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Mathematics and metacognition in adolescents and adults with learning disabilities

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Abstract

A majority of studies on learning disabilities have focused on elementary grades. Although problems with learning disabilities are life-affecting only a few studies focus on deficits in adults. In this study adults with isolated mathematical disabilities (*n*=101) and adults with combined mathematical and reading disabilities (*n*=130) solved tests on procedural calculation and number knowledge, numerical facility and visuospatial skills. Metacognitive skilfulness was assessed through calibration measures, a questionnaire, stimulated recall, and thematic analyses after a qualitative interactive interview with a flexible agenda to discover the interviewee's own framework of meanings and to avoid imposing the researcher's structures and assumptions. In our dataset the isolated group (MD) did worse than the comorbid group (M+RD) on mental representation, dealing with contextual information and number knowledge. However the comorbid group did worse on the number sense tasks. No significant differences were found between the MD and M+RD adults for fact retrieval, procedural calculation and visuo spatial tasks. In addition adults with MD overestimated their mathematics results, whereas individuals with M+RD underestimated their results in the calibration task. Moreover, adults with M+RD thought that they were worse on the evaluation of the own results, the evaluation of the own capacities and on monitoring when things went wrong compared with adults in the M+RD group. Thematic analyses revealed that many adults had problems with planning and keeping track of steps and that supporting surroundings were important protective factors towards the chances of success. Consequences for the assessment of metacognition in adults and for the support of adults with mathematical disabilities are discussed.

Keywords: metacognition, mathematical learning disabilities, assessment, comorbidity

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Introduction

Mathematics and mathematical learning disabilities

It is hard not to overemphasize the importance of mathematical literacy in our society (Swanson, Jerman, & Zheng, 2008). In everyday life situations we need to be in time, pay bills, follow directions or use maps, look at bus or train timetables or comprehend instruction leaflets and expiry dates. A lack of mathematical literacy was found to affect people's ability to gain full-time employment and often restricted employment options to manual and often low paying jobs (Desoete, 2007a; Dowker, 2005).

Most practitioners and researchers currently report a prevalence of mathematical disabilities between 3-14% (Barbaresi, Katuskic, Colligan, Weaver, & Jacobsen, 2005; Desoete, 2007a; Dowker, 2005; Shalev, Manor, & Gross-Tsur, 2005).

Comorbidity

Reading disabilities and mathematical disabilities co-occur more frequently than would be expected by chance, sampling bias, population stratification, definitional overlap and rater biases (Desoete, 2008). The comorbidity rate of combined mathematical and reading disabilities (M+RD) varies from 17% to 43% (Fuchs & Fuchs, 2002; Light & DeFries, 1995). In a recent meta-analysis Swanson et al. (2009) found no support for the notion that the differentiation between M+RD and isolated RD was related to variations in reading across the reviewed studies.

Also in adults comorbidity remains an important topic (Clark, Watson, & Reynolds, 1995; Pennington, 2006). Nevertheless only a limited number of studies focus on comorbidity in adolescents and adults. Martinez and colleagues revealed that adolescents with M+RD had more problems at schools and were more often depressive than adolescents without learning disabilities. However, on the one hand, in contrast with the 'severity hypotheses, they found no difference between M+RD and adolescents with an isolated learning disability (Martinez & Semrud-Clikeman, 2004). On the other hand they revealed, in line with the 'severity hypotheses', that the M+RD group had a more negative perception than peers with an isolated learning disability about the social support they encountered (Martinez, 2006). In sum, there are inconsistent results in adolescents and adults on whether comorbidity can be explained through the 'severity hypotheses' or not.

In literature several models evolved out of an attempt to understand comorbidity within an individual (Neale & Kendler, 1995; Pennington, 2006; Rhee, Hewitt, Corley, Willcutt, & Pennington, 2005). Some of them are: the cognitive subtype hypothesis, the severity hypothesis and the three independent disorders model. The 'cognitive subtype hypothesis' expects the group with comorbid disabilities to have more severe deficits (both quantitative and qualitative) than the group with isolated disabilities (e.g., Kibby, Marks, Morgan, & Long, 2004). The severity hypothesis predicts that the problems of the comorbid group are more severe than the problems of the isolated groups (e.g., Pennington, 2006). The three independent disorders model (e.g., van der Sluis et al., 2004) predicts that problems of the comorbid group are an additive combination of the problems of the isolated groups.

