background. Participants were typically developing, with no reported affective or cognitive disorders. The current sample includes 15 more participants than Lagattuta and Sayfan (2013, *N* = 265) because these participants no longer needed to be excluded for problems in eye-tracking data. Child participants received $15.00; adult participants received course credit.

Materials and Procedure

Past-to-future reasoning task: Baseline trials—Participants responded to four baseline trials, shown on laminated picture cards, that each featured a focal character who encounters an individual (the "perpetrator") who he or she had never seen before (e.g., a red-haired boy). In the final scene, the focal character and the perpetrator are shown profile, looking at each other with no discernable facial expression (see Lagattuta & Sayfan, 2011). Participants predicted the focal characters' future-oriented thoughts (binary choice: "Does [the focal character] think [the perpetrator] is going to do something *good* or *bad*?"), emotions (binary choice: "How do you think [the focal character] feels right now? Does [the focal character] feel *happy* or *worried*?"), and decisions (binary choice: "What do you think [the focal character] will do next? Do you think [the focal character] is going to *go near* or *stay away* from [the perpetrator]?").

Past-to-future reasoning task: Past-experience trials—Participants also responded to eight past-experience trials shown as movies on a computer monitor using the same style of drawings (see *Figure 1* for an example, including the test questions). Past-experience trials each featured a focal character who has two previous experiences with a specific perpetrator. *Consistent-past* trials included past events of the same valence: The perpetrator acted negatively (NN) or positively (PP) towards the focal character on two occasions. In contrast, in *inconsistent-past* trials, the perpetrator acted positively towards the focal character one day and then negatively the next time, or vice versa (PN and NP). In the final scene, the focal character sees the perpetrator again. Participants predicted the focal characters' thoughts, emotions, and decisions using identical questioning from the baseline trials. Participants responded to two trials of each specific type (i.e., two NN, two PP, two PN, and two NP trials).

Past-to-future reasoning task: Coding and scoring—While Lagattuta and Sayfan (2013) analyzed each of the mental state judgments separately, the current study examined the frequency that participants aligned their thought, emotion, and decision judgments into valence-matched mental state triads or dyads. To do so, we used SPSS syntax to recode the binary data. Participants received scores (0 to 4 for baseline trials, 0 to 2 for each type of past-experience trial) totaling the number of trials that they (1) provided *valence-matched mental state triads* (anticipate something good + feel happy + approach, or anticipate something bad + feel worried + avoid), (2) *valence-matched thought-emotion dyads* (thought = emotion in valence), (3) *valence-matched thought-decision dyads* (thought = decision in valence), and (4) *valence-matched emotion-decision dyads* (emotion = decision in valence). We converted these scores to proportions to allow for direct comparison between the baseline and past-experience trials. *Figure* 2 provides all of the possible valence-matched and valence-mismatched triads and dyads.

Inhibitory control—Participants completed two IC opposite games: *happy-sad* (Lagattuta, Sayfan, & Monsour, 2011) and *day-night* (Gerstadt, Hong, & Diamond, 1994). Children and adults were presented with cards depicting suns and moons (for day-night) and happy and sad faces (for happy-sad), and told that they were going to play an opposite game. For each opposite game, participants were instructed to label the cards with the opposite name (i.e., for day-night, say “day” to moons and “night” to suns; for happy-sad, say “happy” to sad faces and “sad” to happy faces). After four practice trials, participants completed 20 test trials of each task. We used cumulative response time and error rates for analyses; both were coded from audio recordings. Time started once the first card hit the table and ended when the participant gave his or her final response. Participants were counted as correct if they gave the correct response as their first and only utterance. Interrater reliability was assessed on 20% of the sample with >92% agreement within +/− 1 second and +/− 1 error. We chose to use both errors and total response time as our measures of IC because we aimed to examine the IC-ToM link from early childhood to young adulthood. While work with young children often uses just error rates (e.g., Montgomery & Koeltzow, 2010; Sabbagh, Xu, Carlson, Moses, & Lee, 2006)**,** research with older children and adults frequently relies on response times (e.g., Prencipe et al., 2011). Moreover, prior work has demonstrated that error rates and cumulative response time are strongly correlated (Kramer, Lagattuta, & Sayfan, 2015; Lagattuta et al., 2011), and both have been associated with advanced ToM (Kennedy et al., 2015; Lagattuta et al., 2010, 2014).

Working memory—We measured working memory with the *memory for sentences* task from the fourth edition of the Stanford-Binet Intelligence Scale (Thorndike, Hagen, & Sattler, 1986). Here, the experimenter reads increasingly complex sentences and the participant attempts to repeat each back verbatim. We scored performance using the standardized procedures. This task is frequently used as a measure of working memory because successful performance requires participants to hold increasing amounts of information in mind as well as to process sentence structure, tasks that recruit working memory skills (Caplan & Waters, 1998). The memory for sentences task has also been previously used successfully as a predictor of advanced ToM in 4- to 10-year-olds and adults (Kennedy et al., 2015; Lagattuta et al., 2010, 2014).

