Child Development, January/February 2009, Volume 80, Number 1, Pages 115 – 133

Young Children's Reasoning About the Effects of Emotional and Physiological States on Academic Performance

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This study assessed young children's understanding of the effects of emotional and physiological states on cognitive performance. Five, 6-, 7-year-olds, and adults (N = 96) predicted and explained how children experiencing a variety of physiological and emotional states would perform on academic tasks. Scenarios included: (a) negative and positive emotions, (b) negative and positive physiological states, and (c) control conditions. All age groups understood the impairing effects of negative emotions and physiological states. Only 7-year-olds, however, showed adult-like reasoning about the potential enhancing effects of positive internal states and routinely cited cognitive mechanisms to explain how internal states affect performance. These results shed light on theory-of-mind development and also have significance for children's everyday school success.

High-stakes standardized tests are becoming the norm in the American educational system, even in elementary school (e.g., Goertz & Duffy, 2003). In preparation for these tests, teachers and parents often advise children to make sure they "get a lot of rest" and "eat a good breakfast" to optimize their performance on test day. Such everyday advice is backed by scientific research. Adults and children who get adequate rest score higher on tests measuring attention, memory, executive control, and concentration than those who have had poor sleep (Alapin et al., 2000; Randazzo, Muehlbach, Schweitzer, & Walsh, 1998). Moreover, studies show that hunger and nutritional deprivation can significantly impair cognitive performance (Alaimo, Olson, & Frongillo, 2001; Murphy et al., 1998).

Physiological conditions are not the only type of internal state that affects cognitive performance. In recent years, there has been increasing empirical attention to the influence of people's emotions and moods on their ability to attend, think, learn, remember, and problem solve (Clore, Schwarz, & Conway, 1994; Damasio, 2003; Dolan, 2002; Isen, 1999). "Don't worry, be happy" is not a commonly heard test-taking tip, but it may be excellent advice. Studies show that adults induced into negative emotional states perform significantly worse on tasks measuring creativity, flexible thinking, problem solving, and memory than those induced into positive emotional states (Ashby, Isen, & Turken, 1999; Davis, Kirby, & Curtis, 2007; Fredrickson, 2001; Isen, 1999; Saavendra & Earley, 1991, but see Bless & Fiedler, 1995; George & Zhou, 2002). Comparable effects on motivation and task performance have also been observed in children aged 3 – 16 years (Bartlett, Burleson, & Santrock, 1982; Greene & Noice, 1988; Hom & Arbuckle, 1988; Rader & Hughes, 2005).

In the current research, we examine 5- to 7-year-old children's reasoning about the effects of emotional and physiological states on cognition. Specifically, we evaluate the extent to which young children believe that certain positive and negative internal states have the potential to impair or to enhance students' academic performance. Given evidence that internal states do exert such effects, children's understanding of these phenomena is an important aspect of their metacognitive development. Knowledge of the factors—both inside oneself and in the external

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This work was supported by a National Science Foundation (NSF) grant (SBE-0354453), as part of the Science of Learning Centers program, and by the Tamaki Foundation. Any opinions, findings, and conclusions expressed in the article are those of the authors and do not necessarily reflect the views of NSF.

We would like to thank our research participants and the school and research staff who contributed to this study. We also thank Erika J. Ruberry for her assistance with the project.

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0009-3920/2009/8001-0011

environment—that can affect one's cognitive functioning lays the groundwork for self-regulated cognition, crucial for success in school and in the workplace (see Schutz & Davis, 2000; Wolters, 2003; Zimmerman, 1990). For example, if one is unaware that studying in a noisy room interferes with learning, one may not take steps to ensure that the room is quiet. If one does not know that negative emotions can impair task performance, one may not work to control one's mood during a high-stakes test or may misidentify the cause of a poor outcome after the fact. Thus, children's emerging theories of mind have consequences for their learning when they enter school (Astington & Pelletier, 1996; Lalonde & Chandler, 1995; Wellman & Lagattuta, 2004). We target 5- to 7-year-olds for this study because children rapidly acquire knowledge about thinking and thought-emotion connections during this period.

Between 3 and 8 years of age, children develop an understanding of the mental processes involved in attention, thinking, and problem solving (Amsterlaw, 2006; Flavell, Green, & Flavell, 1995a; Kuhn, 2000). For example, 6- and 8-year-olds know better than 4-year-olds that attention is limited in the sense that a person cannot fully attend to two or more things at the same time: If one is busy trying to identify a person in a class photo, one is not also simultaneously attending to the picture frame (Flavell et al., 1995a, 1995b; Pillow, 1989). Even young preschoolers recognize factors that can affect a person's ability to listen and concentrate. Miller and Zalenski (1982) found that most 4-year-olds reported that a person (doll) could listen to his or her mother better if noisy objects were removed from the room or if he or she went into a quiet room. They were also aware that motivation plays a role: People listen better when they want to listen (see also Miller & Shannon, 1984). Thus, by at least 5–6 years of age, children understand that attention and cognitive performance are affected by both internal (interest and effort) and external factors (environmental noise).

During the preschool and early elementary years, children also develop insight that thoughts and emotions meaningfully connect. By the age of 4–5 years, children know that people's feelings can be influenced by their beliefs as well as their desires (Hadwin & Perner, 1991; Harris, Johnson, Hutton, Andrews, & Cooke, 1989; Rieffe, Terwogt, & Cowan, 2005; Wellman & Banerjee, 1991). Between 3 and 7 years of age, children also grasp that the focus of a person's thoughts can cause or change emotions: A person can start to feel sad if he or she suddenly remembers an upsetting event (e.g., Flavell & Flavell, 2004; Lagattuta & Wellman, 2001; Lagattuta, Wellman, & Flavell, 1997; Pons & Harris, 2005). They can start to feel worried just by thinking about a negative event that might happen in the future (Lagattuta, 2007). Research on children's coping strategies further suggests that between 5 and 10 years of age, children increasingly understand that people can use their minds to control their emotions—even in the absence of a change in the external situation—by using strategies such as cognitive reframing or distraction (Altshuler & Ruble, 1989; Band & Weisz, 1988; Lagattuta et al., 1997).

Despite this strong base of research on children's understanding of how thoughts influence emotions, we know little about children's reasoning about the opposite relationship: how emotions, or other kinds of internal states, can impact people's ability to attend, learn, and perform. One exception is a study by Bennett and Galpert (1992) who examined 5- and 8-year-old children's predictions about whether a story protagonist would perform worse, the same, or better on a math test if he or she was feeling sad. Results showed that roughly 50% of 5- and 8-year-olds judged that negative emotions would impair performance. Although this study provides an important initial step, several questions remain. Because reasoning about positive emotions was not assessed, it is unknown whether children believe that positive emotions impair, enhance, or have no influence on thinking. Moreover, it is not known how children's reasoning about the impact of negative and positive emotions on thinking compares to their reasoning about other internal states and external factors that can affect attention, thinking, and problem solving including noise level, motivation, sleep, and nutrition.

To provide a comprehensive examination of developmental changes in children's knowledge about the effects of internal states on school performance, we asked 5- to 7-year-old children, as well as adults, to predict and explain how people in a variety of physiological and emotional states would perform on challenging cognitive tasks, such as math, reading, and spelling tests. Scenarios included: (a) two types of negative emotions (sad and angry), (b) two types of positive emotions (happy and proud), (c) two types of negative physiological conditions (hungry and tired), and (d) two types of positive physiological conditions (satiated and wide awake). As control conditions, we further assessed children's judgments about external factors that were likely (noisy vs. quiet room) and unlikely (change in rug, clothes, and hairstyle) to affect thinking performance, as well as a no-change control.

If children recognize that relevant changes in internal states or external conditions have implications for a person's cognitive functioning, then they should predict enhancement of performance for positive internal state (and quiet room) cases, impairment of performance for negative internal state (and noisy room) cases, and no change in performance for control conditions. In addition to eliciting participants' *predictions* of performance, we also characterize children's causal understandings about the mechanisms responsible for these effects by eliciting their *explanations* about why and how these factors affect thinking. Multiple-assessment approaches measuring both predictions and explanations are especially revealing about the development of children's knowledge (see Lagattuta, 2005; Wellman & Lagattuta, 2000; Wellman & Liu, 2004). We include adults to compare their reasoning with that of young children.

