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Development of Constructivist Theory of Mind from Middle Childhood to Early Adulthood and Its Relation to Social Cognition and Behavior

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Abstract

Two studies examined the development of constructivist theory of mind (ToM) during late childhood and early adolescence. In Study 1 a new measure was developed to assess participants' understanding of the interpretive and constructive processes embedded in memory, comprehension, attention, comparison, planning, and inference. Using this measure, Study 2 tested a mediational model in which prosocial reasoning about conflict mediated the relation between constructivist ToM and behavior problems in high school. Results showed that the onset of constructivist ToM occurs between late childhood and early adolescence, and that adolescents who have more advanced constructivist ToM have more prosocial reasoning about conflict, which in turn mediated the relation with fewer serious behavior problems in high school, after controlling for academic performance and sex. In both studies, females showed more advanced constructivist ToM than males in high school.

Key terms

theory of mind; hostile attribution bias; middle childhood; adolescence; young adults

Theory of mind (ToM) is the ability to view people as psychological beings. Children develop a ToM when they can consider mental states (such as desires, thoughts, and beliefs) and the links between mental states and behavior (Wellman, Cross, & Watson, 2001). Because most research on ToM development has focused on early childhood, less is known about how children understand the mind during the middle childhood and beyond (Astington & Hughes, 2013; Hughes & Leekham, 2004).

Researchers have used several different methods to investigate later developments in ToM. These include tasks requiring reasoning about others' communicative intentions (Filippova & Astington, 2008), considering a speaker's perspective that guides behavior (Dumontheil, Apperly, & Blakemore, 2010), and thinking about another person's thoughts regarding how

another person thinks or feels (termed second-order reasoning, Miller, 2009, 2012; Perner & Wimmer, 1985). Several tasks have been constructed to assess sensitivity to different emotional reactions, including the "Reading the Mind in the Eyes Test" (Baron-Cohen et al., 2001), which involves presenting photos of the eyes and asking participants to identify the emotional state. Other tasks assess understanding that emotional reactions depend on how statements are "taken" or interpreted. These include the "Strange Stories" (Happé, 1994; White, Hill, Happé, & Frith, 2009) and "Silent Films" tasks (Devine & Hughes, 2013), which involve presenting a series of short vignettes about social scenarios (e.g., joke, pretense, sarcasm, white lie) and asking participants to explain the protagonist's behavior based on mental states. The "Stories from Everyday Life" task (Kaland et al., 2002) is similar, but includes more complex vignettes. In the "Faux Pas" (Baron-Cohen et al., 1999) and "Awkward Moments" tasks (Heavey, Baron-Cohen, & Rutter, 2000) the protoganist inadvertently says something awkward or embarrassing and participants are asked to identify the awkward statement or the other's emotional reaction. Bosacki and colleagues have developed a task that involves reasoning about ambiguous social interactions and querying participants about several forms of social understanding (e.g., empathy; Bosacki, 2000; Bosacki & Astington, 1999).

In contrast, Fabricius and Schwanenflugel (1994; Fabricius, Schwanenflugel, Kyllonen, Barclay & Denton, 1989) have studied the development from middle childhood to adulthood of understanding interpretive diversity; namely, that "knowledge can be more or less certain, that feelings of uncertainty are important in evaluating information, that things can have multiple meanings, and that these meanings can arise solely from differences in interpretive mental processes" (Schwanenflugel, Fabricius, & Noyes, 1996, p. 288). Their and others' work (Chandler, Boyes & Ball, 1990) has shown that pre-adolescents are only beginning to understand the constructivist nature of active mental processes. Constructivist ToM accounts are in line with views about the development of naïve epistemology, that is, conceptions of knowledge and how knowledge is constructed (Kitchener, 2002). Constructivist notions have pervaded nearly all discussions of adult ToM (Hofer & Pintrich, 1997), and research has charted developing awareness and acceptance of uncertainty and multiplicity of interpretation in late high school (Chandler et al., 1990) and early adulthood (King & Kitchener, 1994).

Fabricius, Schwanenflugel, and colleagues used various methods to investigate the conceptual organization and underlying structure of mental processes. In some studies they asked participants to judge the similarity in the way pairs of scenarios engaged mental activities (e.g., How similar is "Telling your friend everything you had to eat today in the school cafeteria" and "Listening to the announcements in a noisy cafeteria" in terms of the way you would use your mind?; Fabricius et al., 1989; Parault & Schwanenflugel, 2000; Schwanenflugel, Fabricius, & Alexander, 1994). In others, they asked participants to make similarity judgments between pairs of mental verbs (e.g., How similar is "memorizing and seeing" in terms of the way you use your mind? Alexander, Noyes, MacBrayer, Schwanenflugel, & Fabricius, 1998; Schwanenflugel, Fabricius, & Noyes, 1996; Schwanenflugel, Fabricius, Noyes, Bigler, & Alexander, 1994). In others, they asked them to select the specific set of mental verbs that might be extended to mental activity scenarios (e.g., Is "telling your mom about how much longer it'll take to finish your homework" an

example of *estimating*, *guessing*, *comparing,* and/or *remembering,* etc? Schwanenflugel, Fabricius, Noyes, et al., 1994; Schwanenflugel, Henderson, & Fabricius, 1998). The conceptual underpinning of these methods is the theory-based view of concepts (Murphy, 2002; Murphy & Medin, 1985), in which conceptual structure and organization of concepts is reflective of deeper, underlying naïve theories that persons have about a domain. The ontological distinctions in the underlying theory constrain and give differential weight to the features that are relevant bases for categorizing entities, and the causal-explanatory mechanisms in the theory specify the links among concepts. By examining the changing organization of mental processes and the emergence of mental activity categories using multidimensional scaling and clustering methods, Fabricius, Schwanenflugel, and colleagues were able to infer important developmental changes in theory of mind that drove underlying changes in the conceptual organization of mental activities.

