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Giftedness and Metacognition: A Short-Term Longitudinal Investigation of Metacognitive Monitoring in the Classroom

Kate E. Snyder[1], John L. Nietfeld[2], and Lisa Linnenbrink-Garcia[1]

Abstract

The current study investigated differences in metacognition between high school gifted ($n = 44$) and typical ($n = 23$) students and examined local calibration accuracy as a potential mechanism for partially explaining superior exam performance by gifted students. Metacognition was measured using student self-reports of metacognitive awareness, acquired at the start of a semester-long course on biology, and students' global (pre- and posttest) and local (item-by-item) confidence judgments to assess monitoring across four biology exams over the course of one semester. Gifted students outperformed typical students on both local and global postdictive measures of calibration. However, there were no statistically significant differences in global predictive judgments or calibration bias. Local, item-by-item calibration accuracy partially mediated the relation between giftedness and exam performance. Implications for both theory and practice are discussed.

Keywords

gifted, metacognition, calibration, self-regulated learning

Metacognition can be broadly conceptualized as the ability to understand, regulate, and use one's cognitive processes in a constructive manner (Flavell, 1979). It is widely viewed as a critical hallmark of expert performance in that experts organize greater amounts of knowledge in a more effective manner, use more appropriate strategies, and regulate their thinking and performance more effectively than nonexperts. Some researchers in the field of gifted education have hypothesized that gifted individuals are distinct from their typical peers because they think like experts, particularly within the individual's area of exceptional ability (Carr & Taasoobshirazi, 2008; Jaušovec, 1998). Similarly, Sternberg (2001) conceptualized giftedness as developing expertise in which gifted students acquire expertise at a more rapid rate than typical students. As such, gifted individuals should be more proficient, and potentially more expert-like, in their understanding and use of metacognitive strategies.

Several researchers have noted that much of the research examining metacognition and giftedness has focused on memory tasks or reading comprehension, often in laboratory settings (Carr & Taasoobshirazi, 2008; Martini & Shore, 2008). Furthermore, this prior laboratory work was mostly conducted with younger children (Alexander & Schwanenflugel, 1996). More recently, researchers conducted more ecologically valid studies by exploring metacognition and self-regulation in gifted adolescents in middle school and high school science classrooms. Among gifted students, there was no difference in the use of self-reported self-regulatory strategies between 10th and 12th grade science students (Tang & Neber, 2008), or in self-reported cognitive and self-regulatory strategies between elementary and high school gifted students (Neber & Schommer-Aikins, 2002). Self-reported self-regulated learning was strongly linked to adaptive motivational beliefs but only weakly linked to scientific inquiry skills (Yoon, 2009). However, because these studies did not include a comparison group of typical students, it is difficult to draw conclusions regarding differences between metacognitive processing in gifted and typical students.

Accordingly, the current study extends prior research by examining differences in metacognition between gifted and typical high school students in the classroom context. Specifically, we investigated differences between gifted and typical high school students using several indicators of metacognitive ability, including local and global calibration accuracy and calibration bias during in-class science exams. To measure potential metacognitive skill gains, we employed

[1]Duke University, Durham, NC, USA
[2]North Carolina State University, Raleigh, NC, USA

Corresponding Author:
Kate E. Snyder, Department of Psychology & Neuroscience, Duke University, PO Box 90086, Durham, NC 27708-0086, USA
Email:kef17@duke.edu

a short-term longitudinal design in which we measured performance over the course of four exams in one semester. Furthermore, we examined whether more accurate metacognitive processing on an item-by-item level helped explain, at least in part, gifted adolescents' superior exam performance. Though not a specific goal of the current study, this design may also inform us about metacognition in typical students.

Theoretical Background

Metacognition can be conceptualized as having two primary components: knowledge of cognition and regulation of cognition (Brown, 1987; Flavell, 1987; White & Frederiksen, 2005). Knowledge of cognition encompasses stored knowledge about cognitive processes, strategies, and one's own cognitive abilities. This knowledge consists of knowing what strategies to use, how to use them, and when to use them (Baker, 1989; Schraw, 1998). Knowledge of cognition is a critical component of metacognition in that individuals need to have general knowledge about various learning strategies, including how and when to use them (Baker, 1989; Schraw, 1998). Prior research suggests gifted students possess more metacognitive knowledge, particularly declarative knowledge, than typically developing students (Alexander, Carr, & Schwanenflugel, 1995; Carr, Alexander, & Schwanenflugel, 1996). These differences follow a monotonic pattern of development into high school (Alexander et al., 1995). Interestingly, even gifted students with learning disabilities have shown greater knowledge of cognition than typical students with learning disabilities (Hannah & Shore, 1995).

However, simply possessing good metacognitive knowledge is not sufficient for effective metacognition. One needs to effectively implement strategies and monitor performance (e.g., regulate cognition) in order to see benefits. Regulation of cognition refers to active monitoring of cognitive processes and the actual use of strategies employed (Flavell, 1979; Schraw, 1998). Components include planning, information management, monitoring, debugging, and evaluation (Baker, 1989; Schraw, 1998). One particularly important and challenging form of regulation of cognition is metacognitive monitoring, which is the active regulation and awareness of one's comprehension and performance on a task (Butler & Winne, 1995; Schraw, 1998; Schraw & Moshman, 1995). Calibration, a form of metacognitive monitoring referring specifically to the match between one's perception or judgment of one's performance with one's actual performance, is essential for self-regulation and effective learning (Nietfeld, Cao, & Osborne, 2006; Stone, 2000; Thiede, Anderson, & Therriault, 2003). Well-calibrated students often perform better, make more accurate predictive and postdictive global calibration judgments, judge their own metacognitive ability more accurately, and are able to use information gained during testing to estimate their final performance level (Nietfeld & Schraw, 2002; Schraw, 1994). Metacognitive monitoring is inherently complex in that students likely draw on reserves of working memory (Schwartz, 2008) and background knowledge (Nietfeld & Schraw, 2002) to effectively monitor performance. As such, it is an important aspect of metacognition to examine, especially in comparing typical and gifted students.

Monitoring accuracy is measured using a variety of indices. The current study used measures of calibration, or absolute accuracy, in which students' confidence judgments were matched against actual performance (Dunlosky & Metcalfe, 2009). This type of assessment is recommended for studies that wish to examine changes in accuracy over time (Dunlosky & Metcalfe, 2009; Nietfeld, Cao, & Osborne, 2005). In the current study, calibration accuracy was considered as the absolute value of the difference between a student's confidence judgment and actual performance and was measured at both the local (item-by-item) level and the global (pre- or posttest) level (Schraw, 1994). Calibration bias was also measured and conceptualized as the direction of error in calibration inaccuracy, whereby positive bias indicated overconfidence and negative bias indicated underconfidence (Dunlosky & Metcalfe, 2009).

Accurate global monitoring can also prove to be a difficult skill. Predicting one's performance on an academic task or estimating one's readiness to complete a task (one form of global monitoring) is an important, yet difficult endeavor at any age (Baker, 1989; Hacker, Bol, Horgan, & Rakow, 2000). Prediction is a particularly advanced skill because it requires the individual to not only assess the breadth of their current knowledge base but also estimate the difficulty of the task and estimate future performance based on those judgments. Furthermore, improvements in predictive calibration accuracy have been demonstrated only in students who consistently perform well on exams (Bol & Hacker, 2001). In contrast, lower performing students continue to struggle with both assessing their general knowledge of the subject and predicting performance on a test (Hacker et al., 2000).

Postdiction, another form of global calibration, is defined as reflective evaluation in a global sense once one has completed a task or exam. Postdictive judgments only require the student to reflect on the accuracy of past performance and thus, are often more accurate than predictive judgments (Baker, 1989; Bouffard-Bouchard, Parent, & Larivée, 1993; Nietfeld et al., 2005), even among lower performing students (Hacker et al., 2000). However, Schraw (1994) found that knowledge of cognition supported accurate postdictive evaluations: Only students high in knowledge of cognition used information gained during testing to better evaluate their performance. Students low in knowledge of cognition showed no improvement over their initial predictive judgments.