Method

Participants

Participants were 72 children, 24 children at each of three age levels: 5-year-olds (M = 5.7 years, SD = 0.2; 13 girls and 11 boys), 6-year-olds (M = 6.3, SD = 0.2; 12 girls and 12 boys), and 7-year-olds (M = 7.2, SD = 0.4; 10 girls and 14 boys). Children were recruited from two elementary schools in a large metropolitan area and from a university-maintained database of research volunteers. According to self-report, the sample was 75% Caucasian, 15% Asian, 4% Hispanic, 3% American Indian/Alaskan Native, and 7% other backgrounds. Parents provided information about their educational attainment: 86% of children came from homes where both parents had completed college and 64% of children had at least one parent with a graduate or professional degree. A sample of 24 college students (M = 18.9 years, SD = 0.7; 12 women and 12 men) from an introductory psychology course served as the adult comparison group. The adult sample was 46% Caucasian, 42% Asian, 8% Hispanic, and 12% other backgrounds.

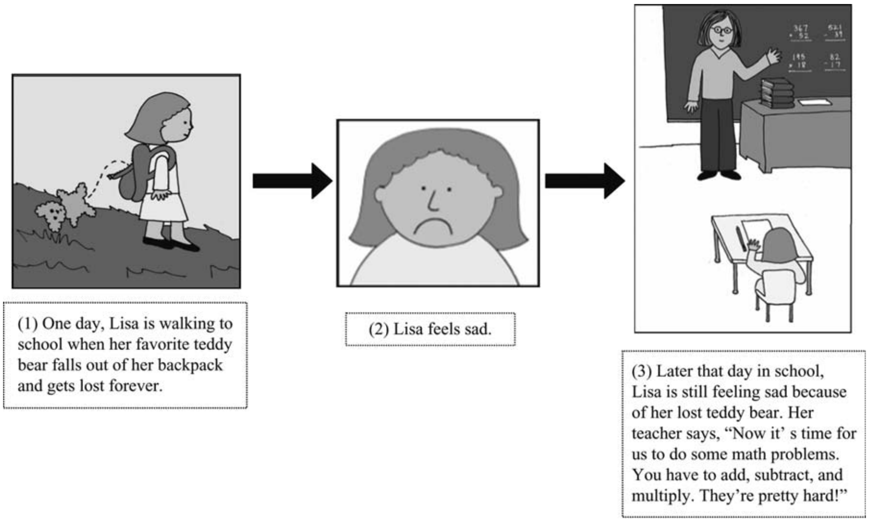
Procedure

Task description and materials. We created a story task to test children's and adults' knowledge about the effects of different kinds of internal states and external conditions on cognitive performance. There were 15 scenarios in total (see the Appendix for sample stories). All stories had a similar structure and used language appropriate for young children. There were both male and female protagonists, and characters depicted in the drawings had a range of hair and skin tones appropriate to the participant sample.

The eight focal stories featured characters who had to complete challenging cognitive tasks after experiencing an event that produced a negative or positive change in their *physiological* or *emotional state*. Specifically, four stories described characters who experienced positive (full/healthy and wide awake) or negative (hungry and tired) physiological states and four stories described events that caused the character to have positive (happy and proud) or negative (sad and mad) emotions. We selected these particular emotions because even 4-year-olds show a basic understanding of all these emotions, can categorize them as negative or positive in valence, and can identify their expression (Harris, Olthof, Terwogt, & Hardman, 1987; Russell & Paris, 1994; Tracy, Robins, & Lagattuta, 2005). Although studies have shown that children younger than 7 years sometimes have difficulty understanding causes of pride, they show clear knowledge that it is a positive emotion related to happiness (e.g., Harter & Whitesell, 1989; Lagattuta & Thompson, 2007).

To compare children's understanding of internal states versus other relevant external factors, two *noisy–quiet* stories described protagonists working in either very noisy or very quiet work environments. Several additional scenario types were included as control conditions, allowing us to assess whether children could appropriately restrict predictions of performance improvements and impairments to cases where relevant changes took place. For these story types, it would be most appropriate to expect no change in story characters' task performance. In the *no-change* control story, no new events or state changes occurred. *Neutral-change* control stories described changes (e.g., wearing blue clothing, having a new rug in the classroom) that were neutral in valence and should have no impact on characters' task performance. *Valence-change* control stories described changes that were positive or negative (hair looking messy vs. nice) but still should not affect task performance. Valence stories tested whether children might rely only on valence to predict performance (e.g., linking any "negative change" to poorer performance). Changes to hair were useful for this purpose because these had positive or negative valence but were not directly visible to the story protagonist, thereby reducing the potential for cognitive effects such as distraction.

Simple colorful pictures were used to illustrate the events of each story during task presentation, as shown in the example in Figure 1. Here, a girl loses her favorite teddy bear on the way to school and feels



(1) One day, Lisa is walking to school when her favorite teddy bear falls out of her backpack and gets lost forever.

(2) Lisa feels sad.

(3) Later that day in school, Lisa is still feeling sad because of her lost teddy bear. Her teacher says, "Now it' s time for us to do some math problems. You have to add, subtract, and multiply. They're pretty hard!"

"How will Lisa do? Will she do the same as she usually does, or will she do better, or worse?"

Figure 1. Sample pictures and story text from the task.

sad. Later that day she is still feeling sad about it, when her teacher gives her class a difficult math assignment. We wanted to know whether children would predict changes to the story character's school performance in such cases.

Pictures were displayed on laminated 5 × 6 in. cards that were laid out on the table in front of the child as the researcher narrated each story. Picture sets were carefully constructed to control for several factors. First, all picture sets had a focal image that depicted the central subject matter of the story – that is, the characters' internal state, outward appearance, or surrounding environment. Emotional state stories (see Figure 1) accomplished this with a close-up of the character's face showing an unambiguous emotional expression (sad = down-turned mouth, mad = slanted eyebrows and straight mouth, happy and proud = upturned mouth). Second, to minimize emotional confounds in other story types, characters in nonemotion stories were shown with their faces obscured or cropped from the image. For example, ''feeling hungry'' used a cropped image of the character's torso with his hands clutching his belly. ''Feeling tired'' depicted the character with drooping eyelids brushing her teeth in the morning with the toothbrush covering the mouth. The last image for each story (shown during the target question) always depicted the child from behind, seated at a school desk, so that no facial expression could be discerned.

The target question for each story asked children to predict the character's performance on a school task. Across the 15 stories, seven different tasks were described. These were selected to reflect various types of school subjects and thinking processes that are familiar and understandable to 5- to 7-year-old children: doing math problems, learning science, reading a story, taking a spelling test, remembering pictures from a book (memory), playing a word game (language arts), and following directions to make a paper airplane (spatial reasoning and problem solving). To control for the fact that children might view some tasks as easier than others (and, therefore, less likely to be affected by changes in the character's internal states; see Flavell & Flavell, 2004), the teacher in the story always described tasks as ''pretty hard.'' In pilot testing, a group of 10 children (*M* age = 6.5, *SD* = 0.3; 5 boys and 5 girls) listened to the stories and rated the difficulty of each task on a 3-point scale, from 0 (*not hard at all*), to 1 (*kind of hard*), to 2 (*very hard*). The average rating across all school tasks was 1.2, with means for individual tasks ranging from 0.9 to 1.7. For each item, 70% – 100% of children rated the task as ''kind of hard'' or ''very hard.'' Thus, children perceived most tasks as moderately difficult.

Task presentation. Children were tested individually either in a university laboratory or in a quiet area of their school. Sessions lasted approximately 25 min and were videotaped. For each story, children were asked to *predict* the story character's performance and to *explain* their prediction. Children made their predictions of performance on a pictorial rating scale. The scale was a laminated 12.5 × 3.5 in. card showing five yellow stars of increasing size. At the start of the session, the researcher instructed children to ''use the stars to say how well the people in the stories are doing on things'' and explained that the center star was for when people do *about the same* as they usually do, the two small stars were for when people do *worse* than they usually do, and the two big stars were for when people do *better* than they usually do. More specifically, the labels given to each star (in ascending order) were: *a lot worse, a little bit worse, about the same, a little bit better,* and *a lot better.* To reinforce this visually and to anchor the scale around the midpoint, the center star was presented with a pale blue background and the other stars had a white background.