The organization of mental concepts and activities revealed by these methods indicated that 8- and 10-year-olds and adults represented mental processes according to two major dimensions: (a) an information processing dimension (distinguishing input activities such as *searching* and *seeing* from output activities such as *estimating* and *describing*); and (b) a dimension revealing the constructivist nature of mental activity capturing the degree of uncertainty that pervades this information processing system (e.g., distinguishing certain, less constructive activities such as *seeing* and *memorizing* from uncertain, more constructive mental activities such as *searching* and *estimating*). Increasing weight was given to the certainty dimension with age. Most developmental changes occurred between age 10 and adulthood. Across studies, adults distinguished a greater number of specific processes, particularly ones related to an understanding of more constructivist mental activities. These findings revealed a constructivist conception of interactive and pervasive mental processes that operate even during information acquisition and that mediate between inputs and cognitive outcomes such as memories, plans, and decisions. These constructivist insights also showed some cultural differences; Japanese university students' verb similarity judgments did not evidence an "uncertain problem-solving" category consisting of the verbs *examine, explore, check, search,* and *question* that was particularly evidenced by their German counterparts (Schwanenflugel, Martin & Takahashi, 1999).

These studies also revealed developmental changes in the emergence of mental concepts that might provide the foundation for understanding of the constructivist nature of mental activity, causing cause people who are exposed to the same information to represent it differently. For example, adults marked the conceptual boundaries between comprehension and recall, which should allow them to understand that one can hear or remember something but not understand it. They also recognized the effortful, voluntary, and selective features of attention, which should allow them to understand ways in which information acquisition can be faulty.

Importantly for the purposes of the current study, however, these previous studies did not include a direct test of understanding interpretative diversity. One goal of our current series of studies is to provide a measure that will include such a direct test of the understanding of interpretive diversity. In Study 1 we developed an individual difference measure of interpretative diversity theoretically derived from these insights into constructivist ToM

development. The measure involved 10 scenarios in which mental processes could cause observers to have perceptions, memories, understandings, conclusions, and decisions that diverge to some degree from each other and from the informational input. The measure tests whether participants ascribed interpretive diversity and, importantly, whether they attributed it to active, interpretive mental processes as opposed to stimulus-related factors. Finally, the previous studies left a sizable gap between 10 years of age and adulthood, which we addressed by including 8-, 10- 12-, and 14-year-olds and adults in order to determine the inflection point in understanding interpretative diversity.

In Study 2, we tested the theoretical prediction that understanding how mental processes themselves can cause interpretative diversity should be related to better social problem-solving skills. Our hypothesis was that understanding that the nature of mental processes is such that people can easily misinterpret things should make it easier to avoid making hostile attributions of intended harm in ambiguous situations. We employed the new individual difference measure with 14-year-olds to test a mediational model in which prosocial reasoning about conflict mediated the relation between understanding interpretive diversity and school-documented behavior problems.

Study 1

Method

Participants—There were 100 participants (50 males), divided equally among five U.S. school grade levels: Third grade (8–9 years of age; 12 males, 8 females), fifth grade (10–11 years; 10 males), seventh grade (12–13 years; 10 males), ninth grade (14–15 years; 10 males), and college (8 males). Exact ages were not available for individuals. The distribution of males and females did not differ across age groups, χ (4) = 1.600, N = 100, p = .809. Child participants were recruited from an elementary school, a middle school, and a high school located within a middle- to upper-middle class school district located in the Southwestern region of the U.S. All child participants were white, non-Hispanic, with the exception of two African-American children in the 8- to 9-year-old age group, and one in the 10- to 11-year-old age group. Adult participants were college students who took part as a component of their research requirement in an introductory psychology class. An additional 20 college students participated in a pilot study to construct interview procedures and coding schemes.

Materials—The interview consisted of ten questions, shown in Table 1. These questions were developed to explore participants' understanding of the active, constructive nature of several mental processes (Comprehension, Memory, Attention, Comparison, Planning, and Inference). Surface features were varied across the ten questions to provide a mixture of questions that included one or two persons' mental processes; mental processes that operated on visual, auditory, or verbal information; and descriptions that provided more or less contextual information about the targeted mental process. To keep response burden reasonable, these surface features were not varied systematically or crossed factorially.

Procedure—All procedures were approved by the Institutional Review Board and in accordance with guidelines established by the American Psychological Association. Each

participant was interviewed individually by the third author, who read the questions aloud to the participant. The interviewer recorded the participant's responses and the countermands used during the interview (see below). Order of questions (either forward as shown in Table 1, or reverse) was counterbalanced across participants. Participants first answered "Yes" or "No" to each question (or "Different" or "Same" to the Planning, Comparison, and Inference questions). Responses of "Yes" and "Different" were followed with a request to provide an explanation for the answer. If participants provided a minimal explanation, they were queried further; e.g., "How does that work?" or (for Memory A) "Would they think it really happened?"

Responses were coded as "Yes, with Active Mental Process explanation," "Yes, with Non-Active/Non-Mental Process explanation," or "No." If a participant's response to a question included more than one explanation, the response was coded as "Yes, with Active Mental Process explanation" if at least one of the explanations fit that type. Table 1 gives examples of the two types of explanations. Responses of "Yes, with Non-Active/Non-Mental Process explanation" included different stimulus- or knowledge-based explanations depending on the question, such as references to mistakes or errors, to poor quality of perceptual information, or to knowledge or competence differences between people, as well as failures to give explanations (e.g., "I don't know how."). If the interviewer judged that the participant gave an initial Non-Active/Non-Mental Process explanation, he countermanded that explanation once to give the participant a second chance to produce an Active Mental Process explanation. For example, depending on the explanation, the interviewer might ask the participant to consider that knowledge deficiencies or perceptual difficulties were not the cause of the problem, or remind the participant what the question stipulated, or ask the participant to consider only normal, everyday experiences. For purposes of calculating reliability, and for the primary analyses, we used the final responses, which were those that were either not countermanded or given after a countermand. A second, trained rater independently coded the responses (Yes, with Active Mental Process explanation, Yes, with Non-Active/Non-Mental Process explanation, No) of 15 (three per age) participants (15%). Raters agreed 90.5% of the time (kappa =.49).

