

# World Dyslexia Forum

3 – 5 February 2010, UNESCO - Paris



## *Hemispheric specialization and dyslexia*

Maria Luisa Lorusso

Scientific Institute "E. Medea"

Bosisio Parini (LC), Italy

*in collaboration with* Dirk Bakker

Vrije University, Amsterdam (NL)



# *Are dyslexics all alike?*

- Undisputed answer: no
- Disputed description: what?
  - Several differences are described for individuals with dyslexia, including:
    - Linguistic (naming, lexical access, phonemic awareness, verbal memory, etc.)
    - Auditory (verbal and nonverbal sound discrimination)
    - Visual (eye movements, fixations, visual perception)
    - Motor (clumsiness, motor coordination, balance)
    - Attentional (sustained attention, selective attention, etc.)

# *So, dyslexics are not all alike*

## ■ But why?

### ■ Possibilities:

- A) only one process is crucial in causing dyslexia. All the other deficits are “associated disorders”, i.e. they have no causal role and are unrelated to the reading problem, but they might be caused by the same factor that causes dyslexia.
- B) several dyslexia subtypes exist, and the causal factor (or “core deficit”) can be different for each one.
- C) there are several causal factors in dyslexia, and these can manifest themselves to different extents in different individuals.

# *Dyslexia subtypes*

Various classifications, based on:

- A) performance with different types of words (phonological vs surface dyslexia, Boder, etc.)
- B) developmental models of reading (Frith, Bakker, ecc.)
- C) reading characteristics (Bakker, van der Lely, ecc.)
- D) neuropsychological profiles (Rourke, Satz & Morris, Wolf & Bowers, Bakker, etc.)

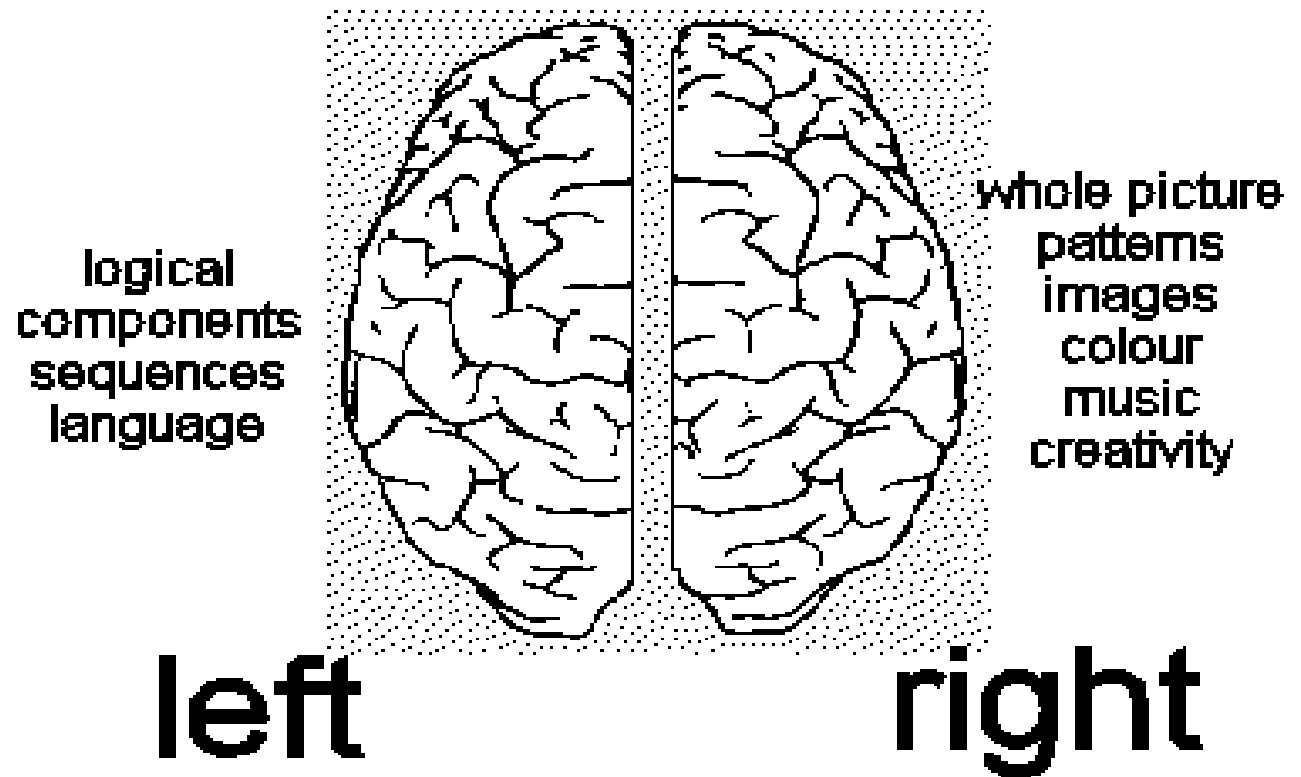
# *Bakker's classification (Balance Model):*

P, L, M-types

- Differing on:
  - Reading speed (L-types quicker)
  - Accuracy (P-types more accurate)
  - Type of errors (time-consuming in P-types vs. substantive in L-types)
  - Prevalent hemispheric activation during reading (RH in P-types vs LH in L-types)
  - Neuropsychological profile (linguistic, visual-spatial, attentional etc.)

# *The two hemispheres*

From Evans, 2003



# *Balance Model: underlying principles*

Reading acquisition relies first on greater involvement of the right hemisphere, then on a progressively greater involvement of the left hemisphere.

Some children (P-types) fail to show this shift and keep relying on thorough decoding strategies (RH-based)

Other children (L-types) shift too early to linguistic anticipation strategies (LH based)

In several cases the child is not able to activate either kind of strategy (M-types)

## *Balance Model:*

The idea of a shift from RH- to LH-prevalent activation during early reading acquisition has first been supported by ERP studies, and it has recently been confirmed by several neuroimaging studies



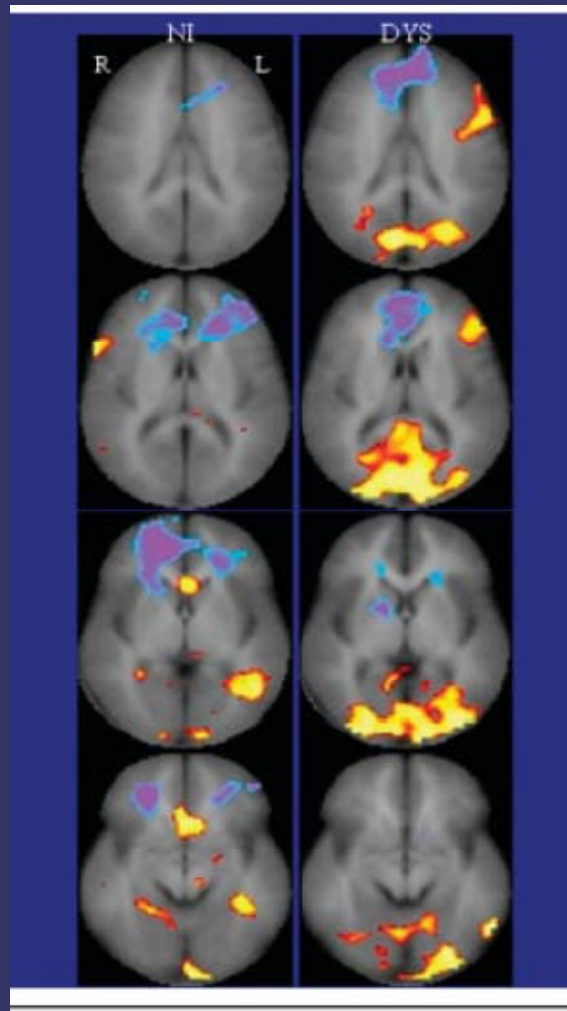
# Support for the Balance Model:

## Age-Related Changes in Reading Systems of Dyslexic Children

Shaywitz, Skudlarski, Holahan, Marchione, Fulbright, Zelterman, Lacadie, Shaywitz.

Ann Neurol 2007

**“Results:** In nonimpaired readers, systems in the left anterior lateral occipitotemporal area developed with age, whereas systems in the right superior and middle frontal regions decreased. In contrast, in dyslexic readers, systems in the left posterior medial occipitotemporal regions developed with age. Older nonimpaired readers were left lateralized in the anterior lateral occipitotemporal area; there was no difference in asymmetry between younger and older dyslexic readers.”



*Correlation maps between age and activation during a nonword rhyming task. Brain regions in red and yellow indicate a positive correlation, in blue and purple a negative correlation between age and activation*

# Support for the Balance Model:

From Shaywitz SE, Shaywitz BA, Fulbright R, et al (2003).

