

Measurement Error Creates Decrement of Performance IQ in Children with SLI

J. Bruce Tomblin, Xuyang Zhang, Paula Buckwalter, & Marlea O'Brien
The University of Iowa

Rationale

Several studies have reported a decrement of performance IQ (PIQ) in children with SLI. This decline in PIQ has been thought to suggest that either cognitive skills in children with SLI decline with age or that the measures upon which PIQ are based become more dependent upon

Study	Time Lapse	Initial Mean PIQ	Final Mean PIQ
Tallal, et al. (1991)			
With Family History	5 years	108	99
Without Family History	5 years	110	102
Tonblin et al. (1992)	Childhood to Adulthood	98.5	89.8

verbal mediation (Leonard, 1998).

The evidence for a decline in PIQ can be found in several studies. In each case groups of individuals initially were selected because of poor language and normal PIQ. When re-examined later, PIQ was on average lower than initially obtained.

Aram, et al. (1984) followed children from preschool to early teens and found that 20% children with SLI changed from PIQ above 85 to below 85.

Ziegler, Tallal, and Curtiss (1990) also reported that many of the children referred to their study as having performance IQs above 85 were found by them to have performance IQs below 85.

Hypothesized Explanation for Declines in Performance IQ

Decline in PIQ is due to measurement error and use of a cut-off excluding children with low IQs.

The decline in performance IQ may be a product of regression effects that are traceable to measurement error. This error usually causes a regression of group means to the population mean when a group is sampled because they are below or above the mean. This error can also cause a regression away from the mean if a group is sampled because they do not have scores below a certain level such as performance IQs below 85. This is due to the fact that measurement error is symmetrically distributed around each true score. Sampling so that individuals below a cut point are eliminated will result in some individuals with true scores below the cut point remaining in the sample. As shown in Figure 1.

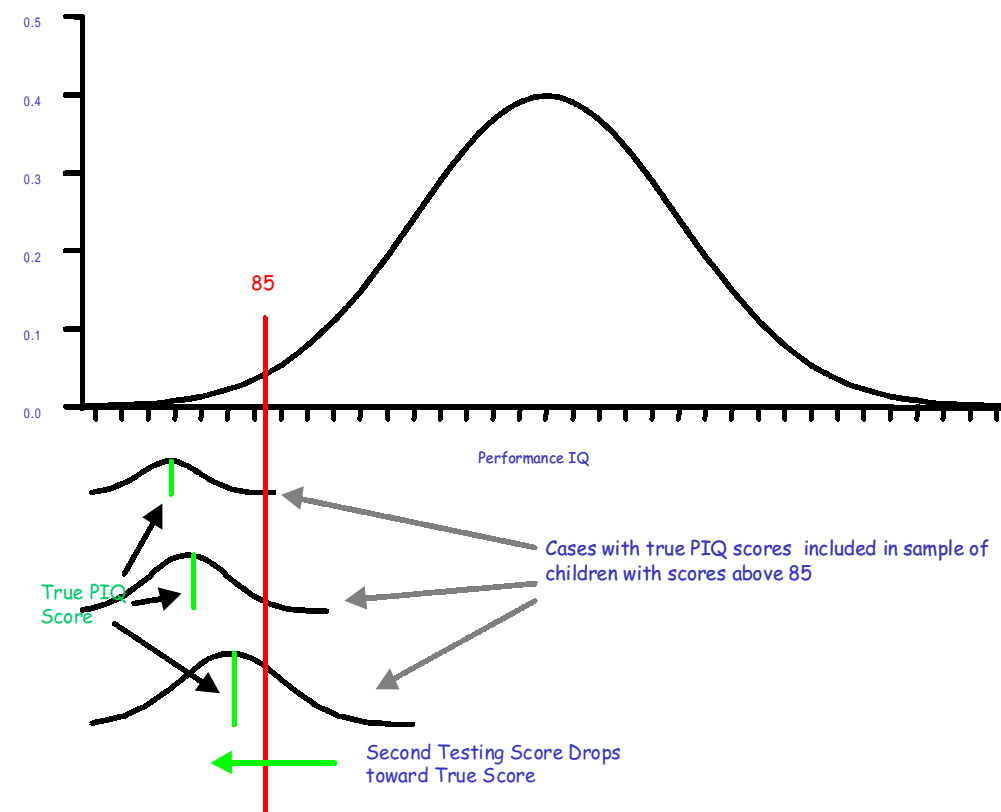


Figure 1. Regression toward true scores

Question:

How well does a mathematical modelling of the effect of measurement error fit the obtained data on performance IQ decline in a large sample of children with SLI?

