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Effects of Math Anxiety and Perfectionism on Timed versus Untimed Math Testing in Mathematically Gifted Sixth Graders

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Abstract

This study was designed to examine the effects of math anxiety and perfectionism on math performance, under timed testing conditions, among mathematically gifted sixth graders. We found that participants had worse math performance during timed versus untimed testing, but this difference was statistically significant only when the timed condition preceded the untimed condition. We also found that children with higher levels of either math anxiety or perfectionism had a smaller performance discrepancy during timed versus untimed testing, relative to children with lower levels of math anxiety or perfectionism. There were no statistically significant gender differences in overall test performance, nor in levels of math anxiety or perfectionism; however, the difference between performance on timed and untimed math testing was statistically significant for girls, but not for boys. Implications for educators are discussed.

Most school-based performance measures are administered with a time limit (Dreyden & Gallagher, 1989). Timed math performance is often worse than untimed math performance (Kellogg, Hopko, & Ashcraft, 1999), even among gifted students (Dreyden & Gallagher). This may be because of insufficient time to complete all test problems or because the timed testing is sufficiently anxiety-provoking to hinder performance. It is important to assess the possible effects of math anxiety on performance, because high math anxiety may lead students to avoid math (Hembree, 1990) by choosing not to enroll in advanced (Ashcraft, 2002) or elective math courses (Ashcraft & Kirk, 2001). Math avoidance may ultimately affect whether a person decides against a math-related college major and subsequent career choices (Ashcraft).

Although it may appear as common sense that mathematically gifted children experience little if any math anxiety when solving math problems, there is little empirical evidence to either support or refute this notion (Lupkowski & Schumacker, 1991). Dreger and Aiken (1957) suggest that math anxiety occurs even among students gifted in mathematics. Gifted children are often described as perfectionistic (Parker, 1997); but it is unknown whether perfectionism enhances or exacerbates math performance, and whether effects of perfectionism interact with level of math anxiety among mathematically competent individuals. The present study was designed to explore the possible relationship between math anxiety and perfectionism on math performance during *timed* versus *untimed* testing conditions in mathematically gifted children. Our interest was not the child's performance level, but whether there was a discrepancy in math performance accuracy during timed versus untimed testing, and whether this discrepancy is influenced by math anxiety or perfectionism.

Math Anxiety

Math anxiety is one of the nonintellectual factors that affects a child's performance on mathematics. Richardson and Suinn (1972) defined math anxiety as "the feeling of tension and

anxiety that interferes with manipulation of numbers and the solving of mathematical problems in a wide variety of ordinary life and academic situations” (p. 551). Many studies of math anxiety have focused on high-school and college students enrolled in grade-appropriate courses (e.g., Suinn, Edie, Nicoletti & Spinelli, 1972; Suinn, Taylor, & Edwards, 1988). For example, Kellogg et al. (1999) assessed math performance on timed versus untimed tests among 30 undergraduate psychology students who were assigned to one of three anxiety groups—low, medium, or high—based on self-reported ratings. Math performance scores were lower on the timed test, to equivalent degrees, in all three groups. Few studies have addressed whether similar effects occur in gifted individuals, or in children. Lupkowski and Schumacker (1991) found that the talented 15- to 18-year-olds in their study were less mathematically anxious than most college students; furthermore, they found no correlation between anxiety level and performance on the math portion of the Scholastic Aptitude Test (SAT). In the present study, we examined whether math anxiety level, as measured by self-report, influenced math performance in gifted students who are younger than participants from the two aforementioned studies.

Perfectionism

Mathematically gifted children are, as a group, described as perfectionistic (Parker, 1997). In a sample of female college students, Frost and Marten (1990) discovered that students who scored in the upper quartile on the Multidimensional Perfectionism Scale (MPS) performed more poorly on a writing task than students who scored in the lower quartile on the MPS. To our knowledge, there are no comparable studies of the direct relationship between level of perfectionism and mathematics performance in academic settings. This study was designed to address this gap.

Children with average to above-average levels of perfectionism may be highly motivated to achieve in all situations (Hamachek, 1978), including both timed and untimed testing conditions. Such motivation may drive someone to attempt to match his or her own untimed performance, during timed testing. If this is the case, we would expect a smaller performance discrepancy between timed and untimed testing among highly perfectionistic children relative to children with lower perfectionism. We hypothesized that this effect would emerge in our study: as perfectionism level increased, the discrepancy in math performance between the timed and untimed conditions would decrease.

