Children’s Naive Theories of Intelligence Influence Their Metacognitive Judgments

David B. Miele
University of Maryland, College Park

Lisa K. Son
Barnard College

Janet Metcalfe
Columbia University

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Abstract

Recent studies have shown that the metacognitive judgments adults infer from their experiences of encoding-effort vary in accordance with their naive theories of intelligence. To determine whether this finding extends to young children or whether they instead rely on a single heuristic for interpreting encoding-effort (as has been suggested), we conducted a study in which third and fifth graders read texts that were presented in an easy- or difficult-to-encode font. Children who viewed intelligence as fixed interpreted effortful encoding as a sign of limited ability and reported lower levels of comprehension as their effort increased. In contrast, children who viewed intelligence as malleable interpreted effortful encoding as a sign of increased mastery and did not report lower levels of comprehension.
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What children believe about the nature of intelligence can have important effects on the ways in which they regulate their own learning. For instance, after receiving negative feedback about their performance on a learning task, children who believe that intelligence is a fixed and unmalleable entity (i.e., entity-theorists) are more likely to disengage from the task than children who believe that intelligence can be developed incrementally through hard work (i.e., incremental-theorists). Although stable individual differences in children’s beliefs about the malleability of intelligence begin to emerge as early as the first grade, these beliefs seem not to have effects on children’s behavior until the fifth grade. In a study by Cain and Dweck (1995), fifth graders (but not first or third graders) were more likely to attribute their failure to complete a challenging task to a lack of ability and less likely to want to repeat the task if they had endorsed an entity as opposed to an incremental theory of intelligence (TOI). Similarly, Bempechat, London, and Dweck (1991) showed that, among fifth graders (but not third graders), children with an entity theory took significantly longer than children with an incremental theory to complete a challenging set of problems after they experienced failure.

It is likely that these effects are based on differences in the way that entity and incremental-theorists conceive of the relationship between ability and effort. In a study of elementary school children, Pomerantz and Ruble (1997) found that (across grades 2-5) holding an entity TOI was associated with decrements in performance following failure, but only when children also conceived of intelligence as a stable capacity that was inversely related to effort (such that people who complete a task with low effort are viewed as smarter than people who complete the same task with high effort; see also Miller, 1985). In a more recent study of seventh graders, Blackwell, Trzesniewski, and Dweck (2007) demonstrated that older children’s beliefs
about the relationship between intellectual ability and effort mediated the effects of their theories on their judgments about how to respond to academic challenge. Because entity-theorists at this age tended to view ability as inversely related to effort, they inferred that the effort or difficulty they experienced while learning a new subject meant that their intellectual abilities were lacking (otherwise the subject should have been easy to master) and, as a result, they concluded that they should devote less time to the subject in the future. In contrast, because incremental-theorists viewed ability and effort as being positively related, they were more likely to infer that the effort they experienced was a sign of increasing mastery and, as a result, concluded that they should devote more time to the subject in the future (see also Hong, Chiu, Dweck, Lin, & Wan, 1999; but cf. Stipek & Gralinksi, 1996).

Given that a clear conception of the relationship between ability and effort seems to be necessary for children’s TOIs to affect their behavior, it has been posited that the reason younger children do not exhibit such effects may be because they have not yet achieved this level of understanding (Butler, 1999; Dweck, 2002; Miller, 1985; Pomerantz & Ruble, 1997). This explanation is supported by research which suggests that, although by the age of 8, children are beginning to differentiate between ability and effort as separate factors that can affect performance, it is not until they reach 10 or 11 that they start to think of ability as a stable capacity that is distinct from effort (Nicholls, 1978; Nicholls & Miller, 1984).

However, an alternative explanation is that, younger children do actually possess a sufficient understanding of the relationship between ability and performance (Surber, 1980), but have not yet linked these concepts to their goals and behavioral strategies as part of a coherent meaning system that governs their self-regulation (e.g., Stipek & Gralinksi, 1991; see Dweck, 2002, 2003). This explanation is supported by research on metacognitive development, which
shows that for children younger than Grade 5, there is a disconnect between their metacognitive judgments (i.e., their judgments about what they do and do not know) and their study strategies (Bisanz, Vesonder, & Voss, 1978; Dufresne & Kobasigawa, 1989). For example, Metcalfe and Finn (2011) showed that, although both third and fifth graders were accurate in their judgments of future memory, fifth graders chose to restudy items that they believed they did not already know, whereas third graders chose randomly.

