




脑科学视野下的数学 学习困难诊断与干预

周新林
认知神经科学与学习国家重点实验室
2012-12-02



认识大脑功能

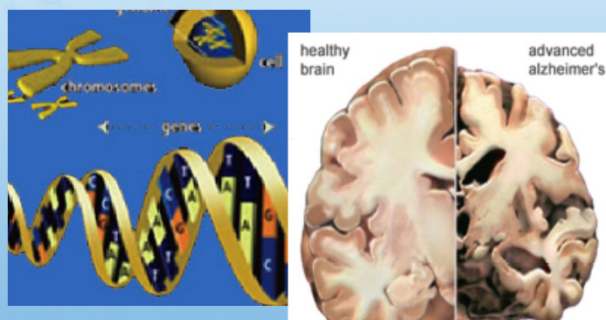
促进大脑功能

目录

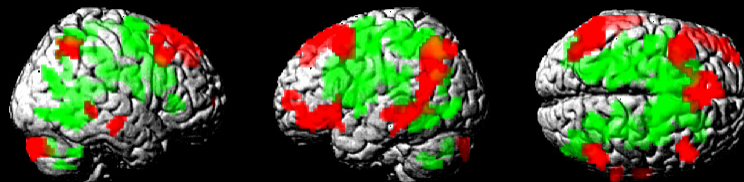
- 1. 基础研究是否有助于教育
- 2. 什么是数学学习困难
- 3. 数学学习困难的诊断
 - 学业诊断
 - 认知诊断
 - 脑成像诊断
- 4. 数学学习困难的干预
 - 认知干预
 - 学业评估与干预
 - 神经刺激与成像干预
- 5. 讨论与总结



1. 基础研究是否有助于教育



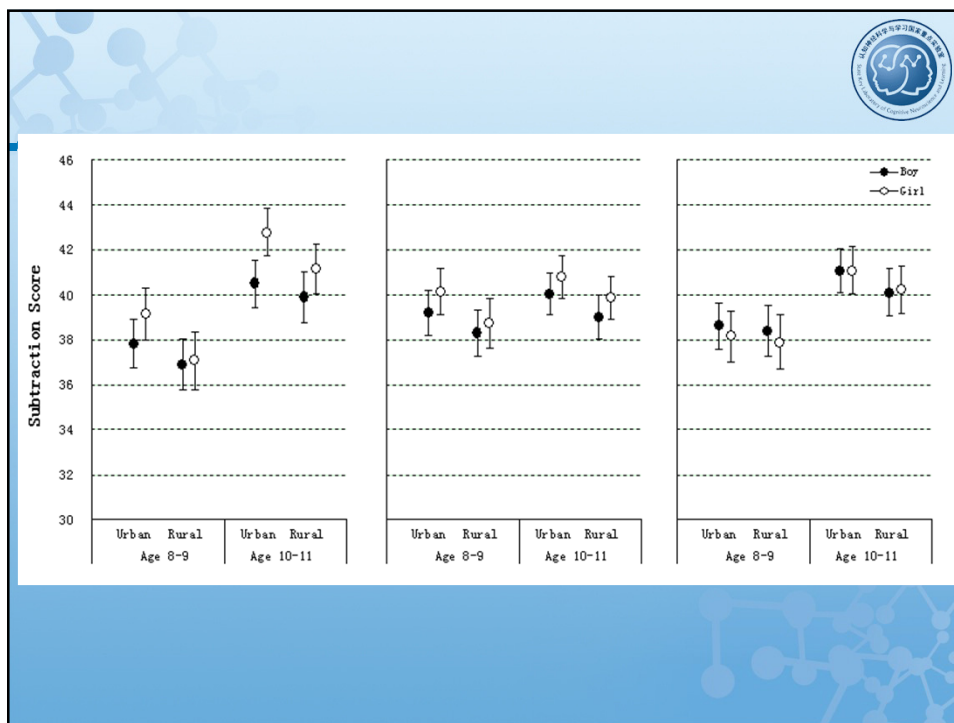
Arithmetic word problem vs. Calculation



1. 基础研究是否有助于教育



- 以计算能力性别差异研究为例：
 - 女生的计算能力优于男生
 - 假设女生的算术优势与其语言优势有关 (Wei et al., 2012, Psychological Science)



1. 基础研究是否有助于教育



- 以计算能力性别差异研究为例：
 - 该研究结果得到了Psychological Science杂志主编的高度评价，认为“这篇优秀的文章为数学能力性别差异的研究做出了重要贡献”。
 - 我们以此论文参加第15届ISSID会议，获得“the ISSID Blazej Szymura Travel Award”奖励，其主席在信中写道“We received a large number of high quality applications, but we were particularly impressed by your application”（尽管我们收到大量高水平的申请，但是你的申请给我们留下了尤为深刻的印象）。

1. 基础研究是否有助于教育



- 以计算能力性别差异研究为例：
 - 文章发表后，美国心理科学协会对我们进行了采访，并于2012年2月23日发表了题为“Girls’ Verbal Skills Make Them Better At Arithmetic”的科学新闻报道；该篇报道在第一时间被Science Daily转载。从2012年2月到2012年10月，已有300多家网站对这一科学新闻进行转载或链接。

Girls' verbal skills make them better at arithmetic, study finds - Mozilla Firefox

www.sciencedaily.com/releases/2012/02/120223133012.htm

ScienceDaily®

News Articles Videos Images Books

Health & Medicine Mind & Brain Plants & Animals Earth & Climate Space & Time Matter & Energy Computers & Math Fossils & Ruins

Science News

... from universities, journals, and other research organizations

Girls' Verbal Skills Make Them Better at Arithmetic, Study Finds

ScienceDaily (Feb. 23, 2012) — While boys generally do better than girls in science and math, some studies have found that girls do better in arithmetic. A new study published in *Psychological Science*, a journal of the Association for Psychological Science, finds that the advantage comes from girls' superior verbal skills.

