脑科学视野下的数学学习困难诊断与干预

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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

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- 1. 基础研究是否有助于教育
- 2. 什么是数学学习困难
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- 4. 数学学习困难的干预
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  - **学业评估与干预**
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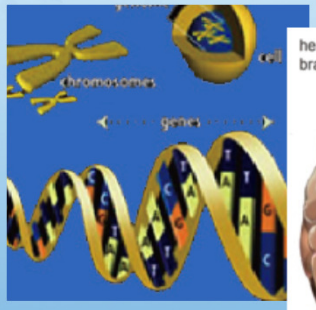
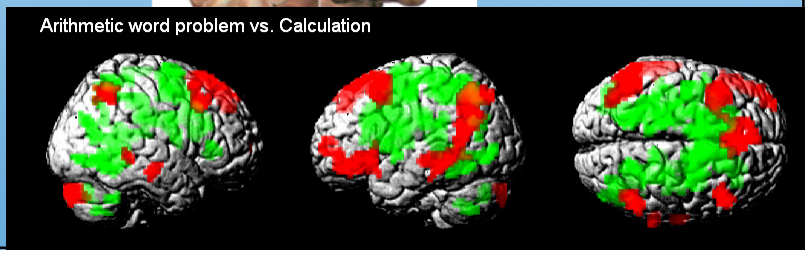
- **5. 讨论与总结**

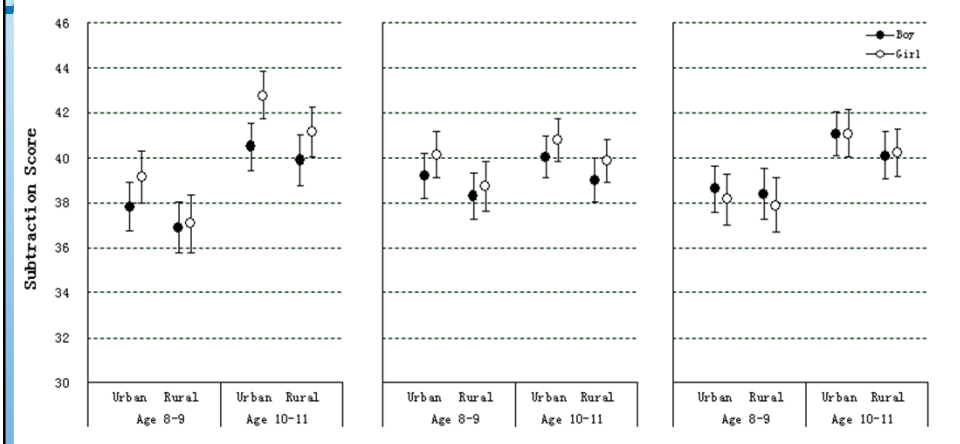
1. 基础研究是否有助于教育





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
ScienceDaily
Your source for the latest research news
Science News
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)
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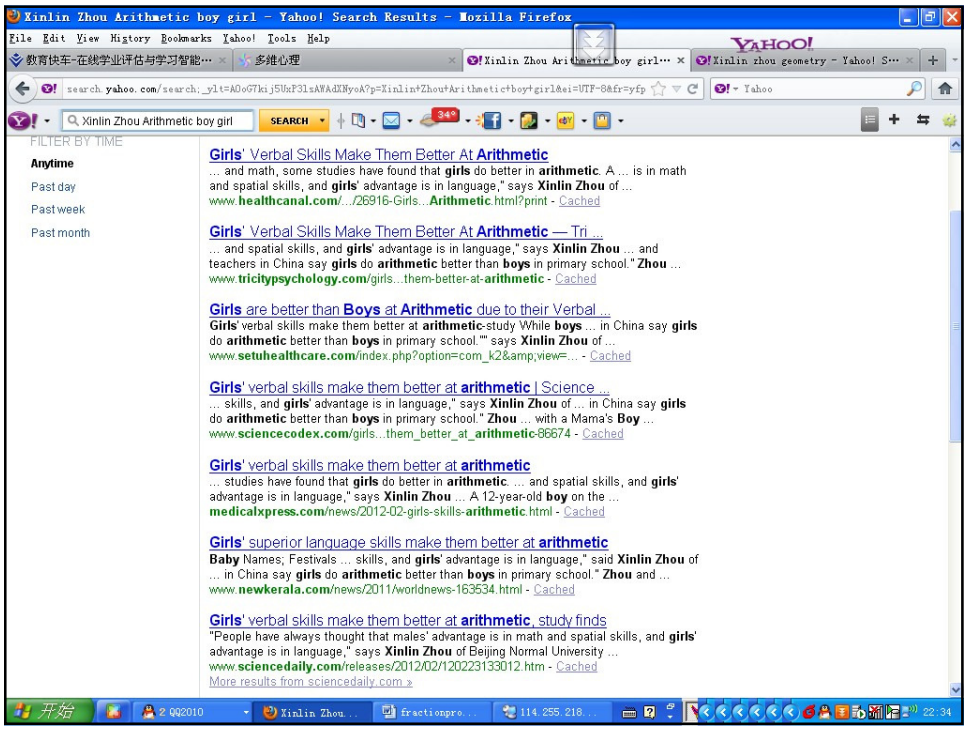
Xinlin Zhou Arithmetic boy girl - Yahoo! Search Results - Mozilla Firefox
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Girls' verbal skills make them better at arithmetic
Girls' superior language skills make them better at arithmetic
Girls' verbal skills make them better at arithmetic, study finds


