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Emotional and Behavioral Characteristics Over a Six-Year Period in Youths With Persistent and Nonpersistent Dyscalculia

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The authors examined behavior problems in a matched sample of 58 youths with persistent dyscalculia (PD) and nonpersistent dyscalculia (NPD). Participants were classified as having dyscalculia at age 10–11 years. Parents completed the Child Behavior Checklist for their children at ages 10–11, 13–14, and 16–17 years, while the youths did so at the last two age periods. Only at age 16–17 years were there significantly more problems, particularly attention problems and externalizing problems, reported by parents for PD youths compared to NPD youths. A higher percentage in the PD group than in the NPD group received scores in the clinical range for externalizing problems. However, the mean levels of behavior problems at this age and the earlier ages were within the normal range for both groups. For youth-reported problems, the only significant difference was for attention problems at 16–17 years. Therapeutic interventions should focus on the academic domain and improving and altering behavioral patterns.

Keywords: *longitudinal research method; dyscalculia; behavior disorders; BD*

Although academic and cognitive deficits are hallmarks of children with learning disabilities (LD), these children are also at risk for a broad range of behavioral and emotional problems (Beitchman & Young, 1997). Concurrent LD and behavior problems have been reported for children in early elementary school, preadolescence, and adolescence (Gadeyne, Ghesquitre, & Onghena, 2004; Prior, Smart, Sanson, & Oberlaid, 1999; Willcutt & Pennington, 2000). The types of problems seen in children with LD include externalizing and internalizing problems, with attentional problems being particularly predominant (Gadeyne et al., 2004; Prior et al., 1999; Shalev, Auerbach, & Gross-Tsur, 1995).

Although most research on LD has focused on specific reading disability (Beitchman & Young, 1997) and consequently on emotional and behavior problems associated with it, other learning disabilities, such as dyscalculia, also carry an increased risk for emotional and behavior problems. Attentional problems and internalizing and externalizing problems frequently co-occur with dyscalculia (Prior et al., 1999; Shalev et al., 1995).

LD, including dyscalculia, is commonly defined in terms of an age, grade-level, or aptitude discrepancy in achievement with diagnostic stability over time. For dyslexia, the diagnostic stability ranges from 20% to over 50% depending on age of initial diagnostic classification (Rutter, Tizard, Yule, Graham, & Whitmore, 1976; Shaywitz, Escobar, Shaywitz, Fletcher, & Mackuck, 1992; Waring, Prior, Sanson,, & Smart, 1996). With respect to dyscalculia, stability ranges from 40% to 65% (Mazzocco & Myers, 2003; Shalev, Manor, & Gross-Tsur, 2005; Shalev, Auerbach, Manor, & Gross-Tsur, 2000).

Although continuity of behavior problems across age has been examined in psychiatric samples, such as children with attention-deficit/hyperactivity disorder (ADHD; Biederman et al., 2001; Fischer, Barkley, Fletcher, & Smallish, 1993), it has not been investigated prospectively in an LD sample for which there was an evaluation of

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behavior problems at time of initial LD diagnosis and subsequently both a reevaluation of LD diagnosis and behavior problems. Waring et al. (1996) did report on behavior problems at two time points in a subsample of children with reading problems, but no evaluation of behavior problems was done at the initial evaluation of reading problems at Grade 2. The subsample was composed of children who showed persistent reading disability and those who recovered by Grade 6. Behavior problem ratings were done at Grades 4 and 6. Those with persistent reading problems had higher levels of parent-reported hostile–aggressive behavior in Grades 4 and 6 than did the children whose reading skills improved.

It is the purpose of this article to examine the continuity of behavior problems in adolescence in a sample of youths with persistent dyscalculia (PD) and nonpersistent dyscalculia (NPD). If we assume that behavior problems are a reaction to lack of academic success in school (Huntington & Bender, 1993; Lynam, Moffitt, & Stouthamer-Loeber, 1993; Stanton, Feehan, McGee, & Silva, 1990), then we would expect both groups to show similar levels of behavior problems at the time when diagnosed initially with dyscalculia. As arithmetic achievement improves in those youths with NPD, we would expect a concomitant decrease in their emotional and behavior problems, but not for those who persist in their dyscalculia. However, if the behavior problems are an integral part of the underlying neuropsychological deficits responsible for the dyscalculia, as suggested by the model of nonverbal learning disabilities syndrome, then we would expect no specific association between emotional and behavioral problems and degree of dyscalculia (Casey, Rourke, & Picard, 1991).

An important source of information about adolescent behavior problems is the youths themselves, particularly because meta-analysis has shown that the average correlation between parent and youth behavior ratings is only .25 (Achenbach, McConaughy, & Howell, 1987). Underreporting of problems by youths tends to occur in samples of children with chronic physical conditions (Huberty, Austin, Harezlak, Dunn, & Ambrosius, 2000) or psychiatric problems (Handwerk, Larzelere, Friman, & Soper, 1999). Similar findings were reported in a Norwegian study of children with dyslexia, although their parents reported significantly more problems in their children than did parents of a comparison group of children. In contrast, there were no group differences when the youths were the source of information (Heiervang, Stevenson, Lund, & Hugdahl, 2001).

