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Research Paper

Are WISC IQ scores in children with mathematical learning disabilities underestimated? The influence of a specialized intervention on test performance

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ABSTRACT

Background: Intelligence measures play a pivotal role in the diagnosis of mathematical learning disabilities (MLD). Probably as a result of math-related material in IQ tests, children with MLD often display reduced IQ scores. However, it remains unclear whether the effects of math remediation extend to IQ scores.
Aims: The present study investigated the impact of a special remediation program compared to a control group receiving private tutoring (PT) on the WISC IQ scores of children with MLD.
Methods: We included $N = 45$ MLD children (7–12 years) in a study with a pre- and post-test control group design. Children received remediation for two years on average.
Results: The analyses revealed significantly greater improvements in the experimental group on the Full-Scale IQ, and the Verbal Comprehension, Perceptual Reasoning, and Working Memory indices, but not Processing Speed, compared to the PT group. Children in the experimental group showed an average WISC IQ gain of more than ten points.
Conclusion: Results indicate that the WISC IQ scores of MLD children might be underestimated and that an effective math intervention can improve WISC IQ test performance. Taking limitations into account, we discuss the use of IQ measures more generally for defining MLD in research and practice.

What the paper adds?

Children with MLD have been found to have lower IQ scores than their typical achieving peers. This might stem from lower intellectual capacity. However, low IQ test performance might also be the result of poor math skills, since many IQ subtests contain math-related material. This study is the first to systematically investigate whether improving the math skills of children with MLD through a specialized intervention program also affects test performance on the WISC IQ test. Understanding the influence of low math skills on IQ test performance is critical because eligibility for intervention programs and inclusion criteria in scientific research often partly rely on one-time measurements of IQ scores.

Results indicate that the WISC test performance of children with MLD can be improved via effective remediation programs, and that math skills seem to be an important factor in WISC performance. The potential underestimation of IQ scores not only calls the central role of minimum IQ in MLD diagnoses into question but could also explain the conflicting results in research on deficits in children with MLD. Here, the use of strict and varying IQ cut-off scores as exclusion criteria might result in divergent sample

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characteristics, and thus hinder research on MLD core deficits. This study, therefore, provides further evidence in favour of re-considering the use of minimum IQ cut-offs or discrepancy-based criteria in research and practice.

1. Introduction

Defining and identifying children with mathematical learning disabilities (MLD) is the subject of on-going controversy in the field of unexpected scholastic underachievement in mathematics. This applies especially to the integral role of IQ, at least in the sense of a minimum IQ as a marker for MLD. Although there is convincing evidence that children with MLD lack basic numerical skills regardless of the curriculum taught in school, there is little consensus on how to define children with MLD (or developmental dyscalculia) in contrast to children who simply have math problems (e.g., Kaufmann et al., 2013; Moeller, Fischer, Cress, & Nuerk, 2012). No core deficit has been identified so far (e.g., Kaufmann et al., 2013; Mazzocco & Myers, 2003), and several authors argue that MLD is a heterogeneous disorder with several subtypes that might not share the same core deficit (Kaufmann et al., 2013; Mazzocco & Myers, 2003).

In research and to a certain extent in practice, two formulas are usually used to identify children with MLD. The first is known as the aptitude-achievement discrepancy criterion (AAD) as outlined by the *International Classification of Diseases* (ICD-10; World Health Organisation, 2005). For this, a child's achievement in math has to be substantially (usually 1–2 SD) lower than their IQ score. Despite ongoing critical debate on the poor reliability and validity of this measure, the AAD criterion is still used by both psychologists and researchers (cf. Fletcher & Vaughn, 2009; Klassen, Neufeld, & Munro, 2005; Stuebing et al., 2002; Zirkel & Thomas, 2010) in many countries.

The second and now more frequently used formula in research defines MLD as severely low achievement (usually < 10– < 25 percentile on a standardized math test). However, several authors criticize that diagnoses using this formula are highly dependent on the measure used to test for numerical deficits (e.g., Kaufmann et al., 2013). Desoete, Roeyers, and Clercq (2004) showed that prevalence rates vary substantially as a function of the measure used.

