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# The Training of Metacognitive Monitoring in Children

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**The current research tested whether a monitoring ability could be improved above and beyond spontaneous development via explicit teaching. Participants (ages 5-6) were trained to monitor their memories by making confidence judgments through the process of placing bets. Following a picture memory task, participants made either high bets or low bets to indicate their confidence in their previous memory responses. Half of the participants were explicitly taught how to bet appropriately, whereas the other half was not. Two memory tasks tested the effects of training: A picture memory test and a transfer vocabulary procedure. Results showed that during training, participants learned to respond bet appropriately, demonstrating a general monitoring ability. More critically, during testing and transfer, participants in the explicitly taught condition were superior at selective betting to children who were not explicitly trained.**

## Introduction

A crucial element in a child's educational development is the ability to form study strategies that might enhance learning. For example, during study, a child may need to decide which items to study and which items to ignore. Or, a child might need to decide whether to continue studying or to stop studying a particular item. In order to make such study decisions, it must first be assumed that the child is able to differentiate between the learnability of the various to-be-learned items. This ability—to know how easy or how well learned an item is—has been shown to be fundamental to strategy formation during study (Koriat & Goldsmith, 1996; Son, 2004; Son & Metcalfe, 2000; Thiede & Dunlosky, 1999). The ability to monitor the learnability of an item is one specific component of a metacognitive skill that has been investigated largely in human adults. The main goal of this research is to investigate spontaneous monitoring abilities in young children and the potential benefits of explicit teaching methods.

Metacognition, which has been classically defined as knowing about one's knowledge, has been an ability that has been researched enormously over the past 30 years . For the most part, the field has focused on the ability of a human adult to report metacognitive judgments describing their own cognitions. Nelson and Narens (1990, 1994) were the first to formally design a framework of the relation between metacognition and cognition. In the framework, cognitions, which may include memories, perceptions, and emotions, are considered object-level tasks. Judgments and assessments, which occur at a metacognitive level, may then be reported to describe the state of the object-level cognitions. Similarly, metacognitive judgments can inform and influence subsequent object-level cognitions. Thus, the framework consists of an interactive, dual-layer system of cognitions and metacognitive judgments.

Metacognitive judgments have typically been defined as being either prospective (i.e. judgments of learning) or retrospective (i.e. confidence judgments). The following is an example of the interaction between cognition and metacognition when making a retrospective judgment: A child retrieves the answer to a particular question, such as "What is 5 + 5?" The child's memory for the answer, say "10" would be the object-level cognition. The child can then potentially form a

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retrospective metacognitive judgment of the cognition—e.g. "I'm very confident that I knew the correct answer." And, this judgment might then allow the child to cease further study of that item—changing the child's subsequent study behavior. The ability to make accurate judgments at the metacognitive level (i.e. correct cognitions are associated with higher metacognitive judgments) forms the monitoring component of the framework, whereas the ability to use those judgments to control subsequent cognitions (i.e. lower judgments may be associated with longer subsequent study times) forms the control component. In the current research, we focus on the monitoring component—can a young child make accurate confidence judgments?

Given that metacognitive monitoring is a necessary component of strategy formation, it seems logical to believe that metacognitive strategies, if taught in school to young learners, might enhance or accelerate learning. Surprisingly, there have only been a few studies that address this question (Dunlosky & Nelson, 1992; Hamman, Berthelot, Saia, & Crowley, 2000; Koriat, Lichtenstein, and Fischhoff, 1980; Moley, Hart, Leal, Santulli, Rao, Johnson, and Hamilton, 1992). One study, which investigated middle-school teacher practices of guiding student learning to engage in metacognitive strategies, concluded that teacher's coaching of learning is positively associated with student's strategic learning ability (Hamman et al., 2000). Although this study demonstrated that teachers who coach learning of a particular skill may influence the student's activities as they perform that specific task, the student's increased learning ability might have been influenced by other classroom variables. Evaluations of the strategies implemented by teachers have also been made largely through observational studies (adapted from Moley et al., 1992) and student's self-report questionnaires (MSLQ). However, controlled experiments have not been emphasized. Our goal was to compare the performance of children exposed to metacognitive strategies with those not exposed to such strategies—both groups of the same age.

In general, monitoring paradigms have been well established. However, many of the methods have been adapted for adults. For instance, in a typical experiment, subjects are given a list of items to learn. After studying each item, subjects are asked to make a metacognitive judgment by verbally reporting how certain or uncertain they feel about a decision they have made. For example, when making confidence judgments, people are asked a question, such as "What is the capital of Mongolia?" After a response has been made, people are typically asked to give their confidence rating on a numeric scale (e.g. 0-100) . Although this procedure has been the usual method for testing monitoring abilities, one concern in using this method with children is that children may find using the numeric scale confusing, or may use it inaccurately. Thus, a preliminary challenge of this research was to investigate children's monitoring abilities using a method that measures confidence behaviorally rather than verbally. To this end, we turned to the monitoring literature in non-human animals.