Neural Systems for Compensation and Persistence:

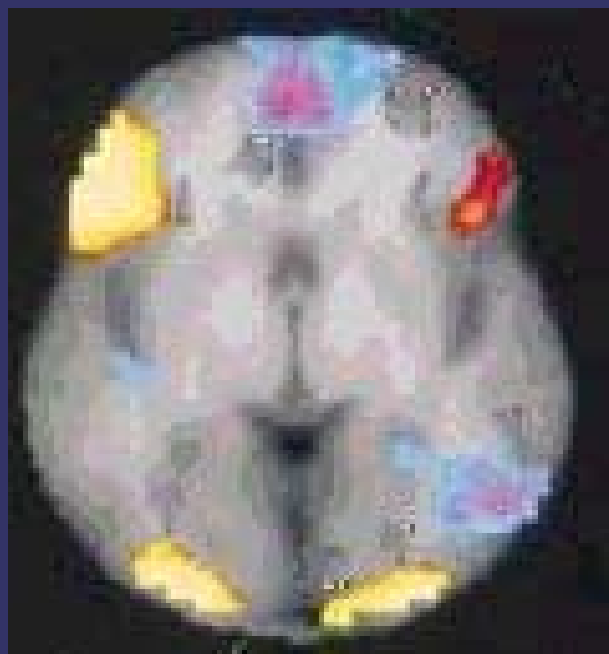
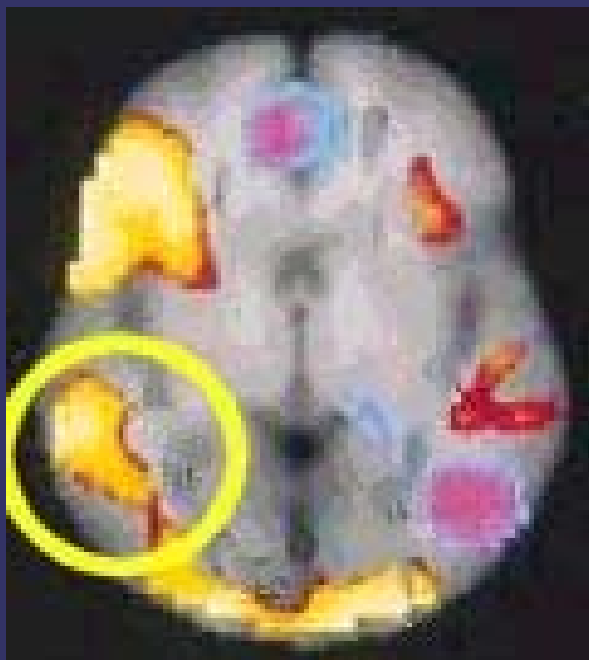
Young Adult Outcome of Childhood Reading Disability. *Biological Psychiatry* 54:25-33

## Rhyming task

Normal reader

Dyslexic,  
persistent poor reader

Dyslexic,  
improved



# *Support for the Balance model:*

Turkeltaub PE, Gareau L, Flowers DL, Zeffiro TA, Eden GF (2003)  
Development of neural mechanisms for reading. Nat Neurosci  
6:767–773

**“We found that learning to read is associated with two patterns of change in brain activity: increased activity in left-hemisphere middle temporal and inferior frontal gyri and decreased activity in right inferotemporal cortical areas. Activity in the left-posterior superior temporal sulcus of the youngest readers was associated with the maturation of their phonological processing abilities. These findings inform current reading models and provide strong support for Orton's 1925 theory of reading development.”**

# *Support for the Balance Model:*

Simos, P.G., Fletcher, J.M., Foorman, B.R., Francis, D.J., Castillo, E.M., Davis, M.F., Mathes, P.G., Denton, C.A., & Papanicolaou, A.C. (2002).

**Brain activation profiles during the early stages of reading acquisition.** *Journal of Child Neurology*, 17, 159–163.

**“In the present study, we demonstrate for the first time the presence of an aberrant brain mechanism for reading in children who have just started acquiring reading skills. Children who, at the end of kindergarten, are found to be at risk for developing reading problems display markedly different activation profiles than children who have, at this stage, already mastered important prereading skills. This aberrant profile is characterized by the lack of engagement of the left-hemisphere superior temporal region, an area normally involved in converting print into sound, and an increase in activation in the corresponding right-hemisphere region.”**

# *Support for the Balance Model:*

M. E. Porta, R. Kraft, and L. Harper (2010)  
Hemispheric Asymmetry Profiles During Beginning  
Reading: Effects of Reading Level and Word Type

Developmental Neuropsychology, 35, 96–114

**“The results suggest that the holistic specialization of the right hemisphere helps young children to recognize written words with high levels of imageability and that the utilization of this specialization decreases as children’s reading skills develop.”**

# *Subtypes: Data from an Italian sample*

- 123 children
- aged 7-15
- Classified as P, L or M-types
  - P-type, if speed  $z < -1$ ) and time-consuming errors  $> 60\%$ ;
  - L-type, if speed  $z \geq -1$ ) and substantive errors  $> 60\%$ ;
  - M-type: in all other cases

# *Subtypes: Data from an Italian sample*

Tests administered:

- Text reading (MT test)
- Word and nonword reading (Sartori et al.)
- Word, nonword and sentence writing to dictation (Sartori et al.)
- Phonemic blending and elision (Cossu)
- Memory for words, letter span and digit span forward/backward (TEMA- Tomal)
- Interhemispheric (callosal) transfer (tactile)

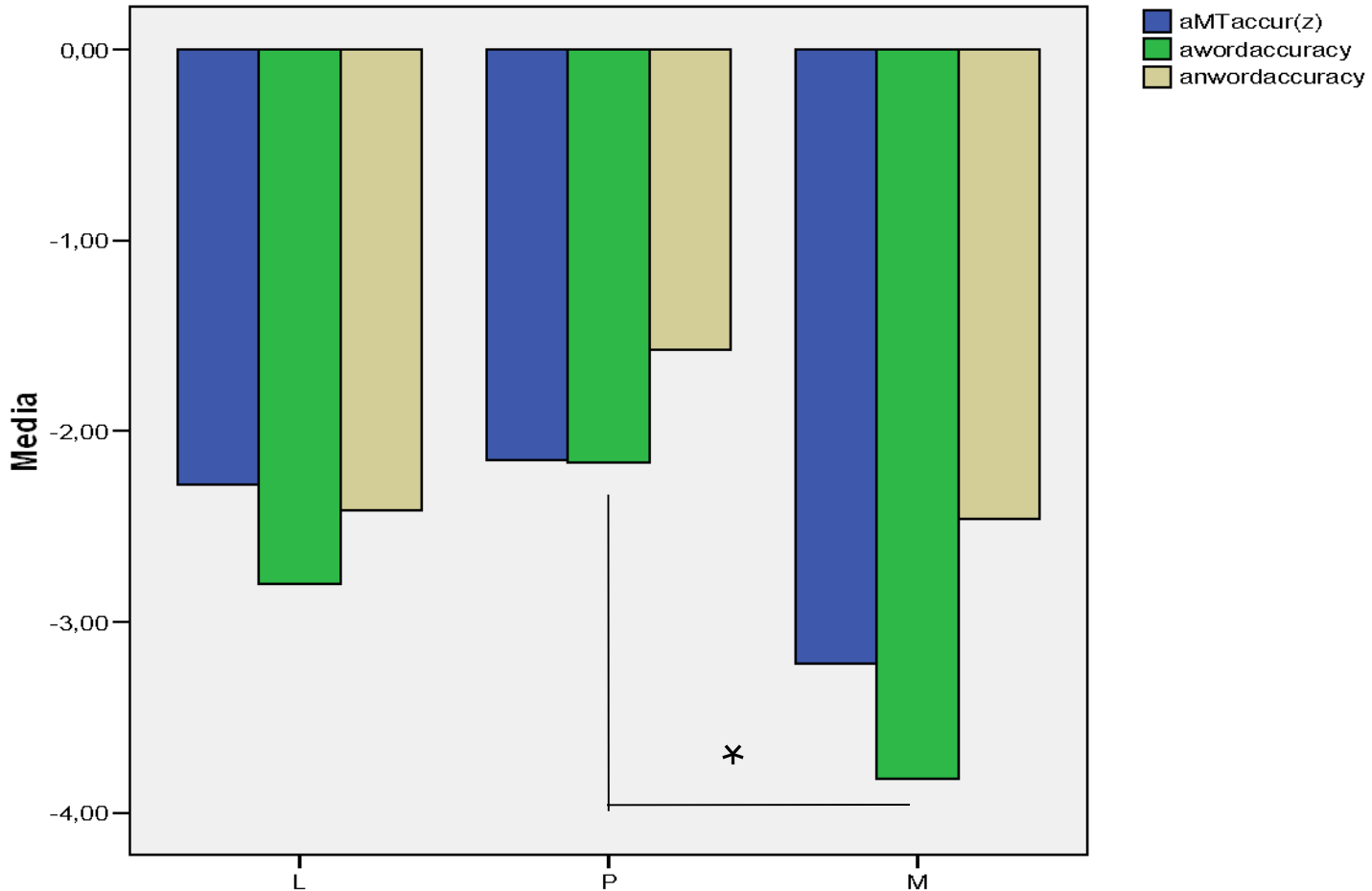
# *Subtypes: further data (N=20)*

Tests of auditory processing of nonverbal/verbal stimuli

- TOJ (temporal order judgement) with tones variable for ISI ( $\leq 40$ ,  $> 40$  ms) and duration (75 or 250 ms)
- Serial memory (sequences of 4 and 5 stimuli)
- Discrimination of minimal pairs (synthesized)
- Categorization of minimal pairs (synthesized)