To conclude, the debate on comorbidity remains unsolved. In the case of the 'cognitive subtype hypothesis' the difficulties of the group with mathematical and reading disabilities would be more severe (both quantitative and qualitative) compared with the group of adults with isolated disabilities. According to the severity hypothesis a quantitative but no qualitative difference is predicted between both groups. Another possible explanation is the three independent disorders model whereby the mathematical problems of the group with mathematical and reading disabilities are considered to be the same as those of the group with isolated mathematical disabilities. The reading problems of the comorbid group are considered to be the same as those of the group with isolated reading disabilities.

Metacognition

It is nowadays widely accepted that metacognitive knowledge and skills influence mathematical problem solving (e.g., Borkowski, Chan, & Muthukrishna, 2000). Metacognition refers to the ability of individuals to be aware of and monitor their learning processes. Metacognition has traditionally been differentiated into two central components, namely metacognitive knowledge and metacognitive skills. In young children a combination of prediction and evaluation skills was successful to differentiate children with mathematical learning disabilities from below-average performing peers and average performers from expert problem solvers (Desoete, Roeyers, & Buysse, 2001).

There are different methods to assess metacognition (Veenman, Van Hout-Wolters, & Afflerbach, 2006). Self-report questionnaires, hypothetical interviews and stimulated recall, think-aloud protocols and systematical observations are fruitfully being used (e.g., Desoete, Roeyers, & Huylebroeck, 2006; Efklides, 2001; Elshout-Mohr et al., 2003; Pressley, 2000; Pugalee, 2001; Veenman, 2005). In addition in the performance calibration and post-diction paradigm participants are asked after the solution of a mathematics task, to assess the correctness of the solution (e.g., Lin & Zabrucky, 1998). A comparison is made of whether evaluation after a task corresponds with the actual performance on the task.

To conclude, research on individual differences in metacognition has mainly used quantitative and interviewer structured research techniques. However, on the basis of such data, it is often very difficult to discover the interviewee's own framework of meanings and to avoid imposing the researcher's structures and assumptions (e.g., Coffey, Atkinson, 1996;

Frank, 2004; Seale, Gogo, Gubrium, & Silverman, 2004; Tesch, 1991). It has been suggested that researchers have to remain open to the possibility that the concepts and variables that emerge may be very different from those that might have been predicted at the outset (e.g., Creswell, 2003; Flick, 1998; Holliday, 2002; Ritchie & Lewis, 2003). Therefore a thematic analysis including a less intrusive qualitative interactive interview with a flexible agenda combined with a semi structured interview on core questions not covered the first part might be advised. The present study aims to add such data to enhance the existing body of research and to look for emergent themes and meanings of metacognition in adults with mathematical learning disabilities.

Aims of the study

In this study we aim to investigate whether adults with mathematical and reading disabilities (M+RD) show a similar profile of mathematics deficits compared with adults with isolated mathematical disabilities (MD) and if eventual differences can be explained through the severity or cognitive subtype hypothesis (M+RD>MD). The second aim of this study is to investigate whether MD adults differ in metacognitive skills and performance calibrations from M+RD adults and if qualitative research can add to our understanding of metacognition.

Method

Participants

Only at least average adults with a previous diagnosis of learning disability, learning problems across at least two successive grades and remediation not leading to improvements were accepted in the cohort of adults with learning disabilities.

Our sample included 101 adults with isolated mathematical disabilities (MD) and 130 adults with combined mathematical and reading disabilities (M+RD).

Measures

Mathematics measures. Mathematical performances of all participants were tested. Since in mathematical disabilities often procedural deficits, number knowledge deficits, semantic memory deficits and visuospatial deficits are described (Cornoldi, Venneri, Marconato, Molin, & Montinaro, 2003; Geary, 2004; Stock, Desoete, & Roeyers, 2006), we included the CDR with the P- and K-tasks for procedural and number knowledge deficits, a test on retrieval of arithmetic number facts from semantic memory (see TTR), and the DyscalculiUM with the comprehension of graphical information for visuospatial deficits.