How do gifted students compare with typical students with regard to metacognitive monitoring? In prior research, there was no significant relation between general ability (as measured by the Raven's Progressive Matrices) and monitoring ability (Nietfeld & Schraw, 2002). Moreover, Greene, Moos, Azevedo, and Winters (2008) found no differences in the use of monitoring between gifted and typical middle school students on a challenging think-aloud task, despite better performance among the gifted students. Accurate metacognitive monitoring is generally difficult for all students, even for those who are gifted (Alexander et al., 1995). However, some evidence suggests that gifted students may possess the mental capabilities necessary for successful metacognitive monitoring. For example, gifted individuals displayed more efficient working memory (Calero, García-Martín, Jiménez, Kazén, & Araque, 2007; Dark & Benbow, 1991), which is a factor in managing the mental demands of effective metacognitive monitoring. Jaušovec (1998) found that gifted young adults were more neurologically efficient than nongifted young adults during problem-solving tasks, particularly when problems were difficult. Specifically, gifted individuals more effectively activated portions of the brain needed for the task at hand. In addition, both knowledge of the domain at hand and knowledge of cognition are related to accurate monitoring ability (Nietfeld & Schraw, 2002). Although these individual factors do not directly provide evidence that gifted individuals are more proficient in metacognitive monitoring than their typical peers, some view these findings as evidence of potential for advantages in metacognitive tasks (Carr & Taasoobshirazi, 2008).

In summary, metacognition is an essential component of learning and is a notable characteristic of how experts organize information (Glaser & Chi, 1988; Sternberg, 2001). Some theorists assert that gifted individuals, even at young ages, are distinct from their typical peers in that they think like experts in a more organized, high-level manner. A review of the relevant literature finds that research on metacognition and giftedness has been largely inconclusive; however, more efficient working memory in the gifted (Calero et al., 2007) suggests that gifted students may have an advantage in demanding tasks such as metacognitive monitoring. Evidence that gifted individuals possess greater domain knowledge and have higher levels of knowledge of cognition (Alexander et al., 1995) also supports this hypothesis. Thus, a process-level investigation into why gifted students perform better than typical students on exams is critical. What mechanisms may be driving this difference? We examined the role of monitoring accuracy to study these relations.

Of note, some of the inconclusive findings regarding giftedness and metacognition may be due to gaps in the literature. Researchers such as Martini and Shore (2008) noted that the majority of studies focused on general tasks in reading comprehension or memory, using mostly younger children in a laboratory setting. Thus, there is still a need for studies exploring the relation between metacognition and giftedness in an actual classroom context (Alexander et al., 1995), particularly in mathematics and science (Carr & Taasoobshirazi, 2008). Although some prior work examined factors such as cultural, gender, and grade differences for the use of self-reported strategy usage in gifted elementary, middle, and high school students (e.g., Neber & Schommer-Aikins, 2002; Tang & Neber, 2008; Yoon, 2009), these studies did not compare gifted students against typical students. By focusing our examination on both gifted and typical adolescents, the current study aimed to further our understanding of how metacognition functions for gifted and typical students in an ecologically valid setting.

Current Study

We examined differences between gifted and typical adolescents using a sample of students who shared similar environmental factors (same teacher, curricula, and exams). To gain a deeper understanding of students' awareness of and use of metacognitive strategies, we employed a multimethod approach in which students estimated their metacognitive abilities through a self-report questionnaire and by making global (pre- and posttest) and local (item-by-item) confidence judgments to assess monitoring across four biology exams over the course of one semester. We examined mean-level differences across time, as well as investigated if local calibration accuracy mediated the relation between gifted status and exam performance.

We expected an advantage for gifted students in self-reported knowledge and regulation of cognition based on prior findings (Alexander et al., 1995; Hannah & Shore, 1995). We also expected gifted students to excel at calibration, due to greater hypothesized working memory functioning that would better equip them to handle the demands of metacognitive monitoring (Calero et al., 2007; Dark & Benbow, 1991; Jaušovec, 1998). Furthermore, we expected greater short-term gains in calibration accuracy among gifted students because gifted students would benefit more from repeated practice of making monitoring judgments. We hypothesized more accurate predictions for exam performance among gifted students because of greater domain knowledge (Alexander et al., 1995). Global postdictive calibration should also be more accurate among gifted students if these students indeed have greater knowledge of cognition (Alexander et al., 1995) and gain more information about exam performance during the exam because of accurate local monitoring ability (Schraw, 1994). Finally, we predicted that local calibration accuracy would partially mediate the relation between giftedness and exam performance, which would provide one explanation for high achievement among gifted students. Local calibration accuracy was chosen as a mediating variable because it measures how well students are able to monitor and judge their performance on each individual exam item, and thus may partially explain the relation between giftedness and test performance.

Method

Participants

A total of 67 students enrolled in one of five semester-long 10th-grade biology courses at a public high school in southeastern United States participated in the study. All five classes were taught by the same teacher using identical exams and curricula. Three of the classes were a homogeneous grouping of only gifted students (n = 44) and the remaining two classes were a homogeneous grouping of typical students (n = 23).

Gifted status was determined by the school district following criteria set forth by the state's Board of Education. Students could be identified as gifted in one of two ways. Option A required students to score in the 99th percentile (for students younger than third grade) or above the 96th percentile (for students third grade and older) on a standardized test of ability, as well as score above the 90th percentile on a standardized test of achievement or score more than 90 (out of 100 total points) on an evaluation of a product or performance, judged by an expert. Option B required students to qualify under three of the four following criteria: scoring above the 96th percentile on a test of standardized ability, scoring above the 90th percentile on an achievement test in reading or mathematics, scoring above the 90th percentile on a standardized test of creativity, and scoring above the 90th percentile on a standardized motivational rating scale ("Education Program for Gifted Students," 1998). All the students in the courses designated as gifted qualified for the course in one of two aforementioned manners.

Measures and Procedures

Students completed both a short form of the Raven's Progressive Matrices (Arthur, 1994) that measured general reasoning ability and the Metacognitive Awareness Inventory (a self-report measure of metacognitive awareness) at the start of the semester prior to taking any exams. On each of the four exams over the course of the semester, students completed both local (item-by-item) and global (test-level) confidence judgments.

Raven's Progressive Matrices. To confirm gifted status, the Raven's Progressive Matrices (Raven, 1962) was administered to all participating students. The Raven's Progressive Matrices is a measure of general reasoning ability (Carpenter, Just, & Shell, 1990). Participants completed the validated short form (Arthur, 1994), which contains 13 items. Other studies have also used the Raven's Progressive Matrices as a measure of general ability (Nietfeld et al., 2006; Nietfeld & Schraw, 2002). Internal reliability for the Raven's test was acceptable ($\alpha = .75$). As expected, the gifted students (M = .70, SD = .16) scored higher than the typical students (M = .44, SD = .23), $F(1, 65) = 25.85$, $p > .001$, lending support for their gifted status assigned by the school system.

Metacognitive Awareness Inventory. MAI is a 52-item questionnaire used to assess metacognitive awareness (Schraw & Dennison, 1994). The first subscale, measuring knowledge of cognition, consisted of 17 items assessing one's knowledge about metacognitive strategies, including what they are, how to use them, when to use them, and one's ability regarding the strategies ($\alpha = .81$). A sample item evaluating knowledge of cognition is, "I am a good judge of how well I understand something." The second subscale, measuring regulation of cognition, consisted of 35 items assessing five components of regulation: planning, information management, monitoring, debugging, and evaluation ($\alpha = .85$, sample item: "I slow down when I encounter important information"). Students responded to items using a 5-point Likert-type scale (1 = *strongly disagree*, 5 = *strongly agree*). The average response for both subscales was calculated.