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 arithmeti
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
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
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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 ...
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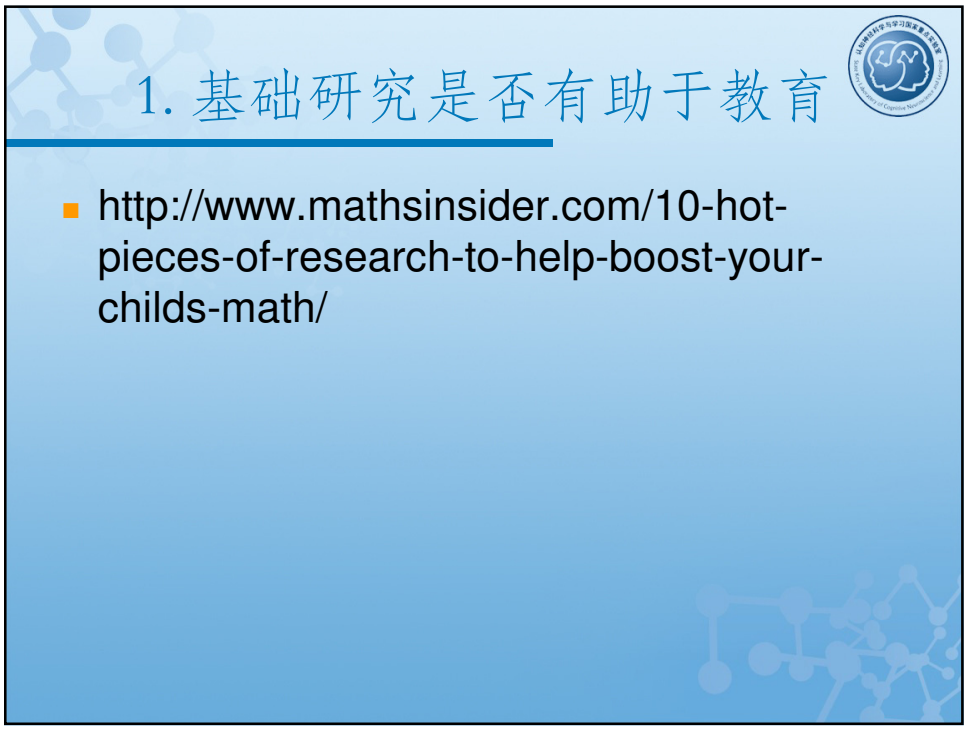

1. 基础研究是否有助于教育
http://www.mathsinsider.com/10-hot-pieces-of-research-to-help-boost-your-childs-math/


10 Hot Pieces of Research to Help Boost Your Child's Math
Posted by Caroline Mukisa in Motivation, Resources
1
Share
This is a guest post by Neltje M from MyCriminalJusticeCareers.com.
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.