In this article, we address three questions as they relate to youths with dyscalculia:

1. Do behavior problem differences related to dyscalculia persistence already exist at the initial diagnosis of dyscalculia?
2. Do youths with PD versus NPD differ subsequently in level and type of behavior problems?
3. What is the extent of agreement between parent-reported and youth-reported behavior problems as it relates to persistence of dyscalculia?

To examine these questions, this study utilized parent-reported and youth-reported behavior problem data on a sample of children with dyscalculia. Parents completed the *Child Behavior Checklist* (CBCL; Achenbach, 1991a) at three time points concurrent with a reassessment of the child's dyscalculia classification. Youths completed the *Youth Self-Report* (YSR; Achenbach, 1991b) at the last two assessment periods.

When studying developmental disorders and their association with psychopathology, the comorbidity of a specific learning disability, in this case dyscalculia, with other learning disabilities and with ADHD is an issue. Lewis, Hitch, and Walker (1994) found that in an epidemiological sample of 1,029 youths ages 9–10 years, 2.3% had both arithmetic and reading problems. In a longitudinal sample of 445 children followed from kindergarten, 33% diagnosed as learning disabled in third grade met criteria for ADHD (Shaywitz & Shaywitz, 1986). In our cohort of children age 10–11 years with dyscalculia, 26% had ADHD and 17% had reading problems (Gross-Tsur, Manor, & Shalev, 1996). Therefore, if an association is found between dyscalculia and behavior problems, the contribution of comorbid conditions will be examined.

Method

Participants

This sample consisted of 58 youths who were part of a longitudinal study of developmental dyscalculia. These youths were drawn from a sample of 104 children with dyscalculia followed prospectively from ages 10–11 years to 16–17 years and who were classified as having dyscalculia at ages 10–11 years. They were reassessed at ages 13–14 years and at 16–17 years (Gross-Tsur et al., 1996; Shalev et al., 2000; Shalev et al., 2005). Twenty-nine youths (14 boys and 15 girls) designated as having PD were matched with 29 youths (14 boys and 15 girls) classified as having NPD. Matching was based on gender and IQ (without the arithmetic subtest).

The 104 children with dyscalculia were drawn from a cohort of 3,029 fourth-grade children attending mainstream city schools who had undergone testing of arithmetic skills. At this time, 140 were classified as having dyscalculia (Gross-Tsur et al., 1996). Dyscalculia was determined using a two-stage screening process. In the first stage, all 3,029 fourth graders took a group-administered arithmetic achievement test assessing counting skills, knowledge of number facts, and ability to solve complex arithmetic exercises and word problems. Of the 600 children scoring in the lowest 20% on this test, 555 entered the second stage, which took place in fifth grade when the children were 11.1 ± 03 ($M \pm SD$) years old. Each of these children was individually administered an arithmetic battery, standardized on age-matched controls (Shalev, Manor, Amir, & Gross-Tsur, 1993). A child was diagnosed as having dyscalculia if his or her full-scale IQ was greater than or equal to 80 and the score achieved on the second arithmetic test was in the lowest 5th percentile for school grade. One hundred and forty children fulfilled the diagnostic criteria for dyscalculia and underwent further testing, which included reading and writing evaluations, an IQ test (the *Wechsler Intelligence Scale for Children–Revised;* Wechsler, 1974), and neuropsychological tests. Parents provided information regarding socioeconomic status, including profession and years of education (Gross-Tsur et al., 1996).

Three years later, when the children were 14.2 ± 01 years old and studying in eighth grade, 123/140 (88%) members of the original cohort were restudied (Shalev, Manor, Auerbach, & Gross-Tsur, 1998). They were evaluated for arithmetic, reading, and spelling proficiency (Shalev et al., 1998).

The second follow-up took place 6 years after the diagnosis of dyscalculia was first given. The assessment at the 6-year follow-up included standardized arithmetic, reading, and writing tests and a questionnaire regarding educational interventions (after-school tutoring, school tutorials, or resource room).

The arithmetic test used was based on the neurocognitive model that evaluates number comprehension, number production, number calculation, and arithmetic error types (McCloskey, Caramazza, & Basili, 1985; Shalev et al., 1993; Shalev et al., 1998). The arithmetic tests given at the different grades were essentially identical, with the following exceptions: At the 3- and 6-year follow-up, questions on number comprehension and production that had been associated with small variances at the 3-year follow-up were not included, and questions on fractions and decimals were added for 13–14 year olds and 16–17 year olds (8th and 11th graders), respectively. A complete version of the test appears in the appendix. A cutoff at the 5th percentile was used to delineate dyscalculia.

At Grades 3 to 6, 8, and 10, reading and writing assessments were carried out. These assessments were standardized at the same time and in the same way as the arithmetic tests (Shalev et al., 1993; Shalev et al., 1998). For the reading evaluation, the children read aloud a paragraph of class-appropriate material. The test was timed, and errors in word recognition were scored. The spelling test was a timed dictation of a short paragraph chosen from grade-appropriate texts. The criterion for reading and writing problems was a score in the lowest 5th percentile of the class.