"People have always thought that males' advantage is in math and spatial skills, and girls' advantage is in language," says Xinlin Zhou of Beijing Normal University, who cowrote the study with Wei Wei, Hao Lu, Hui Zhao, and Qi Dong of Beijing Normal University and Chuansheng Chen of the University of California-Irvine. "However, some parents and teachers in China say girls do arithmetic better than boys in primary school."



Some studies have found that girls do better in arithmetic. Now, a new study finds that the advantage comes from girls' superior verbal skills. (Credit: © pressmaster / Fotolia)

See Also:

Mind & Brain

- Gender Difference
- Intelligence
- Language Acquisition

Computers & Math

- Mathematics
- Math Puzzles
- Mathematical

Related Stories

Friends' School Achievement Influences High

Just In: Earthworms to Blame for Decline of Some Birds

Social Networks: Recommend this story on Facebook, Twitter, and Google +1.

Other bookmarking and sharing tools: More

Xinlin Zhou Arithmetic boy girl - Yahoo! Search Results - Mozilla Firefox

search.yahoo.com/search..._y1t=AD067kiJ50x731sAWA2JHyaP?XinlinZhouArithmeticboygirl&ei=UTF-8&fr=yfp

Filter by time: Anytime, Past day, Past week, Past month

Girls' Verbal Skills Make Them Better At Arithmetic

... and math, some studies have found that girls do better in arithmetic. A ... is in math and spatial skills, and girls' advantage is in language," says Xinlin Zhou of ...

Girls' Verbal Skills Make Them Better At Arithmetic — Tri ...

... and spatial skills, and girls' advantage is in language," says Xinlin Zhou ... and teachers in China say girls do arithmetic better than boys in primary school." Zhou ...

Girls are better than Boys at Arithmetic due to their Verbal ...

Girls' verbal skills make them better at arithmetic.study While boys ... in China say girls do arithmetic better than boys in primary school." says Xinlin Zhou of ...

Girls' verbal skills make them better at arithmetic | Science ...

... skills, and girls' advantage is in language," says Xinlin Zhou of ... in China say girls do arithmetic better than boys in primary school." Zhou ... with a Mama's Boy ...

Girls' verbal skills make them better at arithmetic

... studies have found that girls do better in arithmetic. ... and spatial skills, and girls' advantage is in language," says Xinlin Zhou ... A 12-year-old boy on the ...

Girls' superior language skills make them better at arithmetic

Baby Names; Festivals ... skills, and girls' advantage is in language," said Xinlin Zhou of ... in China say girls do arithmetic better than boys in primary school." Zhou and ...

Girls' verbal skills make them better at arithmetic, study finds

"People have always thought that males' advantage is in math and spatial skills, and girls' advantage is in language," says Xinlin Zhou of Beijing Normal University ...

Girls' verbal skills make them better at arithmetic ... - Science Daily
www.sciencedaily.com/.../02/120223133012.htm - 网页快照 - 翻译此页
 ScienceDaily (Feb. 23, 2012) — While boys generally do better than girls in science and math, some studies have found that girls do better in arithmetic.

Girls' Language Skills Could Help Them Do Math
jezebel.com/.../girls-language-skills-could-help-th... - 网页快照
 23 Feb 2012 — Boys are good at math, girls are good at langu.
 Girls' Verbal Skills Make Them Better at Arithmetic [ScienceD

能够让你帮助孩子学数学的10项研究

10 Pieces of Research That Can Help You Help Your Child With Math
www.mathsinsider.com/10-hot-pieces-of-research-... - 网页快照 - 翻译此页
 10 Apr 2012 — 1. Girls verbal skills make them better at arithmetic. In a study published in Psychological Science, it has found that girls can do better at math ...

女孩的語言能力有助於算術能力 SocioBio
www.sociobio.com/news/.../boy-girl-arithmet... - 台湾 - 网页快照 - 转为简体网页
 2012年4月4日 — "Girls' verbal skills make them better at arithmetic, study finds."
 ScienceDaily, 23 Feb. 2012. Web. 24 Feb. 2012. 研究論文: Xinlin Zhou, Wei Wei ...

Girls' verbal skills make them better at arithmetic - Science Daily | e ...
esciencenews.com/.../girls-verbal-skills-make-them... - 网页快照 - 翻译此页
 23 Feb 2012 — While boys generally do better than girls in science and math, some studies have found that girls do better in arithmetic. A new study finds that ...

Girls' Verbal Skills Make Them Better at Arithmetic - ScienceNewline
www.sciencenewline.com/.../2012022401450004.html - 翻译此页
 24 Feb 2012 — While boys generally do better than girls in science and math, some studies have found that girls do better in arithmetic. A new study published ...

1. 基础研究是否有助于教育



- <http://www.mathsinsider.com/10-hot-pieces-of-research-to-help-boost-your-childs-math/>

Firefox | 多维心理 | Girls' Verbal ... | 10 Pieces of R... | 10 Pieces of R... | Girls' verbal ... | Gender Differ...

www.mathinsider.com/10-hot-pieces-of-research-to-help-boost-your-childs-math/


10 Hot Pieces of Research to Help Boost Your Child's Math

Posted by [Caroline Mukina](#) in [Motivation](#), [Resources](#)

1 This is a guest post by [Neltje M](#) from [MyCriminalJusticeCareers.com](#).

Share Often, kids say that the subject that they "hate" the most is math. Math can be difficult for some students because they just don't understand the way that math works. I know for myself, math was never something that came easy. I had to spend agonizing hours over a couple of problems when I was in high school. Now that I have my own children, I realize their pain. However, instead of thinking negatively about math, there has been research that has shown that children are much more adapt to learning math than you think. Here is the top research that has been done.