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

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

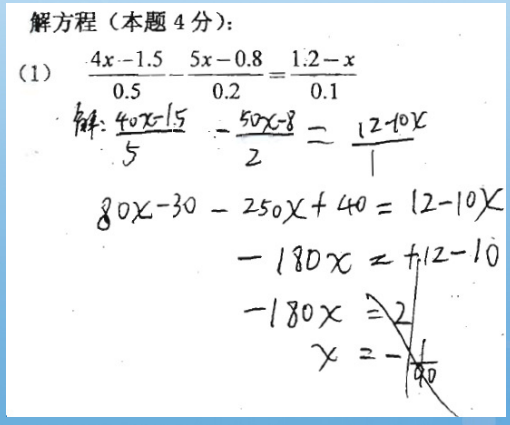
- **方法之一：学业诊断**
  - 教师自编测验
  - 学区统一测验
  - 标准化测验
    - 我们正在开发基本数学概念掌握水平测验，这一测验适用于3岁以上所有人群

Study	Criterion	Classification test	Label
Hanich et al. 2001)	35th percentile	Mathematics Composites from the Woodcock–Johnson Psycho-Educational Battery-Revised	Mathematics difficulties
Jordan et al. (2002)	35th percentile	Mathematics Composites from the Woodcock–Johnson Psycho-Educational Battery-Revised	Mathematics difficulties
Jordan et al. (2003)	35th percentile	Mathematics Composites from the Woodcock–Johnson Psycho-Educational Battery-Revised	Mathematics difficulties
Geary et al. (2000)	35th percentile	Mathematics Reasoning subtest of the Wechsler Individual Achievement Test	Mathematics disabilities
Geary et al. (1999)	30th percentile	Mathematics Reasoning subtest of the Wechsler Individual Achievement Test	Mathematics disabilities
Siegel & Ryan (1989)	25th percentile	Arithmetic subtests of the Wide Range Achievement Test	Arithmetic disabilities
Koontz & Berch (1996)	25th percentile	Iowa Test of Basic Skills	Arithmetic learning disabilities
McLean & Hitch (1999)	25th percentile	Graded Arithmetic-Mathematics Test	Specific arithmetic learning difficulties
Rousselle & Noël (2006)	15th percentile	A numerical and arithmetical tests battery	Mathematical disabilities
Geary et al. (2007)	15th percentile 23th < score < 39th	Numerical Operations subtest of Wechsler Achievement battery	Mathematical learning disabilities Low achieving children
Geary et al. (2008)	11th percentile 11th < score < 25th	Numerical Operations subtest of Wechsler Achievement battery	Mathematical learning disabilities Low achieving children
Bull & Johnston (1997)	Below the mean score	Group Mathematics Test	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

