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Children's Naive Theories of Intelligence Influence Their Metacognitive Judgments

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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 elementary schoolchildren, a study was conducted in which 27 third graders (M_{age} = 8.27) and 24 fifth graders (M_{age} = 10.39) read texts presented in easy- or difficult-to-encode fonts. The more children in both grades viewed intelligence as fixed, the less likely they were to interpret effortful or difficult encoding as a sign of increasing mastery and the more likely they were to report lower levels of comprehension as their perceived effort increased. This suggests that children may use naive theories of intelligence to make motivationally relevant inferences earlier than previously thought.

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 by the first grade children are able to report entity and incremental theories of intelligence (TOIs) that are relatively stable across brief periods of time (see Dweck, 2003), these theories seem not to have effects on children's judgments or behavior until the fifth grade. In a study by Cain and Dweck (1995), fifth graders (but not first or third graders) who attributed their failure to complete a challenging task to a lack of ability and who attempted to avoid future challenge were more likely to endorse an entity as opposed to an incremental TOI. Similarly, Bempechat, London, and Dweck (1991) showed that among fifth graders (but not third graders), children with an entity theory were more likely than children with an incremental theory to explain being "smart" in terms of performance goals (e.g., getting A's in school) as opposed to learning goals (e.g., doing all your homework) and took significantly longer to complete a challenging set of problems after they experienced failure.

It is likely that these effects are based on differences in the way entity and incremental theorists conceive of the relation between ability and effort. In a study of elementary schoolchildren, Pomerantz and Ruble (1997) found that (across Grades 2–5) entity beliefs were associated with decrements in performance following failure, but only when intelligence was viewed as inversely related to effort (which was more likely to be the case for fifth graders than for early elementary schoolchildren; see also Miller, 1985). Similarly, in a more recent study (Blackwell, Trzesniewski, & Dweck, 2007), seventh graders endorsing entity beliefs were more likely to infer that the effort or difficulty 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, were less likely to devote additional time to the subject

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in the future. In contrast, incremental theorists were more likely to infer that the effort they experienced was a sign of increasing mastery and, as a result, were more likely to devote additional time to the subject in the future (see also Hong, Chiu, Dweck, Lin, & Wan, 1999; but cf. Stipek & Gralinski, 1996).

Given that a clear conception of the relation between ability and effort seems to be necessary for children's TOIs to affect their behavior, it has been posited that the reason early elementary schoolchildren 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 suggesting that although by age 8 years, 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 years 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 early elementary schoolchildren do actually possess a sufficient (though not fully mature) understanding of the relation between ability and effort (Heyman & Compton, 2006; 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 & Gralinski, 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., judgments about what they do and do not know) and study strategies (Bisanz, Vesonder, & Voss, 1978; Dufresne & Kobasigawa, 1989). For example, Metcalfe and Finn (in press) 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 is that although children's TOIs might not directly affect their goal orientation or their motivation to engage in learning tasks prior to fifth grade, these theories may still have important effects on the metacognitive judgments early elementary schoolchildren make about their own learning—judgments that will eventually be used to make decisions about what and how to study (e.g., Metcalfe & Finn, in press; Thiede, Anderson, & Therriault, 2003). Previous research has shown that as early as third grade, children base their metacognitive judgments on their experiences of encoding effort. In general, the easier it feels to process new information, the more confident children are about their learning (e.g., Koriat, Ackerman, Lockl, & Schneider, 2009b). 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 or difficulty 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 perceived encoding effort increased (due to changes in text coherence, font clarity, proprioceptive feedback, or semantic relatedness), presumably because they interpreted 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 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 this 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 fifth grade, early elementary schoolchildren 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 they are at least able to conceive of ability as a stable capacity that can be inversely related to effort, then even early elementary schoolchildren may base their judgments of learning on their TOIs, regardless of whether or not they eventually use these judgments to regulate their learning. Such a finding would show, for the first time, that children begin using their TOIs to make motivationally relevant inferences prior to fifth grade.