What this alternative explanation suggests then is that, although children’s TOIs might not directly affect their motivation to engage in learning tasks prior to the fifth grade, these theories may still have important effects on the metacognitive judgments young children make about their own learning—judgments that will eventually be used to make important decisions about what and how to study. Previous research has shown that, as early as the third grade, children base their metacognitive judgments on their experiences of encoding-effort. In general, the easier it feels to process new information—e.g., when processing occurs more quickly (Hoffman-Biencourt, Lockl, Schneider, Ackerman, & Koriat, 2010; Koriat, Ackerman, Lockl, & Schneider, 2009b)—the more confident children are about their learning. Although individual differences in this domain have not previously been investigated, the consistency of the relation between encoding-effort and judgment confidence has led to the suggestion that children might uniformly interpret easy or fluent encoding as a sign of increased learning (e.g., Koriat, Ackerman, Lockl, & Schneider, 2009a).

It has recently been shown, however, that adults do not interpret fluent encoding in a uniform manner. Instead, they rely on their TOI to interpret their experiences of effort when making judgments of comprehension and memory (Miele, Finn, & Molden, 2011; Miele & Molden, 2010). For instance, entity-theorists reported lower levels of comprehension and
memory as encoding-effort increased (due to changes in text coherence, font clarity, proprioceptive feedback, or semantic relatedness), presumably because they interpreted their feelings of increased effort as a sign that they had reached the limits of their ability. In contrast, incremental-theorists did not report lower levels of comprehension and memory as encoding-effort increased and, in some cases, even reported higher levels of comprehension, presumably because they interpreted their increased effort as a sign of greater engagement in the task.

In the present study, we seek to extend this finding by exploring how it applies to children. On the one hand, because most children do not possess fully differentiated concepts of ability and effort prior to the fifth grade, young children may not be able to draw the kinds of sophisticated inferences necessary for their beliefs about intelligence to affect their judgments of learning. On the other hand, if young children are at least able to conceive of ability as a stable capacity that can be inversely related to effort, then even children in the third grade may base their judgments of learning on their TOI, regardless of whether or not they eventually use these judgments to regulate their learning.

To investigate how TOIs affect metacognition of comprehension at this transitional stage of development, we conducted an experiment with third and fifth graders using a paradigm that has previously been implemented with college students (Miele & Molden, 2010, Experiment 3; Rhodes & Castel, 2008). During our experiment, children with different TOIs read two short texts, one which was presented in a visually clear font and another which was presented in an unclear font. Past research has shown that when the perceptual cues in a task are effortful to process, participants tend to misattribute their feelings of effort to the task itself (e.g., Novemsky, Dhar, Schwarz, & Simonson, 2007; see Schwarz, 2004). Thus, by manipulating the font used to display the two texts, we expected that the children would experience the perceptually unclear
version of each text as more effortful to process than the perceptually clear version, even though the two versions contained exactly the same content.

After reading each text, the children rated how well they understood the material and answered a series of multiple-choice questions designed to test their comprehension. Our primary hypothesis was that children who endorsed an entity TOI would interpret the feelings of increased effort they associated with the unclear versions of the texts as a sign that they had reached the limits of their ability to understand them and, thus, would report lower levels of comprehension for these versions than for the clear versions. In contrast, we predicted that children who endorsed an incremental TOI would interpret their feelings of increased effort as a sign of developing mastery and, thus, would not report lower levels of comprehension for the unclear versions. Although we expected entity- and incremental-theorists to differ in their judgments of comprehension for clear versus unclear versions of the texts, we did not expect a difference in their actual comprehension of the material. That is, in the absence of performance feedback, TOIs should only affect how children interpret their experiences of encoding-effort, as opposed to how much effort they actually put into the comprehension task or how capable they are of understanding the material.

