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Math Anxiety in Elementary and Secondary School Students

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We assessed math anxiety in 6th- through 12th-grade children ($N = 564$) as part of a comprehensive longitudinal investigation of children's beliefs, attitudes, and values concerning mathematics. Confirmatory factor analyses provided evidence for two components of math anxiety, a negative affective reactions component and a cognitive component. The affective component of math anxiety related more strongly and negatively than did the worry component to children's ability perceptions, performance perceptions, and math performance. The worry component related more strongly and positively than did the affective component to the importance that children attach to math and their reported actual effort in math. Girls reported stronger negative affective reactions to math than did boys. Ninth-grade students reported experiencing the most worry about math and sixth graders the least.

The negative effects of math anxiety on students' achievement in mathematics has interested researchers for several years. Richardson and Woolfolk (1980) discussed how certain features of math, such as its precision, logic, and emphasis on problem solving, make it particularly anxiety provoking for some individuals. Studies have documented the negative effects of math anxiety on math performance and achievement (Richardson & Suinn, 1972; Suinn, Edie, Nicoletti, & Spinelli, 1972). Several researchers also have proposed that math anxiety contributes to observed sex differences in mathematics achievement and course enrollment patterns (e.g., Fennema, 1977; Fox, 1977; Tobias & Weissbrod, 1980).

Various questions concerning math anxiety have received scant research attention. First, the dimensionality of math anxiety has not been explored fully. In the test anxiety area, Liebert and Morris (1967) distinguished two components of test anxiety, worry and emotionality. *Worry* is the cognitive component of anxiety, consisting of self-deprecatory thoughts about one's performance. *Emotionality* is the affective component of anxiety, including feelings of nervousness, tension, and unpleasant physiological reactions to testing situations. Morris and Liebert showed that these two components of anxiety are empirically distinct, though they are correlated, and that worry relates more strongly than emotionality to poor test performance (see Morris, Davis, & Hutchings, 1981, for a review of the work on worry and emotionality). Anxiety theorists (e.g., Sarason 1986; Wine, 1971, 1980) believe that the worry or cognitive component of test anxiety interferes most with achievement performance.

Most measures of math anxiety focus on affective reactions to math. For instance, Dreger and Aiken's (1957) three-item math anxiety scale is used to assess emotional reactions to mathematics. Richardson and Suinn's (1972) 98-item Mathematics Anxiety Rating Scale (MARS), the most frequently used measure of math anxiety, is designed to assess anxious reactions to using mathematics in ordinary life and academic situations. Researchers assessing the dimensionality of the MARS and its counterpart for use with adolescents, the MARS-A (Suinn & Edwards, 1982), have obtained somewhat mixed results. In Richardson and Woolfolk's (1980) factor analysis of the MARS, one major factor emerged. This factor may be characterized best as an emotionality factor, insofar as the MARS is primarily a measure of negative affective reactions to mathematics. By contrast, Rounds and Hendel (1980) found evidence for two factors in their analysis of responses to the MARS. They labeled one factor Math Test Anxiety and the other Numerical Anxiety, the latter referring to anxiety about math in everyday situations. Each factor contained about an equal number of items. Suinn and Edwards (1982), using the MARS-A, also found evidence for these two factors, though 89 of the 98 items loaded on the Numerical Anxiety factor and only 9 on the Test Anxiety factor. However, these two factors distinguish between negative affective reactions in nonevaluative versus testing situations, not between affective and cognitive aspects of math anxiety.

Second, questions concerning the distinctiveness of math anxiety as a psychological construct have been raised. Fennema and Sherman (1976), using their math attitudes scales, found that math anxiety and math ability concepts were highly correlated ($r = -.89$) in a sample of high school students. More work is needed to see whether these constructs can be distinguished more clearly.

Third, most studies of math anxiety have been conducted with high school and college-age students, and thus little is known about its prevalence in younger populations. The few studies of math anxiety in younger students show that math anxiety scores, like test anxiety scores, increase across age (Brush, 1980; Meece, 1981). We also know little about whether there are gender differences in math anxiety among younger students, though it appears that during the elementary and junior high school years, boys express slightly more

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positive affect about math than do girls (Aiken, 1976). During the high school and college years, female students report more anxiety about math than do male students (Betz, 1978; Brush, 1980). However, Meece (1981) concluded that grade-level differences in math anxiety were stronger and more prevalent than gender differences.