General procedure—Participants were tested individually in a quiet room by a female experimenter; all sessions were video-recorded and audio-recorded. The order of trial types (baseline, NN, PP, PN, NP) and binary answer choices were counterbalanced, with the condition that baseline trials always occurred first in the testing order. Although we counterbalanced the order of thought and emotion questions across trials, the decision question always came last. We wanted the participant to predict the characters' emotions and thoughts that preceded their behavioral decisions. The entire session (training, baseline, and past-experience trials) took approximately 60-75 minutes. In a different session, children completed the IC and WM tasks, along with other tasks not reported here. Session order was counterbalanced. Adults completed all tests within one 2-hour session. For more details regarding these procedures, see Lagattuta and Sayfan (2011, 2013) and Lagattuta et al. (2011).

Results

Results are presented in four sections. First, we examine participants' formation of valence-matched mental state triads—their tendency to predict that if a focal character anticipates that the perpetrator will do something good, he or she will feel happy, and approach the perpetrator; whereas, if the focal character thinks the perpetrator will do something bad, he or she will feel worried, and avoid the perpetrator. Then, we explore the frequency of valence-matched mental state dyads (see *Figure 2*). In the third section, we analyze the type of breaks participants most often make in their mental state judgments. Final analyses investigate relations between individual differences in EF (IC and WM) and the provision of valence-matched mental state triads. For all analyses, we set alpha at .05. We used Tukey's HSD post hoc tests to follow up on significant main effects and simple effects tests to inspect significant interactions.

Mental State Triads

We first explored developmental changes in the formation of valence-matched mental state triads. A 4 (age: 4- to 5-year-olds, 6- to 7-year-olds, 8- to 10-year-olds, adults) × 2 (sex) × 5 (trial: baseline, NN, PP, PN, NP) repeated measures ANOVA revealed main effects for age, $F(3, 272) = 25.67$, $p < .001$, $\eta p^2 = .22$, sex, $F(1, 272) = 4.27$, $p = .04$, $\eta p^2 = .02$, and trial, $F(4, 269) = 32.64$, $p < .001$, $\eta p^2 = .33$, qualified by an Age × Trial interaction, $F(12, 813) = 2.42$, $p = .004$, $\eta p^2 = .04$. Four- to 7-year-olds aligned thoughts, emotions, and decisions by valence less frequently than older children and adults (*p*s < .001). Across age, participants expected mental states to cohere by valence more often when perpetrators acted consistently in the past (NN, PP) than when they acted inconsistently (PN, NP) or when there was no past experience (baseline), *p*s < .001. Inconsistent and baseline trials did not differ (*ps* > .39). Males ($M = .79$, 95% CI [.76, .82]) formed more valence-matched mental state triads than females ($M = .75$, CI [.72, .78]).

As shown in *Figure 3*, although general trends followed the main effects, a more nuanced pattern between age and past-experience type (baseline, NN, PP, PN, NP) emerged. Noteworthy, the 4- to 5-year olds formed the fewest valence-matched mental state triads for baseline trials whereas adults provided the least valence-matched triads for the NP trials. In addition, while all other age groups performed similarly on the two types of consistent-past trials (NN = PP), 4- to 5-year-olds formed fewer valence-matched triads for the NN than PP variant ($p < .05$). Indeed, 4- to 5-year-olds were the only age group that did not systematically vary the valence stability of their mental state judgments in accord with the consistency of past event information.

Mental State Dyads

We next analyzed which of the three dyads (thought-emotion, emotion-decision, thought-decision) participants most often matched in valence. A 4 (age) × 2 (sex) × 5 (trial) × 3 (dyad) repeated measure ANOVA resulted in main effects for age, $F(3, 272) = 25.60$, $p < .001$, $\eta p^2 = .22$, sex, $F(1, 272) = 4.44$, $p = .036$, $\eta p^2 = .02$, trial, $F(4, 269) = 31.93$, $p < .001$, $\eta p^2 = .32$, and dyad, $F(2, 271) = 10.79$ $p < .001$, $\eta p^2 = .07$, qualified by Age × Trial, $F(12, 813) = 2.38$, $p = .005$, $\eta p^2 = .03$, and Age × Trial × Dyad, $F(24, 801) = 1.61$, $p = .032$, $\eta p^2 = .05$ interactions.