Results

Preliminary analyses explored rates and effects of countermanding. On average, the interviewer countermanded about three explanations per child in each of the two younger age groups, and two in each of the three older age groups; these rates did not differ significantly, $F(4, 99) = 1.83$, $p = .12$. During coding, it was noted with hindsight when the interviewer had failed to countermand a Non-Active/Non-Mental Process explanation. This happened on average less than once per child. The number of missed countermands per child in the youngest age group (.85) was larger than in the other age groups (.15, .40, .05, .15, respectively), $F(4, 99) = 6.75$, $p < .001$. This could have potentially resulted in some relative underestimation of the youngest children's ability to produce Active Mental Process explanations; however, in the youngest age group there was no difference in the proportion (out of 10 questions) of Active Mental Process explanations before ($M = .33$) versus after countermands ($M = .34$; $t(19) = 1.45$, $p = .16$). There was significant improvement after countermands at each of the other age groups, ts (19) > 2.85, ps < .01, although the

improvement was slight, never more than .08. Overall, the proportion of Active Mental Process explanations increased from .52 before countermands to .56 after countermands. Non-Active/Non-Mental Process explanations decreased (.30, .17), and that decrease was largely made up for by an increase in "No" responses (.18, .27) after countermands. We calculated the proportion of time subjects responded to countermands with another Non-Active/Non-Mental Process explanation (.44 of the time), or a "No" response (.37), and these rates did not differ from each other or by age group.

A Sex X Order X Age Group ANOVA on the proportion of responses (out of 10 questions) in each response category revealed only main effects of Age Group and no interactions: For Active Mental Process explanations $F(4, 80) = 10.99$, $p < .001$; for Non-Active/Non-Mental Process explanations $F(4, 80) = 8.33$, $p < .001$; for No responses $F(4, 80) = 2.64$, $p = .040$. Table 2 shows the mean proportions and standard deviations of each response category in each age group. Planned LSD tests comparing adults to each of the four younger age groups revealed that 8- to 9-year-olds and 10- to 11-year-olds were less likely to give Active Mental Process explanations and more likely to give Non-Active/Non-Mental Process explanations than adults (p's < .01), and that 8- to 9-year-olds were more likely to give No responses than adults.

Table 3 shows the mean proportions of Active Mental Process explanations for each question, and Spearman's ρ correlations with age group. The Comprehension A question appeared substantially more difficult ($M = .15$) than the other questions, while the Comprehension B question was the only one that did not significantly correlate ($r = .02$) with age group. All other questions correlated significantly positively with age group.

We explored the structure of the questions by conducting a Principal Components Analysis (PCA) using the Active Mental Process explanations given to each question. PCA extracts the first component that explains the greatest proportion of variance among the items. Any subsequent components are orthogonal to the first. If all of the questions do in fact tap children's understanding of the common constructivist nature of these examples of six mental processes that varied along several different surface features, then all the questions should load positively on the first component. To address the potential problem that the first component of the PCA might only reflect the items' responsiveness to age, we first conducted a binary logistic regression of age group onto each question and saved the unstandardized residuals for each question to use in the PCA. The residual is the difference between the observed value of the question and the value predicted by age group; thus, it removes the variance explained by age group. The residuals are interval and thus appropriate for PCA.

Table 3 shows the component loadings on the first two components. The first component (Eigenvalue = 2.29) accounted for 22.90% of the variance, and the second (Eigenvalue = 1.43) accounted for an additional 14.30% of the variance. As predicted, all questions loaded positively on the first component, indicating that the first component represented the underlying constructive nature of these mental processes. In addition to loading positively on the first component, four questions also loaded strongly on the second component, two positively (Attention A and Comparison) and two negatively (Memory B and Planning). The

second component appears to represent the surface feature of visual inspection (assuming that participants thought that planning a trip requires inspecting a map), and distinguishes between visual inspection in which something is not seen (as stated explicitly in Attention A and implied in Comparison) and visual inspection in which everything is seen (as stated explicitly in Memory B and implied in Planning).

Discussion

Findings from the new Constructivist ToM measure revealed that the inflection point in attributing interpretative diversity to mental processes occurred between 10 and 12 years of age. This s consistent with previous research in which 10-year-olds showed limited ability to distinguish between mental processes that tend to be more or less interpretative, such as attention versus seeing and hearing, and understanding versus remembering (e.g., Schwanenflugel et al., 1994). The significant increase in Active Mental Process explanations coincides with the traditional onset of formal operational thinking according to Piaget (1970); furthermore, even among college adults, performance only reached 70%. This suggested that the constructivist ToM measure would be sensitive to individual differences even at the older ages.

The youngest children, aged 8 to 9 years, gave “No” responses only about one-third of the time, and “No” responses trended lower across the older age groups. Thus at all ages participants most often judged that people’s subjective experience of things can differ from objective reality and can differ from one person to another. However, 8- to 9-year-olds and 10- to 11-year-olds were more likely than adolescents and college adults to attribute those differences to mistakes or errors, to poor quality of perceptual information, or to knowledge or competence differences between people. Research on the development of naïve epistemology (Kitchener, 2002) often examines only whether participants ascribe interpretative diversity, but the current findings highlight the importance of how participants understand the source of interpretive diversity. The current findings showed that participants who provided Active Mental Process explanations did so spontaneously when first asked for an explanation. When given a second opportunity, the great majority (81%) of those participants at all ages who had initially provided Non-Active/Non-Mental Process explanations either continued to respond with a different Non-Active/Non-Mental Process explanation or responded “no.” This suggests that the Constructivist ToM measure is a useful tool for assessing awareness of active mental processes. It is still possible, however, that some participants did not understand the implicit request to provide Active Mental Process explanations. Future research should examine whether explicit requests for Active Mental Process explanations would affect rates of responses.

