Reading derived words by Italian children with and without dyslexia: The effect of root length

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- **Italian** is a **transparent Orthography** with highly regular grapheme-to-phoneme mappings

- When reading Italian aloud, correct pronunciation can be obtained relying on **small reading units** (letters and phonemes)

- Italian children have **high reading accuracy** by the end of first grade (Seymour et al., 1993)

- However, the use of small units (graphemes and phonemes) results in **slow reading**

- The goal of the developing reader is to build **larger reading units**, to increase fluency, and get faster lexical access and comprehension

- Whole-words are the largest reading units, but **morphemes** are **reading units of an intermediate size**, exploitable to increase reading fluency

- Italian children with dyslexia fail to develop reading units of a large size (i.e., words), because of limitations in their visuo-perceptual span

- They make several and long-lasting fixations within a word with several small amplitude saccades (De Luca et al., 1999; 2002)

- They typically read rather accurately, but very slowly and serially (Spinelli et al., 2005)

- Italian children with dyslexia have increasing difficulties with increasing word length (Zoccolotti et al., 1999; 2005)

- However, long words composed of morphemes (roots and derivational suffixes) are read aloud by dyslexics faster than matched words not composed of morphemes (Burani, 2010)

- Morphemes are shorter reading units than the whole-word (too long for them to be processed in a single fixation), but are larger reading units than graphemes (that entail slow analytical sub-lexical processing)

Derived word

Simple word

CANTANTE

COSTUME

CANT

ANTE

C A N T A N T E

C O S T U M E

- Typically developing readers also benefit of morphemes (reading units shorter than the whole stimulus) but only in:

  - Pseudowords
  - Low-frequency words

i.e., stimuli that would be read via smaller units (graphemes and phonemes) in case morphemic constituents were absent

- Readers with dyslexia read consistently faster morphologically complex stimuli, both

  - Pseudowords and Words (Burani et al., 2008)
  - High- and Low-frequency words (Marcolini et al., 2011)

- Morpheme-based reading speed is a main function of the **Root** (Traficante et al., 2011) that provides a head-start to morphemic decomposition (Bertram & Hyönä, 2003)

THE PRESENT STUDY :

Does root length modulate children's morphemic processing?

NASINO	CAVALLINO
(small nose)	(young horse)

- Longer roots are more informative access units with less lexical competitors than shorter ones, but they require an intact eye-scanning system to be processed as a unit in a single fixation (Rayner, 1979; O' Regan et al., 1984; Hyönä et al., 2017)

NASINO	CAVALLINO
(small nose)	(young horse)

- Long roots should be processed efficiently by good readers, but might exceed the visual scanning capacities of a dyslexic reader
- Prediction: Long roots promote faster lexical access and reading speed in typically developing readers only

Participants:

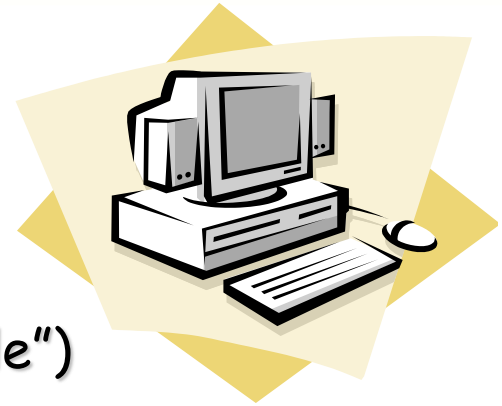
- Forty typically developing 6th graders
  Within normal limits for reading speed and accuracy

- Twenty 6th grade readers with dyslexia
  Marked reading delay on a standard reading battery for either speed or accuracy or both. IQ level within normal limits.

Matched for gender, age and non-verbal intelligence (Raven test)

Word naming

(Reading aloud task: "Read it aloud as fast and as accurately as possible")



Dependent measures:

- RTs (onset of pronunciation)
- Accuracy

Materials

Sixty **low-frequency** (0-56 per million) words, with a root and a derivational suffix (*e.g.*, **PIED-INO**, 'little foot').