1. Girls verbal skills make them better at arithmetic.



Simply en
INST

查找 www.facebook.com ...

开始 | 筒子等4... | 实验室1... | Professi... | Java EE... | 10 Piece... | Microsof... | Note.txt... | 20121122 | Drainsand... | WorkingP... | 114,255... | 2011年新... | 2011年新... | 第二辑... | 未

Firefox | 多维心理 | Girls' Verbal ... | 10 Pieces of R... | 10 Pieces of R... | Girls' verbal ... | Gender Differ...

www.mathinsider.com/10-hot-pieces-of-research-to-help-boost-your-childs-math/

1. Girls verbal skills make them better at arithmetic.



In a study published in *Psychological Science*, it has found that girls can do better at math because of their verbal skills. Encourage your little girl to talk about the math she's doing.

2. Puzzle Play Improves Math Skills



查找 www.facebook.com ...

1. 基础研究是否有助于教育



- 总之，基础研究对教育实践有重大启示

2. 什么是数学学习困难



- 直观上就是学习成绩落后
- 存在不同的类型，称为亚类型
 - 数字系统（例如作为非母语的英语数字系统）
 - 数学事实的记忆
 - 数学推理
 - 数学概念/术语

3. 数学学习困难的诊断



■ 方法之一：学业诊断

- 教师自编测验
- 学区统一测验
- 标准化测验
 - 我们正在开发基本数学概念掌握水平测验，这一测验适用于3岁以上所有人群

Study	Criterion	Classification test	Label
Hanich et al. (2001)	35 th percentile	Mathematics Composites from the Woodcock-Johnson Psycho-Educational Battery-Revised	Mathematics difficulties
Jordan et al. (2002)	35 th percentile	Mathematics Composites from the Woodcock-Johnson Psycho-Educational Battery-Revised	Mathematics difficulties
Jordan et al. (2003)	35 th percentile	Mathematics Composites from the Woodcock-Johnson Psycho-Educational Battery-Revised	Mathematics difficulties
Geary et al. (2000)	35 th percentile	Mathematics Reasoning subtest of the Wechsler Individual Achievement Test	Mathematics disabilities
Geary et al. (1999)	30 th percentile	Mathematics Reasoning subtest of the Wechsler Individual Achievement Test	Mathematics disabilities
Siegel & Ryan (1989)	25 th percentile	Arithmetic subtests of the Wide Range Achievement Test	Arithmetic disabilities
Koontz & Berch (1996)	25 th percentile	Iowa Test of Basic Skills	Arithmetic learning disabilities
McLean & Hitch (1999)	25 th percentile	Graded Arithmetic-Mathematics Test	Specific arithmetic learning difficulties
Rousselle & Noël (2006)	15 th percentile	A numerical and arithmetical tests battery	Mathematical disabilities
Geary et al. (2007)	15 th percentile	Numerical Operations subtest of Wechsler Achievement battery	Mathematical learning disabilities
Geary et al. (2008)	23 th < score < 39 th	Numerical Operations subtest of Wechsler Achievement battery	Low achieving children
	11 th percentile		Mathematical learning disabilities
Bull & Johnston (1997)	11 th < score < 25 th	Group Mathematics Test	Low achieving children
	Below the mean score		Low-ability in mathematics
Temple & Sherwood (2002)	1 year below the chronological age	Wechsler Objective Numerical Dimensions (WOND)	Number fact disorder
Price et al. (2007)	1.5 SD below the mean score	Standardised arithmetical test (RMAT)	Developmental dyscalculia
Shalev et al. (1997)	2 years below grade level	Standardised arithmetical battery	Developmental dyscalculia
Landerl et al. (2004)	3 SDs below the mean score	A timed arithmetical test	Developmental dyscalculia
Rubinsten et al. (2005)	No criteria ^a	Standardised arithmetical battery	Developmental dyscalculia



3. 数学学习困难的诊断



■ 方法之二：认知诊断

- 基本认知能力诊断
- 学业认知能力诊断
 - 语言认知
 - 数学认知

■ 学生为何做错

解方程（本题 4 分）：

$$(1) \quad \frac{4x-1.5}{0.5} - \frac{5x-0.8}{0.2} = \frac{1.2-x}{0.1}$$

解： $\frac{40x-15}{5} - \frac{50x-8}{2} = \frac{12-10x}{1}$

$$80x-30 - 250x+40 = 12-10x$$

$$-180x = 12-10$$

$$-180x = 2$$

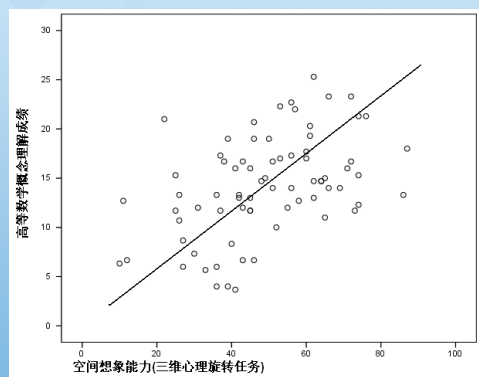
$$x = -\frac{1}{90}$$





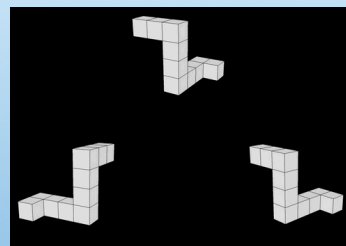
■ 认知诊断的必要性：与认知能力有关

- 心理旋转能力与高等数学成绩的关系



空间加工能力越强，数学成绩越好

(Wei et al, 2011)