Study 2

A constructivist ToM seems important in social reasoning because it should help one understand how people can seriously disagree even when they are exposed to the same information; however, it is unknown whether a constructivist ToM facilitates the acquisition of social problem solving skills. Much research has established that younger children’s development of ToM has social consequences. For example, in early childhood, ToM

(measured via false belief tasks) relates to teachers' ratings of prosocial skills (Lalonde & Chandler, 1995; Watson, Nixon, Wilson, & Capage, 1999; Weimer & Guajardo, 2005), observations of peer interactions during free-play (Watson et al., 1999), and acceptance from peers (Slaughter, Dennis, & Pritchard, 2002). Capage and Watson (2001) also found that false belief task performance was a better predictor of social competence than was the ability to generate solutions to interpersonal problems. Additionally, longitudinal research has shown that early success on false belief tasks predicts better social competence later (Caputi, Lecce, Pagnin, & Banerjee, 2012; Eggum et al., 2011; Fink, Begeer, Hunt, & de Rosnay, 2014). During middle childhood, ToM (measured using Happé's Strange Stories) relates to teachers' rating of social competence (in 10–11 year olds; Liddle & Nettle, 2006), social understanding, and peer ratings of social-interaction skills (in 10–13 year olds, Bosacki & Astington, 1999).

In Study 2 we tested the hypothesis that the degree to which adolescents understand the role of active, interpretative mental processes in everyday cognitive situations would relate to better prosocial reasoning about conflict as well as more prosocial behavior. The specific mechanism that we envisioned is that understanding that people can misinterpret things because that is the nature of mental processes should help avoid "hostile attribution bias;" i.e., taking ambiguous information personally as intended harm (Dodge, 1980). In turn, avoiding making hostile attributions should protect adolescents against getting involved in serious aggressive behavior problems. Thus we tested a mediational model in which prosocial reasoning about conflict mediated the relation between understanding the role of active, interpretative mental processes in everyday cognitive situations and avoiding serious behavior problems in high school. Given past ToM research that has shown that girls outperform boys during early adolescence (Bosacki & Astington, 1999; Calero, Salles, Semelman, & Sigman, 2013), and that ToM relates to school achievement across the early and middle childhood years (Lecce, Caputi, & Pagnin, 2014), we also controlled for sex and academic performance (i.e., Grade Point Average) as factors in the model.

We administered a subset of the Constructivist ToM items and a Social Problem Solving scale (Slaby & Guerra, 1988) to a large sample of 14- to 15-year-olds during the school day. Because of the large number of participants and the school context we developed a shortened, paper-and-pencil version of the Constructivist ToM measure. We also obtained school records of referrals to school authorities for disciplinary action stemming from behavioral infractions during the year, and grade point average.

Method

Participants—The entire freshman class of an ethnically diverse, lower-middle-class high school located in in the Southwestern region of the U.S participated. (Typical ages for "freshman" in the U.S. are 14 and 15 years). The following year the new freshman class, composed of different individuals, also participated (across both years total participating n = 569; 54% male). State census records indicated that the majority (72.9%) of the participants came from neighborhoods in which the median annual family income was between $30,000 and $39,000. Ethnicity was as follows: White, 50.1%, Black, 17.5%, Hispanic, 26.6%, Asian, 4.1%, and Native American, 1.7%. No participating students were enrolled in English

as a Second Language classes; 19.1% were enrolled in honors classes; 7.5% were enrolled in Special Education classes. Grade point average was 2.70 on a 4-point scale.

Procedures—All procedures were approved by the Institutional Review Board and in accordance with guidelines established by the American Psychological Association. The paper-and-pencil survey measures were distributed to participants by their teachers on a pre-arranged day as part of their Freshman English classes.

Measures

Constructivist ToM: Students completed a shortened, paper-and-pencil version of the Constructivist ToM instrument consisting of six of the shorter items, which we deemed were more appropriate for a paper-and-pencil version. The items included Memory A and B, Comprehension A and B, and Attention A and B, and were administered in that order. For this survey participants were instructed to first circle "yes" or "no," for each question and if "yes," then write an explanation. The following statement was added to Comprehension A: "Assume that what was said was in a language that they could understand." Inter-rater reliability was calculated by having the two trained raters, who shared the coding between them, independently code the same 100 (18%) students' explanations as either Active Mental Process or on-Active/Non-Mental Process explanations. Raters agreed 89.4% of the time (Kappa =.86).

Social Problem Solving: Students completed a paper-and-pencil version of the Social Problem-Solving Questionnaire (Slaby & Guerra, 1988). They first read the following story, in which the sex of the person in the story matched their own:

> You're playing on your school's softball team and have a big game coming up. You've been trying to practice as much as you can after school. One day you go outside to practice with a friend but can't find any bats. You see a guy (girl) sitting on the bench just twirling a bat around. "Hey, let me borrow that for a while," you say. "No way," says the guy (girl).

Participants answered the following seven questions. (1) *Problem Definition*: "What is the problem?" Participants chose between one hostile (i.e., "This girl (guy) won't let you use her bat, even though she's not using it.") and one non-hostile ("You don't have a bat and want to practice.") definition of the problem. (2) *Goal Selection*: "If you were to solve this problem what would be your goal?" Participants chose between one hostile ("Show the girl (guy) not to mess with me.") and one non-hostile ("Get a bat so you can practice.") goal. (3) *Number of Facts*: "Would you need more information? If so, what?" Participants listed the needed facts. (4) *Number of Solutions*: "What are all the ways you think you can solve this problem?" Participants listed the solutions. (5–6) *Best* and *Second Best Solutions*: "What do you think is the very best solution / the second best solution?" Participants chose from their list of solutions. (7) *Number of Consequences*: "What are all the things that might happen if you grabbed the bat and hit her?" Participants listed the consequences.

Problem Definition and Goal Selection were scored dichotomously (hostile = 0; non-hostile = 1). For Number of Facts, Solutions, and Consequences the total number of nonidentical

responses were counted for each question. For Best and Second Best Solutions, trained coders scored each as effective = 1 (non-violent and non-hostile; e.g., “Wait until another bat is free.” “Ask if he’d like to practice with us so that we’d be sharing the bat.”) or ineffective = 0 (e.g., “Take the bat by force.” “Beat him down and take the bat.”). Inter-rated reliability was assessed by a means of a third coder who coded 25 (4.6%) randomly selected participants’ Best and Second Best Solutions. Percent agreement was 98%. Each of the above seven questions was used as an indicator of a child’s Social Problem Solving skills.