Exam performance. Exam performance was measured using the number of correctly answered test items on each of four biology exams. Various types of questions were used for the four exams, including multiple-choice, fill-in-the-blank, matching, and diagram identification. The first exam consisted of 58 mixed-type items, the second exam consisted of 47 mixed-type items, the third exam consisted of 38 multiple-choice items, and the fourth exam consisted of 30 mixed-type items, with each exam covering a different biology unit. Each exam assessed students' knowledge and understanding of the content from the unit just completed; none of the exams was cumulative. All items were scored as a 1 if the question was answered correctly and as a 0 if the response was incorrect. Exam scores were standardized for comparison by dividing the total correct by the total possible score. There was high internal reliability across all four exams (Exam 1 $\alpha = .87$, Exam 2 $\alpha = .90$, Exam 3 $\alpha = .89$, Exam 4 $\alpha = .86$).

Measures of calibration accuracy. Global predictive calibration accuracy was measured by asking students before each exam to predict how many questions they would answer correctly. The instructions at the start of the test read, "BEFORE the test: I think I will answer ___ questions correctly out of (the number of total questions on the exam)." Global postdictive accuracy was measured by asking students to estimate how many questions they believed they answered correctly immediately after they finished the test. The instructions read, "AFTER the test: I think I answered ___ questions correctly out of (the number of total questions on the exam)." The estimate was then divided by the number of total questions to standardize for comparison across tests, and the absolute difference between test performance (as a proportion score) and the estimate (as a proportion score) was used as a measure of global accuracy for both predictive and postdictive estimates. Agreement between one's postdictive judgment and actual performance gives a measure of global calibration accuracy (Schraw, 1994).

For local calibration accuracy, confidence judgments (Schraw, 1995) were assessed for all items on each of the four exams. Participants recorded confidence judgments for each item on all four exams by making a slash-mark along a 100-mm line (Schraw & Roedel, 1994). Each line had a number that corresponded with the exam item. The left end of the 100-mm line was marked with 0% and the right end of the line was marked with 100%. Instructions at the beginning of each exam read, “Please place a slash along the line that shows how confident you are that your answer is correct.” All confidence judgment lines were given on separate page apart from the exam. No training for how to make or improve metacognitive monitoring judgments was given.

An example of a typical exam question with its corresponding judgment line is as follows:

> Some flatworms have clusters of nerve cells that control the nervous system. Each cluster is called a(n):
> a. ganglion
> b. brain
> c. eyespot
> d. flame cell
>
> ____
> 0% 100%

Calibration was measured on both an index of accuracy (Keren, 1991) and an index of bias (Yates, 1990). Calibration accuracy is calculated by taking the absolute value of the difference between confidence judgments and performance for each item, then summing all items and dividing by the total number of exam items. For example, a confidence judgment of 64 on a correct item would be calculated as the absolute value of $1 - .64 = .36$. Lower scores represent more accurate calibration and monitoring. A 0 represents perfect accuracy and a 1 represents perfect inaccuracy. Calibration bias, which may be conceptualized as the direction of monitoring inaccuracy or error, is calculated by taking the signed difference between the average confidence and average performance score on each exam. Positive scores represent overconfidence, and negative scores indicate underconfidence. Greater distance from 0 represents greater bias. For example, a student who receives a score of 90% on an exam and has an average confidence rating of 80 for that exam would get a bias score of $-.10$, ($.80 - .90$), indicating underconfidence.

Results

To examine differences between gifted and typical students' metacognition and its relation to exam performance, we conducted as series of analyses. Bivariate correlations and descriptive statistics are presented in Tables 1 and 2, respectively.

Comparison of Gifted and Typical Students on the Metacognitive Awareness Inventory

Differences between gifted and typical students' self-reported knowledge of cognition and regulation of cognition were examined using a multivariate analysis of variance (MANOVA) with gifted status as the between-subjects variable. The multivariate effect of gifted status was not statistically significant, $F(2, 65) = .79$, $p = .45$, $\eta^2 = .02$. This indicates that, contrary to our hypothesis, there were no statistically significant differences between gifted and typical students on the MAI for either self-reported knowledge of cognition (gifted $M = 3.94$, $SD = .46$; typical $M = 3.84$, $SD = .37$) or self-reported regulation of cognition (gifted $M = 3.46$, $SD = .46$; typical $M = 3.31$, $SD = .48$).

Comparison of Gifted and Typical Students on Exam Performance and Global and Local Calibration Accuracy

Exam performance, local calibration accuracy and global calibration accuracy were assessed across the four exams. To examine both mean level differences and changes over time, we conducted a repeated-measures MANOVA across the four dependent measures: exam performance, local calibration accuracy, predictive accuracy, and postdictive accuracy. Time (exams) was included as the within-subjects variable and giftedness was included as the between-subjects variable. There was a significant main effect of time at the multivariate level, $F(12, 36) = 7.22$, $p < .001$, $\eta^2 = .71$. There was also a significant effect of gifted status at the multivariate level, $F(4, 44) = 6.91$, $p < .001$, $\eta^2 = .39$. The multivariate time × giftedness interaction was not statistically significant, $F(12, 36) = 1.10$, $p = .39$, $\eta^2 = .27$. Guided by the overall repeated-measures MANOVA, we conducted a series of follow-up univariate analyses for each outcome for main effects and between-subjects effects. The time × gifted status interaction was not examined further, as it did not reach statistical significance at the multivariate level.

Exam performance. As expected, gifted students ($M = .90$, $SD = .06$) consistently outperformed their typical peers ($M = .79$, $SD = .11$) on all four exams, $F(1, 62) = 33.72$, $p < .001$, $\eta^2 = .35$. This is not surprising given these students' gifted status, but it generally supports the assumption that gifted students would show more knowledge or expertise in biology than their peers. There was also a main effect of time, $F(3, 186) = 23.21$, $p < .001$, $\eta^2 = .27$, such that all students improved test performance over the course of the semester ($M1 = .81$, $SD = .10$; $M2 = .87$, $SD = .10$; $M3 = .88$, $SD = .09$; $M4 = .89$, $SD = .09$). However, most of this improvement occurred between the first and second exams.

Local calibration accuracy. Consistent with our hypothesis, gifted students ($M = .15$, $SD = .08$) were consistently more accurate in their local monitoring judgments than typical students ($M = .24$, $SD = .10$) on average across the four exams, $F(1, 60) = 15.31$, $p < .001$, $\eta^2 = .20$. There was also a main effect of time, $F(3, 180) = 13.44$, $p < .001$, $\eta^2 = .18$, see Figure 1a; accuracy improved from the first to the second exam and became relatively stable through the third and fourth exams ($M1 = .21$, $SD = .09$; $M2 = .16$, $SD = .10$; $M3 = .17$, $SD = .09$; $M4 = .16$, $SD = .10$). This main effect of time was linear, $F(1, 60) = 18.42$, $p < .001$, $\eta^2 = .23$, suggesting an overall improvement in accuracy over time. The effect was also quadratic—$F(1, 60) = 7.48$, $p < .01$, $\eta^2 = .11$—and cubic—$F(1, 60) = 11.25$, $p < .01$, $\eta^2 = .16$—which indicates

