Upgrading to Math Cognition 2.0: Where We Need to Go

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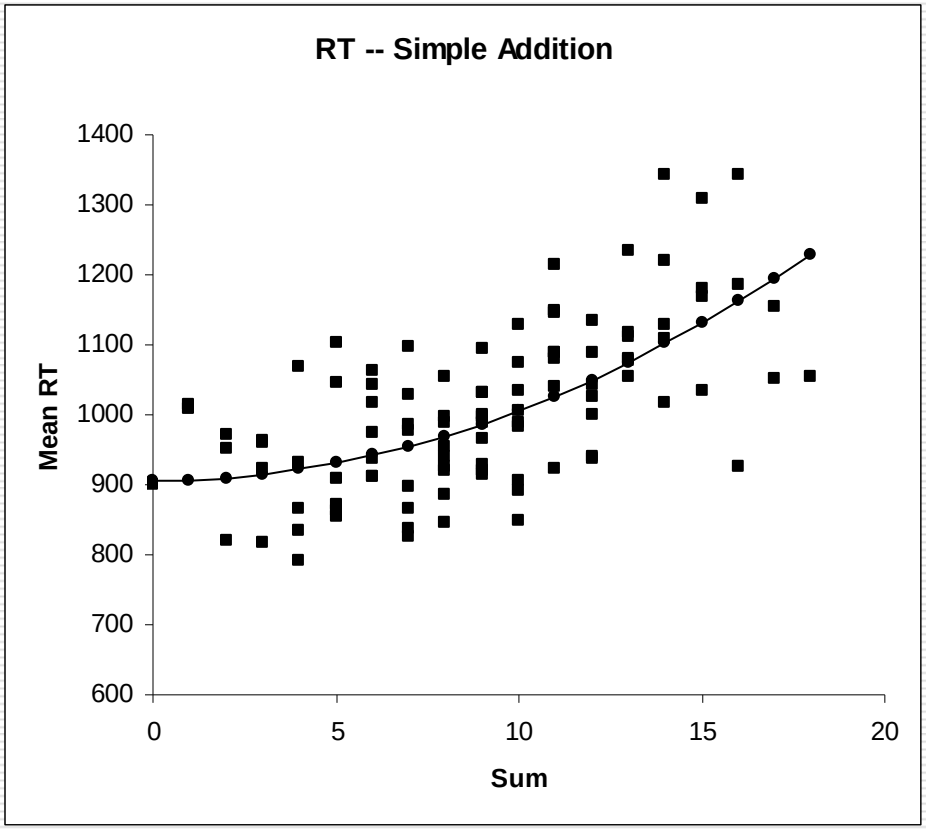
3 Basic Issues

- Math effects – learning and performance up to young adulthood
- Role of Working Memory in Math
- Math Anxiety – cognitive impact

Two Themes

- Math Cognition mired in methodology of 1980s – RTs, errors, verbal reports
- Missing important connections to reality – American kids are failing at math (e.g., recent news on 8th grade algebra)

