MANUAL

TEST OF RAPID MENTAL ARITHMETIC (TRMA)

A Introduction

1. The Test of Rapid Mental Arithmetic (TRMA) is a set of six speeded tests that measure how quickly a child or adult can compute mental arithmetic problems in the four core processes of addition, subtraction, multiplication and division. The testing is done without use of concrete aids or calculators/electronic devices of any kind. The six tests are administered sequentially, and provide a diagnostic profile, depending on age.

2. There are two further switching tasks. One involves random switching between addition and subtraction; the other random switching between all four processes. The switching tasks were particularly designed to give diagnostic information on persons with Specific Learning Disorder, as per DSM 5 criteria. These persons, of any age, often confuse which process to employ, and this tendency may be highlighted by the switching process. They also tend to make more random errors. Switching tasks are more commonly associated with Neuropsychological assessment, as an indicator of mental flexibility, in children (Korkman, Kirk and Kemp, 2007), and in adults (Delis, Kaplan & Kramer, 2001). But problems of arithmetic switching are presumed to reflect SLD symptoms directly, not their connection to problems of inflexibility more generally. Availability of the TRMA for clinical practice may help to clarify these predictive validity issues.

3. In general, the TRMA is a robust and convenient test to use. Its utility is based on the premise that rapid rote recall of basic number facts is a core life skill, like automatic familiarity with letter sequencing in the alphabet. Rapid fluency in accessing number facts is the second step in the normal acquisition of numeracy. The first step is capacity to recognize, name and write numbers up to 10, and to associate numbers with a visual display in any format (conservation). Familiarity with the order of numbers (seriation and ordination), and the recognition of zero as a place value follows. These skills must be established in the first years of schooling, although some children have acquired them before they start school.

4. Familiarity with simple addition and subtraction is usually established in year 1 and gradually leads by a conceptual leap into multiplication, and later still division. Children's level of understanding and automatic fluency in their use then develops through the primary grades. Their maintenance beyond that into adulthood depends on ongoing teaching or vocational practice. The TRMA is an instrument designed to measure this progression, for whatever purpose, in a quick and convenient manner over the full developmental range.

B. Rationale for Mental Arithmetic

1. In addition to its obvious value in everyday life, the ability to work accurately with numbers has also been identified as one of the enabling skill sets necessary for success in learning science, technology, engineering and mathematics (the STEM subjects) (Gravemeijer et al., 2017; Siekmann and Korbel, 2016). Automatic and accurate recall of number facts can greatly reduce the cognitive load involved in solving quantitative problems.

2. The capacity to perform mental arithmetic rapidly and accurately is based on repetition and practice throughout the primary school years, as has long been recognized (EDSA, 1958; Williams, 1948; McRae undated; Westwood, 2016). The present norms, together with earlier research using the BNFT (Basic Number Facts Test, Westwood, 2003) clearly demonstrate that speeded skills for all four processes accrue in a distinct linear fashion from year 1 through year 6. They then shift abruptly to a plateau form in secondary school. This change appears to reflect a change in teaching/learning emphasis rather than any neuro-developmental shift, due to increasing reliance on calculators of some form and decreasing practice of mental arithmetic skills.

3. Teachers were previously exhorted whilst in training to allocate prime daily teaching time to number "drill", to regular use of Speed and Accuracy Workbooks (no longer in print), to rapid oral questioning of number facts, often with a competitive edge, and use of card and dice throwing games. The primary objective was to build rapid, lasting recall of number facts in the four processes, especially addition and multiplication, augmented by reliable number heuristics when recall faltered.

4. The traditional focus on rapid recall was challenged in the 1970's and 1980's by a "pendulum shift" towards conceptual understanding of mathematics through an investigative and problem solving approach (Westwood, 2003, p3), often termed "Whole Maths" (Geary 2001, Westwood 2003). There was never any research to justify this shift of emphasis. In some ways it replicated the other pendulum shift away from explicit phonics teaching in the name of "Whole language" approaches in the teaching of early literacy.

5. Many teachers and researchers actively opposed this shift from rapid proficiency in core number facts. However it took about fifteen years before educationists more broadly realized the impact, and started to advocate for a return to proficiency in number facts (Westwood 2003, p3). This swing commenced around 1996 in Australian schools and led to numerous publications advocating for better numeracy standards in the USA, UK and Australia (OPSTED, 1997; Loveless, 2001; Westwood, 2000; Westwood, 2008).