In this study, we assessed these three issues. Sixth- through 12th-grade children completed a Math Anxiety Questionnaire (MAQ) initially developed by Meece (1981). The MAQ includes items designed to measure possible cognitive and affective components of math anxiety, in accordance with Liebert and Morris's (1967) work in the test anxiety area. We assessed whether similar components of math anxiety could be identified. Children completed the MAQ as part of a comprehensive 2-year longitudinal investigation of children's attitudes, beliefs, values, and performance in mathematics (see Eccles, Wigfield, Meece, Kaczala, & Jayaratne, 1986, for a description of the full study). In this study we assessed relations between math anxiety and other key math attitudes, beliefs, values, and math performance measured in the larger study as one way of assessing the distinctiveness of math anxiety as a construct.

Last, we assessed age and gender differences in math anxiety in two ways. First, we examined whether older and younger students and whether boys and girls responded to the items on the MAQ in similar ways by testing the structural invariance of the covariance matrices of each group. Second, we looked for age and gender differences in the scales created from the factor analyses. On the basis of previous findings, we hypothesized that math anxiety would increase over age. Girls were expected to express more math anxiety than were boys, especially at the upper grades.

Method

Participants

The Year 1 sample consisted of approximately 740 predominately White, middle-class students in 5th through 12th grades. In Year 2, the sample contained approximately 575 children in Grades 6–12 (88% of the Year 1 students in Grades 5–11). Of those children, 564 (298 boys and 266 girls) completed the MAQ. We used the mathematics classroom as an intermediate sampling unit. Classrooms at each grade level were chosen randomly from among the classrooms whose teachers volunteered to participate in this study. Within each classroom all students were asked to participate. Project staff members administered questionnaires to students who had agreed to participate in the study and who had returned permission slips indicating parental consent. All questionnaires were administered during the spring of each year of the study, and most constructs were assessed both years. However, the MAQ was given only during Year 2, and so in the analyses reported in this study, we used primarily Year 2 data.

Student Attitude Questionnaire

The Student Attitude Questionnaire (SAQ) has been used and refined in two major studies of children's beliefs and attitudes about mathematics (for detailed descriptions of the SAQ, see Eccles et al., 1983; Eccles et al., 1986). It contains items assessing students' expectancies for success, incentive values, perceived ability, perceived effort, and perceived task difficulty in both math and English, and many other constructs, such as sex role identity, sex stereotyping of math as a male domain, causal attributions, and children's perceptions of their parents' and teachers' attitudes regarding their abilities in math. Most of these constructs were assessed with two or more items, allowing scales to be developed for those constructs. The math scales used in the the correlational analyses in our study can be grouped into the following categories: math ability perceptions, including children's math ability and performance perceptions (αs = .80 and .77) and current and future expectancies in math (αs = .82 and .81); the task demands of math, including the difficulty of the current math course, effort required to do well in math, and actual effort expended in math (αs = .79, .77, and .43, respectively); and achievement values in math, including math interest, importance, usefulness (αs = .67, .67, and .78, respectively).

The Math Anxiety Questionnaire

The MAQ was developed in several steps. Initially, Meece (1981) defined six possible dimensions of anxious or negative reactions to mathematics for assessment: dislike, lack of confidence, discomfort, worry, fear and dread, and confusion/frustration. Items were constructed or adapted from existing math anxiety scales to assess these different dimensions. After some pilot work with the original set of items to eliminate those with low variability, 22 items for assessing these different dimensions were incorporated into a battery of measures given to 250 students in Grades 5–11 in a study conducted before our study.