Referrals for Behavioral Infractions: School records (names redacted) of the total number of times participants were referred to school authorities for disciplinary action stemming from behavioral infractions (e.g., verbal abuse, threatening others, disruption, fighting, destroying school property, etc.) for the academic year were obtained from personnel at the participants' school.

Grade Point Average (GPA): Participants’ grade point averages (names redacted) for the academic year were obtained from personnel at the participants' school.

Results

In order to confirm that in the paper-and-pencil format the six chosen questions loaded positively on the first principal component, we conducted a Categorical Principal Component Analyses (CATPCA, Version 1.1, in SPSS, Version 22) using the Active Mental Process explanations given to each question. The first component (Eigenvalue = 1.53) accounted for 25.42% of the variance, and the second (Eigenvalue = 1.12) accounted for an additional 18.72% of the variance. Table 4 shows the component loadings on the first two components. As predicted, all questions loaded positively on the first component, which represented the common constructive nature of these mental processes. In addition to loading positively on the first component, the two Attention questions loaded negatively on the second component, and the other four loaded positively. In both Attention questions some information is not seen or not heard, whereas in the three that loaded most strongly positively (Comprehension A, Comprehension B, Memory B) all information is seen or heard. The second component thus appears to represent the surface feature of degree of information acquisition.

We conducted a parallel CATPCA (which allows for some variables to be ordinal and some interval) on the Social Problem Solving questions. The first component (Eigenvalue = 1.92) accounted for 27.44% of the variance, and the second (Eigenvalue = 1.35) accounted for an additional 19.29% of the variance. Table 5 shows the component loadings on the first two components. All questions loaded positively on the first component, which represented social problem solving skills. The second component distinguished questions that asked for a list of alternatives (Number of Facts, Solutions, and Consequences) versus a choice between alternatives (Problem Definition, Goal Selection, Best Solution, Second Best Solution).

Participants’ scores on the first component (object scores) in CATPCA weight each question in terms of its centrality to the construct being measured. For that reason we used these object scores as the measures of Constructivist ToM and Social Problem Solving in

subsequent analyses. Table 6 shows the correlations, means, and standard deviations of the measures. Constructive ToM, Social Problem Solving, and Referrals for Behavioral Infractions were correlated with GPA (positively for the first two variables, and negatively for the third) and with sex. Females gave more Active Mental Process explanations, showed better social problem solving skills, and had fewer referrals than males. Finally, Constructive ToM and Social Problem Solving were negatively correlated with Referrals for Behavioral Infractions.

Structural equation modeling (Mplus Version 7.31; Muthén & Muthén, 2010) was used to test the hypothesized mediated effect from Constructivist ToM (predictor) through Social Problem Solving (mediator) to Behavioral Infractions (outcome). It was important to control for GPA and sex because both were related to all three variables. Accordingly, GPA and sex were entered into the model along with Constructivist ToM as three co-varying predictors of both Social Problem Solving and Behavioral Infractions. Paths from all three to both the mediator and the outcome represent the independent contribution from each, controlling for the other two. For purposes of the current study, the paths from GPA and sex to Social Problem Solving and Behavioral Infractions were not of theoretical interest. Mediation was accessed using RMediation, which provides a confidence interval to determine the significance of the mediation based on the distribution-of-the-product method (Tofighi & MacKinnon, 2011). The distribution-of-the-product method has described as the best statistical method to obtain a confidence interval for mediated effects (Tofighi & MacKinnon, 2011).

Figure 1 shows the model. Model fit was not estimated because the model was a saturated model. Constructivist ToM predicted increased Social Problem Solving after controlling GPA and sex ($\beta = .09$, $p < .05$), and social problem solving predicted decreased Referrals of Behavioral Infractions after controlling GPA and sex ($\beta = -.15$, $p < .001$). The mediational path from Constructivist ToM to Referrals of behavioral infractions via social problem solving was significant since the confidence interval did not include zero (unstandardized −0.009, 95% C.I. [−0.02, −0.001]).

Discussion

The paper-and-pencil version of the Constructivist ToM measure proved to be a useful adaption of the interview version. First, results of structural equation modeling showed that grade point average was positively related to Constructivist ToM. While this could have been due to overlap in the types of academic abilities (e.g., reading comprehension) required to both earn high grades and perform well on the Constructivist ToM survey, it also could reflect broader relations between academic outcomes and ToM, as has been found among younger children (Lecce, Caputi, & Pagnin, 2014; Pelletier, 2006). Second, structural equation modeling showed that independent of grade point average, females outperformed males on Constructivist ToM. This was unexpected given the overall lack of sex differences in Study 1. These findings add to the mixed findings on sex differences in ToM development, which might be related to the earlier puberty-related developmental processes occurring in females, or influenced by differences in social skills and language abilities at different ages, although we did control for academic performance. For example, Bosacki and

Astington (1999) found that female pre-adolescents' ability to understand thoughts and emotions in others was mediated by general language ability. Our findings are unique because they address the understanding of active, interpretive mental processes, and they suggest that a sex difference favoring females emerges during mid-adolescence when children are expanding and consolidating their initial insights into the constructivist nature of mental activity.

Results of the structural equation modeling supported our hypothesized mediational model, in which prosocial reasoning about conflict mediated the relation between understanding the role of active, interpretative mental processes in everyday cognitive situations and avoiding referrals for serious aggressive behavior problems in high school, including endangering, threatening, intimidating, fighting, and assault. There is little surface similarity between the Constructivist ToM items and the Social Problem Solving items. The former ask about everyday cognitive processes; the latter about everyday social conflict. Our hypothesis was that the better that adolescents understand that the nature of mental processes is such that people can easily misinterpret things, the easier it should be for them to avoid making hostile attributions of intended harm in ambiguous situations. The role of hostile attributions in prompting conflict and violence is well established (e.g., Dodge, 1980). Thus our findings are consistent with a process in which more advanced insight into the constructivist nature of mental activity eventually translates into protecting adolescents against getting involved in serious behavior problems in high school, and that this consequence is propagated through enhanced protection against making hostile attributions. Future longitudinal research should test these causal paths, and could provide the foundation for intervention at the level of understanding interpretative diversity.