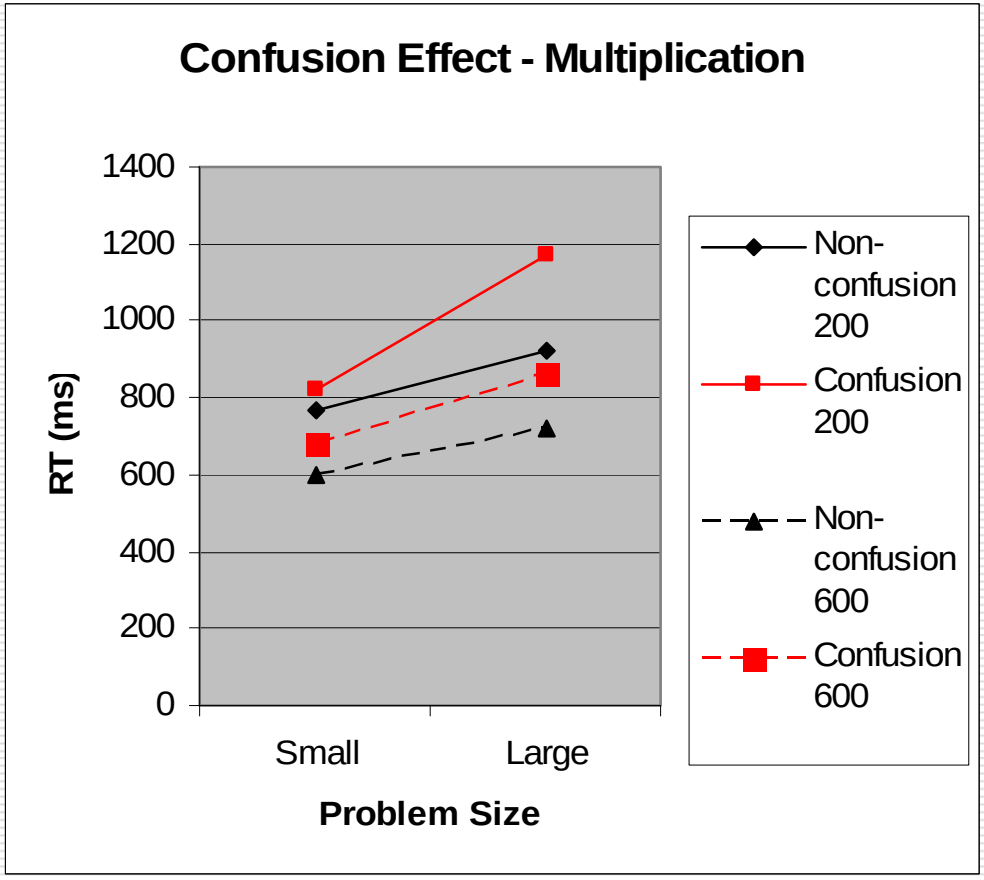
Ashcraft & Battaglia (1978)– simple addition facts



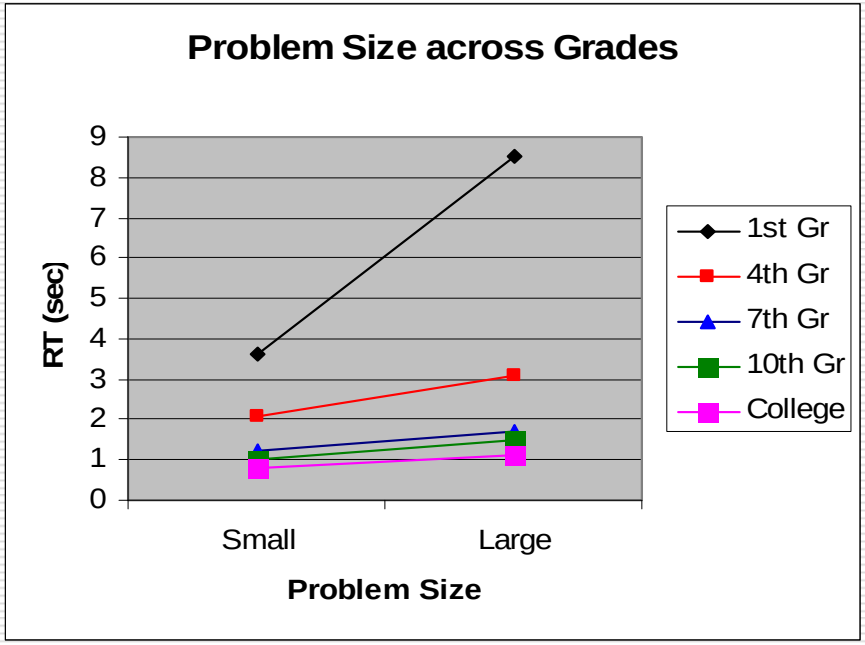
Three salient questions

- If we remember addition answers, then what is the memory representation like?
- When do we switch from counting to memory?
- AND – what causes the problem size effect? Why does it persist with adults?

Confusion and Priming Effects, Stazyk, Ashcraft, & Hamann (1982)