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 presented in a visually clear font and another presented in an unclear font. Past research has shown that when the perceptual cues in a task are difficult 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 the more children endorsed an entity TOI, the more likely they would be to interpret the feelings of increased effort or difficulty 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, to report lower levels of comprehension for these versions than for the clear versions. In contrast, we predicted that the more children endorsed an incremental TOI, the more likely they would be to interpret their feelings of increased effort as a sign of developing mastery and, thus, the *less* likely they would be to report lower levels of comprehension for the unclear versions. Critically, we did not expect children's TOIs to affect their actual comprehension of the material, for two reasons: First, there is nothing to suggest that entity and incremental theorists should differ in their ability to understand visually clear or unclear texts (see Miele & Molden, 2010). And, second, in the absence of explicit performance feedback or any overt signs of failure, it seemed unlikely that children would make performance attributions that would affect how much effort they put into the brief comprehension task.

Method

Participants

Fifty-one children from an elementary school in New York City participated as part of an afterschool program. The sample, which included 27 third graders (M_{age} = 8.27; 54% female) and 24 fifth 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% European American) and socioeconomic status (60% were eligible for free lunch). Due to experimenter error, age and gender statistics were collected for only 44 of the participants. Treatment of participants was in accordance with APA ethical standards.

Stimuli

The first age-appropriate 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. 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 versions appeared in dark brown 26-point Times font with 21-point leading, whereas the unclear versions appeared in light-gray 26-point Bradley Hand ITC TT Bold font with 36-point leading (see Figure 1).

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 land, but fish must stay in the water all the time. Fish never get hot or cold. They are called cold-blooded because they are always the same temperature as the water around them. That means they have no need for hot soup, or cold lemonade, or cozy blankets, or cool sandals. All in all, it's probably more fun being us.

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Figure 1. Examples of the "clear" and "unclear" fonts used to display the texts used in the study.

Questionnaires

To measure TOIs, we administered a well-validated six-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 = .21, kurtosis = .18) was created by reverse-coding the incremental items and averaging across all six responses for each participant. This index was used as a *continuous* predictor when analyzing the results of the study.

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 ($\alpha = .55$, $M = 4.06$, $SD = .91$, skewness = −.60, kurtosis = .19) was formed by reverse-coding the negative effort beliefs and averaging across five responses for each participant (one response was dropped from the index because it had a particularly low item–total correlation, −.15).

Procedure

Participants were told that they would "read a couple of short texts" and answer questions about what they had learned. Although the 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, then 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 averaging across participants' responses to all three questions in each text condition ($\alpha_{clear} = .71$, $\alpha_{unclear} = .62$). After reporting their judgments for each text, participants completed four multiple-choice questions assessing *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 6 *SD* 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, with repeated measures on the second factor. In the second step, we added the midpoint-centered TOI index as a continuous covariate to conduct a mixed analysis of covariance (ANCOVA). ANCOVA was used because, unlike linear regression, it allowed us to examine the interaction between a continuous predictor and a repeated measures factor. The main effect of font clarity was tested in the first step 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 two- and three-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 to estimate the effect for participants who scored on the entity side of the index, and at 1.5 *SD* below the midpoint to estimate the effect for participants who scored on the incremental side of the index (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, η_p^2 = .23. There was also a main effect of grade, F(1, 43) = 7.09, p = .01, η_p^2 = .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, η_p^2 = .006, or qualified by a Font Clarity × TOI interaction, F(1, 43) = .14, p = .71, η_p^2 = .003. An analysis of study time (which was log-transformed to eliminate positive skew) showed that font clarity also affected participants' actual 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, η_p^2 = .07. There was neither a main effect of TOI, F(1, 46) = .70, p = .41, η_p^2 = .02, nor a Font Clarity × TOI interaction, F(1, 46) = 1.35, p = .25, η_p^2 = .03. However, there was a Font Clarity × TOI × Grade interaction, F(1, 46) = 4.57, p = .04, η_p^2 = .09, such that the main effect of font clarity on reading time was driven mostly by fifth graders and was stronger the more incremental their beliefs were about intelligence (see the Discussion).