The MAQ completed by students in our study contained items that in the prior study had adequate variability and loaded highly on the factors derived by Meece (1981). An additional item concerning students' dread of mathematics was added to the scale, as was an item concerning how much time children would like to spend on math in school. Five items concerning lack of confidence in math were dropped from Meece's original scale because those items overlapped too much with self-concept of ability. Researchers assessing both math and text anxiety have found that such overlap makes it difficult to distinguish the two constructs (Fennema & Sherman, 1976; Nicholls, 1976). The 19 items were incorporated into the SAQ during Year 2. Each item was answered on a 7-point scale. Initial analyses of these items showed that all had adequate variability, and none were skewed. In the analyses reported here, because of our concern with distinguishing math anxiety and low math ability perceptions, four items concerning math confusion and frustration were dropped because they also overlapped too much with math ability perceptions. In addition, four items concerning dislike of math were dropped because exploratory factor analyses of the 15 remaining items showed that these four items form a separate factor, and disliking math is not same as being anxious about it. The 11 items retained in the analyses reported here are presented in Table 1.[1] These items focus on negative affective reactions to doing math activities in school and on students' concerns about their performance in mathematics.

Results

Exploratory Factor Analyses

A principal-components factor analysis with orthogonal and oblique rotations was done on the remaining 11 items. Both Kaiser's criterion and Cattell's (1966) scree test were

[1] The additional items are available from the authors upon request.

Table 1
Math Anxiety Questionnaire Items Included in the Factor Analyses

1. When the teacher says he/she is going to ask you some questions to find out how much you know about math, how much do you worry that you will do poorly? (*not at all, very much*)
2. When the teacher is showing the class how to do a problem, how much do you worry that other students might understand the problem better than you? (*not at all, very much*)
3. When I am in math, I usually feel (*not at all at ease and relaxed, very much at ease and relaxed*).
4. When I am taking math tests, I usually feel (*not at all nervous and uneasy, very nervous and uneasy*).
5. Taking math tests scares me. (*I never feel this way, I very often feel this way*)
6. I dread having to do math. (*I never feel this way, I very often feel this way*)
7. It scares me to think that I will be taking advanced high school math. (*not at all, very much*)
8. In general, how much do you worry about how well you are doing in school? (*not at all, very much*)
9. If you are absent from school and you miss a math assignment, how much do you worry that you will be behind the other students when you come back to school? (*not at all, very much*)
10. In general, how much do you worry about how well you are doing in math? (*not at all, very much*)
11. Compared to other subjects, how much do you worry about how well you are doing in math? (*much less than other subjects, much more than other subjects*)

Note. Scales for each item ranged from 1 to 7.

used to select the number of factors. A two-factor solution best described the data (the first three eigenvalues were 3.95, 1.98, and 0.85). There were no double loadings higher than .30. The first factor (Negative Affective Reactions) can be conceptualized as tapping primarily strong affective reactions to mathematics (e.g., fear, dread, nervousness) and the second (Worry) as tapping cognitive concerns about doing well in math. The first seven items in Table 1 loaded on the first factor, and the last four loaded on the second factor. In the oblique rotation, the factors were negatively correlated ($r = -.40$). Given the relative clarity of these factors, we explored them further by using confirmatory factor analysis (CFA).

Confirmatory Factor Analyses

The CFAs had two main purposes. The first was to examine the fit of the factor structure model suggested by the exploratory factor analyses and to see whether certain changes in that model might lead to a better fit. The second was to assess whether there was invariance in the covariance matrices across different groups of students, particularly (a) older and younger students and (b) boys and girls. For the age group comparison, two age groups were examined: a younger group consisting of the elementary and junior high school students (6th, 7th, 8th, and 9th graders) and an older group consisting of the high school students (10th, 11th, and 12th graders). The CFAs were done with the LISREL VI program (Jöreskog & Sörbom, 1981). Several goodness-of-fit indices were examined, including Jöreskog and Sörbom's (1981) Goodness-of-Fit Index (GFI), chi-square, examination of the relations of the parameters to their standard errors, and the normalized residuals.

Initial models were generated for the sample as a whole, for the 6th–9th graders, and for the 10th–12th graders. Several assumptions were made: First, the two-factor model would best fit the data; second, each item would have a nonzero loading on only one factor (the factor that it loaded on in the exploratory analysis); and third, the errors of measurement would be uncorrelated. To test the assumption that the two-factor model would best fit the data, we computed chi-square difference tests (Long, 1983), comparing the two-factor model against a null model specifying that the variables are mutually independent. In addition, a one-factor model specifying that all the items loaded on a single factor was compared with the null model. Both the one-factor and the two-factor models showed highly significant improvements in fit over the null model. Because the chi-square differences were much stronger between the two-factor model and the null model than between the one-factor and the null models, the two-factor model was selected as the preferred model.