Warm-up tasks trained children how to use the scale to make judgments about people's performance. The first warm-up task required children to make judgments using all points of the scale, including the "no-change" response. The researcher showed children a series of drawings about a girl ("Janet") who is playing a game to see how high she can jump. The first drawing depicted Janet's typical performance ("Usually Janet can jump *this* high. That's how high she jumps most of the time"). Three additional drawings showed Janet jumping: (a) higher than she usually does, (b) lower than she usually does, and (c) the same as she usually does. Children were shown each drawing in turn and were asked to use the scale to respond to the question: "How did Janet do this time—the same as she usually does, or better, or worse?" (If children said "better" or "worse," they were subsequently asked to indicate on the scale whether they thought it was *a lot* or *a little bit* worse/better.) Children's responses to the three questions were recorded and errors corrected as necessary.

The second warm-up task elicited children's judgments about the impact of high versus low effort on cognitive performance, something children of this age should understand (Miller & Shannon, 1984; Miller & Zalenski, 1982). Children were shown a drawing of a boy ("Casey") sitting at a school desk and were asked to predict his school performance based on his level of effort and attention. First, they predicted Casey's performance when "Casey isn't trying to do well on his school work at all" and does not look or listen to his teacher. Then, they predicted Casey's performance when "Casey is really trying extra hard to do a good job on his school work" and looks and listens carefully to his teacher. Failure to predict impaired performance in the first case and improved performance in the second case was noted but not corrected.

Finally, before proceeding to the experimental task, the researcher listed each response option and asked children to point to the corresponding star (e.g., "Which star is for when people do about the same as they usually do?") in the order: *about the same (no change), a little bit better, a lot better, a little bit worse, a lot worse*. Children were corrected as necessary and did not proceed to the main task until they could match all responses correctly. If children made two or more errors on any of the five warm-up task questions, or could not learn the points of the scale even after correction by the researcher, they were not included in the final sample.

For the experimental task, the researcher read each story aloud and children predicted the character's performance using the scale. After each prediction, children were also asked to explain their responses (e.g., "Why do you think she will do worse this time?"). Explanations were requested for all trials, regardless of whether children predicted impairment, improvement, or no change. If children said "I don't know" or failed to respond, requests were repeated. If children explained the character's performance in relation to an internal state or external condition but did not describe why or how that factor would influence performance (e.g., "She'll do worse because she's sad"), the researcher requested more information (e.g., "*Why* will it make her do worse if she's sad?"). When it was clear that children had no further explanations, the experimenter proceeded to the next trial. Children's explanations were transcribed verbatim from the videotapes and coded for the type of explanation given (see below).

Adult participants received the task as a written questionnaire. Participants read each scenario and made predictions about the protagonist's performance on a 5-point numerical scale, with points labeled as described above for children. They also provided written explanations for their responses. Pictures were not used with the task for adults.

Story order and counterbalancing. For all participants, the first scenario presented was the no-change control story, in which the character experienced no new events or state changes. This was because we did not want to prime children to attend to characters' emotions or internal states. Presentation order for the remaining 14 stories was counterbalanced by dividing the stories into two blocks of seven stories, with each block containing one example of each story type: positive emotion, negative emotion, positive physiological state, negative physiological state, noisy–quiet, neutral change, and valence change. Two different groupings, determined by randomly assigning stories to blocks, were used. (Half of the participants received *proud, sad, wide awake, hungry, different clothes, messy hair,* and *quiet room* as one block, and *happy, mad, full/healthy, tired, new rug*, and *noisy room* as the other. The other half of the participants received an alternate grouping.) To control for order effects, presentation order for each task block (first vs.

second) was counterbalanced within age groups, and scenario order was randomized within blocks. School tasks (e.g., reading, math) were varied across stories so that each participant received one example of each school task per block of seven stories. Within age groups, school tasks were assigned to stories so that all possible combinations were represented, and each combination appeared with similar frequency (i.e., 3–4 times per age group).

Explanation coding. Participants' explanations reflected a range of ideas about the factors influencing characters' task performance. From careful reading of the complete transcripts, we identified 10 categories of explanations, including references to: the character's general ability level; the difficulty of the school task; motivations or desires; perceptions; emotions; physiological states; cognitive functioning; past, present, or future events; and social or moral rules. An additional category included "don't know," no response, off-topic, or responses that did not fit into other categories. Descriptions of the codes and examples are given in Table 1. For each story trial, a response could be coded into one or multiple categories. For example, the explanation, "She'll do much better because she's feeling happy and that makes her concentrate even harder" would be coded as both an *emotion* and a *cognition* explanation. In this example, the participant refers to the character's emotion as the cause of the performance ("because she's feeling happy") and further elaborates on how the character's emotional state affects her cognition ("that makes her concentrate even harder").

Explanations were coded by two independent raters using transcripts that concealed participants' age, race, and sex. To analyze the frequency of specific explanation categories as a function of scenario type and age, each trial was coded for the *presence* (1) or *absence* (0) of each of the 10 explanation categories. Values were then summed by story type to yield the number of scenarios for which participants gave each explanation. As a check of interrater agreement, 20% of the data were coded by both raters and kappas calculated for each coding category. Kappas ranged from .75 to .94 ($M = .88$), indicating high interrater agreement.

Results

Warm-Up Task Performance and Rating Scale Use

Only one child, a 5 year old, was disqualified from the study because he failed to show adequate understanding of the scale during the warm-up tasks. This child was replaced. All children in the final sample demonstrated competence with the scale by correctly answering at least four of the five warm-up questions and successfully matching all points of the scale with the appropriate verbal labels. Most children (83%) had perfect performance on the five warm-up questions. Errors were not more common among younger children: Of the 12 children who missed a warm-up question, three were 5-year-olds, two were 6-year-olds, and seven were 7-year-olds. Most children (93%) also correctly identified all five points of the scale when questioned about them directly. Five children (three 5-year-olds and two 7-year-olds) made initial errors but were successful after feedback from the researcher. On the main task, there were no observed age differences in the mean number of scale points (of five) participants used, $F(3, 92) = 0.80, p > .05$. Means for 5-year-olds, 6-year-olds, 7-year-olds, and adults, respectively, were: 4.0 ($SD = 0.9$), 4.3 ($SD = 0.7$), 4.3 ($SD = 0.7$), and 4.3 ($SD = 0.8$).

Table 1
Explanation Coding Category Descriptions and Examples

Coding category	Description	Example
Situation	References to past, present, or future events	"Because she lost her teddy bear."
Emotional state	References to character's emotional state	"Because she's feeling happy."
Physiological state	References to character's body or physiological state	"Because he's hungry."
Cognition	References to character's thoughts, cognitive functioning, or brain	"Because he won't be able to concentrate."
Motivation	References to character's motivations or desires	"Because she doesn't feel like doing her math."
Ability	References to character's general ability level	"Because he's old enough to read stories."
Task	References to the difficulty of the school task	"Because spelling is hard."
Perception	References to the character's perceptions or senses	"Because he might not be able to hear very well."
Social/moral rules	References to social or moral rules	"Because he's supposed to listen to his teacher."
No code	Uncodable responses	"I don't know."