Othographically, phonologically and semantically transparent; all with familiar roots and suffixes.

- Word length **(6-11 letters)**
- Root length **(3-6 letters)**
- Suffix length **(3-5 letters)**

Sixty simple filler words, to prevent a forced parsing strategy

DITONE (big toe) POTENZA (power) SALVEZZA (safety) OCCHIATA (glance)

PAROLACCIA (bad word) SCHERZETTO (joke) LONTANANZA (distance)

Word length - Root length correlation:
$r = .79$

Root length residualized
as predicted from Word length
(Kuperman et al., 2010)

Data Analysis

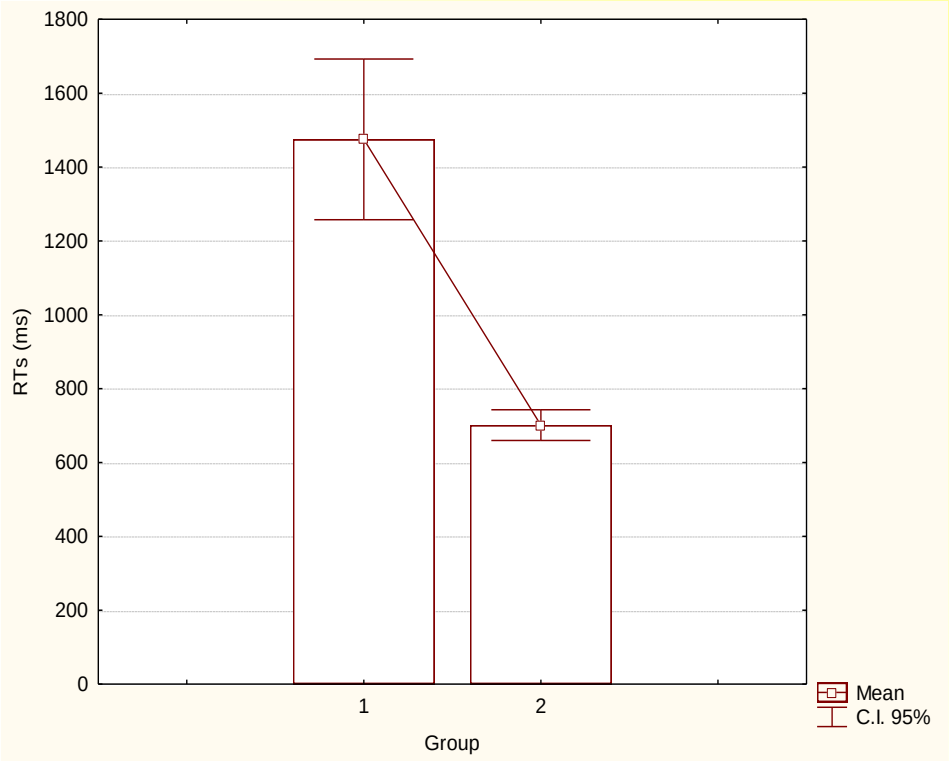
- Linear mixed-effects regression (Baayen *et al*., 2008) on RTs
- Generalized mixed-effects regression on Errors

Fixed effect Predictors :

- Word frequency
- Word length
- Root frequency
- Root family size
- Root length
- Suffix frequency
- Suffix productivity

All frequency (tokens) and numerosity (types) measures calculated on a **written child frequency count.**

RTs raw data



Children with dyslexia

M = 1475 ms

Typically developing children

M = 701 ms

Due to the large difference between groups both in mean values and in dispersion measures, analyses of data were carried out within each group separately

Analysis on RTs

Typically developing children

Random effects	*SD*		
Participant	**0.163942**		
Item	**0.047742**		
Residual	**0.147817**		
Fixed effects	***Estimate***	***t value***	***pMCMC***
(Intercept)	**6.649216**	**112.05**	**0.0001**
Word Length	**0.035650**	**4.69**	**0.0001**
Root Frequency	**-0.024713**	**-2.82**	**0.0050**
Root Length	**-0.022230**	**-2.79**	**0.0052**
Suffix Product.	**-0.014995**	**-2.00**	**0.0398**
Suffix Freq. x SuffixProduct.	**0.026961**	**2.05**	**0.0340**