Until very recently, it was believed that only humans possess the ability of metacognition (Metcalfe and Shimamura, 1994; Tulving and Madigan, 1970). However, there is now a handful of studies that has shown that even animals are able to report uncertainty using behavioral measures (Hampton 2001; Shields, Smith, and Washburn, 1997; Smith, Schull, Strote, McGee, Egnor,and Erb, 1995; Smith, Shields, Allendoerfer, and Washburn, 1998; Smith, Shields, Schull, and Washburn, 1997; Son and Kornell, 2005; Kornell, Son, and Terrace, 2007). For example, Smith et al. (1995) gave monkeys an "escape" option to avoid performing a task when they were uncertain. Son and Kornell (2005) tested the ability to make retrospective confidence judgments in rhesus macaques using a betting procedure. In the procedure, monkeys first made an object-level response (e.g. Which line is the longest?). After making the response, monkeys make a confidence judgment by choosing a "high" or "low" bet. The experimenters accomplished a betting paradigm by using a token economy with various contingencies. If the monkeys chose to bet high, they could either gain or lose two tokens, depending on the accuracy of the response. If they chose to bet low, they would receive one token, regardless of whether the previous answer were correct or incorrect. The bets were assumed to represent confidence—high or low—in their knowledge.

The current research tested children's moni-

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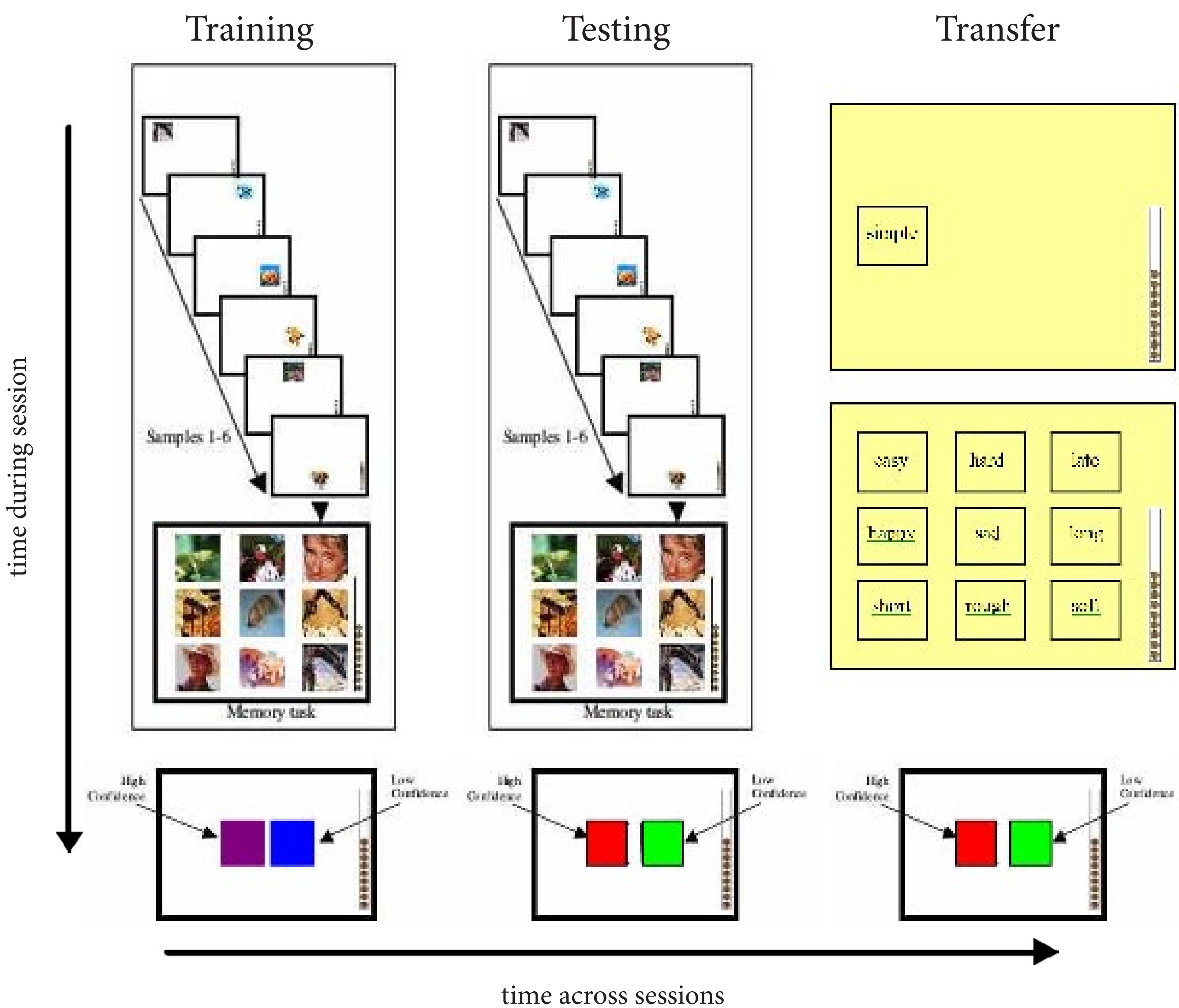


**Figure 1. Three Phases of Study**
During training, six sample pictures were shown one at a time. In the memory test, nine items were shown, one of which (the target) had been in the preceding list of samples. For the confidence judgment, two bet icons representing high and low confidence were presented; pressing high confidence resulted in a gain of 3 tokens given a correct memory test, but the loss of 3 tokens given an incorrect memory test; pressing low confidence resulted in the sure gain of one token regardless of memory performance. When the tokens reached 12, a point was earned and the tokens reset to 9. During testing, the same memory test was presented, along with two novel icons for the judgment task. During transfer, the memory test was a synonym task in which after a vocabulary word had been presented, the synonym was to be selected amongst 8 distractors. The judgment icons were the same as was in the test phase.