Although there are conflicting definitions of perfectionism (Hamachek, 1978; Hewitt & Flett, 1991; Parker & Adkins, 1995), in the present study we focus on the multidimensional definition proposed by Frost, Marten, Lahart, and Rosenblate (1990), who define perfectionism as “the setting of high standards of performance which are accompanied by tendencies for overly critical self-evaluations” (p. 450). We acknowledge that both overall perfectionism and specific aspects of perfectionism may be associated with math anxiety. For this reason, we relied upon a broader perfectionism measure, the aforementioned MPS, that includes both an overall score and subtest scores.

Several studies have demonstrated a relationship between perfectionism and anxiety (Parker & Mills, 1996), yet Frost and Dibartolo (2002) concluded that this potential relationship deserves further research attention. We examined whether math anxiety and perfectionism act as separate influences on the discrepancy in math performance under timed versus untimed testing conditions in mathematically gifted sixth graders.

Rationale for the Present Study

The present study was designed to contribute to knowledge about how and when test-taking situations influence test performance among gifted children. In view of the lack of research in

the younger gifted population, the present study focused on mathematically gifted sixth graders. We included students from only one grade in order to limit the variability in math competence acquired throughout the elementary- and middle-school years. Although sixth graders as a group demonstrate much variability in levels of math achievement, the variability would have been greater if we also included children from additional grades.

Consistent with earlier findings (Dreyden & Gallagher, 1989; Kellogg et al., 1999), we anticipated that timed math performance would be less accurate than untimed math performance. We hypothesized that the discrepancy in math performance during timed versus untimed testing would be positively correlated with level of math anxiety and negatively correlated with the level of perfectionism. Finally, we also predicted that math anxiety and perfectionism would be negatively correlated in this sample of gifted sixth graders.

Method

Participants

The participants were drawn from children who qualified for a talent search conducted through a major university. This national talent search identifies students who score at or above the 97th percentile on any nationally normed, standardized aptitude or achievement test. Recruitment mailings were sent to parents of all 226 sixth graders who qualified for the talent search, who were enrolled in at least one gifted math program offered by the university, and who lived within approximately 35 miles of the investigators' institution. A total of 23 children enrolled after the first mailing. To increase sample size, a second mailing was sent to all parents who did not respond to the first mailing, which yielded an additional 13 participants. Total enrollment included 20 boys (mean age = 11.7 years, $SD = 0.42$) and 16 girls (mean age = 11.7, $SD = 0.33$).

Instruments

Math performance—For measurements of timed and untimed math performance, we administered paper and pencil tests requiring children to perform math calculations — ranging from simple to complex — involving fractions, decimals, calculus, and trigonometry. We developed two comparable forms of a calculation test, using the Woodcock-Johnson-III (WJ-III) calculations subtest as a guide for grade-appropriate problems. In our versions of the calculations tests, our aim was to provide an accurate performance ceiling while also allowing sufficient variability in performance among our participants. To achieve this aim, we included problems of equivalent difficulty and type to those appearing in the WJ-III calculation subtest, and additional problems that involved exponents, algebraic inequalities, decimal multiplication, or mixed-fraction multiplication. The two forms included problems that were of comparable type and difficulty. Although the two forms were not standardized, they were appropriate for the present study because we were interested in the number of math problems solved correctly during different testing conditions. There is no established reliability for our brief, investigator-developed math tests. However, each child received both tests in counterbalanced order (as described later). Thus, it was possible for us to test for potential differences resulting from the two test forms, and none were found. Raw scores were computed by summing the number of correct responses with a maximum possible score of 40 per test.

Math anxiety—The Mathematics Anxiety Rating Scale—Elementary (MARS-E) was developed by Suinn et al. (1988) for use with fourth to sixth graders. The MARS-E is a 26-item, 5-point, Likert-type survey with items such as “Mark how nervous you would feel if you had to add up a cash register receipt after you bought several things” and “Mark how nervous you would feel in thinking about a math test an hour before the test.” The total score for the MARS-E is a sum of points for all items. Students reaching the 75th percentile, at a raw score

of 57 (out of 130) or higher, are considered to have high math anxiety (Suinn et al., 1988). Published reliability for the MARS-E is .88 and the correlation between MARS-E and a standardized math achievement test is $r = -.31$ (Suinn et al., 1988). In the present study, we used the total score as a continuous variable; also, for categorical analyses, we used the published cutoff score to differentiate groups with higher versus lower math anxiety.

To increase the likelihood that a high MARS-E score was specific to math anxiety, it was important to determine whether participants had possible general anxiety disorder. The Screen for Child Anxiety Related Emotional Disorders (SCARED) —Child Form, developed by Birmaher et al. (1997), was used to screen children for this purpose. The SCARED—Child Form is a 41-item, 3-point, Likert-type scale survey. Items include statements such as, “I worry about things that have already happened.” Based on the standardization norms, a total of 31 points or higher (out of 82) is believed to indicate specific risk for anxiety disorder. We used this cutoff score to identify participants at risk for general anxiety disorder, who were then excluded from analyses dealing with math anxiety.