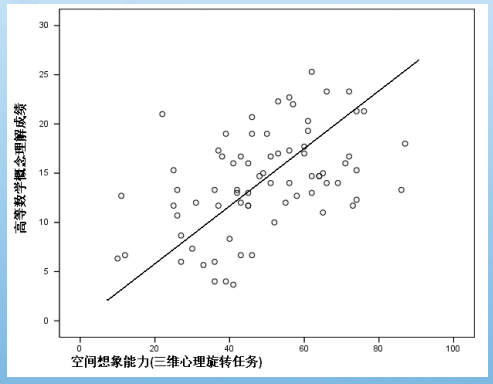
3. 数学学习困难的诊断

- **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**

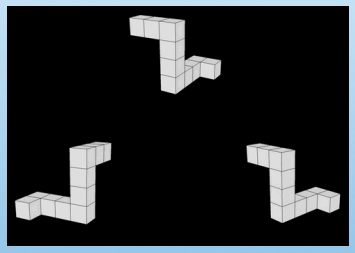


- 认知诊断的必要性：与认知能力有关
  - 心理旋转能力与高等数学成绩的关系



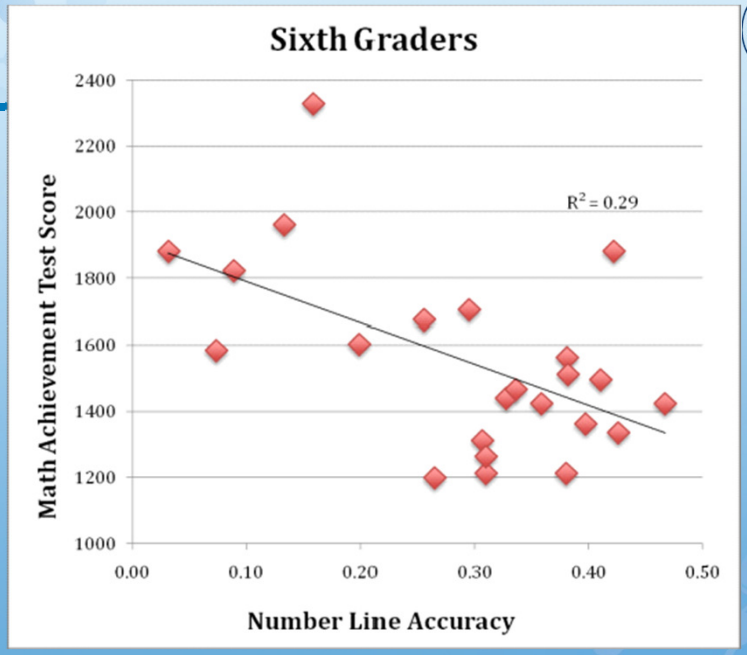
空间加工能力越强，数学成绩越好

(Wei et al, 2011）



样本空间（x,y）x≥0, y≥0, x+y≤6}
下面哪个集合A代表随机事件：（
）
1，A={（x,y）|x≥0,x≤6}
2，A={（x,y）|x≥0,y≤6}
3，A={（x,y）|x≥0,y≥0,x+y≤1}
4，A={（x,y）|x≥0,y≥0,x+y≤10}