toring abilities by using the betting paradigm using a memory task that had been used in Kornell, Son, and Terrace (2007). In their experiment, monkeys were presented with a series of pictures. Following the presentation, they were presented with one of the old pictures in an array of 9 pictures. The task was to identify the old picture. Following their response, the monkeys were presented with the betting choices. Their results demonstrated that the monkeys were indeed metacognitive as they chose to bet "high" risk more often when they correctly identified the picture than when the incorrectly identified the picture. The results with the monkeys showed that although it took a long training period before the monkeys understood the betting contingencies, they eventually acquired the skill of metacognitive monitoring—the monkeys made high bets after correct trials and low bets after incorrect trials. These results suggest that monitoring is not a spontaneous process in animals, and thus, cannot be assumed to be in young children. The data also suggest that with enough training, or teaching, monitoring abilities may improve, and may transfer immediately to novel tasks (see Kornell, Son, and Terrace, 2007).

Using the betting paradigm with points rather than food reward, the current study explored the question of whether young children are able to monitor their knowledge, whether a monitoring ability is spontaneously present once cognitive learning skills are tested—in first grade—and whether metacognitive monitoring skills can be improved through explicit teaching strategies. It was hypothesized that children who are taught explicitly to monitor their knowledge will be better able to do so than those children who were not specifically instructed. In addition, we predicted that teaching children to think about their meta-knowledge would help them continue to do so even when presented with novel tasks.

# Method

## Participants

The participants in this study were thirty-three elementary school students in grade 1 (ages 5-6), at a local public school, P.S. 75. The school consists of a 50/50 ratio of boys to girls, and is made up of 44.62% Hispanic, 26.05% African-American, 21.14% Caucasian-American, 7.47% Asian-American, 0.35% American-Indian, and 0.37% Other. The children participating in this study were chosen based on parental interest and consent. Thirty-two of the children were English speaking while one of the children was Spanish speaking. For the Spanish-speaking child, the experiment was the same in both the training and transfer phases of the experiment. For the testing phase of the experiment, the child was presented with Spanish words along with English translations (with English distractors)—which would, we also hoped, expose the child to basic English vocabulary. Even with this slight difference, all of the data could be analyzed in the same way because of the nonverbal nature of the task.

## Design

The experiment consisted of three between-subjects conditions: Encourage, Taught, and Control. Eleven children were assigned randomly to each of the three conditions. Children in all conditions performed the object-level memory task. In both the Encourage and Taught conditions, the children performed a meta-level judgment as well using the betting procedure. The only difference between the two conditions was that the children in the Encourage condition were not explicitly told how to make their bets, but instead were merely encouraged to assess their object-level memory performance, by mere exposure to the betting paradigm. Children in the Taught condition, however, were explicitly told how they should make their bets based on their assessment of their object-level memory task. They were also told to think about how certain or uncertain they had been in their previous memory response—a procedure used to increase awareness in each child's own learning. Those in the Control condition did not perform the meta-level assessment task during training.

## Procedure

The experiment was conducted during an after-school program in a classroom at P.S. 75 on iMac McIntosh

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computers. Participants were tested individually on a computer with the assistance of an adult. Stimuli consisting of pictures (as in Kornell, Son, and Terrace, 2007) or vocabulary words were presented on the computer screen. The task was to obtain as many points as one could, which the children were told to do, and which seemed an inherent desire for all of the children immediately upon beginning the experiment. The point score was continuously displayed at the bottom right-hand side of the screen so that the participants always knew how many points had been earned. To obtain points, participants had to accumulate 12 tokens in a "bank" that was also continuously displayed on the right side of the screen. At the start of each session, the bank was set at 9 tokens. Each time 12 tokens were earned, a point was given, and the bank reset itself to 9 tokens. Within each session, there were two types of tasks: an object-level memory task and a meta-level bet task.

In the object-level task, participants were presented with six sequential pictures, randomly positioned on the screen. In order to move on to a new picture, participants had to click on each picture with the mouse. Once the participant clicked on the first picture, that one disappeared and a second, novel picture appeared in another location on the screen. The participant then had to click the new picture and this procedure continued until all six pictures were seen. This was a self-paced procedure to ensure that the children were attending to all of the pictures.  After clicking on the sixth picture, one of the old pictures appeared amongst a 3X3 array of eight distractors. Their task was to identify, by clicking with the mouse, which the picture that had been previously seen. There was no feedback for their response.

After making their response—in the meta-level task—participants saw a new screen in which two risk icons were presented, one indicating low bet, and the other indicating high bet. A high bet resulted in the addition of three tokens (in the token bank) if the previous answer had been correct and the removal of three tokens if their previous answer had been incorrect. Selecting a low bet resulted in the addition of one token, regardless of the accuracy of their previous response. To account for any bias towards either the high-bet icon or the low-bet icon, a time delay was added prior to the appearance of the more-biased of the risk icons. Note that the students did not have any feedback on their memory response at any time. Their only feedback on each trial was the movement of the tokens.

