Romanian screening instrument for dyscalculia

Fotinica Gliga*, Teodora Gliga

*Special School Sf.Nicolae/FPES, University of Bucharest, Romania
Birkbeck College, University of London, United Kingdom

Abstract

The current study is a pilot test of a screening instrument aimed at flagging children at-risk for dyscalculia. The screening test is designed so that it can be applied by any teacher with minimal instruction and financial investment and it is based on Number Sense battery, NUCALC battery and, first of all, romanian mathematical curriculum. Out of the 45 students from Bucharest (8-11 years) participating in this study, ten scored under the cut-off point of 10, three of which scored under 5. All these children, deemed at risk for dyscalculia, scored above the threshold for mental delay on two IQ tests.

1. Introduction

Quite frequently children struggle with learning to tell the time, estimating the change they need to receive or counting backwards. These early difficulties with manipulating quantities, when not addressed properly, can lead to life long underachievement. Research on the cognitive and neural causes of mathematical difficulties has shown that they can be a result of a specific deficit in number processing. Such initial deficits in quantity estimation and discrimination and in understanding basic concepts like quantity conservation and reversibility, despite otherwise typically developing mental abilities, are referred to as developmental dyscalculia (Kosc, 1974; Gross-Tsur, Manor & Shalev, 1996). Its estimated prevalence is about 6% (Kosc, 1974; Badian, 1983; Gross-Tsur, Manor & Shalev, 1996) and it affects both children and adults (Anca & Hategan, 2009).
There are various theories regarding the nature of this deficit. Recent neuro-cognitive theories highlight the central role of understanding numerosity (the number of objects in a set). Dehaene (2001, p.16) talks about a number sense - “a short-hand term for our ability to quickly understand, approximate and manipulate numerical quantities”. His triple cod theory (Dehaene & Cohen, 1995) recognizes the importance of three codes used for number representation: verbal (used to keep track of numbers while doing various operations on them), visual (the use of a mental number line) and semantic (used for number comparison). Butterworth, 2010, proposes that dyscalculia can be the result of a specific deficit in representing the numerosity of a set of elements and manipulating these representations in arithmetic. The screening for dyscalculia, an important step in the diagnose process, identifies the skills and difficulties highlighted by the above theories. When tested in children, the ability to read numbers, to understand number constancy, to add and compare the magnitude of one-digit numbers (Mazzocco, 2005), to estimate numerosity (Geary et al., 2009) or to count backwards, positioning numbers on an analogue scale (Deloche et al., 1995 in Koumoula et al., 2004) have been shown to predict later math disabilities/difficulties. These items need to be considered “in terms of the developmental changes in mathematical thinking that typically occur during the school years” (Mazzocco, 2005, p.319). For example when testing kindergarten and primary school children it is preferable to use paper-pencil tests which use real objects (Number Sense Test of Jordan et al., 2007;The Number Sets Test of Geary et al., 2009). Also in most screening tests for kindergarten and primary school children problem solving is embedded in stories or drawing activities (Jordan et al., 2007; Koumoula et al., 2004). The Neuropsychological Test Battery for Number Processing and Calculation in Children (NUCALC), one such paper-pencil test, was designed to assess number concepts, number facts and arithmetic procedures (Koumoula et al., 2004). The Number Sense battery (Jordan et al., 2007) included measures of counting, number knowledge (e.g., numerical magnitude comparisons), nonverbal calculations (with objects), story problems, and number combinations. A screening test is that which identifies, by means of consistent application of some criterion, those in need of further assessment and remediation of their special needs (Turner, 1997). Those highlighted as at-risk are expected to go through a diagnostic process, subsequently. The diagnostic process for dyscalculia which is based on the use of standardized tests, has to shows a discrepancy between poor numerical abilities and good mental abilities (IQ > 80) (DSM IV TR, 2000). To define the clinical threshold for dyscalculia, various criteria have been proposed: a difference of 1-2 standard deviations between skills (IQ) and mathematical performance, a 2-year difference between the specific age-performances and actual performances or an absolute criterion, e.g. the weakest 5 - 10% scores for arithmetic at each age, or an absolute score, less than 10 percentile (Shalev & vonAster, 2008).