Method

Participants

Children with SLI

Ninety-four children participating in the Midwest Collaboration on SLI who were identified as SLI in kindergarten were followed into second grade. Children with SLI were below 10%ile (-1.28 SD) on composite language performance and their PIQ was greater than 85.

Typically Developing Children

Thirty-four typically developing first grade volunteers

Measures

PIQ Measure

First Testing: 2 Subtests of the WPPSI performance scale (Block Design and Object Completion)

Second Testing: 5 subtests of WISC-III performance scale.

Language Measure

TOLD:2-P Vocabulary and grammar measures in addition to a narrative recall and comprehension test.

Three composite scores were obtained:

Composite Language Score (x1)

First Testing PIQ (x2)

Second Testing PIQ (x3)

Procedure

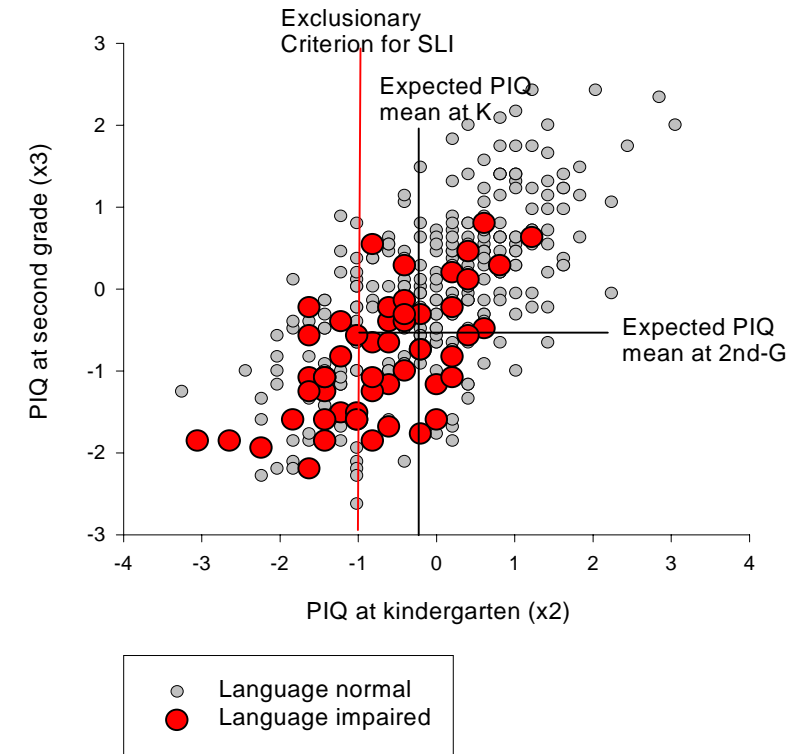
Performance IQ and language measures were obtained for the children with SLI in kindergarten and the Performance IQ was obtained again two years later in second grade. Performance IQ and language was obtained for the typically developing first grade children in a test-retest format with no more than four weeks separating the first and second testing.

The test-retest correlation between the first and second testing of the typically developing children provided an estimate of the measurement error of the performance

Analysis

The three scores obtained from the first grade children were used to generate a multivariate normal distribution using the language scores from the first testing (x1), the performance IQ from the first testing (x2), and the performance IQ from the second testing (x3).

These three composite scores for each child functioned as a random vectors (\mathbf{x}) in a tri-variate normal distribution defined by the co-variance matrix S . When language scores were cut into normal (grey dots) and disordered (red dots), the distribution can be illustrated graphically as:



The density of the distribution is:

$$f(x) = \frac{1}{2\pi^{3/2} \sqrt{|\Sigma|}} e^{-\frac{x' \Sigma x}{2}}$$

Figure 2. Hypothetical PIQ distribution

For kindergarten SLI group:

The expected PIQ mean at K was computed as:

$$\frac{\int_{-\infty}^{\infty} \int_{-\infty}^{\infty} \int_{-\infty}^{-1.28} x_2 \cdot f(x) dx_1 dx_2 dx_3}{\int_{-\infty}^{\infty} \int_{-\infty}^{\infty} \int_{-\infty}^{-1.28} f(x) dx_1 dx_2 dx_3}$$

(shown as the vertical line in Figure 2)

The expected PIQ mean at 2nd-G was computed as:

$$\frac{\int_{-\infty}^{\infty} \int_{-\infty}^{\infty} \int_{-\infty}^{-1.28} x_3 \cdot f(x) dx_1 dx_2 dx_3}{\int_{-\infty}^{\infty} \int_{-\infty}^{\infty} \int_{-\infty}^{-1.28} f(x) dx_1 dx_2 dx_3}$$

(shown as the horizontal line in Figure 2)

The covariance among the two performance IQ tests (Time 1 and Time 2) and the Time 1 language measure obtained from the typically developing first graders provided the parameters for these computational formulas. The resulting values provided the expected change in PIQ scores on a second testing in a group of children selected because they had performance IQs above 85 (> -1 SD) and language scores below -1.28.