Similar to the triad analysis, 4- to 7-year-olds formed fewer valence-matched mental state dyads than 8- to 10-year-olds and adults, *p*s < .001. Females ($M = .83$, CI [.81, .85] provided fewer valence-matched dyads than males ($M = .86$, CI [.84, .88]), $p = .036$. Participants offered valence-matched mental state dyads more frequently in consistent-past trials (NN, PP) versus inconsistent-past trials (PN, NP) or baseline trials (*p*s < .001). Again, baseline trials did not differ from inconsistent-past trials (*ps* > .27). Across age, participants more frequently valence-aligned thoughts and emotions (people who anticipate a positive future feel happy; people who anticipate a negative future feel worried) than they linked emotions with decisions or thoughts with decisions (*p*s < .001), with the latter two dyads not differing from each other ($p = .45$).

As shown in *Figure 4*, a more complex relation appeared among age, trial, and dyad. Six- to 10-year-olds followed the main effect pattern by providing more valence-matched thought-emotion, emotion-decision, and thought-decision dyads for consistent-past compared to inconsistent-past or baseline trials (*p*s < .05). Adults, in contrast, had lower coherence in emotion-decision and thought-decision dyads for NP trials compared to PN and baseline trials (*p*s < .05). Similar to mental state triad analyses, 4- to 5-year-olds produced significantly fewer valence-matched dyads (emotion-thought, emotion-decision) for NN versus PP trials, they provided valence-matched thought-emotion dyads least often for baseline trials (*p*s < .05), and they did not cleanly distinguish between consistent-past and inconsistent-past trials.

Decisions Breaks

In the two dyads where participants expected the least coherence by valence (emotion-decision, thought-decision), the common thread was the decision component. We thus probed the decision judgments to examine what type of decision broke triads most often—approach or avoid. To examine break type, we calculated the proportion of decision breaks across trials that were negative (i.e., participants provided the following forecasts: anticipate something good + feel happy + *avoid*) or positive (anticipate something bad + feel worried + *approach*). The sample ($N = 160$: 43 4- to 5-year-olds, 44 6- to 7-year-olds, 43 8- to 10-year-olds, 30 adults) for this analysis was reduced because it only included participants who made at least one decision break. A 4 (age) × 2 (sex) × 2 (valence: approach break, avoid break) repeated measures ANOVA resulted in a main effect of valence, $F(1, 152) = 37.50$, $p < .001$, $\eta p^2 = .20$, subsumed by an Age × Valence interaction, $F(3, 152) = 2.78$, $p = .043$, $\eta p^2 = 05$. Across age, participants made more avoidant decision breaks ($M = .70$, CI [.63, .76]) than approach decision breaks ($M = .30$, CI [.24, .37]). The interaction revealed that although all age groups followed this main effect, the discrepancy between negative and positive breaks decreased with age.

Working Memory and Inhibitory Control

Next, we examined the influence of IC and WM on children's and adults' provision of valence-aligned thought, emotion, and decision judgments. To streamline analyses, we combined the consistent-past trials (NN, PP) together as well as the inconsistent-past (PN, NP) and baseline trials together, informed by the preceding trial-type analyses.

Because happy-sad and day-night were strongly correlated (errors: rs > .56, ps < .001, time: rs > .67, ps < .001), we created cumulative response time and error composites. As shown in Tables 1 and 2, age (but not gender) was significantly correlated with IC errors, IC response time, and WM (see Lagattuta et al., 2011 for more detailed analyses by age and IC trial type). Table 2 also reveals significant correlations between age, sex, IC (errors and response time), WM, and the provision of valence-matched mental state triads. Although not listed in Table 2, all of the following variables also significantly correlated with the frequency of valence-matched mental state dyads (age: .25 < rs < .35, ps < .001; IC errors and time: −.45 < rs < −.20, ps < 001; WM: .22 < rs < .43, ps < 001). For the consistent-past trials, sex was correlated with emotion-thought and thought-decision dyads (rs < −.12, ps < .039) and marginally related to emotion-decision dyads ($r = -.11$, $p = .063$). Participant gender did not predict the provision of coherent mental state dyads for inconsistent-past and baseline trials (rs > −.09, ps > .14).

Since our primary interest was valence-matched mental state triads, we conducted hierarchical linear regressions with predictors entered in the following order: (1) age and sex, (2) WM, (3) IC (errors and time), (4) Age × Sex interaction (5) interactions between Age × IC errors and Sex × IC errors. All other interactions were excluded due to multicollinearity issues (VIFs > 24.36; VIFs > 10 are cause for concern, O'Brien, 2007).

For consistent-past trials (NN, PP), the third model was the best fit ($R^2 = .33$, $\Delta R^2 = .06$, $F(2, 274) = 12.38$, $p < .001$). After controlling for age ($\beta = .39$, $p < .001$) and sex ($\beta = -.16$, $p = .003$) in the first step, and WM in the second ($\beta = .37$, $p < .001$), IC (errors: $\beta = -.14$, $p = .034$ and reaction time: $\beta = -.25$, $p < .001$) added significant variance. While sex ($\beta = -.14$, $p = .006$) and WM ($\beta = .23$, $p = .001$) remained significant predictors, the addition of IC eliminated the effect of age ($\beta = .04$, $p = .54$). Thus, males and individuals with better EF expected greater valence alignment among thoughts, emotions, and decisions on the consistent-past trials.