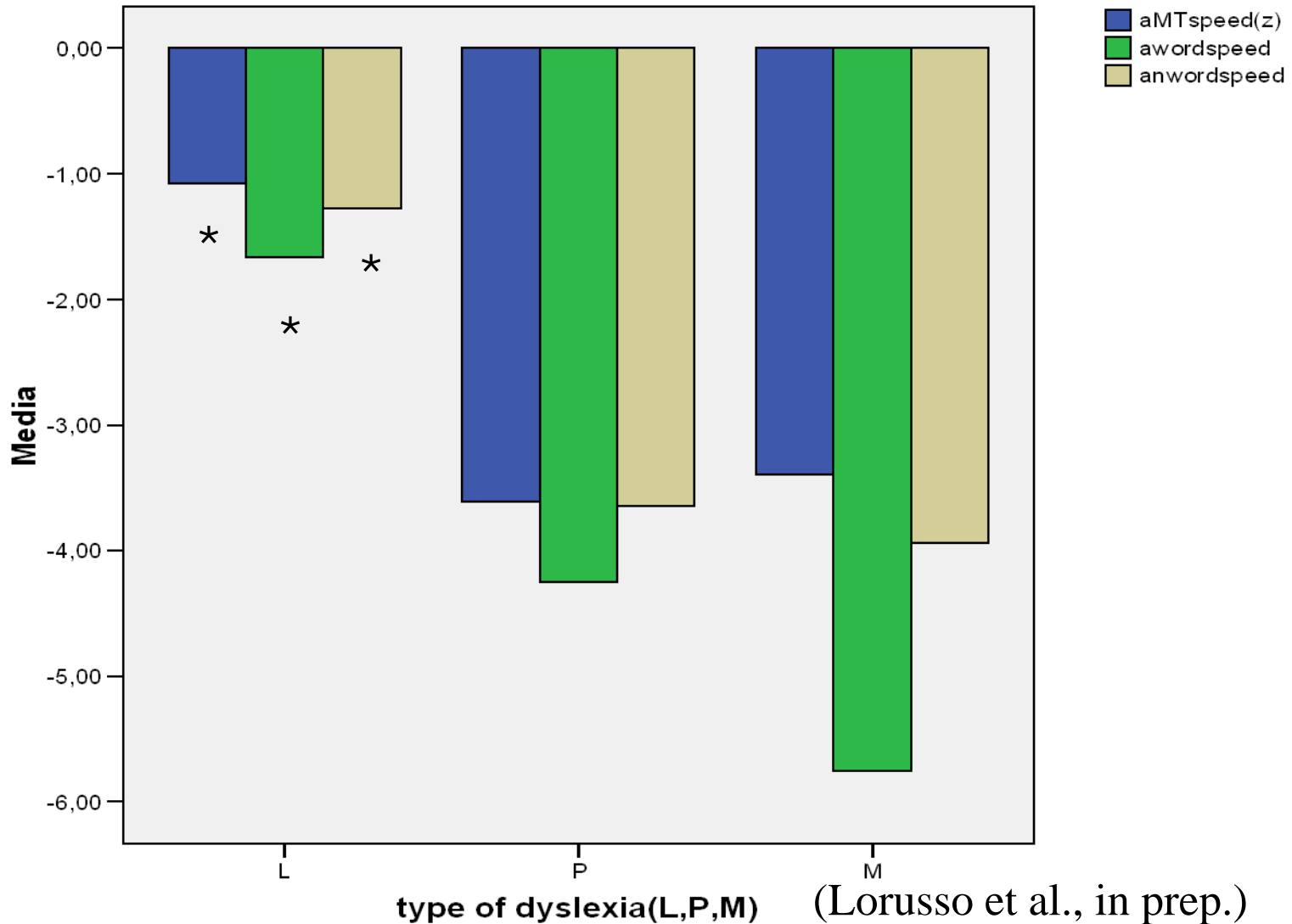


# Differences: reading accuracy

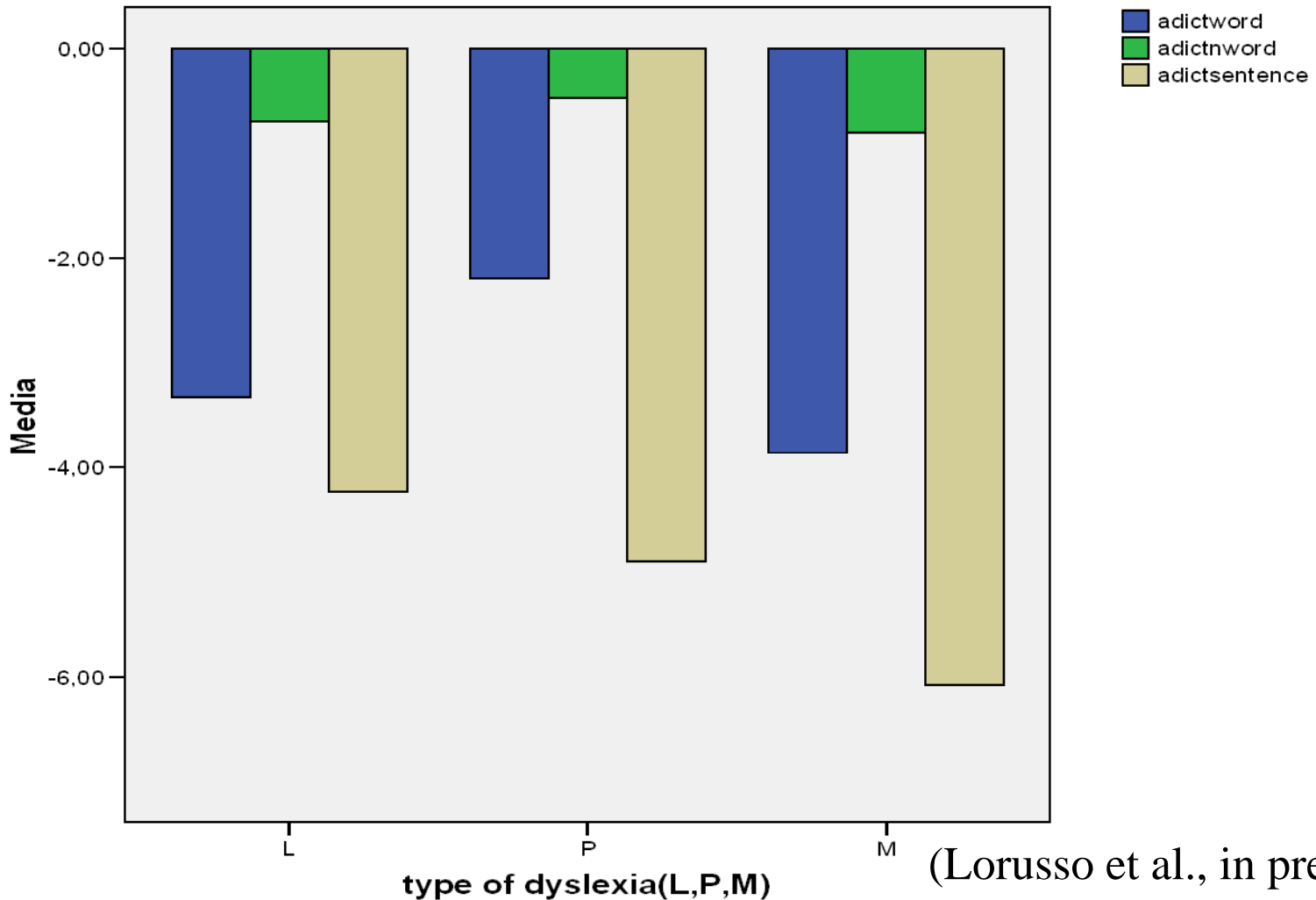


type of dyslexia(L,P,M) (Lorusso et al., in prep.)