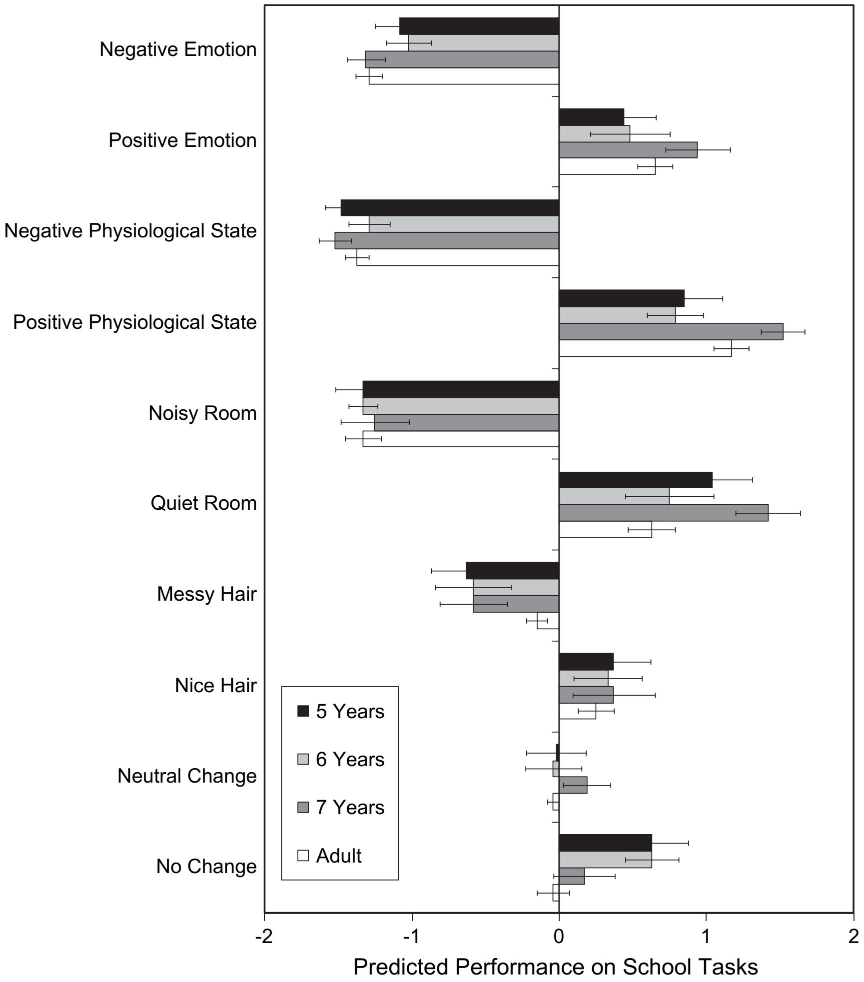


Figure 2. Mean ratings of story characters' performance by age and story type.
Note. Ratings greater than zero indicate predictions of improved performance, ratings less than zero indicate predictions of impaired performance, and ratings equal to zero indicate predictions of no change in performance. Error bars are standard errors of the means.

Prediction Data

Figure 2 displays participants' mean ratings of story characters' task performance by age and story type. Participants' responses were converted to a −2 (*a lot worse*) to +2 (*a lot better*) scale, with 0 (*same as usual*) as the midpoint. For most analyses, repeated measures analyses of variance (ANOVAs) were used to test for age and story type effects, post hoc comparisons were performed with Tukey's honestly significant difference (HSD) test, and effect sizes are presented as partial eta squares. Additionally, one-sample *t* tests were used to assess whether the absolute amount of impairment or improvement participants predicted was significantly different from 0, the scale midpoint.

Preliminary analyses tested for effects of sex, scenario order, and school task. Sex and order effects were tested by including each of these variables, along with age, as independent variables in repeated measures ANOVAs for each story type. No significant main effects or interactions for sex or scenario order were observed, $F < 2.62$, $p > .05$. To test for school task effects, separate 4 (age) × 7 (school task) ANOVAs were conducted on each scenario, treating school task as a random factor. Again, no significant effects were found, $F < 1.67$, $p > .05$.

Emotional and physiological state stories. Emotional and physiological state stories described characters who experienced positive or negative changes in their internal states. These scenarios were the primary focus of our study. Prediction data were analyzed with a 4 (age) × 2 (state: emotional or physiological) × 2 (valence: positive or negative) repeated measures ANOVA, yielding a main effect of valence, $F(1, 92) = 432.7$, $p < .001$, $\eta_p^2 = .83$. As shown in Figure 2, participants more frequently judged that characters experiencing positive internal states would show improved performance, whereas characters experiencing negative internal states would show impaired performance. Analyses confirmed that the valence effect was significant for both emotional, $F(1, 95) = 190.78$, $p < .001$, $\eta_p^2 = .67$, and physiological state stories, $F(1, 95) = 422.22$, $p < .001$, $\eta_p^2 = .82$.

A State × Valence interaction, $F(1, 92) = 26.86$, $p < .001$, $\eta_p^2 = .23$, indicated that valence effects were stronger for physiological states than for emotional states. Simple effects tests showed that on average, participants predicted more improvement for positive physiological states than for positive emotional states ($M = +1.1$ vs. $+0.6$, out of a maximum possible rating of +2), $F(1, 95) = 18.28$, $p < .001$, $\eta_p^2 = .16$, and more impairment for negative physiological states than for negative emotional states ($M = -1.4$ vs. -1.2 out of a maximum possible rating of -2), $F(1, 95) = 11.51$, $p < .01$, $\eta_p^2 = .11$. There was also an Age × Valence interaction, $F(3, 92) = 3.37$, $p < .05$, $\eta_p^2 = .10$, indicating that age differences in participants' reasoning about internal states were restricted to children's judgments about positive, $F(3, 92) = 2.74$, $p < .05$, $\eta_p^2 = .08$, rather than negative, $F(3, 92) = 1.13$, $p > .05$, internal states. As shown in Figure 2, 7-year-olds and adults predicted significantly higher levels of improvement for positive internal states than did younger children, $p < .05$ (Tukey's HSD).

One-sample t tests confirmed that in contrast to 7-year-olds and adults, the absolute improvement 5- and 6-year-olds predicted for positive emotion stories was not consistently greater than 0. In contrast, all age groups' ratings for positive physiological state, negative physiological state, and negative emotional state stories differed significantly from 0, $t(23) > 3.31$, $p < .01$. Indeed, as shown in Table 2, even individual-level data revealed that 75%–96% of 5-year-olds successfully predicted impairment of performance in negative state cases—performance comparable to that of 7-year-olds and adults.

Additional Wilcoxon signed-ranks tests on the frequency data in Table 2 compared improvement, impairment, and no-change predictions within story types to test whether participants responded similarly to the two scenarios within each of the four story categories—for example, answering similarly to *happy* and *proud* (positive emotion) scenarios. Three of the four story types showed no item differences at any age. The only difference occurred for positive physical state stories, $z = -2.17$, $p < .05$, where 5-year-olds and adults, but not 6- and 7-year-olds, gave more improvement predictions to the "wide awake" story versus the "full/healthy" story.

Several different patterns of individual responding could have produced nonsignificant group means for younger children in positive emotion cases: (a) frequent predictions of "no change"; (b) equal numbers of children predicting impairment, improvement, and no change; or (c) a bimodal response pattern with some children predicting improvement and others impairment. Chi-square tests indicated that 5- and 6-year-olds were not performing at chance on the two positive emotion stories, $\chi^2(2, N = 24) > 7.0$, $p < .05$, and individual-level data were more consistent with a bimodal pattern. As shown in Table 2, a substantial proportion of younger children actually predicted impairment for these two cases. Although adults did not always predict performance improvements due to positive internal states, they rarely predicted impaired performance in these cases, instead predicting no change. We explore participants' reasoning about these effects further when we consider the explanation data (see below).

Noisy–quiet stories. The noisy–quiet stories described characters who experienced either noisy or quiet environments while performing school tasks. A 4 (age) × 2 (story version: noisy or quiet) ANOVA showed a significant effect of story version, $F(1, 92) = 235.07$, $p < .001$, $\eta_p^2 = .72$, with no age effects. T tests showed that all ages predicted significant improvement of performance for quiet and significant impairment of performance for noise, $p < .05$.

No-change control story. The no-change control story described a character who experienced no new events or internal state changes. Results of a one-way ANOVA revealed significant age differences in participants' performance ratings, $F(3, 92) = 3.05$, $p < .05$, $\eta_p^2 = .09$. One-sample t tests showed that both 5- and 6-year-olds predicted significant improvement in the character's performance, even though the experimenter mentioned no change in internal states or external factors, $p < .05$, whereas 7-year-olds and adults predicted no change.

Neutral-change control stories. Neutral-change control stories described neutral events that were unlikely to affect characters' internal states or cognitive performance (e.g., new rug in the classroom). For these cases, no significant age effects were found for mean performance ratings, $F(3, 92) = 0.49$, $p > .05$, $\eta_p^2 = .02$, and absolute amounts of improvement/impairment were nonsignificant, $p > .05$. Individual-level data (see Table 2) indicated somewhat different patterns of responding for the "rug" and "clothes" stories: Compared to adults, children were more likely to predict impairment in the rug story, $\chi^2(6, N = 96) = 23.20$, and improvement in the clothes story, $\chi^2(6, N = 96) = 21.83$, $p < .01$.