Method

Participants

Fifty-one children from an elementary school in New York City participated as part of an after-school program. The sample, which included 27 3rd graders ($M_{age}=8.27$; 54% female) and 24 5th graders ($M_{age}=10.39$; 56% female), was drawn from a school population that was heterogeneous in terms of ethnicity (28% African-American, 52% Hispanic, 7% Asian, 13% White) and socioeconomic status (60% were eligible for free lunch). Age and gender statistics
are based on demographic data collected for 44 of the participants. Treatment of participants was in accordance with APA ethical standards.

**Stimuli**

Two age-appropriate texts were used. The first text (148 words; Flesch readability score=88.9; Flesch-Kincaid grade-level score=3.6), about “being a fish,” was selected from the Grade 3 Illinois Standards Assessment Test (ISAT). The second text (170 words; Flesch readability score=92.9; Flesch-Kincaid grade-level score=2.2), about “Jimmy’s treasure,” was selected from the Super Teacher Worksheets website. Clear and unclear versions of both texts were created by manipulating the font used to display them. The clear version of the texts appeared in black 26-point Times font, whereas the unclear versions appeared in light-grey 26-point Bradley Hand ITC TT Bold font (see Figure 1).

**Questionnaires**

To measure TOIs, we administered a well-validated 6-item questionnaire (designed specifically for use with children; Dweck, 1999), which asked participants to rate their agreement (1-6) with statements such as “Your intelligence is something that you can’t change very much.” A single, normally distributed index of participants’ beliefs in the relative stability or malleability of intelligence ($\alpha=.73$, $M=2.99$, $SD=.98$, Skewness=.34, Kurtosis=.66) was created by reverse coding the incremental items and then averaging across all six responses for each participant. Although TOIs were measured and analyzed continuously, for ease of exposition, we label the 12 participants who (on average) agreed that intelligence is fixed (scores>3.5) as entity-theorists; 3 of these participants had very high scores on the index (>5.0) and can be thought of as strong entity-theorists. In contrast, we label the 35 participants who agreed that intelligence is malleable (scores<3.5) as incremental-theorists; 8 of these participants
had very low scores on the index (<1.0) and can be thought of as strong incremental-theorists. The 3 participants who scored at the midpoint of the index (scores=3.5) might best be considered ambivalent.

To measure participants’ beliefs about effort, we administered six items from a scale developed by Blackwell et al. (2007), which asked participants to rate their agreement (1-6) with positive (e.g., “The harder you work at something, the better you will be at it”) and negative (e.g., “The best way to tell if you’re good at something is to see how quickly you catch on to it”) statements about the role of effort in achievement. A single continuous index of effort beliefs (α=.55) was formed by reverse coding the negative effort beliefs and then averaging across five responses for each participant (one response was dropped from the index because it had a low item-total correlation, -.15).

Procedure

Participants were told that they would “read a couple of short texts” and then answer questions about what they had learned. Although the two texts were always presented in the same order, the clarity of each text was counterbalanced between participants. That is, some participants began with the clear version of the fish text and then read the unclear version of the treasure text, while others read the unclear version of the fish text, followed by the clear version of the treasure text. Participants were given as much time as they needed to read each text, and the time was recorded by the computer. After reading each text, participants were prompted to make judgments of comprehension along several dimensions using a 1-6 scale. Specifically, they were asked, “How well do you feel you understand the text?”, “How certain are you that you will answer questions correctly about the text?”, and “How confused about the text do you feel?”. Two judgment indices were constructed by reverse-scoring the confusion items and then
averaging across participants’ responses to all three questions in each text condition ($\alpha_{\text{clear}}=.71$, $\alpha_{\text{unclear}}=.62$). After reporting their judgments for each text, participants completed four multiple-choice questions assessing their actual comprehension. Once they finished answering these questions for the second text, participants completed the TOI-questionnaire and the Effort Beliefs items. Finally, participants responded to a two-item manipulation check, which asked them to rate, on a scale from 1 to 6, how difficult it was “to read the font used to display the first text (about fish)” and “the font used to display the second text (about Jimmy).” The term “font” was explained to children who were unfamiliar with the word.