In Romania, the lack of standardized tools for early screening and diagnosis of dyscalculia results in the perpetuation of mathematical difficulties in adult life with corresponding consequences on societal integration. The few attempts to understand math difficulties (e.g. Ungureanu, 1998, Ghergut, 2005) or the diagnostic process for dyscalculia were mainly concerned with the psychological processes involved in the acquisition and usage of arithmetical operations (e.g. auditory and visual perception and memory, spatial-temporal and right-left orientation)(Anca & Hategan, 2009). The representation and manipulation of numerosity, which seems central to dyscalculia, has been overlooked.

The current research stemmed from the need to develop the first Romanian screening instrument for dyscalculia. When creating screening instruments it is important to take into account local math curriculum and not just to translate foreign instruments (Locuniak & Jordan, 2008). Thus, our objectives were: (1) to create a paper-pencil screening test (ST) for students in primary school (7-11 year-olds) with which we can determine the risk of dyscalculia and (2) to differentiate this difficulty from mental disability/disorder through intelligence tests (Dearborn and Verbal Weschler Scale). The ST was designed to be a simple and easily to be applied by any teacher / professor with minimal training, thus reducing the
time and costs involved. We have designed the ST as a paper-pencil tool and combined arithmetic skills testing through play, as in the Number Sense Test (Jordan et al., 2007) with assessing of number concepts and arithmetic procedures through problem solving and exercises as in NUCALC (Deloche et al., 1995, vonAster, 2001 in Koumoula et al., 2004).

2. Methods

2.1 Sample presentation

Our participants were 45 students in grades II (13 students) and III (32 students) belonging to a normal inclusive school in Romania (Bucharest). The sample includes students aged 8-11 years (Average = 9, SD = 1), of which 24 are boys and 21 girls. About half of students tested (n=24), were selected because of poor results in mathematics (they scored under 5, the minimum threshold for Mathematical Performance Test for grade II, III), confirmed by the appreciation (Qualificatives) of the class teachers.

2.2 Procedure

ST was applied individually by the "educational psychologist", the average application time being 20 minutes. Dearborn nonverbal test of intelligence, standardized in Romania (Bontila, 1971) was applied to the entire sample of students. To assess the language skills of those at risk for dyscalculia the verbal sub-test of WISC-R (vocabulary, comprehension, similarities, information and digit-span) was applied.

2.3 Statistical analysis

For data processing we used SPSS 16. A one-way ANOVAs for unequal samples (sample of pupils at risk of dyscalculia and typically developed students) was applied as well as Pearson correlation for assessing the relationship between different tests’ performance.

2.4 Screening Test Presentation

The ST includes 13 items, the maximum score being 14 points. The construction of this instrument was based on Number Sense battery (Jordan et al., 2006)(e.g. two items use handling of coins) and NUCALC battery developed by a multidisciplinary group of researchers (Deloche et al., 1995 in Koumoula et al., 2004) and used in cross-cultural studies (e.g. in Greece, Koumoula et al., 2004) as well as on mathematics curriculum for primary grades (I-IV). The test items should highlight difficulties with approximating numbers, identification of small quantities without counting (subitizing), numerosity coding as well as use of mathematical language (Butterworth, 2005). Items require students to: (1) count forwards/backwards using material support (coins) or not; (2) estimate numerosities without counting; (3) read / write numbers; (4) compare numbers; (5) place numbers on an undivided horizontal scale; (6) solve math problems (problem solving) orally; (7) memorize series of one-digit numerals and (8) make simple calculations. Items vary depending on the age of the students. For example “Count orally backwards”, used different steps for 7 year olds than for 8 to 11 year olds; “Word problems” are solved using a single operation, subtraction but mathematical language and numerals are different depending on age. We have outlined two categories at risk for dyscalculia: severe (0-5 points, 2SD from the mean value) and moderate (6-9 points, 1SD from the mean value), 10 to 14 points indicating no-risk.

3. Results
The application of the ST identified 4 students at risk of dyscalculia in the 2nd grade group (30.7%) and 6 in the 3rd grade group (18.7%). Out of 10 students at risk of dyscalculia, 3 scored 0-5 points, meaning a risk for severe dyscalculia and 7 scored 6-9 points, a moderate risk for dyscalculia. Most of the tested students received 11 points (14 students) or 10 points (7 students). Students at risk of severe dyscalculia (scores 2-4) only responded to the items that required counting upwards, using visual support and could compare written Arabic numbers. Only the student who scored 4 compared the numbers given orally and only 2 students memorized properly series of one-digit numerals. Items answered by less than half of students at risk of dyscalculia were referring to: writing Arabic numbers expressed orally, oral mental calculation and solving word problems or counting backwards and memorizing a series of one-digit numerals backwards.