Family neighborhood income did not relate to Active Mental Process explanations, Social Problem Solving, or Referral for Behavioral Infractions. This is perhaps not surprising given the low variability in median annual family income, and the fact that it was measured at the neighborhood level rather than the individual level. Future research should examine relations among these variables at the individual level in a socio-demographically broad range of participants.

General Discussion

The two studies make theoretical and practical contributions toward understanding the continued development of ToM subsequent to the hallmark understanding of false beliefs in early childhood. Theoretically, these studies demonstrate that a constructivist ToM based on an understanding of the selective, interpretive, and uncertain nature of active mental processes develops mainly between the ages of 10 and 12 years. Most young adolescents were able to explain that the mental activity involved in selective attention, memory, comprehension, inference, comparison, and planning could lead to different cognitive outcomes when the initial input was the same. Interestingly, not even our college sample of young adults was at ceiling on this measure. Practically, these studies provide a useful measure of constructivist ToM that is sensitive to sex differences and individual differences in academic performance during early adolescence, and is related to prosocial reasoning about conflict, which in turn mediated the relation to aggressive school behavior. These

findings extend other research showing improvement during these ages in understanding and using others' intentions and perspectives in communicative situations (Dumontheil, Apperly, & Blakemore, 2010; Filippova & Astington, 2008). They also fit with work by Bosacki and colleagues (Bosacki, 2000; Bosacki & Astington, 1999) that documents relations between social understanding and social competence during middle childhood.

The present findings are unique in that our measure focuses on children's developing understanding of interpretative mental processes involved everyday cognitive situations, as opposed to explicitly focusing on the understanding and use of social cues (e.g., smiling, nodding) and differing perspectives to guide social behavior. We have shown that the development of constructivist ToM involves understanding that cognitive processes affect one's knowledge, decisions, judgments, etc. Our findings indicate that young adolescents begin to apply this newly-gained understanding to social situations by helping them avoid inferring hostile intent in ambiguous situations, which in turn helps them avoid engaging in aggressive behavior in school.

Limitations and Future Directions—The new measure of Constructivist ToM was designed to tap awareness of constructive aspects of six mental processes (attention, memory, comprehension, inference, comparison, and planning) in an individual interview format, in which responses are open-ended and the interviewer can probe initially incorrect answers. One potential limitation of the measure is the implicit request to provide mental process explanations. Future research should examine whether making explicit requests to provide mental process explanations affects rates of mental and non-mental processing responses across age groups. We demonstrated that the measure can be shortened and adapted to a paper-and-pencil format, which relies on additional reading and writing skills. Although relations held after controlling for academic performance, future research should test the feasibility of a closed-ended response scale for ease of scoring. Finally, longitudinal investigations of the causal paths suggested in the current findings are needed.

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Appendix. Interviewing and Coding Instructions

Interviewing

1. First ask the child for a "yes" or "no" answer, then ask him to explain "How could that happen?"
2. Feel free to ask the child to elaborate; e.g., "How does that work?" or (for Memory A) "Would they think it really happened?"
3. Countermand responses that qualify as "Yes, with Non-Mental Process explanation" to give the child a second opportunity.
4. Some Non-Mental Process explanations may explicitly contradict the question; e.g., (for Comparison) "Yes, because one sees something the other doesn't." Countermand these by reminding the child of what the question stipulates. Others may implicitly contradict the question by referring to altered states (drugs, hypnosis) or supernatural beings. Countermand these by asking the child to consider everyday, normal situations.

Coding

Code each of the participant's answers as either "Yes, with Mental Process explanation," "Yes, with Non-Mental Process explanation," or "No." If a child gives a Mental Process explanation and a Non-Mental Process explanation, code it as the former. For example, if in response to Attention B, the child said, "Yes, they could be deaf, or they could just start paying attention to something else," code it as a Mental Process explanation.

Items

1. **Comprehension A:** Could somebody hear everything that someone said to them, but not understand it?
    - **a.** Yes, with Mental Process explanation.
        1. Misunderstanding or a problem of interpretation (misinterpret what the person said, hear it but get the meaning wrong.)
    - **b.** Yes, with Non-Mental Process explanation
        1. No understanding (language problem, knowledge deficit, don't know topic, foreign vocabulary, speaking gibberish, etc.)

2. Perceptual problems (he forgot some of it, speaker was too quiet, too fast, too far away, etc.)
3. Yes, with a contradictory explanation (all of what the person said was not heard, listener not paying attention, etc.)
4. Yes, but they don't know how.

c. No.

2. **Comprehension B:** Could somebody remember everything that someone said to them but not understand it?

   a. Yes, with Mental Process explanation.

      1. Explicitly distinguishes between remembering and understanding (e.g., memorizing vs. analyzing; remembering words vs. understanding meaning, etc.), and describes it as generally possible, not just in special cases involving foreign vocabulary, knowledge deficits, difficult topics, speaking gibberish.

   b. Yes, with Non-Mental Process explanation.

      1. Does not distinguish between remembering and understanding, only mentions understanding (e.g., he does not understand because it's foreign vocabulary), or only mentions remembering.
      2. Yes, with a contradictory explanation (he forgot part, wasn't paying attention, etc.)
      3. Yes, but they don't know how.

   c. No

3. **Attention A:** Can somebody look at something but not see it?

   a. Yes, with Mental Process explanation.

      1. Inattentive (attention is elsewhere, see with eyes but not with mind, etc.)

   b. Yes, with Non-Mental Process explanation.

      1. Perceptual problems (visual deficits, lighting problems, too dark, not trying, difficult stimuli, 3D pictures, etc)
      2. Yes, with a contradictory explanation:

- "look" at a mental vision (countermand by saying "We mean, look with your eyes.")
- "not see" as in not understand it (countermand by saying, "We mean, not see it with your eyes.")
- see it differently than someone else (countermand by saying, "We mean, not see it."
- not be able to distinguish it, as in you aren't trained to see the difference (e.g., a scientific image) (countermand by saying, "We mean everyday situations that don't require special training or talent.")

3. Yes, but they don't know how.

c. No

4. **Attention B:** Can somebody listen to something, but not hear it?

a. Yes, with Mental Process explanation.