6. Westwood has been the only researcher to identify this shift in emphasis quantitatively. In 1975 he utilized a sizeable data base of 1372 children from 6-11 years tested on the Millgate Speeded Number Facts Test (Broughton 1975A, 1975B), and contrasted this with a repeat of the same test in 1995, employing a sample of 2297 children from 26 schools. His sampling was opportunistic, but clearly representative (Westwood, 2003).

He demonstrated that a widespread de-emphasis on explicit teaching and practice of mental arithmetic led to a significant decline in proficiency over the two decades. This decline was minor for Addition and Subtraction in the early years, but reached statistical significance at the 99 percentile level for children aged 9 – 11. For Multiplication the effect was much greater and evident across all age levels. Children in 1975 could complete 4 to 5 items more per minute than in 1995. ($p < .001$). The result for Division was similar although the effect size was not as marked. Children in 1975 still completed 2 to 4 more correct items than in 1995 ($p < .001$). The later group had about 16% of children who could barely tackle division at all due to reliance on calculators and lack of explicit practice.

These results can be juxtaposed with widespread anecdotal observation of a decline in standards in mental arithmetic proficiency. This is most readily apparent in peoples' dealing with financial transactions of all kinds. It is not a subject for argument; there really has been a marked decline in proficiency which can be extrapolated far more broadly within Australia and some other countries.

Whether this deterioration has been arrested remains a matter of conjecture. This standardization of TRMA provides a contemporary indication of speeded proficiency skill that is representative of current competence. The greater discriminability of the test makes it more robust for diverse applications. This includes the interaction between neuro-developmental phenomena like Specific Learning Disability and everyday classroom teaching practice.

C Uses of TRMA

The TRMA format and its current standardization data on both children and adults is presented as a multi-disciplinary instrument that may have clinical and educational utility for multiple purposes:

1. Psychologists and school counsellors assessing children, adolescents or adults who are struggling at school, TAFE, or university, or are displaying mental health issues that might have a basis in significant academic skills deficits. The TRMA is intended to be used as an "add on" instrument to accompany other academic assessment of literacy and numeracy skills. These are used in conjunction with a range of other cognitive and communication skill tests and checklists. Preliminary work indicates that TRMA may be especially pertinent in the diagnosis of Specific Learning Disorder (dyscalculia) as per DSM 5 criteria, and may guide more targeted intervention in numeracy skills.

2. Teachers of all grade levels from primary to TAFE may find TRMA useful for diagnosis, screening or monitoring purposes, as a convenient measure of mental arithmetic proficiency that is reliant on rapid recall. This may assist in remedial planning or placement or even review of curriculum priorities.

3. Counsellors involved in adult recruitment or vocational selection roles, who need a reliable instrument to measure mental arithmetic proficiency under speeded recall conditions. This may prove pertinent for a wide range of different vocations or professions, eg drug calculation skills for nurses, practical calculation skills for building tradesmen, engineers, mechanics, chefs and military personnel. Retail/sales applications have now been largely circumvented by the widespread adoption of "swipe" technology. This has contributed to a major decline in these skills.

4. Rehabilitation workers, OTs, Psychologists and Speech Pathologists dealing with clients overcoming the impact of a motor or neurological disability or an accident of some kind may find TRMA helpful as an "add-on" instrument for both diagnosis and as a monitoring tool for intervention.

5. In all cases it is preferable to examine a complete diagnostic profile and not overlook the currency of the basic addition or subtraction skills. There may also be potential for conducting a parallel assessment with TRMA that **permits** the use of a calculator or other electronic device, in order to contrast the way skills are accessed. A later revision of the test might also include analysis of item error rates in the grade samples, which may have added diagnostic value.

D Description and Standardisation

1. Each of the six tests has 30 items and a common time limit of 60 seconds. The tests are administered sequentially in a set, taking about seven minutes overall. The core tests are derived from the "Millgate" or "One Minute Tests of Basic Number Facts" (Westwood, 1974, 1987, 2003, 2004), utilising one and two digit numbers. They are known to discriminate effectively across the primary grades, and each displays a consistent linear trend Westwood, (2003, 2004).

2. Later use of the BNFT in Eyre Peninsula schools indicated that the tests "peaked" around grade 6 or 7, and then flattened in a plateau across the secondary years. The change was attributed to greater dependency on calculators and greatly reduced practice of mental arithmetic skills. This could not be evaluated using the BNFT because of the limited "high end" discriminability of its items.