To check that a low ST score does not reflect a general developmental delay Dearbon IQ test was used. The group of children at risk for dyscalculia had IQs between 80 and 99 (Mean = 90, SD = 5.6) whilst the typically developed group had IQs between 74 and 141 (Mean = 95.5, SD = 14.8). The test showed that all students at risk of dyscalculia had a typical intelligence. An ANOVA in which the grade (2nd or 3rd) and the diagnosis (dyscalculia risk, typically developing) were introduced as variables yielded non-significant effects of Grade ($F$(1.44) <1) or Diagnosis: ($F$(1.44) = 1.99, $p$ > 0.1). These results indicate that the average IQ does not differentiate children at risk of dyscalculia, from the typically developed group. Thus ST has helped us find children with specific difficulties in numerical skills. The results obtained with the ST and IQ tests are highly correlated in the entire sample ($r$ = 0.46, $p < 0.01$) as well as when only typically developing children are analyzed ($r$ = 0.74, df=33, $p <0.01$). Because of the small number of subjects in this group of students at risk of dyscalculia (n = 10), the p-values are statistically insignificant.

Using the verbal section of the Wechsler Scale, we determined that the group of students at risk of dyscalculia had a Verbal IQ between 83 and 106 (Mean = 92.9, SD = 7.69), indicating a normal verbal intelligence. A higher standard deviation was obtained from memorizing sequences of one-digit numerals (SD = 3.5, $F$ = 12.27) probably due to weak short-term memory. This result possibly reflects poor mental calculation or problem solving (Butterworth, 2005) and confirms the result obtained from similar items of ST. This is a good example of the difficulty with dissociating IQ from numerical abilities.

4. Discussion

The purpose of this short communication was to report the creation of the first ST for dyscalculia in Romania and to test, on a very small sample, that it differentiates students with math difficulty from those with mental/math disability. After analyzing the data obtained by applying the ST, the screening tool has led us to a group of students at risk of dyscalculia (n = 10). Their difficulties have occurred in those items that previously linked to dyscalculia: estimating quantity with or without material support or graphical representation (without counting they cannot appreciate the amount), counting backwards or repeating sequences of one-digit numerals of increasing length backwards or mental calculation. Not all these "weaknesses" appear on each student at risk of dyscalculia, something that confirms the observation made by Dowker (2005). This is in support of the triple code theory, which proposed the existence of independent number mental representations (Dehaene & Cohen, 1995). Based on DSM IV TR, (2000) diagnostic criteria, dyscalculia should not be caused by mental retardation, sensory disabilities or poor education. Dearborn and verbal subtest of WISC-R confirmed that those students identified as at risk of dyscalculia had a normal IQ (80-109), good vocabulary and general knowledge and good understanding of social situations and of word similarities. Future studies will have to show that this test has high fidelity, content validity, construction and proper criteria validity. To generalize the results obtained in this study is necessary to apply ST to a representative sample of students from a variety of schools. In a
larger sample it will be important to also estimate the impact of conditions such as ADHD or anxiety, of insufficient or inappropriate educational methods, as well as a lack of family support (Shalev & von Aster, 2008). Future research should examine the stability and sensitivity of ST. For example, we should verify if the time limitation of certain items (i.e. items of oral calculation, problem solving) increases the sensitivity of ST detecting the risk of dyscalculia. We hope that this study will make education specialists more aware of the risk of treating all those that struggle with mathematics equally. The dyscalculic student is neither lazy nor mentally disabled. She/he is a child with a particular difficulty in mathematics and could be helped by personalized interventions, focused on training the ability to manipulate quantities (e.g. digital intervention programs: Number Race, Wilson, Dehaene et al., 2006; Dots2Track, Butterworth & Laurillard, 2010: Numeracy Recovery program, Dowker, 2005). We hope that this short communication will set the stage for a differentiating approach of children with this condition, in Romania.

References