Table 2
Number of Participants Predicting Impairment, No Change, and Improvement of Cognitive Performance by Story Type and Age

	Emotional state stories											
	Happy			Proud			Sad			Mad		
	Impair	No change	Improve	Impair	No change	Improve	Impair	No change	Improve	Impair	No change	Improve
5 years	10	2	12	9	2	13	18	4	2	21	1	2
6 years	9	2	13	6	3	15	19	3	2	20	2	2
7 years	6	4	14	4	1	19	21	3	0	20	2	2
Adult	0	10	14	4	5	15	24	0	0	22	1	1
	Physiological state stories											
	Full/healthy			Wide awake			Hungry			Tired		
	Impair	No change	Improve	Impair	No change	Improve	Impair	No change	Improve	Impair	No change	Improve
5 years	8	3	13	3	4	17	23	1	0	23	1	0
6 years	4	5	15	3	6	15	21	2	1	23	0	1
7 years	1	3	20	2	1	21	21	2	1	24	0	0
Adult	0	7	17	0	1	23	23	1	0	24	0	0
	Other stories											
	Different Clothing			Different Rug			Nice Hair			Messy Hair		
	Impair	No change	Improve	Impair	No change	Improve	Impair	No change	Improve	Impair	No change	Improve
5 years	6	8	10	13	7	4	6	8	10	14	7	3
6 years	6	12	6	11	7	6	5	10	9	11	10	3
7 years	4	13	7	7	12	5	6	9	9	13	9	2
Adult	1	23	0	2	21	1	1	17	6	4	20	0
	Quiet room			Noisy room			No change (baseline)					
	Impair	No change	Improve	Impair	No change	Improve	Impair	No change	Improve			
5 years	4	2	18	22	1	1	4	8	12			
6 years	6	4	14	24	0	0	2	9	13			
7 years	1	4	19	22	0	2	3	15	6			
Adult	2	7	15	23	1	0	4	17	3			

Valence-change control stories. Changes in outward appearance (nice vs. messy hair) were expected to have little bearing on characters' cognitive performance. A 4 (age) × 2 (valence: positive or negative) ANOVA, however, revealed a main effect of valence, $F(1, 92) = 30.09$, $p < .001$, $\eta_p^2 = .25$, with participants predicting better performance for nice hair and worse performance for messy hair. One-sample t tests showed that all three child age groups reported significant impairment in characters' performance in the messy hair story, $p < .05$, but the degree of improvement predicted in the nice hair story was not significantly different from 0. Means for adults (improvement or impairment) were nonsignificant.

Explanation Data

As described in the Method, participants' explanations for story characters' performance in each scenario were scored for the *presence* (1) or *absence* (0) of each of the 10 explanation categories listed in Table 1. The no-code, moral/social rules, perception, ability, task, and motivation explanations appeared too infrequently to support analyses ($M < 1.5$ trials out of 15). Thus, analyses were restricted to situation, emotion, physiological, and cognitive explanation types. Collapsed by age, overall means for these categories (in number of trials out of 15) were as follows: situation ($M = 8.2$, $SD = 2.5$), emotion ($M = 4.5$, $SD = 1.9$), physiological ($M = 2.9$, $SD = 1.3$), and cognitive ($M = 5.8$, $SD = 3.3$). Mean scores by age and story type are given in Figure 3. (Recall that there were two trials for each story type; thus, the maximum score for each explanation category is 2.) Data were analyzed with repeated measures ANOVA.

Emotional and physiological state stories. As shown in Figure 3, the most frequent explanation types for emotional state stories were emotion, situation, and cognitive explanations, and the most frequent explanation types for physiological state stories were physiological, situation, and cognitive explanations. Two separate 4 (age) × 2 (state: emotional or physiological) × 2 (valence: positive or negative) repeated measures ANOVAs on emotion and physiological explanations confirmed main effects of state: Emotion explanations were more frequent for emotional state stories, $F(1, 92) = 721.99$, $p < .001$, $\eta_p^2 = .89$, and physiological explanations were more frequent for physiological state stories, $F(1, 92) = 502.73$, $p < .001$, $\eta_p^2 = .85$. There was also a State × Valence interaction for physiological explanations, $F(1, 92) = 21.27$, $p < .001$, $\eta_p^2 = .19$. Simple effects analyses showed that participants offered more physiological explanations in negative versus positive physiological state stories, $F(1, 95) = 23.10$, $p < .001$, $\eta_p^2 = .20$, but rates of physiological explanations were similarly low for both positive and negative emotion stories. There were no age effects for these explanation types.

In contrast, results for cognitive explanations showed significant main effects for age, $F(3, 92) = 4.29$, $p < .05$, $\eta_p^2 = .11$, and valence, $F(1, 92) = 12.62$, $p < .01$, $\eta_p^2 = .12$, both qualified by a significant Age × Valence interaction, $F(3, 92) = 6.40$, $p < .01$, $\eta_p^2 = .17$. Although adults made more references to the cognitive consequences of emotional and physiological state changes than 5-, 6-, and 7-year-olds (Tukey's HSD), this age effect was restricted to negative, $F(3, 92) = 7.78$, $p < .001$, $\eta_p^2 = .20$, versus positive, $F(3, 92) = 0.51$, $p > .05$, stories. Separate analyses by valence further demonstrated an Age × State interaction for positive stories, $F(3, 92) = 3.58$, $p < .05$, $\eta_p^2 = .10$. As Figure 3 shows, there were no observable age differences in cognitive explanations for positive emotion stories, $F(3, 92) = 0.63$, $p > .05$, but rates of cognitive explanation increased with age for positive physiological state stories, $F(3, 92) = 2.78$, $p < .05$, $\eta_p^2 = .08$.

Parallel analyses for situation explanations also showed age effects, $F(3, 92) = 2.88$, $p < .05$, $\eta_p^2 = .09$, with levels decreasing with age (Tukey's HSD indicated significant differences between children and adults, $p < .05$). There was also a Valence × State interaction, $F(1, 92) = 17.48$, $p < .001$, $\eta_p^2 = .16$, that appeared to reflect higher levels of situation explanations in negative emotion and positive physiological state cases and lower levels in positive emotion and negative physiological state cases.

Descriptive data provide further details about the content and sophistication of children's verbal responses. Over the full set of emotional and physiological state stories, children cited the character's internal state as the cause of their task performance for nearly six of the eight trials ($M = 5.9$, $SD = 1.7$). This rate is comparable to that of adults ($M = 5.2$, $SD = 1.7$). Of particular interest was the extent to which participants explained connections between internal states and academic performance by citing

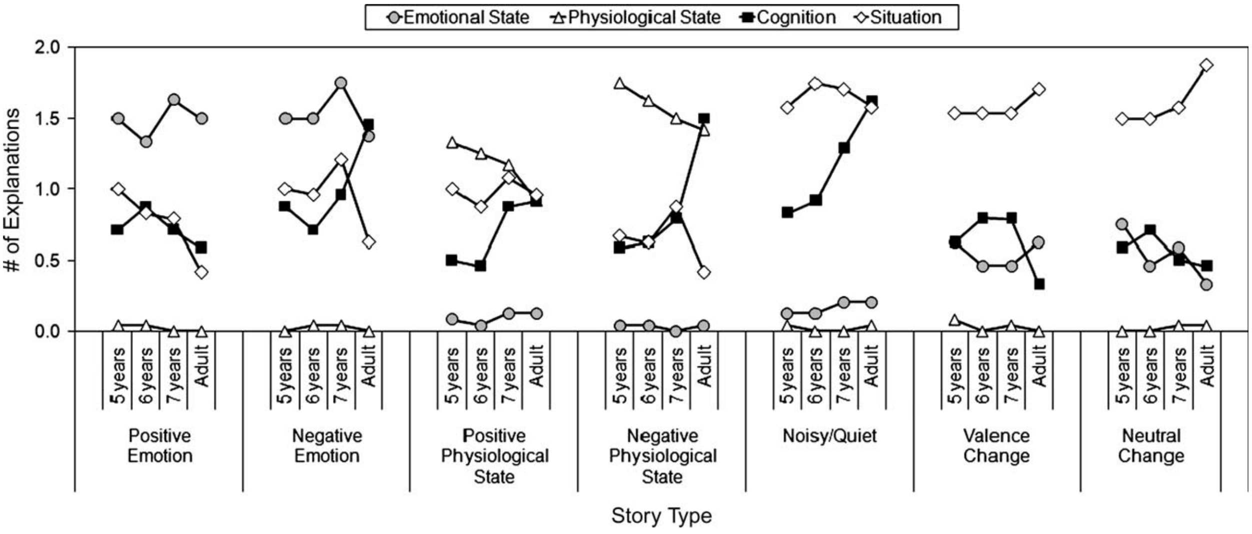


Figure 3. Frequency of explanation categories by age and story type.
Note. The figure shows the mean number of story trials (out of a maximum of 2) for which participants gave each type of explanation. Data are shown for the most frequent explanation categories only.