Table 1. Bivariate Correlations Among Variables

Measure	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Raven's score	—	.35	.06	.37	.48	.45	.52	–.27	–.25	–.67	–.11	–.11	–.22	–.49*	–.24	–.43*	–.38	–.45*	–.45*	–.04	–.03	.04	–.08
MAI (Knowledge)	.17	—	.60**	.29	.08	–.02	.21	–.44*	–.37	–.29	–.14	–.35	–.28	–.25	.07	–.37	–.04	–.17	–.10	.07	–.15	.14	–.18
MAI (Regulation)	.06	.79***	—	.02	–.12	–.23	.07	–.34	.05	–.01	.06	–.14	.03	.01	.23	–.04	–.09	–.13	.01	–.03	.08	.43*	.04
Exam 1 performance	.33*	.19	.15*	—	.69***	.53*	.67**	–.38	–.55*	–.62**	–.18	–.25	–.46	–.38	–.35	–.86***	–.66**	–.56**	–.46*	–.20	.08	.13	–.24
Exam 2 performance	.23	.27	.09	.46**	—	.83***	.54**	–.50*	–.22	–.80***	–.42	–.28	–.40	–.61**	–.58**	–.66**	–.79***	–.77***	–.47*	.02	–.04	.08	.09
Exam 3 performance	.22	.20	.15	.40**	.36*	—	.62**	–.48*	–.38	–.70**	–.35	–.35	–.56*	–.50*	–.66**	–.54*	–.83***	–.86***	–.76***	.36	.36	.09	.43
Exam 4 performance	.33*	–.20	–.05	.41**	.37*	.03	—	–.48*	–.59**	–.67**	–.26	–.39	–.71**	–.55**	–.45*	–.61**	–.61**	–.66**	–.79***	.12	.39	.36	–.14
Exam 1 prediction	–.23	–.08	.03	–.34*	–.36*	–.18	–.44**	—	.34	.45	.38	.54**	.35	.26	.37	.33	.39	.60**	.29	–.02	–.04	–.43	.00
Exam 2 prediction	–.48**	–.26	–.24	–.32*	.11	.02	–.30	.27	—	.46*	.42	.26	.88***	.49*	.54*	.46*	.17	.39	.51*	–.29	–.45*	–.10	.14
Exam 3 prediction	–.22	–.31*	–.24	–.11	–.13	–.06	–.38*	.44**	.28	—	.49*	.30	.60*	.81***	.55*	.68**	.56*	.75***	.53*	–.04	.20	–.04	.19
Exam 4 prediction	–.28	–.26	–.14	–.19	–.26	–.17	.13	–.03	.27	–.09	—	.31	.74**	.57**	.78***	.29	.10	.54**	.33	–.33	.05	–.36	–.12
Exam 1 postdiction	–.22	–.20	–.17	–.22	–.15	–.29	–.18	.55***	.03	.53***	.26	—	.40	.43*	.33	.50*	.25	.39	.33	–.45*	.05	–.16	–.08
Exam 2 postdiction	–.23	–.47**	–.46**	–.09	.07	–.05	–.05	.15	.55***	.46**	.22	.20	—	.88***	.74**	.42	.35	.55*	.73**	–.56*	–.71**	–.48*	–.09
Exam 3 postdiction	–.16	–.22	–.11	.16	.06	–.16	–.11	.29	.20	.58***	.17	.57***	.53***	—	.59**	.44*	.45	.52*	.42	–.38	.06	–.08	.13
Exam 4 postdiction	–.04	–.12	–.19	.09	.15	–.01	.32	–.22	.03	.00	.42**	.02	.19	.28	—	.42	.59**	.68**	.59**	–.42	–.44	–.23	–.35
Exam 1 LCA	–.47**	–.32*	–.27	–.75***	–.36*	–.58***	–.30*	.27	.37*	.17	.19	.34*	.26	.09	.02	—	.67**	.63**	.56*	.04	.02	–.14	.07
Exam 2 LCA	–.40**	–.41**	–.14	–.45**	–.71***	–.43**	–.43**	.36*	.14	.29	.36*	.26	.29	.25	–.13	.58***	—	.90***	.68**	–.16	–.42	–.17	–.41
Exam 3 LCA	–.26	–.29	–.15	–.23	–.17	–.46**	–.33*	.35*	.12	.29	.09	.42**	.27	.43**	.01	.58***	.61***	—	.76***	–.34	–.35	–.38	–.39
Exam 4 LCA	–.42**	–.28	–.11	–.37*	–.22	–.20	–.68***	.26	.26	.28	.15	.30	.15	.23	.05	.53***	.55***	.74***	—	–.44*	–.64**	–.45*	–.40
Exam 1 local bias	.23	.20	.12	–.39*	–.29	.03	.03	.08	–.22	–.06	–.03	–.18	–.21	–.37*	–.11	–.22	–.09	–.55***	.42**	—	.43	.11	.60**
Exam 2 local bias	.21	.13	.08	–.14	–.55***	–.06	.10	–.02	–.34*	–.15	–.06	–.21	–.48**	–.43**	–.14	–.19	–.13	–.54***	.43**	.63***	—	.45*	.58**
Exam 3 local bias	.25	.25	.13	–.05	–.08	–.21	.33*	–.22	–.28	–.33*	–.10	–.30*	–.40**	–.45**	–.08	–.23	–.37*	–.71***	.71***	.62***	.66***	—	.28
Exam 4 local bias	.14	.09	.15	–.19	–.31*	.13	–.38*	.14	–.01	–.01	–.27	–.22	–.23	–.31*	–.39*	–.22	–.07	–.58***	.34*	.64***	.55***	.60***	—

Note: MAI = Metacognitive Awareness Inventory; LCA = local calibration accuracy. Upper and lower diagonals denote typical and gifted students, respectively.
*$p < .05$. **$p < .01$. ***$p < .001$.

Table 2. Means and Standard Deviations of Variables by Time and Gifted Status

	Measure						
						MAI	
	LCA	Bias	Pre	Post	RPM	KOC	ROC
Exam 1							
Gifted	.19 (.07)	.00 (.01)	.06 (.05)	.05 (.03)			
Typical	.28 (.11)	.01 (.11)	.07 (.07)	.11 (.11)			
Average	.22 (.10)	.00 (.01)	.06 (.06)	.07 (.07)			
Exam 2							
Gifted	.14 (.08)	−.01 (.08)	.07 (.06)	.04 (.03)			
Typical	.22 (.10)	−.02 (.10)	.10 (.09)	.11 (.15)			
Average	.16 (.09)	−.02 (.09)	.08 (.07)	.06 (.09)			
Exam 3							
Gifted	.15 (.08)	−.03 (.10)	.08 (.08)	.05 (.04)			
Typical	.23 (.09)	−.05 (.08)	.13 (.10)	.09 (.08)			
Average	.17 (.09)	−.04 (.09)	.10 (.09)	.06 (.06)			
Exam 4							
Gifted	.14 (.08)	−.03 (.08)	.09 (.07)	.05 (.04)			
Typical	.21 (.10)	−.02 (.11)	.09 (.10)	.10 (.12)			
Average	.16 (.09)	−.03 (.09)	.09 (.08)	.07 (.08)			
Overall							
Gifted	.15 (.08)	−.02 (.09)	.08 (.07)	.05 (.04)	.70 (.16)	3.94 (.46)	3.46 (.46)
Typical	.24 (.10)	−.02 (.10)	.10 (.10)	.11 (.30)	.44 (.23)	3.84 (.37)	3.31 (.48)
Average	.18 (.10)	−.02 (.10)	.09 (.08)	.07 (.08)	.61 (.22)	3.91 (.43)	3.41 (.46)

Note: LCA = local calibration accuracy; Bias = calibration bias; Pre = predictive global calibration accuracy; Post = postdictive global calibration accuracy; RPM = Raven's Progressive Matrices; MAI = Metacognitive Awareness Inventory; KOC = Knowledge of Cognition subscale; ROC = Regulation of Cognition subscale. Data are presented as mean (standard deviation).

that there were several increases and decreases in accuracy across the four exams.

Global calibration accuracy. Contrary to expectations that gifted students would be better able to predict performance, neither group held an advantage in global predictive accuracy, $F(1, 54) = 1.87$, $p = .17$, $\eta^2 = .03$. In the univariate analyses, there was a statistically significant main effect of time for global predictive accuracy, $F(3, 162) = 3.04$, $p = .03$, $\eta^2 = .05$; see Figure 1b. However, these results should be interpreted cautiously as they were not statistically significant in the univariate findings from the MANOVA, $F(3, 141) = 1.09$, $p = .36$, $\eta^2 = .02$. With respect to global postdiction accuracy, the results were as expected. Gifted students ($M = .05$, $SD = .04$) were statistically significantly more accurate than typical students ($M = .10$, $SD = .30$) in their postdictive judgments throughout the semester, $F(1, 52) = 9.65$, $p = .003$, $\eta^2 = .16$; see Figure 1c. However, there was no statistically significant main effect of time, $F(3, 156) = .53$, $p = .66$, $\eta^2 = .01$.

