

Number magnitude, magnitude of symbolic numbers or global magnitude deficit in DD?

A study through approximate additions in children and adults

MARIE-PASCALE NOEL
& SANDRINE MEJIAS

Cambridge September 13-14/2012

Basic deficit in developmental dyscalculia

- A basic numerical deficit?
 - of the Approximate number system (ANS) [Wilson & Dehaene, 2007; Butterworth 1999]
 - Of the access between symbolic numbers and the number magnitude representation (Rousselle & Noël, 2007)
 - ✦ Studies assessing DD and control children's abilities in comparing pairs of collections or of symbolic numbers
 - ✦ Changes in the profile of experimental results according to the age of the participants

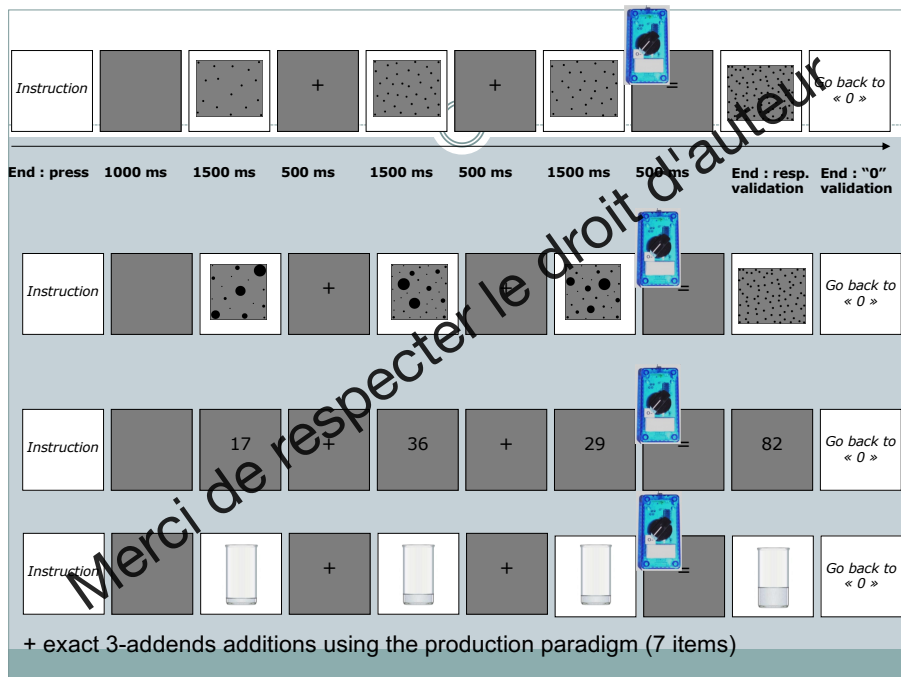
Changes in the profile with age

	age	symbolic	Non-symbolic
De Smedt & Gilmore (2011)	6 y.o.	MLD<C	MLD=C
Rousselle & Noël (2007)	7 y.o.	MLD<C	MLD=C
Landerl et al. (2004)	8-9 y.o.	MLD<C	-
Iuculano et al. (2008)	8-9 y.o.	MLD<C	MLD=C
Piazza	10 y.o.	-	MLD<C
Mussolin, Mejias & Noel (2010)	10-11 y.o.	MLD<C	MLD<C
Price & Ansari (2007)	12 y.o.	-	MLD<C

- With the comparison paradigm: inevitable confound between number and perceptual dimensions for the non-symbolic numbers (e.g., Gebuis & Reynvoet, 2011)
 - Need of using another paradigm
 - Use of a production paradigm in which participants have to estimate the results of additions

- Walsh (2003): proposition of a global magnitude system
 - Do DD suffer from a more general deficit of the magnitude system, beyond the numerical dimension ?
 - => Use of a condition in which participants have to estimate the result of the addition of amount of liquid in a glass

- Production paradigm in which participants have to estimate the result of additions of
 - Non-symbolic numbers: Dots collections
 - Symbolic numbers: Arabic numerals
 - Non-numerical magnitude: surface area (amount of water in a glass)