For the combined inconsistent-past and baseline analysis, the second model provided the best fit ($R^2 = .15$, $\Delta R^2 = .03$, $F(1, 276) = 8.27$, $p = .004$). Controlling for age ($\beta = .35$, $p < .$

001) and sex (β = −.06, p = .29) in the first step, WM (β = .20, p = .004) added significant variance. Age (β = .23, p = .001) remained a significant predictor with the inclusion of WM. Therefore, older participants and individuals with stronger WM created more valence-matched mental state triads on inconsistent-past and baseline trials.

Discussion

Results revealed age-related increases between 4 and 10 in predicting valence-aligned interrelations among people's thoughts, emotions, and decisions: People who anticipate positive future events feel happy and make approach decisions; those who expect negative future events feel worried and choose to avoid. On trials where children and adults did not expect full triadic coherence, they still typically linked characters' thoughts and emotions, but predicted decisions of the opposite valence. Indeed, the most common break was an avoidant decision disrupting an otherwise positive triad—a person anticipates a positive future and feels happy, but still chooses to avoid the situation. Differences also emerged among the varying trial types, with scenarios featuring consistent-past information (NN, PP) eliciting more valence-matched mental state triads and dyads compared to inconsistent-past (PN, NP) and baseline (no past) trials. Across age, males exhibited greater valence alignment in mental state predictions compared to females. In addition, individuals with higher IC and WM more often formed valence-matched mental state triads. Together, these findings provide new insight into further advances and individual differences in ToM during middle childhood and beyond, with implications for clinical practice.

Age-Related Changes

The frequency of valence-matched mental state triads and dyads increased with age: 8- to 10-year-olds and adults formed more valence-aligned judgments about how people would think, feel, and act compared to 4- to 7-year-olds. Interestingly, even adults did not form coherent mental state triads for 100% of trials, suggesting that reasoning about mental state coherence continues to evolve across the lifespan. That being said, 4- to 5-year-olds anticipated full triadic coherence in roughly two-thirds of trials and expected dyadic coherence in more than three-fourths trials. Moreover, all age groups formed valence-matched triads and dyads well above chance. These data extend related ToM research showing significant changes in reasoning about interrelations among different kinds of mental states between 3 and 10 years of age (see Lagattuta, 2014; Lagattuta et al., 2015). Here, we also confirm that thought-emotion connections appear more straightforward for all age groups compared to linking people's thoughts and decisions or their emotions and decisions (Bartsch et al., 2007, Lagattuta & Wellman, 2001).

Effects of Past Experience Information

Supporting our hypothesis, children and adults formed more coherent connections among thoughts, emotions, and decisions (anticipate something good + feel happy + approach; anticipate something bad + feel worried + avoid) when characters encountered perpetrators who had consistently harmed (NN) or helped them (PP), compared to contexts where perpetrators had acted inconsistently (PN, NP). This same general pattern occurred for mental state dyads. Even with greater surface simplicity (there is no past history information to integrate), baseline trials aligned with inconsistent-past trials. These data suggest that children and adults consider future uncertainty when predicting how people will think, feel, and act: Greater uncertainty (no past, inconsistent past) means less coherence among mental states. Further intriguing is that the “weakest link” was the decision component. Regardless of age, participants most often broke otherwise positive triads with avoidant decisions (i.e., anticipate positive + feel happy + *avoid*). These data fit with related studies indicating that people often make avoidant decisions when faced with uncertainty across a variety of social, health, and economic contexts (e.g., Altshuler & Ruble, 1998; Bell, 1982; Brashers, Goldsmith, & Hsieh, 2002; Ehlers & Clark, 2000).

Despite these general trends by trial type, there were specific deviations by age that provide insight into the development of social-cognitive reasoning. For example, whereas 4- to 5-year-olds formed coherent triads most easily when the past information was consistent and positive (PP), they treated double negative trials (NN) like inconsistent-past trials (PN, NP). This contrasts with older age groups who treated PP and NN trials equivalently. These findings likely reflect younger children’s tendency to overestimate the likelihood of positive future events (Lagattuta & Sayfan, 2013; Lipko, Dunlosky, & Merriman, 2009), and their stronger belief in the persistence of positive versus negative behaviors compared to older children . Such a positivity bias could lead young children to predict that characters could still feel happy, think positively, or even decide to approach perpetrators who harmed them twice in the past—thus, breaking what should otherwise be a triad of negative mental states. That 4- to 5-year-olds did not provide more valence-matched mental state triads or dyads for consistent-past versus inconsistent-past trials (as did individuals 6 years and older) further confirms that younger children have more difficulty identifying uncertain situations (Lagattuta & Sayfan, 2011, 2013; Lyons & Ghetti, 2011; Robinson et al., 2006). Potentially, this improved differentiation by past-experience type may also have been driven by growing awareness that some situations elicit mixed emotions (Gnepp & Klayman, 1992; Harris, 1983; Harter & Buddin, 1987; Lagattuta, 2005; Larsen, To, & Fireman, 2007), diverse thoughts (Lagattuta et al., 2010, 2014), and conflicting desires (Choe, Keil, & Bloom, 2005; Rostad & Pexman, 2014).