Perfectionism—To evaluate each participant’s level of perfectionism, each child was asked to complete the Multidimensional Perfectionism Scale (MPS) self-report form developed by Frost et al. (1990). The MPS is a 35-item, 5-point, Likert-type scale questionnaire. It includes test items that address six constructs: “concern over mistakes” which reflects the child’s tendency to perceive mistakes as personal failure; a “personal standards” rating that reflects the child’s own standards for self-evaluation; a “parental expectations” rating that reflects the child’s perception of parental standards for the child; a “parental criticism” rating that reflects the child’s perception of parent’s excessively critical evaluations; a “doubts about actions” rating that reflects the child’s own doubts concerning ability to accomplish tasks; and finally, the “organization” rating that is used to measure the child’s tendency to be orderly and organized. The organization subscale is empirically separate from the remaining subscales; it is the subscale least correlated with the other MPS subscales and with other published measures of perfectionism. The overall MPS score is a linear combination of all the subscale scores except for the organization subscale. We calculated both the overall MPS total score and a set of individual subscale total scores as continuous variables for analysis. Also, for the categorical analyses, we used the 50th percentile cutoff (66.0) for the overall MPS score to differentiate groups with higher versus lower perfectionism. The group mean and standard deviation values from our sample, 68.9 and 17.66, respectively, are close to the values reported for a normative sample, 71.6 and 14.1 (Parker & Stumpf, 1995). The reliability indices reported for the MPS overall perfectionism score are good, ranging from .87 (Parker & Stumpf) to .90 (Frost et al., 1990).

Procedure

Testing was carried out over a 3-month period during the school year. Informed consent was obtained from parents and a written assent was gathered from child participants. Each participant was randomly assigned to one of the four possible conditions (see Table 1) to counterbalance possible order effects for the math test: Condition Order (i.e., timed condition first vs. untimed condition first) or Test Form Order (i.e., Form 1 given first vs. Form 2 given first).

Each child was first administered one of the two forms of the calculations test under either the timed or untimed condition. Under both conditions, participants were asked to work through the problems as quickly and accurately as possible. The participants were instructed to mark a problem with an “S” if the problem was too difficult, and to solve the problems in order. They were not permitted to go back and work on earlier problems. Erasing was permitted. Under the timed condition, the participants were notified that there was a 10-minute time limit

to finish the problems. A bright yellow stopwatch was put in view of the child, and the child was asked to stop working when 10 minutes had elapsed. The same instructions were given for the untimed condition, except that participants were told that they could take as much time as needed to finish the problems, and no stopwatch was left in view; however, participants were timed surreptitiously.

Following the initial calculations test, all participants were asked to complete the three questionnaires, given in a fixed order (see Table 1). Instructions printed on each survey were read aloud to the participants. The alternate form of the math test was administered after the surveys were completed. For example, if the child had been given the timed test first, the untimed test was presented last. The entire session took approximately 1 hour.

Data Analyses

To determine the appropriate statistical tests to use for analyses, we first assessed normality of the distribution of scores for each measure by searching for possible outliers. Outliers were defined as data points that were greater than 2 standard deviations from the mean score. One such outlier (2 standard deviations below the mean) was identified, and this participant was excluded from all subsequent data analyses. The final sample for data analyses consisted of 35 children, comprised of 19 boys and 16 girls.

There were three major variables of interest: measures of math anxiety, perfectionism, and math performance under timed versus untimed testing using a calculations test. For most analyses, total raw scores were entered. When a discrepancy score was calculated, the total number of problems correctly solved during the timed condition was subtracted from the total number of problems correctly solved during the untimed condition. These variables of interest appear in Table 2 in addition to the potential confounding variables (test form used and order of testing condition). For analyses, we used *t*-tests and ANOVA procedures as appropriate. Paired *t*-tests were conducted for within-subject variables whenever possible and unpaired *t*-tests for between-subject variables. Effect sizes were calculated using Cohen's *d* statistic. Correlations between variables were analyzed using simple and multiple regression models if scores were normally distributed, or using non-parametric procedures if scores were not normally distributed (such as MPS subscale scores). Chi-square analyses were performed to compare the number of children assigned to a behavioral category (i.e., lower vs. higher math anxiety, and lower vs. higher perfectionism) as a function of condition order. All tests performed were based on two-tailed significance levels.