The Cognitive Developmental skills in aRithmetics (CDR, Desoete & Roeyers, 2006) is a test on number-naming or reading (NR), dealing with operation symbols (S), knowledge (K) of the base-ten structural relationships, procedural (P) skills to solve mathematical tasks in a number problem format (e.g., 47-9 = ___), linguistic skills (L) enabling children to understand and to solve one-sentence mathematical problems in a word-problem format, (e.g., 9 less than 47 is ___), mental representation (M) skills, contextual skills (C) enabling the mathematical problem solving in a more than one-sentence word-problem, skills to select relevant information (R) and number sense skills (N). The psychometric value has been demonstrated on a sample of 871 Dutch-speaking adults in Flanders. Cronbach's α's were .80 for NR-tasks, .70 for S-tasks, .82 for K-tasks, .81 for P-tasks, .66 for L-tasks, .88 for M-tasks, .83 for C-tasks, .81 for R-tasks, .88 for N-tasks. Gutmann's split-half and Spearman-Brown's coefficients were .70 and .72 respectively.

The Arithmetic Number Fact Test (Tempo Test Rekenen, TTR) (de Vos, 1992) is a test on 200 arithmetic number-fact problems (e.g. 5x9=...). Children have to solve as many number-fact problems as possible out of 200 in 5 minutes. The test has been normed for Flanders on 872 adults. Cronbach's alpha was .90, the Guttman Split-Half Coefficient was .93, the Spearman-Brown coefficient was .95.

The DyscalculIUM (version 2.4.0) (Trott & Beacham, 2006) measures six facets of adult arithmetical problem solving: number knowledge (e.g., what number is represented here?), comparison of numbers (words, operations symbols and positions on the number line), comprehension of graphical information (bar charts and tables), abstraction skills, the knowledge to deal with spatial and temporal information and conceptual or operational skills in adults. The test has been normed for Flanders on 872 adults. Cronbach's alpha was .76, the Guttman Split-Half Coefficient was .83, the Spearman-Brown coefficient was .84. Cronbach's α's for the subtests varied from .94 to .98.

Metacognitive measures. In the Cognitive Developmental skills in aRithmetics (CDR, Desoete & Roeyers, 2006) the number of correct answers is the performance score (e.g., 30/45 on the test). In addition, persons have to gauge confidence in the correctness of the given answers (e.g., 'I think I will obtain 40/45 on this test'). The difference between the performance and evaluation score is the calibration score (e.g., here –10). The psychometric value has been demonstrated on a sample of 871 Dutch-speaking adults in Flanders.

The adult questionnaire (see Appendix A), which was created for this study, is a rating scale (10-item) questionnaire on metacognitive skills (e.g. I never (1) / always (4) knows in advance whether an exercise will be easy or difficult). The questionnaire was adapted from studies (Desoete & Roeyers, 2006). Test–retest correlations of .83 (p < .01) and interrater reliabilities varying between .99 and 1.00 (p < .01) were found. In this study Cronbach's α of .92 was found for the test score (10 items).

An in depth interview took place lasting 1 to 2 hours. First adults were asked to tell their whole story, from when they first noted problems at school. In a second part a semi-structured interview with stimulated recall took place on core metacognitive topics of the adult questionnaire. Thematic analyses on metacognition were conducted on the transcripts of both interviews.

Procedure

All subjects were first interviewed and then assessed individually, where they completed the TTR (de Vos, 1992), CDR (Desoete & Roeyers, 2006) and the DyscalculIUM (Trott & Beacham, 2006).

With informed consent, the interviews took mainly place in respondent's homes and lasted one to three hours and were audio taped and fully transcribed. If people preferred, they were interviewed and tested somewhere else. In the first part of the interview people are asked to tell the story of what happened to them, from when they first began to suspect there were problems. When the story was finished the researcher asked additional semi-structured questions, identified from previous literature review. Transcribed transcripts were returned to each adult for revision if necessary. From the transcripts categories or themes were developed. Sections of text were marked and linked to sections of text from other interviews that covered similar issues or experiences by using NVivo8. Themes were considered in the context of all the interviews. The different psychologists regularly discussed the coding and interpretation of the data.