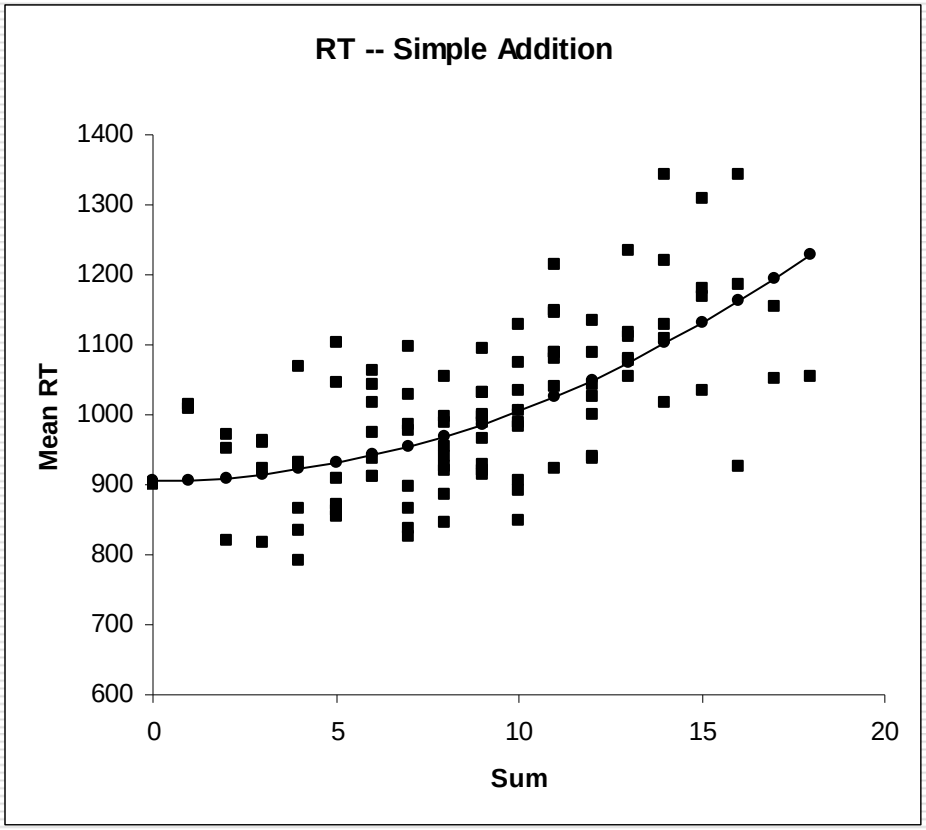
Age Effects – simple addition (Ashcraft, Fierman, Hamann, etc. 1982, 1985)



But what causes the problem size effect?

- Is it strength in memory?
- Is it history of errors?
- Is it reliance on procedures or strategies?
- Are these interrelated?
- How do we find out?

Return to scatterplot



Prescription – seek a better method

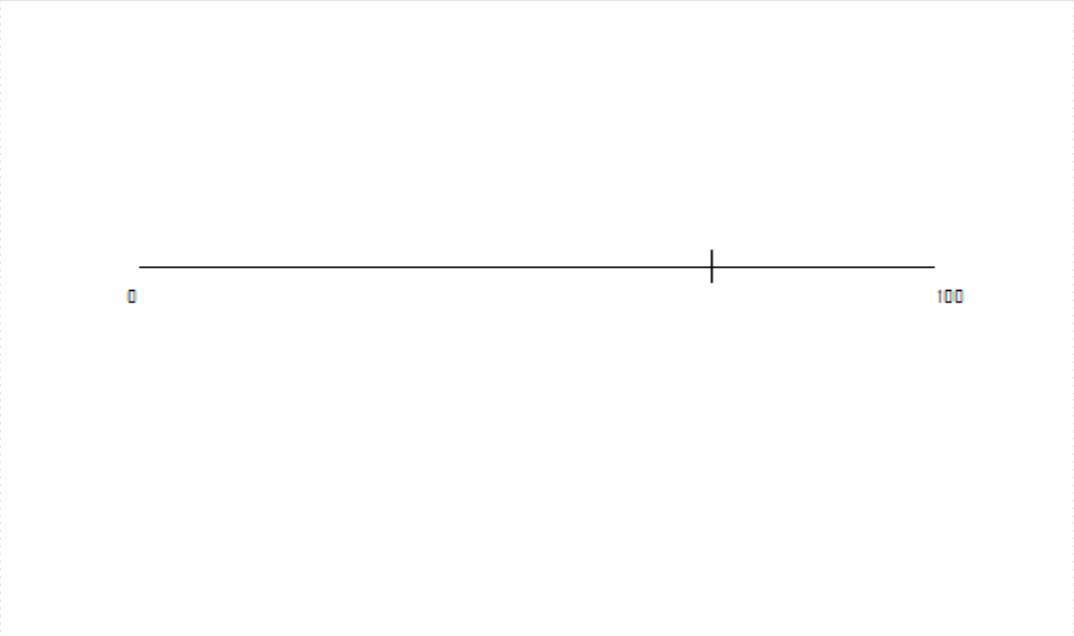
- Take a detour to the topic of number line estimation, a la Siegler's important work with children