Judgments of Comprehension

Consistent with previous studies (Koriat et al., 2009a, 2009b; Rhodes & Castel, 2008), there was a significant main effect of font clarity, F(1, 48) = 6.67, p = .01, η_p^2 = .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, η_p^2 = .07, such that the more strongly participants endorsed entity beliefs about intelligence, the lower they rated their comprehension overall, as well as a significant main effect of grade, F(1, 46) = 4.72, p = .04, η_p^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 × TOI interaction, F(1, 46) = 5.44, p = .02, η_p^2 = .11, which was *not* moderated by grade, F(1, 46) = .005, p = .94, η_p^2 < .001. The more strongly participants endorsed entity beliefs, the higher they rated their comprehension for the Clear versions of the texts compared to the unclear versions. Estimated at 1.5 SD above the midpoint of TOI the index, the effect of font clarity was significant, t(46) = 3.15, p = .003. In contrast, the more strongly participants endorsed incremental beliefs, the less of an effect the font-clarity manipulation appeared to have on their judgments. Estimated at 1.5 SD below the midpoint of the TOI index, the effect of font clarity was not significant, t(46) = .16, p = .87.

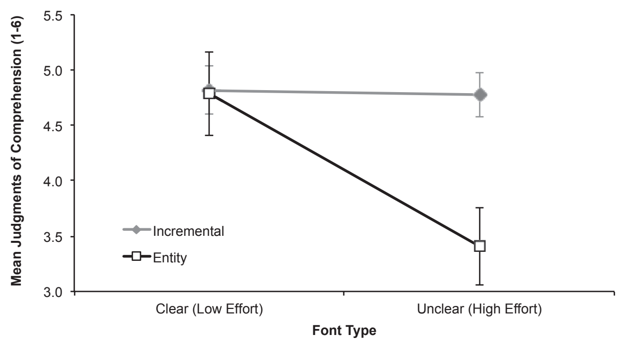

Figure 2. For both grades, entity and incremental theorists' mean judgments of comprehension after reading perceptually clear and unclear versions of the texts. Means were estimated at 1.5 SD above the midpoint of the theories of intelligence index for participants who scored on the entity side of the index and 1.5 SD below the midpoint for participants who scored on the incremental side of the index. Error bars reflect standard errors of the mean.

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, η_p^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 × TOI interaction, F(1, 46) = 2.20, p = .15, η_p^2 = .05, or a Font Clarity × TOI × Grade interaction, F(1, 46) = .57, p = .45, η_p^2 = .01, which suggests that the differential effects of manipulated effort on entity and incremental theorists' judgments of comprehension were at least partly 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 the more strongly participants endorsed entity beliefs about intelligence, the *less* strongly they endorsed 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 Font Clarity × Effort Beliefs interaction, $F(1, 46) = 7.45$, $p = .01$, $\eta_p^2 = .14$. The less strongly participants endorsed positive beliefs about effort, the higher they rated their comprehension for the clear versions of the texts compared to the unclear versions. Estimated at 1.5 *SD* below the midpoint of effort beliefs index, the effect of font clarity was significant, $t(46) = 3.63$, $p < .001$. In contrast, the more strongly participants endorsed positive beliefs about effort, the less of an effect the font-clarity manipulation appeared to have on their judgments. Estimated at 1.5 *SD* above the midpoint of the effort belief index, the effect of font clarity was not significant, $t(46) = .21$, $p = .83$.

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.