The examiners, psychologists skilled in learning disabilities, received practical and theoretical training in the assessment and interpretation of mathematics and calibration. They also received a training in conducting non-directive in depth narrative interviews and in gathering data from semi structured interviews with open ended questions as well as in analyzing and writing up narratives. In order to guarantee reliability of the assessment, each examiner had to interview and test one adult and score the protocol in advance. This interview, transcription and protocol were analyzed by the author of this study. All examiners were provided with feedback. The test-protocols were not included in the analyses of this study. In addition, systematic, ongoing supervision and training was provided during the assessment of the first 10 adults.

Results

Procedural skills and number knowledge

In order to look for differences between adults with MD and M+RD a Multivariate Analysis of Variance (MANOVA) was conducted with procedural skills, number knowledge but also number-naming or reading, dealing with operation symbols, linguistic skills, mental representation skills, contextual skills, skills to select relevant information and number sense skills as dependent variables and belonging to the group of MD and M+RD as a factor. With an effect size of .21, we found a power of 1.00.

The MANOVA revealed a significant main effect for the performance group on the multivariate level (F (10, 217) = 5.03, $p \leq .0005$).

In the total model, performance group was predicted for 22% (1-Wilk's Lambda) by the performance groups. Univariate significant between-subject effects were found for M, C and N and calibration tasks (see Table 1). Means and Standard Deviations of the performance groups are presented in Table 1.

Table 1. Mean typical scores on CDR

	MD *M*	M+RD *M* (*SD*)	*F* (1,227) (*SD*)
NR-tasks	3.27 (1.18)	3.19 (1.17)	0.25
S-tasks	3.30 (1.46)	3.50 (1.46)	1.13
P-tasks	2.12 (1.47)	2.02 (1.46)	0.28
L-tasks	2.01 (1.58)	2.21 (1.48)	0.99
K-tasks	3.60 (1.36)	3.78 (1.24)	1.04
M-tasks	1.64 (1.90)	2.12 (1.34)	4.88*
R-tasks	2.53 (1.21)	2.57 (1.31)	0.06
C-tasks	1.68 (1.12)	2.17 (1.23)	9.31*
N-tasks	3.54 (1.30)	3.17 (1.39)	4.26*
Calibration tasks	1.56 (6.76)	-1.17 (8.54)	6.88*

* p ≤ .05

As can be concluded from Table 1 adults with M+RD were better than MD performers on the mental representation and dealing with contextual information, whereas MD performers were better than M+RD adults on number sense tasks and both groups also differed on calibration.

Retrieval of number facts

In order to look for differences on fact retrieval between adults with MD and M+RD a Multivariate Analysis of Variance (MANOVA) was conducted with the number correct additions, subtractions, multiplications, divisions and mixed exercises as dependent variables and belonging to the group of MD, M+RD as a factor. With an effect size of .03, we found a power of .49.

The MANOVA revealed a no significant main effect for the performance group on the multivariate level (*F* (5, 222) = 1.42, *p* = .22). In the total model, performance group was predicted for 3% (1-Wilk's Lambda) by the performance group. Means and Standard Deviations of the performance groups are presented in Table 2.

Table 2. Mean typical scores on TTR

	MD *M* (*SD*)	M+RD *M* (*SD*)	*F* (1,226)
Additions	29.35 (5.68)	27.97 (5.89)	3.18*
Subtractions	25.34 (6.10)	24.27 (6.39)	1.64
Multiplications	23.06 (7.52)	23.72 (8.03)	0.39
Divisions	20.87 (9.83)	19.69 (8.78)	0.91
Mixed exercises	23.52 (6.99)	23.21 (6.99)	0.11

* p ≤ .07

A trend of difference was found between the fast retrieval of additions between MD and M+RD individuals. M+RD individuals solved less exercises correctly than MD adults.