In the two-factor model, the factor loadings all were quite large in relation to their normalized residuals (8–10 times as large), and the loading pattern was similar to that in the exploratory analyses. Jöreskog and Sörbom's (1981) GFI reached .90 in the whole sample and younger group analyses and approached it in the analysis of the older students (.91, .91, and .88, respectively). The ratios of chi-square to degrees of freedom were 6.68 in the whole sample, 3.76 in the 10th- to 12th-grade group, and 4.24 in the 6th- to 9th-grade group.

One way to improve the fit of the model was to relax the constraint of no correlated error of measurement—in particular, to relax the constraint with respect to two items concerning nervousness while taking math tests (Items 4 and 5), which had very similar wording. This change produced a better model fit. The GFIs for all three groups were .93, .93, and .90, and the ratios of the chi-square to degrees of freedom were 5.55 for the whole sample, 3.25 for the 10th- to 12th-grade group, and 3.68 for the 6th- to 9th-grade group. Chi-square difference tests between this model and the previous model were significant at the .01 level in all three groups. These difference tests indicated the revised model provided a better fit. Factor loadings for this model are presented in Table 2.

The LISREL VI program allows the researcher to compare the factor structure in different subgroups of respondents. Such comparisons are particularly important in developmental studies in which researchers wish to compare means that are based on factor scores across different age groups. If the factor structure varies across ages, it can be misleading to compare means based on factor scores derived from a single factor structure (Alwin & Jackson, 1981). Jöreskog and Sörbom (1981) outlined a series of steps by which researchers can test structural invariance in different groups. The most rigorous involves testing the invariance of covariance matrix structures; if this test is met, then any given factor structure model will fit the same in the groups.

We first compared the covariance matrices of the younger (6th- through 9th-grade) and older (10th- through 12th-grade) students. This test indicated that the matrices were invariant across the age groups. The GFIs for this test were .98 for the younger students and .93 for the older students, and the ratio

Table 2
Standardized Lambda Coefficients (Factor Loadings) for the Confirmatory Factor Analysis of the Math Anxiety Questionnaire

	Factor	
Item	Negative affective reactions	Worry
1	.66	
2	.52	
3	−.58	
4	.60	
5	.72	
6	.66	
7	.62	
8		.68
9		.64
10		.87
11		.54

Note. Item numbers correspond to those in Table 1. $N = 564$.

of chi-square to degrees of freedom was 1.82, indicating quite similar structure across the two groups.

We next examined the covariance matrices for boys and girls. Because there were no age differences, the covariance invariance test for boys and girls was done across age groups. As with the older and younger students, the covariance matrices of the boys and girls were quite similar. The GFIs were .96 for girls and .97 for boys, and the ratio of chi-square to degrees of freedom was 1.62, again indicating invariance across groups. These analyses indicate that the factor model presented earlier would fit the data similarly across the groups of interest.

Correlational Analyses

Using unit weighting of the items, we created scales based on the two factors. The alphas were .82 for the negative affective reactions scale and .76 for the worry scale. These scales were correlated with the math ability perceptions, perceived task demands, and math values scales described earlier. Grades in math from Year 1 and Year 2 of the study also were included in these analyses.

Correlations for the whole sample are presented in Table 3. In nearly every case the correlations of the negative affective reactions scale and other scales were higher than were the correlations involving the math worry scale. This pattern is particularly apparent in the relations of the affective scale with the ability-related scales (ability, perceived performance, expectancies), as well as difficulty of current math course, in comparison with the relations of the worry scale with these scales. The correlations between negative affective reactions, ability perceptions, performance perceptions, and expectations were moderate to fairly strong, ranging from −.50 to −.62. The same correlations substituting the worry scale ranged from −.01 to −.25. The worry scale related more strongly to the importance of math scale and the scale concerning the amount of effort that students actually put into math. These positive correlations indicate that students who believe that math is important and put more effort into it are more concerned about doing well in math.