This study compared the mathematically expected PIQ change to the change obtained in our sample of children followed from kindergarten to second grade.

Results

Obtained PIQs

The obtained means in performance IQ for the children with SLI when tested in kindergarten and again in 2nd grade as well as the decrement in the mean IQ are shown in Figure 3. The pattern of a decrement in performance IQ found in the previous research is also seen in these data.

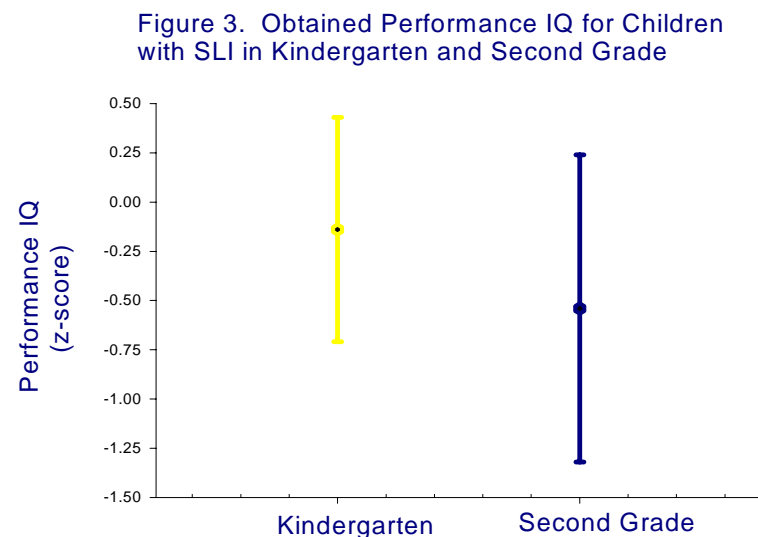


Figure 3. Means of obtained PIQ

Co-variance Matrix from Test-Retest

A co-variance matrix obtained from the first grade group of 34 was computed in order to provide estimates of the measurement error that could be expected with these measures. The covariance provided the parameters for the estimation of expected mean scores.

$$\Sigma = \begin{bmatrix} 1 & .445 & .500 \\ .445 & 1 & .577 \\ .500 & .577 & 1 \end{bmatrix}$$

A comparison between the obtained PIQ decrement to the expected:

The expected decrement was 0.41 and the obtained decrement was 0.40 (see Figure 4). Thus measurement error seemed to account for the obtained performance IQ decrement from kindergarten to second grade.

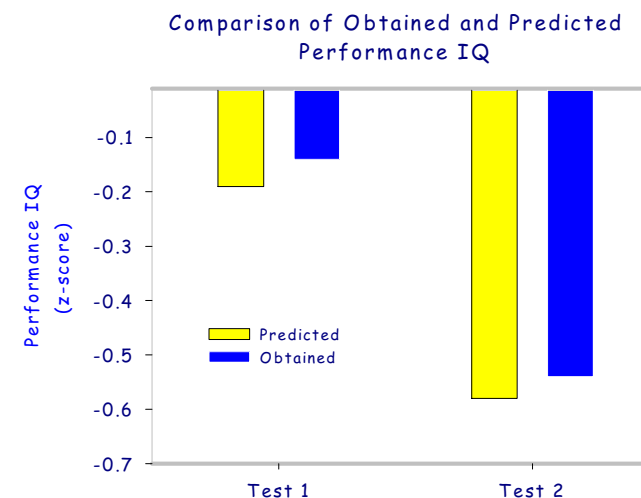


Figure 4. A comparison between expected and obtained

Discussion and Conclusion

The present study showed that, when an initial performance IQ served both as an exclusionary criterion for SLI diagnosis and the baseline to determine whether or not the follow-up PIQ for the SLI group decreased, the decrement could have been simply caused by the measurement error.

However, if the initial PIQ did not serve as a criterion for excluding children from the follow-up measure and there is still a decrement from the initial measure to the follow-up, the measurement error would not be a plausible explanation for the PIQ decrement.

Therefore, before we take the PIQ declining in children with SLI seriously, we should be sure that the declining is not caused by measurement error. Only if no children have been excluded after the initial measure because of a low score, can the declining be true.

Acknowledgement

This study was supported by contract NIH-DC-19-90 from the National Institute on Deafness and Other Communication Disorders and clinical research center grant P0-DC-02748, also from the National Institute on Deafness and Other Communication Disorders.