Calibration bias. Calibration bias is interpreted differently from the other monitoring accuracy measures. For this scale, a score of 0 equals no bias, with more positive scores indicating overconfidence and more negative scores indicating underconfidence. Because of the differences in the interpretation of this measure compared with the other measures of calibration, a separate 4 × 2 repeated-measures ANOVA was conducted to examine calibration bias with time (exam) as the within-subjects variable and giftedness as the between-subjects variable. Contrary to expectations, neither group was more over- or underconfident on an item-by-item basis, $F(1, 58) = .088$, $p = .76$, $\eta^2 = 0.0$. However, there was a main effect of time, $F(3, 174) = 5.73$, $p = .001$, $\eta^2 = .09$, that was both linear, $F(1, 58) = 11.47$, $p < .01$, $\eta^2 = .16$, and quadratic in nature, $F(1, 58) = 5.30$, $p = .025$, $\eta^2 = .08$; see Figure 1d. All students began the semester with little calibration bias, became slightly more underconfident in their judgments for the following two exams, and were less underconfident for the fourth exam ($M1 = .00$, $SD = .10$; $M2 = -.02$, $SD = .09$; $M3 = -.04$, $SD = .10$; $M4 = -.02$, $SD = .10$). There was no statistically significant time × giftedness interaction, $F(3, 174) = .82$, $p = .48$, $\eta^2 = .01$.

Calibration Accuracy as a Mediator of the Relation Between Giftedness and Performance

Next, we predicted that local calibration accuracy, a fine-grain measure of self-regulated learning, would partially

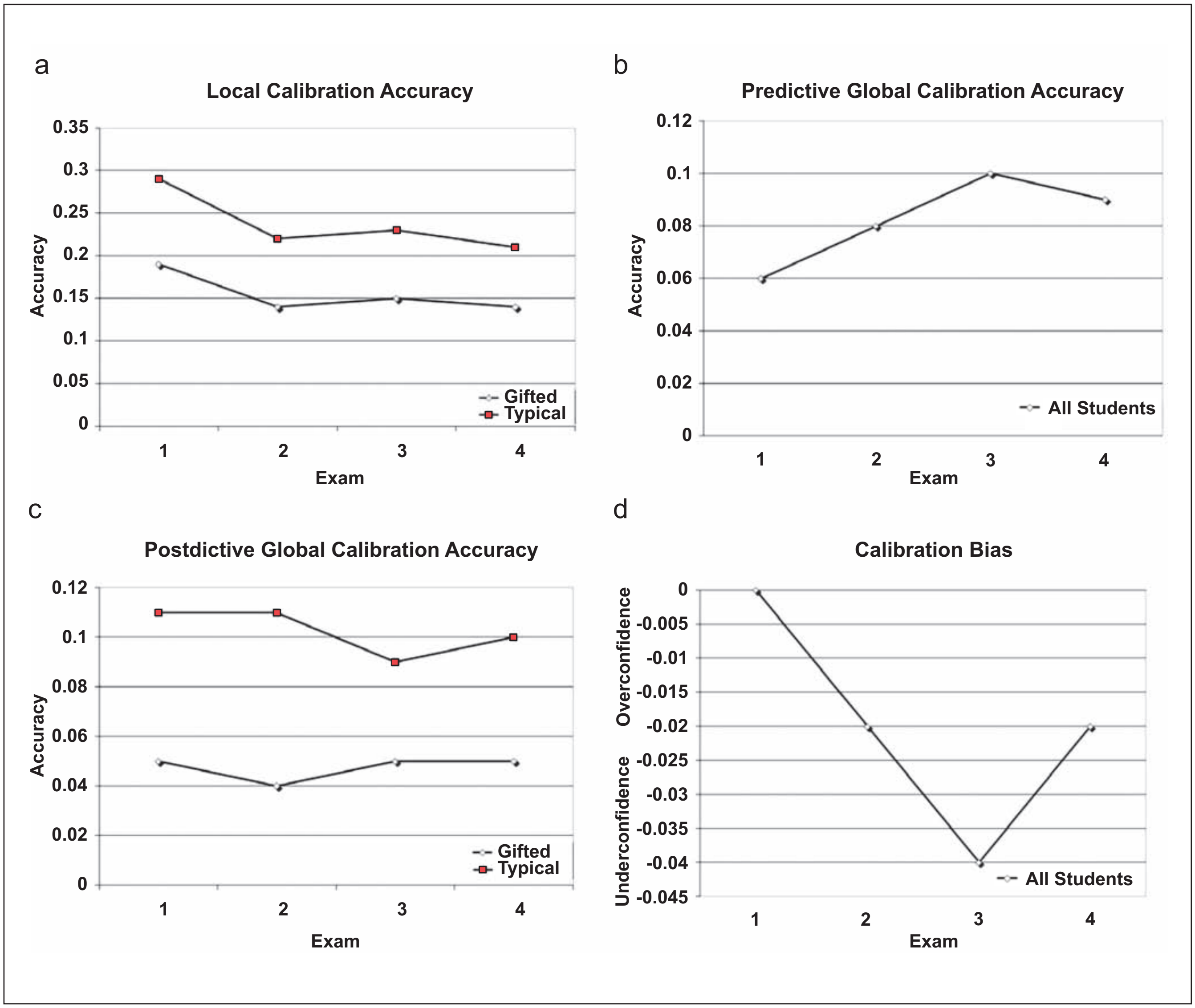

Figure 1. Calibration accuracy and calibration bias: (a) local calibration accuracy where 0 is perfect accuracy; (b) predictive global calibration accuracy; (c) postdictive global calibration accuracy; and (d) calibration bias

explain the relation between giftedness and exam performance. That is, we hypothesized that being able to accurately judge exam performance may assist students in adjusting their responses during the exam and ultimately enhance performance. Thus, if gifted students are better calibrated on an item-by-item basis, this may be another mechanism, apart from heightened ability or intelligence, that helps explain their superior exam performance. Accordingly, we examined local calibration accuracy as a mediator between giftedness and exam performance. Although a mediational analysis with correlational data cannot speak to a causal relation between local calibration accuracy and exam performance, it can help us parse apart whether local calibration accuracy partially explains the relation between giftedness and exam performance.

We conducted a series of multiple regression analyses for each of the four exams to determine if local calibration accuracy partially mediated the relation between giftedness and performance for each exam. Following the guidelines set forth by Baron and Kenny (1986), a number of criteria must be met for mediation to occur. First, there must be a significant relation between the predictor and outcome variables. To examine this, we regressed exam performance on gifted status. Consistent with our earlier ANOVAs, there was a statistically significant relation between giftedness and performance on the first exam ($\beta^* = .59$, $p < .001$, $sr^2 = .34$). Second, the predictor and mediating variables must be significantly related. A multiple regression analysis in which the mediating variable, local monitoring accuracy, was regressed on gifted status indicated that there was a