Visuospatial skills

In order to look for differences on visuospatial skills between adults with MD and M+RD, a Multivariate Analysis of Variance (MANOVA) was conducted with the subtests of the DyscalculiUM as dependent variables and belonging to the group of MD or M+RD as a factor. With an effect size of .09, we found a power of 0.96. The MANOVA revealed a significant main effect for the performance group on the multivariate level (*F* (6, 224) =3.78; *p* =.001). In the total model, performance group was predicted for 9% (1-Wilk's Lambda) by the performance groups. Means and Standard Deviations of the performance groups are presented in Table 3. Univariate significant between-subject effects were found for number knowledge but not for the visuospatial tasks (see Table 3).

As can be concluded from Table 3, adults with M+RD had better scores on number knowledge than adults with MD. No significant differences were found between both groups on visuospatial tasks.

Table 3. Mean typical scores on DyscalculiUM

	MD *M* (*SD*)	M+RD *M* (*SD*)	*F* (1,229)
Number knowledge	9.26 (1.89)	9.72 (1.76)	3.60*
Comparison of numbers	16.60 (3.21)	17.20 (4.29)	1.36
Graphical comprehension	12.02 (2.91)	12.21 (3.04)	0.23
Abstraction	5.83 (1.95)	6.19 (1.62)	2.35
Orientation	12.66 (2.14)	12.12 (2.90)	2.53
Procedural skills	11.74 (2.69)	11.95 (2.62)	0.33

* $p < .05$

In depth and semi structured thematic analyses

Thematic analyses revealed that almost all adults with MD or M+RD were better at mathematical reasoning and written calculation than in mental calculation. They had low accuracy in mental calculation. If they could write down steps or perform written calculations, the problems disappeared. However, some subjects were highly erratic at mental calculation and written calculation tasks. The mechanical process of subtraction and division, especially the long division multi-step process, remained confusing for most adults. Calculators helped to master these difficulties. In addition, a lot of adults still had problems with the tables of multiplication and division. About 60% of the MD adults and 75% of the M+RD adults thought multiplication tables whereas 66% of the MD adults and 81% of the M+RD adults considered division tables to be hard. Some of them thought that multiplication went better than division.

> TR4 "*I still don't know my tables by hard. This was a big problem in elementary school. In secondary education this was less of a problem since we could use a calculator then. … I also did not remember definitions in mathematics. If I could say it with my own words it went better, but if you wanted literal definitions I could not do them*"

About 83% of the MD adults and only about 9% of the M+RD adults spontaneously talked about problems with percentages, decimal numbers, fractions, proportions and measuring counts during the interview. Of this group 25% of the MD group and about 18% of the M+RD group still had problems working with percentages in adulthood. Moreover about 23% of the MD group and 18% of the M+RD group had problems interpreting decimal numbers. During the interview 74% of the MD group and 94% of the M+RD group discussed problems with fractions, 84% of the MD group and 94% of the M+RD group still had problems with proportion and 77% of the MD group and 71% of the M+RD group talked about problems with measurements whereas 86% of the MD group and 82% of the M+RD group failed in situations with content and surface related tasks.

> TR8 "*10 or 50%, I know, but the rest is a problem*"
> TR 61 *"50% is an easy one when no one is around. But 30% is more difficult. I always have trouble to calculate how much discount I get"*
> TR 85.. *" I have a problem with the placement of the comma to decimal numbers"*
> TR 91…*"I manage in daily life for example km is no problem, but the formula's are difficult … From a cookbook converting the amounts of 4 to2 people is very difficult. My friend has typed all the recipes with the right quantities for me."*
> TR 102…*"I manage, but it takes a long time. I also still have a problem with fractions, proportions and measuring count of mathematics. Also content and calculate surface is difficult for me."*

Other stumbling blocks in almost all adults were naming mathematical concepts, terms or operations. Especially abstract concepts of time and direction in mathematical contexts lead to incorrect interpretation, as did use of numerical symbols and/of arithmetic signs. Many of the adults also lacked accurate estimation skills. Moreover, some adults described problems with visual-spatial tasks. They rotated numbers en failed in spatial placement of numbers on a number line and in geometric tasks where they have to rely on algebraic notations or graphical plots. About 21% of the MD adults and 56% of the M+RD adults mentioned during the interview that they often twisted numbers and 47% of he MD group and 48% of the M+RD group described it takes them a considerable amount of time to know the right from the left. About 36% of the MD group and 71% of the M+RD group described problems explaining tables and 39% of the MD group and 41% of the M+RD group described chart interpretation errors during the interview. Moreover, 19% of the adults talked about problems clock reading during the interviews. Adults often they used digital clocks because they still had problems to understand the analogical clocks. They also failed to represent of draw a plan of the surrounding streets, and to locate lands, oceans on a map.