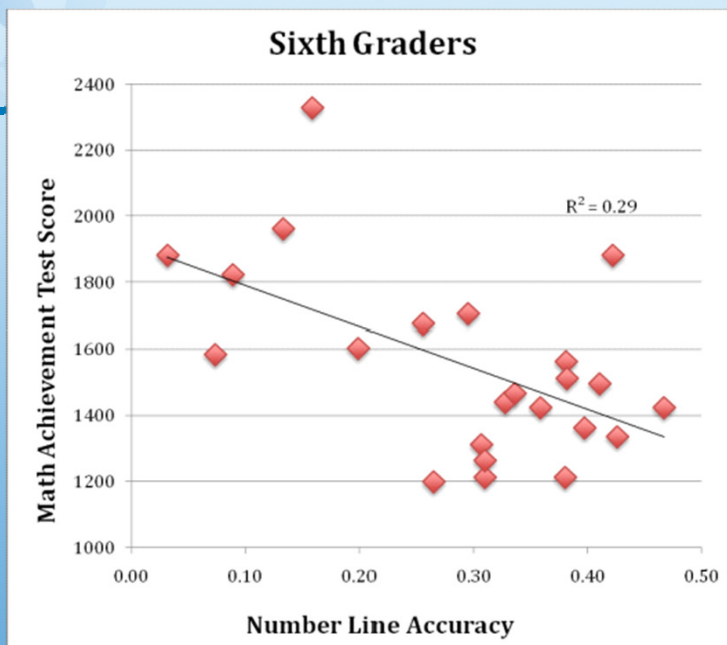
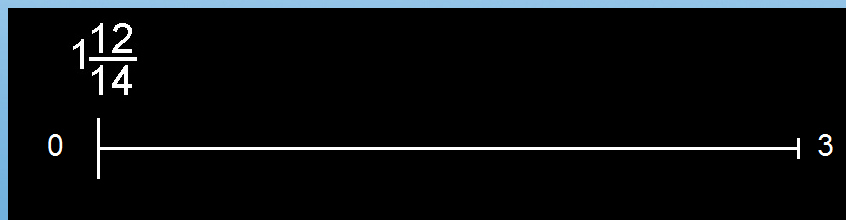
样本空间 $(x,y) \ x \geq 0, y \geq 0, x+y \leq 6$

下面哪个集合A代表随机事件：()

- 1, $A = \{ (x,y) \mid x \geq 0, x \leq 6 \}$
- 2, $A = \{ (x,y) \mid x \geq 0, y \leq 6 \}$
- 3, $A = \{ (x,y) \mid x \geq 0, y \geq 0, x+y \leq 1 \}$
- 4, $A = \{ (x,y) \mid x \geq 0, y \geq 0, x+y \leq 10 \}$



