



Attivare il cervello: la stimolazione cerebrale non invasiva

**GIORNATE DI
NEUROPSICOLOGIA
DELL'ETÀ EVOLUTIVA
XI edizione
20 - 23 gennaio 2016**

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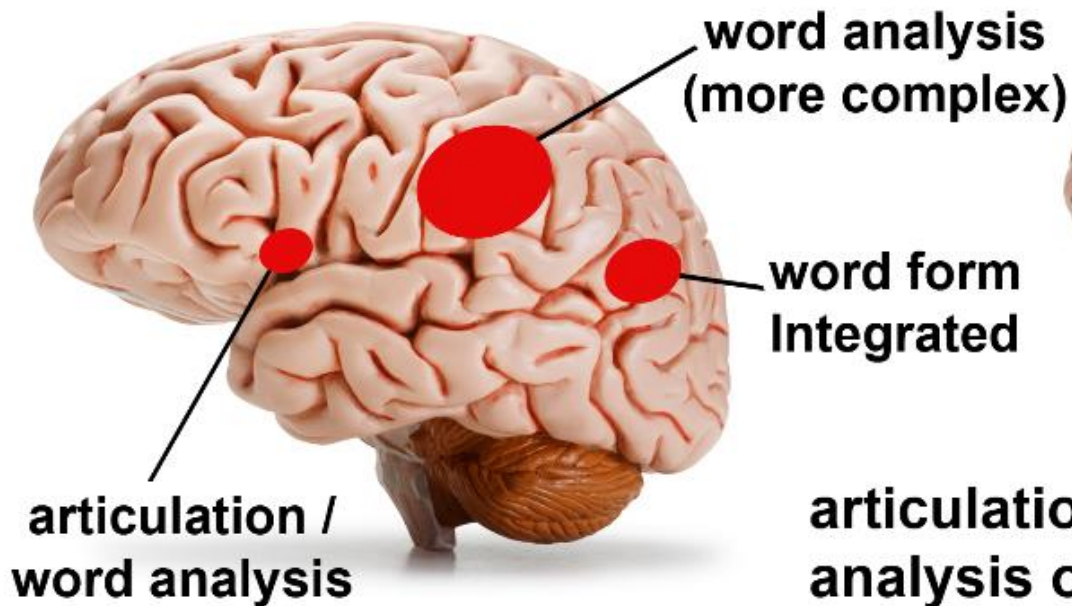
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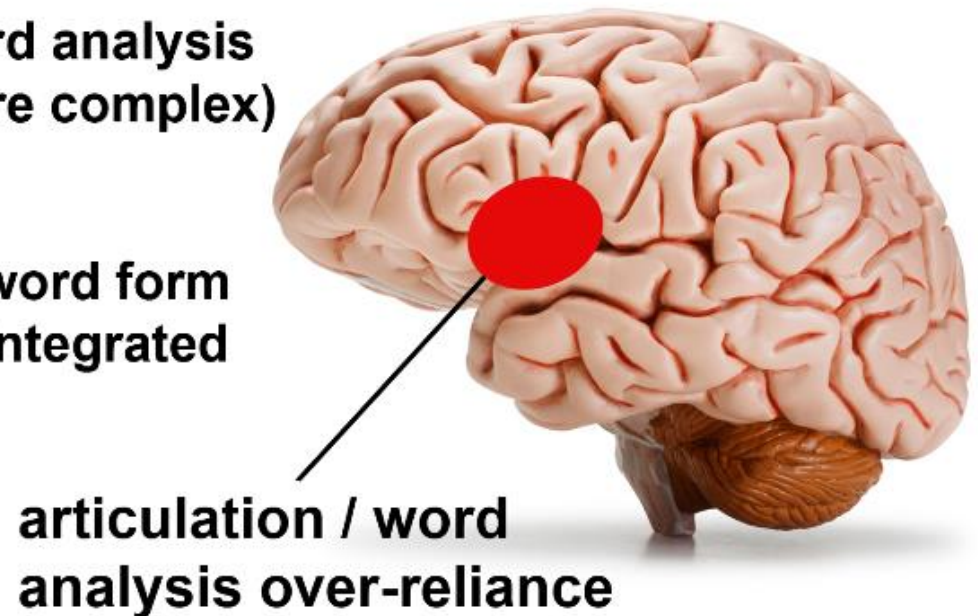
Bambino Gesù
OSPEDALE PEDIATRICO

ALTERAZIONI CEREBRALI NEI DISLESSICI

Non - Impaired Reader



Reader with Dyslexia



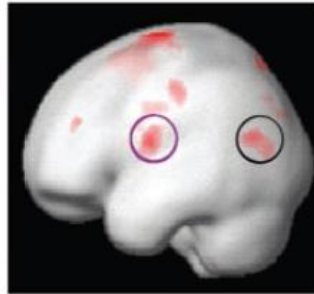
Neural deficits in children with dyslexia ameliorated by behavioral remediation: Evidence from functional MRI

Elise Temple^{††}, Gayle K. Deutsch[§], Russell A. Poldrack[¶], Steven L. Miller[¶], Paula Tallal^{||††}, Michael M. Merzenich^{||††}, and John D. E. Gabrieli^{†§}

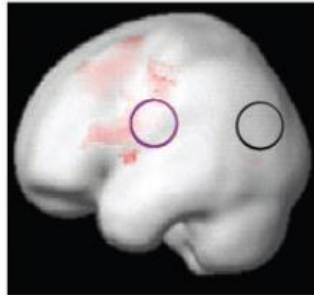
2860–2865 | PNAS | March 4, 2003 | vol. 100 | no. 5

A Children with no remediation

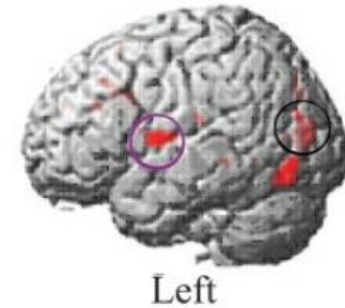
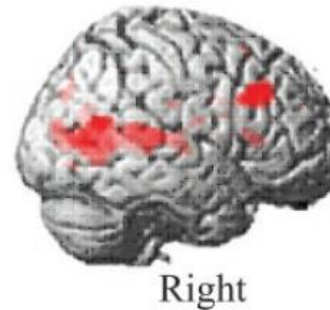
Normal reading children
while rhyming



Dyslexic reading children
while rhyming
before remediation



B Dyslexic children increases after remediation



Training linguistico e di processamento uditivo

Correlazione tra

Attivazione temporo-parietale sx e miglioramento lettura
(normalizzazione)

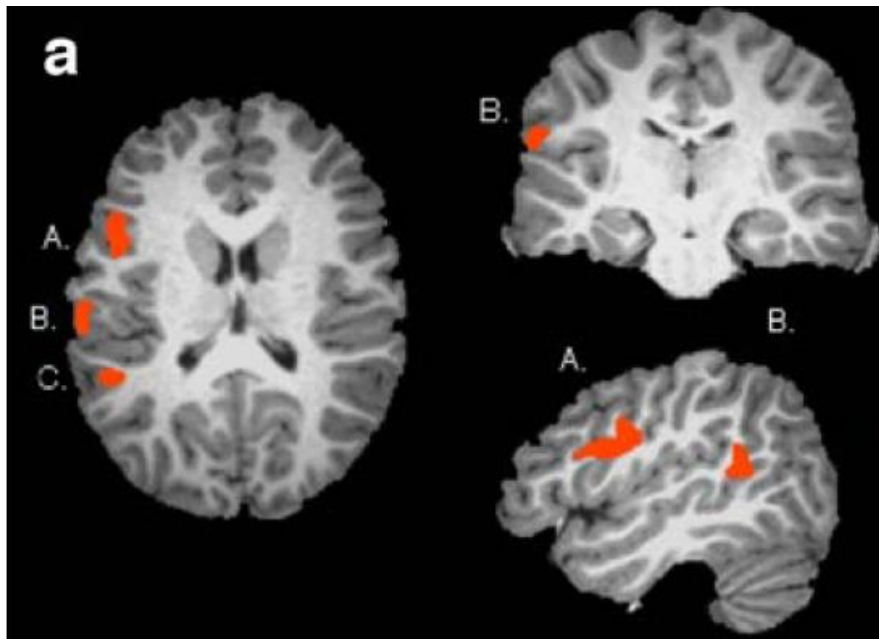
Attivazione compensatoria in altre regioni cerebrali

Differentiating the neural response to intervention in children with developmental dyslexia

Timothy N. Odegard • Jeremiah Ring •
Stephanie Smith • John Biggan • Jeff Black

Ann. of Dyslexia (2008) 58:1–14
DOI 10.1007/s11881-008-0014-5

Trattamento: consapevolezza fonologica, fonetica, fluenza, lessico (90 min 4v)



Differenza nella risposta
individuale al trattamento

RISPONDENTI:
Normalizzazione L-IPL e L-STG
Compensazione R-IFG

TRATTAMENTO

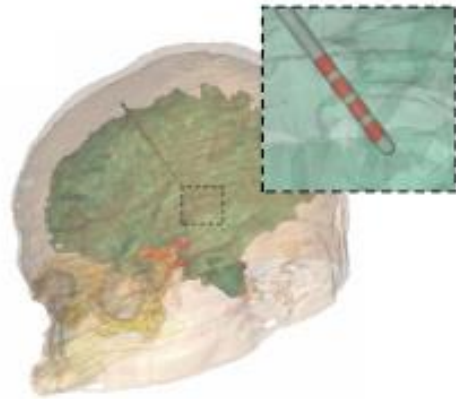
- ✓ trattamento migliora le abilità di lettura
- ✓ agisce anche sull'attivazione corticale in aree critiche
- ✓ normalizzazione o compensazione

Cambiamenti attività cerebrale possono essere per se stessi un meccanismo necessario per il miglioramento comportamentale (Stuss et al., 2011).