underlying cognitive mechanisms. Both 5- and 6-year-olds described cognitive mechanisms for emotional or physiological state effects in 34% of the cases where they provided either an emotion or a physiological explanation, with 7-year-olds doing so in 41% cases and adults doing so in 56% cases. For all age groups, the majority of cognitive explanations focused on the impact of the internal state on the character's attention to the task at hand (e.g., "Because she's sad, so she won't concentrate on the book. She'll just think about her teddy bear"). Such responses constituted 83% of 5-year-olds', 73% of 6- and 7-year-olds', and 82% of adults' cognitive explanations. References to other kinds of effects, such as effects on memory or learning (e.g., "Because if she gets more sleep then she can think more") were less frequent, as were references to effects on the brain (e.g., "Because he's healthy it helps his brain"). On average, these constituted 16% and 6% of participants' responses, respectively.

Finally, recall that the prediction data reported previously showed that some younger children predicted impairment for characters in positive emotion stories. Across all three child groups, the high majority (70%) of children explained this prediction by stating that the character would have difficulty concentrating or paying attention as the result of the positive emotion (e.g., "Because he feels so proud of himself, so he's distracted with how proud he is"). Thus, children also showed awareness that positive emotions can have negative effects on cognition.

Noisy–quiet stories. Situation and cognitive explanations were the most frequent explanation types for the noisy–quiet stories at all ages. Cognitive explanations increased with age, $F(3, 92) = 5.68$, $p < .001$, $\eta_p^2 = .16$. Post hoc tests with Tukey's HSD revealed that 5- and 6-year-olds gave fewer cognitive explanations than 7-year-olds and adults, $p < .05$.

No-change control story. Because participants only received one no-change control trial, explanation data were analyzed with chi-square. Results showed that emotion explanations increased with age, $\chi^2(3, N = 96)$, $p < .001$, from 0% of 5-year-olds' explanations to 25% of adults' explanations. Ability explanations were the most frequently given explanation type for both children and adults; 47% of children and 67% of adults referenced the characters' ability level in responding to the baseline case.

Neutral-change and valence-change control stories. Situation, emotion, and cognitive explanation types were the most frequent explanation categories for neutral change and valence control stories at all ages. No significant age differences were observed for any explanation type. Interestingly, emotion explanations for the valence control stories (e.g., "Maybe she's a little embarrassed because her hair is all messy.") were more frequent than expected at all ages and suggested that participants often inferred changes in story characters' emotions as a result of having messy or nice hair. In 40 of 55 cases of predicted impairment (73%) and 12 of 36 cases of predicted improvement (33%) in the valence control scenarios, children cited a change in the characters' emotion as causing a change in task performance. Adults less frequently predicted performance changes for these stories, but those who did cited emotional causes. In four of five cases of predicted impairment (80%) and all six cases of predicted improvement (100%), adults cited emotional effects.

Explanations for predictions of "change" versus "no change." The preceding analyses included all explanations participants provided to account for story characters' school performance, regardless of whether they were predicting impairment, improvement, or no change in performance. Final analyses thus examined whether explanations differed systematically by prediction type. Of central interest were effects for *cognitive explanations*, as these explanations index robust knowledge about mind-body and emotion-thought connections and also showed the clearest increases with age. Because the number of change versus no-change predictions varied for each participant, analyses of prediction type effects used proportional data (i.e., for each prediction type, the number of trials with cognitive explanations divided by the total number of trials of that type). Data for all 15 trials were included for each participant.

A 4 (age) × 3 (prediction type: impairment, improvement, or no change) repeated measures ANOVA found a significant effect of prediction type, $F(2, 168) = 42.0$, $p < .001$, $\eta_p^2 = .33$, and a significant Age × Prediction Type interaction, $F(6, 168) = 4.41$, $p < .001$, $\eta_p^2 = .14$. Simple effects analyses indicated that participants were more likely to cite cognitive mechanisms when predicting change (M proportion of trials = 0.47, $SD = 0.26$) versus no change ($M = 0.18$, $SD = 0.28$) in story characters' performance, $F(1, 85) = 86.93$, $p < .001$, $\eta_p^2 = .51$. They were also more likely to cite cognitive mechanisms when predicting impairment ($M = 0.51$, $SD = 0.30$) versus improvement ($M = 0.39$, $SD = 0.31$), $F(1, 94) = 10.10$, $p < .01$, $\eta_p^2 = .10$. Analyses by age group indicated that the general pattern of providing more cognitive explanations for change versus no-change predictions was upheld at all ages, all ps $< .05$, with one exception. Five-year-olds provided cognitive explanations significantly more often for performance impairment ($M = 0.41$, $SD = 0.24$) compared to improvement

($M = 0.24$, $SD = 0.29$) or no change ($M = 0.19$, $SD = 0.32$), $F > 6.65$, $p < .05$; however, they were no more likely to cite cognitive mechanisms when predicting improvement versus no change, $F(1, 21) = 0.53$, $p > .05$.

Discussion

The goal of this research was to assess young children's understanding of the effects of emotional and physiological states on cognitive performance and thereby to shed light on children's theory-of-mind development and their practical know-how about thinking and learning. Our results demonstrate that 5- to 7-year-olds are indeed aware that emotions and physiological states can significantly enhance or impair performance on cognitively demanding tasks. At the same time, however, there are clear developmental changes in children's ability to predict and explain these effects.

Prior research (e.g., Bennett & Galpert, 1992; Miller & Shannon, 1984; Pillow, 1989) has shown that by 5–6 years of age, children understand that certain internal factors (interest, effort, and sadness) and external factors (environmental noise) affect people's performance on thinking and learning tasks. These are important conceptual achievements that reflect children's mastery of basic theory-of-mind concepts—for example, the link between people's goals and their actions and the significance of perceptual access for knowledge acquisition (e.g., Flavell, 2004; Wellman & Lagattuta, 2000). Aspects of our own data confirm these prior findings. In our warm-up task, children reliably predicted that listening and trying hard would lead to better performance on school work and that not listening and not trying would lead to poorer performance. Moreover, in the experimental task, children performed near ceiling (and at adult levels) in predicting that performance would improve in a quiet environment and decline in a noisy environment and that strong negative emotions (sadness and anger) would have a negative impact on cognitive functioning.

We also present new data on young children's reasoning about the cognitive effects of a wider variety of internal and external states. Although previous studies have reported that children show an earlier understanding of internal versus external influences on cognition (e.g., Miller & Shannon, 1984; Miller & Weiss, 1982), our results demonstrate that over a broader range of factors such developmental patterns are more nuanced. Specifically, we found evidence of three important developmental changes in children's reasoning about the influence of internal states on cognitive performance: (a) children understand impairment of cognitive performance due to negative internal states earlier than they understand enhancement due to positive internal states; (b) with age, children increasingly reference cognitive mechanisms such as distraction to explain the impact of internal state changes on task performance, especially in situations involving impaired performance; and (c) with age, children improve in their ability to differentiate factors that do and do not impact cognitive performance.