It was also apparent that the BNFT did not differentiate effectively as a clinical tool with adults, again showing poor "high end" discriminability. A new set of tests was needed to measure speeded proficiency over a broader range of difficulty.

3. The TRMA tests were developed with these objectives in mind. They retained simple one or two digit problems in the first 20 items, much like the BNFT. They then had new, increasingly difficult items, which required heuristics beyond rote recall of routine addition or multiplication tables. The test was initially standardized with simple Age Equivalents, from data collected in a single school, and then trialled in clinical practice. The test displayed excellent utility, consistent validity and discriminability over a wide range.

4. The TRMA was re-standardised with a broader representative sample of 1268 from schools across the state, within grade levels 1 to 11, and an adult sample in varied site locations. Data was collected in 2014/2016 on an opportunistic basis. All school-based testing took place late in the school year, and was reasonably consistent.

The order of difficulty of the items could not be analysed using Item Difficulty Scaling (eg Rasch Analysis) as utilized in many other standardized tests (eg Elliott and Smith 2011) due to the test format. Informal use indicated that the test discriminated effectively for both children and adults, with no problems of comprehension or idiosyncratic completion.

5. **The school age sample**

Principals from 24 schools covering departmental, private, rural, suburban and remote sites were invited to participate. All were enthusiastic, but only seven finally participated following discussions with staff and councils, a rate of 29%. The sampling was thus opportunistic. The identity of all schools remains confidential by prior agreement. Schools provided and retained their own paper copies of the tests, and completed testing and scoring as per protocol at their own convenience. Data was provided on spreadsheets and was de-identified except for the child's gender. The data set had a slightly higher proportion of girls due to school sampling, and girls performed better overall. It was not considered appropriate nor necessary to provide gender-based norms.

A few year 12 children were tested, but were excluded due to low numbers. All children in each school participated on the day with the consent of school staff as a normal curriculum activity. Parental consent was thus not warranted.

6. Feedback

Each school received a confidential group summary of their own data compared with the total sample for their own remedial purposes or curriculum planning. Feedback on individual children was at the discretion of the class teacher. Analysis was by SPSS Software for the combined data base, using the number of correct items completed as the key indicator. Data on frequency of errors was collected, but has not been incorporated at this time.

7. SES effects

The seven schools participating in this opportunistic sample represented a diverse range of SES backgrounds as defined by the ICSEA. (Index of Community Socio-Educational Advantage, 2014). This school-based score was a significant predictor of TRMA Scores for the combined sample of 1268 children using multi-variable regression analysis, consistent with other research.

The net differences in items correctly completed were small, and not comparable with the larger discrepancies found by Westwood in his survey across two decades (Westwood, 2003).

Given the opportunistic nature of the sampling it was considered inappropriate to try to "correct" for SES factors. The data was used in its unadulterated form, given that there was a proportional and representative cross-section of elite suburban schools, "middle class" schools and disadvantaged schools, from both suburban and rural locations.

8. The Adult Sample

This was drawn from four collection sites during 2016, after initial approaches to a much larger list of work places. These included the ADF, the Police and Fire Brigade, group medical or laboratory practices and so on. The sampling is thus opportunistic and not representative, but covered an age range of young adults, older adults in a stable work environment, and retirees with a history of stable work experience.

The details of the four participating samples are as follows:

a)

Group Travel Agents in a business organizing high end group travel (N = 15). The sample was 80% female and had a mean age of 48. Recruitment was by the Office Manager. All staff present agreed to participate.

b)

Retirees in a private gated Retirement Village with independent living homes, conducted by a fellow retiree (N = 28). The sample was 64% female, aged 62 to 87 (mean = 76 years), and covered a diverse range of prior occupations (professional/managerial – 22%, trades – 22%, public sector teachers and police – 22%, office administration – 33%).

c)

Public sector psychologists and trainee psychologists at a workshop on Rural Psychology practice (N = 19). The group was mainly female (63%), and mostly in their 20s (mean = 28 years).

d)

A small group of managers/professionals in a Canadian Ski resort, recruited by a participant (N = 7), they were all female, and young adult (mean = 34 years).

This gave a combined Adult sample of 69 with a higher proportion of females (71%). All were fully employed, or in training, or retired from steady employment. It was not possible for logistical or administrative reasons to get a more representative sample of men at this time.