Futuro promettente
per la riabilitazione cognitiva



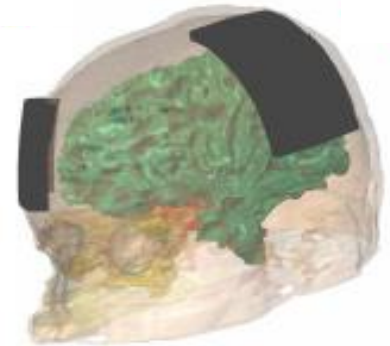
STIMOLAZIONE CEREBRALE



**Deep
Brain
Stimulation**

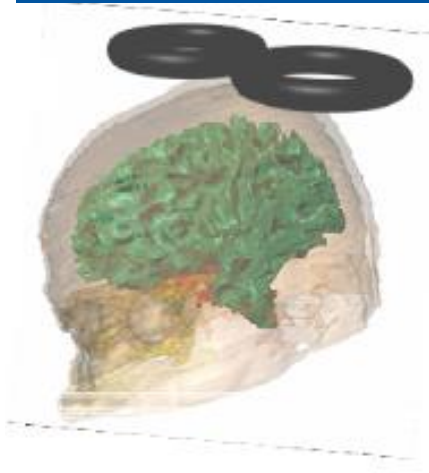


**Transcranial
Magnetic
Stimulation**



**Transcranial
Direct
Current
Stimulation**

STIMOLAZIONE CEREBRALE NON-INVASIVA



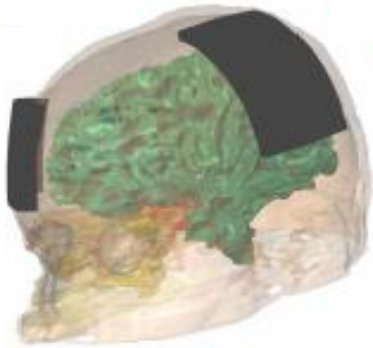
Transcranial Magnetic Stimulation

Coil sullo scalpo genera campo magnetico che determina corrente elettrica nel cervello

Depressione, Emicrania, Disturbi psichiatrici e cognitivi

- ✓ Abbastanza focale
- ✓ Non invasiva
- ✓ Abbastanza sicura
- ✓ Costosa

STIMOLAZIONE CEREBRALE NON-INVASIVA



Transcranial Direct Current Stimulation

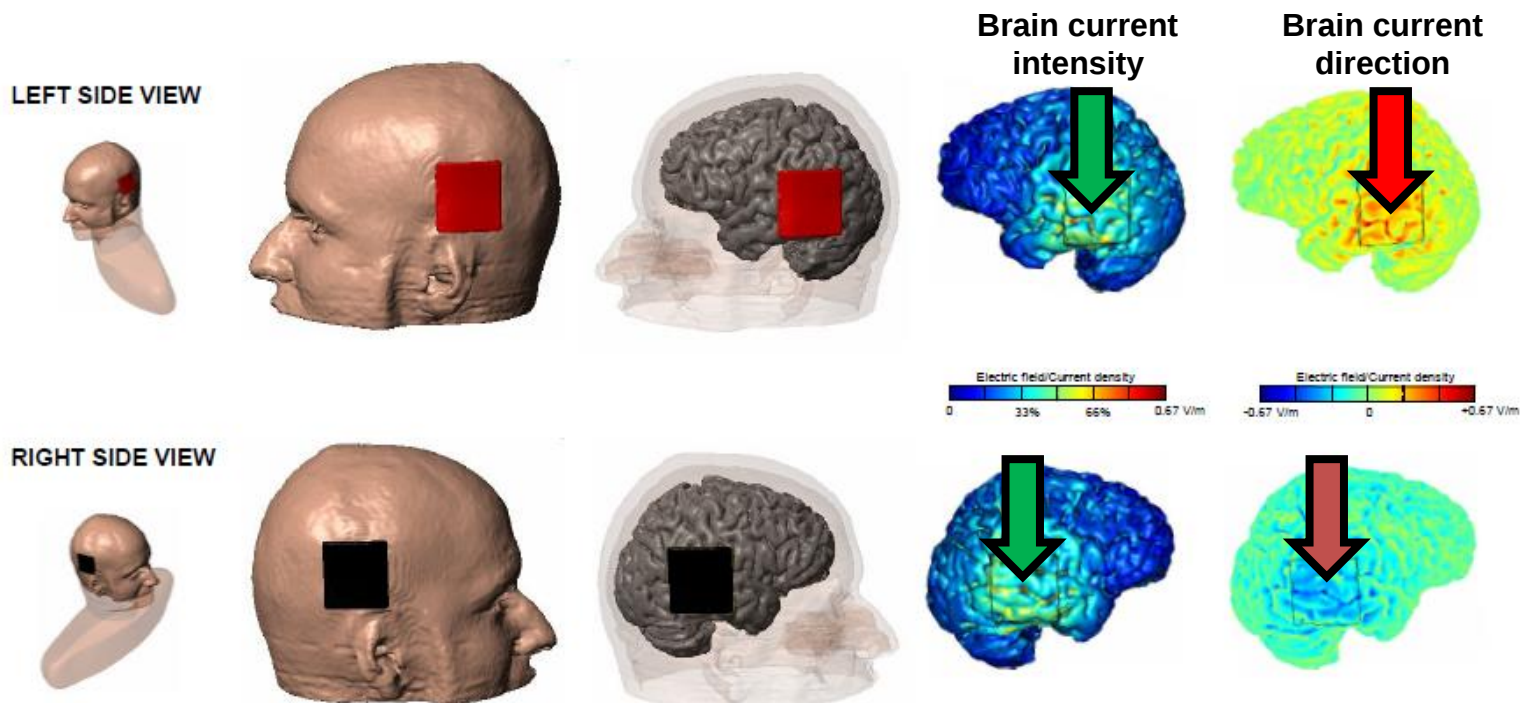
Elettrodi sullo scalpo inviano corrente elettrica debole (tra 1 e 2 mA) nel cervello

Abilità cognitive, disturbi psichiatrici, dolore cronico

- ✓ Non focale
- ✓ Non invasiva
- ✓ Sicura
- ✓ Non costosa

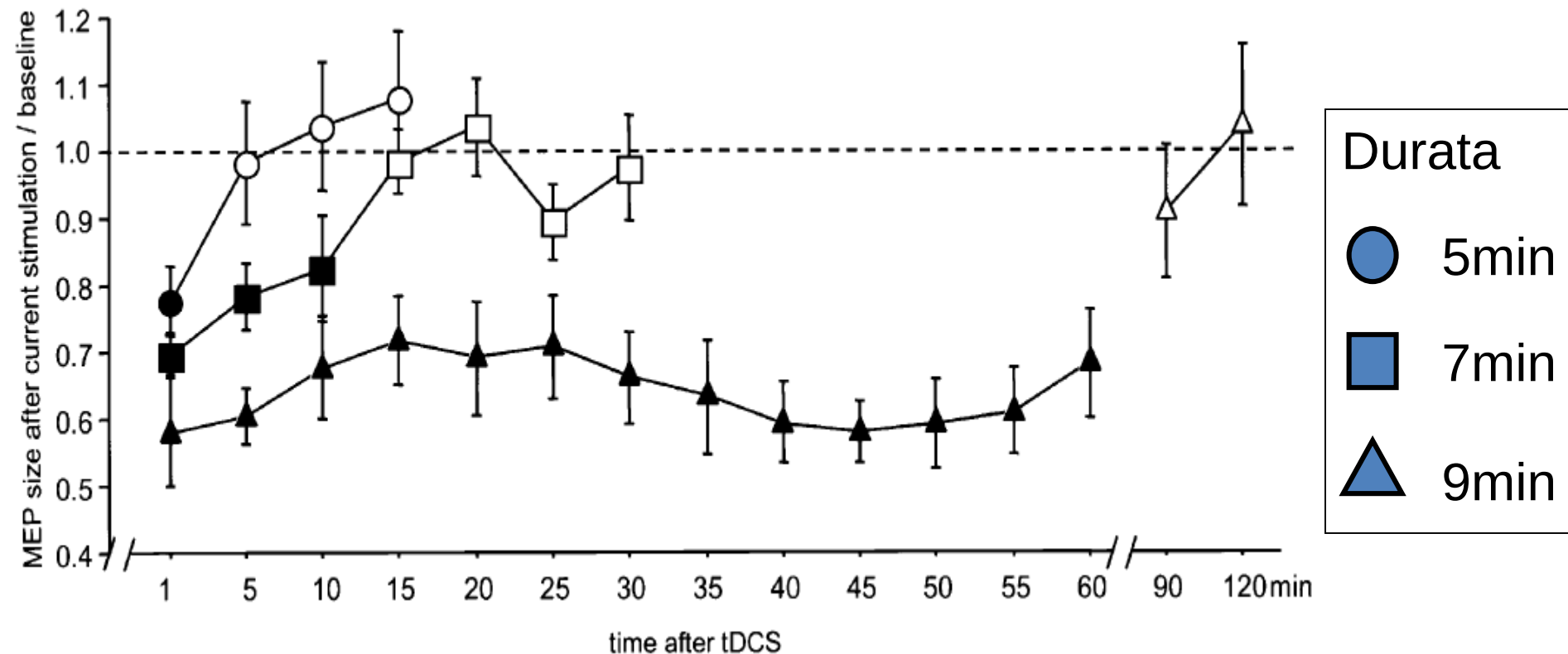
tDCS

- ✓ 2 elettrodi connessi da una stimolatore di corrente continua
- ✓ flusso di corrente fra ANODO (+) e CATODO (-)
- ✓ la corrente verso l'INTERNO sotto l'ANODO
e verso l'ESTERNO sotto il CATODO



tDCS EFFETTO PERSISTENTE

- ✓ persiste dopo la fine della stimolazione
- ✓ più minuti di stimolazione più lento il ritorno alla baseline



tDCS TOLLERABILITÀ IN ETÀ EVOLUTIVA



ELSEVIER

Contents lists available at [ScienceDirect](http://www.sciencedirect.com)