Understanding Impairment Before Enhancement

Young children predicted performance decrements due to negative internal states more often than they predicted performance improvements due to positive internal states. Predicting positive effects of positive internal states increased from 5 to 7 years, with this age effect most pronounced for positive emotions. Although 5- and 6-year-olds predicted significant improvements due to positive physiological states, only 7-year-olds and adults predicted significant improvements due to positive emotions. It is worth noting that even adults were not unanimous in their judgments about the effects of positive internal states; they treated the connection between positive states and improvement as weaker than the connection between negative states and impairment. Indeed, 10 of 24 adults (42%) reported that feeling happy or proud would have no effect on task performance. Here, the adult folk theory reflects findings from behavioral studies: The impairing effects of negative emotions typically *are* more robust than the enhancing effects of positive emotions. Indeed, some studies have found that positive moods can impair performance (e.g., Forgas, 1995; George & Zhou, 2002; Phillips, Bull, Adams, & Fraser, 2002). Another possible reason for weaker effects for positive state changes has to do with how people understand the baseline against which state changes are calibrated: Both children and adults may assume that positive states (i.e., being rested, happy, satiated) are more normative in people's everyday lives compared to negative states, leading to smaller perceived effects for further positive changes.

Children's vigilance about factors that impair cognitive performance is remarkable in light of abundant evidence that children tend to be overly optimistic about their own and others' cognitive abilities, a tendency that persists even when tasks are difficult and there is a prior history of failure (e.g., Lockhart, Chang, & Story, 2002; Parsons & Ruble, 1977; Stipek & Hoffman, 1980). Paradoxically, we found that young children tended to predict performance decrements even due to positive internal states. These data suggest that impairment effects may have a certain primacy or salience in children's causal understanding about the influence of emotions and body states on cognition. Children's tendency to predict impairment for a wide range of cases also demonstrates that their success on the task was *not* simply accomplished via a valence-matching heuristic—that is, predicting positive outcomes for positive events and negative outcomes for negative events (see Amsterlaw, 2006; Piaget, 1932).

Why should children exhibit earlier and better understanding of factors that impair cognitive performance versus factors that enhance thinking and learning? One likely reason is that children spend more time thinking and talking about the causes and consequences of negative internal states. In general, people are far more likely to seek reasons for their failures than for their successes (see Roese, 1997; Roese & Hur, 1997; Weiner, 1985). Developmental studies of natural language data mirror this. Lagattuta and Wellman (2002) found that 2- to 5-year-old children talk more frequently with their parents about causes of emotions during everyday conversations about negative as opposed to positive emotions. Young children also demonstrate greater knowledge about the influence of thinking on negative as opposed to positive emotions (Lagattuta & Wellman, 2001).

Increasing References to Cognitive Mechanisms With Age

Across multiple story types, there was a developmental increase in cognitive explanations to account for changes in characters' task performance. This is consistent with previous reports indicating that children's metacognitive knowledge about attentional focus and control improves considerably between the ages of 4 and 8 years (see Flavell, 2004). Here, it is interesting to note that younger children successfully *predicted* the effects of emotions and physiological states on academic performance prior to being able to *explain* the underlying cognitive mechanisms. Young children may have a more limited causal understanding about why these phenomena occur. Indeed, some younger children may view mechanisms in terms of changes in *perception* rather than in cognition. Compared to older children and adults, 5- and 6-year-olds more often described changes in characters' performance as caused by changes in their ability to see or hear the teacher, rather than changes in their ability to think, attend, or concentrate. For example, some young children said that feeling tired would cause a child to do more poorly because she would close her eyes and not see the teacher. Such perception-related explanations significantly declined with age (a one-way ANOVA as a function of age was significant, $F(3, 88) = 4.04, p < .05$). A transition from a perceptual to a cognitive understanding of performance is consistent with theory-of-mind research demonstrating that children understand perception–knowledge links prior to mastering more complex understandings of cognitive processes (Wellman & Liu, 2004).

Participants of all ages, including adults, made explicit references to underlying cognitive causes more often when explaining why a character's performance would decline versus why it would improve or stay the same. This again demonstrates that children show earlier, more sophisticated understandings of impairment versus enhancement and that adults also show a clearer understanding of cognitive mechanisms underlying impairment. Notably, there are no studies in the metacognition literature about whether children understand causes of impaired memory or problem solving prior to understanding causes of enhanced cognition. This is likely the result of a heavy focus on children's knowledge about strategies that *improve* rather than degrade cognitive processes; for example, their understanding of rehearsal, chunking, and elaboration strategies to increase memory (see Siegler & Alibali, 2005).

Differentiation of Factors That Do and Do Not Affect Cognitive Performance

The inclusion of several control scenarios further elucidate developmental changes in children's beliefs about which factors do and do not affect cognitive performance. On the no-change scenario, 5- and 6-year-olds (but not 7-year-olds and adults) predicted that even in the absence of any *stated* precipitating factor, protagonists would generally do better than they have in the past on academic tasks. This occurred even though we always included the no-change scenario as the first trial to avoid the possibility of priming effects (i.e., heightened attention to emotional or physiological states). Moreover, our warm-up questions included training on no-change predictions to ensure that children understood this was an acceptable answer.

There are several reasons why younger children may have responded differently to this scenario. First, 4- to 6-year-olds often elaborate on story scenarios even when not prompted by an experimenter (see Lagattuta et al., 1997). Second, because young children may be more vulnerable to demand characteristics of tasks or questions when trying to please interviewers (e.g., Bruck & Ceci, 1999), they may have assumed that the experimenter expected a "something has changed" response or else she would not have asked the question (although this does not explain why children's change predictions favored improvement and were not at chance). There is also evidence that age effects for the no-change scenario may reflect developmental changes in how children understand "ability" —in this case, academic or intellectual ability. Specifically, consistent with findings from Heyman and Giles (2004), young children tend to expect positive traits, such as intelligence, to increase over both the short (tomorrow) and the long term (when a grown-up), leading them to overgeneralize expectations of improved performance. Indeed, our data indicate that when explaining predictions for the no-change scenario, many children (47%) invoked notions of ability to account for the character's performance (e.g., "Because he is smarter and can do it").

Children were also more likely than adults to predict that negative changes in a person's hairstyle would impair their academic performance. This appeared to be due to children's greater tendency to infer negative emotions due to the change (e.g., "She feels embarrassed about her hair"). Thus, even though the experimenter did not explicitly state that the messy hair made the character feel bad, children (reasonably) inferred an emotional change took place and reasoned about its ultimate cognitive consequences, just as they did for emotion scenarios.

For neutral-change control stories, none of the age groups predicted significant effects of the color of the protagonist's clothing or the classroom rug on academic performance. This suggests that even young children can appropriately refrain from predicting effects for some types of changes. In contrast to the no-change scenario, the experimenter's reference to a specific external change (e.g., new rug) may have curtailed children's tendency to create new story details or to base performance predictions on notions of ability. Nevertheless, individual-level data (see Table 2) indicated that although children's predictions of no change were more frequent for neutral-change control stories than for positive or negative internal-state stories, many children still predicted positive or negative effects for these cases. As with the valence-change control stories, explanation data for neutral-change stories suggest that younger children often read more into these stories than expected: Many believed that wearing blue clothes would make the story character feel "happy" or that the gray rug would "bother" or "distract" the child from her work. A straightforward possibility is that younger children may actually experience more intense emotional reactions, interest, or attention to these everyday events compared to older children and adults, and they project their own experiences onto the story characters.

Limitations and Future Research

We recognize certain limitations of this study that could be addressed in future research. First, we chose to focus on cases where negative internal states would likely impair performance and positive internal states enhance performance. Our data from adults confirm that this is a common folk theory of emotion. We know from experimental studies, however, that scientific findings are not always in line with folk beliefs. For example, negative emotions can lead to improved cognitive performance in some cases, as when they facilitate retrieval of mood-congruent memories (Bower, 1981; Lewis & Haviland-Jones, 2000).

Second, we purposely limited our scenarios to cases where individuals' current internal states were caused by prior life events not the school task itself. This raises the question of how children would respond to scenarios in which characters experience emotions elicited by specific academic tasks—for example, a child who is "afraid" of math tests. Educational research has shown that such emotions significantly predict children's academic performance (see Meyer & Turner, 2002; Zambo & Brem, 2004). Children's reasoning about these emotional experiences will be an important area for research in both developmental psychology and the learning sciences.

Third, our scenarios included school tasks familiar to children (all of which were explicitly described in the scenarios as "pretty hard"), and our study results showed that school task did not significantly factor into children's performance predictions. Still, future research could examine more closely children's beliefs about whether internal states affect some kinds of academic tasks more than others and also whether children's understanding of these effects is connected to their *own* actual (or self-identified) academic strengths and weaknesses.