As previously stated, dyscalculia was diagnosed if the performance of the child on the standardized arithmetic test was in the lowest 5th percentile of the class. The diagnosis was considered persistent (stable, or PD) if the youth was still scoring in the lowest 5th percentile in late adolescence (age 16–17 years) on our standardized arithmetic test. If the youth was scoring above the 5th percentile, he or she was classified as having NPD. It should be noted that among those who were classified as having NPD, 97% scored in the lowest quartile of their class, indicating that they still had difficulties in arithmetic. All children were in mainstream education classes and were from lower-middle-class socioeconomic backgrounds. (For further details of the total sample, see Gross-Tsur et al., 1996)

Table 1 presents a comparison of characteristics of the PD and NPD groups at the first assessment period (10–11 years old). As can be seen, there is no difference between the groups in parental education and full-scale IQ (without arithmetic subtests). A higher percentage of youth in the PD group compared to the NPD group had reading and writing problems (all p values > .15) and higher scores on the *Conners' Abbreviated Behavioral Parent and Teacher Rating Scale* (Conners, 1973) (Wilks's $\Lambda = 0.91$, $p > .10$). At ages 16–17, 10.3% and 20.7% of the PD group had reading and writing problems, respectively, compared to 17.2% and 13.8% of the NPD group. The differences were not significant. In each group, 38% of the youths received mathematical educational interventions at ages 13–14. At ages 16–17, 34.5% (10/29) of the NPD group received math tutoring, whereas 27.6% (8/29) of the PD group received math tutoring; the difference was not significant.

Measures

CBCL and YSR (Achenbach, 1991a, 1991b). The CBCL is a questionnaire measure of parent-reported behavioral and emotional problems. The questionnaire consists of 118 questions rated on a scale from 0 to 2

Table 1
Comparison of Characteristics of Youths With Persistent Dyscalculia (PD) and Nonpersistent Dyscalculia (NPD) at Age 10–11 Years

Characteristic	Persistent Dyscalculia	Nonpersistent Dyscalculia
Mothers' years of education	10.6 (3.5)	10.0 (2.8)
Fathers' years of education	10.4 (2.3)	10.0 (2.8)
Full-scale IQ (without arithmetic subtest)	99.1 (8.9)	99.4 (8.6)
Reading problems	27.6%	14.3%
Writing problems	24.1%	10.7%
Abbreviated Behavior Rating Scale–parent report[a]	9.2 (7.8)	5.9 (5.2)
Abbreviated Behavior Rating Scale–teacher report[a]	16.5 (8.5)	12.8 (8.4)

Note: Means with standard deviations in parentheses, except where percentages are shown.
a. Conners (1973).

(0 = *not true*, 1 = *sometimes true*, 2 = *true*). The 1991 CBCL is suitable for ages 4–18 years. A Total Behavior Problems score is derived through the summation of responses to the questions. In addition, the CBCL yields two wide-band syndromes, Internalizing and Externalizing Problems, and eight narrow-band syndromes: Withdrawn, Somatic Complaints, Anxious/Depressed, Social Problems, Thought Problems, Attention Problems, Delinquent Behavior, and Aggressive Behavior. The YSR is the self-report version of the CBCL and suitable for adolescents between the ages of 11 and 18 years. The YSR yields scores on the same scales as the CBCL. For both the CBCL and YSR, raw scores can be converted to *T* scores based on normative data. A commercially available computer program was used to score the ratings and convert the raw scores into *T* scores.

Procedure

All assessments of the youths were done at the neuropediatric unit of Shaare Zedek Medical Center. While their children were being assessed, mothers completed the CBCL on their children. At the follow-ups when the youths were 13–14 years old and 16–17 years old, they completed the YSR. Serious attempts were made to obtain CBCL teacher report forms, but obstacles raised by both parents and teachers rendered this unfeasible. Institutional review board approval was received for the execution of the study, and informed consent was obtained from the participants at each assessment period.

Statistical Analyses

Repeated measures ANOVAs were used to examine the extent to which the PD and NPD groups differed across age periods in level and type of behavior problems. Gender was used as a fixed effect. For the CBCL, the within-group effect had three levels (3 age periods), whereas for the YSR, there were two levels (2 age periods) for the within-group effect. Univariate analyses were done when there were significant main effects ($p < .05$) on the repeated measures ANOVAs. When called for, Bonferroni tests were used for post-hoc comparisons. Effect size (ES) was calculated when there were significant group or age period effects. According to Cohen (1988), effect sizes of .20 are small, .50 are medium, and .80 are large.

For significant group main effects, multiple regression analyses were used to examine whether the behavioral results might be explained, at least in part, by reading and writing problems and/or ADHD symptoms at ages 10–11 and not only by dyscalculia persistence. The possible contribution of reading and writing problems at ages 16–17 to the prediction behavioral outcome at that age was assessed using multiple regression. Only the teacher-report Conners' score was entered as a predictor variable in the analysis of CBCL scales to avoid the problem of the same informant completing both the Conners' and the CBCL scales, as was the case for parents. For the YSR, both teacher- and parent-report scores were entered into the regression.

To determine if there were dyscalculia group effects for the percentage of youths receiving scores in the clinical range on the syndrome scales, we used *T* scores ≥ 70 (98th percentile) for the narrow-band syndromes and *T* scores ≥ 64 (90th percentile) for the wide-band syndromes and for Total Behavior Problems. According to Achenbach and Rescorla (2001), these *T* scores significantly discriminate between children referred to mental health and special education services for behavioral and emotional problems and similar children who are not referred. Chi-square analyses were used to examine clinical range group differences, and Bonferroni correction was used to reduce the chance of Type I error due to multiple comparisons.