Simple number estimation task

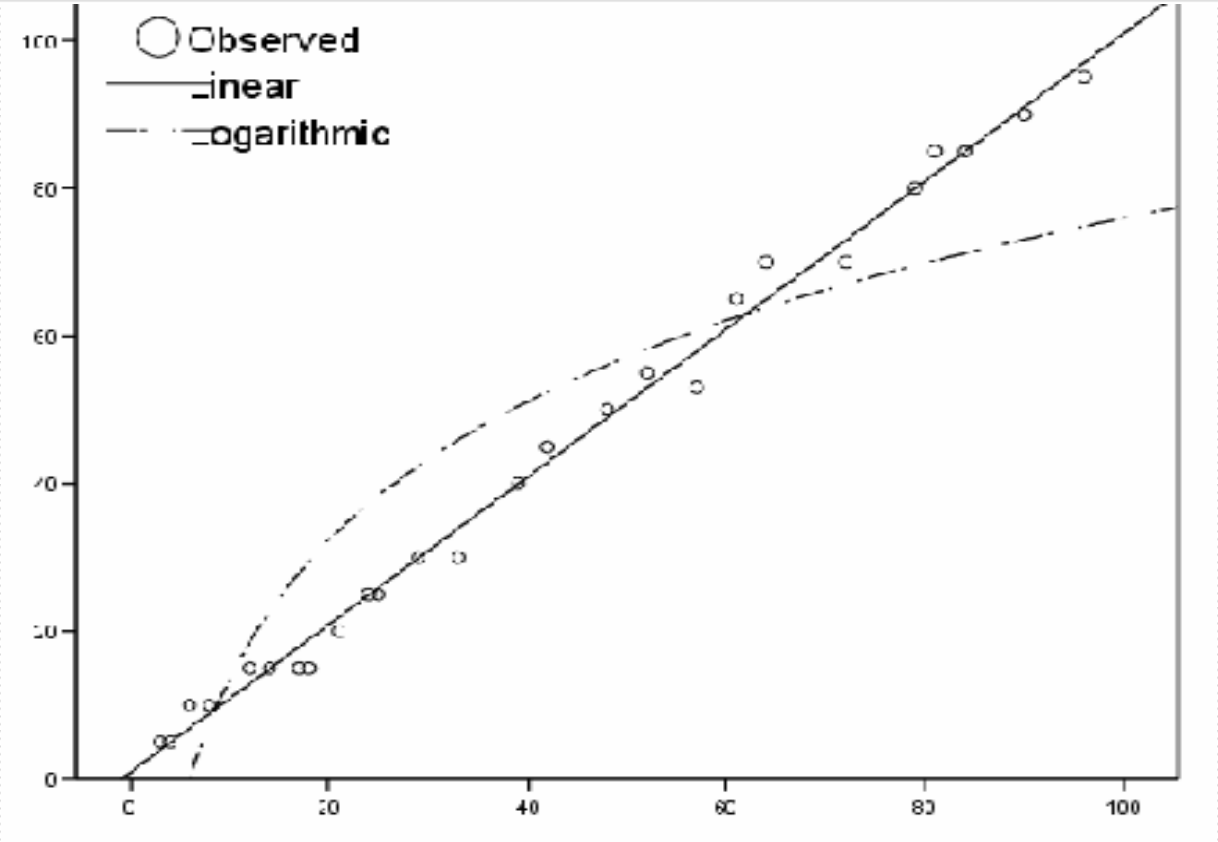
- Lines labeled 0-100 or 0-1000
- Position to number – hatch mark
- Number to position – give number, child marks position
- Measure deviations from correct