Results

One of the third graders spent an inordinate amount of time reading the texts (over six standard deviations above the mean). Data from this individual were eliminated, leaving responses from 50 participants for analysis. Except where reported, dependent measures were analyzed using the same three-step process. In the first step, we conducted a 2 (grade) × 2 (font-clarity) mixed analysis of variance (ANOVA), with repeated measures on the second factor. Then, in the second step, we added the mean-centered TOI-index as a covariate in order to conduct a mixed analysis of covariance (ANCOVA). The main effect of font-clarity was tested in the first step in order to maximize efficiency and to avoid scaling artifacts (see Algina, 1982; Thomas, 2009; Thomas et al., 2009). The main effects of grade and TOI, as well as all 2- and 3-way interactions, were tested in the second step. Finally, in keeping with previous studies from the adult literature, if the primary interaction of interest (i.e., font-clarity × TOI) was significant, we conducted simple-effect analyses at 1.5 SD above the midpoint of the TOI-index for entity-theorists and 1.5 SD below the midpoint for incremental-theorists (Aiken & West, 1991).

Manipulation Check
To determine the effectiveness of the manipulation, we analyzed participants’ ratings of reading difficulty (ratings were missing for three participants). The text displayed in the clear font was reported as less difficult to read ($M=1.98, SE=.23$) than the text displayed in the unclear font ($M=3.08, SE=.26$), $F(1,45)=13.54, p<.001, \eta^2_p=.23$. There was also a main effect of grade, $F(1,43)=7.09, p=.01, \eta^2_p=.14$, such that the texts were perceived as less difficult to read ($M=1.98, SE=.30$) by the fifth graders than by the third graders ($M=3.08, SE=.29$). Importantly, these effects were not accompanied by a main effect of TOI, $F(1,43)=.27, p=.60, \eta^2_p=.006$, or qualified by a font-clarity $\times$ TOI interaction, $F(1,43)=.14, p=.71, \eta^2_p=.003$. An analysis of study times (which were log-transformed to eliminate positive skew) confirmed that font-clarity affected effort: participants spent marginally more time reading the perceptually unclear versions of the texts ($M=86.01$ s, $SE=5.16$) than the clear versions ($M=80.33$ s, $SE=5.92$), $F(1,48)=3.82, p=.06, \eta^2_p=.07$. There was neither a main effect of TOI, $F(1,46)=.70, p=.41, \eta^2_p=.02$, nor a font-clarity $\times$ TOI interaction, $F(1,46)=1.35, p=.25, \eta^2_p=.03$. However, there was a font-clarity $\times$ TOI $\times$ grade interaction, $F(1,46)=4.57, p=.04, \eta^2_p=.09$, such that the main effect of font-clarity on reading time was driven mostly by incremental-theorists in the fifth grade. Because this interaction was not present in any of our primary analyses, we have refrained from interpreting it.

**Judgments of Comprehension**

Consistent with previous studies (Hoffman et al., 2010; Koriat et al., 2009a, 2009b, Rhodes and Castel, 2008), there was a significant main effect of font-clarity on judgments of comprehension, $F(1,48)=6.67, p=.01, \eta^2_p=.12$, such that participants reported higher comprehension for the clear versions of the texts than for the unclear versions. There was also a marginal main effect of TOI, $F(1,46)=3.36, p=.07, \eta^2_p=.07$, such that incremental-theorists
reported higher levels of comprehension than entity-theorists, as well as a significant main effect of grade, $F(1,46)=4.72$, $p=.04$, $\eta^2=.09$, such that fifth graders reported higher levels of comprehension ($M=4.83$, $SE=.17$) than third graders ($M=4.31$, $SE=.16$). However, as shown in Figure 2, the effects of font-clarity and TOI were qualified by the predicted font-clarity $\times$ TOI interaction, $F(1,46)=5.44$, $p=.02$, $\eta^2=.11$, which was not moderated by grade, $F(1,46)=.005$, $p=.94$, $\eta^2<.001$. Whereas entity-theorists reported higher levels of comprehension for the clear versions of the texts than for unclear versions, $t(46)=3.15$, $p=.003$, incremental-theorists’ judgments were not influenced by font-clarity, $t(46)=.16$, $p=.87$.