Moreover, a minimum IQ is required in many cases to differentiate between children with MLD and children with intellectual disabilities. The threshold for this minimum IQ varies as well, but usually lies between 70 and 85, without taking measurement error or confidence intervals into account. Often, this minimum level of aptitude is also relevant in AAD diagnoses. As a result of the variation in these definitions, a child with a one-time IQ measurement of 84 would not be considered math disabled but rather intellectually disabled in one study (e.g., Brankaer, Ghesquière, & De Smedt, 2014; Schleifer & Landerl, 2011), but would have to have an IQ score of 69 to be excluded from MLD research or specialized intervention in another (e.g., Fuchs et al., 2009). Several authors have shown that these varying criteria lead to wide variation in what children are classified as MLD (e.g., Mazzocco & Myers, 2003; Murphy, Mazzocco, Hanich, & Early, 2007). Moreover, low achievement and AAD criteria do not seem to overlap much, and AAD criteria appear to be less stable than the former (e.g., Mazzocco & Myers, 2003).

In addition to these problems, children's concentration and motivation can fluctuate. Overlooking measurement error in math measures more generally, but especially in IQ test scores, can lead to misdiagnoses in the sense of either false positives or false negatives, and can also affect the reproducibility and generalizability of findings in learning disabilities research (cf. Cotton, Crewther, & Crewther, 2005; Dennis et al., 2009).

Furthermore, the empirical basis for differentiating between discrepant (MLD) and non-discrepant (low-achieving) children as well as between low-achieving children with above (MLD) and below threshold IQ (intellectually disabled) is lacking. There is stable evidence from reading disabilities research that these groups cannot be differentiated on the basis of any of a number of reading-related and cognitive measures, and no differences in response to intervention have been found (cf. Stuebing et al., 2002). A smaller number of similar results have been found for children with MLD. For example, Jiménez Gonzalez and Espinsel (1999) demonstrated that measures of core cognitive characteristics do not differ among children with math difficulties and a below-average IQ and children with an IQ within the normal range. Furthermore, math disabled discrepant children do not differ from non-discrepant children on word problems (Jiménez Gonzalez & Espinsel, 1999), arithmetic fact retrieval (Busch, Oranu, Schmidt, & Grube, 2013), numerical magnitude processing (Brankaer et al., 2014), or working memory capacities (e.g., Maehler & Schuchardt, 2011).

Furthermore, IQ was not found to predict the growth rates of various mathematical competencies such as exact calculation, place-value tasks, story problems or approximate calculation (e.g., Jordan, Hanich, & Kaplan, 2003). There are some contradictory findings showing differences between groups (e.g., Tolar, Fuchs, Fletcher, Fuchs, & Hamlett, 2016); however, the severity of impairment seems to be the decisive factor in explaining differences in cognitive variables (c.f. Elliott & Resing, 2015; Tolar et al., 2016).

In reaction to the ongoing reliability and validity critiques of the role of IQ in the defining and identifying learning disabilities (Büttner & Hasselhorn, 2011; Mazzocco & Myers, 2003; Stanovich, 2005), some countries – like the United States – have shifted to a multi-tiered approach applying response-to-intervention criteria (RtI). Here, children are classified as learning disabled if they do not significantly improve as a result of remediation. However, this approach is seldom used in MLD research, probably for economic reasons. In addition, in many countries, the implementation of systematic multi-tiered intervention is still in its early stages (if it exists at all), and RtI criteria are not feasible. As a result, access to and eligibility for MLD remediation programs or special education support often require AAD or at least severely low achievement, often in combination with a minimum IQ criterion, which can lead to delayed access to these programs in some cases (c.f. Stuebing et al., 2002). This is especially true in many European countries, where multi-tiered intervention programs have not been systematically implemented in public schools. Some countries, like Belgium, have combined different approaches to diagnosing MLD to improve consistency (e.g., Desoete et al., 2004); however, IQ is still an essential component of the diagnosis when AAD or minimum IQ criteria are used.

For this reason, further investigations of IQ scores among children with MLD is of great importance for research as well as for