Grade Level and Gender Differences in Math Anxiety

Age and gender differences in the two scales were assessed in a 7 × 2 (Grade × Gender) analysis of variance (ANOVA). On the math worry scale, the grade-level main effect was significant, $F(6, 555) = 4.01$, $p < .01$. The means did not show a consistent ascending or descending pattern; rather, math worry was highest in 9th-grade students ($M = 5.46$), intermediate (and at similar levels) in 7th-, 8th-, 10th-, 11th-, and 12th-grade students ($M \cong 5.00$), and lowest in 6th-grade students ($M = 4.63$). In general, with respect to the 7-point scale, these means are rather high in all grade-level groups. No grade-level effects were observed on the negative affective reactions scale.

On the negative affective reactions scale, girls ($M = 3.82$) reported experiencing significantly more negative affect about math than did boys ($M = 3.28$), $F(1, 555) = 27.41$, $p < .001$. No gender differences were observed on the worry scale, and there were no interactions of gender and grade on either scale. Though there were no interactions of gender and grade on the scales, one-way ANOVAS in which we assessed gender effects on the negative affective reactions and worry scales were performed separately at each grade level. In these analyses none of the gender effects were significant on the worry scale. Girls' negative affective reactions to math were stronger than those of boys at each grade level; the gender differences were significant for 6th-, 7th-, 9th-, and 11th-grade students.

Discussion

Our results show that different components of math anxiety can be distinguished and that they are similar in younger and

Table 3
Correlations of the Math Anxiety Scales With Math Attitudes and Math Performance

Construct	Negative affective reactions	Worry
Worry scale	.33**	1.00
Math ability perceptions scales		
Perceived ability	−.60**	−.10*
Perceived performance	−.55**	−.10*
Current expectancies	−.52**	−.09*
Future expectancies	−.53**	−.01*
Math task demands scales		
Current difficulty	.62**	.27**
Required effort	.57**	.38**
Actual effort	.22**	.37**
Math achievement values scales		
Interest	−.35**	.12*
Importance	−.18**	.36**
Usefulness	−.18**	.11*
Math performance: Grades		
Year 1	−.22**	.02
Year 2	−.26**	.02

* $p < .05$. ** $p < .01$.

older children and in boys and girls. The two components of math anxiety emerging from the factor analyses were similar to those identified by test anxiety researchers. One component primarily taps negative affective reactions to math, such as nervousness, fear, and discomfort. The other component primarily taps worries about doing well in mathematics. The correlations between the two factors suggests there is some overlap in the two components, as does the fact that two items concerning students' worries about doing poorly in front of the teacher loaded on the negative affective reactions scale. These two items also seem to reflect student's negative reactions to mathematics—in this case, worries about poor performance. The factor-analytic findings reported here, along with those in the test anxiety area, provide some convincing evidence for distinguishing between affective and cognitive components of anxiety.

The conceptual distinctiveness of these two components also can be seen in their relations with other math attitudes, beliefs, and math performance. The negative affective reactions scale correlated more strongly and negatively than the worry scale to children's math ability perceptions, performance perceptions, expectancies, and math performance. In contrast, scores on the worry scale related more strongly (and positively) to the actual effort that students say they put into math, and to the importance that they attach to math.

What explains these different patterns? Research on test anxiety (e.g., Sarason, 1986; Wine, 1980) has shown that highly anxious students are overly concerned with the possible consequences of failure. The negative emotional states that these self-focused cognitions evoke can interfere with attentional and learning processes so that test or task performance is impaired. In our study, the negative affective reactions scale seems to provide the best measure of this debilitating math anxiety, as indicated by its negative relation with math performance. In contrast, math worry or concern as assessed here related negligibly to math performance. Instead, it was positively related to the importance that students attach to math and the amount of effort that they reported putting into it. The degree of concern that students express about doing well in mathematics actually may have some positive motivational consequences for the amount of effort that students put into math, which could have long-term positive effects on math performance.

These relations are different from those reported by Liebert and Morris (1967) and Morris et al. (1981). Their studies showed that their test anxiety Worry scale relates more strongly and negatively to test performance than their Emotionality scale. One explanation for these different patterns is that our math worry scale and their Worry scale may be designed to assess different levels of concern or worry. The items on our scale concern worries about doing *well* in math, whereas the items on Liebert and Morris's Worry scale concern worry about doing *badly*. Thus Liebert and Morris's worry scale may tap the self-focused or task-irrelevant cognitions that inhibit performance because they arouse concerns about failure (see Wine, 1980). A degree of worry or concern may be needed to motivate students to try harder; without that, students may see no reason to try. However, if this worry or concern becomes too strong and is focused on possible poor performance, it may interfere with performance. In addition, some of the items on Liebert and Morris's Worry scale tap self-appraisals of ability. Therefore, the level of worry assessed by their scale may be mediated by perceptions of low ability. In contrast, our worry scale related more strongly to the perceived value of math than to math ability perceptions.