Pearson correlations were used to examine the association between parent- and youth-reported problems. Raw scores were used for the correlational analysis because the same *T* score is given to one or more raw scores, particularly at the lower end of the narrow-band scales, thus truncating the distribution of scores. Paired *t* tests were used to examine mean differences in parent and youth reports. These were two-tailed tests.

Results

Tables 2 and 4 present the means and standard deviations by group and age for the CBCL and YSR behavior

Table 2
Means and Standard Deviations (in parentheses) of *Child Behavior Checklist*[a] Syndrome Scales by Group

	Persistent Dyscalculia			Nonpersistent Dyscalculia		
Problem Scale	10–11 Years	13–14 Years	16–17 Years	10–11 Years	13–14 Years	16–17 Years
Total Behavior	54.7 (11.3)	52.7 (12.6)	55.2 (9.8)	51.5 (13.5)	47.7 (12.5)	48.1 (11.4)
Internalizing	54.2 (10.8)	50.9 (13.2)	55.0 (9.3)	54.1 (12.3)	49.0 (11.8)	49.8 (12.2)
Externalizing	53.6 (11.2)	52.2 (12.0)	54.6 (11.2)	49.6 (10.5)	47.5 (9.6)	47.6 (8.3)
Withdrawn	56.7 (8.4)	55.5 (8.7)	56.1 (9.2)	58.6 (10.6)	54.9 (7.0)	54.5 (8.9)
Somatic	55.3 (5.8)	52.6 (5.8)	55.2 (7.4)	56.4 (7.4)	53.4 (6.9)	57.4 (10.4)
Anxious/depressed	56.1 (7.6)	56.7 (9.4)	56.3 (6.2)	55.5 (7.6)	54.3 (5.9)	53.2 (5.4)
Social	58.3 (9.8)	54.7 (6.5)	55.2 (7.3)	55.0 (7.6)	53.1 (5.8)	52.5 (4.8)
Thought	56.1 (5.6)	53.7 (6.3)	54.2 (5.5)	54.5 (6.6)	53.9 (3.3)	52.5 (4.9)
Attention	60.2 (9.2)	59.3 (10.7)	59.0 (9.1)	58.9 (9.3)	56.9 (9.5)	52.9 (4.8)
Delinquent	55.7 (7.5)	53.7 (6.3)	57.4 (8.1)	54.1 (7.2)	51.2 (2.8)	51.6 (2.9)
Aggressive	56.6 (7.8)	56.7 (9.7)	57.0 (7.8)	53.9 (5.9)	53.5 (5.6)	52.6 (4.5)

a. Achenbach (1991a).

problem scales. As can be seen, the mean scores for both groups are within the normal range on all the behavior problem scales.

CBCL behavior problem scores. There were significant multivariate main effects of dyscalculia (PD and NPD) group for Attention Problems, $F(1, 53) = 4.13$, $p < .05$; Delinquent Behavior, $F(1, 54) = 8.56$, $p < .01$; Aggressive Behavior, $F(1, 54) = 5.46$, $p < .05$; Externalizing Problems, $F(1, 54) = 5.41$, $p < .05$; and Total Behavior Problems, $F(1, 54) = 4.02$, $p < .05$. At the time of the initial diagnoses, when the participants were 10–11 years old, there were no differences between those who continued at later ages to meet research criteria for dyscalculia (PD) and those who no longer reached criteria (NPD), although overall the PD group scores on the scales were higher. Univariate analyses showed significant differences at ages 16–17 years for Attention Problems, $F(1, 53) = 10.05$, $p < .001$, ES = .40; Aggressive Behavior, $F(1, 54) = 7.33$, $p < .01$, ES = .33; Externalizing Problems, $F(1, 54) = 6.94$, $p = .01$, ES = .33; and Total Behavior Problems, $F(1, 54) = 6.31$, $p < .05$, ES = .32. For Delinquent Behavior, the univariate effect approached significance at ages 13–14, $F(1, 54) = 3.63$, $p = .062$, ES = .25, and was significant at ages 16–17, $F(1, 54) = 13.21$, $p < .001$, ES = .43. In all univariate comparisons, the group of youths with PD received significantly higher problem scores than the group with NPD. There were no significant main effects for gender or significant interactions among the variables.

Multiple regression analyses showed that Conners' teacher-reported ADHD symptoms made significant contributions to the prediction of Externalizing Problems, Delinquent Behavior, and Total Behavior Problems at ages 16–17. The betas for Conners' teacher-reported ADHD symptoms and dyscalculia group, respectively, were 0.37, $p < .005$, and 0.30, $p < .05$, for Externalizing Problems; 0.30, $p < .05$, and 0.38, $p < .005$, for Delinquent Behavior; and 0.29, $p < .05$, and 0.29, $p < .05$, for Total Behavior Problems. Conners' teacher-reported ADHD symptoms did not contribute to the prediction of Attention Problems or Aggressive Behavior. Reading and writing problems at 10–11 years and at 16–17 years did not predict behavioral outcome at ages 16–17.