Results

Preliminary analyses were carried out with a two-factor (Gender and Test Form Order) Analysis of Variance (ANOVA) to assess potential main effects on timed versus untimed math performance. For Test Form Order we distinguished between Form 1 calculation test given first and Form 2 calculation test given first. There were no main effects of gender, $F(1, 33) = 0.63$, or of test form order, $F(1, 33) = 1.01$; $ps > .32$. We also found no main effect of test form used, $t(34) = -.83$. Thus, it was not necessary to include these variables in subsequent analyses.

Primary Analyses

Timed versus untimed math performance—To examine effects of testing condition and condition order, we carried out a two-factor (Testing Condition: Timed vs. Untimed; and Condition Order: Timed Condition First vs. Untimed Condition First) ANOVA with repeated measures on the first variable and the total number correct on the math test as the dependent variable. Consistent with the existing literature, there was a main effect of testing condition, with more accurate performance during the untimed versus the timed testing condition, $F(1,$

33) = 15.989, $p < .001$. Although there was no main effect of condition order, there was a significant interaction between testing condition and condition order, $F(1, 33) = 8.766$, $p < .01$. Post-hoc paired t -tests revealed that math performance during timed testing was significantly lower than performance during untimed testing, but only if the timed testing condition occurred first, $t(16) = -5.618$, $p < .0001$. Timed versus untimed performance scores did not differ if the untimed testing condition was given first, $t < 1$ (See Table 3).

Math Anxiety Ratings—Based on the screening results from the SCARED, 5 children met criteria for being at-risk for general anxiety disorder. Our subsequent analyses included measures of math anxiety, so it was prudent to exclude these 5 children from those analyses. Thus, the analyses reported in this section are based on data from the remaining 30 children.

A regression model was used to assess the relationship between the discrepancy in math performance during timed versus untimed testing and math anxiety level. Contrary to our prediction, a significant negative correlation emerged, $r = -.447$, $p < .02$. The MARS-E score accounted for about 20% of the variability seen in the math-performance discrepancy ($r^2 = .199$).

In view of the significant interaction between testing condition and its order (timed testing first vs. second) as described earlier, it was important to examine the possible influence of test order itself (i.e., first vs. second test) on the relationship between testing condition and math anxiety level. However, when the variable test order was added to the multiple regression model, the resulting r -value remained the same as when this variable was excluded ($r = -.447$). We also carried out a simple regression to examine the relationship of test order and math-anxiety level, and found no significant correlation, $r = .137$.

Math-anxiety effects were also examined categorically, with participants assigned to a higher ($n = 15$) or lower ($n = 15$) math anxiety group based on cutoff criteria established by Suinn, et al. (1988). A two-factor (Testing Condition: Timed vs. Untimed; and Math-Anxiety Level: Lower vs. Higher) ANOVA was carried out with repeated measures on the first variable and total number correct on the math test as the dependent variable. Consistent with the analyses reported earlier, there was a main effect of testing condition—lower scores during timed versus untimed testing, $F(1, 28) = 8.409$, $p < .01$. There was no main effect of math-anxiety level, $F < 1$, but there was a significant interaction between testing condition and math-anxiety level, $F(1, 28) = 6.379$, $p < .02$. Post-hoc t -tests revealed significantly poorer math performance during timed versus untimed testing, but only in the lower-math-anxiety group, $t(15) = -3.589$, $p < .01$ (Table 3).

We considered whether lower math scores during timed versus untimed testing among children in the lower math-anxiety group may have resulted from a higher number of children with lower math anxiety in the group receiving the timed condition first. We found however, that 53% of the children assigned to the lower math-anxiety group had the timed condition first, and 47% had the untimed testing first. This difference was not statistically significant, $p = .269$.

To assess the possibility that children with higher math anxiety have lower math competence than children with lower math anxiety, an unpaired t -test was used to assess math performance during the untimed testing. There was no significant difference in math scores, $t < 1$, suggesting that math competence is comparable in these two groups. However, because math competence may also influence an individual's ability to complete math problems under time constraints, merely comparing math performance under untimed conditions may not truly reflect the whole spectrum of math competence. Hence, the issue of math competence level was addressed, but not completely resolved in this study.

Perfectionism Rating—We predicted that higher perfectionism would be associated with a smaller discrepancy in math performance during timed versus untimed testing. We found a significant negative correlation between this discrepancy and the MPS perfectionism score, $r = -.478$, $p < .01$, which supported our hypothesis. The MPS score accounted for about 23% of the variability in the math-performance discrepancy, $r^2 = .228$.

We used a multiple regression model to explore the possible effect of test order (i.e., whether scores on the second test were better than scores on the first test, regardless of which test form was used). This enabled us to assess possible practice or fatigue effects on the relationship between discrepancy in math performance and perfectionism level. When the independent variable of test order was added to the initial regression model, the r -value was virtually identical (r increased from $-.478$ to $-.483$). When we carried out a simple regression to examine the relationship of test order with perfectionism level, we found no significant correlation, $r = .03$, $r^2 = .001$. Thus, test order did not contribute to the relationship between the discrepancy in math performance and perfectionism.