- Three addends additions requiring carrying over and with sums equal to 34, 52, 82 or 132 (6 items for each sum in each condition)
- E.g., $16 + 19 + 17$ (for 52)

Participants

- To study the developmental changes, two age groups were contacted: children and adults

Study 1: 10-11 y.o. Children (grade 5)

- 19 DD:
 - × < pc 15 in a calculation fluency test
 - × < pc 15 in a math battery
 - × Judged by the teacher as having some or severe difficulties in math
- 19 controls :
 - × Same classrooms
 - × Score between pc 15-85 in the math tests
 - × Teacher reports no diff in math

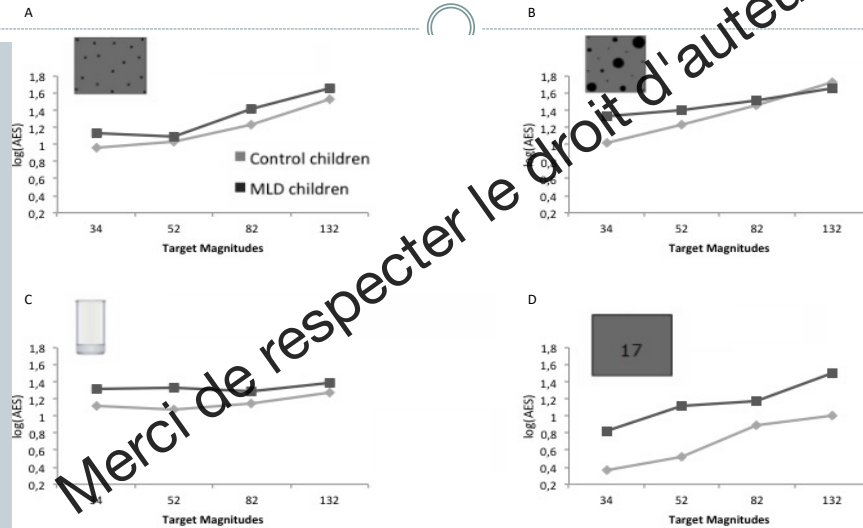
Results

- Estimates and variability of the estimates increased with the target
- stable COV (SD/Mean) in each condition and group but COV are larger for DD than controls

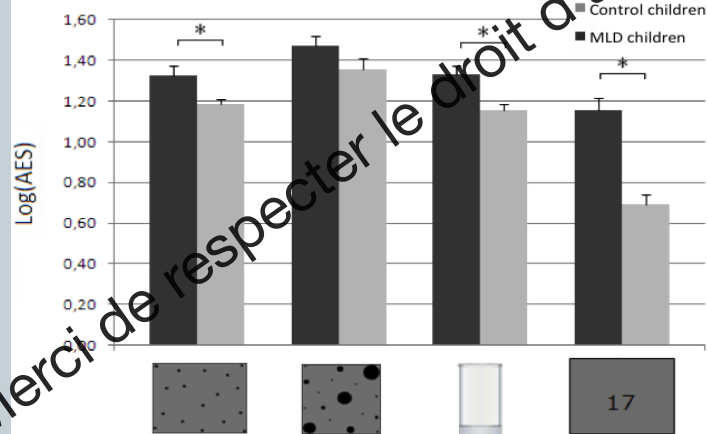
- Precision of the estimate

- AES: Absolute error score : $|\text{estimate} - \text{target}|$
- ANOVA target x task x group
 - × AES increases with target size ($p < .0001$) in all conditions except in the glass condition