- 分数数轴加工能力与6、8年级学生数学成绩有高相关
- 见数据表





■ 基本认知诊断的内容

- 工作记忆容量
- 执行功能
- 空间能力
- 注意力
- 记忆力



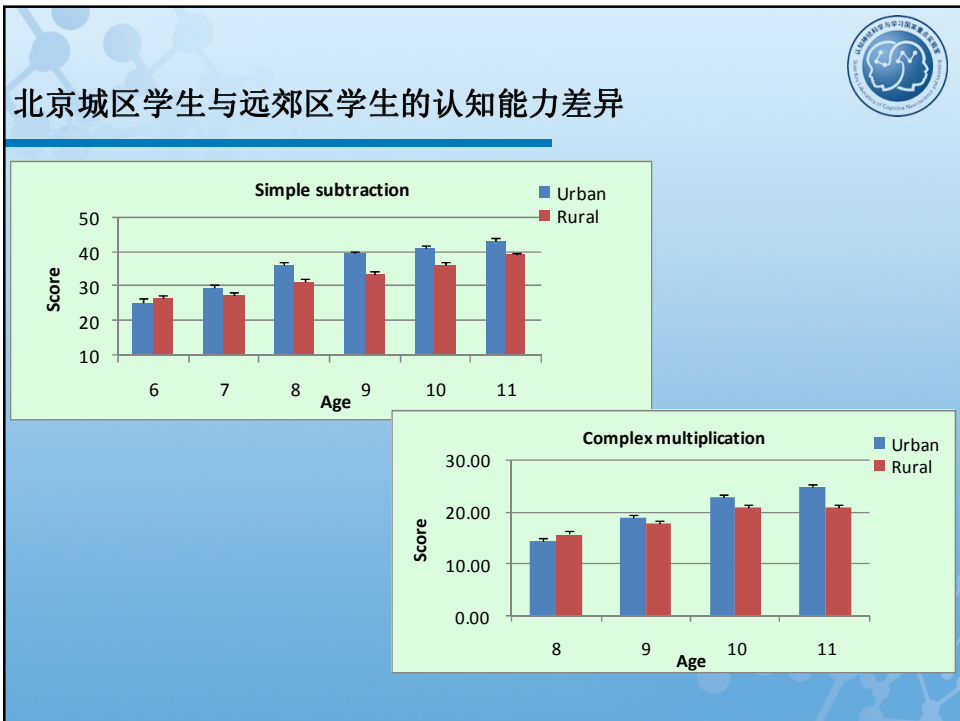
■ 学业认知能力诊断

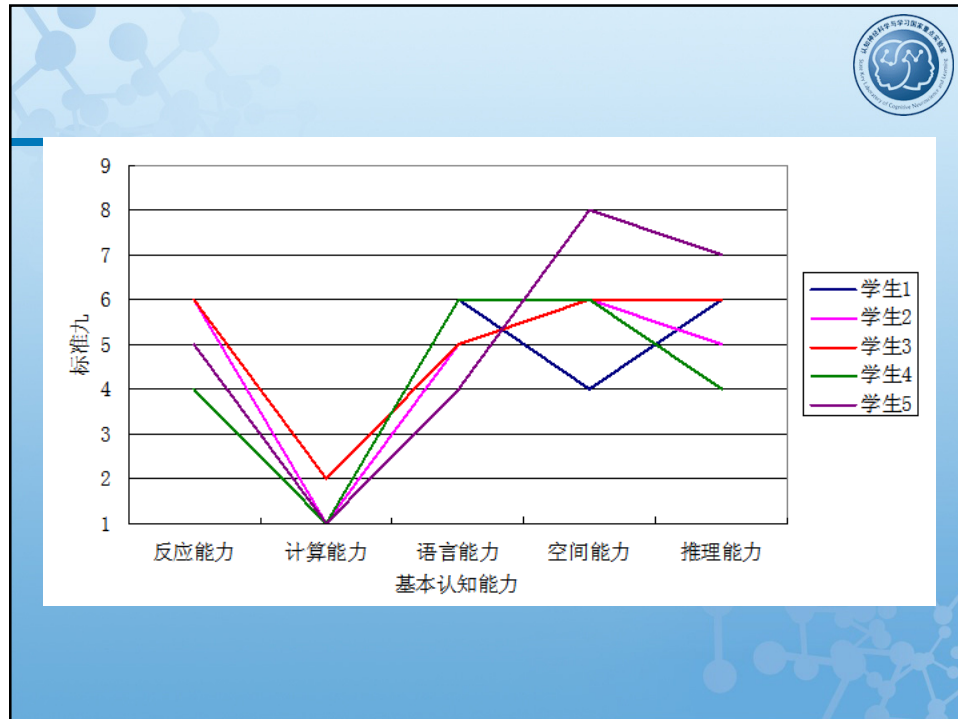
- 语言认知能力诊断
 - 以押韵任务和语句填空任务为例
- 数学认知能力诊断
 - 以数字大小比较和简单减法为例



以北京学生认知能力为常模，中国某地区认知能力测验结果

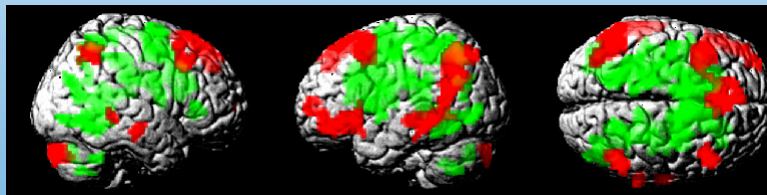
学校、年级	选择反应时	减法	词语理解	三维心理旋转	推理
xx小学三一班	5.39	4.07	4.00	5.18	4.16
xx小学三一班	5.82	4.42	4.66	4.94	4.22
xx小学三二班	5.77	3.85	3.25	4.88	4.31
xx小学四二班	5.30	3.33	3.63	4.95	2.96
xx小学四六班	5.17	4.13	4.35	4.67	4.08
总平均分	5.49	3.96	3.98	4.92	3.95






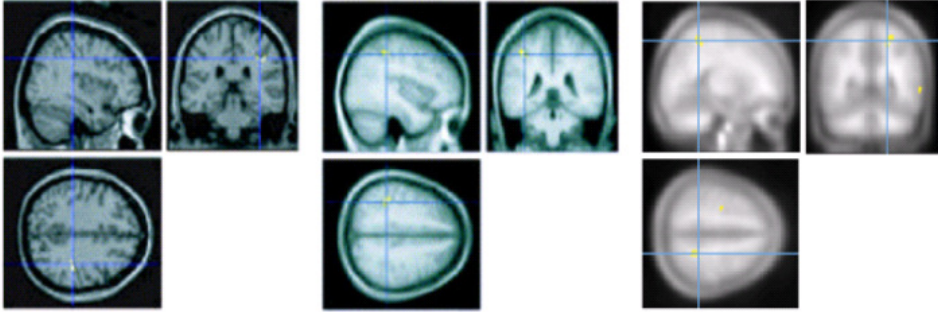
3. 数学学习困难的诊断

- 方法之三：脑成像诊断






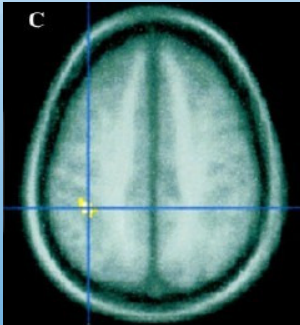
特纳综合症 (43, -30, 37) 早熟 (-39, -39, 45) 计算障碍 (22, -45, 55)



计算障碍儿童在右侧顶内沟的灰质显著少于控制组
(Rotzer et al., 2008)