The 30 participants included in this analysis were assigned to either the higher ($n = 12$) or lower perfectionism ($n = 18$) group, using the 50th percentile in our study sample as the cutoff to differentiate groups. We carried out a two-factor (Testing Condition: Timed vs. Untimed, and Perfectionism: Lower vs. Higher) ANOVA, with repeated measures on the first variable and total number correct on the math test as the dependent variable. In addition to the main effect of testing condition, with poorer math scores on timed versus untimed testing, $F(1, 28) = 5.459$, $p < .05$, there was a main effect of perfectionism level (lower vs. higher), $F(1, 28) = 5.255$, $p < .05$. There was also a significant interaction between these two variables, $F(1, 28) = 6.586$, $p < .02$. A post-hoc unpaired t -test indicated a significant discrepancy in math performance in the lower-perfectionism group, $t(17) = -3.471$, $p = .0016$, but not in the higher-perfectionism group, $t < 1$ (See Table 3).

We explored whether the significantly lower math score during timed versus untimed testing in the lower-perfectionism group resulted from a coincidentally higher number of children with lower perfectionism receiving the timed testing first. We found that 55.6% of the children assigned to the lower-perfectionism group had the timed condition first, and 44.4% had the untimed condition first—a difference that was not statistically significant, $p = .098$.

To explore how math competence correlates with perfectionism, a correlation analysis was conducted with math scores on the untimed testing and perfectionism rating. The correlation was not statistically significant, $r = .337$, $p = .069$.

Relationship between Math Anxiety and Perfectionism—A significant positive correlation emerged between the MARS-E and MPS scores, $r = .496$, $p = .021$. Therefore, we examined whether specific aspects of perfectionism were most strongly correlated with math anxiety. Subscale scores were not normally distributed, so we used nonparametric Spearman Rank analyses. Only three subscales in the MPS—concern over mistakes ($r_s = .590$, $p < .01$), doubts about actions ($r_s = .488$, $p < .01$), and parental criticism ($r_s = .502$, $p < .01$)—were significantly (and positively) correlated with the MARS-E score. There was no evident correlation between the MARS-E score and either the personal standards or organization ratings, r_s values $< .048$. Although ratings for parental expectations were positively correlated with the MARS-E score, this correlation did not reach statistical significance, $r_s = .314$, $p = .07$. As reported earlier, the MARS-E score accounted for about 20% of the variance in the discrepancy between timed and untimed math performance ($r^2 = .199$), and the MPS score accounted for approximately 23% of this variance ($r^2 = .228$). Despite being correlated, each variable contributed some unique variance to the discrepancy, because combined, the MPS and MARS-E scores accounted for approximately 28% of the variance ($r^2 = .286$).

Secondary Analyses

The primary analyses were based on the accuracy of math test performance. The present study concerned the effects of timed versus untimed testing conditions, so it was appropriate to also examine the amount of time children used to complete their math tests. We found that children took almost twice as long to complete the math test during the untimed condition than during the timed condition (17.0 vs. 9.4 minutes), $t(34) = 6.717, p < .0001$. Children with higher math anxiety spent more time than children with lower math anxiety in completing the untimed math test (19.9 vs. 14 minutes, respectively), $t(28) = 2.27, p < .05, d = 0.83$, but spent comparable amounts of time on the timed test (~ 9.4 minutes), $t < 1$. There was no significant difference in the time used between higher and lower-perfectionism groups during either condition, t 's < 1 .

Although there was no main effect of gender on timed versus untimed math performance, we explored whether the discrepancy in math performance was significant for both boys and girls. Using paired t -tests, we found that boys were equally as accurate on timed versus untimed testing, $t(16) = 1.32, M_{\text{timed}} = 20.41, SD = 3.50$ and $M_{\text{untimed}} = 21.17, SD = 2.24$. In contrast, girls were less accurate during timed testing relative to their own untimed performance, $M_{\text{timed}} = 19.46, SD = 3.05$ and $M_{\text{untimed}} = 20.85, SD = 2.61, t(12) = 2.84, p = .015$. This was the only gender difference to emerge, but the effect size was moderate, $d = 0.49$.

Discussion

The purpose of this study was to address how math anxiety and perfectionism affect math performance under timed versus untimed testing conditions in mathematically gifted sixth graders. Our findings were consistent with those of earlier studies (Dreyden & Gallagher, 1989) in demonstrating that math performance was significantly less accurate during timed testing than during untimed testing. Our findings also expand upon previous studies in that we demonstrated situations that interact with this discrepancy in math performance level. First, math performance was less accurate during timed testing only when a timed test was the first test to be administered during a testing session. Second, the discrepancy in math performance was negatively correlated with levels of both math anxiety and perfectionism—higher levels of math anxiety or perfectionism were associated with smaller discrepancies in timed versus untimed test performance. Although math anxiety and perfectionism were themselves positively correlated, we found that both of these factors contributed independently to variability in test performance.