The procedure consisted of three phrases: *Training*, *Testing*, and *Transfer*, described below and pictorially depicted in Figure 1.

**Training Phase.** Participants in both the Encourage and Taught conditions were given both the object-level and meta-level task on each trial—they were asked to report their memory for the old picture in the 3X3 array followed by a bet judgment that presented their confidence in the previous memory. Both groups received exactly the same number of trials. The only difference was that in the Encourage condition, participants were not told what the bet icons represented, whereas in the Taught condition, participants were asked if they were "sure" or "unsure" immediately following their object-level memory task. If they said, "sure," then the children were told to select the high-bet icon, while they were told to select the low-bet icon when they stated they were "unsure." This occurred on every trial. Children in the control condition only performed the object-level memory task—they were only told to choose the old picture in the 3X3 array. If their memory for the old picture were correct, then they would earn 3 tokens and a point. If they were incorrect, they would lose 3 tokens.

There were two sessions during the training phase; the first session consisted of sixty trials while the second session was reduced to 30 trials (this was because we noticed that the children had become tired after about half of the trials in the first session). Following the training phase, testing was initiated.

**Testing Phase.** In this phase, all groups were presented with both the object-level and meta-level tasks. After everyone performed the same object-level memory task that was completed during the training phase (with different pictures), participants were presented with a screen that displayed two icons; a high-bet icon and a low-bet icon. However, the icons were visually different than those that were seen by the Encourage condition and the Taught condition during the training phase. During this phase, participants in all of the conditions experienced the same procedure in that none of the participants were explicitly told how to bet. The contingencies of choosing each risk response remained the same as before.

**Transfer Phase.** During the transfer phase, the participants also completed identical procedures. When the participants began the task, a word appeared on the screen. After reading the words themselves, or having the word read to them (depending on ability), the participant clicked on the word. At this point, nine words appeared on the screen in the same 3X3 array as the pictures had, and the task was to identify which word was closest in meaning to the original word that appeared on the screen. The trials had a wide range of difficulty—some were very hard (e.g. occupation – job), and some were very easy (e.g. large – big) or even identical (e.g. blue – blue). After making their selection, participants were presented with the same high-bet and low-bet icons that appeared during the testing phase. The contingencies of choosing each risk response remained the same. The synonym session lasted for 30 trials.

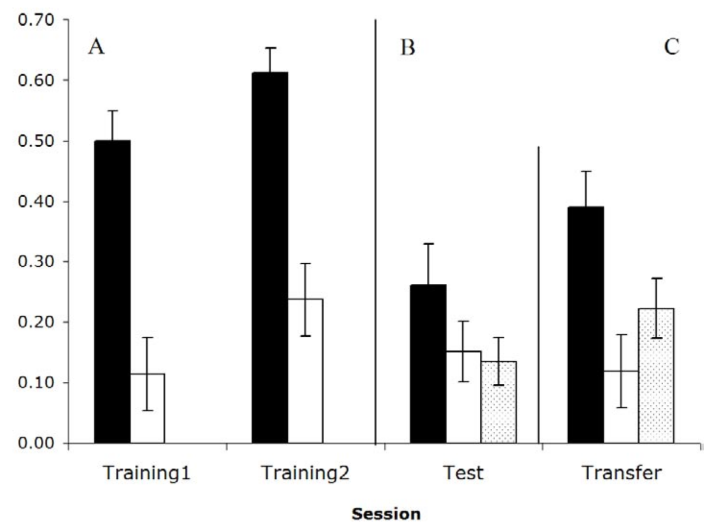


**Figure 2.** The mean correlations between object-level accuracy and meta-level bets for the Taught and Encourage conditions during training sessions (Panel A), and the correlations for the Taught, Encourage, and Control conditions during the test session (Panel B) and the vocabulary transfer session (Panel C). A more positive correlation indicates a more accurate monitoring ability—the more accurate the performance, the higher amount that was risked.

## Results

### Statistical Analyses

All statistical analyses were conducted using SPSS and Statview. Several analyses were conducted in order to assess whether children could monitor their learning appropriately. First, the correlation between object-level response (memory accuracy for picture or synonym) and meta-level confidence judgment (bet response) was measured, for each child. A high correlation signified that if a child was correct on a given trial, then he/she was more likely to select high bet than low bet—indicating that they behaved differentially for strong memories and weak memories, risking more when certain and less when uncertain. A similar but secondary analysis was conducted that measured the percentage of trials on which each child selected high bet after all correct trials and all incorrect trials. Each of the analyses was conducted separately for the training sessions and testing/transfer sessions. For both the correlations and the high-risk percentage data, analyses of variance (ANOVAs) were conducted. Post-hocs were conducted where appropriate. A probability level of $p < .05$ was used as the criterion for statistical significance, and a level of $p < .10$ was used as the criterion for a marginal trend. Estimates of effect size, calculated as partial eta-squared, will be denoted as d.