Also intriguing was that adults were least likely to attribute coherent thought-emotion-decision triads to focal characters when they encountered perpetrators who previously harmed and then helped them in the past (NP). Although adults may recognize that the perpetrator may be trying to “make up for it,” they could still appreciate lingering cause for concern. That is, although the character might think something good is going to happen, there are also reasons to be cautious, causing feelings of worry or avoidant decisions. One positive interaction is not sufficient to exonerate the previous negative interaction. Indeed, the psychological literature supports this positive-negative asymmetry: Negative stimuli bear more weight than positive information (see Baumeister, Bratslavsky, Finkenauer, & Vohs, 2001 for a review). Thus, it may take more than one positive “make-up attempt” to reverse the skepticism caused by a negative interaction, which may lead adults to form fewer coherent mental state triads in this condition.

Sex Differences

Lagattuta and Sayfan (2013) found no sex differences when participants' thought, emotion, and decision judgments were analyzed separately. The current results reveal that males and females do differ, however, in their expectations about interconnections among these mental states. Males more often provided valence-aligned predictions for how people will think, feel, and act than did females. Although this gender difference had a small effect size, it remained significant independent of age and individual differences in EF.

In some respects, these findings are surprising given prior research indicating that females show more advanced understanding of emotions than males during early and middle childhood (e.g., Bosacki & Astington, 1999; Calero et al., 2013; Devine & Hughes, 2013; Lagattuta, 2014) and that there are no sex differences in performance on many ToM tasks (e.g., Wellman et al., 2001). Why should females, starting from a young age, identify more situations than males where there can be valence *misalignment* among mental states? The biggest clue comes from the most common break of mental state triads and dyads: avoidant decisions. That is, despite judging that the character would anticipate something good and/or feel happy, the predicted decision is that he or she will stay away from the perpetrator. We know from related work that female children and adults view the future as more uncertain (Lagattuta, 2007; Lagattuta & Sayfan, 2011), experience more anxiety, and make more avoidant decisions than do males (Altemus, 2006; McLean, Asnaani, Litz, & Hofmann, 2011). The current findings add to this literature by revealing early emerging social-cognitive differences in how females anticipate people's thoughts, emotions, and decisions to align.

Contributions of Executive Function

Replicating recent work (Austin, Groppe, & Elsner, 2014; Bock, Gallaway, & Hund, 2015; Kennedy et al., 2015; Lagattuta et al., 2010, 2014) the current study documents an EF-ToM relation from early childhood into adulthood. These findings add much needed data to the emerging literature on individual differences in ToM in middle childhood (see Hughes & Devine, 2015; Lagattuta et al., 2015). More specifically, the current study demonstrates that individuals with superior WM and IC provided more valence-matched mental state triads on consistent-past trials (NN, PP), and stronger WM predicted the creation of more valence-matched triads on the inconsistent-past (PN, NP) and baseline trials. Working memory likely aided performance by helping individuals manipulate past event evidence as well as track the consistency of their three mental state judgments; skills needed across trial types. Superior IC may have further benefited children and adults on the consistent-past trials by helping them inhibit consideration of the opposite-valenced future event, thus facilitating the maintenance of valence coherence across judgments. Such inhibition is unnecessary for inconsistent-past or baseline trials since they involved both negative and positive information or no past events.

It is further notable that whereas age was no longer significant on the consistent-past trials with the addition of WM and IC, age remained a significant predictor of valence-matched mental state triads for inconsistent-past and baseline trials. Lagattuta and Sayfan (2013) found that with age, children made sharper distinctions between NP and PN trials, despite their mathematical equivalence (judging that characters would feel more worried on PN versus NP trials). They interpreted these data to indicate that older individuals rely more heavily on intuitive heuristics (Jacobs & Potenza, 1991; Reyna & Ellis, 1994). The current findings bolster this hypothesis by demonstrating conceptual differences in how children and adults think about people's mental states in these events that cannot be explained by development in EF alone. Similarly, the fact that gender remained significant on the consistent-past trials despite the addition of EF, also supports our interpretation that there may be differences between how males and females interpret future uncertainty and reason about interrelations among mental states.