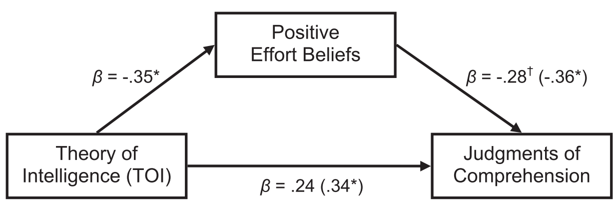

Figure 3. Mediational model of direct and indirect effects of theories of intelligence (TOIs) on judgments of comprehension, controlling for grade. The outcome variable in this model was computed by subtracting participants' judgments of comprehension for the unclear texts from their judgments of comprehension for the clear texts. Thus, the direct effect of TOI on judgments of comprehension actually represents the Font Clarity × 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.
$^{\dagger}p = .05$. $^{*}p < .05$.

Discussion

This study demonstrates that variation in third and fifth graders' TOIs leads to important differences in the way they metacognitively assess their own learning. The more participants endorsed entity beliefs about intelligence, the lower they judged their comprehension to be for the versions of the texts that felt difficult to process (i.e., the unclear versions) compared to the versions that felt easy to process (i.e., the clear versions). In contrast, the more participants endorsed incremental beliefs about intelligence, the less of an effect the font-clarity manipulation appeared to have on their perceived comprehension. As the results of our mediation analysis demonstrate, this pattern can be explained in terms of the effect TOIs had on participants' interpretations of their encoding effort. Participants who tended to endorse entity beliefs reported lower levels of comprehension as difficulty increased because they were less likely than participants who endorsed incremental beliefs to interpret increases in effort as a sign that they were putting in the extra work needed to master a challenging task and perhaps more likely to interpret their effort as an indication that they had reached the limits of their ability to understand the material (though relatively few participants endorsed overall negative views of effort).

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 unqualified effects of TOIs on achievement-related behavior in children younger than Grade 5 (see Dweck, 2002, for a review). It suggests that children begin using their TOIs to make motivationally relevant inferences earlier than previously thought (see Dweck, 2002). Thus, the reason that prior studies did not find any effects of third graders' TOIs on their behavioral responses to challenge may not be because they failed to use TOIs to make inferences about their own effort and ability, but because they had not reached the point in their development at which they systematically translate these inferences into behavioral strategies. As mentioned earlier, this possibility is consistent with research (e.g., Metcalfe & Finn, in press), suggesting that early elementary schoolchildren have a metacognitive "production deficiency" (Veenman, Van

Hout-Wolters, & Afflerbach, 2006)—a disconnect between their metacognitive knowledge and their study strategies.

One limitation of this study is a lack of evidence for the proposed disconnect between third graders' inferences about ability and their self-regulation. Although the study was not designed to test this proposal, it should be noted that fifth graders (but *not* third graders) put more time or effort into reading the challenging, unclear text the more they endorsed incremental beliefs. The lack of an association between TOIs and effort in third graders may have resulted from the proposed disconnect. However, the lack of association was also observed in adults (though perhaps for different reasons; Miele & Molden, 2010), suggesting that further investigation of the proposal is necessary. Another limitation of this study is that it does not directly address the question of exactly when children's TOIs begin to affect their metacognitive judgments. However, it is seems unlikely that children's TOIs would affect their judgments prior to third grade given that first and second graders do not appear to use their experiences of effort as cues for making judgments of learning (Koriat et al., 2009a, 2009b).

Finally, these findings have important implications for self-regulated learning and education. Because, children's interpretations of encoding effort are not uniform, but instead are based 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 incremental theorists sometimes become overconfident in their judgments of learning when processing feels effortful (see Miele et al., 2011), they may terminate study before the material has been adequately learned (Dunlosky & Rawson, 2012). The implication for educators is that it might be unwise to unconditionally promote the adoption of an incremental TOI. In some cases, children may need to be aware that increases in perceived effort are indicative of insufficient learning (Koriat, 2008).

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