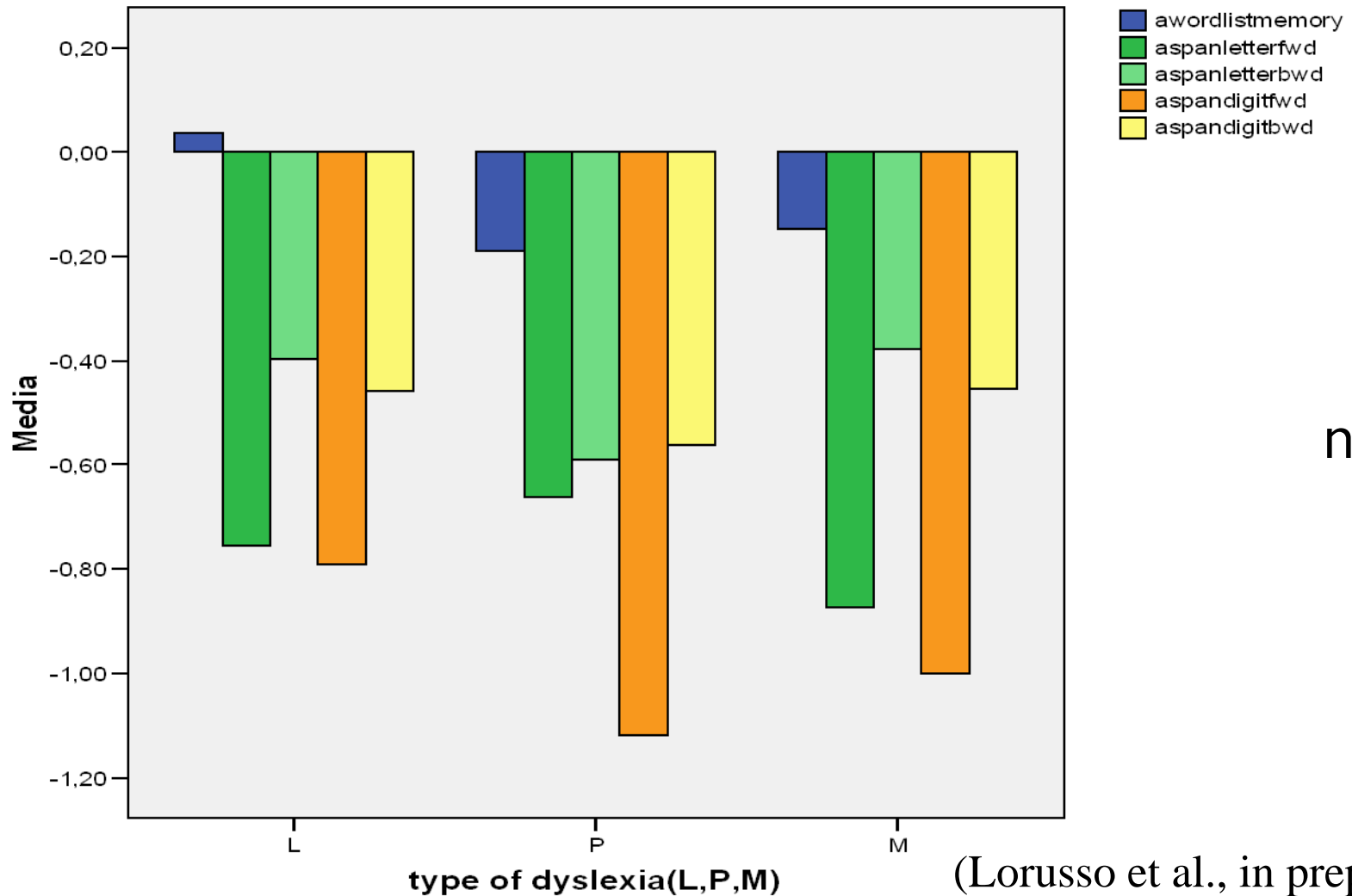
# Differences: reading speed



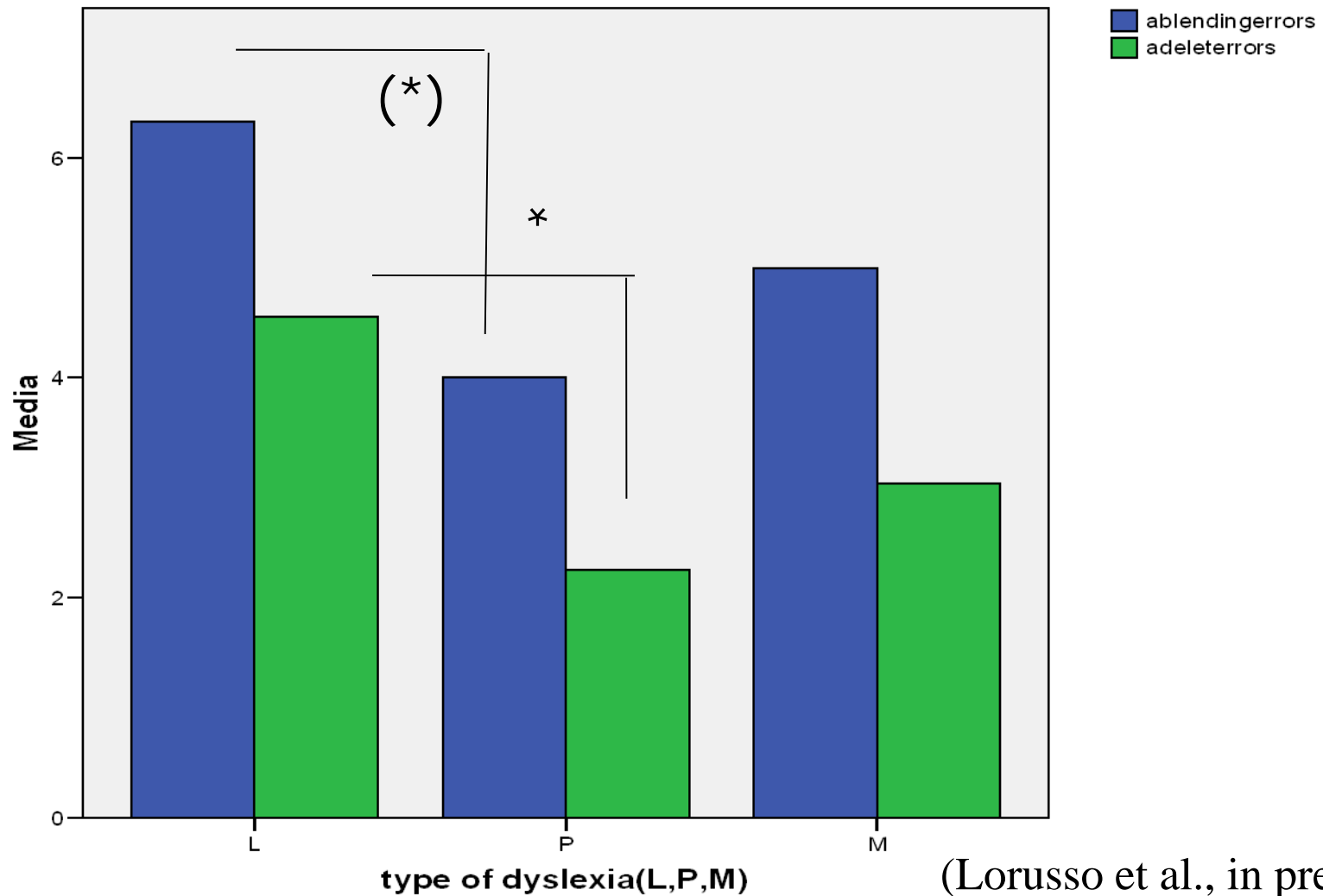
# Differences: writing accuracy



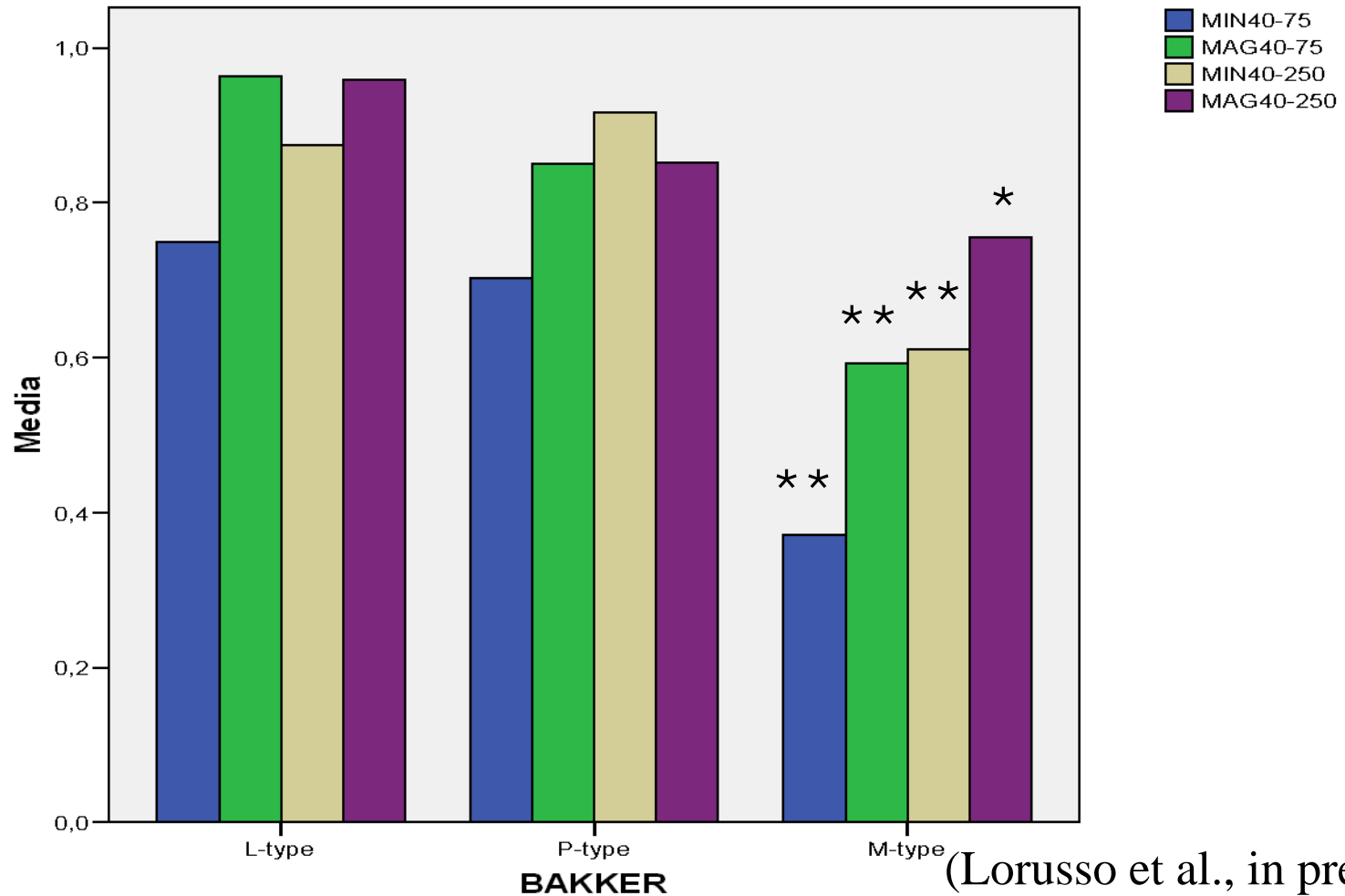
# Differences: verbal memory



# Differences: phonemic awareness

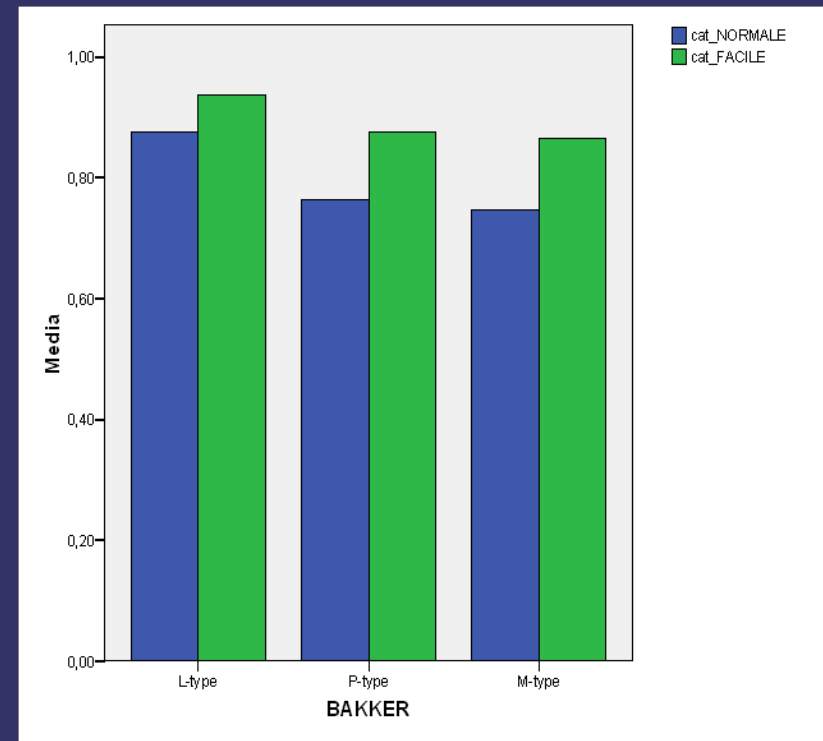