Brain Stimulation

journal homepage: www.brainstimjrn.com

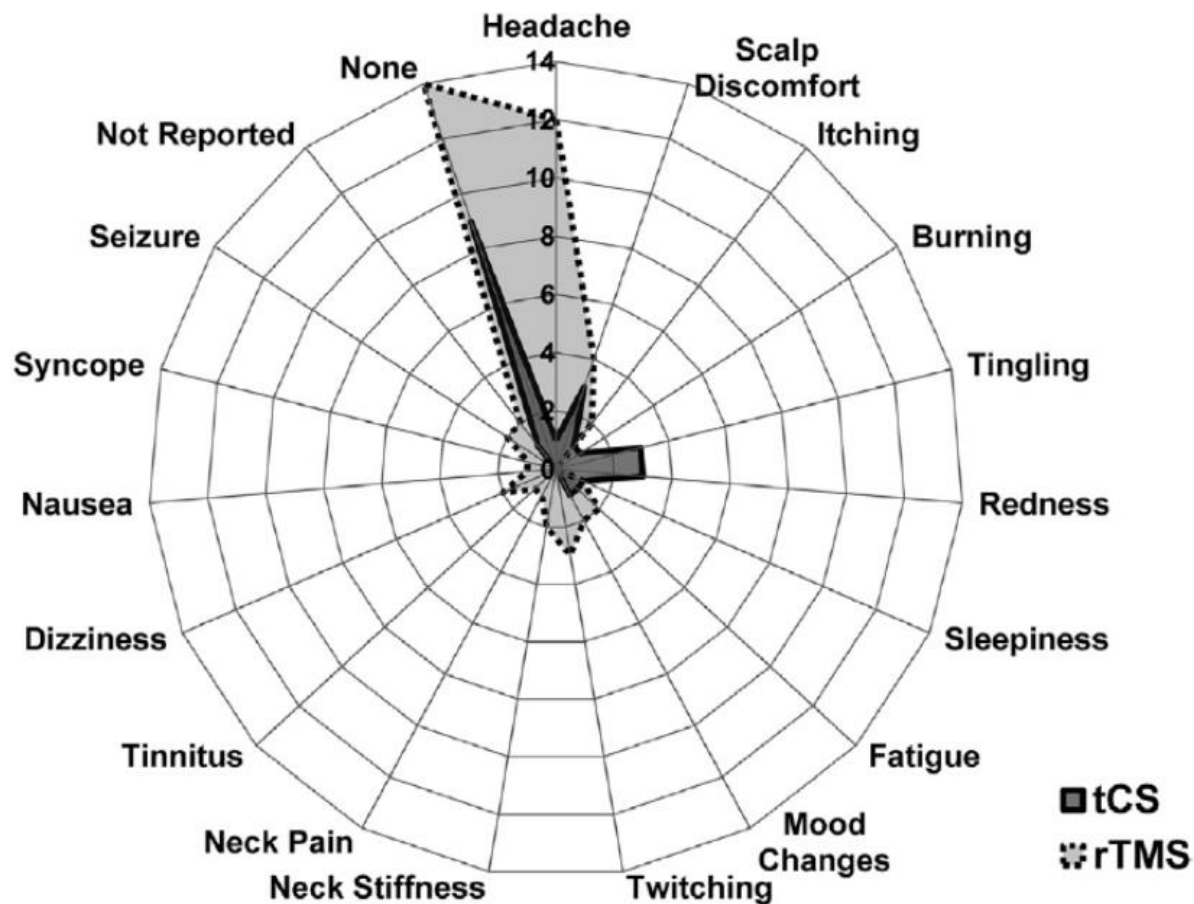
Review Article

Safety of Noninvasive Brain Stimulation in Children and Adolescents

Chandramouli Krishnan^{*,1}, Luciana Santos¹, Mark D. Peterson, Margaret Ehinger

51 STUDI : 35 rTMS – 16 tDCS

513 bambini – 2,5-17,8 aa



STIMOLAZIONE CEREBRALE E DISLESSIA

Intervenire su:

AREE CEREBRALI TIPICAMENTE IPOATTIVE NELLA DE

AREE CEREBRALI ATTIVATE DA UN EFFICACE TRAINING



Strumento **complementare** dei protocolli di trattamento standard?

Velocizzare e **consolidare i cambiamenti neurofisiologici** che sottostanno al trattamento comportamentale

Nei normolettori adulti

TMS E LETTURA

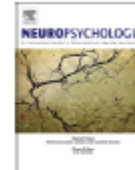
Neuropsychologia 50 (2012) 2645–2651



Contents lists available at SciVerse ScienceDirect

Neuropsychologia

journal homepage: www.elsevier.com/locate/neuropsychologia



High frequency rTMS over the left parietal lobule increases non-word reading accuracy

Florian Costanzo^a, Deny Menghini^a, Carlo Caltagirone^{b,c}, Massimiliano Oliveri^{b,d}, Stefano Vicari^{a,*}

■ Words ■ Non-words □ Text

singola sessione (6 min)

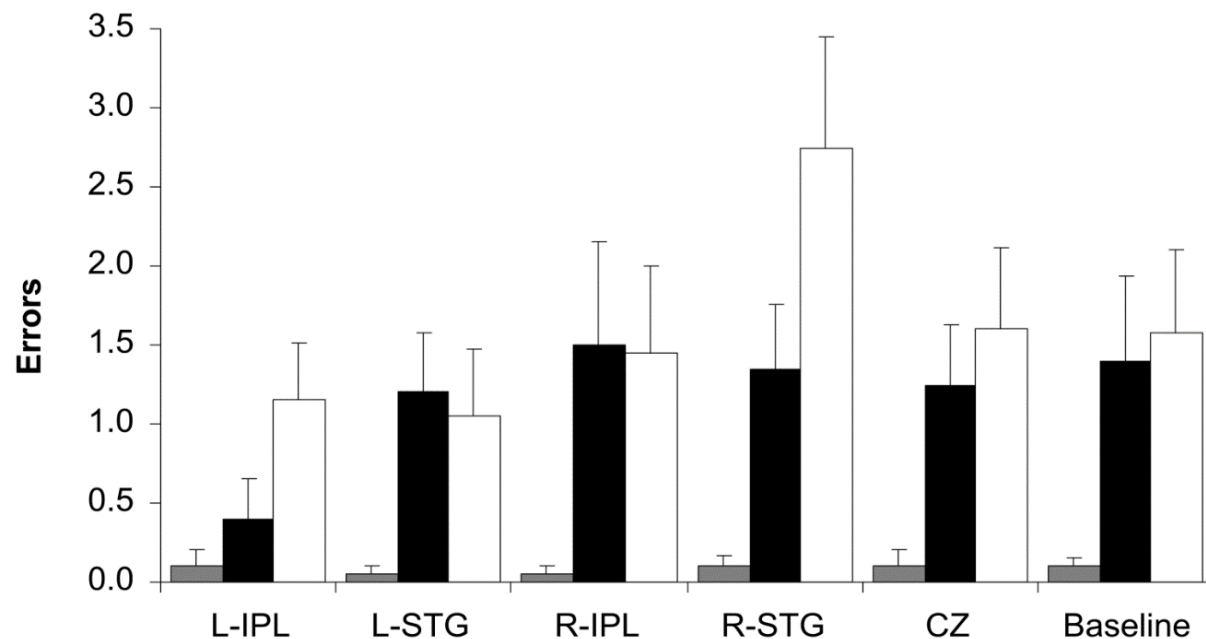
rTMS facilitatoria 5 HZ

10 normolettori

Risultati errori:

L-IPL < non parole

R-STG > brano



tDCS E LETTURA

Brain Stimulation (2012) 5, 201–7



Left lateralizing transcranial direct current stimulation improves reading efficiency

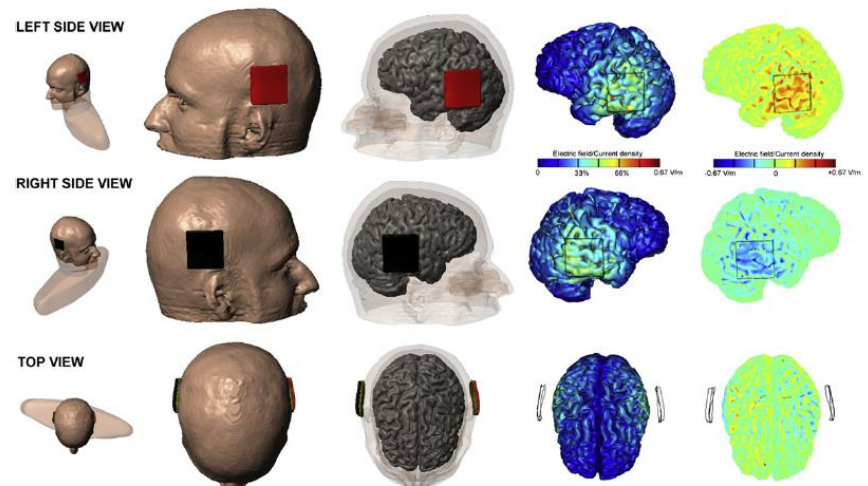
Peter E. Turkeltaub,^a Jennifer Benson,^a Roy H. Hamilton,^a Abhishek Datta,^b Marom Bikson,^b H. Branch Coslett^a