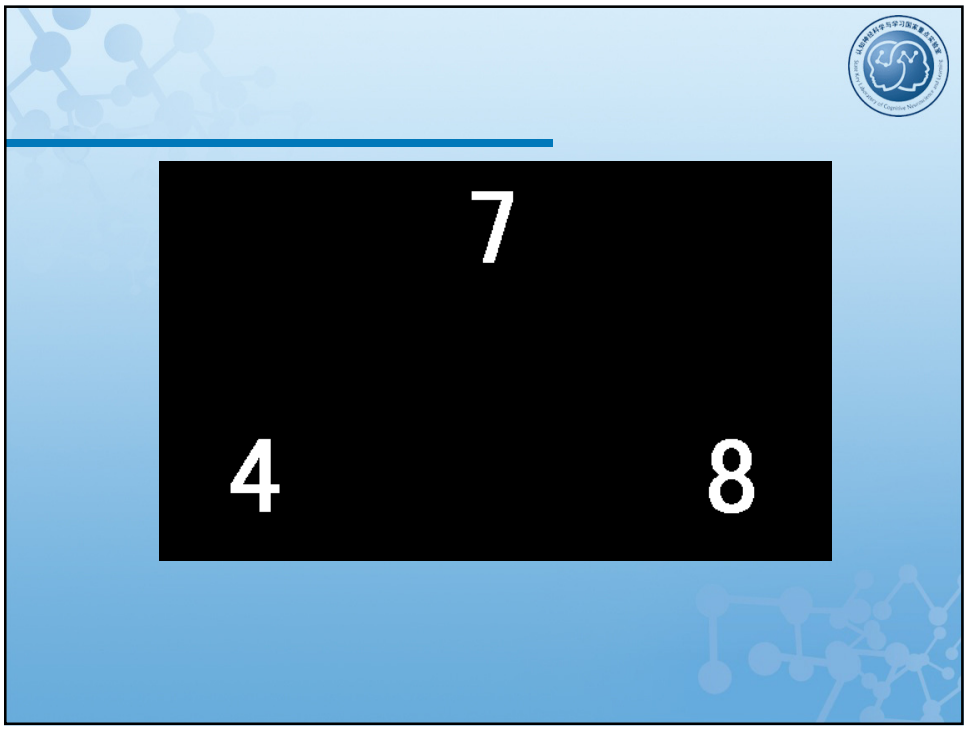
- 分数数轴加工能力与6、8年级学生数学成绩有高相关
- 见数据表



- **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

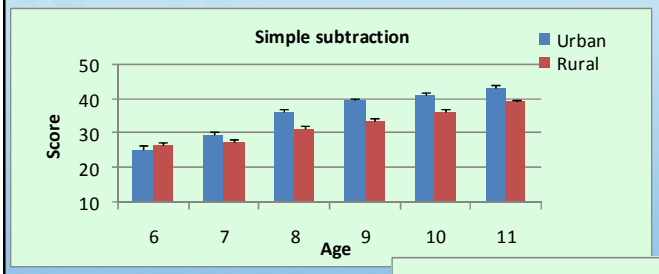

这个瓶子里装的是（　）水。
泉　全
答案在左边，按左边键
答案在右边，按右边键

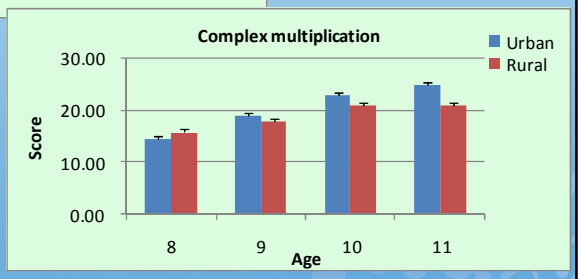

7
4
8

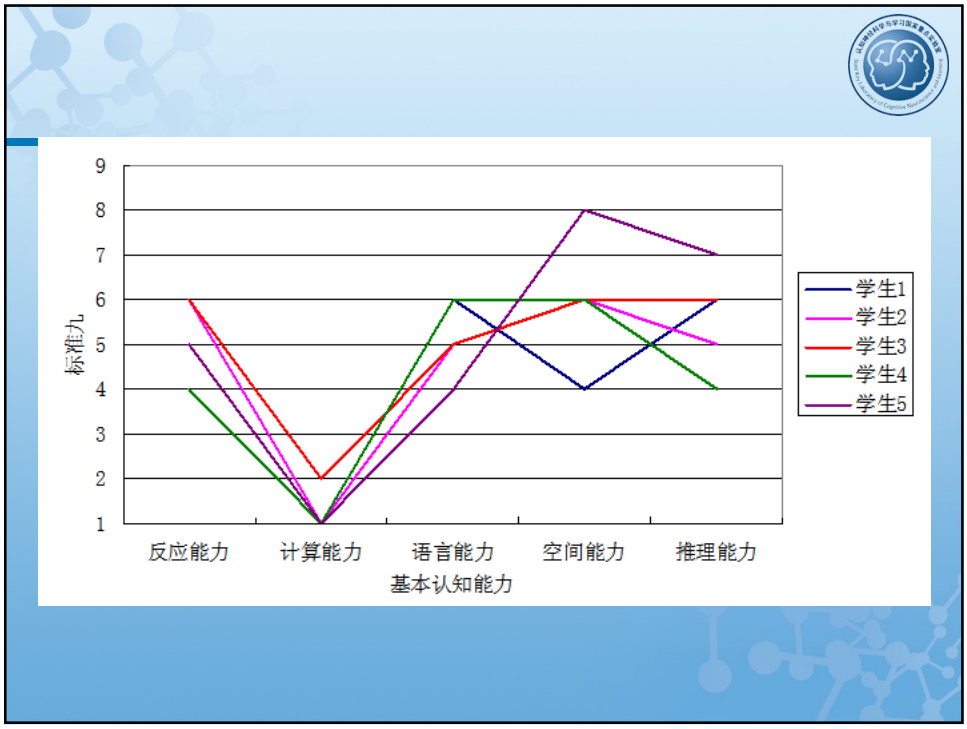
以北京学生认知能力为常模，中国某地区认知能力测验结果

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

北京城区学生与远郊区学生的认知能力差异

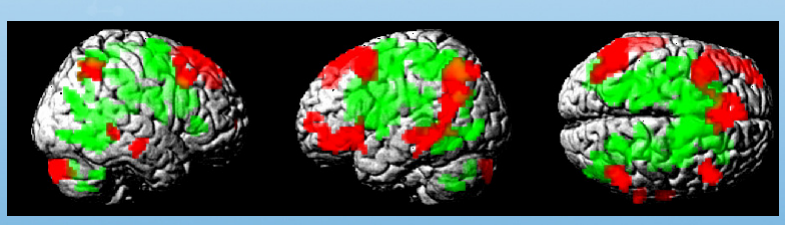


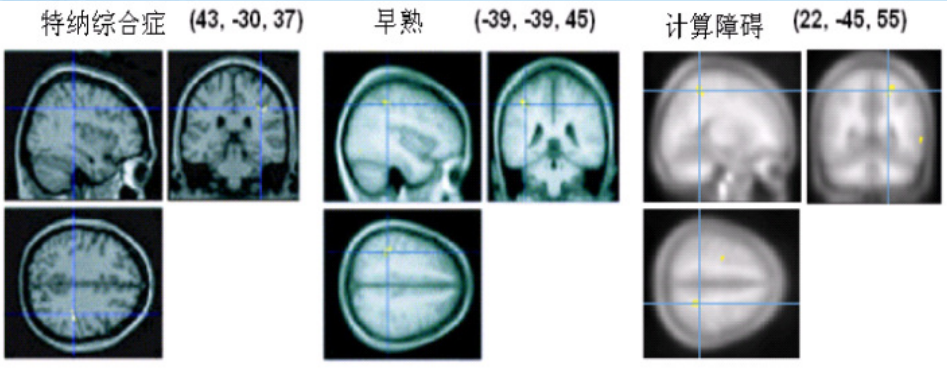