Fourth, our procedure involved asking children to make performance predictions case by case. Children did not make *direct comparisons* about the relative enhancing/impairing effects of positive, negative, or neutral events. Future research could examine children's direct comparisons of the effects of different kinds of internal states and external factors.

Finally, the children in our study came from families with fairly high levels of parental education, which may have affected our results. It will be important, both for practice and theory, to validate these findings in other relevant populations.

Conclusions

Children's developing theories of mind are held together by rich causal knowledge, allowing them to reason backward and forward about links between mind, world, and behavior. The current study offers new insights by identifying basic developmental patterns in children's reasoning about how internal states influence cognitive functioning: Young children understand impairment of thinking performance due to negative internal states earlier than they understand enhancement due to positive internal states, and their knowledge of emotional effects on cognition lags behind their awareness of other important internal (hunger, fatigue, interest, and effort) and external factors (environmental noise). Beyond contributing to theories of social cognition, these results have practical significance: Changes in emotional and physiological states are a regular part of children's everyday experience in the school setting. Helping young students acquire the knowledge and skills necessary to monitor and regulate them is critical for their success.

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Appendix: Examples of Task Stories

Positive Emotion Stories

Happy—Memory task. One day Judy is walking to school when she finds a really cool, special rock on the side of the road. It is blue and gold and shiny. Judy feels happy. Later that day in school, Judy is still feeling happy because of her cool rock. Her teacher says, "OK, everyone, now it's time for a remembering game. I'm going to show you lots of different pictures in this book, and at the end I want to see how many things you can remember. It's pretty hard." Judy usually does okay remembering hard things like these. How do you think she will do right now, when she is feeling happy?

Proud—Spatial problem-solving task. One morning Max's friend Joey gives him a very nice card. It says, "Dear Max, you are the best friend in the whole world. From Joey." Max feels proud. Later that day in school, Max is still feeling proud because of Joey's nice card. His teacher says, "OK, everyone, now it's time to make special paper airplanes. You have to follow a lot of directions to do it just right. It's pretty hard." Max usually does okay following hard directions like these. How do you think he will do right now, when he is feeling proud?

Negative Emotion Stories

Sad—Language task. One day Lisa is walking to school when her favorite teddy bear falls out of her backpack and gets lost forever. Lisa feels sad. Later that day in school, Lisa is still feeling sad because of her lost teddy bear. Her teacher says, "OK, everyone, now it's time to play a word game. I want to see how many different words you can think of that start with X, Y, or Z. It's pretty hard." Lisa usually does okay on hard word games like these. How do you think she will do right now, when she is feeling sad?

Mad—Reading task. One morning Sam is playing outside in the sandbox before school. He builds a big sandcastle. Then some mean kids come up to him and jump all over his sandcastle until it is all ruined. Sam feels mad. Later that day in school, Sam is still feeling mad because of his ruined sandcastle. His teacher says, "OK, everyone, now it's time for reading. We are going to read a story in our new reading books. It's pretty hard." Sam usually does okay reading hard stories like these. How do you think he will do right now, when he is feeling mad?

Positive Physiological State Stories

Wide awake—Spelling task. One night Becky goes to bed extra early, before her regular bedtime. She has a nice long sleep and gets lots of rest. In the morning when Becky gets up, she feels wide awake. Later that day in school, Becky is still feeling wide awake because of her long sleep. Her teacher says, "OK, everyone, now it's time for a spelling test. I'll say the words and you write down how they are spelled. They're pretty hard." Becky usually does okay on hard spelling tests like these. How do you think she will do right now, when she is feeling wide awake?

Full and healthy—Spatial problem-solving task. One morning before school Robert eats an extra big and healthy breakfast with yummy cereal, toast, eggs, orange juice, and an apple. After breakfast, Robert feels full and healthy. Later that day in school, Robert is still feeling full and healthy because of his big, healthy breakfast. His teacher says, "OK, everyone, now it's time to make special paper airplanes. You have to follow a lot of directions to do it just right. It's pretty hard.'' Robert usually does okay following hard directions like these. How do you think he will do right now, when he is feeling full and healthy?

Negative Physiological State Stories

Tired—Language task. One night Hannah stays up late watching TV with her parents. She goes to bed way past her regular bedtime and she only gets to sleep a very short time. In the morning when she gets up, Hannah feels tired. Later that day in school, Hannah is still feeling tired because of staying up late. Her teacher says, ''OK, everyone, now it's time to play a word game. I want to see how many different words you can think of that start with X, Y, or Z. It's pretty hard.'' Hannah usually does okay on hard word games like these. How do you think she will do right now, when she is feeling tired?

Hungry—Science task. One morning before school John doesn't have any time to eat breakfast—he doesn't even drink any milk or juice before he goes out the door. When John gets to school he feels hungry. Later that day in school, John is still feeling hungry because of not eating breakfast. His teacher says, ''OK, everyone, now it's time for a science lesson. We are going to learn lots of new things about the solar system. It's pretty hard.'' John usually does okay learning hard stuff like this. How do you think he will do right now, when he's feeling hungry?

Noisy – Quiet Stories

Noisy room—Spelling task. One day when Kevin gets to school, there are some workers up on top of the school, fixing the roof. The workers are banging with their hammers right above Kevin's classroom—bang, bang, bang! It is noisy in Kevin's classroom. Later that day in school, it is still noisy in Kevin's classroom because of the workers banging on the roof. His teacher says, ''OK, everyone, now it's time for a spelling test. I'll say the words and you write down how they are spelled. They're pretty hard.'' Kevin usually does okay on hard spelling tests like these. How do you think he will do right now, when it's noisy in his classroom?

Quiet room—Memory task. One day when Ryan gets to school, they are having an ''extra-quiet day'' in Ryan's classroom. That means everyone is doing their work extra quietly and nobody is talking or making any noise. It is quiet in Ryan's classroom. Later that day in school, it is still quiet in Ryan's classroom because of their ''quiet day.'' His teacher says, ''OK, everyone, now it's time for a remembering game. I'm going to show you lots of different pictures in this book, and at the end I want to see how many things you can remember. It's pretty hard.'' Ryan usually does okay remembering hard things like these. How do you think he will do right now, when it's extra quiet in his classroom?

Valence-Change Control Stories

Nice hair—Math task. One day Kate is getting ready for school. She sees her blue hair bows sitting on her dresser and she decides to wear them to school. She puts the bows in her hair. Her hair looks nice. Later that day in school, Kate's hair is still looking nice because of her hair bows. Her teacher says, ''OK, everyone, now it's time to do some math problems. You have to add, subtract, and multiply. They're pretty hard.'' Kate usually does okay on hard math problems like these. How do you think she will do right now, when her hair is looking nice?

Messy hair—Reading task. One morning before school Susan is playing on the playground with her friends. It is very windy outside, and the wind blows Susan's hair all around. When she goes inside, Susan's hair looks messy. Later that day in school, Susan's hair is still looking messy because of the wind blowing it. Her teacher says, ''OK, everyone, now it's time for reading. We are going to read a story in our new reading books. It's pretty hard.'' Susan usually does okay reading hard stories like these. How do you think she will do right now, when her hair is looking messy?

Neutral-Change Control Stories

Different rug—Science task. One day when Allie gets to school, there is a new rug in her classroom. The new rug is gray. It covers the whole floor of the classroom. The floor looks all gray. Later that day in school, the floor is still looking gray because of the new rug. Her teacher says, ''OK, everyone, now it's time for a science lesson. We are going to learn lots of new things about the solar system. It's pretty hard.'' Allie usually does okay learning hard stuff like this. How do you think she will do right now, when the floor is gray?

Different clothing—Math task. One day, David is getting ready for school. He sees his blue shirt and pants in the closet and he decides to wear them to school. He gets dressed. He looks all blue. Later that day in school, David is still looking all blue because of his blue clothes. His teacher says, "OK, everyone, now it's time to do some math problems. You have to add, subtract, and multiply. They're pretty hard." David usually does okay on hard math problems like these. How do you think he will do right now, when his clothes are blue?

No-Change Control Story (Baseline)

Tim goes to school every day. One day when Tim is at school, his teacher says, "OK, everyone, now it's time for a remembering game. I'm going to show you lots of different pictures in this book, and at the end I want to see how many things you can remember. It's pretty hard." Tim usually does okay remembering hard things like these. How do you think he will do right now?