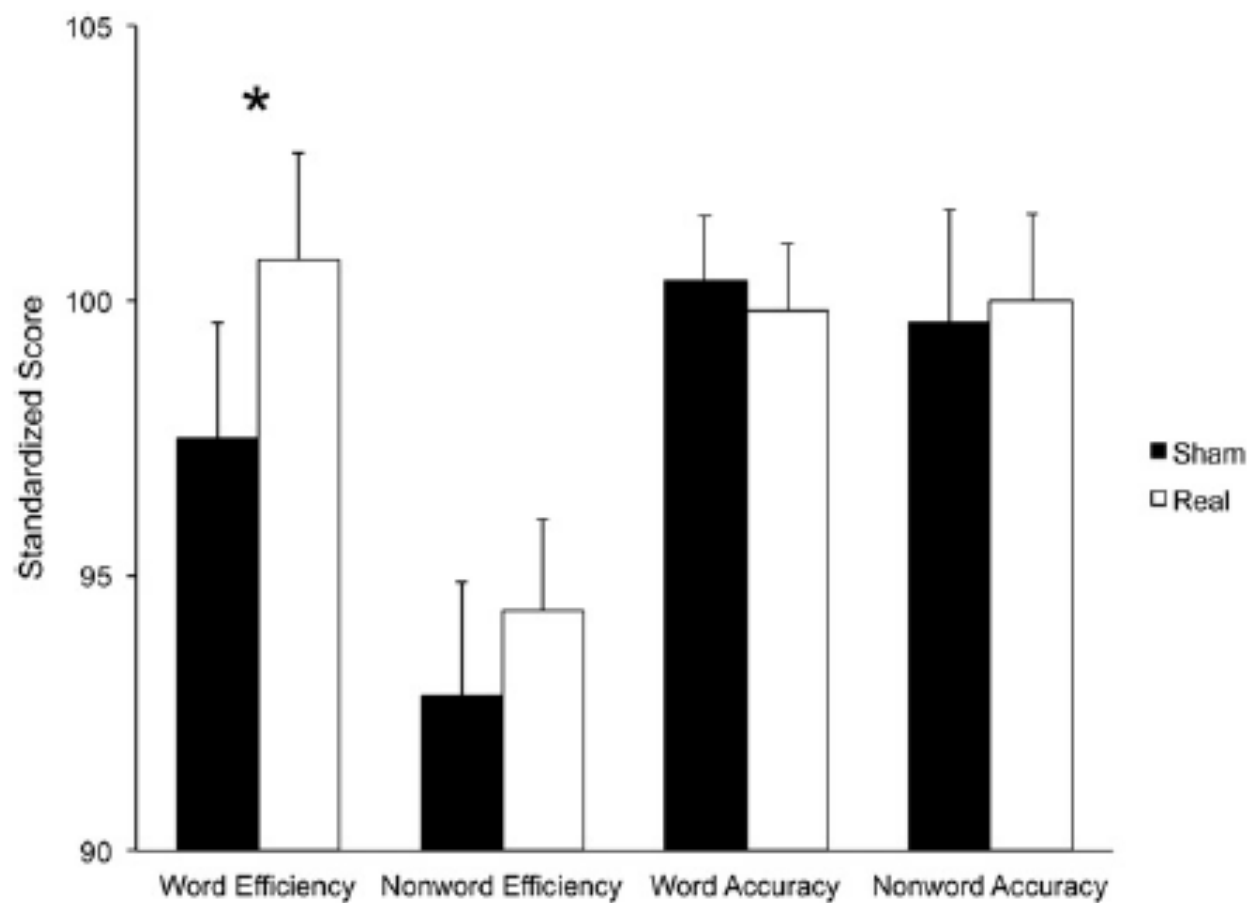
25 (15 F)

SITI: R- e L- pTC

Stimolazione reale e SHAM

1.5 mA di corrente (20 min)





Interazione con il grado di abilità di lettura

tDCS E LETTURA



Transcranial direct current stimulation modulates efficiency of reading processes

Jennifer M. Thomson^{1*}, Deniz Doruk², Bryan Mascio¹, Felipe Fregni² and Carlo Cerruti¹

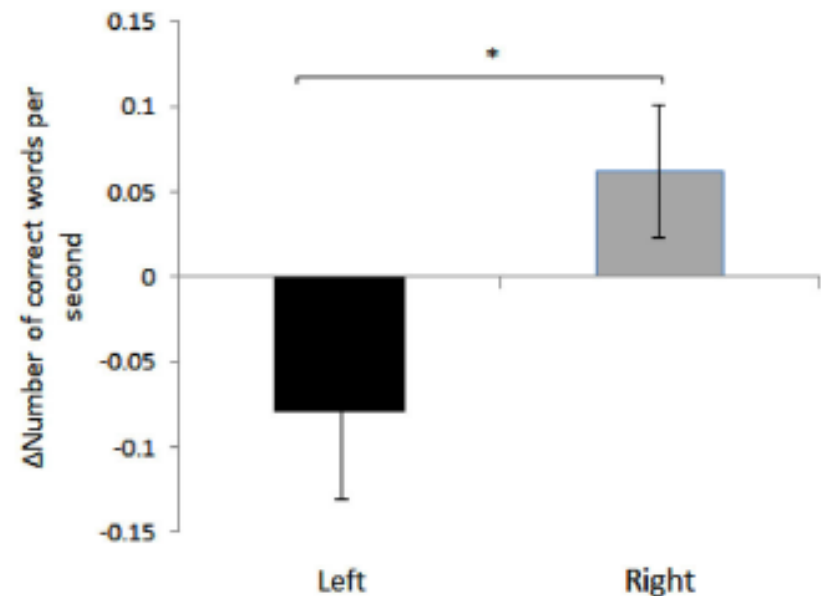
39 normolettori

SITI: Area Wernicke L/R (CP5;CP6)

- Stimolazione anodica e catodica
(referente orbito-frontale)

- no SHAM

2 mA di corrente (20 min)



Nei dislessici adulti

TMS E DISLESSIA

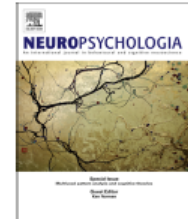
Neuropsychologia 51 (2013) 2953–2959



Contents lists available at ScienceDirect

Neuropsychologia

journal homepage: www.elsevier.com/locate/neuropsychologia



How to improve reading skills in dyslexics: The effect of high frequency rTMS



Floriana Costanzo^a, Deny Menghini^a, Carlo Caltagirone^{b,c}, Massimiliano Oliveri^{b,d}, Stefano Vicari^{a,*}

singola sessione (6 min)