3. 数学学习困难的诊断

- 方法之三：脑成像诊断

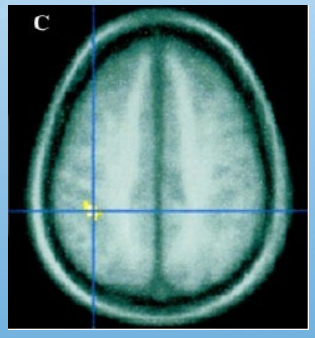




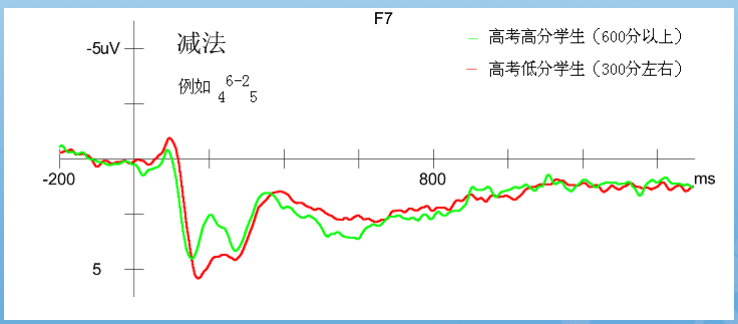
计算障碍儿童在右侧顶内沟的灰质显著少于控制组

(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

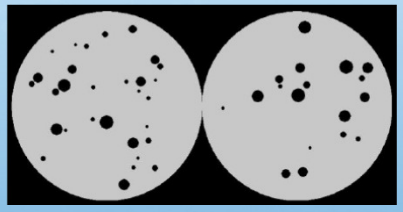


Table 3: Rotated component matrix for the 10 tests.

	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
Forware 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.

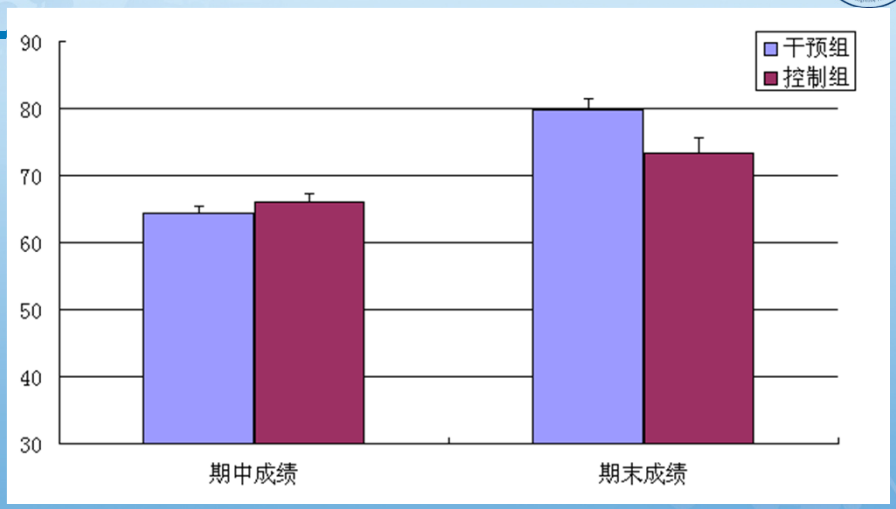
- 方法之一：认知干预
  - **学业认知能力干预**
    - **以数感训练为例**