Future researchers should explore more fully the links between math achievement values and anxiety. The value students attach to math could moderate or augment the effects of poor performance on students' math anxiety. For instance, students who do poorly in math but attach little importance to it may not be anxious about math. Students doing poorly in math but who want to do well may report higher levels of math anxiety. Research focusing on the influence of perceptions of ability, math values, and math performance on math anxiety may help better explain the development of math anxiety.

Our results also show that math anxiety should be conceptually distinguished from perceptions of math ability. As we mentioned earlier, some researchers have found that math anxiety is very highly and negatively correlated with perceptions of math ability (Fennema & Sherman, 1976). We attempted to retain items on the MAQ that did not confound anxiety and perceptions of ability, and the negative affective reactions scale in particular accomplished this. Our results show that the anxiety that students report represents more than a lack of confidence in math; rather, it also centers on negative affective reactions to math. In regard to intervention efforts to alleviate math anxiety, we would suggest that techniques to build anxious students' confidence in their math ability may not be enough to alleviate the strong negative affective reactions to math that they experience. Math-anxious students also may need training to reduce their fear and dread of math. As has been found in the test anxiety area (see Tryon, 1980), intervention efforts focusing on both the cognitive and affective components of math anxiety may prove to be the most effective way to reduce its debilitating effects.

Another purpose of this study was to examine age and gender differences in math anxiety. Younger and older students responded to the MAQ in similar ways, as indicated by the tests of the invariance of the structure of the covariance matrices of children's responses. There were significant grade-level differences on the worry scale showing that children reported the most concern about math performance in 9th grade and the least in 6th grade. The findings for the 6th graders could be due to the less pressured environment of the elementary school; in comparison with junior high and high school, the elementary school environment does not emphasize evaluation as much (see Eccles, Midgley, & Adler, 1984). In the school districts included in this study, students are tracked into different math classes (on the basis of their math performance) in 9th grade; these students may have been most concerned about math because of the shifts in their comparison groups that occurred at that time (see Schwarzer & Schwarzer, 1982). In general, however, the differences across grade levels on both scales were not large, indicating relatively little change in anxiety scores through junior and senior high (see Manley & Rosemier, 1972, for similar evidence in the test anxiety area).

In regard to gender differences, there were no differences in the structure of boys' and girls' responses to the MAQ, which indicates that they were answering the items in similar ways. Boys and girls also did not differ in their reports of math worry, which indicates that they were equally concerned about doing well in mathematics. However, girls reported experiencing more negative affective reactions to math than did boys. Similar findings have been reported by others (Betz, 1978; Brush, 1980; Meece, 1981). These findings could have implications for girls' continued participation in mathematics. Though boys and girls seem to be equally concerned about math, girls' stronger negative affective reactions to math might mean that as math courses get harder, they will be more likely to stop taking math when they have that option. Several researchers have shown that math-anxious students are less likely to take advanced or optional courses in mathematics (Brush, 1980; Sherman & Fennema, 1977). The influence of math anxiety on students' performance and participation in math needs further clarification, particularly as it relates to gender differences in these patterns.

To conclude, we have shown that cognitive and affective components of math anxiety can be identified. We also have shown how these components relate to students' perceptions of math ability, valuing of math, and math performance. Researchers should now examine the antecedents of the affective and cognitive components of math anxiety in the home and school environments in order to provide a better understanding of their developmental course. They also should assess when the two components of math anxiety can be identified in younger elementary school students. Because most of the work in the anxiety area has focused on the relations of anxiety, perceptions of ability, and performance, we believe that further exploration of links between math anxiety, math values, math performance, and continued participation in math would make a significant contribution in this area. Last, we would suggest that intervention programs to alleviate the negative effects of math anxiety must deal with both affective and cognitive aspects of math anxiety. These programs should be implemented during the elementary school years, before children's anxiety about math becomes strongly established.

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