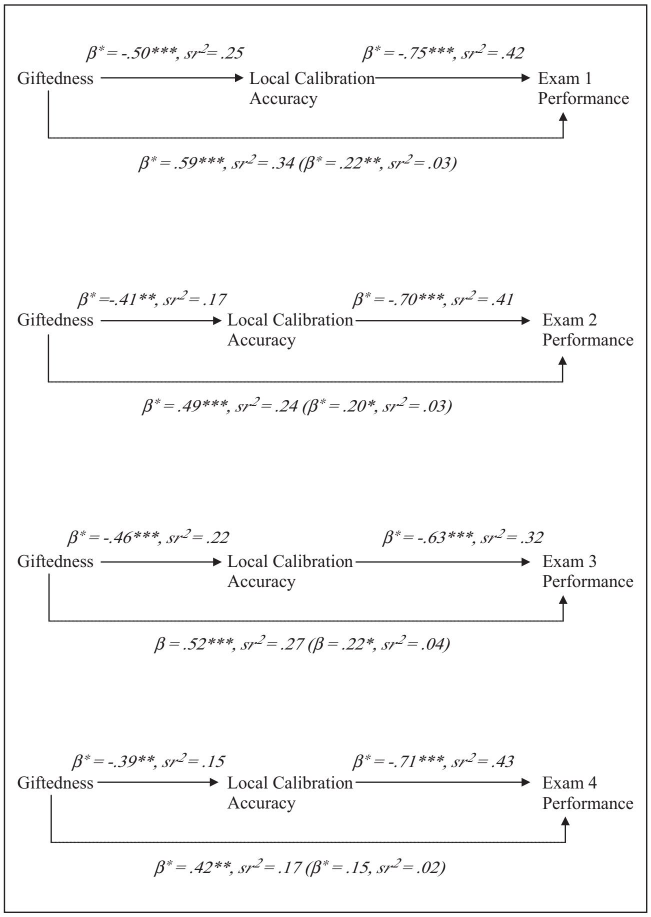

Figure 2. Mediation analyses for Exams 1 through 4

statistically significant relation between gifted status and local calibration accuracy ($\beta^* = -.50$, $p < .001$, $sr^2 = .25$) for the first exam, which was again consistent with the earlier ANOVAs. Finally, we conducted a third hierarchical regression analysis in which exam performance was regressed on gifted status and local monitoring accuracy. The results from this analysis established the two final criteria for mediation. Specifically, local monitoring accuracy was significantly related to first exam performance ($\beta^* = -.75$, $p < .001$, $sr^2 = .42$) and the relation between giftedness and first exam performance decreased from $\beta^* = .59$, $p < .001$, $sr^2 = .34$ to $\beta^* = .22$, $p < .01$, $sr^2 = .03$, when local monitoring accuracy was included in the model (see Figure 2a). The Sobel test (Sobel, 1982) confirmed that this decrease in the association between gifted status and exam performance was statistically significant ($z = 4.27$, $p < .001$). Together, these analyses provide evidence that the relation of gifted status to first exam performance was partially mediated by local calibration accuracy, suggesting that gifted students' ability to accurately monitor performance on an item-by-item level may help to support superior exam performance.

The same series of analyses were conducted for the remaining three exams, yielding a similar pattern of findings (see Figures 2b, 2c, and 2d). Moreover, the Sobel test confirmed mediation for the second ($z = 3.34$, $p < .001$), third ($z = 3.79$, $p < .001$), and fourth ($z = 3.12$, $p < .001$) exams. Although it should be noted that these analyses are based on correlational data and cannot fully address issues of causality based on a lack of full temporal precedence, these analyses provide support for our hypothesis that gifted students' superior local calibration helps to explain, at least in part, why gifted students performed better than typical students on the four exams.

Discussion

Given gifted students' superior cognitive skills, it stands to reason that gifted students may also have a metacognitive advantage relative to typically achieving peers. Findings from the current study partially supported this idea. As expected, gifted students were more accurate in judging performance on an item-by-item level suggesting that gifted students are more able than typical students to identify strengths and weakness at the local level. Gifted students also more accurately judged their performance after the exam than did typical students. Contrary to our hypotheses, there were no significant differences between gifted and typical students in predictive ability or exam bias or in self-reported knowledge or regulation of cognition.

Overall, our findings suggest that gifted students have superior metacognitive abilities both in terms of local item-by-item accuracy and postdictive monitoring. It is important to note that gifted students held an advantage in local monitoring even during the first exam, suggesting that this skill may already be present even at the start of the semester. All students improved local monitoring ability, perhaps because of familiarity with the exam format. However, gifted students maintained the advantage throughout the semester.[1] Gifted students' superior global postdictive monitoring likely reflects an enhanced metacognitive ability among gifted students to reflect on their performance based, in part, on the synthesis of their more accurate item-by-item judgments. It is also possible that these more accurate global postdictive abilities occur because of a history of prior successful exam experiences rather than enhanced monitoring capabilities. That is, if a student consistently performs well on exams, predicting high achievement on yet another exam should result in an accurate postdictive judgment.

Some prior work has shown that gifted students do not always complete tasks more quickly than typical students, but rather, these students invest more time in the planning component of the task (Shore & Lazar, 1996; Steiner, 2003). Accuracy, rather than speed, characterizes metacognitive processes in gifted students (Shore, 2000). As such, it is possible that the gifted students in our sample were better able to reflect on prior knowledge and more accurately monitor performance on the item-by-item level because of more careful planning, thus contributing to better overall performance.

Though the current study did not include a measure of planning, future work would benefit from examining this factor alongside other measures of metacognition.

Our mediational analyses further suggest that gifted students' superior exam performance is at least partially explained by their enhanced local calibration accuracy. It appears gifted students are better skilled in the detailed aspects of test taking that include close monitoring of progress, and this is also reflected in more accurate postdictive assessments of exam performance, as compared with typical students. This finding provides some support for the notion that gifted students are more effective at implementing metacognitive skills in academic tasks, and may help partially explain why gifted students often perform better than typical students on exams. An alternative explanation may be that gifted students are more relaxed and less impulsive while taking exams because of prior good performance. This reduced impulsivity allows the students to be more reflective on each item accuracy judgment. Alternatively, it is also possible that calibration accuracy is mediated by exam performance, which is the reverse of what we posit here. As these data are only correlational in nature, the direction of this relation remains somewhat unclear. However, although it is likely that the relation between local calibration and exam success is reciprocal in nature, these findings provide support for the important relation between local calibration and exam performance. Future work with microgenetic designs may help to isolate temporal precedence and causality between these two constructs.

One interesting finding that we were able to observe by following students across four exams was a mid-semester lag in calibration bias; both typical and gifted students experienced greater underconfidence for the second and third exam. However, it is possible that this lag is an artifact of some aspect of the current study, and future work should aim to replicate it. If this finding is replicated, the middle of the semester may be a time at which students can benefit from teacher intervention in the form of increased scaffolding or monitoring training and feedback. This teacher support could assist both gifted and typical students in obtaining greater calibration between confidence and performance.

Contrary to expectations, our results also suggested that there was no difference between gifted and typical students' self-reported knowledge of cognition or regulation of cognition. The failure to find differences in self-reported regulation of cognition is surprising given that gifted students scored higher on observed measures of regulation of cognition. Moreover, the findings regarding knowledge of cognition are inconsistent with prior research suggesting that gifted students possess greater knowledge of cognition (Alexander et al., 1995; Carr et al., 1996). Furthermore, given that students high in regulation of cognition typically tend to also score high in knowledge of cognition (Schraw, 1994), we would have expected gifted students in the current study, who scored higher in both local and postdictive calibration accuracy, to score higher on the questionnaire assessing knowledge of cognition.

One possible explanation for our failure to find differences between gifted and typical students' knowledge of cognition is that there is a change in the developmental pattern by adolescence. Prior research suggests that gifted students in the early elementary school years surpass their peers in metacognitive knowledge (Schwanenflugel, Stevens, & Carr, 1997). Research investigating grade level differences in self-reported self-regulated learning in science courses has found little difference between 10th- to 12th-grade gifted students (Tang & Neber, 2008) or between elementary to high school (Neber & Schommer-Aikins, 2002). Thus, it is conceivable that by high school, typical students have "caught up" with their gifted peers (Shore, 2000).

One explanation for our lack of differences for self-reported metacognitive knowledge is that typical students may not accurately assess their level of metacognitive knowledge (in other words, they do not know what they do not know with regard to strategy use and their ability to use those strategies effectively and thus may not be reporting them accurately). This fits with our finding that there were no significant differences between gifted and typical students' self-reported regulation of cognition, despite differences based on observed measures of calibration (local and postdictive accuracy). Alternatively, it is also possible that this similarity in metacognitive knowledge for gifted and typical students may also occur more frequently in classes that are not specifically designed to challenge students such as the one examined in the current study, as both typical and gifted students may perceive that they are able to accurately self-regulate learning in this context.