1. Inattentive (focusing on something else, "tune it out," etc.)

b. Yes, with Non-Mental Process explanation.

1. Perceptual problems (too soft, too fast, not trying, deaf, listen to something that doesn't make noise, listen to two things and one is louder, etc.)

2. Yes, with a contradictory explanation:

- "listen" to an auditory hallucination (countermand by saying "We mean, listen with your ears.")
- "not hear" as in not understand it, or not remember it (countermand

by saying, “We mean, not hear it with your ears.”)

- hear it differently than someone else (countermand by saying, “We mean, not hear it.”
- not be able to distinguish it, as in you aren’t trained to hear it (e.g., certain chords that require ear training) (countermand by saying, “We mean everyday situations that don’t require special training or talent.”)

3. Yes, but they don’t know how.

c. No

5. **Attention C:** If somebody was listening to music for a few minutes, could they just stop hearing it?

a. Yes, with Mental Process explanation.

1. Attention stops going to the music and goes to something else.

b. Yes, with Non-Mental Process explanation.

1. No longer has the opportunity to hear the music (goes to sleep, turns off radio, etc.)

2. Yes, with a contradictory explanation.

3. Yes, but they don’t know how.

c. No

6. **Memory A:** Could somebody remember something that never really happened?

a. Yes, with Mental Process explanation.

1. Constructive Memory (they think they are remembering something that really happened because

- their memory has altered it,
- they make up something, and then believe it really happened,

- other people try to influence them or implant memories, and they believe it really happened,
- they have a dream, and then they believe it really happened.)

b. Yes, with Non-Mental Process explanation.

1. Remembering a past mental state or fiction:

- they know that they are remembering something that didn't really happen (dreams, fantasies, imagination, TV shows, movies, etc.)
- they think they are remembering something that really happened because someone told them a false story.

2. Yes, with a contradictory explanation.

3. Yes, but they don't know how.

c. No

7. **Memory B:** Could two people watch the same thing happen and both see and hear everything, but remember it very differently?

a. Yes, with Mental Process explanation.

1. Different conceptual perspectives or interpretations.

2. Selective Attention—focusing on different aspects.

b. Yes, with Non-Mental Process explanation.

1. Perceptual problems (exposed to slightly different perceptual experience, watched from different angles, different visual abilities, one person is better, etc.)

2. Yes, with a contradictory explanation:

- one person misses something (countermand by saying, “They both see and hear everything.”
- one lies (countermand by saying, “But does he remember it differently?”
- one forgets something (countermand by saying, “But if he doesn’t forget something, can he remember it differently?”)

3. Yes, but they don’t know how.

c. No.

8. **Comparison:** If two people looked at two objects equally carefully, could you have one of them decide that the two objects were really very different, and the other one decide that the two objects were very really very much the same?

a. Yes, with Mental Process explanation.

1. Interpretation differences (focusing on different aspects or features, “thinking differently”).

b. Yes, with Non-Mental Process explanation.

1. Perceptual Problems (blind, poor vision, too far away, see from different visual angles, one is smarter, etc.)

2. Yes (or No), with a contradictory explanation:

- “Not if the two objects are identical, like two same sized squares” (countermand by saying, “What if they are not identical?”)

3. Yes, but they don’t know how.

c. No

9. **Planning:** What if two people who were both good planners were asked to plan the same trip. It’s a long driving trip to a far away city. The two people try to make the best plan they can for getting there. If they both

make good plans, could it end up so that the two plans are very different in terms things like the kinds and amount of clothes to take, the amount of money to take, the roads to take, and how much time it would take to get there? Or would the two plans have to be pretty much the same?

a. "Different," with Mental Process explanation.

1. Subjective differences (personality preferences, different wants, different minds, different evaluations, etc.)

b. "Different," with Non-Mental Process explanation.

1. Objective equality of two routes (plans could be different but equally good if there were two equally good routes, for example one left and one right around the mountain). (countermand by saying, "What if there are lots of different ways, not just two that are the same length?")

2. One is smarter, knows a better way, knows short cut, etc.

3. "Different," with a contradictory explanation:

- child assumes they are two different trips to two different cities (countermand by saying "Both trips go to the same place.")

4. "Different," but they don't know how.

c. No

10. **Inference:** What if there were two good detectives who had to try to solve a mystery. A crime had been committed and there were two people—person A and person B—who could have committed the crime. Each detective examines all the clues and thinks about it carefully. Could it happen that one detective concludes that person A probably did it, and the other detective concludes that person B probably did it, or would they have to decide on the same person?

a. "Different," with Mental Process explanation.

1. Interpretation differences (mentally weight different features in different ways; focus on different aspects or features, etc.)

b. "Different," with Non-Mental Process explanation.

1. Perceptual Problems (blind, blurry vision, far away, etc.)

2. "Different," with a contradictory explanation:

- one is more knowledgeable, a better detective, or one makes a mistake (countermand by saying. "They are both good, one is not better than the other.")

3. "Different," but they don't know how.

c. No

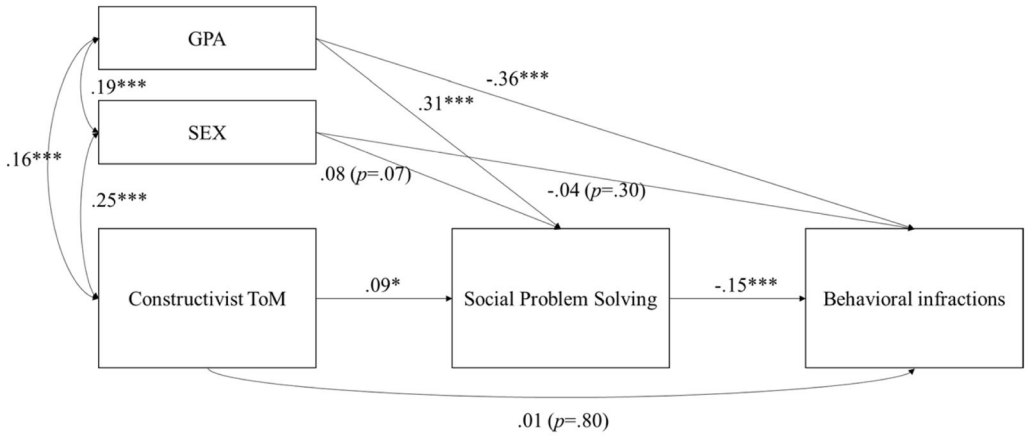

Figure 1.