### Training

During training, both the Encourage and the Taught conditions were presented with both the object-level and meta-level tasks (The control condition was not presented with the meta-level task). That is, these participants made a memory response, and a bet judgment on each trial. The mean correlations between object-level accuracy and bet judgment are presented in Panel A of Figure 2. As expected by the instructions given to the two groups, the correlations in the Taught condition were significantly higher than those of the Encourage condition for both session 1, t(15) = 3.44, SE = .11, and for session 2, t(16) = 4.28, SE = .09. In addition, for both sessions, the Taught participants had significantly positive correlations (Session 1: M = 0.50, t(10) = 6.64, SE = .08; Session 2: M = 0.61, t(9) = 14.13, SE = .04). And for the Encourage condition, although positive, the correlation reached statistical significance only in session 2 (Session 1: M = 0.11, N.S., Session 2: M = 0.24, t(7) = 2.89, SE = .08).

As an alternative analysis, the percent of trials on which a high bet was selected was computed for correct object-level responses and for incorrect object-level responses separately. Figure 3 displays the proportions of high bets for correct and incorrect trials for both the Taught and Encourage conditions. As is shown, the proportions were high for correct trials and low for incorrect trials for both conditions, and, in support of the correlation data presented above, the proportions are more optimal (higher for the correct and lower for the incorrect trials) for the Taught condition than the Encourage condition (Session 1 correct/incorrect Taught: 0.74/0.20; Encourage: 0.58/0.37; Session 2 correct/incorrect: Taught: 0.75/0.17; Encourage: 0.58/0.38). The ANOVA testing the proportion of high risk resulted in a main effect of trial type (correct/incorrect), F(1, 19) = 61.20, MSE = 3.11, d = 0.76, and an interaction between trial type and condition, F(1, 19) = 12.75, MSE = 0.65, d = 0.40. There was no effect of session.

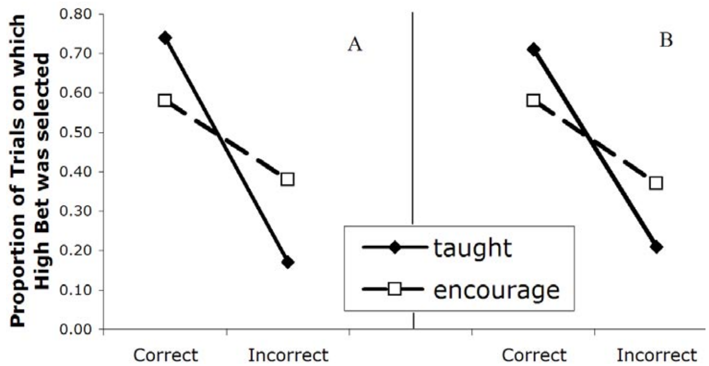


**Figure 3.** Proportions of high bet selected for correct and incorrect trials during the first two training sessions by the Taught and Encourage conditions. The steeper the slope—the more risked for correct trials, and less risked for incorrect trials—the better the monitoring ability.

## Additional Analyses

An interesting potential hypothesis embedded in our primary hypothesis is to assume that the better one's monitoring ability, the better one's learning—or vice versa, the better one is at learning, the more advanced one may be at monitoring one's learning. In order to see, then, whether memory performance would be affected by (parallel to) the monitoring performance, mean accuracy was computed for both the Taught condition and the Encourage condition. The mean accuracies for both conditions were not significantly different from each other in session 1 (Taught: 42.6%; Encourage: 44.8%), nor were they different for session 2 (Taught: 42.0%; Encourage: 41.2%; p's > .10). Although we do not make any conclusions here, we believe that more research needs to be conducted in order to test the assumption that improving a learner's metacognitive strategies will improve their object-level learning.

Another question might be to see if there is a baseline bias to select either high bet or low bet depending on the type of instructions one received. For example, by receiving explicit instructions of what the bet icons represent, might that knowledge make a child more daring—more prone to select high bet? We had hoped that although there might be a difference in monitoring strategies, we would not bias the different groups of children in any direction in terms of the raw proportion of times that they selected high or low bet. The percentage of trials on which high bet was selected by the Taught and Encourage conditions were 47.6 and 49.0, respectively, for session 1, and 41.6 and 46.0, respectively, for session 2. There were no significant differences, as we had predicted. This gives further strength to the findings that systematic monitoring strategies are being manipulated rather than a general criterion for selecting a high or a low bet.

## Testing (Picture Task)

The test phase was the first critical phase of the experiment. All three conditions—Taught, Encourage, and

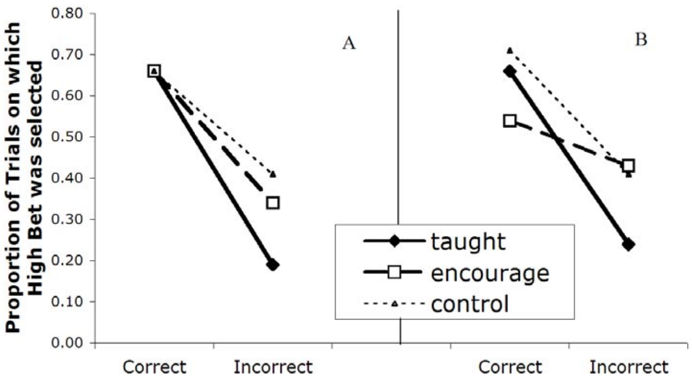


**Figure 4.** Proportions of high bet selected for correct and incorrect trials during the test session (Panel A) and the synonym session (Panel B) by the Taught, Encourage, and Control conditions.