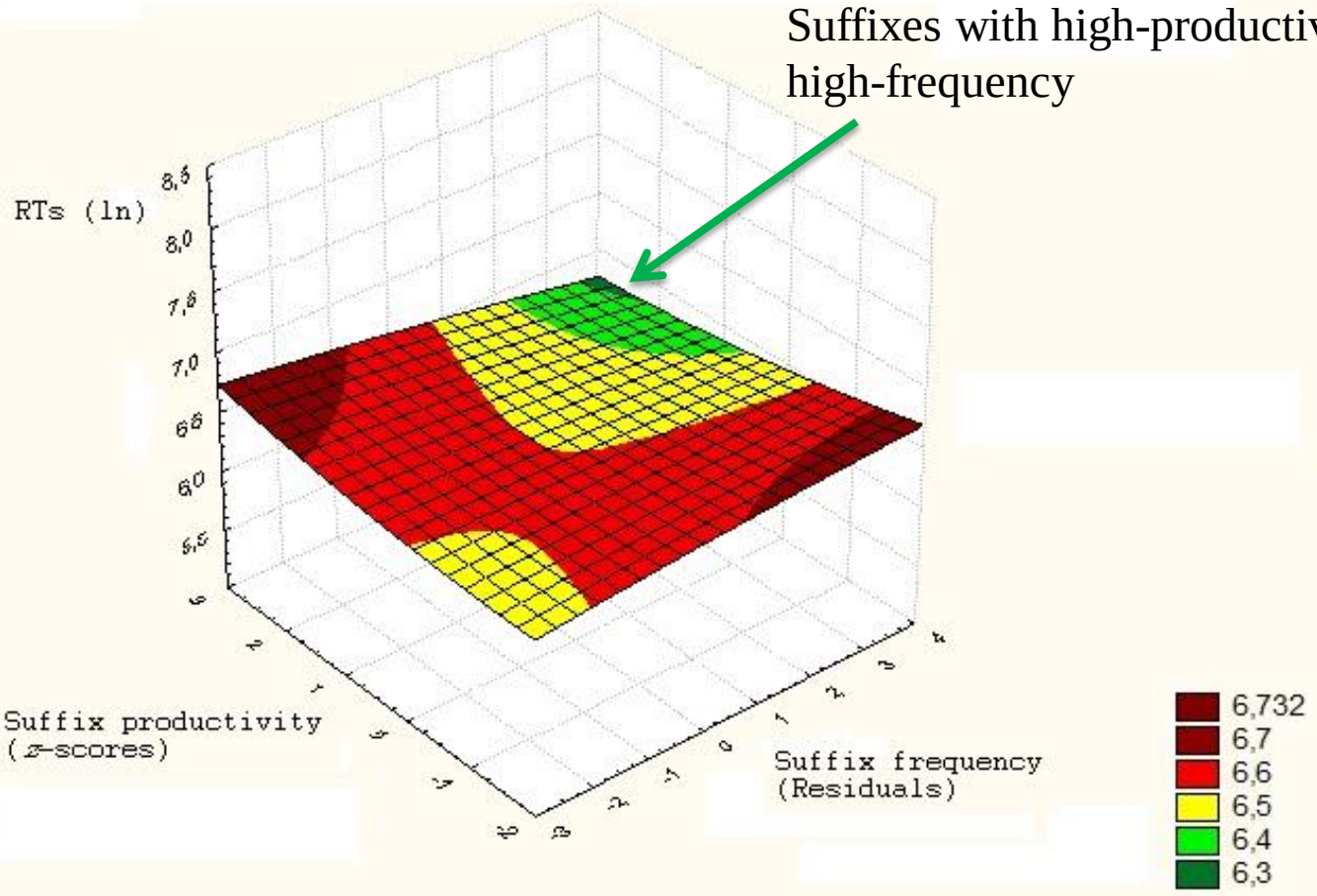
Analysis on RTs

Typically developing children				Children with dyslexia		
Random effects	***SD***			***SD***		
Participant	**0.163942**			**0.295547**		
Item	**0.047742**			**0.062495**		
Residual	**0.147817**			**0.324213**		
Fixed effects	***Estimate***	***t value***	***pMCMC***	***Estimate***	***t value***	***pMCMC***
(Intercept)	**6.649216**	**112.05**	**0.0001**	**7.46124**	**64.50**	**0.0001**
Word Length	**0.035650**	**4.69**	**0.0001**	**0.04460**	**3.43**	**0.0006**
Root Frequency	**-0.024713**	**-2.82**	**0.0050**	**-0.04854**	**-3.12**	**0.0022**
Root Length	**-0.022230**	**-2.79**	**0.0052**			
Suffix Product.	**-0.014995**	**-2.00**	**0.0398**			
Suffix Freq. x SuffixProduct.	**0.026961**	**2.05**	**0.0340**			

Typically Developing Children

Suffix frequency x Suffix productivity

Faster RTs:
Suffixes with high-productivity and high-frequency



Slower RTs:

- Suffixes with high-productivity and low-frequency
- Suffixes with low-productivity and high-frequency

Accuracy

Typically developing readers: 2.2 % Errors

Children with dyslexia: 9.6 % Errors

Typically Developing Children

Accuracy

Random effects	*SD*			
Participant	**0.34567**			
Item	**0.59047**			
Fixed effects	***Estimate***	***Std.Error***	***zvalue***	***Pr(>|z|)***
(Intercept)	**3.6940**	**0.2548**	**14.497**	**<2e-16**
Word Frequency	**0.2296**	**0.1167**	**1.967**	**0.0492**
Suffix Product.	**0.4131**	**0.1889**	**2.187**	**0.0287**

Children with Dyslexia

Accuracy

Random effects	*SD*			
Participant	0.61867			
Item	0.40200			
Fixed effects	*Estimate*	*Std.Error*	*zvalue*	*Pr(>|z|)*
(Intercept)	2.20057	0.22578	9.746	<2e-16
Word Frequency	0.16193	0.07734	2.094	0.036286
Suffix Product.	0.44018	0.12835	3.429	0.000605

Summary and conclusions : RTs