Clinical Implications

Cognitive-behavioral therapies (CBT, e.g., Ellis, 1991) stress that people's thoughts can have emotional and behavioral consequences; clients are trained to recognize and change maladaptive ways of thinking, feeling, and acting. The current results show that despite several strengths in young children's understanding of interconnections among these mental states (e.g., even 4- to 5-year-olds formed valence-matched mental state triads the majority of trials), 4- to 7-year-olds formed fewer valence-matched mental state triads and dyads than did older age groups. Four- to 5-year-olds also did not reliably make distinctions by type of past experience; that is, they did not expect characters' mental states to be more aligned by valence for consistent-past versus inconsistent-past trials. This lower awareness of interrelations among mental states may limit the effectiveness of CBT in young children. Indeed, the existing literature contends that age and cognitive ability moderate therapy outcomes in children (e.g., Durlak, Fuhrman, & Lampman, 1991; Grave & Blissett, 2004; Ollendick, Grills, & King, 2001; Southam-Gerow & Kendall, 2000). Importantly, our results also indicate that all age groups expect more valence coherence between thoughts and emotions compared to emotion-decision or thought-decision relations. Therefore, focusing on thought-emotion understanding may be an ideal starting place for CBT with children and even adults. Once this base is established, the therapist could move on to thought-decision and emotion-decision dyads, and finally to the full cognitive triad.

Limitations and Future Directions

The current sample was comprised of predominantly white, middle to upper class, nonclinical participants. Samples that differ by race, ethnicity, family education level, or exposure to stressful events may respond differently. For example, maltreated children show lower emotion understanding (Pears & Fisher, 2005), delayed development of ToM (Cicchetti, Rogosch, Maughan, Toth, & Bruce, 2003; O'Reilly & Peterson, 2015), greater attention to threat cues, and higher anxiety (see Cicchetti & Ng, 2014; Shackman, Shackman, & Pollak, 2007). Therefore, doing a similar study in populations who have experienced trauma could reveal how life experiences shape how children and adults think about interrelations among thoughts, emotions, and decisions. One might expect that they would form fewer valence-matched mental state triads and dyads as well as show a more protracted developmental trajectory.

It would also be informative to examine additional sources of individual differences in children's and adults' reasoning about interconnections among thoughts, emotions, and decisions. For example, there is growing evidence that children who are more securely attached exhibit more sophisticated understanding of people's mental states and emotions (de Rosnay & Harris, 2002; Pavarini, de Hollanda Souza, Kozak, 2013; Symons & Clark, 2000). Most of this work, however, has been done with children younger than age 5, raising questions as to whether attachment quality continues to shape how older children and adults reason about mental states. It would also be interesting to explore relations between individual differences in emotional mental health and reasoning about interrelations among thoughts, emotions, and decisions. Previous studies have found, for example, that anxious children interpret ambiguous situations as more threatening and endorse more avoidant decisions than non-anxious controls (e.g., Barrett, Rapee, Dadds, & Ryan, 1996). Thus, more anxious individuals may have different beliefs about coherence among people's thoughts, emotions, and decisions. Finally, individuals with higher verbal abilities have been shown to perform better on a variety of ToM measures in early childhood as well as older age groups (Banerjee et al., 2011; Botting & Conti-Ramsden, 2008; Caillies & Le Sourn-Bissaoui, 2008; Filippova & Astington, 2008). Even though the language demands in the current research appear low on the surface (i.e., responses to binary questions), the social-cognitive concepts that support children's developing ability to think about interrelations among mental states may be closely tied to growth in verbal abilities.

Conclusions

The current data expand ToM research by examining children's and adults' reasoning about the triadic coherence of thoughts, emotions, and decisions. We demonstrate significant increases between 4 and 10 years of age in anticipating valence alignment among these mental states: Thinking negatively evokes worry and avoidant decisions, whereas positive thoughts lead to happiness and approach decisions. Children and adults expected thoughts and emotions to cohere by valence more often than thoughts with decisions or emotions with decisions. Across age, individuals with superior WM and IC provided more valence-matched mental state triads, indicating that EF continues to aid ToM during middle childhood and adulthood.

These findings suggest that the ability to form valence-matched mental state triads improves with age and development in EF. Although true, there is more to this story than documenting further "advances" or "improvements" in ToM. What also changes with age is children's awareness of the kinds of contexts where people's mental states should be more versus less coherent. Children older than 6 years and adults judged that thoughts, emotions, and decisions would more often align by valence when a person encounters individuals who had treated them consistently in the past versus acted inconsistently or were unfamiliar. Moreover, across age, females expected less coherence by valence than males in how people will think, feel, and act (e.g., happiness or positive thoughts could still lead to avoidance). Thus, the "correct" answer is not always a valence-matched mental triad, and broken triads can result from different causes. For example, one child may break a triad due to less developed EF skills, another from lack of conceptual understanding, and a third because she has formed different beliefs about when or if mental states will cohere. We raise these issues because as researchers start to investigate more complex features of ToM in middle childhood and beyond, the typical "present versus absent" paradigm will not be sufficient (e.g., At what age does a child understand false belief?). Once children have developed solid knowledge that people have desires, beliefs, thoughts, emotions (etc.), what likely evolves with age and further life experiences are intuitions about the sources, contents, interconnections, and consequences of those mental states.