Control—were presented with the object-level memory task, and a novel risk judgment task (the task was novel for both the Taught and Encourage conditions since the high- and low-bet icons were unfamiliar). The correlations between memory accuracy and bet selection for the Taught, Encourage, and Control conditions were 0.26, 0.15, and 0.14, respectively (see Panel B of Figure 2). Although the ANOVA did not reach statistical significance, numerically, correlations in the Taught condition were higher than those of the Encourage and Control conditions. We believe that this non-significant difference may be due to the fact that one session might not be extensive enough to see significant differences and believe that the differences may extend further in the subsequent analyses during the transfer phase that we will present shortly.

Participants in the Taught condition also selected high risk more for correct responses (66%) than for incorrect responses (19%)—the disparity greater than those of the Encourage condition (66% for correct responses, 34% for incorrect responses) and the Control condition (66% for correct responses, 41% for incorrect responses). As is shown in Panel A of Figure 4, the Taught condition has a steeper slope than both encourage and control conditions.

We also calculated whether there were differences in memory performance for the three conditions which there were not, and risk-bias differences for the three conditions, which there were not.

## Transfer (Vocabulary Task)

The final phase of the experiment was the most critical one, because it tested all three conditions on monitoring ability given a novel object-level task. Previously, some processes used during training could have been used during the test phase, since the object-level task was not new. And as a result, the bet judgments could have also been affected similarly. Here, however, we had faith that the synonym task was adequately different than the memory task used during training.

The mean correlations between synonym accuracy and bet judgment for the Taught, Encourage, and Control conditions were 0.39, 0.12, and 0.22, respectively (see Panel C of Figure 3). The Taught condition once again had the numerically highest correlation, although the effect did not reach statistical significance. However, since we were mainly interested in the difference between the Taught and the Encourage conditions, we conducted planned post-hoc comparisons for just those two conditions. The results showed that the Taught condition monitored their memory performance marginally better than the Encourage condition, $t(17) = 1.92$, $SE = 0.14$, $p = 0.06$, suggesting that explicit instructions early in training may improve monitoring on subsequent, novel tasks.

As before, we computed the proportion of trials on which high bet was selected for correct and incorrect trials. Again, the Taught condition participants were better able to select discriminately. Proportions for correct/incorrect trials were: Taught: 0.66/0.24, Encourage: 0.54/0.43, Control: 0.71/0.41. The data are presented in Panel B of Figure 4—as is shown, the steepest slope lies with the Taught condition. The ANOVA resulted in a main effect of Trial type, $F(1, 28) = 20.64$, $MSE = 0.75$, $d = 0.42$, and a marginal interaction between Trial type and Condition, $F(2, 28) = 3.02$, $MSE = 0.11$, $d = 0.18$, $p = 0.06$, indicating the largest discrepancy between proportion of high bet for correct and trials in the Taught condition.

As before, there were no significant differences in memory performance for the three conditions, nor were there any differences in risk preference.

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## Discussion

Our first critical finding was that children develop a metacognitive monitoring ability spontaneously through experience. Although the children in the Encourage condition did not perform significantly well during the first session of training, by session 2, their correlations were significantly positive. Thus, the results showed that children in first grade can and do monitor their memories accurately, particularly when using a behavioral measure such as betting. Our second critical finding was that when given explicit instructions—the Taught condition—about how to monitor one's memories, optimal decisions were achieved at a faster rate—within one session of training—and those improvements continued to obtain for subsequent and novel tasks.

The data speak to the natural development of metacognitive monitoring processes in young learners. Harris (1992) has proposed that children are introspectively aware of their own mental states and may use this awareness to infer the mental states of other people through a kind of role-taking or simulation process. Shultz (1980; 1991) argues that, by age 3, children possibly develop an early concept of intentions—positing an internal mental state that guides behavior. This ability, they argue, improves by age 4. By the end of the preschool period, children appear to have acquired some important truths about the mental state of knowing. However, in general they seem to have only a hazy conception of what it means for someone to know something and about how knowledge is acquired (Flavell, 1999; Perner, 1991). It has also been found that appreciable understandings of the mind as constructive processors arrive in middle childhood (Carpendale and Chandler, 1996; Fabricius and Schwanenflugel, 1994; Pillow, 1995; Wellman and Hickling, 1994). All of the above characterize a gradual development of metacognitive monitoring abilities, culminating at approximately the beginning of elementary school—age 5. The data presented here empirically support this notion that, indeed, at around age 5, most children seem able to report judgments of certainty and uncertainty through betting.

Many researchers and educators have also theorized about the notion that monitoring skills—the ability to know and not know—develops so that learning strategies will subsequently develop. For example, in adults, it has been found that metacognitive judgments may be used to systematically control study strategies such as study-time allocation (See Son and Metcalfe, 2000, for a review) and spacing strategies (Son, 2004). In education, Willingman (2003-2004) has also proposed that when a student believes he or she knows the material, he or she will cease attempting to learn more—a type of study-time allocation strategy guided by one's metacognitive monitoring judgments. He further questions, however, why it is that students, at times, are mistaken about what they do and do not know. His proposal is that there should be strategies that teachers can implement in the classroom. According to Willingham, teachers can help students think about their own knowledge in ways that provide more accurate assessments of what they know and don't know. This proposal complements the ideas of Schneider (1985) who thought that children have difficulty monitoring their own memories because they rarely think about their own memories. In agreement with those past proposals, we emphasize here that there be a shift from the development of individual learning strategies to the explicit teaching of learning strategies.