There were changes in behavior problem scores over time for the following scales: Internalizing Problems, $F(2, 108) = 3.46$, $p < .05$; Somatic Complaints, $F(2, 106) = 5.18$, $p < .01$; Social Problems, $F(2, 108) = 5.17$, $p < .01$; Attention Problems, $F(2, 106) = 3.61$, $p < .05$; and Delinquent Behavior, $F(2, 108) = 3.24$, $p < .05$. Specifically, there were significant decreases in scores from ages 10–11 to 13–14 for Internalizing Problems ($p < .05$, ES = .17), Somatic Complaints ($p < .05$, ES = .22), and Social Problems ($p < .05$, ES = .17), and a borderline difference for Delinquent Behavior ($p = .06$). For Somatic Complaints, there was a significant increase in problems from ages 13–14 to 16–17 ($p < .05$, ES = .21). For Social Problems and Attention Problems, there were significant decreases from ages 10–11 to 16–17 ($p < .05$ for both, ES = .17 for Social Problems and ES = .20 for Attention Problems).

The percentages of youths who fell into the clinical range on the CBCL are presented in Table 3. The only difference found, albeit a borderline one, was for Externalizing Problems ($\chi^2 = 6.44$, corrected $p = .06$) at 16–17 years. More youths in the PD group than in the NPD group received scores in the clinical range.

YSR behavior problem scores. Table 4 shows the means and standard deviations by group and age for the YSR

Table 3
Percentage of Youths With Persistent Dyscalculia (PD) and Nonpersistent Dyscalculia (NPD) With Clinically Significant Scores on the *Child Behavior Checklist*[a] Syndrome Scales at Three Age Periods

	Persistent Dyscalculia			Nonpersistent Dyscalculia		
Problem Scale	10–11 Years	13–14 Years	16–17 Years	10–11 Years	13–14 Years	16–17 Years
Total Behavior	24.1	20.7	24.1	13.8	6.9	10.3
Internalizing	24.1	20.7	24.1	20.7	17.2	13.8
Externalizing	24.1	20.7	27.6	3.4	6.9	3.4
Withdrawn	10.3	13.8	6.9	13.8	3.4	3.4
Somatic	3.4	3.4	13.8	6.9	3.6	17.2
Anxious/depressed	10.3	10.3	3.4	6.9	3.4	3.4
Social	13.8	3.4	3.4	10.3	3.4	0.0
Thought	0 .0	3.4	3.4	3.4	3.4	0.0
Attention	17.2	13.8	10.3	17.2	13.8	0.0
Delinquent	10.3	3.4	6.9	3.4	0.0	0.0
Aggressive	13.8	10.3	3.4	3.4	0.0	0.0

a. Achenbach (1991a).

Table 4
Means and Standard Deviations (in parentheses) of the *Youth Self-Report*[a] Syndrome Scales by Group

	Persistent Dyscalculia		Nonpersistent Dyscalculia	
Problems Scale	13–14 years	16–17 years	13–14 years	16–17 years
Total Behavior	51.7 (9.5)	47.0 (7.4)	50.0 (8.9)	43.9 (6.1)
Internalizing	50.8 (8.8)	46.0 (6.4)	52.1 (8.9)	43.9 (7.6)
Externalizing	52.9 (10.2)	49.4 (8.6)	49.3 (8.7)	46.9 (7.3)
Withdrawn	54.8 (6.1)	51.9 (3.6)	55.3 (6.7)	51.5 (3.1)
Somatic	52.2 (4.9)	51.2 (2.4)	53.6 (8.1)	50.9 (2.0)
Anxious/depressed	54.7 (6.8)	51.3 (2.4)	54.3 (6.6)	51.4 (3.1)
Social	55.0 (6.3)	52.5 (5.5)	53.5 (5.1)	50.6 (1.7)
Thought	53.1 (4.4)	51.9 (4.2)	52.9 (4.2)	51.0 (1.9)
Attention	55.1 (6.5)	54.6 (5.7)	52.8 (4.0)	51.2 (2.4)
Delinquent	56.6 (7.4)	54.0 (5.5)	53.4 (5.6)	53.0 (4.3)
Aggressive	55.2 (7.2)	52.8 (4.8)	52.8 (5.4)	51.4 (2.7)

a. Achenbach (1991b).

scales scores. The only significant main effect for dyscalculia group was for Attention Problems, $F(1, 51) = 7.69$, $p < .01$. Univariate analyses showed that the difference was due to Attention Problem scores at ages 16–17 years with the PD group rating themselves higher than the NPD group, $F(1, 51) = 9.25$, $p < .01$, ES = .36. In the regression analysis, the only significant beta was for dyscalculia group (beta = .32, $p < .05$). The Conners' scores and reading and writing problems did not contribute to the prediction of behavior problem.