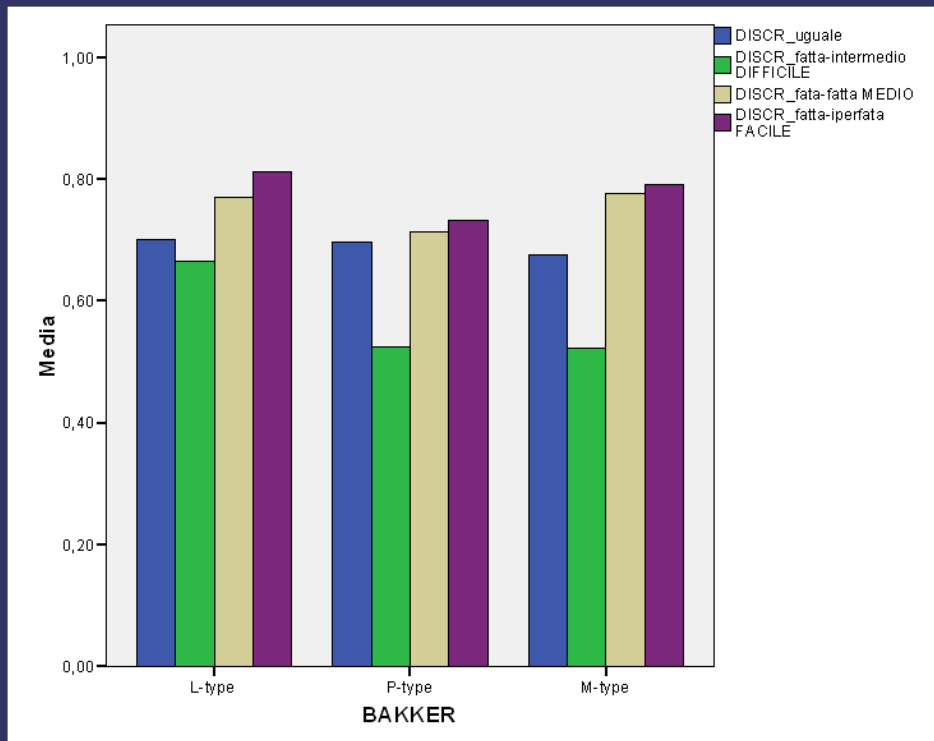


# Differences: auditory processing (nonverbal)



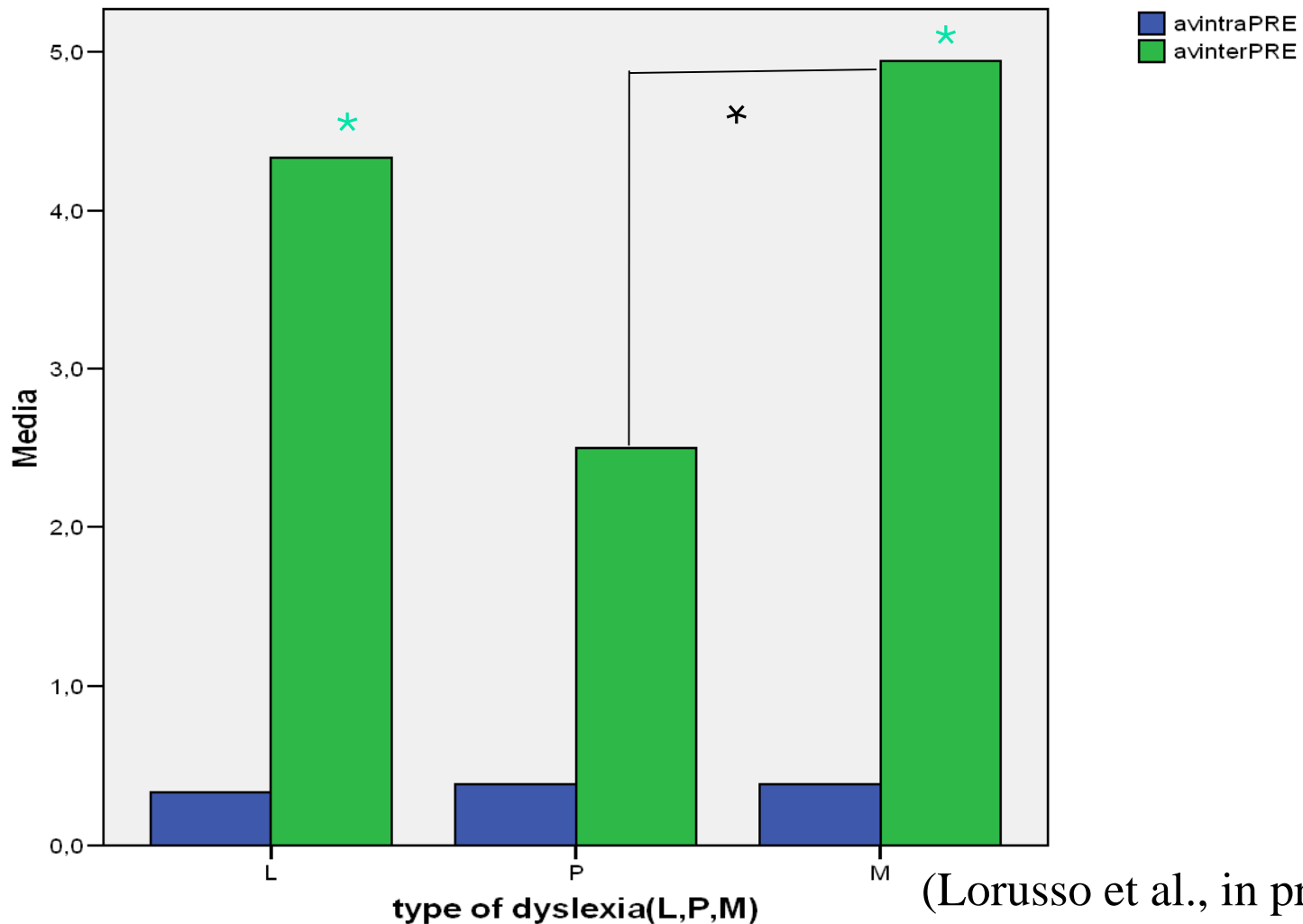
# Differences: auditory processing (verbal)

No differences in discrimination and categorization tasks



(Lorusso et al., in prep.)