Number line

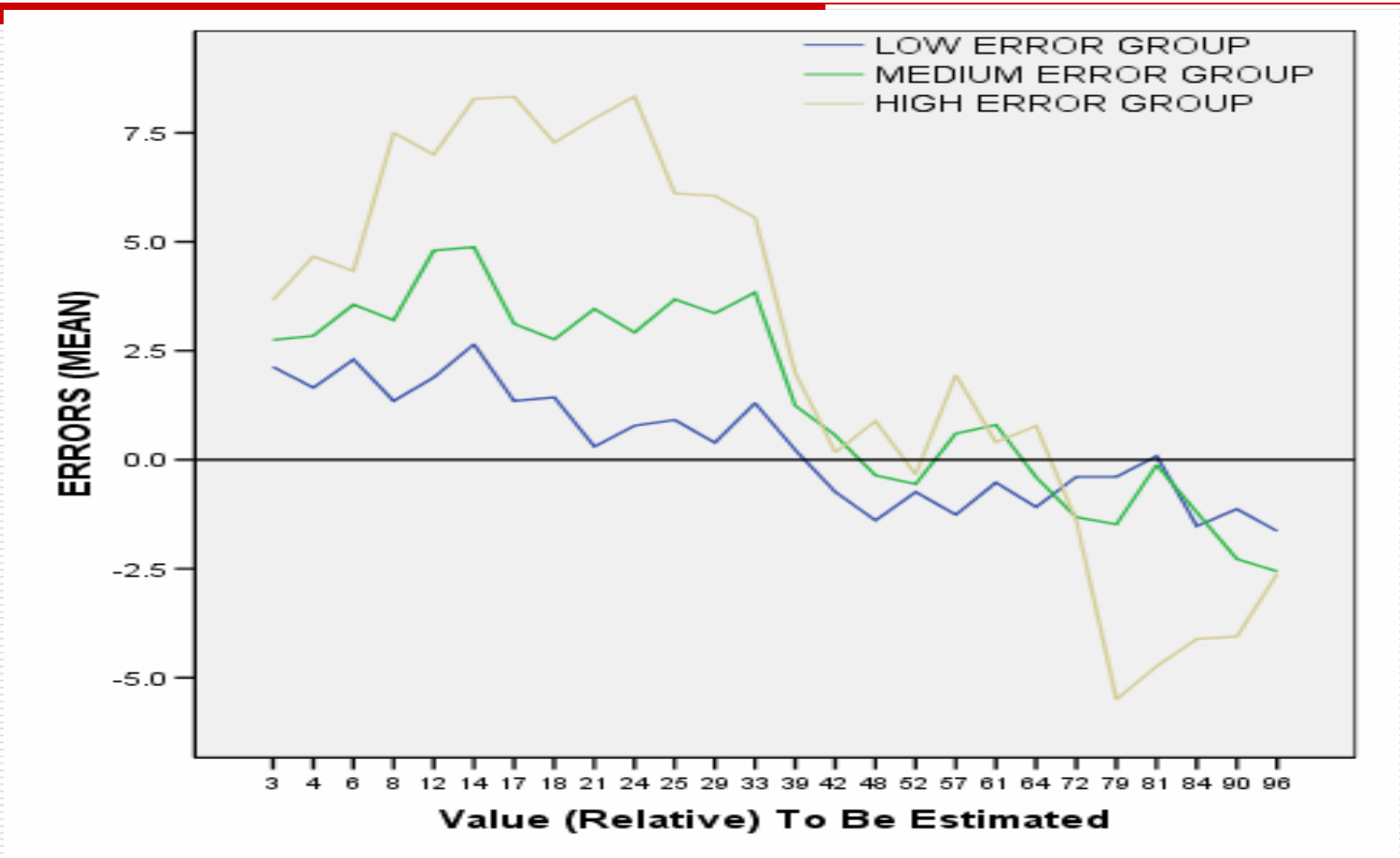
Position to number



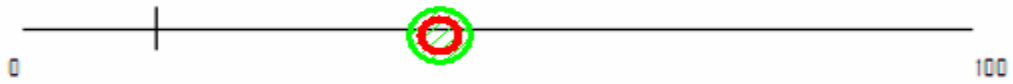
Linear/Log plot



Adults' errors (Ashcraft et al., in prep)