**Test performance**

Somewhat surprisingly (cf. Diemand-Yauman, Oppenheimer, & Vaughan, 2010), the results revealed a main effect of font-clarity, $F(1,48)=6.30$, $p=.02$, $\eta^2=.12$, such that participants performed better on the comprehension questions after reading the clear versions of the texts ($M=86.62$, $SE=3.14$) than after reading the unclear versions ($M=79.33$, $SE=3.94$). However, this effect was not qualified by a font-clarity $\times$ TOI interaction, $F(1,46)=2.20$, $p=.15$, $\eta^2=.05$, which suggests that the differential effects of manipulated effort on entity- and incremental-theorists’ judgments of comprehension were due to differences in their interpretation of encoding-effort as opposed to differences in their actual encoding of the texts.

**Effort Beliefs**

To determine whether participants’ effort beliefs mediated the effect of TOIs on their judgments of comprehension, we first looked to see if the TOI and effort beliefs indexes were correlated. The results showed a significant negative correlation, $r(48)=-.34$, $p=.02$, such that entity-theorists were less likely ($M=3.44$, $SE=.28$; estimated at 1.5 SD above the midpoint of the TOI index) than incremental-theorists ($M=4.36$, $SE=.17$; estimated at 1.5 SD below the
midpoint) to endorse positive beliefs about the role of effort in achievement. Next, we examined the effect of effort beliefs on judgments of comprehension. The results revealed main effects of font-clarity and grade, which were qualified by the predicted significant font-clarity x effort beliefs interaction, $F(1,46)=7.45, p=.01, \eta^2_p=.14$. Participants with strong positive beliefs about effort (estimated at 1.5 SD above the midpoint of the effort-beliefs index) reported equivalent levels of comprehension for the clear and unclear versions of the text ($Ms=4.69$ and 4.55, $SEs=.19$ and .20, respectively), $t(46)=.21, p=.83$. In contrast, participants with strong negative beliefs about effort (estimated at 1.5 SD below the midpoint) reported significantly higher levels of comprehension for the clear versions ($M=5.34, SE=.34$) of the texts than for the unclear versions ($M=3.89, SE=.35$), $t(46)=3.63, p<.001$.

Finally, to provide a formal test of mediation, we used a bootstrapping procedure with 10,000 bootstrap resamples. Compared to tests that assume a normal distribution of indirect effects (e.g., the Sobel test), bootstrap methods are a more accurate means of assessing mediation for small- to moderately-sized samples (see Shrout & Bolger, 2002). The procedure, which was developed by Preacher and Hayes (2008), allowed us to estimate the total indirect effect of TOIs on judgments of comprehension (with effort beliefs as the mediator and grade as a covariate), as well as a bias-corrected 95% confidence interval for the estimate. Because the confidence interval (which ranged from .01 to .34, $M=.13$) did not include zero, the indirect effect can be considered significant at $p<.05$ (Shrout & Bolger, 2002). Thus, as depicted in Figure 3, the effect of TOIs on judgments of comprehension was significantly mediated by effort beliefs.

**Discussion**

The current study demonstrates that variation in third and fifth graders’ TOIs leads to important differences in the way they metacognitively assess their own learning. While entity-
theorists reported lower levels of comprehension for the versions of the texts that felt effortful to process (i.e., the unclear versions) compared to the versions that felt easy to process (i.e., the clear versions), incremental-theorists did not show differences in perceived comprehension between text conditions. As the results of our mediation analysis demonstrate, this pattern can be explained in terms of differences in the way that entity and incremental-theorists interpreted their experiences of encoding-effort. Entity-theorists reported lower levels of comprehension as effort increased because they interpreted this effort as an indication that they had reached the limits of their ability to understand the material. In contrast, incremental-theorists did not report lower levels of comprehension across conditions because they interpreted increases in effort as a sign that they were putting in the extra work needed to master a challenging task.