> TR 5 "*I always pay with big money because I can not pay appropriate in the store. I never check my change*"
> TR 14 "*I often twist numbers, especially on large numbers"*
> TR 21 "*I twist numbers, when I am tired"*
> TR 44 "*I twist numbers in digital clocks and telephone numbers"*
> TR 64: "*I remember the left and right with a trick. If I am concentrated I do not confuse them*"
> TR 73 "*I always look in the living room for the time on the video recorder, since this is a digital clock. In the kitchen there is a large analogical clock, but I never use that one.*
> TR 85 "*I was often punished because I was too late at school when I went with friends to the town centre at noon and remained too long there*
> TR 89 "*If someone says to me you have 5 minutes I think I can still take a shower, read a news paper and so on, but this is mostly not the case. So I am mostly too late or very much too early on an appointment*"

Metacognition

Calibration. As can be concluded from Table 1 adults with MD differed from M+RD performers on calibration (F (1, 226) = 6.88, p<.01). Individuals with MD overestimated their mathematics results, whereas individuals with M+RD underestimated their results in the calibration task.

Metacognitive skilfulness. In order to look for differences on the metacognitive questionnaire between adults with MD and M+RD, a Multivariate Analysis of Variance (MANOVA) was conducted with the 10 metacognitive questions as dependent variables and belonging to the group of MD or M+RD as a factor. With an effect size of .21, we found a power of 1.00. The MANOVA revealed a significant main effect for the performance group on the multivariate level (F (10, 184) = 4.97; p <.0005). In the total model, performance group was predicted for 22% (1-Wilk's Lambda) by the performance groups. Means and Standard Deviations of the performance groups are presented in Table 4.

Table 4. Mean typical scores on Metacognitive Questionnaire

	MD *M* (*SD*)	M+RD *M* (*SD*)	*F* (1, 187)
Task difficulty estimating	2.06 (0.92)	1.82 (0.84)	3.70*
Correctness of the solution estimating	3.08 (0.95)	2.76 (1.09)	4.78*
Planning and working according to plan	2.49 (0.98)	2.42 (1.12)	0.21
Working precise on difficult exercises	2.50 (0.76)	2.68 (1.09)	1.58
Knowing when one will be correct or not	2.15 (0.73)	2.00 (0.89)	1.53
Panicking instead of adapting the plan	2.10 (0.76)	2.66 (1.21)	13.45*
Telling in advance how one will work	2.55 (0.94)	2.53 (1.14)	0.02
Finding mistakes and correcting them	3.00 (0.81)	3.11 (1.03)	0.67
Knowing when to start to finish in time	2.50 (0.95)	2.49 (1.22)	0.01
Knowing how to study and learn	2.36 (1.06)	2.50 (1.09)	0.81

* p <.05

Adults with M+RD were better on task difficulty (prediction) and correctness of solution (evaluation) estimation. The M+RD group did significantly panic less than adults in the MD group. Instead they adapting the plan when things went wrong (monitoring).

Thematic analyses on the in depth interview and stimulated recall data. About 42% of the adults (46% of the MD group and 38% of the M+RD group) described during the in depth interview problems with planning and monitoring. None of them spontaneously referred to a lack of prediction skills and only ten adults talked about insufficiencies in evaluation skills. Thematic analyses revealed that many MD and M+RD adults had problems with planning and keeping track of steps. Some adults described how they studied for the wrong exam, did not work further on an assignment if they could not solve the previous question, forgot things and could not plan efficiently. Their working place was not very well organized, they often could not select main ideas from less important topics or they had problems to act according to appointments.