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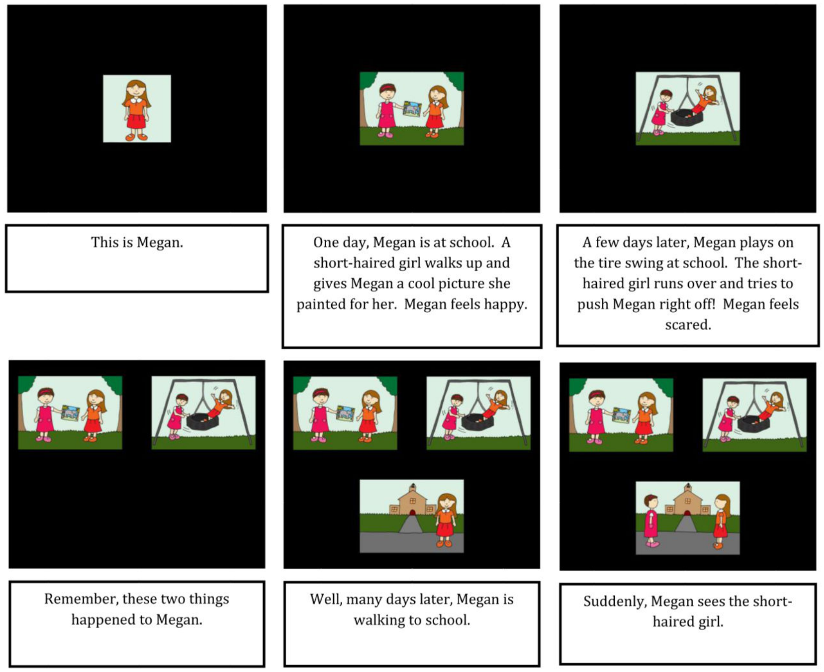

Figure 1.

Example of a PN trial. After hearing the story, participants were asked three forced-choice questions: (1) "How do you think [Megan] feels right now? Does she feel *worried or happy*?" (2) "Does [Megan] think that [the short-haired girl] is going to do something *good* or *bad*?" (3) "What do you think [Megan] will do next? Do you think she will she *stay away* from [the short-haired girl] or *go near* [the short-haired girl]?"

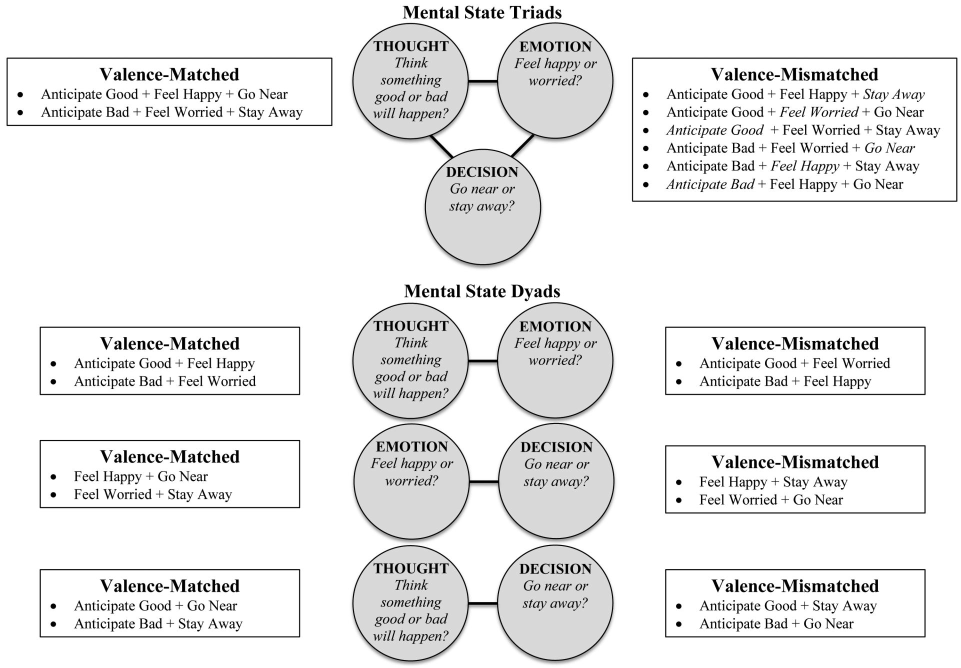

Figure 2.
All possible valence-matched and valence-mismatched triads and dyads.