video



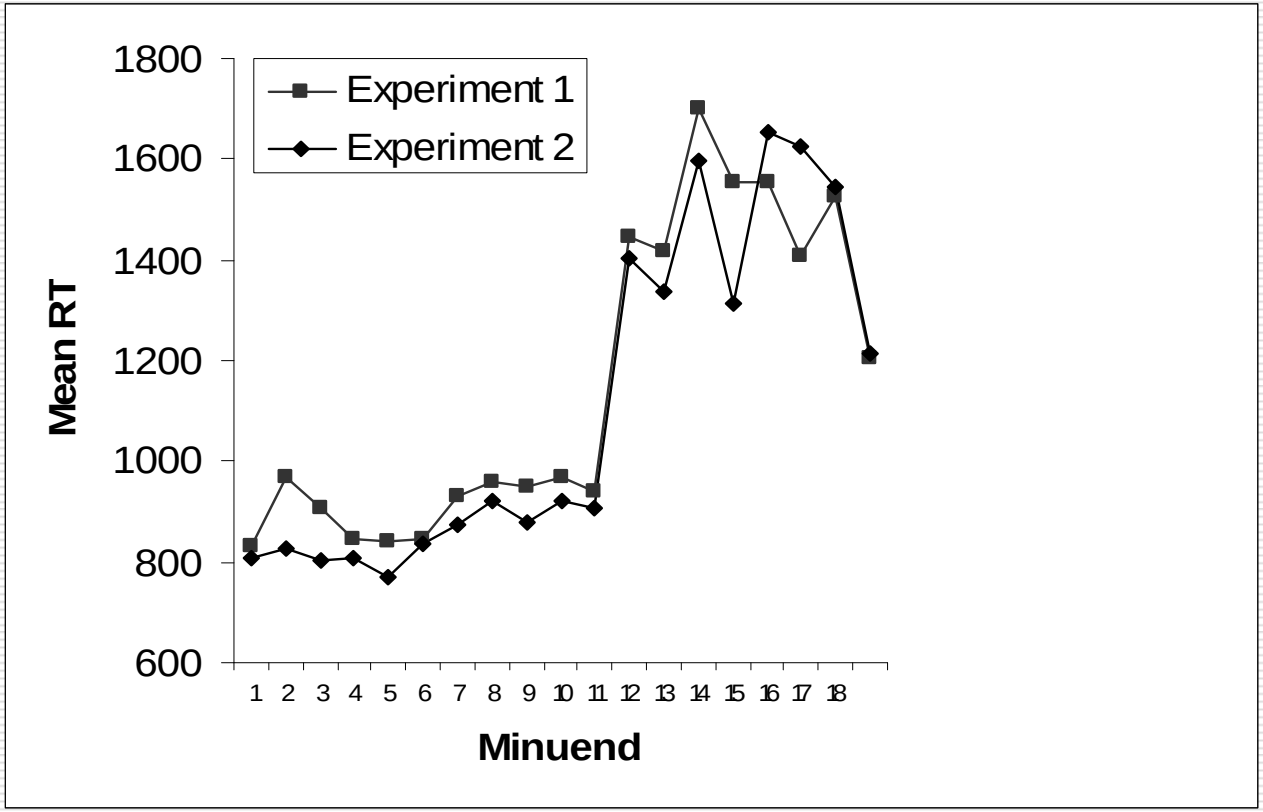
Take eye-tracking into problem size effect

- Are there gaze patterns related to strategy use?
- Are gaze patterns similar across operations?
- Will gaze patterns reveal cognitive operations in higher levels of math difficulty, e.g., algebra?