There are several possible explanations for this set of findings, some of which we were able to explore statistically. It is possible that performance during timed math testing was weaker than (later) untimed test only because familiarity with a math test enhances test performance on later testing (in this case, during the second of two tests). If that were the case, then we would expect children's performance to improve on a second math test regardless of whether the first or second test given was timed. Although there was a main effect of test order—such that children fared better on the second of two tests given to them—this effect was significant only when the first of the two tests was timed. Thus, test order alone does not explain our findings.

Although test familiarity may enhance test performance, time pressure may lead to heightened anxiety, which may hamper or sharpen a child's test performance. Perhaps the negative impact of timed testing was mediated by the familiarity of the test, a notion consistent with our finding that timed testing was not inferior to untimed testing when the latter preceded the former. Among children whose first math test was timed, there was both the absence of test familiarity and the presence of time-pressure. Children who received the untimed testing first benefited from both the test familiarity and the absence of time pressure. This notion is consistent with

our finding that performance on untimed tests when given first was comparable to performance on either timed or untimed tests when given second. Thus, our findings support not only the benefit of practice, but also implicate the role of very recent practice or very relevant practice, to later test performance. More specifically, our findings suggest that suboptimal performance occurs when a timed test is taken without any practice, because the lowest scores occurred only when timed testing was the first test to be administered.

The role of familiarity was observed only indirectly, by comparing the effects of test order. That “familiarity effects” were implicated in our study was somewhat surprising, given that all of the participants undoubtedly had some familiarity with the nature of the test they received. The calculation test that we used, which was based on the WJ-III, is similar in format to most standardized tests of paper-and-pencil math calculations. Although the potential “familiarity” in our study does not address effects of testing children with completely novel test problems or test instruments, our findings do implicate the influence of recent practice on optimizing later timed testing, and these effects are observed even when the nature of the tests being given is familiar.

The need for recent practice was not implicated in all cases, however, because there was no effect of test order when the first test given was untimed. We found that math anxiety and perfectionism influenced the discrepancy in math performance during timed versus untimed testing, as discussed below.

Math Anxiety

We hypothesized that higher math anxiety would hinder math performance during timed testing. In contrast, we found the opposite was true: as math anxiety increased, the discrepancy in math performance decreased. Children’s performance accuracy on timed versus untimed testing was relatively unchanged in the higher anxiety group, and in both instances was comparable to that observed in children with lower anxiety during untimed testing. Lower performance on timed (vs. untimed) math testing was evident in only the lower (vs. higher) math-anxiety group.

Our findings are in contrast with those of Lupkowski and Schumacker (1991), who found no relationship between math achievement and math-anxiety level in mathematically gifted, 15- to 18-year-old adolescents. In our study of gifted sixth graders, math anxiety appeared facilitative. Facilitative anxiety acts as a stimulant of efficient response and elicits better performance; whereas debilitating anxiety inhibits the desired behavior and suppresses true ability (Alpert & Haber, 1960). According to Kellogg et al. (1999), time pressure is not a contributor to the worrisome thoughts that occupy individuals with high math anxiety during arithmetic testing. If this is true, then math performance of children with higher math anxiety would not be severely affected by the external time constraint during timed testing, and children would maintain their high performance level during both the timed and untimed testing. Our findings are consistent with this notion, and with general principles of applied psychology. For example, the Yerkes-Dodson law (Yerkes & Dodson, 1908) asserts that there is a curvilinear relationship between arousal and task performance, with optimal performance occurring at some moderate level of arousal or motivation. In our study, the anxiety level induced by timed testing may have been moderate rather than severe, given the competency levels presumed for these highly capable math students.

Indeed, the notion of math anxiety is conceptually confounded with math competence (Ashcraft, 2002). Poor performance on a math test may be due to low competence rather than to heightened math anxiety. In the present study, math competence was estimated by examining the children’s math performance on the untimed condition, as advocated by researchers of math anxiety (e.g., Ashcraft). Children with lower versus higher math anxiety had comparable

performance levels during the untimed condition, suggesting comparable degrees of math competence. Some argue however that math competence is more accurately assessed under timed constraints (e.g., Jordan & Montani, 1997), in which case it would not be possible for us to differentiate math anxiety and math competence in the present study.