Most adults attributed the problems with planning and monitoring to a lack of concentration or sustained divided task related attention. The impact of poor metacognitive skills on school results and employment prospects was according to the respondents even bigger then the influence of poor mathematical or reading skills. They often also had more problems accepting these metacognitive limitations, than to deal with the mathematics or reading related limitations. They also told that the environment did not understand the metacognitive problems and attributed them to of bad faith or a lack of commitment placing them substantial disadvantage compared to non-disabled peers without those problems.

> TR 3: *I often am mad at my self, because I think it is a lack of character or perseverance not to be able to concentrate during exams or homework*
> TR 5 *My teacher had no patience with me forgetting my book or being to late with an assignment. He said that all other students were in time and that there was always something with me ….*

In the stimulated recall interview 29% of the MD respondents and 60% of the M+RD group also described to have prediction difficulties and 41% of the MD respondents and 43% of the M+RD group also described to have evaluation difficulties, whereas they did not describe such problems during the in depth interview. When the interviewer asked them why they did not talk about this in the in depth interview, they told that ‘they did not know that we were researching those kind of things’ or ‘they did not know we these aspects were important to talk about’. These differences illustrate that adults make subjective estimations about the aim of the interview and the questionnaire and act according to them. This makes it unclear whether tests and questionnaires really reflect the ongoing thoughts and metacognitive skills.

All most all adults told that their performance was very much dependent on the task condition and on the person demanding this task. Often they described how they had no problem during a whole year and all troubles started again with a new teacher, school or job. For almost all adults with MD and M+RD supporting surroundings were important protective factors towards the chances of success. They also told that tests not always detected there problems, because it was often not a question of not being able, but rather a matter of not succeeding in time-limited conditions, requiring unreasonable effort, being less certain or needing more time for tasks.

> TR3 "*Some math teachers allowed us to use an individualized mathematics glossary of concepts and formulae. They let me use this glossary during exams. This made the difference. Not all teachers allowed this, what made it difficult*".
> TR23 "*My wife checks all my papers for mistakes and manages my agenda… I listen very carefully to what my colleagues tell me about conferences they went to*"
> TR32 "*I always am too early or too late for an appointment. Sometimes I am 2 hours to early.*"

Discussion

This study revealed that a lot of adults with mathematical disabilities still have problems to solve mathematical tasks in dual-task or limited-time conditions. In addition, adults with isolated mathematical disabilities (MD) were better than adults with mathematical and reading disabilities (M+RD) on the number sense tasks and on fast retrieval of additions. Adults with combined disabilities (M+RD) solved more mental representation tasks correctly, had better number knowledge and had less problems to deal with contextual information compared with adults with MD.

Thematic analyses revealed that almost all adults with MD or M+RD were better at mathematical reasoning and written calculation than in mental calculation. Moreover, a lot of adults still had problems with the tables of multiplication and division. Most MD adults and a few M+RD adults described problems with percentages, decimal numbers, fractions, proportions and measurements during the interview. Other stumbling blocks in almost all adults were naming mathematical concepts, terms or operations. Many of the adults also lacked accurate estimation skills. Finally, some MD and M+RD adults described problems with visual-spatial tasks and clock reading.

Overall, the results clearly confirm the importance of metacognition even in adulthood. On calibration measure and the questionnaire our dataset revealed that individuals with MD overestimated their mathematics results, whereas individuals with M+RD underestimated their results. Moreover, adults with M+RD were better on task difficulty (prediction) and correctness of solution (evaluation) estimation. The M+RD group did significantly panic less than adults in the MD group. Instead they adapting the plan when things went wrong (monitoring).

In addition, results show the value of in depth interviews and semi structured stimulated recall interviews as non intrusive and actual measures of the metacognition. Thematic analyses on the in depth interviews revealed problems with planning and monitoring in adulthood on most MD and M+RD participants. However, only very few of the adults with MD or M+RD spontaneously referred to a lack of prediction or evaluation skills during these in depth interviews, although they described problems on those aspects in the stimulated recall interview. These results reveal, in line with previous research (Desoete, 2007b), that the choice of diagnostic instruments highly determines the study outcome. Even in in depth interviews with a researcher remaining open to the possibility of unpredicted outcome, participants still have a picture of the research questions and tend to give socially desirable answers bringing or not bringing information according to this picture. It is not because a person does not describe certain problems spontaneously in the in depth interview that this person does not experience these problems. However also the opposite phenomenon was present. Some respondents answered to have problems on the metacognitive questionnaire. They however described a low impact of these problems in the stimulated response condition. Based only on the answer on the questionnaires one could have an imprecise or even incorrect picture of the degree or impact of problems. A stimulated recall after finishing the questionnaire showed a better picture of the interviewee's own framework of meanings and avoided incorrect assumptions.