Table 5
Percentage of Youths With Persistent Dyscalculia (PD) and Nonpersistent Dyscalculia (NPD) With Clinically Significant Scores on the *Youth Self-Report*[a] Syndrome Scales at Two Age Periods

	Persistent Dyscalculia		Nonpersistent Dyscalculia	
Problem Scale	13–14 Years	16–17 Years	13–14 Years	16–17 Years
Total Behavior	10.3	0.0	10.3	0.0
Internalizing	6.9	0.0	13.8	0.0
Externalizing	17.2	11.0	10.3	0.0
Withdrawn	0.0	0.0	3.4	0.0
Somatic	3.4	0.0	10.3	0.0
Anxious/depressed	6.9	0.0	6.9	0.0
Social	3.4	3.7	0.0	0.0
Thought	0.0	0.0	0.0	0.0
Attention	3.4	0.0	0.0	0.0
Delinquent	3.4	0.0	0.0	0.0
Aggressive	6.9	0.0	0.0	0.0

a. Achenbach (1991b).

There were significant decreases in self-reported behavior problems from ages 13–14 years to 16–17 years on the following scales: Total Behavior Problems, $F(1, 52) = 17.51$, $p < .001$, ES = .32; Internalizing Problems, $F(1, 52) = 30.88$, $p < .0001$, ES = .38; Externalizing Problems, $F(1, 52) = 4.62$, $p < .05$, ES = .17; Withdrawn, $F(1, 52) = 19.88$, $p < .0001$, ES = .31; Somatic Complaints, $F(1, 51) = 4.47$, $p < .05$, ES = .19; Anxious/Depressed, $F(1, 52) = 12.44$, $p < .001$, ES = .30; Social Problems, $F(1, 52) = 14.31$, $p < .001$, ES = .26; and Thought Problems, $F(1, 52) = 8.21$, $p < .01$, ES = .19.

The percentage of youths falling into the clinical range did not differ by group when the reports were based on self-reported problems (see Table 5).

Cross-Informant Comparison

As shown in Table 6, there were significant correlations between parent and youths at ages 13–14 years for the PD group on 8 of the 11 behavior problem scales. For the NPD group at this age, there were only two significant correlations—Withdrawn and Internalizing Problems. By 16–17 years, the correlational pattern between the groups was more similar in that there were few significant correlations between parents and youths in their reports of behavior problems. For the PD group, agreement continued to be significant for Internalizing Problems and Delinquent Behavior.

An analysis of mean differences between parent and youth reports was also done separately by group. Youths in both the PD and NPD groups at 13–14 years rated themselves

Table 6
***Child Behavior Checklist*[a] and *Youth Self-Report*[b] Correlation Coefficients for Syndrome Scales by Group and Age**

	Persistent Dyscalculia		Nonpersistent Dyscalculia	
Problem Scale	13–14 Years	16–17 Years	13–14 Years	16–17 Years
Total Behavior Problem	.53**	.26	.22	.22
Internalizing	.50**	.43*	.38*	.22
Externalizing	.56***	.32	.14	.22
Withdrawn	.33	.45*	.50**	.30
Somatic	.12	.35	.34	.36
Anxious/depressed	.60***	.09	.02	.19
Social	.47*	–.08	–.22	–.10
Thought	.34	.19	–.01	.05
Attention	.50**	–.06	–.08	.39*
Delinquent	.60***	.38*	.10	.30
Aggressive	.50**	.18	.10	.20

a. Achenbach (1991a).
b. Achenbach (1991b).
$*p < .05$. $**p < .01$. $***p < .001$.

lower on Attention Problems, $t(28) = 2.36$, $p < .05$, ES = .22, and $t(28) = 2.15$, $p < .05$, ES = .27, respectively, and higher on Delinquent Behavior, $t(28) = 2.24$, $p < .05$, ES = .21, and $t(28) = 1.97$, $p = .058$, ES = .24, than parents rated them.

At 16–17 years, there were significant differences for the PD group on Withdrawn, $t(26) = 2.54$, $p < .05$, ES = .27; Somatic Complaints, $t(25) = 2.53$, $p < .05$, ES = .23; Anxious/Depressed, $t(26) = 3.63$, $p < .01$, ES = .45; Attention Problems, $t(25) = 2.05$, $p = .051$, ES = .28; Delinquent Behavior, $t(26) = 2.10$, $p < .05$, ES = .22; Aggressive Behavior, $t(26) = 2.45$, $p < .05$, ES = .30; Internalizing Problems, $t(26) = 4.34$, $p < .01$, ES = .46; Externalizing Problems, $t(26) = 2.14$, $p < .05$, ES = .24; and Total Behavior Problems, $t(26) = 3.67$, $p = .001$, ES = .38. For the NPD group, there were significant differences on Somatic Complaints, $t(28) = 3.43$, $p < .01$, ES = .40; Social Problems, $t(28) = 2.06$, $p < .05$, ES = .26; Attention Problems, $t(27) = 2.27$, $p < .05$, ES = .25; and Internalizing Problems, $t(28) = 2.39$, $p < .05$, ES = .28. For both groups, parents rated the youths as having more problematic behavior than the youths rated themselves.

Discussion

In this 6-year prospective longitudinal study, we followed children who were originally diagnosed with dyscalculia at ages 10–11 years. For this article, we selected a subsample of 29 youths with arithmetic scores in the lowest 5th percentile at ages 16–17 years; they were designated as the persistent dyscalculia, or PD, group. They were matched by IQ and gender to 29 youths who did not reach criterion for persistent dyscalculia at 16–17 years, who formed the nonpersistent dyscalculia, or NPD, group. Although youths in the NPD group did not meet research criteria for dyscalculia, they still had significant difficulty in arithmetic because their scores were in the lowest quartile of their grade (Shalev et al., 2005). Thus, we are essentially dealing with a subgroup of individuals with more severe dyscalculia, which we classified as having persistent dyscalculia, and a second group whose problems, though still apparent, were less profound and termed nonpersistent dyscalculia.