# Differences: callosal functions (interhemispheric transfer)





# *Treatment according to the Balance Model*

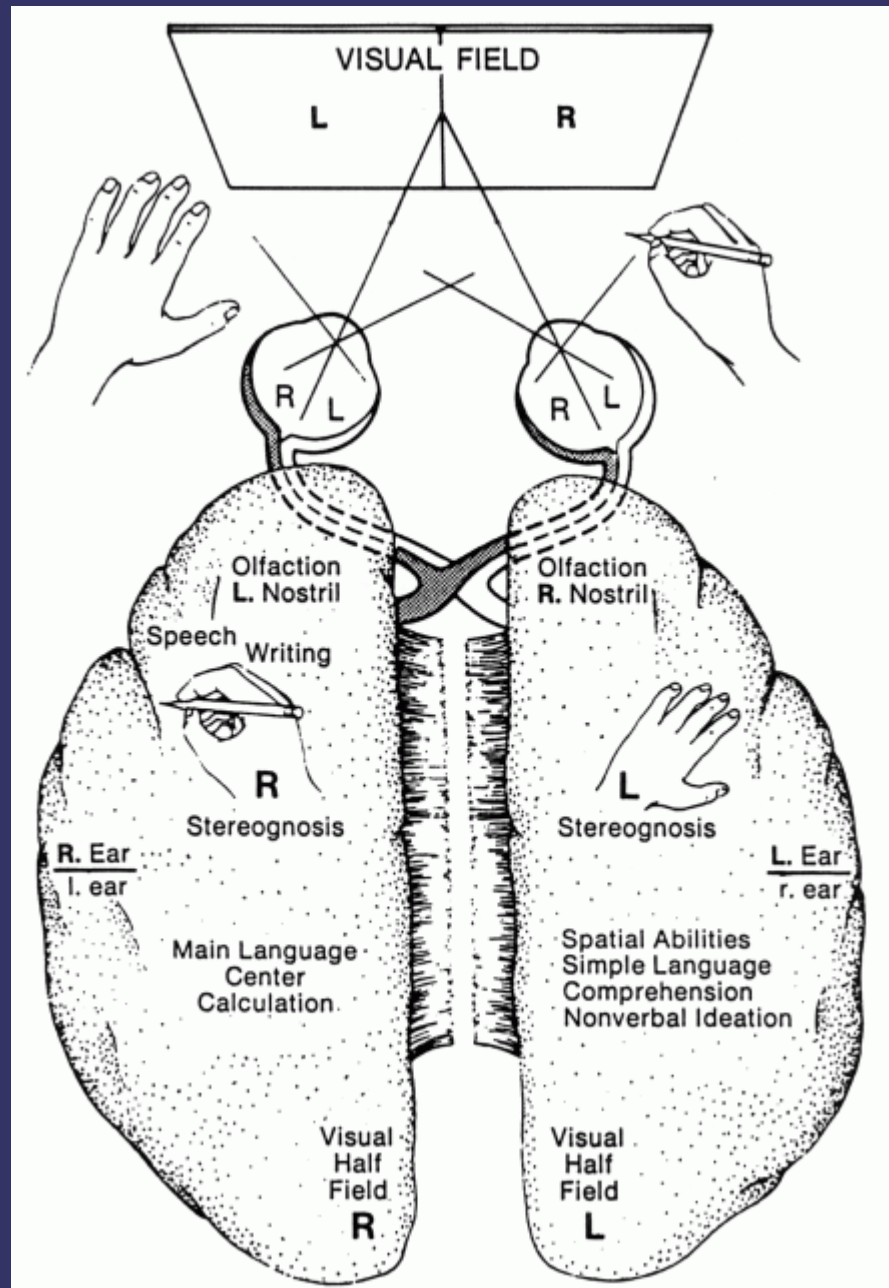
- stimulation of the less involved hemisphere (LH for P-types, RH for L-types, RH followed by LH for M-types)
- use of computerized programs
- direct stimulation through visual pathways (presentation times below 300 ms, control of fixation)
- indirect stimulation through materials and tasks
- 32 sessions, twice a week (4 months)

# THE VISUAL SYSTEM

Right hemifield:  
LH

Left hemifield:  
RH

Central (foveal):  
LH + RH



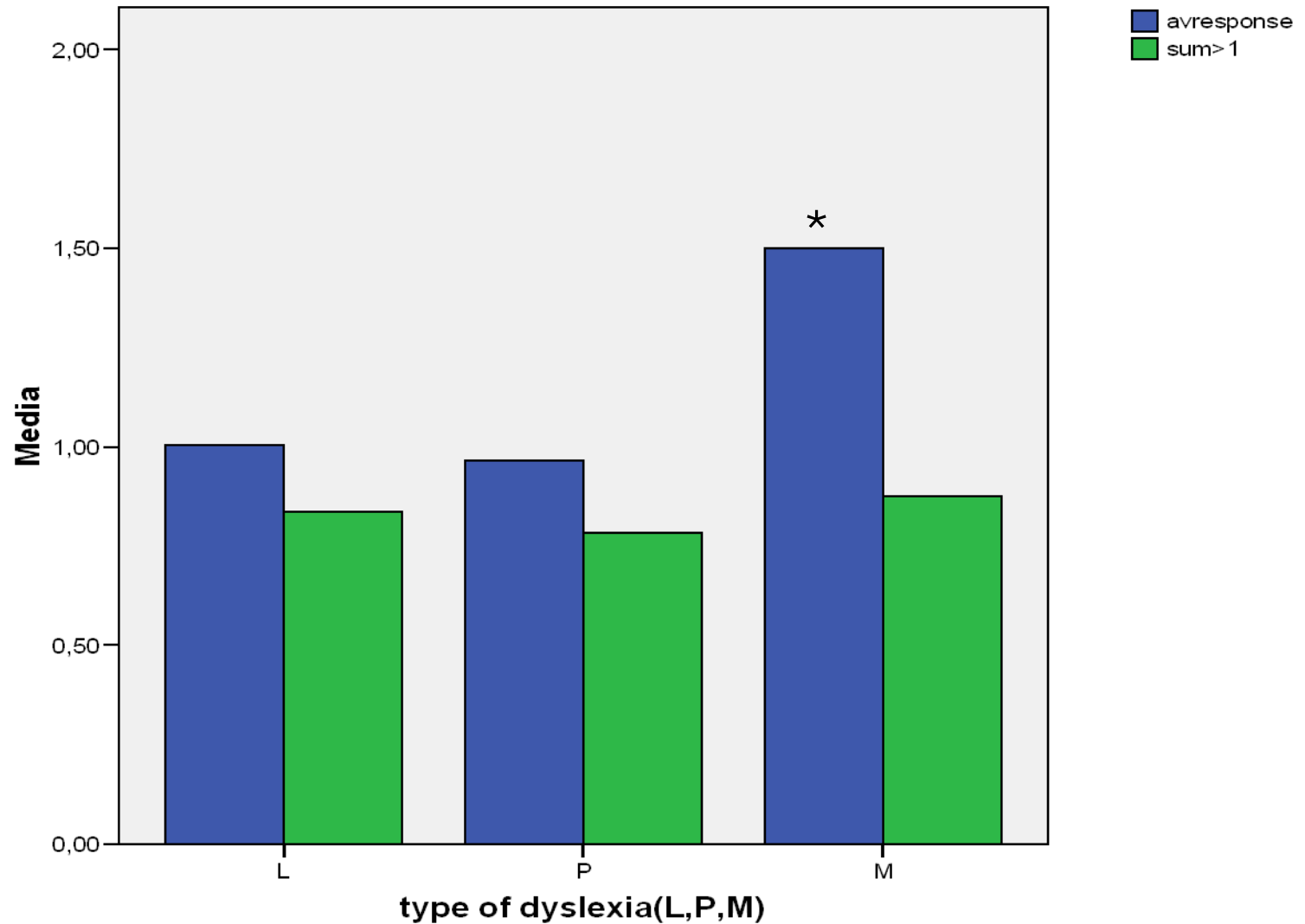
From Duch, 2008:  
How does the brain work?