- The facilitatory effect of root frequency along with the absence of a word frequency effect indicate morphemic processing in all readers.

Summary and conclusions : RTs

- The reversed facilitatory effect of root length in typical readers, over and above the inhibitory effect of word length, indicates more likely activation for longer roots: at similar word lengths, the longer the root, the faster the response

Summary and conclusions : RTs

- The effect of suffix productivity for typical readers suggests that parafoveal morphological information may affect children's speed of processing

Summary and conclusions : RTs

- For readers with dyslexia the facilitation of root frequency in the absence of an effect of word frequency and irrespective of root length suggests a main role of root activation that helps to bypass difficulties in processing whole-words within a single fixation and increases processing speed

Why **Suffix** effect on reading **accuracy**?

(Traficante et al., 2011)

The **Suffix**

- is a strong cue for lexical status

  (Quémart, Casalis, & Duncan, 2012)

- is a **stress attractor**

  (Jarmulowicz, Taran, & Hay, 2007; 2008)

- facilitates co-articulation

  of the morphemic combination in reading aloud

Assembling the pronunciation of (bound) root and suffix after parsing implies re-assigning

Stress

to the complex word (relative to root stress) and planning a new co-articulation of the morphemic combination

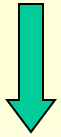
'VETRO	VE'TRAIO
(glass)	(glazier)

Morphological effects indicate

use of **Roots** and **Suffixes**

as reading units of a larger grain size

than the single letter/phoneme



Morphemes reduce the limitations in stimulus scanning in reading and increase **Fluency**

Thank you