rTMS facilitatoria, 5 HZ

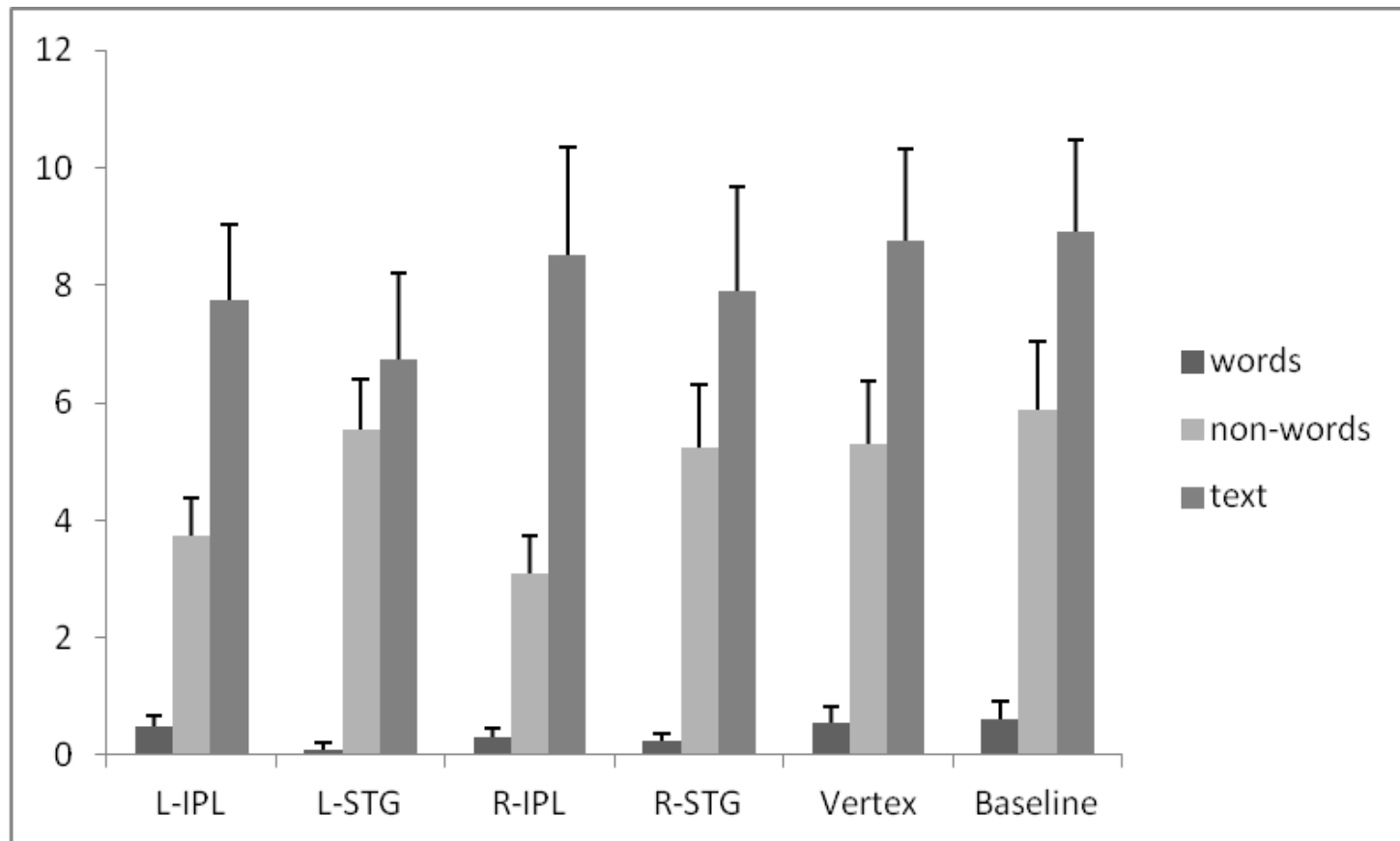
10 dislessici



TMS E DISLESSIA



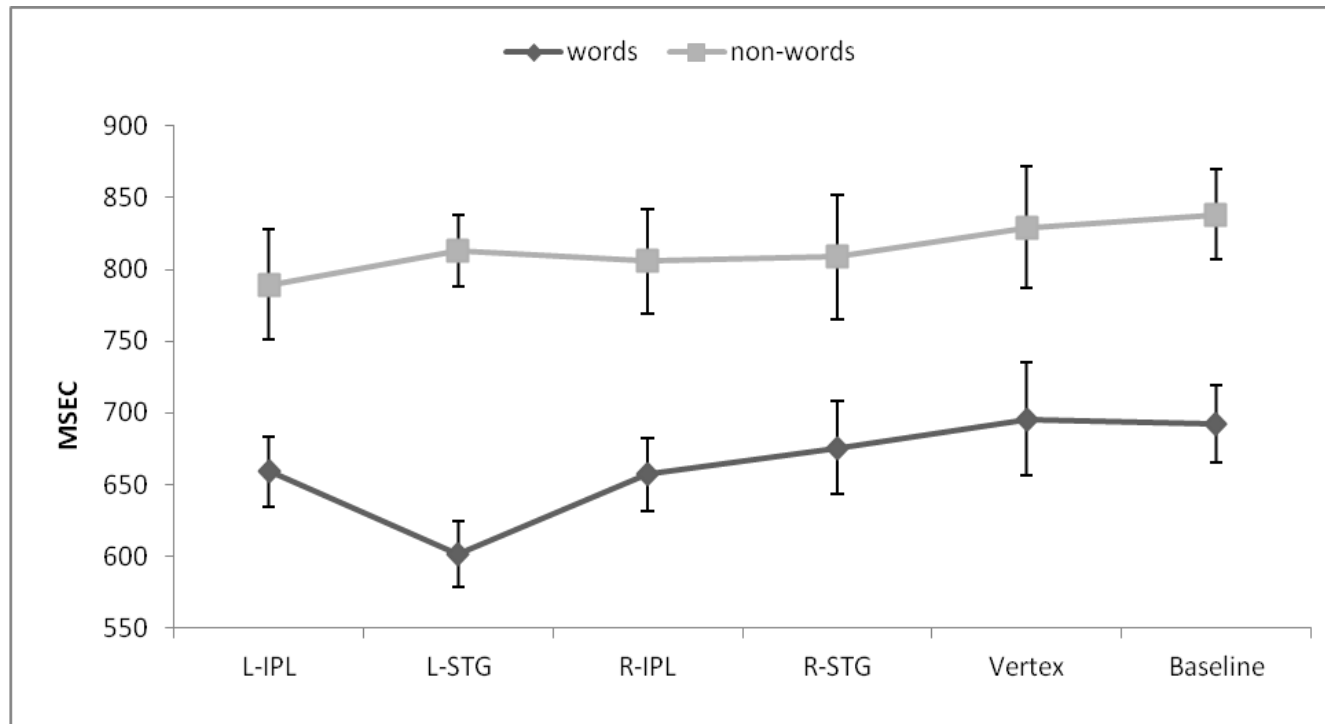
RIDUZIONE ERRORI
Sito e task specifico



TMS E DISLESSIA



RIDUZIONE ONSET Sito e task specifico



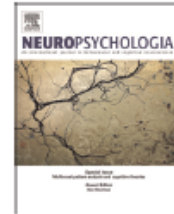
tDCS E DISLESSIA



Contents lists available at [ScienceDirect](#)

Neuropsychologia

journal homepage: www.elsevier.com/locate/neuropsychologia



Improved reading measures in adults with dyslexia following transcranial direct current stimulation treatment



Inbahl Heth^a, Michal Lavidor^{b,*}

	<i>N</i>	Gender	Age	Years of education
Anodal	10	4 Males	27.2(7.2)	13.8(1.5)
Sham	9	5 Males	24.5(5.2)	13.4(1.3)

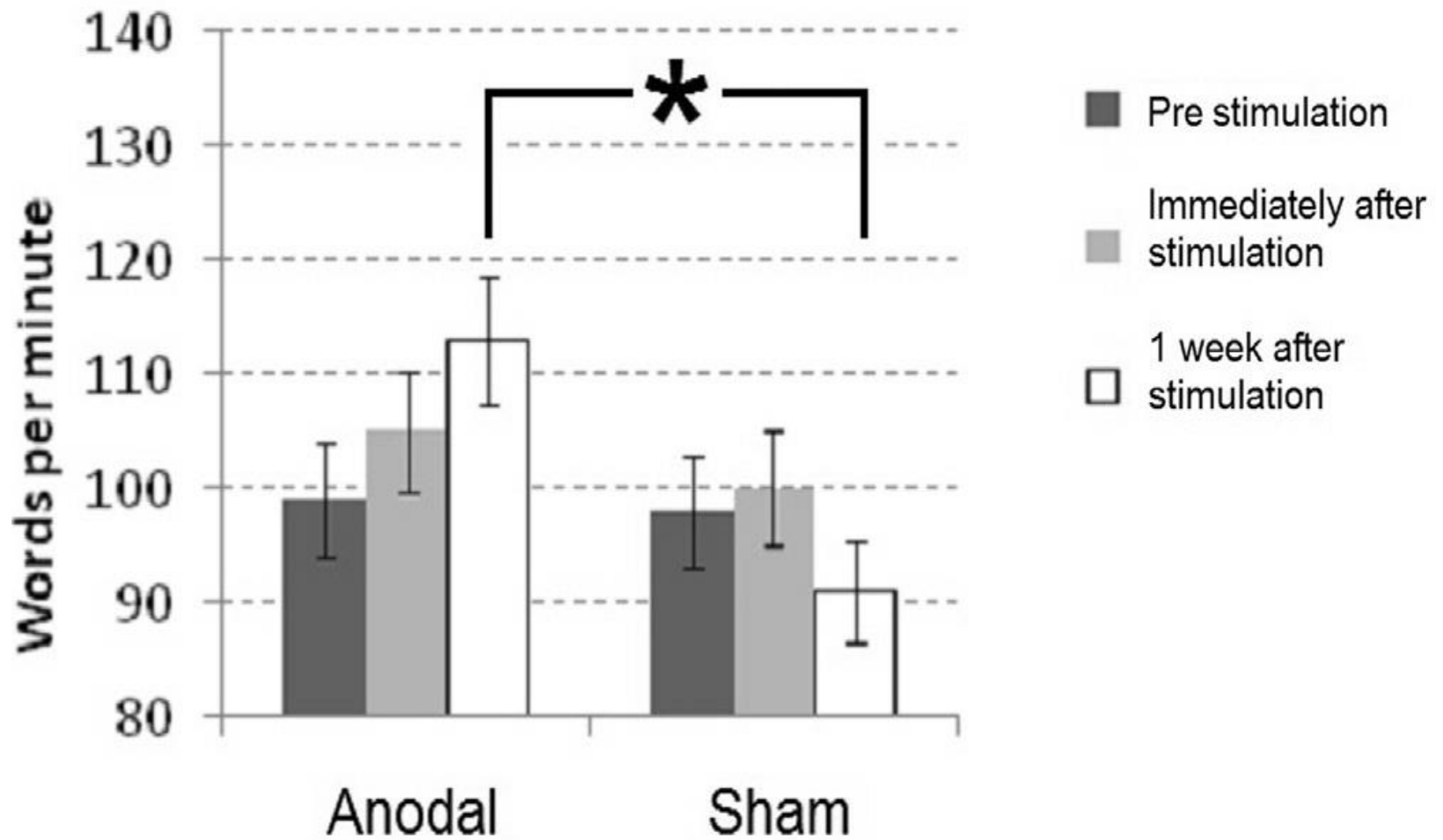
1.5 mA corrente (20 min)

Anodica V5/MT

REALE e SHAM

5 giorni consecutivi

tDCS E DISLESSIA



Nei dislessici in età pediatrica

tDCS E DISLESSIA IN ETA' PEDIATRICA

Reading changes in children and adolescents with dyslexia after transcranial direct current stimulation

Costanzo F. , Varuzza C. , Rossi S. , Sdoia S. , Varvara P. , Oliveri M. , Koch G. , Vicari S. and Menghini D.

Neuroreport (In press)

Definire parametri per la tDCS in bambini e adolescenti dislessici:

- ✓ Polarità di stimolazione?
- ✓ Potenzialità di una singola sessione?