# *Intervention study on Italian dyslexic children: Sample characteristics*

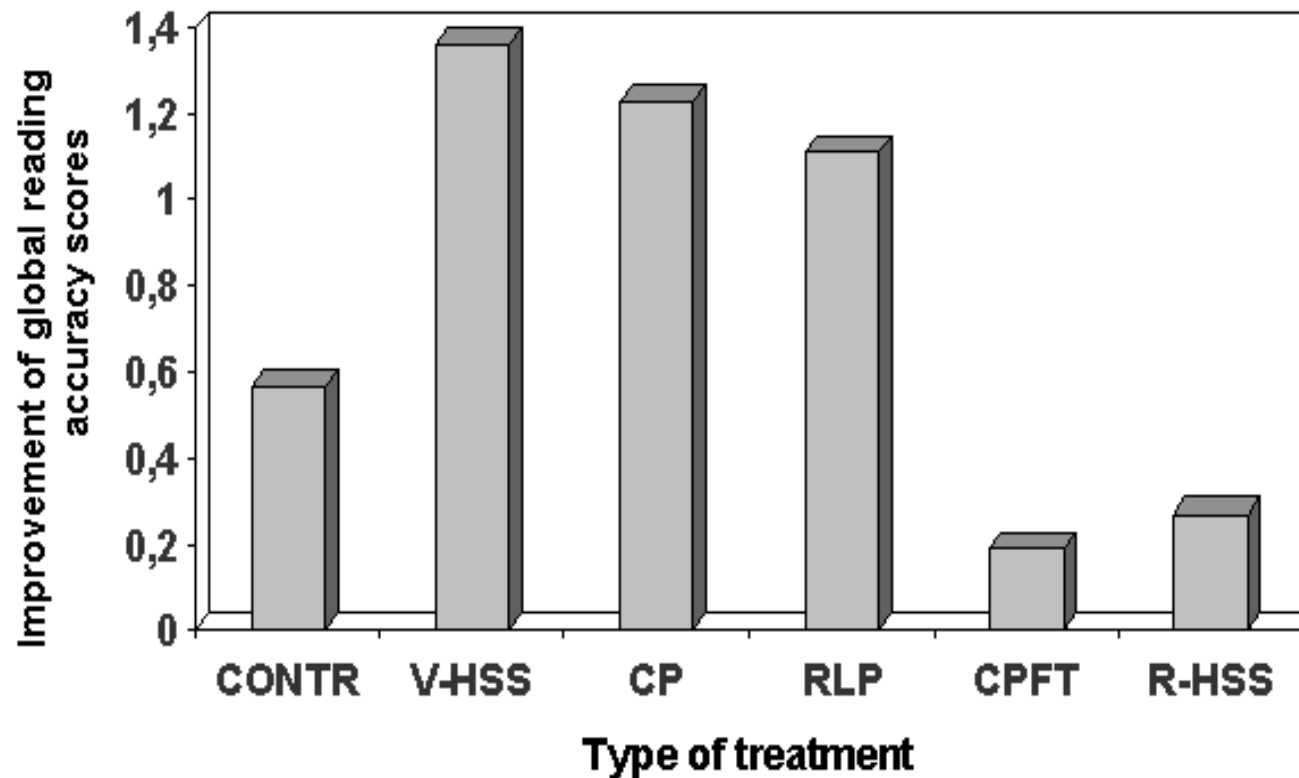


	0: CONTROL	1: V-HSS Standard lateral	2: RLP Random lateral	3: CP central	4: CP-FT Central fixed time	5: R-HSS Reversed	6: RH-stim Right Hem.
Number of participants	13 (12 M, 1 F)	33 (29 M, 4 F)	22 (18 M, 4 F)	18 (15 M, 3 F)	15 (13 M, 2 F)	9 (6 M, 3 F)	13 (8 M, 5 F)
Mean age (DS)	9.69 (1.65)	10.18 (1.86)	10.55 (1.76)	10.78 (2.10)	11.07 (1.44)	11.44 (1.94)	10.62 (1.85)
Mean full IQ (DS)	105.38 (10.42)	104.35 (13.08)	98.52 (11.55)	97.82 (8.50)	101.54 (8.95)	103.88 (11.27)	100.64 (6.33)
Type of dyslexia	3 L 3 P 7 M	5 L 15 P 13 M	5 L 4 P 13 M	2 L 5 P 11 M	1 L 7 P 7 M	2 L 7 P	13 M

# Response to treatment

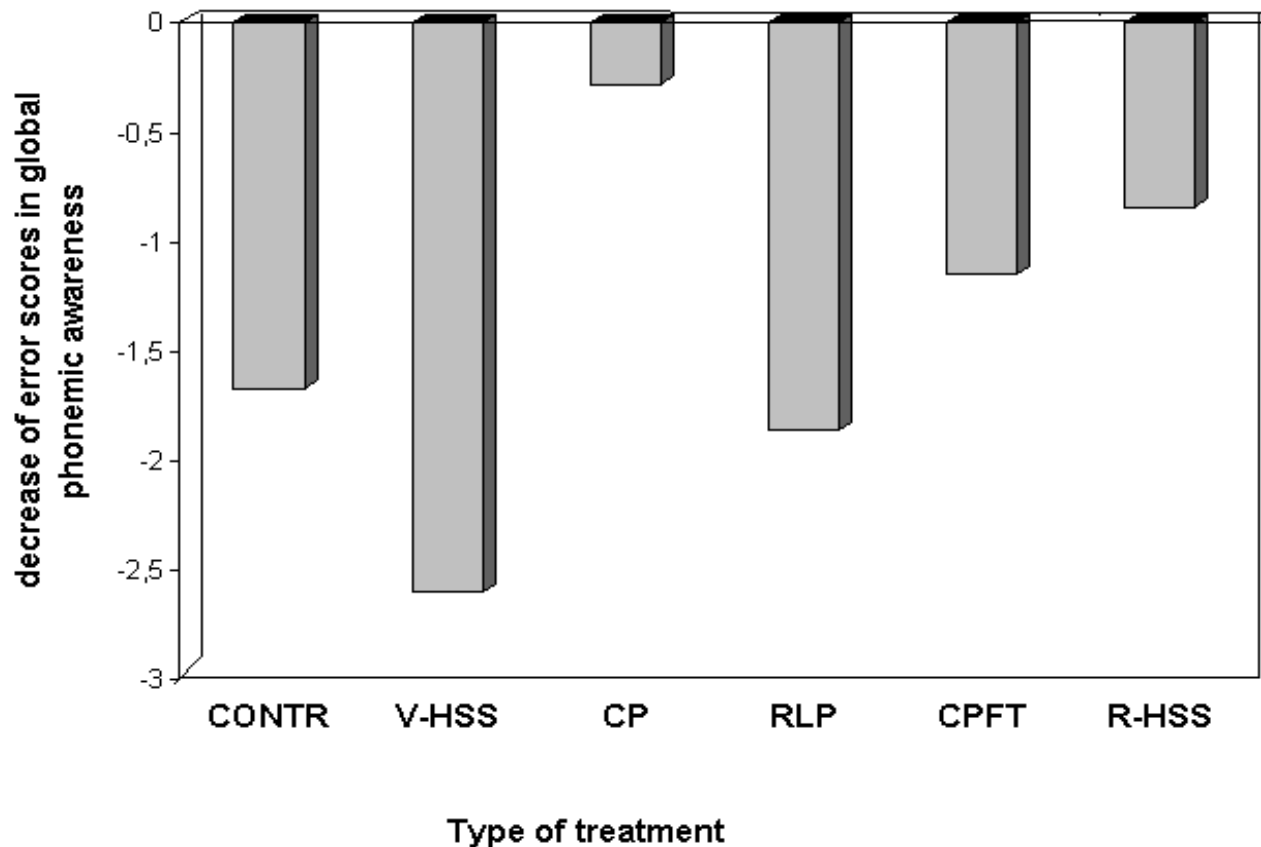


# *Response to treatment: accuracy, P & L-types*



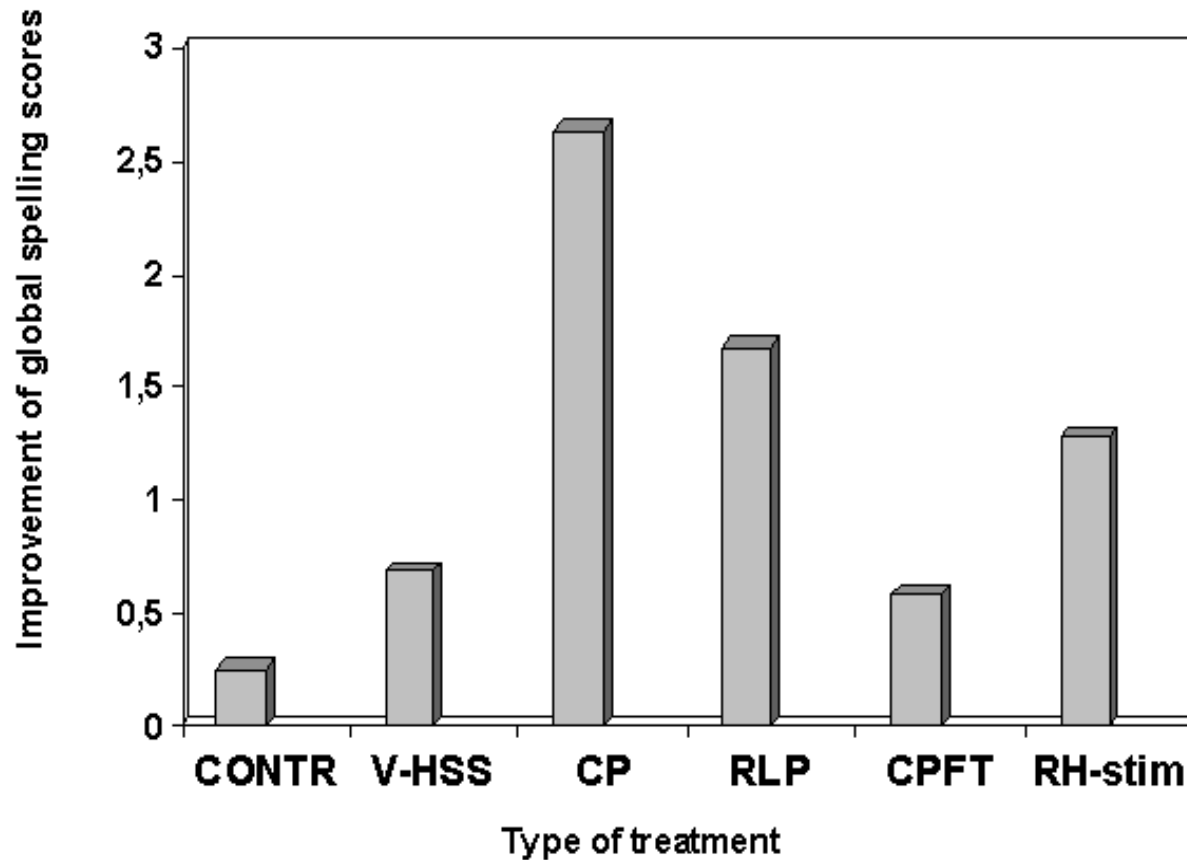
(From Lorusso et al., in press)