9. **Format**

The original clinical trialling and standardization of the TRMA was conducted using a test format on two A4 sheets with three tests per page. For broader applications the test was converted to an interactive format that utilized a visual display of each item singly (eg 8 + 6), with responding via a numerical keyboard utilizing an ipad or other preferred device. The software directs the subject of any age to proceed through the tests in order whilst they are able to perform at least some items successfully.

This format was considered equivalent in validity, easier to administer, more convenient and appealing, and able to provide immediate individual feedback in Standardised Scores as a clinical instrument.

10. **Adequacy of Standardisation**

The present norms are sufficiently robust for educational and clinical decision making, even though a rigorous cross-sectional population sample was not possible. Both school-based and worksite-based adult samples have a disproportionate number of females; it is unclear to what extent this may skew the norms. Given the uncertainty of "current" norms versus those generated in the past it is necessary to accept this level of error variance.

The test is now ready for multi-disciplinary use. Clinical experience indicates that the test and the present standardization have adequate reliability and validity.

E Classroom and Clinical Practice

1. We now have a more nuanced appreciation of the importance of teaching children mental arithmetic as a core part of effective life long numeracy skills. We have belatedly realized that practice and repetition are necessary teaching strategies, and more teachers and parents are trying to find ways to adopt them. We recognize that children need facility in using calculators, but this facility must complement the core need for simple automatic recall of basic number facts, together with a range of heuristics or "rules of thumb" that must be developed to "fill in the gaps" whilst doing a calculation. The question is when and how to teach this, whilst also responding to calls to teach Coding skills (Bita 2015) and other demands in a very crowded curriculum.

2. There is an emerging and consistent literature from educational psychology and neuro psychology disciplines that supports and complements Westwood's earlier findings. It has been demonstrated that a default in proficiency in early number facts has long term impact on later progress in mathematics (Gersten et al, 2012; Gersten Jordan and Flojo, 2005; Duncan et all, 2007). That proficiency may be crucial to adult employment (Bynner and Parsons, 1997). There is also widespread anecdotal support from secondary maths teachers and employers for this link.

3. Rapid access and recall of number facts has also been shown to lead to enhanced confidence and positive feelings in the student learner at all ages (Ackerman and Koriat, 2011; Thompson and Morsabnji, 2014). It also links to reseach on the role of math anxiety in children's performance (Rubinsten and Tannock, 2010). This emergent literature has been reviewed by Hattie and Yates (2014), whose work on Visible Learning principles is increasingly influential in Australian schools.

4. There has been no research examining the effects of when calculators should be introduced, or how they should be employed relative to mental arithmetic skills.

The present TRMA norms show a distinct plateau effect corresponding with the transfer to secondary schooling. There is also a clear indication that speeded proficiency falls away in secondary school. Is this avoidable, and is it something to be addressed in light of other recent evidence? (Hattie and Yates, 2014). The workbooks on Speed and Accuracy that were once a standard feature in nearly every primary classroom have long disappeared and are no longer in print. The only publisher offering something comparable is R.I.C. A few primary teachers continue to design lessons and activities that utilize and promote practice and fluency in mental arithmetic. A range of worksheets is available for download from the *Australian Mathematics Trust* website. It is difficult to gauge what is common classroom practice, especially given the competing claims on teaching time due to the crowded curriculum. TRMA may assist in monitoring schools attempting to better manage these competing priorities.

5. The opportunistic sample of adults available here limits broader generalisation. But it does appear that adult skills in the workplace are much stronger than in secondary school students, and are maintained across the life-span. Some of the best performers on the TRMA were older retired engineers, teachers or managers. This pattern of findings is also congruent with OECD survey data indicating that adults aged 55 to 65 in the UK performed better than younger people aged 16 to 24.

TRMA may be a useful tool for identifying young adults' mental arithmetic competence for particular job descriptions. It may help to determine whether more training, or explicit teaching is needed. Young people may have competencies in more complex mathematic problem-solving, yet lack these foundation skills. The same use might apply for older adults changing jobs.

6. **Dyslexia and Dyscalculia**

The utility of TRMA in diagnosis of Specific Learning Disorder and its remediation appears to be considerable. The prevailing approach is to divide SLD into two components – Dyslexia and Dyscalculia. The first pertains to a significant delay in reading, spelling and writing facility, and places focus on underlying phonological processing deficits. The second pertains to familiarity with number recognition and number processing, including all mental arithmetic. Its causes are still more open to conjecture than Dyslexia, and will not be reviewed here (Landeol et al, 2009; Michaelson, 2007, Kaufman and Von Aster, 2012; Reigosa-Crespo et al, 2011).