At the time of the original diagnosis of dyscalculia when the respondents were 10–11 years old, higher levels of externalizing, internalizing, and attentional problems were reported for boys with dyscalculia compared to a normative comparison group, whereas differences for girls were limited to attentional problems (Shalev et al., 1995). In the present article, the association between PD and NPD and parent-reported and youth-reported behavior problems across the 6 years was examined.

The mean scores for all the CBCL and YSR syndrome scales for both groups were in the normal range, and when there were significant group differences, the effect sizes were small. Thus, even though those in the PD group can be characterized as having severe LD, this does not seem to put them at significant risk for psychopathology. Nonetheless, this group did have significantly higher scores than the NPD group on parent-reported and youth-reported attentional problems and on parent-reported total behavior problems and externalizing behaviors. The significant differences were due to these behavior problems at 16–17 years. Persistence of dyscalculia remained a significant predictor of these problems even when reading and writing problems and teacher-reported ADHD symptomatology were added to the model. Teacher-reported ADHD symptomatology did play a role in the prediction of externalizing problems and total behavior problems. The youths with the highest levels of behavior problems, particularly externalizing problems, were those with PD and high scores on teacher-reported ADHD symptomatology. The association between dyscalculia and behavior problems is in line with the findings of other studies on children with LD (Gadeyne et al., 2004; Prior et al., 1999; Willcutt & Pennington, 2000). The finding that behavior problem level and type of problem, particularly at ages 16–17 years, were associated with dyscalculia persistence indicates the importance of reevaluating not only a diagnosis of LD and its severity but also the behavioral difficulties associated with it, particularly for adolescents with a history of high ADHD symptomatology. As Lerner (2003) suggests, more extensive academic intervention may be called for in cases of comorbid LD and ADHD. In cases of comorbid dyscalculia and ADHD, behavioral intervention together with academic intervention may be warranted.

The significant group differences were not due to an increase in behavior problems in the PD group from ages 10–11 years to 16–17 years but rather to a decrease in reported behavior problems in the NPD group that started at ages 13–14 years and continued at that level to 16–17 years. This decrease in behavior problems in the NPD group gives some support to the hypothesis that the behavior problems seen in children with LD may be a reaction to academic difficulties and not just a comorbid condition with LD (Huntington & Bender, 1993; Lynam et al., 1993; Stanton et al., 1990).

Higher, albeit nonsignificant, levels of externalizing problems were already present at 10–11 years for children who would continue to be diagnosed with dyscalculia at ages 16–17. These findings are consistent with our previous report of more behavioral problems at ages 10–11 years in those children who continued to be classified as having dyscalculia at ages 13–14 years (Shalev et al., 2000). More adolescents with PD than with NPD were classified in the clinical range for Externalizing Problems at 16–17 years according to parent report. This raises the possibility that the trajectory of a persistent disability in arithmetic carries with it an increased risk for clinically significant levels of externalizing problems in late adolescence. This pattern is in line with that found in children with language disorders. In the 7- and 14-year follow-up of a community sample of children with speech and language impairment, the severity of the language problem was associated with later behavioral disturbance. This was true even after controlling for the initial behavioral status (Beitchman et al., 1996; Beitchman et al., 2001).

A higher percentage of the PD group at ages 10–11 was characterized not only as having externalizing problems but also as having a higher percentage of reading and writing problems. These differences failed to reach statistical significance and also did not contribute to the prediction of behavior problems in late adolescence. Nevertheless, reading and writing problems may add incremental risk for continued significant arithmetic problems in a subgroup of children classified as having dyscalculia at ages 10–11 years. It is perhaps these children who need to be followed carefully into adolescence in order to provide them with educational and therapeutic services directed to their LD, and if needed, their behavioral difficulties.

The degree of association between parent- and youth-reported behavior problems is in the range of those reported for youths in clinical samples (Handwerk et al., 1999; Huberty et al., 2000) and is higher for the younger ages. The lower correlations for the older age group may reflect less involvement of the parents in monitoring older adolescents' activities and behaviors (Baranowski, 1981; Feiring & Lewis, 1993; Van Wel, 1994). The low correlations for the older age group would seem to indicate more than just the growing independence of the adolescent because, at least in nonreferred samples, the correlations are much higher (Ferdinand, van der Ende, & Verhulst, 2004). At least one study of adolescent behavior problems found that parental characteristics, such as depression and stress, resulted in a lower level of agreement between parent- and adolescent-reported behavior problems (Youngstrom, Loeber, & Stouthamer-Loeber, 2000). This possibility could not be examined in the present study because parental personality and mental health characteristics were not assessed. It is also possible that a restricted range of parental CBCL scores in the NPD group, particularly for Delinquent Behavior, may have attenuated some of the correlations for this group.