# *Response to treatment: phonemic awareness, P & L-types*



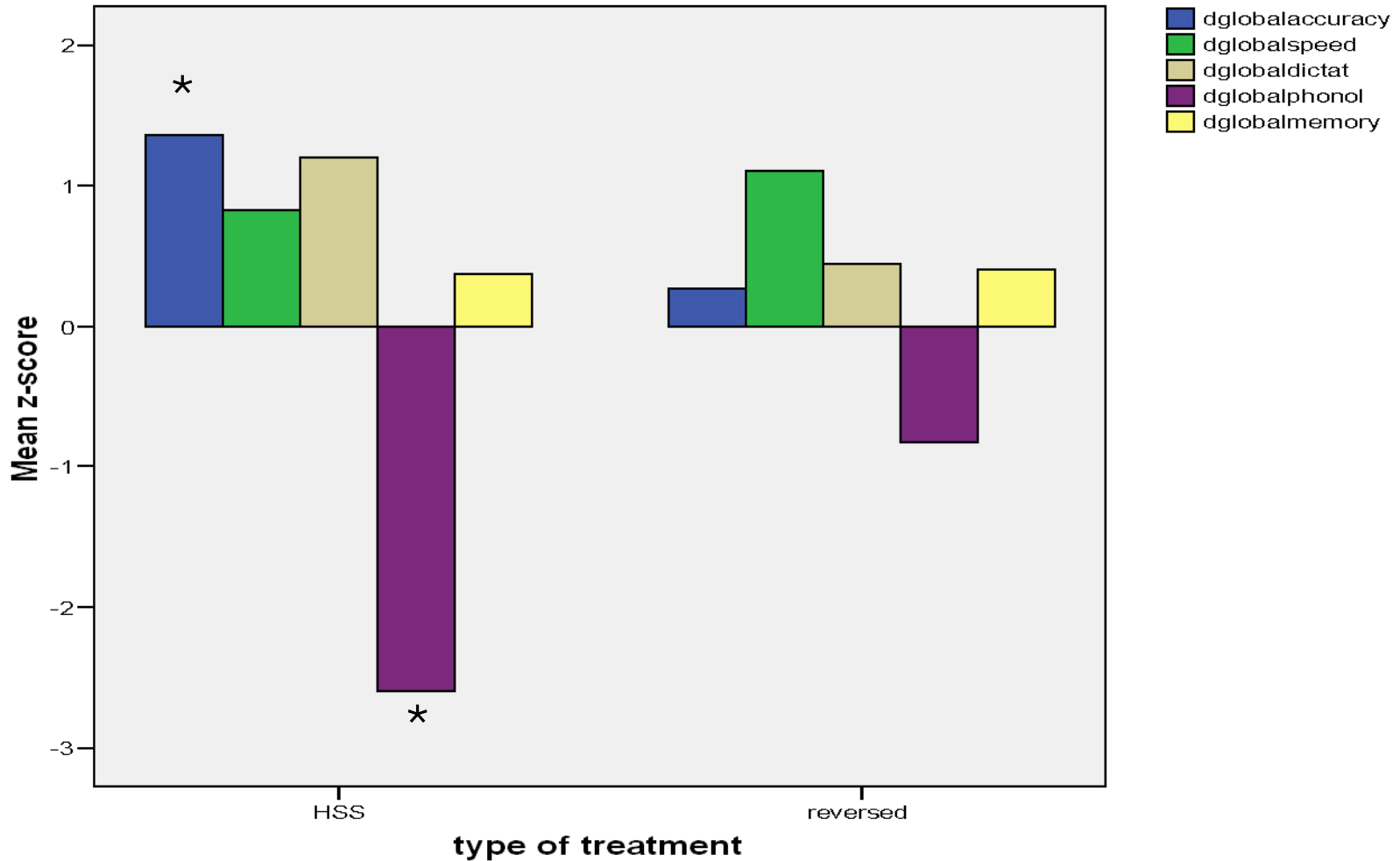
(From Lorusso et al., in press)

# *Response to treatment: writing, M-types*



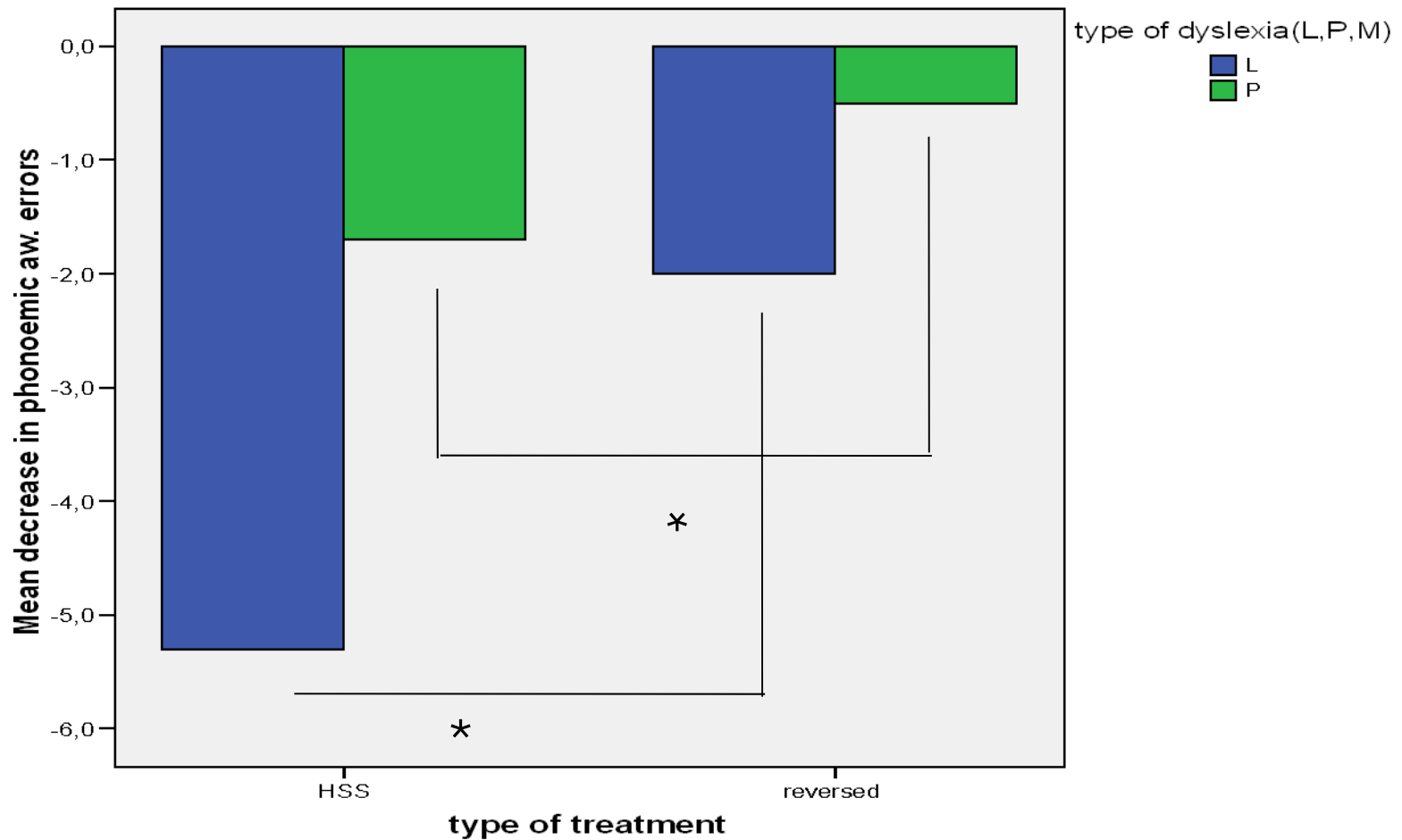
(From Lorusso et al., in press)

# Response to treatment: hemispheric specificity, P & L-types





# Response to treatment: phonemic awareness, appropriate vs non-appropriate hemisphere



# *Summary*

- the role of hemisphere specificity is confirmed
- advantage of “attack strategies” (working on weaknesses rather than on strengths) especially for accuracy
- advantage of unilateral stimulation for reading accuracy
- advantage of simultaneous bilateral stimulation (interhemispheric exchange via corpus callosum?) for orthographic skills
- no advantage of LH stimulation and of bilateral stimulation for improvement of phonemic awareness

# *Conclusions*

- the results of intervention strongly depend on subtype
- the same kind of treatment can induce opposite effects in different subtypes
- it is not easy, though, to reconcile treatment effects with classical neuropsychological models of reading
- importance of intervention planning according to both individual and subtype characteristics and to specific goals (reading vs. writing, etc.)

# Thanks to:

- Carmen Cattaneo
- Andrea Facchetti
- Anna Milani
- Chiara Cantiani
- Camilla Valnegri
- Elisabetta Sala
- Milena Ruffino
- Nello Salandi
- Massimo Molteni
- The speech-therapists
- All the children and their families
  - All of you!