Our data provide empirical evidence of the beneficial effects of "teaching" monitoring strategies to young learners—in support of Willingham's (2003-2004) proposal. Although metacognitive abilities develop naturally at very young ages—as was demonstrated by the Encourage condition—children who were explicitly taught to use the appropriate betting monitoring strategies had a faster learning curve. More importantly, children who were explicitly taught obtained a faster learning to learn curve—demonstrated by the improvement in monitoring accuracy when given a novel task.

The current education system emphasizes the learning of a particular topic—history, math, vocabulary, science are a few examples. However, less emphasis is placed on how students learn to learn any particular topic—a general metacognitive strategy. This study showed that by explicitly instructing students to become more aware of their own learning, monitoring accuracy may be improved—. Further research might explore whether, as a result of improving monitoring accuracy, children's control of their own study strategies may subsequently develop at a more accurate, or faster rate.

## References

1. Carpendale, J. I. & Chandler, M. J. (1996). On the distinction between false belief understanding and subscribing to an interpretive theory of mind. Child Development, 67, 1686-1706.

2. Dunlosky, J. & Nelson, T. O. (1992). Importance of the kind of cue for judgments of learning (JOL) and the delayed-JOL effect. Memory & Cognition, 20, 374-380.

3. Fabricius ,W. V. & Schwanenflugel, P. J. (1994). The older child's theory of mind. In A. Demetriou & A. Efklides (Eds.), Intelligence, mind, and reasoning: Structure and development. Advances in psychology. (pp. 111-132). Amsterdam, Netherlands: North-Holland/Elsevier Science Publishers.

4. Flavell, J. H. (1999). Cognitive Development: Children's Knowledge About the Mind. Annual Review of Psychology, 50, 21-45.

5. Gruneberg, M. M., & Monks, J. (1974). "Feeling of knowing" and cued recall. Acta Psychologica, 38, 257-265.

6. Hamman, D., Berthelot, J., Saia, J., & Crowley, E. (2000). Teachers' coaching of learning and its relation to students' strategic learning. Journal of Educational Psychology, 92, 342-348.

7. Hampton, R. R. (2001). Rhesus monkeys know when they remember. Proceedings of the National Academy of Sciences, 98, 5359-5362.

8. Harris ,P. L. (1992). From simulation to folk psychology: The case for development. Mind & Language. 7, 120-144.

9. King, J. F., Zechmeister, E. B., & Shaughnessy, J. J. (1980). Judgments of knowing: The influence of retrieval practice. American Journal of Psychology, 93, 329-343.

10. Koriat, A. (1975). Phonetic symbolism and feeling of knowing. Memory & Cognition, 3, 545-548.

11. Koriat, A. (1993). How do we know what we know? The accessibility model of the feeling of knowing. Psychological Review, 100, 609-639.

12. Koriat, A. (1995). Dissociating knowing and the feeling of knowing: Further evidence for the accessibility model. Journal of Experimental Psychology: General, 124, 311-333.

13. Koriat, A. (1997). Monitoring one's own knowledge during study: A cue-utilization approach to judgments of learning. Journal of Experimental Psychology: General, 126, 349-370.

14. Koriat, A. (1998). Metamemory: The feeling of knowing and its vagaries. In M. Sabourin & F. Craik (Eds.), Advances in psychological science, Vol. 2: Biological and cognitive aspects (pp. 461-479). Hove, England UK: Psychology Press.

15. Koriat, A. & Goldsmith, M. (1996). Monitoring and control processes in the strategic regulation of memory accuracy. Psychological Review, 103, 490-517.

16. Koriat, A. & Goldsmith, M. (1998). The role of metacognitive processes in the regulation of memory performance. In G. Mazzoni and T.O. Nelson (Eds.), Metacognition and cognitive neuropsychology: Monitoring and control processes (pp.97-118), Mahwah, NJ: Erlbaum.

17. Koriat, A., Lichtenstein, S., & and Fischhoff, B. (1980). Reasons for confidence. Journal of Experimental Psychology: Human Learning and Memory, 6, 107-118.

18. Kornell, N., Son, L. K., & Terrace, H. (2007). Transfer of metacognitive skills and hint seeking in monkeys. Psychological Science, 18, 64-71.

19. Leonesio, R. J., & Nelson, T. O. (1990). Do different metamemory judgments tap the same underlying aspects of memory? Journal of Experimental Psychology: Learning, Memory, and Cognition, 16, 464-470.

20. Mazzoni, G. & Nelson, T. O. (1995). Judgments of learning are affected by the kind of encoding in ways that cannot be attributed to the level of recall. Journal of Experimental Psychology: Learning, Memory, and Cognition, 21, 1263-1274.

21. Metcalfe, J. (1986). Feeling of knowing in memory and problem solving. Journal of Experimental Psychology: Learning, Memory, and Cognition, 12, 288-294.