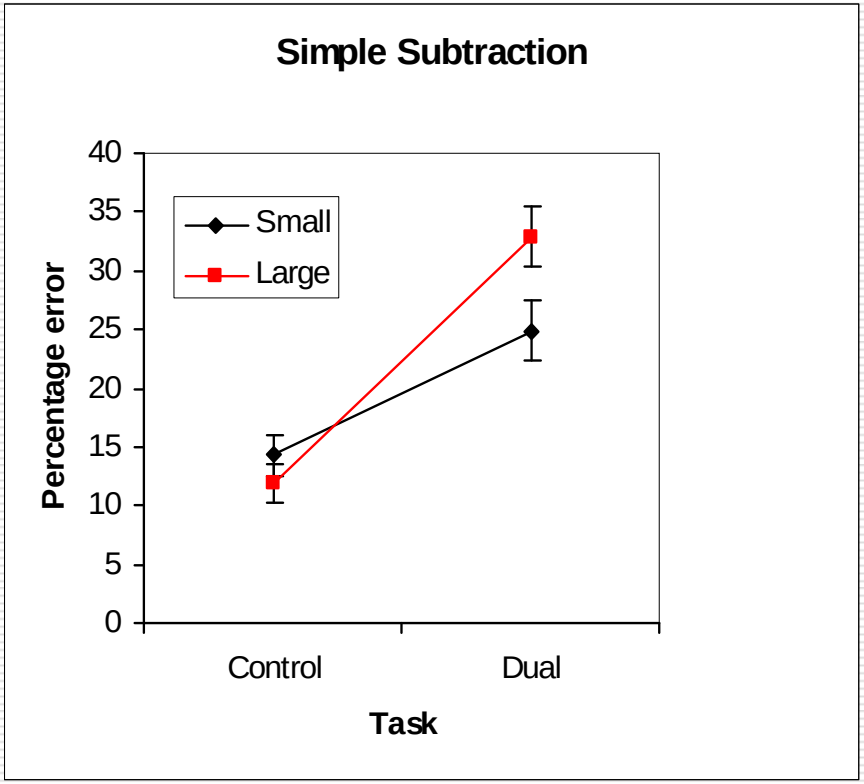
Role of Working Memory in Math

- Working memory implicated in use of strategies, procedural processing
- (in other words, whenever processing involves more than straightforward memory retrieval)
- Dual task performance, independent groups assessed on WM span

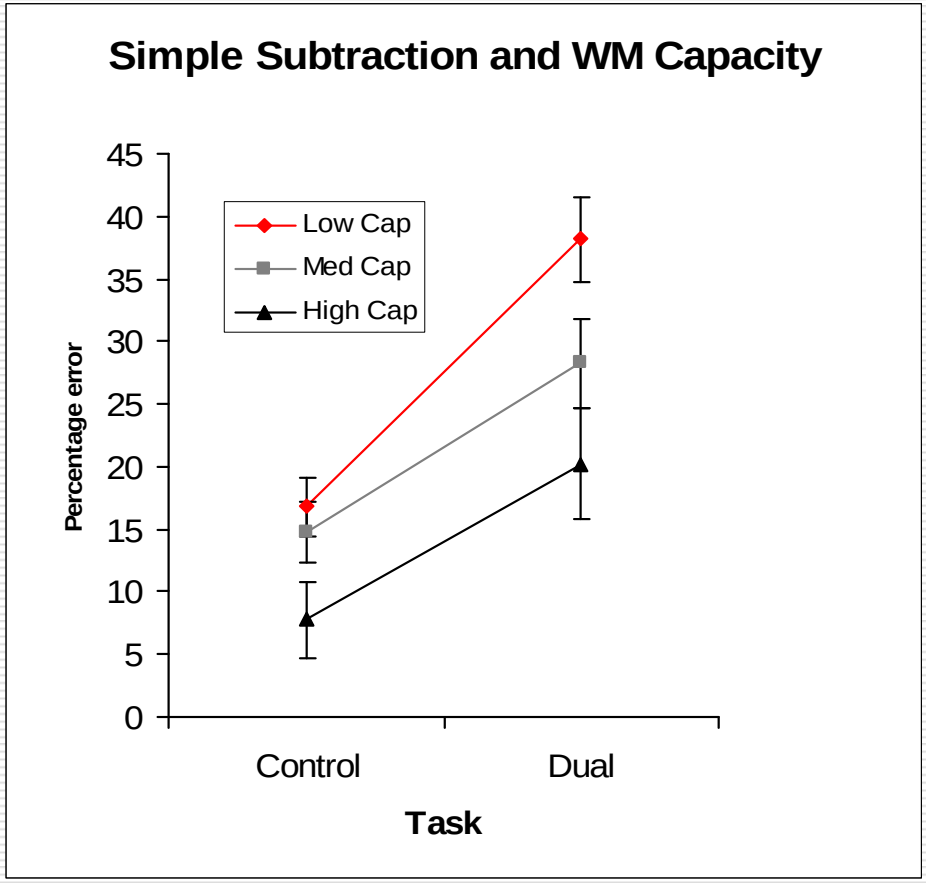
“Simple” subtraction – the problem size effect (Seyler, Kirk, & Ashcraft, 2003)



“Simple” subtraction – dual task errors



“Simple” subtraction and working memory capacity



Working Memory Implication

- Working Memory's role in math clearly documented, even in "simple" subtraction
- Implications of this not yet digested re: basic learning or "foundations of math," automaticity
- Neuroscience of working memory and math has not been done