The current study is strengthened by its ecological validity in that we examined differences between gifted and typical adolescents using both a self-report method of metacognition and real-time measures of global calibration, local calibration, and calibration bias. Although it is generally accepted that metacognitive monitoring is a difficult skill to master at any age level, including adulthood (Baker, 1989), some researchers have suggested that there is no clear metacognitive advantage for gifted students in adolescence (Shore, Koller, & Dover, 1994) or at any point in development (Alexander et al., 1995). However, the results from the current study showed that gifted adolescents maintained consistently more accurate local calibration throughout the semester. This contrast in findings may be because of the classroom context of the current study, as opposed to prior studies conducted in the laboratory. This type of classroom-based work is important in adding to the field's rich knowledge of gifted students' metacognitive skills on laboratory-based tasks. The differences found in the current study between gifted and typical students, situated in the context of a mainly nondifferentiated curriculum, may serve as a baseline effect that can be further examined in a variety of tasks, with varying levels of challenge. The mediational analyses lend support to the idea that local calibration accuracy may explain part of the process by which gifted students achieve at a high level.

Future Directions and Limitations

There are a few limitations in the current study that must be considered. First, the results of the present study must be interpreted through the lens of gifted identification procedures, whereby students are classified as gifted based on a multifaceted criterion ("Education Program for Gifted Students", 1998). These findings may not be applicable to students labeled as gifted through other means, such as IQ tests. The vast majority of studies on the gifted have sampled from a population defined through IQ (Carr et al., 1996) but others use only high achievement as a requisite. These conflicting definitions of giftedness and identification procedures cloud the results of studies on metacognition (Alexander et al., 1995), and more current, complex definitions of giftedness should be examined in future work (Steiner & Carr, 2003). The system used to identify students in the current study is broad in that it encompasses multiple pathways toward identification rather than using a strict cut-off score on one variable. Thus, we would expect results in the current study to generalize to gifted students identified through similar means.

Furthermore, it is also possible that the current findings may stem from the fact that the students were assessed within the science domain. The current study extends prior work (Greene et al., 2006; Steiner, 2003) by investigating metacognition in gifted students within an actual classroom context, rather than a laboratory-based task, but the domain-specific nature of the study may limit generalizability. It is possible that there is less discrepancy between local and global calibration accuracy in other domains where material is organized differently, such as in a humanities course.

Finally, our failure to find differences between gifted and typical students on several aspects of metacognitive ability, such as self-reported knowledge of cognition and regulation, may stem from a lack of curricular challenge. As evidenced by the sample exam question, it is quite likely that the material was not sufficiently challenging to push the gifted students to fully engage metacognitively. An increase in curricular challenge might allow for examination of continued increases in monitoring ability among the gifted (Alexander et al., 1995). Carr and Taasoobshirazi (2008) further hypothesized that sufficient challenge would cause gifted students to suppress simple associative processing and engage at a deeper cognitive level by drawing on various metacognitive processes. Following Dresel and Haugwitz's (2005) discovery of a negative relation between cognitive ability and strategy usage when academic challenge is low, future work should investigate the metacognitive skills of gifted students placed in a rigorously challenging environment. The current study provides a baseline finding of differences that are found when curriculum is relatively easy. Future work could aim to explore if an effect may be found when the material is sufficiently greater in complexity and challenge, particularly in the science domains. Finally, the absence of alignment between judgment calibration and the self-reported levels of metacognition measured with the MAI is another interesting baseline effect to test in future work. It will be interesting to see if this discrepancy persists across varying levels of challenge and different types of tasks and domains.

The classroom environment may also have a significant effect on metacognitive strategy use in gifted students. Although the students in the current study were grouped homogenously by ability, many other school systems integrate gifted students into various types of heterogeneous environments. In addition, levels of challenge may vary across different types of ability grouping and cooperative learning as well. Future work could investigate the effect of external factors such as classroom environment and difficulty of material on the monitoring ability of gifted students, particularly over time. Furthermore, future work should consider potential mechanisms at play in gifted students' metacognitive strategy use, such as working memory. Given the accumulating evidence that metacognition may explain why gifted students perform better, future work is needed to explore what factors contribute to this advantage. Deeper investigation into planning behavior, debugging strategies, and working memory might prove beneficial in trying to understand how these students develop some forms of early expertise in relation to calibration accuracy.

Conclusion

Researchers have long searched for evidence of qualitative differences between gifted and typical individuals. Metacognition appears to be one such area in which gifted students appear to be qualitatively different from typical students (Shore, 2000). The results from the current study contribute to this line of work by examining differences in metacognition for gifted and typical adolescents in a realistic academic context over a brief time period. By investigating differences between gifted and typical students on a variety of metacognitive indicators, we are able to further our understanding of the ways in which gifted students differ from their typical peers. This multimethod approach suggests that measures of calibration accuracy may provide a richer understanding of students' various metacognitive abilities than self-report questionnaires alone. Gifted advantages for both local calibration accuracy and global postdictive calibration accuracy are of particular importance. These findings, combined with finding that local calibration accuracy partially mediates the relation between giftedness and performance, extend our understanding of metacognitive processes in gifted students and provide a starting point for continued work within the classroom context.

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References

Alexander, J. M., Carr, M., & Schwanenflugel, P. J. (1995). Development of metacognition in gifted children: Directions for future research. *Developmental Review, 15*, 1-37.

Alexander, J. M., & Schwanenflugel, P. J. (1996). Development of metacognitive concepts about thinking in gifted and nongifted children: Recent research. *Learning and Individual Differences, 8*, 305-325.

Arthur, A. W. (1994). Development of a short form for the Raven Advanced Progressive Matrices Test. *Educational and Psychological Measurement, 54*, 394-403.

Baker, L. (1989). Metacognition, comprehension monitoring, and the adult reader. *Educational Psychology Review, 1*, 3-38.

Baron, R. M., & Kenny, D. A. (1986). The moderator-mediator variable distinction in social psychological research: Conceptual, strategic, and statistical considerations. *Journal of Personality and Social Psychology, 51*, 1173-1182.

Bol, L., & Hacker, D. J. (2001). A comparison of the effects of practice tests and traditional review on performance and calibration. *Journal of Experimental Education, 69*, 133-151.

Bouffard-Bouchard, T., Parent, S., & Larivée, S. (1993). Self-regulation on a concept-formation task among average and gifted students. *Journal of Experimental Child Psychology, 56*, 115-134.

Brown, A. (1987). Metacognition, executive control, self-regulation, and other more mysterious mechanisms. In F. Weinert & R. Kluwe (Eds.), *Metacognition, motivation, and understanding* (pp. 65-116). Hillsdale, NJ: Erlbaum.

Butler, D. L., & Winne, P. H. (1995). Feedback and self-regulated learning: A theoretical synthesis. *Review of Educational Research, 65*, 245-281.

Calero, M.D., García-Martín, M. B., Jiménez, M. I., Kazén, M., & Araque, A. (2007). Self-regulation advantage for high-IQ children: Findings from a research study. *Learning and Individual Differences, 17*, 328-343.

Carpenter, P. A., Just, M. A., & Shell, P. (1990). What one intelligence test measures: A theoretical account of the processing in the Raven Progressive Matrices Test. *Psychological Review, 97*, 404-431.

Carr, M., Alexander, J., & Schwanenflugel, P. (1996). Where gifted children do and do not excel on metacognitive tasks. *Roeper Review, 18*, 212-217.

Carr, M., & Taasoobshirazi, G. (2008). Metacognition in the gifted: Connections to expertise. In M. F. Shaughnessy, M. V. J. Veenman, & C. Kleyn-Kennedy (Eds.), *Metacognition: A recent review of research, theory, and perspectives* (pp. 109-125). Hauppauge, NY: NOVA.

Dark, V. J., & Benbow, C. P. (1991). Differential enhancement of working memory with mathematical versus verbal precocity. *Journal of Educational Psychology, 83*, 48-60.