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

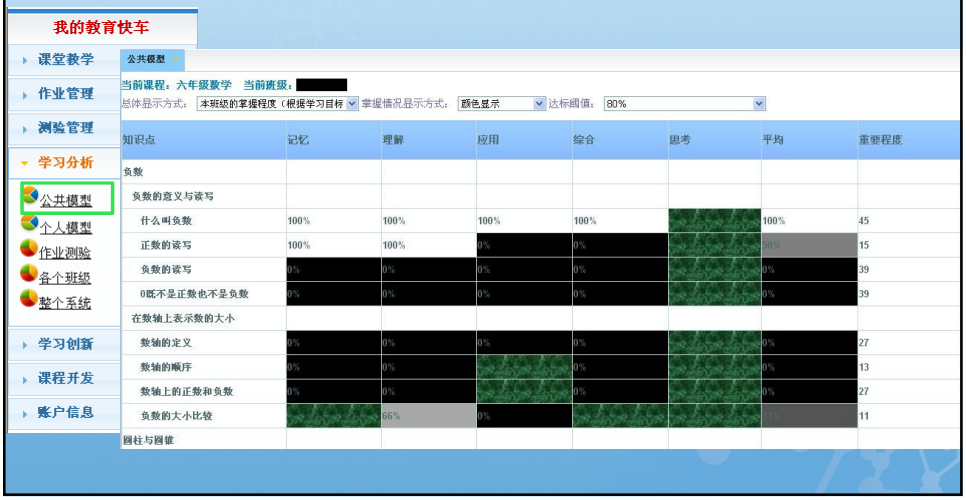


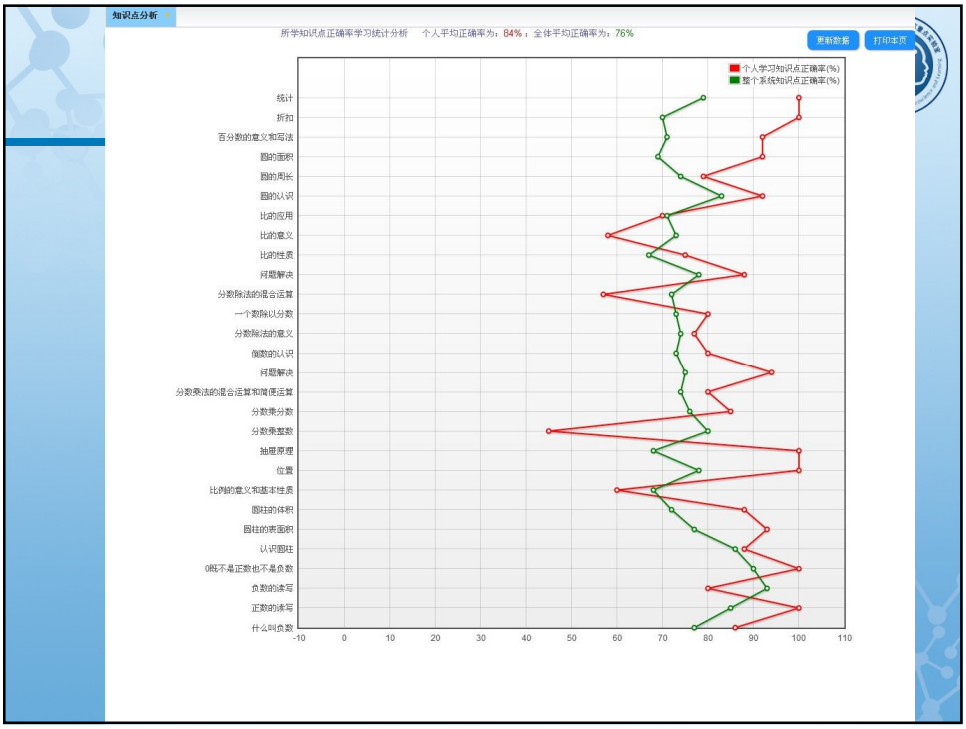
4. 数学学习困难的干预

- 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”