The best known screening test for Dyscalculia is the Dyscalculia Screener (Butterworth, 2003, 2005), conducted under speeded conditions using a software application. This is used by schools and psychologists under license in the UK and Australia. It includes subtests of Dot Counting, Number Comparison, and Timed Arithmetic (Addition and Multiplication). Its high cost as a commercial instrument has limited its wider adoption. Its core clinical algorithm for determining a diagnosis of Dyscalculia is not validated for SLD generally across the age spectrum. (Kaufmann and Von Aster, 2012).

In clinical practice the vast majority of children and adults present with generalized SLD. They display significant difficulties in Word Reading, Spelling and Numeracy, and often struggle to write fluently. It remains to be seen whether the TRMA will prove to be a useful diagnostic tool for this dominant group. Specific Dyscalculia is, by comparison, an infrequent diagnosis using the prevailing instruments. Prevalence rates of 3-5% (Reigosa-Crespo et al, 2011; Kaufmann and Von Aster, 2012) have been reported, but unpublished Australian findings suggest an even more conservative figure applies for dyscalculia as a discreet entity.

TRMA in use

7. The TRMA measures a broader spectrum of timed/speeded mental arithmetic skills. It is relatively cheap, quick and covers a wider range of indicators, including switching. It is designed to be used in conjunction with an (untimed) standardized test of number recognition and general arithmetic skills. Such a test would include fractions, percentages, estimates, long multiplication and division, decimals, and problems expressed in verbal format. No particular test is recommended.

The TRMA is also intended to be used in conjunction with standardized tests of Graded Word Reading and Graded Spelling, as part of the initial testing session. It is always preferable to examine all facets of Specific Learning Disability simultaneously. Other instruments measuring Auditory Discrimination or Phonological Awareness can be added if needed. This also applies to subtests from a cognitive battery, other language tests, or language checklists (eg Bishop, 2003).

A synthesis of these instruments in use will help provide a reliable SLD diagnosis for all age groups. It will also help eliminate false diagnoses such as ADHD, inappropriate prescribing of reading glasses, and Auditory Processing Disorder (APD). (Beck, Clark and Moore, 2016; Bench, Jacobs and Furlonger, 2016; De Bonis, 2015).

Bibliography

- Ackerman, R and Koriat, A. 2011. Response Latency as a predictor of the accuracy of children's reports.
  Applied Experimental Psychology 17(4) 406-417

- Beck, D.L., Clarke, J.L. and Moore, D.R. 2016.Contemporary issues in Auditory Processing Disorders.
  Hearing Review 23(4) 1-10

- Bench, J., Jacobs, K. and Furlonger, B. 2016. Auditory Processing Disorder? Then explain these results!
  Melbourne: Audiology Australia National Conference Papers

- Bishop D.V.M. 2003. Children's Communication Checklist, 2nd Edition
  London : The Psychological Corporation

- Bita, N. 2015. Teaching kids the language of the future.
  Weekend Australian, Nov 7-8, p22.

- Broughton, R. 1975A. One Minute Multiplication Test and One Minute Division Test : An enquiry into the attainment of students at different schools.
  Adelaide : Unpublished (Torrens CAE)

- Broughton, R. 1975B. The Millgate One Minute Arithmetic Tests : Establishment of Norms for Adelaide and a comparison of those derived from the NW of England.
  Adelaide : Unpublished (Torrens CAE)