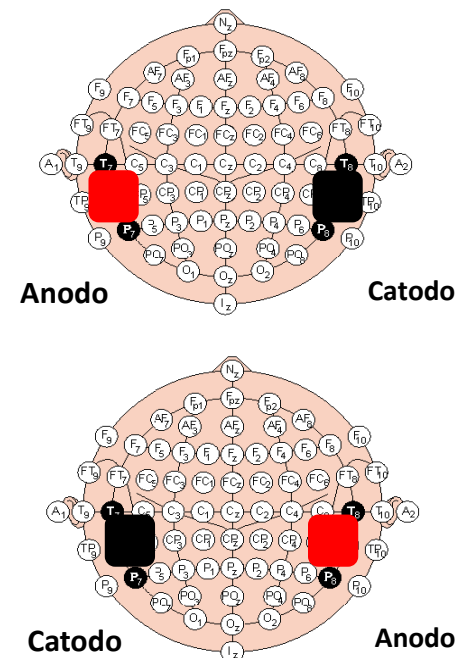
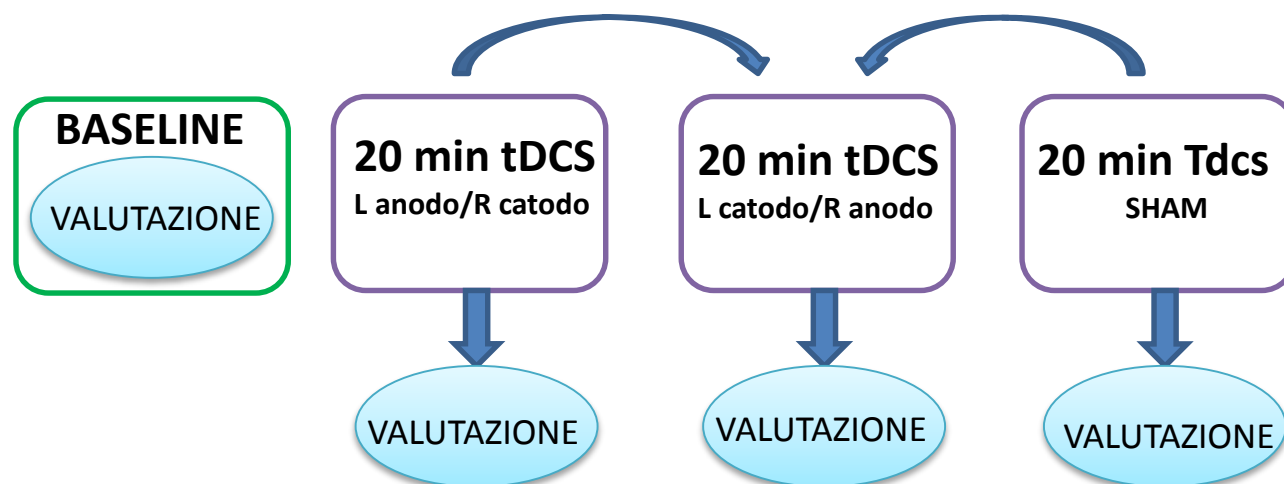
tDCS E DISLESSIA IN ETA' PEDIATRICA

Reading changes in children and adolescents with dyslexia after transcranial direct current stimulation

METODO

✓ AUMENTO LATERALIZZAZIONE parieto-temporale SX

✓ AUMENTO LATERALIZZAZIONE parieto-temporale DX



METODO

DISEGNO:

DOPPIO CIECO, assegnazione RANDOM condizioni

PARTECIPANTI:

19 dislessici destrimani (età 10,1 – 17,8)

MATERIALI: 4 liste paralleleLETTURA

Testo

Parole ad alta frequenza

Parole a bassa frequenza

Non parole

DECISIONE LESSICALESINTESI FONEMICAWORKING MEMORY

N-back verbale

RAPID NAMING

Lettere

Colori

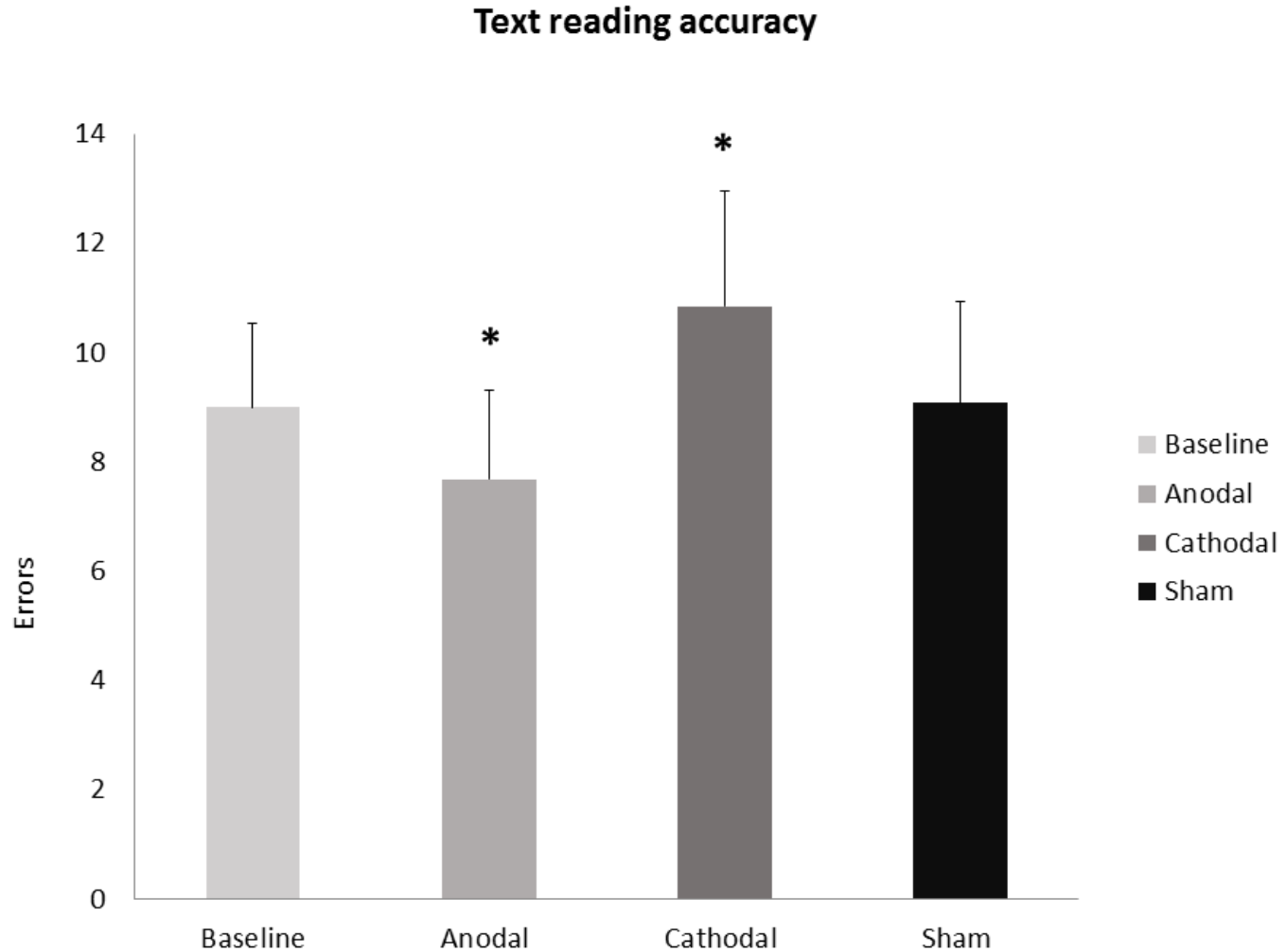
CONFRONTO ANODICA E CATODICA

Reading changes in children and adolescents with dyslexia after transcranial direct current stimulation

	Baseline	Left anodal/right cathodal	Right anodal/left cathodal	Sham	$F_{3,51}$	P	ηp^2
	M $\pm$ SD	M $\pm$ SD	M $\pm$ SD	M $\pm$ SD			
High Frequency Word errors	1 $\pm$ 1.2	1 $\pm$ 1.5	1.3 $\pm$ 2.4	1.1 $\pm$ 2.6	1.45	0.24	0.08
High Frequency Word times ^a	18.2 $\pm$ 8.7	17.2 $\pm$ 8.3	17.6 $\pm$ 12.1	19.1 $\pm$ 12.2	1	0.41	0.06
Low Frequency Word errors	1.9 $\pm$ 1.7	2 $\pm$ 2.1	2.2 $\pm$ 2.9	1.8 $\pm$ 2.4	1.96	0.13	0.10
Low Frequency Word times ^a	25.3 $\pm$ 12.4	24.7 $\pm$ 12.3	26.9 $\pm$ 20.3	25.9 $\pm$ 13.9	0.68	0.57	0.04
Non-word Reading errors	3.3 $\pm$ 3.2	3.5 $\pm$ 4.3	3.4 $\pm$ 3.5	3.7 $\pm$ 4.1	.73	0.54	0.04
Non-word Reading times ^a	36 $\pm$ 17.2	32.9 $\pm$ 12.5	32.7 $\pm$ 13.2	35.5 $\pm$ 25.5	.93	0.43	0.05
Text Reading errors	9 $\pm$ 6.6	7.7 $\pm$ 7.1	10.8 $\pm$ 9.2	9.1 $\pm$ 8.1	7.21	<.001*	0.30
Text Reading times ^b	37.9 $\pm$ 17.1	38 $\pm$ 18.3	37.5 $\pm$ 19.2	38.9 $\pm$ 18.2	0.38	0.77	0.02
Lexical Decision ^c	1393.6 $\pm$ 304	1203.4 $\pm$ 360.4	1309 $\pm$ 414.7	1289.2 $\pm$ 351.4	1.37	0.26	0.08
Phoneme Blending accuracy ^d	4.8 $\pm$ 2.1	5.3 $\pm$ 2.3	5.9 $\pm$ 2.1	5.8 $\pm$ 2.1	4.12	0.01*	0.20
Phoneme Blending times ^a	34.8 $\pm$ 30.7	26.1 $\pm$ 15.5	28.2 $\pm$ 22.8	30.8 $\pm$ 27	3.18	0.03*	0.20
Verbal N-back score	2.4 $\pm$.6	2.5 $\pm$.5	2.7 $\pm$.4	2.6 $\pm$.5	2.79	< 0.05*	0.10
Letter RAN ^a	3.9 $\pm$ 1.2	3.4 $\pm$.7	3.7 $\pm$.9	4.1 $\pm$ 1.5	1.26	0.30	0.07
Color RAN ^a	5.3 $\pm$ 1.5	4.9 $\pm$ 1.2	4.9 $\pm$ 1.4	5.2 $\pm$ 1.7	.77	0.52	0.05

CONFRONTO ANODICA E CATODICA

Reading changes in children and adolescents with dyslexia after transcranial direct current stimulation



PROSPETTIVE

Finora miglioramenti solo TRANSITORI

Parametro ottimale → aumento lateralizzazione sx

Possibile l'applicazione della stimolazione cerebrale
in protocolli TERAPEUTICI
per miglioramenti lettura a LUNGO TERMINE?