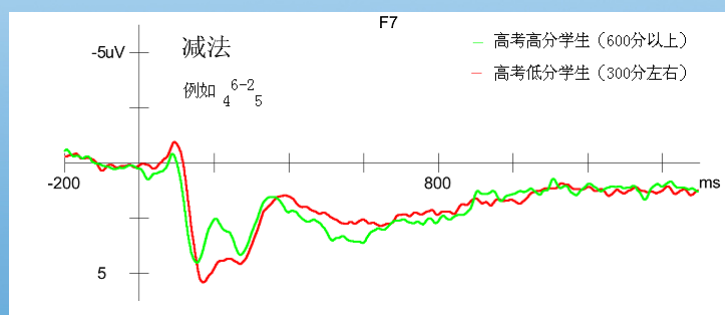


- Isaacs et al (2001)发现患有计算障碍的青少年左侧顶内沟也存在异常





- 最近我们比较了北大学生和高考落榜生在数学认知和语言认知上的差异
- 这种差异也将是数学学习困难和语言学习困难的脑成像诊断的基础



4. 数学学习困难的干预



- 方法之一：认知干预
 - 基本认知能力干预
 - 学业认知能力干预
 - 语言认知能力干预
 - 数学认知能力干预



- 方法之一：认知干预
 - 基本认知能力干预
 - 工作记忆容量
 - 执行功能
 - 空间能力
 - 注意力
 - 记忆力
 - 知觉能力训练



- 以视知觉能力训练为例

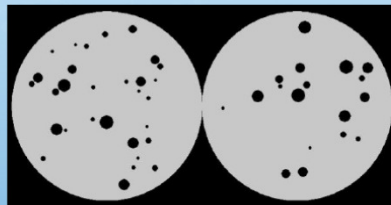


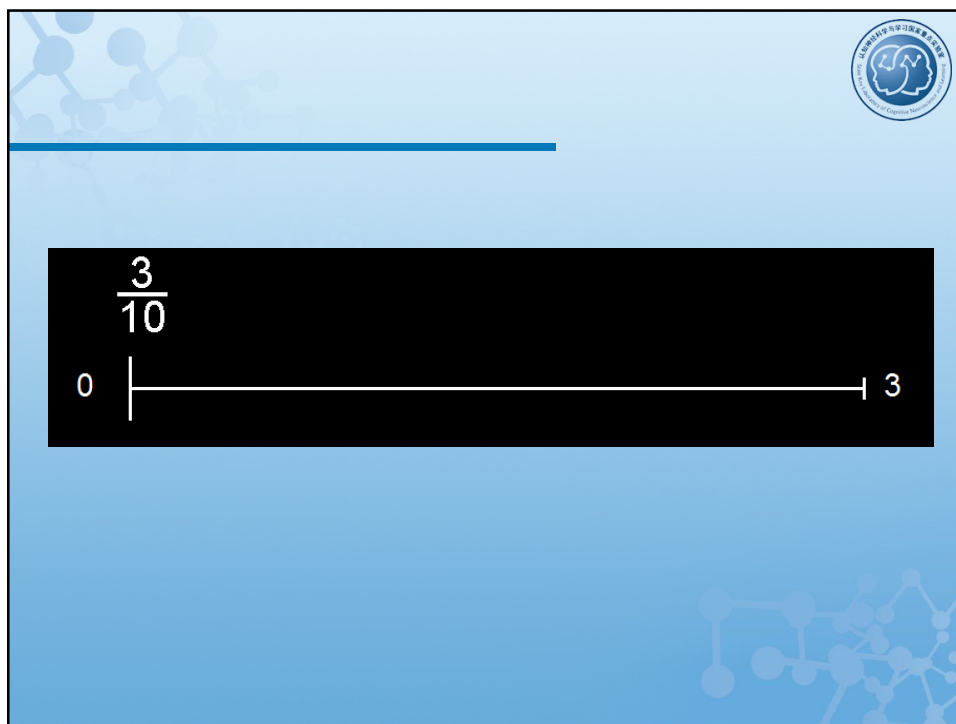
Table 3: Rotated component matrix for the 10 tests.

	Component		
	1	2	3
Figure matching	.770	.020	.152
Numerosity comparison	.755	-.181	.140
Sentence completion	.643	.249	.053
Arithmetic test	.623	.371	.112
Backward verbal working memory	.612	.387	-.013
Word rhyming	.549	.433	.116
Forward verbal working memory	.249	.628	-.078
Visual tracing	.107	.623	.365
Choice reaction time	-.015	-.529	-.030
Raven Progress Matrices	.205	-.106	.769
Mental rotation	.047	.237	.724

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.