The direction of discrepancies between the adolescents at 16–17 years and their parents was the same for both groups. Parents of adolescents with PD and NPD reported higher levels of problems on the CBCL than their children did on the YSR, which is similar to other clinical samples (Handwerk et al., 1999; Huberty et al., 2000; Kolko & Kazdin, 1993; Thurber & Snow, 1990). It is interesting that at 13–14 years, the only significant differences found were for Attention Problems and Delinquent Behavior. For Attention Problems, parents rated the youths higher than they rated themselves, whereas the reverse was true for Delinquent Behavior. Parents may have attributed the problems of their children to attention-related difficulties, whereas the youths themselves may have focused more on delinquent behavior. At early adolescence, the children may interpret their attention problems as bad behavior, while conversely, the parents may interpret their children's behavior as reflecting attentional deficits. At late adolescence, the significant decrease in youths' self-reported problems may be an attempt to underemphasize emotional and behavioral issues that may hinder their ability to integrate into compulsory military service, which is considered a normative experience by Israeli adolescents.

A possible limitation to the generalization of the findings of the current study was the use of a selected subsample of children matched for gender and IQ. Furthermore, we were unable to evaluate the influence of math tutoring, which some of the participants received, owing to the nature of this study, although the groups did not differ in the extent to which they received educational intervention. We did not seek to evaluate the efficacy of arithmetic intervention, and therefore, youths were not randomly assigned to treatment and no-treatment control groups. A further limitation of the study is lack of teacher-reported behavior problems. These were unavailable either because of parental refusal or lack of cooperation from the teachers.

In summary, the results of this 6-year follow-up study demonstrate that the majority of children with dyscalculia, even those classified with PD, have a normative psychosocial profile. Having said this, there still remains an association between this LD and behavioral disturbances, particularly inattention and externalizing problems. Regardless of whether LD negatively affects the child's social and behavioral development or whether the behavioral difficulties and cognitive problems reflect the underpinnings of a neurological dysfunction, both of these domains have to be addressed in any habilitation program for children with dyscalculia.

Appendix
Assessment Battery

1. An age-standardized test of arithmetic skills based on the neurocognitive model of arithmetic as proposed by McCloskey, Caramazza, and Basili (1985) was used (Shalev, Manor, Amir, & Gross-Tsur, 1993). The arithmetic battery taps number processing, number facts, and procedural knowledge. Number processing includes number comprehension and number production, use of the lexical and syntactic elements of numbers, and skills needed to work with both Arabic and lexical numbers. Proficiency in number facts reflects correct usage of arithmetic signs and memorization of arithmetic tables. Procedural (complex arithmetic) knowledge is the ability that enables use of algorithms to add, subtract, multiply, and divide.

Subtests were devised to sample each area of the model (number comprehension, production, and calculation). Examples of tests for number comprehension and production were to match Arabic numerals to appropriate quantity of stimuli; to indicate which nonnumerical stimuli were larger, smaller, or of equivalent size; to determine which of two numbers was smaller or larger; to order numbers serially by magnitude (serial order); and to count stimuli and to write numbers to dictation or copy. Mastery of number facts was tested by overlearned facts in addition, subtraction, multiplication, and division. Procedural knowledge (number calculation) required completion of complex two- and three-digit arithmetic exercises in addition, subtraction, multiplication, and division. There were no questions in this test that require reading.

This test has been standardized on students in Grades 3–6, 8, and 10 (Shalev et al., 1993; Shalev, Manor, Auerbach, & Gross-Tsur, 1998; Shalev, Manor, & Gross-Tsur, 2005).

Arithmetic Battery

Part 1: Number Comprehension and Production

Tests devised primarily for number comprehension

A. Matching written Arabic numerals to quantities. In a multiple-choice task, the children matched the appropriate quantity of drawn stimuli (dots, dashes, and triangles) to a single written Arabic numeral. There were five such tasks and the numbers ranged from 3 to 12.

B. Comprehension of quantities. Two groups of nonnumerical stimuli of different shapes (dots, dashes, etc.) were drawn on five cards. The number of stimuli on each card ranged from two to seven. The children were asked to indicate whether a particular group had more, fewer, or the same number of stimuli.

C. Comprehension of numerical values. The children were presented with five pairs of written Arabic numerals, and for each pair they had to identify which number was larger or which was smaller.

D. Serial order. Children were presented with a sequence of written numbers that they had to put in order, from largest to smallest.

Tasks designed for number production

A. Counting. The children were asked to count aloud numbers of stimuli (dots, dashes, etc.) appearing in rows or groups. The number of stimuli ranged from 5 to 14. There were five such tasks.

B. Production (writing) of numbers. The children were instructed to copy and read five numbers, between one and four digits long, and write them to dictation.

Part 2: Calculation: Number Facts

The children were required to do 20 simple addition, subtraction, multiplication, and division exercises.

Part 3: Calculation: Complex Exercises

The children had to compute complex written arithmetic problems (addition, subtraction, multiplication, and division). The first eight exercises were addition and subtraction, and the remaining eight were multiplication and division.

Part 4: Decimals and Fractions

There were 2 complex addition and 2 complex subtraction exercises requiring knowledge of decimals. There were 10 simple exercises with fractions, 5 addition, 2 subtraction, 3 multiplication, and 1 division. In 7 of the exercises, a common denominator had to be determined to solve the exercise.

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