Another challenge to separating math competence and math anxiety is the influence of the type (s) of math problems that elicit math anxiety. Ashcraft, Kirk, and Hopko (1998) found that individuals with high math anxiety do not have a global deficit in math competence. Among their 91 participants, no anxiety effect was seen in whole-number arithmetic problems; but anxiety effects were apparent when mixed fractions, equations with unknowns, and percentages were introduced. The math problems used in the current study consisted of a variety of the above mentioned types of problems, which may have complicated the relationship between math competence, math anxiety, and math performance.

Perfectionism

An additional possible influence on timed test performance is perfectionism—a characteristic associated with gifted children (Parker, 1997). To our knowledge, there are few studies that have examined the relationship between perfectionism and performance (Frost & DiBartolo, 2002), and fewer still specific to math performance. In the present study, we found that the significant discrepancy in math performance occurred primarily among children with lower perfectionism.

It is possible that the “high” perfectionism observed in our sample reflects a normal sense of perfectionism, as opposed to a pathologic, or neurotic disorder (Hamachek, 1978). Parker (1997) claimed that children with higher perfectionism demonstrated “healthy perfectionism,” characterized by conscientious, goal- and achievement-oriented behavior, and motivation to strive for success. If this is the case, students with higher perfectionism may seek to maximize performance regardless of timed versus untimed testing conditions, leading to a smaller performance discrepancy across conditions—as observed in our study. Parker and Mills (1996) proposed that when perfectionism refers to having high standards and a drive to achieve without inhibiting performance, it is more likely to be considered a virtue rather than a problem. Perfectionism becomes desirable when it stimulates a healthy pursuit of excellence (Hillyer, 1988). In contrast, Parker (1997) described nonperfectionists as easily distracted and lacking self-discipline, with a lower motivation to achieve compared to peers with high perfectionism. A lower motivation to maximize performance during timed testing could lead to a discrepancy in math performance under timed versus untimed testing—as observed in our study. Indeed, in our study, we found a weak but positive correlation between math competence and perfectionism.

We were surprised by the lack of significant differences in total time used by children in the lower and higher-perfectionism groups, in the untimed condition, although the difference was in the predicted direction. This finding is contrary to the assumption that children with higher perfectionism take more time to complete math tests as they strive for excellence. Further, the finding challenges reports of a significant positive correlation between perfectionism level and measures of compulsivity (Frost et al., 1990). In contrast, there was a significant difference in time spent on the untimed test among children with lower versus higher math anxiety, with the latter group taking longer, but not during the timed test. The latter finding likely results from the fact that most participants took the allotted time to complete the timed test.

Relationship between Math Anxiety and Perfectionism

As math-anxiety level increases, perfectionism level also increases. This is not surprising given some of the parallel findings in our study. Frost et al. (1990) demonstrated how perfectionism

is a characteristic that varies along a continuum. We examined several aspects of perfectionism, and found that three measures were positively correlated with math anxiety: concern over mistakes, doubts about actions, and parental criticism. In the present study, the association between a higher score on concern over mistakes or doubts about actions with higher math anxiety may be explained by recognizing the thoughts that can preoccupy individuals who are worried about making errors, or who are doubtful of their own ability when taking a math test. Parental criticism is also positively correlated with level of math anxiety. This is consistent with reports that parents of gifted children may urge their child to live up to high expectations (Hillyer, 1988).

The need to maintain excellence in math may, in turn, heighten math anxiety and perfectionism levels. This may explain why higher levels of both math anxiety and perfectionism actually enhance math performance under both timed and untimed conditions. Future research is warranted to determine if these findings will be replicated in other age groups of the gifted population. Recruiting participants through other channels, such as working with children who are high achievers at school but not identified by a talent search or gifted programs may influence the potential effect of being labeled “gifted.”

Limitations of the Study

There are a number of limitations within this study, mainly those concerning the size and makeup of our sample. Given the small sample size, this study is a preliminary one. Also, our sample included only children identified as gifted in mathematics. It is unknown how or whether the present findings can be generalized to other populations, including younger or older children, and children with normal or below-average math achievement. Furthermore, we separately examined the extent to which math anxiety and perfectionism influenced math performance, and a larger sample would inform us about the complex interactions of these variables of interest. A larger sample would also permit for analysis of different levels of math anxiety and perfectionism, versus only two levels (higher vs. lower). Nevertheless, our study demonstrates that interactions between the variables we studied do occur, and thus illustrates the need to understand these relationships more thoroughly. It would be informative to carry out further studies in which familiarity of math tests was manipulated, as well as the time span between timed and untimed performance, to better understand the potential roles of test familiarity on later test performance.