- 方法之一：认知干预
 - 学业认知能力干预
 - 以数感训练为例





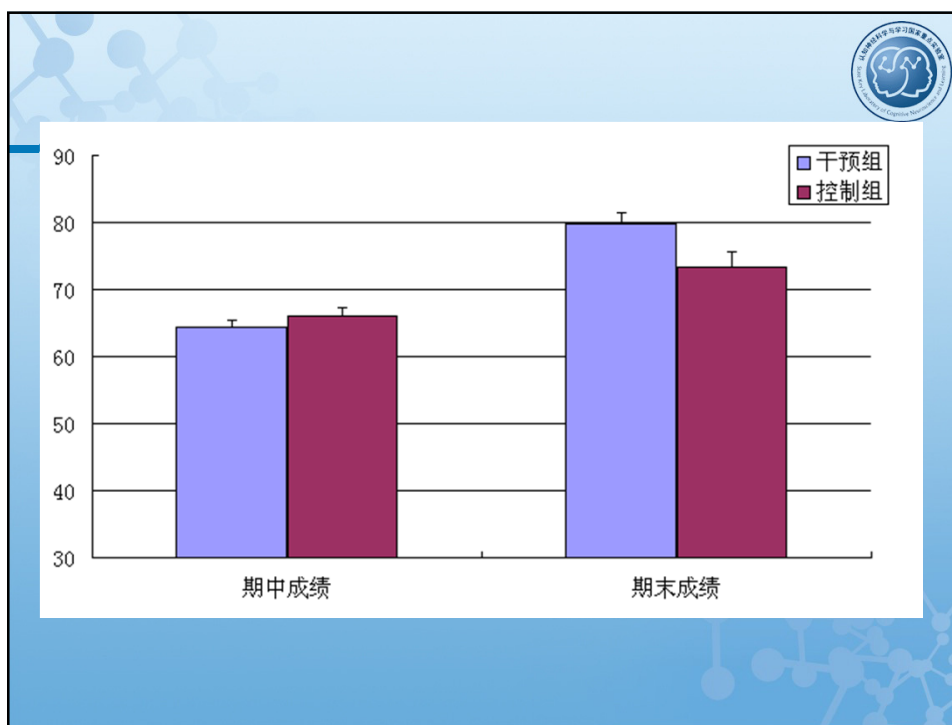
4. 数学学习困难的干预

- 方法之二：学业评估与干预
- www.jykc.net/exam

4. 数学学习困难的干预



- 关于学业评估与干预的一项实验研究
 - 四所学校数学期中考试成绩在班上后20%的共142名5年级学生参加我们的实验，其中一半学生在实验组，一半在控制组。
 - 结果：
 - 平均使用时间是59.8分钟，提高 10.6个百分位
 - 使用4小时以上有6个学生，提高 31.1个百分位
 - 使用5小时以上有3个学生，提高 47.5个百分位



4. 数学学习困难的干预



- 关于学业评估与干预的一项实验研究
 - 先有评估
 - 然后通过问题解决干预
 - 借助“在线学业评估与学习智能系统”

教育快车 在线学业评估与学习智能系统 - Windows Internet Explorer

http://www.jykc.net/exam/

用户名称: Maysie
supercc

登录 | 注册 | 加入收藏 | 设为首页

[首页](#)
[使用说明](#)
[定点练习](#)
[组卷练习](#)
[参加考试](#)
[笔记评论](#)
[我的记录](#)
[课程论坛](#)
[个人信息](#)
[退出系统](#)

系统注册导航
注册

欢迎使用
在线学业评估与学习智能系统

公告 (在线人数/总量: 1/22764)

- 重要公告将通过email发送给各位用户, 请各位用户登录后在“个人信息”中加上email地址; 如果不希望收到公告信息, 请删掉email地址。
- 系统登录可以使用“http://www.jykc.net/exam/”

新闻与进展

项目实验室(15分钟计算机智能化网上家庭作业方案)

系统简介
本系统将利用信息科学技术的优势, 在教育实践中充分转化认知与脑科学研究成果, 以促进学生学习科学、高效和愉快地学习; 不同学科的学习在遵循一般学习规律的同时也有自己的特点。例如, 在英语学习中, 强调在英语交流中学习英语; 对于物理、化学等自然科学学科, 强调从实验经验当中学习, 对于数学的学习, 知识的理解则是至关重要的。

联系方式
Email地址: jykc123@163.com
QQ号码: 1586971849

http://www.jykc.net/exam/login/home.jsp

4. 数学学习困难的干预

■ 关于学业评估与干预的一项实验研究

我的教育快车

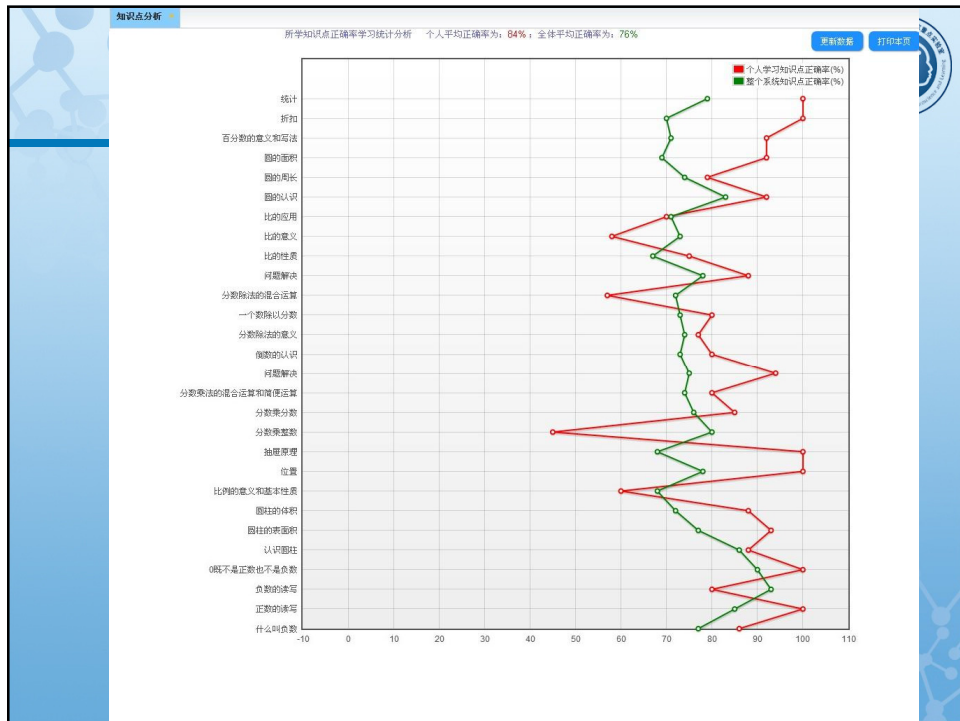
▶ 课堂教学 公共模型

▶ 作业管理 当前课程: 六年级数学 当前班级: ██████████

▶ 测验管理 总体显示方式: 本课程的掌握程度 (根据学习目标) 掌握情况显示方式: 颜色显示 达标阈值: 80%

▼ 学习分析

知识点	记忆	理解	应用	综合	思考	平均	重要程度
负数							
负数的意义与读写							
什么叫负数	100%	100%	100%	100%	100%	100%	45
正数的读写	100%	100%	0%	0%	0%	0%	15
负数的读写	0%	0%	0%	0%	0%	0%	39
0既不是正数也不是负数	0%	0%	0%	0%	0%	0%	39
在数轴上表示数的大小							
数轴的定义	0%	0%	0%	0%	0%	0%	27
数轴的顺序	0%	0%	0%	0%	0%	0%	13
数轴上的正数和负数	0%	0%	0%	0%	0%	0%	27
负数的大小比较	0%	0%	0%	0%	0%	0%	11
圆柱与圆锥							