Mediation model. All paths are reported in standardized path coefficients. * p <.05. **p < .01. ***p< .001.

Table 1

The Ten Questions and Examples of Active Mental Process and Non-Active/Non-Mental Process Explanations

Question	Explanations	
	Active Mental Process	**Non-Active/Non-Mental Process**
1. Comprehension A: Could somebody hear everything that someone said to them, but not understand it?	Could get a different meaning.	Talking too fast.
2. Comprehension B: Could somebody remember everything that someone said to them but not understand it?	Remember a math theorem, but it refers back to a theorem that is unknown to them.	Might not understand directions unless they wrote them down.
3. Attention A: Can somebody look at something but not see it?	Eyes on something, but mind on something else.	If it's camouflaged.
4. Attention B: Can somebody listen to something, but not hear it?	If mind is somewhere else.	If there's other noise so you don't hear it.
5. Attention C: If somebody was listening to music for a few minutes, could they just stop hearing it?	Your mind drifts elsewhere.	If hearing is lost.
6. Memory A: Could somebody remember something that never really happened?	Take what they think happened and start to believe it.	Remember a dream that never happened.
7. Memory B: Could two people watch the same thing happen and both see and hear everything, but remember it very differently?	Ones sees things positively, one negatively.	If one didn't pay attention.
8. Comparison: If two people looked at two objects equally carefully, could you have one of them decide that the two objects were really very different, and the other one decide that the two objects were very really very much the same?	A knife and fork – one says both silverware, other says one has one prong and the other has four.	One sees something, like a small design that the other doesn't.
9. Planning: What if two people who were good planners were asked to plan the same trip. It's a long driving trip to a faraway city. The two people try to make the best plan they could for getting there. If they both make good plans, could it end up so that the two plans are very different in terms of things like kinds and amount of clothes to take, the amount of money to take, the roads to take, and how much time it would take to get there, or would the two plans have to be very much the same?	Two different people think of things differently.	One thinks the train goes faster and the other thinks the plane does, and there's no way to tell who's right without a test.
10. Inference: What if there were two good detectives who had to try to solve a mystery. A crime had been committed and there were two people— person A and person B— who could have committed the crime. Each detective examines all the clues and thinks about it carefully. Could it happen that one detective concludes that person A did it and the other detective concludes that person B did it, or would they have to decide on the same person?	Might understand clues differently or decide different clues are more important than others.	One may go too quickly and not really think about it.

Table 2

Mean Proportions (Standard Deviations) of Response Categories by Age Group in Study 1

Age Group	Yes, with Active Mental Process explanation	Yes, with Non-Active/Non-Mental Process explanation	No
8–9	.34 (.21)	.29 (.20)	.37 (.26)
10–11	.45 (.14)	.25 (.14)	.30 (.16)
12–13	.63 (.29)	.10 (.11)	.28 (.26)
14–15	.68 (.17)	.10 (.06)	.22 (.17)
Adult	.70 (.20)	.11 (.09)	.19 (.16)

Table 3

Mean Proportions (Standard Deviations) of Active Mental Process Explanations for Each Question, Correlations with Age Group, and Component Loadings in Study 1

			Component Loadings[b]	
Item	**Mean (SD)**	**Correlation[a] with Age Group**	**Component 1**	**Component 2**
Comprehension A	.15 (.36)	.22*	.44	.09
Comprehension B	.68 (.47)	.02	.34	.02
Attention A	.35 (.48)	.43**	.40	.58
Attention B	.47 (.50)	.35**	.63	.01
Attention C	.68 (.47)	.23*	.65	−.01
Memory A	.62 (.49)	.42**	.61	−.12
Memory B	.66 (.48)	.40**	.27	−.57
Comparison	.68 (.47)	.30**	.32	.63
Planning	.73 (.45)	.22*	.47	−.59
Inference	.57 (.50)	.27**	.52	.05

*$p < .05$,

**$p < .01$,

[a]Spearman's ρ,

[b]Controlling for age group

Table 4

Mean Proportions (Standard Deviations) of Active Mental Process Explanations for Each Constructivist Theory of Mind Question, and Component Loadings in Study 2

		Component loadings	
	Mean (SD)	**Component 1**	**Component 2**
Comprehension A	.07 (.26)	.17	.51
Comprehension B	.11 (.31)	.16	.38
Memory A	.18 (.39)	.58	.14
Memory B	.46 (.50)	.37	.68
Attention A	.25 (.43)	.74	−.30
Attention B	.31 (.46)	.68	−.38

Table 5

Means (Standard Deviations) for each Social Problem Solving Question, and Component Loadings in Study 2

		Component loadings	
	Mean (SD)	**Component 1**	**Component 2**
Problem Definition	.56 (.50)	.48	−.20
Goal Selection	.87 (.34)	.59	−.46
Number of Facts	.74 (.95)	.40	.60
Number of Solutions	2.25 (1.13)	.65	.46
Best Solution	.95 (.22)	.43	−.45
Second Best Solution	.85 (.361)	.40	−.51
Number of Consequences	2.61 (1.18)	.63	.34

Table 6

Correlations, Means and Standard Deviations of Measures in Study 2

	1	2	3	4	5
1. GPA	--				
2. Sex	.19**	--			
3. Constructive ToM	.17**	.25**	--		
4. Social Problem Solving	.34**	.16**	.16**	--	
5. Referrals for Behavioral Infractions	−.42**	−.13**	−.09*	−.28**	--
Mean	2.70	1.46	0.00	0.00	.22
Range	0–4	1–2	--	--	0–6
SD	.86	.50	1.00	1.00	.64

* $p < .05$.

** $p < .01$.

Note. First component scores (object scores) were used for Constructive ToM and Social Problem Solving. Sex 1 = male, 2 = female.