In our study, math anxiety and perfectionism were measured with self-report questionnaires. Although this method is limited, Reynolds and Sattler (2002) argue that, when assessing internalizing behaviors that are covert in nature, self-report measures are preferred over parents' and teachers' evaluations for studies with children and adolescents. Although the MARS-E has not been standardized for the gifted-child population, Parker and Stumpf (1995) support the use of MPS to measure perfectionism in academically talented children. Conclusions from questionnaire-based studies could be strengthened with other converging evidence obtained by other methods, such as interviews or behavioral observations (Gierl & Bisanz, 1995). The development of alternative methods to assess math anxiety and perfectionism to provide diverse but complementary forms of evidence could be considered in future research. Despite these limitations, the present research contributes to knowledge about how math anxiety and perfectionism are associated with discrepant math performance under timed versus untimed testing.

Conclusion

From an educational standpoint, there are potential implications to be drawn from the findings of this preliminary study. First, simply giving a child a timed test after allowing for practice brought children's scores to the level of their own untimed math performance, regardless of

whether the second test was timed or untimed. Practice did not seem as necessary for untimed tests—but this may be because the tests used in the study were familiar, in nature and content, to all participants. Second, math anxiety and perfectionism seemed to be facilitative in our mathematically gifted sixth graders, perhaps because the level of anxiety associated with timed performance was moderate versus severe. The effect of math anxiety, and—as Brown et al. (1999) remarked—the effect of perfectionism may have important implications for educational and occupational attainment, particularly if either of these factors leads to math avoidance. It is crucial to identify the characteristics and needs of gifted children to facilitate early, optimal intellectual development. Towards this goal, the findings of the present study shed light on the effects of timed testing, and how math anxiety and perfectionism interact with effects of timed testing in affecting math performance of gifted children.

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Table 1

Distribution of Participants and Testing Conditions

Gender	Order	Order of tasks			
		1 st	2nd	3rd	5th
Girls	A n = 4	Timed test (Form 1)	MARS-E	SCARED	Untimed test (Form 2)
	B n = 4	Timed test (Form 2)	MARS-E	SCARED	Untimed test (Form 1)
	C n = 4	Untimed test (Form 1)	MARS-E	SCARED	Timed test (Form 2)
	D n = 4	Untimed test (Form 2)	MARS-E	SCARED	Timed test (Form 1)
Boys	A n = 4	Timed test (Form 1)	MARS-E	SCARED	Untimed test (Form 2)
	B n = 5	Timed test (Form 2)	MARS-E	SCARED	Untimed test (Form 1)
	C n = 6	Untimed test (Form 1)	MARS-E	SCARED	Timed test (Form 2)
	D n = 5	Untimed test (Form 2)	MARS-E	SCARED	Timed test (Form 1)

Note. MARS-E = The Mathematics Anxiety Rating Scale-Elementary; SCARED = Screen for Child Anxiety Related Emotional Disorders; MPS = Multidimensional Perfectionism Scale.

Table 2**Study Design: Primary Variables of Interest Used In the Study**

Within-subject variables

Testing condition: timed versus untimed testing

Test form: Form 1 versus Form 2

Test form order: Form 1 administered first versus second

Test order: first test versus second test score (regardless of whether Form 1 vs. 2, or timed vs. untimed condition, occurred first)

Between-subject variables

Condition order: timed condition first versus untimed condition first

MARS-E score (continuous; also categorical, low vs. high math anxiety group)

MPS score (continuous; also categorical, low vs. high perfectionism group)

Gender

Table 3
Mean and SD Math Calculations Scores for Timed versus Untimed Testing Conditions, and Results Using Paired *t* Tests

Measure	Condition						Cohen's <i>d</i>
	<i>N</i>	Timed		Untimed		<i>p</i> -value	
		<i>M</i>	(<i>SD</i>)	<i>M</i>	(<i>SD</i>)		
Total number correct (out of 40)	35	19.66	(3.31)	20.91	(2.33)	<.01	-.44
Test form							
Form 1	19	19.47	(3.52)	20.42	(2.59)	<.01	-.31
Form 2	16	19.88	(3.14)	21.50	(1.90)	.058	.62
Testing condition order	35						
Timed first, untimed second	17	18.29	(2.66)	20.53	(2.32)	<.0001	-.90
Untimed first, timed second	18	20.94	(3.40)	21.28	(2.35)	.513	.12
Math anxiety	30 ^a						
High math anxiety	15	20.87	(3.36)	21.00	(2.70)	.779	.042
Low math anxiety	15	19.13	(3.10)	21.07	(2.09)	<.01	.73
Perfectionism	30 ^a						
High perfectionism	12	21.83	(3.24)	21.75	(2.38)	.878	.028
Low perfectionism	18	18.78	(2.78)	20.56	(2.31)	<.01	.70

^aNote. Excludes children with SCARED score > 30.