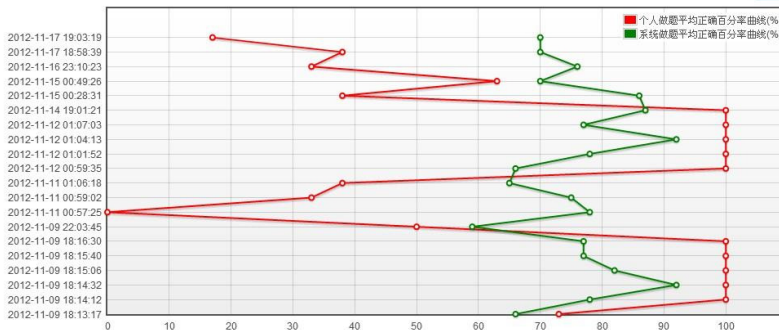
4. 数学学习困难的干预



定点练习分析

个人学习曲线统计分析 个人平均正确率为: 69%; 全体平均正确率为: 76%

更新数据 打印本页



学生模型 (可以选择切换显示模式, 以不同角度显示学生薄弱知识点)

当前显示方式: [自己的掌握程度 (根据学习目标)] 掌握情况显示方式: [颜色显示] 达标程度: [80%]

知识点	记忆	理解	应用	综合	思维	平均	重要程度
四则运算							
四则混合运算的顺序	100%	100%	100%	100%	100%	100%	100
四则混合运算中零的处理	100%	100%	75%	100%	100%	100%	90
四则混合运算的综合应用	75%	75%	75%	100%	100%	87%	90
位置 and 方向							
判断物体的方位	100%	100%	100%	100%	100%	100%	100
判断物体的角度	100%	100%	100%	100%	100%	100%	100
判断物体的距离	100%	100%	100%	100%	100%	100%	100
运算定律与简便计算							
加法定律							
加法交换律	100%	100%	100%	100%	100%	100%	100

学生模型 (可以选择切换显示模式, 以不同角度显示学生薄弱知识点)

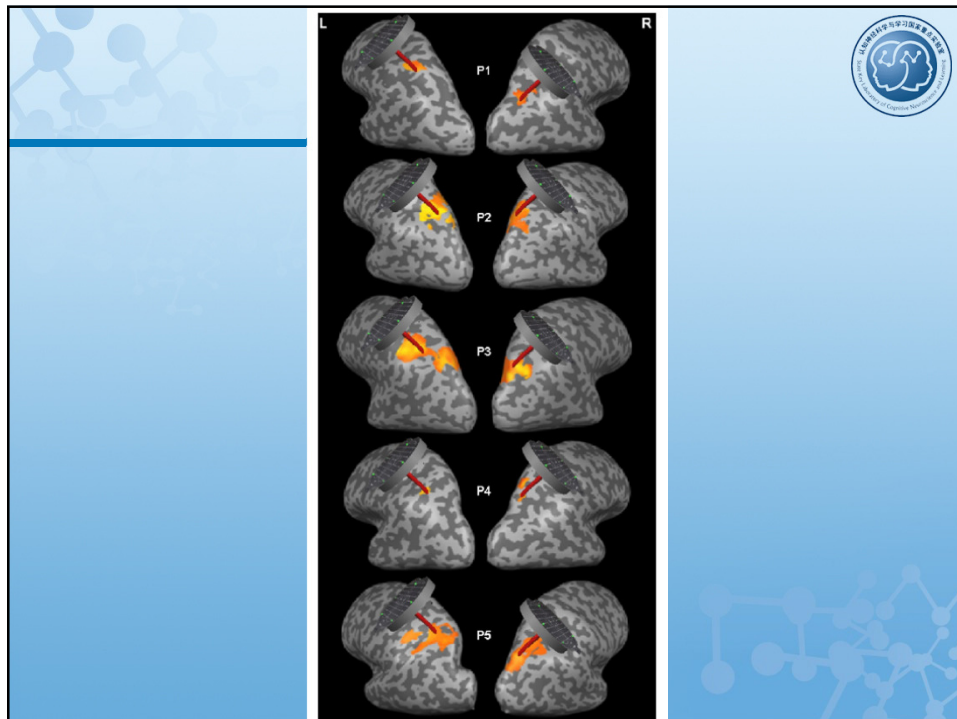
当前显示方式: [自己的掌握程度 (根据学习目标)] 掌握情况显示方式: [颜色显示] 达标程度: [80%]


知识点	记忆	理解	应用	综合	思维	平均	重要程度
四则运算							
四则混合运算的顺序	75%	75%	100%	100%	100%	100%	100
四则混合运算中零的处理	75%	75%	75%	100%	100%	100%	90
四则混合运算的综合应用	75%	75%	75%	100%	100%	100%	90
位置 and 方向							
判断物体的方位	100%	75%	75%	75%	75%	100%	100
判断物体的角度	75%	75%	75%	75%	75%	100%	100
判断物体的距离	75%	75%	100%	75%	75%	100%	100
运算定律与简便计算							
加法定律							
加法交换律	75%	75%	75%	75%	75%	100%	100

4. 数学学习困难的干预




- 方法之三：神经刺激与成像干预
 - 正在研究与开发当中…





5. 讨论与总结

- 数学学习困难的诊断
- 数学学习困难的干预



谢谢!