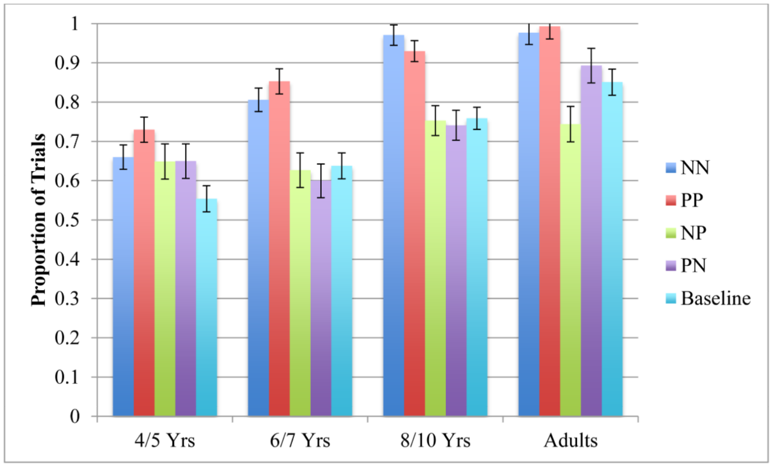

Figure 3.

Proportion of trials participants formed valence-matched mental state triads. NN = two negative past events, PP = two positive past events, NP = positive then a negative past event, PN = positive then a negative past event, Baseline = no past experience. Error bars represent standard errors. All age groups formed valence-matched mental state triads above chance (.25).

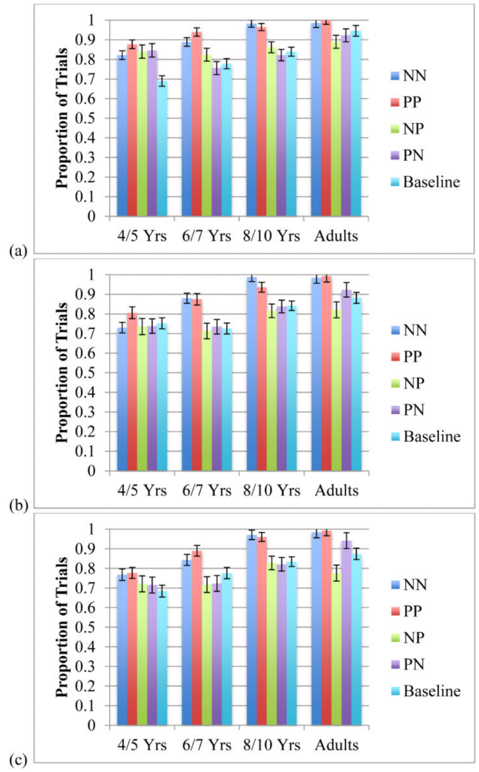

Figure 4.

Proportion of trials participants made valence-matched mental state dyads: (a) Thought-emotion dyads; (b) Emotion-decision dyads; (c) Thought-decision dyads. NN = two negative past events, PP = two positive past events, NP = positive then a negative past event, PN = positive then a negative past event, Baseline = no past experience. Error bars represent standard errors. All age groups formed valence-matched dyads above chance (.50).

Table 1

Means and Standard Deviations for Inhibitory Control and Working Memory

	4-to 5-year-olds	6- to 7-year-olds	8- to 10-year-olds	Adults
IC Total Errors	9.67 (5.73)	5.42 (3.24)	3.77 (2.64)	2.23 (1.85)
IC Total Response Time in Seconds	90.44 (20.53)	67.95 (11.26)	57.93 (12.66)	48.27 (6.00)
WM	17.59 (4.01)	20.53 (3.81)	24.52 (3.76)	27.00 (3.68)

Note. Standard deviations are presented in the parentheses. IC: inhibitory control; WM: working memory. IC metrics are summed across day-night and happy-sad (IC total possible errors = 40). Maximum possible score for WM metric = 42.

Table 2

Bivariate Correlations Between Age, Sex, Executive Function, and Mental State Triads

	Age	Sex	VMT (Consistent -Past)	VMT (Inconsistent-Past + Baseline)	IC Errors	IC Response Time	WM
Age	1						
Sex	−.002	1					
VMT (Consistent-Past)	.39***	−.16**	1				
VMT (Inconsistent-Past + Baseline)	.35***	−.06	.46***	1			
IC Errors	−.47***	.02	−.42***	−.30***	1		
IC Response Time	−.60***	.06	−.50***	−.34***	.57***	1	
WM	.59***	−.02	.47***	.34***	−.52***	−.59***	1

Note.

VMT = Valence-Matched Mental State Triads. Consistent-Past = NN and PP trials. Inconsistent-Past + Baseline = PN, NP, and no-past trials. IC = Inhibitory Control. WM = working memory.

** $p < .01$,

*** $p < .001$;