Bambino Gesù
OSPEDALE PEDIATRICO

tDCS E DISLESSIA IN ETA' PEDIATRICA



Progetto finanziato dal Ministero della Salute (Giovani Ricercatori) 2012

Transcranial direct current stimulation in the treatment of dyslexia: a randomized double-blind study



Deny Menghini

**Floriana Costanzo, Cristiana Varuzza, Serena Rossi, Stefano Sdoia,
Pamela Varavara, Massimiliano Oliveri, Giacomo Koch, Stefano Vicari**

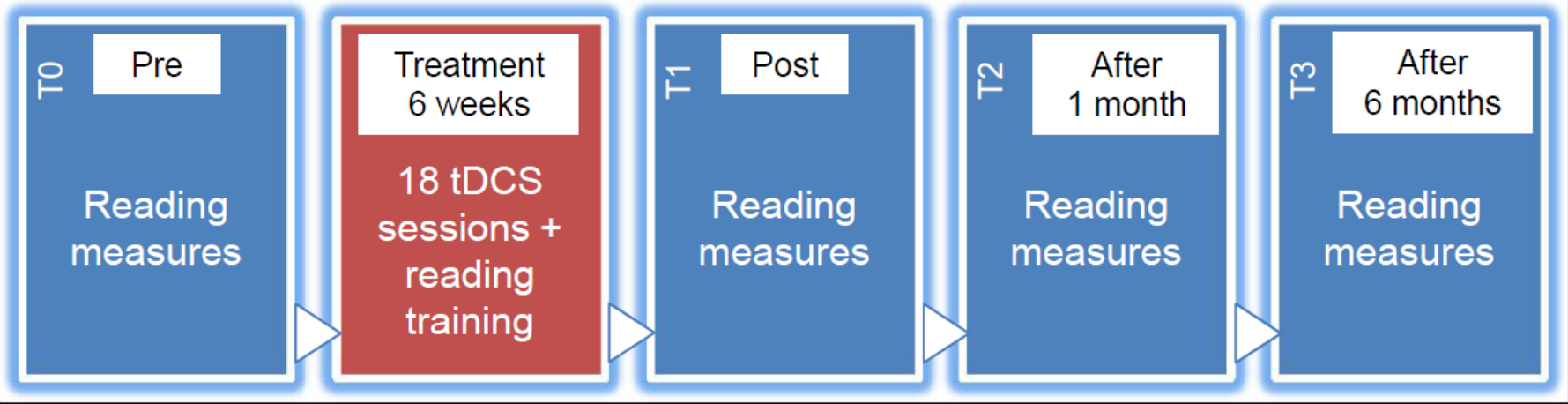
tDCS E DISLESSIA IN ETA' PEDIATRICA

Evidence for reading improvement following tDCS treatment in children and adolescents with Dyslexia

Costanzo F. , Varuzza C. , Rossi S. , Sdoia S. , Varvara P. , Oliveri M. , Koch G. , Vicari S. and Menghini D.

Restorative Neurology and Neuroscience (In press)

Experimental Design



METODO

DISEGNO:

RANDOMIZZATO , CONTROLLATO, DOPPIO CIECO

PARTECIPANTI:

18 dislessici destrimani
(età ≥ 10 anni)

9 tDCS attiva + training cognitivo

9 tDCS placebo + training cognitivo

2 gruppi paragonabili per:

- ✓ età cronologica
- ✓ QI
- ✓ difficoltà di lettura
- ✓ variabili sociali

MATERIALI:

Testo

Parole ad alta frequenza

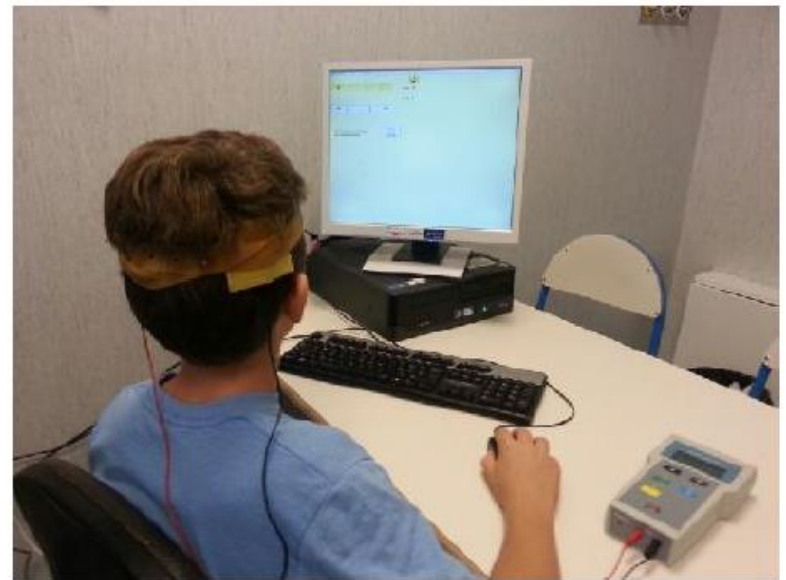
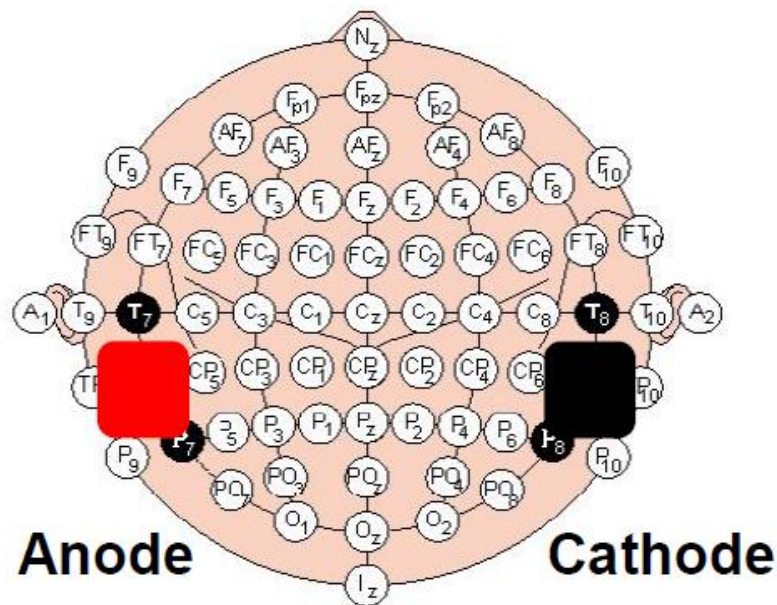
Parole a bassa frequenza

Non parole

(liste parallele)