- Butterworth, B. 2003. Dyscalculia Screener.
  London : NFER Nelson

- Butterworth, B. 2005. The development of arithmetical abilities.
  Journal of Child Psychology and Psychiatry 46 : 3 – 18
- Bynner, J. and Parsons, S. 1997. Does Numeracy Matter?
  London : The Basic Skills Agency
- De Bonis, D.A., 2015. It is Time to Rethink Central Auditory Processing Disorder Protocols for School Age Children. American Journal of Audiology vol 24 124-136
- Delis, D.C., Kaplan, E. and Kramer, J.H. 2001. Delis Kaplan Executive Function System (D-KEFS)
  San Antonio Texas : Psychological Corporation/Pearson
- Duncan, G.J. et al, 2007. School readiness and later achievement.
  Developmental Psychology 43(6) 1428-1446
- Education Department of South Australia 1958. Arithmetic Handbook for teachers in Primary Schools.
  Adelaide : Government Printer
- Elliott, C.D. and Smith, P. 2011. British Ability Scales 3.
  London : G.L. Assessment Ltd
- Geary, D.C. 2001. A Darwinian perspective on mathematics and instruction in T. Loveless (Ed) The great curriculum debate. P 85 – 107.
  Washington, DC : Brookings Institution Press
- Gersten, R., Jordan, N.C. and Flojo, J.R. 2005. Early identification and interventions for students with Mathematics difficulties.
  Journal of Learning Disabilities 38(4) p 293 – 304
- Gersten, R. et al 2012. Universal screening in mathematics for the primary grades : Beginnings of a research base.
  Exceptional Children 78(4) p 423-445
- Gravemeijer, K., Stephan, M., Julie, C., Lin, F.L., and Ohtani, M. (2017). What mathematics education may prepare students for the society of the future?
  International Journal of Science and Mathematics Education, 15, 1: 105-123.
- Hattie, J.A.C. and Yates, G.C.R. 2014. Visible Learning and the science of how we learn.
  London : Routledge : Abbingdon oxon
- ICSEA 2014. Index of Socio-Educational Advantage.
  https://acaraweb.blob.core.windows.net/resources/ About icsea. 2014 pdf
- Kaufman, L, and Von Aster, M. 2012. The diagnosis and management of dyscalculia. Dtsch Arztebl Int 109(45) p 767-78
- Korkman, M., Kirk, U. and Kemp, S. 2007. NEPSY II : A Developmental Neuropsychological Assessment.
  San Antonio : The Psychological Corporation/Pearsons

- Landerl, K. et al, 2009. Dyslexia and dyscalculia : Two learning disorders with different cognitive profiles.
  Journal of Experimental Child Psychology 103 p 309-324

- Loveless, T. 2001. A tale of two math reforms : the politics of the new math and the NCTM. In T. Loveless (Ed). The great curriculum debate p 184-209.
  Washington DC : Brookings Institution Press

- McRae, J. (undated). The Federal Arithmetic for Grade 1-VI. New Victorian Course of Study for Elementary Schools.
  Melbourne : Whitcombe and Tombs Ltd.

- Michaelson, M.T. 2007. An overview of dyscalculia.
  Australian Mathematics Trust 63(3) p 17-22

- OFSTED 1997. Office for Standards in Education. Teachers count.
  London : OFSTED

- IC publications. https://www.ricgroup.com.au

- Reigosa-Crespo, V. et al 2011. Basic Numerical Capacities and Prevalence of Developmental Dyscalculia : The Havana Survey. Developmental Psychology, 10.1037/a 0025356

- Rubinsten, O. and Tannock, R. 2010. Mathematics anxiety in children with developmental dyscalculia. Behavioural and Brain Functions 6 : 46, p 1-13

- Siekmann, G. and Korbel, P. (2016). Defining 'STEM" skills: Review and synthesis of the literature. [Support document 2].
  Adelaide: National Centre for Vocational Education Research.

- Thompson, V. and Morsanyi, K. 2012. Analytic thinking : Do you feel like it? Mind and Society 11(1) p93 – 105

- Watson, A.C., 2017. Learning Begins : The Science of Working Memory and Attention for the Classroom Teacher.
  USA : EBL (ebook)

- Westwood, P., Harris-Hughes, M., Lucas, G., Nolan, J. and Scrymgeour, K. 1974 One Minute Addition Test, One Minute Subtraction Test.
  Manchester UK : Unpublished Report (Manchester College of Education)

- Westwood, P. 1987. Commonsense Methods for children with Special Needs.
  London : Croom Helm

- Westwood, P. 2000. Numeracy and learning difficulties.
  Melbourne : ACER

- Westwood, P. 2003. Drilling basic number facts : should we or should we not?
  Australian Journal of Learning Disabilities Vol 8(4), p 3-25

- Westwood, P. 2004. Numeracy and learning difficulties : Approaches to teaching and assessment.
  London : Fulton
- Westwood, P. (2008). What teachers need to know about numeracy.
  Melbourne: ACER
- Westwood, P. (2016). Numeracy and learning difficulties (2nd ed.).
  Melbourne: ACER
- Williams, D. 1948. A realistic approach to number teaching.
  London : Oxford University Press