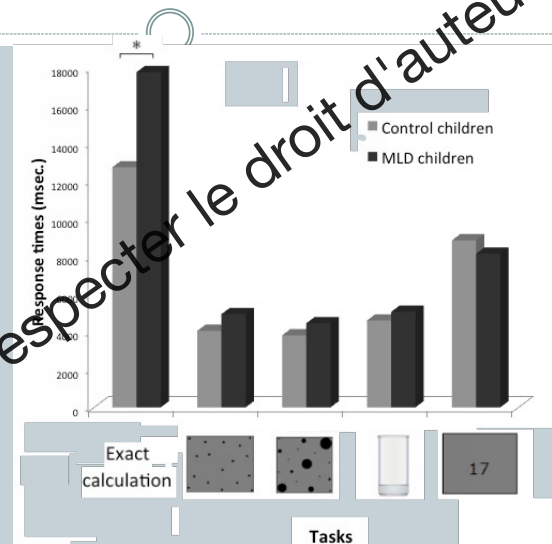
Results



- Larger AES for DD than controls ($p < .0001$) in all the tasks but larger differences in the Arabic condition
- Controls are more precise in the Arabic condition than in the non-symbolic condition,
- For the DD, the Arabic condition does not lead to better estimates than the homogeneous-size dots condition



Analysis of RTs shows that participants are much faster in approximate than exact calculations on Arabic numbers



Significant correlations between the AES and the global math score



Conclusion

- At that age
 - Participants are able to deal with the task
 - ✦ The heterogeneous-size dot is the more difficult task
 - ✦ Estimates of the DD are more variable and less precise than those of controls in the symbolic and non-symbolic tasks as well as in the non-numerical task
 - ✦ => global magnitude deficit ?
 - ✦ NB: The larger difference between controls and DD is in the symbolic condition

Study 2

- Adult participants
 - Recruitment of participants who declared having experienced math difficulties in childhood that led to a diagnosis of DD or remediation
 - 17 adults who were DD (25-40 y.o.)
 - 17 adults control, same age, same studies or profession
- Stimuli
 - Target of 34, 42, 52, 64, 82, 104, 132

Memory span (Matrices) are used as covariates in the next analyses

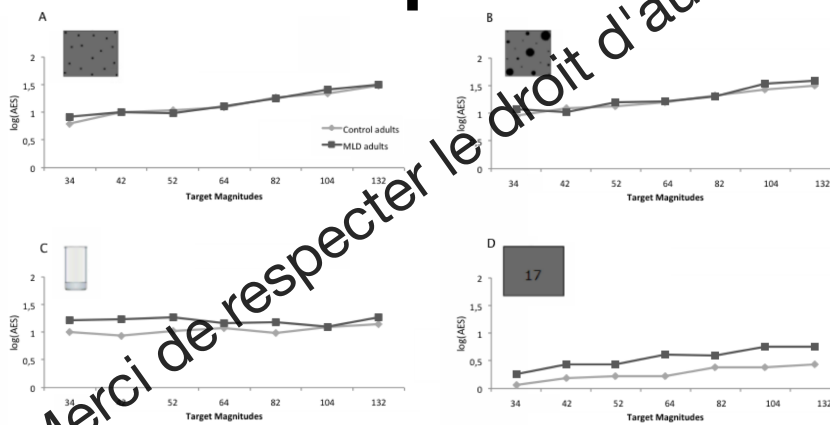
Results

- Stable COV in all the tasks
- Larger COV for the DD group in the Arabic and glass condition

Results

- Estimates increase with the target in all the tasks but the glasses
- Significant differences between the groups in the Arabic condition only, and marginally for the glass condition

Results



Discussion

- Participants were able to deal with the tasks
- Estimates were more accurate in the homog than the hetero condition (sign in children and marginal in adults) => continuous physical variables facilitate the numerical approximation
- glass condition: precision of estimate does not increase with target size => different process or representation

Basic deficit in DD?

- Different profile in the two groups
 - Children: DD were less accurate than controls in all the condition but especially in the symbolic condition
 - Adults: DD were less accurate than controls in the symbolic condition only
- Reduced acuity of the NBS is not observed in young DD children, appears around teenage but disappears in adulthood => temporary deficit, just a delayed maturation of the system
- Possible delay of the non-numerical magnitude as well
- Deficit with Arabic numbers is a stable characteristics of DD