22. Metcalfe, J., Schwartz, B. L., & Joaquim, S. G. (1993). The cue-familiarity heuristic in metacognition. Journal

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of Experimental Psychology: Learning, Memory, and Cognition, 19, 851-864.
23. Metcalfe, J., & Shimamura, A. P. (1994). Metacognition: knowing about knowing. Cambridge, MA: MIT Press.
24. Moley, B. E., Hart, S. S., Leal, L., Santulli, K. A., Rao, N., Johnson, T., & Hamilton, L. B. (1992). The teacher's role in facilitating memory and study strategy development in the elementary school classroom. Child Development, 63, 653-672.
25. Nelson, T. O., & Dunlosky, J. (1991). When people's judgments of learning (JOL) are extremely accurate at predicting subsequent recall: The delayed-JOL effect. Psychological Science, 2, 267-270.
26. Nelson, T. O., & Dunlosky, J. (1994). How shall we explain the delayed-judgment-of-learning effect? Psychological Science, 3, 317-318.
27. Nelson, T. O., & Narens, L. (1990). Metamemory: A theoretical framework and new findings. In Bower, G.H. (Ed.), The psychology of learning and motivation (Vol.26, pp.125-141), New York: Academic Press.
28. Nelson, T. O., & Narens, L. (1994). Why investigate metacognition? In J. Metcalfe, & A.P. Shimamura (Eds.), Metacognition: Knowing about knowing (pp. 1-25). Cambridge, MA: MIT Press.
29. Perner, J. (1991). Understanding the representational mind. Cambridge, MA: MIT Press.
30. Pillow ,B. H. (1995). Two trends in the development of conceptual perspective-taking: An elaboration of the passive-active hypothesis. International Journal of Behavioral Development, 18, 649-676.
31. Schneider, W. (1985). Developmental trends in the metamemory-memory behavior relationship: An integrative review. In D. L. Forrest-Pressley, G. E. McKinnon, & T. G. Waller (Eds.), Cognition, metacognition, and human performance, Vol I, pp. 57-109, New York, Academic Press.
32. Shields, W. E., Smith, J. D., & Washburn, D. A. (1997). Uncertain responses by humans and Rhesus monkeys (Macaca mulatto) in a psychophysical same-different task. Journal of Experimental Psychology: General, 126, 147-164.
33. Shultz ,T. R. (1988). Assessing intention: A computational model. In J. W. Astington and P. L. Harris (Eds.), Developing theories of mind. (pp. 341-367). New York, NY: Cambridge University Press.
34. Shultz, T. R. (1991). Modelling embedded intention. In D. Frye & C. Moore. (Eds.), Children's theories of mind: Mental states and social understanding. (pp. 195-218). Hillsdale, NJ, England: Lawrence Erlbaum Associates.
35. Smith, J. D., Schull, J., Strote, J., McGee, K., Egnor, R., & Erb, L. (1995) The uncertain response in the bottlenosed dolphin (Tursiops truncates). Journal of Experimental Psychology: General, 124, 391-408.
36. Smith, J. D., Shields, W. E., Allendoerfer, K. R., &Washburn, D. A. (1998). Memory monitoring by animals and humans. Journal of Experimental Psychology: General, 127, 227-250.
37. Smith, J. D., Shields, W. E., Schull, J., & Washburn, D. A. (1997). The uncertain response in humans and animals. Cognition, 62, 75-97.
38. Son, L. K. (2004). Metacognitively-controlled spacing of study. Journal of Experimental Psychology: Learning, Memory, and Cognition, 30, 601-604.
39. Son, L. K., & Kornell, N. (2005). Meta-confidence judgments in rhesus macaques: Explicit versus implicit mechanisms. In Terrace, H.S. & Metcalfe, J. (Eds.), The Missing Link in Cognition: Origins of Self-Knowing Consciousness. Oxford University Press.
40. Son, L. K., Kornell, N., & Terrace, H. S. (2003). Confidence judgments by rhesus macaques on a serial memory task. Poster presented at the Annual Meeting of the Psychonomic Society, Nov. 6 - 9, Vancouver, Canada.
41. Son, L. K., & Metcalfe, J. (2000). Metacognitive and control strategies in study-time allocation. Journal of Experimental Psychology: Learning, Memory, and Cognition, 26, 204-221.
42. Thiede, K. W., & Dunlosky, J. (1994). Delaying students' metacognitive monitoring improves their accuracy in predicting their recognition performance. Journal of Educational Psychology, 86, 290-302.
43. Thiede, K. W., & Dunlosky, J. (1999). Toward a general model of self-regulated study: an analysis of selection of items for study and self-paced study time. Journal of Experimental Psychology: Learning, Memory, and Cognition, 25, 1024-1037.
44. Tulving, E., & Madigan, S. A. (1970). Memory and

verbal learning. In P. H. Mussen & M. R. Rosenzweig (Eds.), Annual Review of Psychology. Palo Alto, CA: Annual Reviews.
45. Vesonder, G., & Voss, J. (1985). On the ability to predict one's own responses while learning. Journal of Memory and Language, 24, 363-376.
46. Wellman, H. M. & Hickling ,A. K. (1994). The mind's "I": Children's conception of the mind as an active agent. Child Development, 65, 1564-1580.
47. Widner, R. L., & Smith, S. M. (1996). Feeling-of-knowing judgments from the subject's perspective. 46. American Journal of Psychology, 109, 373-387.
48. Willingham, D. T. (2003-2004). How we learn: Why Students Think They Understand—When They Don't. American Educator.