SET UP

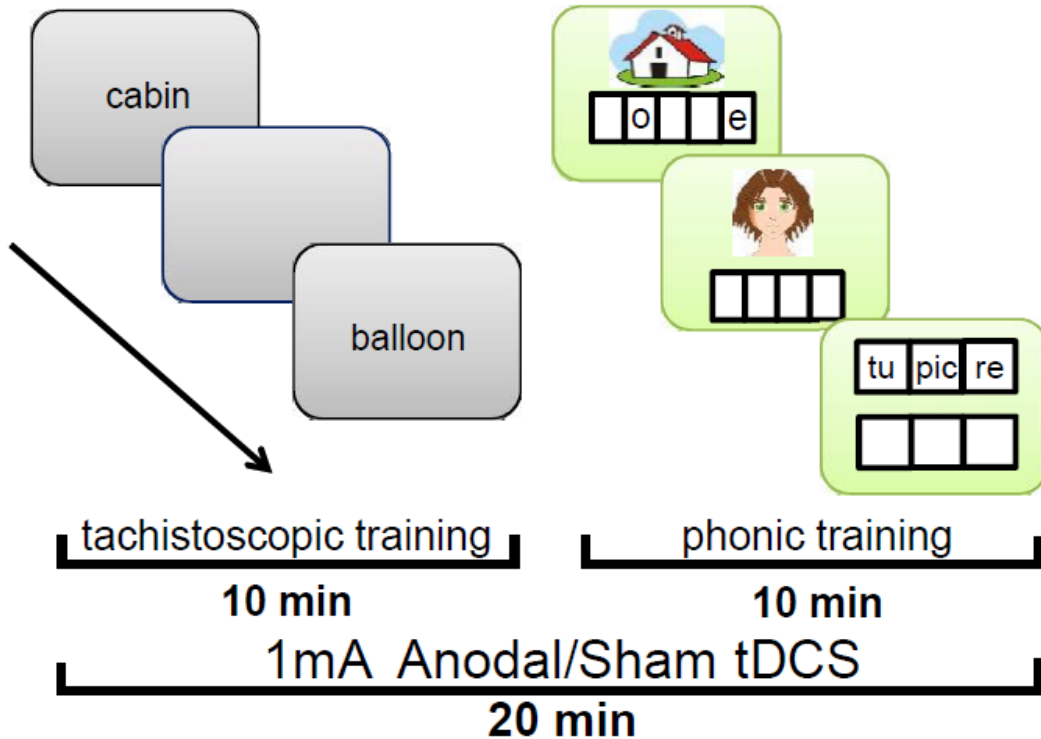
Set-up



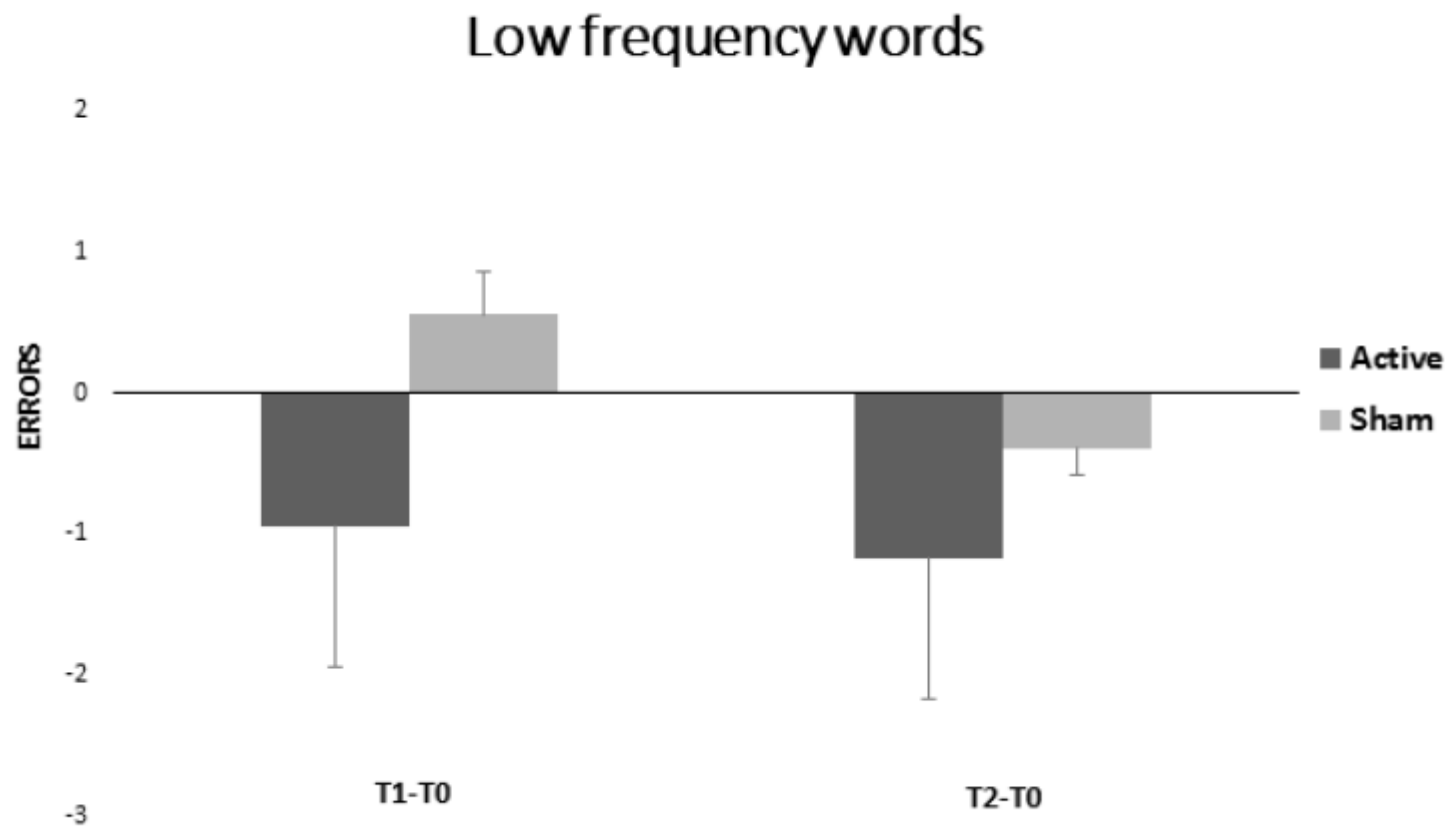
TRAINING

Training session

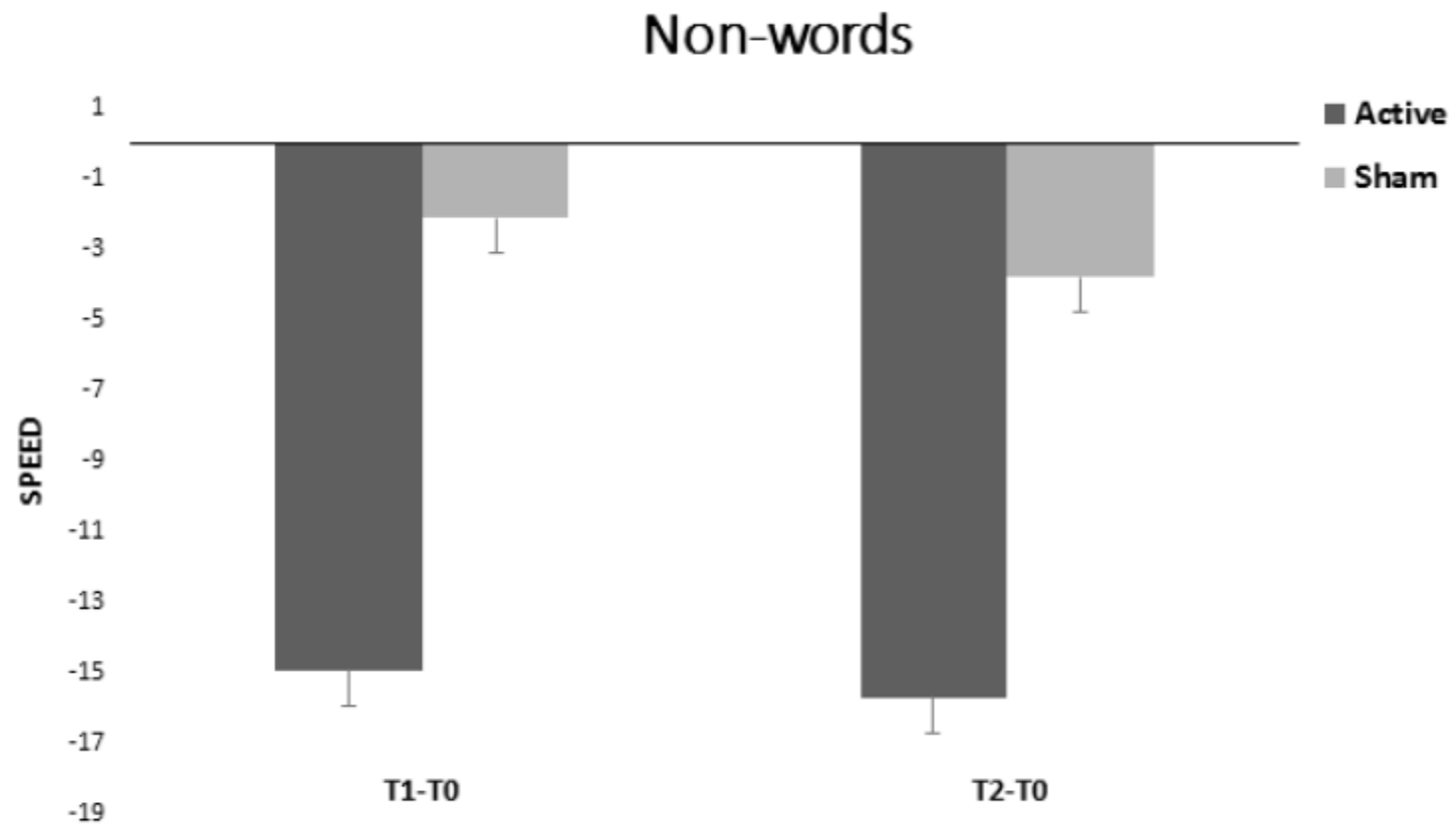
tDCS +
Reading training



RISULTATI



RISULTATI



RISULTATI TOLLERABILITÀ

Adverse effect	Mild (%)	Moderate (%)	Severe (%)
Headache	0.0	0.0	0.0
Neck pain	0.0	0.0	0.0
Scalp pain	0.0	0.0	0.0
Tingling	25.0	0.0	0.0
Itching	25.0	0.1	0.0
Burning sensation	12.5	7.7	0.0
Local redness	12.5	0.0	0.0
Sleepiness	0.0	0.0	0.0
Trouble concentrating	0.0	0.0	0.0
Acute mood changes	0.0	0.0	0.0
Irritability	0.0	0.0	0.0

324
sessioni

DISCUSSIONE

- ✓ Risultati preliminari
- ✓ tDCS prospettiva di trattamento promettente
- ✓ Breve training efficace!
- ✓ Effetti a medio termine



DIREZIONI FUTURE:

- ✓ Efficacia dell'esclusiva tDCS?
- ✓ Stimolazione altre regioni del network di lettura
- ✓ Effetti a lungo termine (dati preliminari a 6 mesi)
- ✓ Protocolli con cicli ripetuti?



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Marco Cecchi

Rosalba Ciai

Anna Maria De Robbio

Silvia Iacobucci

Giorgio Masiello

Angelica Qammaz

Beatrice Romeo

www.specchioriflesso.net

Group	Subject	Sex	Age	IQ ^a	TEXT		HF		LF		NW	
					Err	Spe ^a	Err	Spe ^b	Err	Spe ^b	Err	Spe ^b
Active	1	M	11y9m	102	6	41.4	0.5	23	1.5	26	2	30
Active	2	F	16y8m	136	1	18.2	0	9	2	13	0	18
Active	3	M	10y9m	98	15.5	62.7	2	28	4	48	4	68
Active	4	F	11y11m	110	23.5	43.4	4.5	26	5.5	53	13	89
Active	5	M	11y6m	100	12.5	28	0	11	2.5	20	4	30
Active	6	M	12y6m	110	5.5	48.5	0	20	2	28	0	33
Active	7	F	11y3m	110	16.5	47.3	2	21	2.5	25	6.5	35
Active	8	F	17y1m	118	3	31.2	1	15	1	20	0.5	33
Active	9	F	14y8m	123	5.5	38	0	13.5	0.5	17.2	2.5	29
Sham	10	F	11y1m	120	18.5	32	2	12	2	19	7	27
Sham	11	M	11y1m	110	23.5	76	1.5	30	4	58	9	41
Sham	12	F	12y4m	112	6	26.3	1	11	1.5	1.5	2	18
Sham	13	F	15y6m	94	8	24	0.5	16	0.5	23	0	26
Sham	14	M	12y6m	117	3.5	46	1	15	1	21	2	41
Sham	15	F	16y	100	5	24	1	12	0	10	4	23
Sham	16	F	16y	97	13	34.6	1	18	4	23	2	31
Sham	17	F	15y6m	93	2.5	29.3	0	22	0	23	0	31
Sham	18	F	12y2m	100	19.5	50	3	17	3.5	41	8	34

Note: y = years; m= months; Err = errors; Spe = speed; ^aseconds/syllables x 100; ^bseconds.
 TEXT: text; HF: high frequency words; LF: low frequency words; NW: non-words.