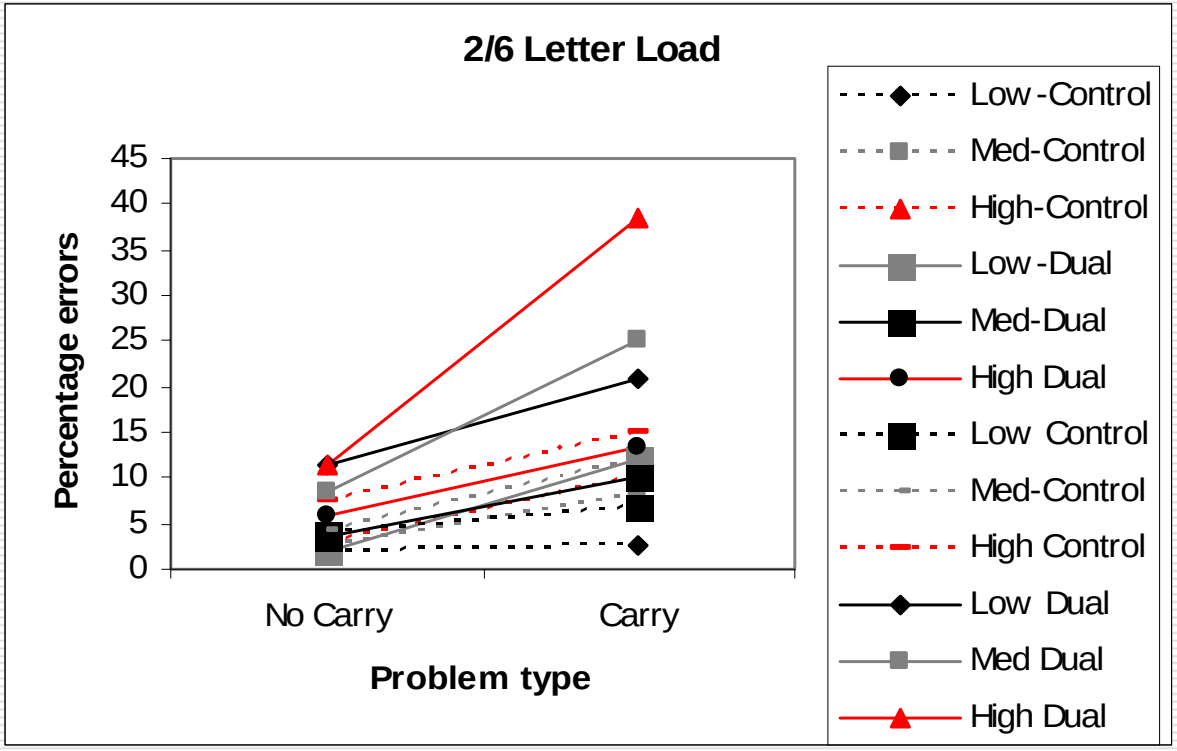
(continued)

- That is –
- No ERP or fMRI data on the problem size effect – memory strength, errors, and strategies should look different
- No ERP or fMRI data on working memory involvement during a math task
- Perhaps our eye-tracker data will help out

Math Anxiety

- General avoidance due to math anxiety – math courses, math careers
- Beyond that, math anxiety affects on-line processes
- Math anxiety compromises working memory, hence all processing that relies on working memory

Math anxiety and carrying in a dual task (Ashcraft & Kirk, 2001)



Conclusion on Math Anxiety

- Math anxiety compromises working memory – math anxiety is itself a secondary task, with participants devoting resources to negative thoughts, worries – a la Baddeley
- Guillaume's (2008) evidence that high math anxious participants recall more of the *really* wrong answers – a la Engle

Overall Conclusions

- Math Cognition has solid conclusions about basic processes and their development, and working memory, BUT
- Needs additional exploration of math anxiety
- Needs neuroscience methods to advance, to attract researchers,
- Needs to lead – be “prescriptive” rather than “descriptive” in terms of math achievement

(continued)

- For example, the problem size effect – whether the increase in RT/errors is due to lower strength, error history, strategy use, or something else
- Do we want a problem size effect? Shouldn't it go away with expertise? With automaticity? Should that be an educational goal, in service of improved learning and performance on higher math?

(continued)

- Does math anxiety result in degraded memory representation and impoverished knowledge, or just disrupted performance?
- Does it affect basic “number sense” from the outset? From adolescence?

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