The fact that this pattern of results emerged for both third and fifth graders is of particular importance considering that previous studies have not found any effects of TOIs on achievement-related behavior in children younger than Grade 5 (Bempechat, London, & Dweck, 1991; Cain & Dweck, 1995; see Dweck, 2002, for a review). It suggests that young children may be better at reasoning about the relations between ability, effort, and performance than previously thought (see Dweck, 2002). It is likely that the reason that prior studies did not find any effects of third graders’ TOIs on their behavioral responses to challenge was not because they failed to use TOIs to make inferences about their own effort and ability, but because they had not yet reached the point in their development at which they systematically translated these inferences into behavioral strategies. As mentioned earlier, this possibility is consistent with research (e.g., Metcalfe & Finn, 2011) suggesting that young children have a metacognitive “implementation deficit”—a disconnect between their metacognitive knowledge and their study strategies.
The fact that third graders showed the same pattern of results as fifth graders and adults also raises the question of when during development this pattern actually emerges. Though it remains to be tested, it is unlikely that children’s TOIs would affect their judgments of learning prior to the third grade. First, developmental studies of children’s metacognitive monitoring suggest that first and second graders may not use their experiences of effort as cues for making judgments of learning (Koriat et al., 2009a, 2009b). Second, studies of how children form ability conceptions suggest that, prior to the third grade, children may have a very limited understanding of the relationship between ability and effort (Nicholls, 1978; Nicholls & Miller, 1984)—which would make it difficult for them to infer low levels of ability from high levels of effort, even if they possessed and entity TOI.

Finally, these findings have important implications for self-regulated learning and education. Because, as the present research indicates, children’s interpretations of their experiences of encoding-effort are not uniform, but are instead are based (at least in part) on their beliefs about intelligence, an imperative for future studies is to examine how differences in entity- and incremental-theorists’ metacognitive judgments affect their choices about how to allocate their study-time. For example, if for certain tasks, incremental-theorists become overconfident in their judgments of learning when processing feels effortful (see Miele, Finn, & Molden, 2011), they may be likely to terminate study before the material has been adequately learned. The implication for parents and educators is that it might not be wise to unconditionally promote the adoption of an incremental TOI. In some cases, children may need to be aware that increases in perceived effort are actually indicative of insufficient learning (Koriat, 2008).

In sum, the present findings reveal the effects of children’s TOIs on their metacognitive judgments of comprehension and, in doing so, suggest a new strategy for investigating the
factors that influence children’s metacognitive judgments. In addition to searching for mechanisms that are innate or universal, developmental researchers should also consider children’s individual belief systems (Molden & Dweck, 2006) when attempting to understand the ways in which they regulate their own learning.
References


Would it be fun to be a fish? They are, after all, quite different from us. Fish have no ears as we do. Their bodies are covered with thin, flat plates called scales. The only sounds they know are what they feel using certain scales along their sides. These are special scales called lateral lines. We get oxygen from the air by using our lungs. Fish get oxygen from the water by using the gills on the sides of their heads. We can play in water and on

Figure 1. Examples of the “clear” and “unclear” fonts used to display the texts used in the study.
Figure 2. For both grades, entity- and incremental-theorists’ mean judgments of comprehension after reading perceptually clear and unclear versions of the texts. Means were estimated at 1.5 SD above the midpoint of the TOI index for entity-theorists and 1.5 SD below the midpoint for incremental-theorists. Error bars reflect standard errors of the mean.
Figure 3. Meditational model of direct and indirect effects of TOI on judgments of comprehension, controlling for grade. The outcomes variable in this model was computed by subtracting participants’ judgments of comprehension for the unclear texts from their judgments of comprehension for the clear texts. Thus, the direct effect of TOI on judgments of comprehension actually represents the font-clarity $\times$ TOI interaction depicted in Figure 2. Values in parentheses indicate direct effects before the initial variable and the mediator were included in a single analysis. $p <= .05$. 