Thematic analyses also revealed that metacognitive problems are often attributed to a lack of persistence or effort by the environment and to a lack of sustained attention or automated self regulation by the persons them selves. This means that including metacognition as an aspect of 'psychoeducation' is important. The goal of this psychoeducation is for the adult, his family and environment to understand and to be better able to deal with the obvious problems on mathematical problem solving but also with the more discrete comorbid metacognitive problems and erase false beliefs about it. The theory is, the better knowledge the persons haves of their problems but also about their own strengths, resources and coping skills, the better they can live with their condition.

Adults with mathematical disabilities often had more problems accepting the metacognitive limitations, than to deal with the mathematics or reading related limitations. They also told that the environment underestimated their metacognitive problems and attributed them to of bad faith or a lack of commitment. The thematic analyses made it clear that metacognition can not be studied overlooking the beliefs and emotions of individuals. One cannot engage in planning without believing in the ability to plan and worrying about the own skills. One can only understand metacognition if not only skills are assessed but also metacognitive knowledge, beliefs, attribution style, motivation and self-esteem are taken into account. We suggest that the use of multiple-method designs, including the evaluation of metacognition, cognition, motivation and emotion to discover the adults own framework of meanings and to avoid imposing the researcher's structures and assumptions

All most all adults told that their performance was very much dependent on the task condition and on the person demanding this task. These results are in line with Veenmans ‘production deficiency’ where subjects have a certain level of metacognitive knowledge and skills at their disposition but fail to use their metacognition due to task difficulty, test anxiety, lack of motivation or their inability to see the appropriateness of metacognition in a particular situation (Veenman, Van Hout-Wolters & Afflerbach, 2006). For almost all adults with MD and M+RD supporting surroundings were important protective factors towards the chances of success. They considered themselves as having planning and monitoring skills at their disposition, but not being able to keep investing the effort and conscious regulation to use these ‘good’ habits. In addition the results were in line with Sternberg’s experiential subtheory (Sternberg, 1985) on intelligence and his definition of automated processes. According to hem, a process that has been automated has been performed multiple times and can now be done with little or no extra thought. Once a process is automated, it can be run in parallel with the same or other processes (Sternberg, 1997). Adults with MD and M+RD describe situations were metacognitive skills never became automated self instructions and always remained activities consciously decided upon and requiring supervising attention no longer available for other things on that moment.

Reflecting on the results of the present study there is evidence that how you test is what you get. In depth and semi structured interviews seem to give additional valuable information on the metacognitive skills and beliefs of adults with mathematical learning disabilities. We suggest that researchers who are interested in metacognition in adults use multiple-method designs, including quantitative and qualitative techniques.

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Appendix
Metacognitive questionnaire

What typifies you during the last 3 months compared with peers? How often does this behaviour occur? **1 = always**
4 = never

Note the corresponding number in □

- Reflecting in advance on how difficult this exercise will be □
P 1
- Controlling the work and estimating the correctness of the solution □
E 1
- Planning and working according the plan □
Pl1
- Working slower and more precise on difficult exercises □
Mo
1
- Knowing in advance where one will be correct or not □
P2
- Panicking if something goes wrong without adapting the plan □
Mo
2
- Able in advance to tell how one will work on a task □
Pl2
- Finding mistakes in a last control and being able to estimate the results of the task □
E2
- Knowing when to start to finish in time □
P3
- Knowing how to study and approach a learning task □
M3

How would you situate you compared with peers? **1 = very low - 4 = very good**
Note the corresponding number in □

- Mathematics □
- Reading □
- Social skills □
- Other remarks :