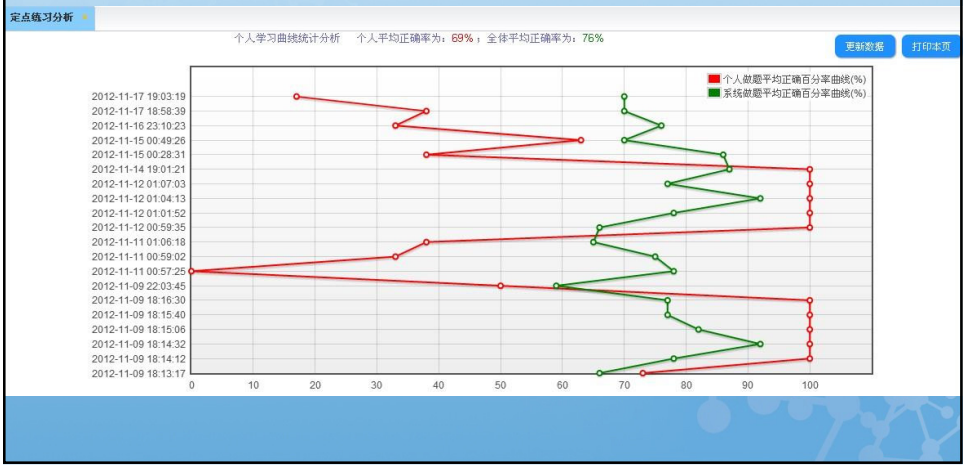
4. 数学学习困难的干预

- 关于学业评估与干预的一项实验研究





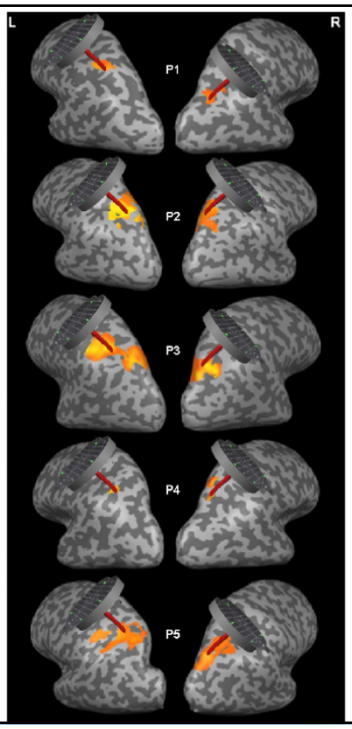
4. 数学学习困难的干预


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
个人做题平均正确百分率曲线(%)
系统做题平均正确百分率曲线(%)
2012-11-17 19:03:19
2012-11-17 18:58:39
2012-11-16 23:10:23
2012-11-15 00:49:26
2012-11-15 00:28:31
2012-11-14 19:01:21
2012-11-12 01:07:03
2012-11-12 01:04:13
2012-11-12 01:01:52
2012-11-12 00:59:35
2012-11-11 01:06:18
2012-11-11 00:59:02
2012-11-11 00:57:25
2012-11-09 22:03:45
2012-11-09 18:16:30
2012-11-09 18:15:40
2012-11-09 18:15:06
2012-11-09 18:14:32
2012-11-09 18:14:12
2012-11-09 18:13:17
0
10
20
30
40
50
60
70
80
90
100


学生模型（可以选择切换显示模式，以不同角度显示改学生优弱势地方）
总体显示方式：
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
达标阈值：
80%
知识点
记忆
理解
应用
综合
思考
平均
重要程度
四则运算
四则混合运算的顺序
四则混合运算中零的处理
四则混合运算的综合应用
位置和方向
判断物体的方位
判断物体的角度
判断物体的距离
运算定律与简便计算
加法定律
加法交换律
确定
关闭窗口

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！