Dresel, M., & Haugwitz, M. (2005). The relationship between cognitive abilities and self-regulated learning: Evidence for interactions with academic self-concept and gender. *High Ability Studies, 16*, 201-218.

Dunlosky, J., & Metcalfe, J. (2009). *Metacognition: A textbook for cognitive, educational, life span, and applied psychology*. Thousand Oaks, CA: Sage.

Education program for gifted students. (1998). Retrieved from http://www.doe.k12.ga.us/_documents/doe/legalservices/160–4-2-.38.pdf

Flavell, J. H. (1979). Metacognition and cognitive monitoring: A new area of cognitive-developmental inquiry. *American Psychologist, 34*, 906-911.

Flavell, J. H. (1987). Speculations about the nature and development of metacognition. In F. Weinert & R. Kluwe (Eds.), *Metacognition, motivation, and understanding* (pp. 21-29). Hillsdale, NJ: Erlbaum.

Glaser, R., & Chi, M. T. H. (1988). Overview. In M. T. H. Chi, R. Glaser, & M. J. Farr (Eds.), *The nature of expertise* (pp. xv-xxviii). Hillsdale, NJ: Earlbaum.

Greene, J. A., Moos, D. C., Azevedo, R., & Winters, F. I. (2008). Exploring differences between gifted and grade-level students' use of self-regulatory learning processes with hypermedia. *Computers in Education, 50*, 1069-1083.

Hacker, D. J., Bol, L., Horgan, D. D., & Rakow, E. A. (2000). Test prediction and performance in a classroom context. *Journal of Educational Psychology, 92*, 160-170.

Hannah, C. L., & Shore, B. M. (1995). Metacognition and high intellectual ability: Insights from the study of learning-disabled gifted students. *Gifted Child Quarterly, 39*, 95-109.

Jaušovec, N. (1998). Are gifted individuals less chaotic thinkers? *Personality and Individual Differences, 25*, 253-267.

Keren, G. (1991). Calibration and probability judgments: Conceptual and methodological issues. *Acta Psychologica, 77*, 217-273.

Martini, R., & Shore, B. M. (2008). Pointing to parallels in ability-related differences in the use of metacognition in academic and psychomotor tasks. *Learning and Individual Differences, 18*, 237-247.

Neber, H., & Schommer-Aikins, M. (2002). Self-regulated science learning with highly gifted students: The role of cognitive, motivational, epistemological and environmental variables. *High Ability Studies, 13*, 59-74.

Nietfeld, J. L., Cao, L., & Osborne, J. W. (2005). Metacognitive monitoring accuracy and student performance in the postsecondary classroom. *Journal of Experimental Education, 74*, 7-28.
Nietfeld, J. L., Cao, L., & Osborne, J. W. (2006). The effect of distributed monitoring exercises and feedback on performance, monitoring accuracy, and self-efficacy. *Metacognition and Learning, 1*, 159-179.
Nietfeld, J. L., & Schraw, G. (2002). The effect of knowledge and strategy training on monitoring accuracy. *Journal of Educational Research, 95*, 131-142.
Raven, J. C. (1962). *Advanced progressive matrices, set II*. San Antonio, TX: Psychological Corporation.
Schraw, G. (1994). The effect of metacognitive knowledge on local and global monitoring. *Contemporary Educational Psychology, 19*, 143-154.
Schraw, G. (1995). Measures of feeling-of-knowing accuracy: A new look at an old problem. *Applied Cognitive Psychology, 9*, 321-332.
Schraw, G. (1998). Promoting general metacognitive awareness. *Instructional Science, 26*, 113-125.
Schraw, G., & Dennison, R. S. (1994). Assessing metacognitive awareness. *Contemporary Educational Psychology, 19*, 460-475.
Schraw, G., & Moshman, D. (1995). Metacognitive theories. *Educational Psychology Review, 7*, 351-371.
Schraw, G., & Roedel, T. D. (1994). Test difficulty and judgment bias. *Memory & Cognition, 22*, 63-69.
Schwanenflugel, P. J., Stevens, T. P. M., & Carr, M. (1997). Metacognitive knowledge of gifted children and nonidentified children in early elementary school. *Gifted Child Quarterly, 41*, 25-35.
Schwartz, B. L. (2008). Working memory load differentially affects tip-of-the-tongue states and feeling-of-knowing judgments. *Memory & Cognition, 36*, 9-19.
Shore, B. M. (2000). Metacognition and flexibility: Qualitative differences in how gifted children think. In R. C. Friedman & B. M. Shore (Eds.), Talents unfolding: Cognition and development (pp. 167-187). Washington, DC: American Psychological Association.
Shore, B. M., Koller, M., & Dover, A. (1994). More from the water jars: A reanalysis of problem-solving performance among gifted and nongifted children. *Gifted Child Quarterly, 38*, 179-183.
Shore, B. M., & Lazar, L. (1996). IQ-related differences in time allocation during problem solving. *Psychological Reports, 78*, 848-850.
Sobel, M. E. (1982). Asymptotic intervals for indirect effects in structural equations models. In S. Leinhardt (Ed.), *Sociological methodology* (pp. 290-312). Washington, DC: American Sociological Association.
Steiner, H. H. (2003). A microgenetic analysis of strategic variability in gifted and average-ability children. *Gifted Child Quarterly, 50*, 62-74.
Steiner, H. H., & Carr, M. (2003). Cognitive development in gifted children: Toward a more precise understanding of emerging differences in intelligence. *Educational Psychology Review, 15*, 215-246.
Sternberg, R. J. (2001). Giftedness as developing expertise: A theory of the interface between high abilities and achieved excellence. *High Ability Studies, 12*, 159-179.
Stone, N. J. (2000). Exploring the relationship between calibration and self-regulated learning. *Educational Psychology Review, 12*, 437-475.
Tang, M., & Neber, H. (2008). Motivation and self-regulated science learning in high-achieving students: Differences related to nation, gender, and grade-level. *High Ability Studies, 19*, 103-116.
Thiede, K. W., Anderson, M. C. M., & Therriault, D. (2003). Accuracy of metacognitive monitoring affects learning of texts. *Journal of Educational Psychology, 95*, 66-73.
White, B., & Frederiksen, J. (2005). A theoretical framework and approach for fostering metacognitive development. *Educational Psychologist, 40*, 211-223.
Yates, J. F. (1990). *Judgment and decision making*. Englewood Cliffs, NJ: Prentice Hall.
Yoon, C. (2009). Self-regulated learning and instructional factors in the scientific inquiry of scientifically gifted Korean middle school students. *Gifted Child Quarterly, 53*, 203-216.

Bios

Kate E. Snyder is a doctoral candidate in developmental psychology at Duke University. She received her MA in psychology from Duke University in 2010 and her BA in psychology from North Carolina State University in 2007. In 2009, she was awarded the Hollingworth Award through the National Association for Gifted Children for her research proposal to examine causal mechanisms in underachievement among gifted individuals. She examines the development of underachievement and talent loss in gifted students with a specific focus on motivational processes.

John L. Nietfeld is an associate professor of educational psychology at North Carolina State University. His research emphasis falls within self-regulated learning (SRL) and metacognition. He has conducted a number of studies investigating how K-12 and college students monitor their behavior on cognitive tasks and is particularly interested in the extent to which training within classroom contexts can facilitate more accurate monitoring of performance and strategy use. Currently, he is collaborating with computer science faculty to examine how to create intelligent game-based learning environments that will facilitate and scaffold SRL skills for elementary and middle school students in science.

Lisa Linnenbrink-Garcia is an assistant professor of developmental psychology in the Department of Psychology and Neuroscience, with a secondary appointment in Education, at Duke University. She received her PhD in education and psychology from the Combined Program in Education and Psychology at the University of Michigan, Ann Arbor. Dr. Linnenbrink-Garcia's research focuses on the development of achievement motivation in school settings and the interplay among achievement motivation, emotions, and learning, especially in the domains of science and mathematics.