Neuroscience & dyslexia : the State of the Art

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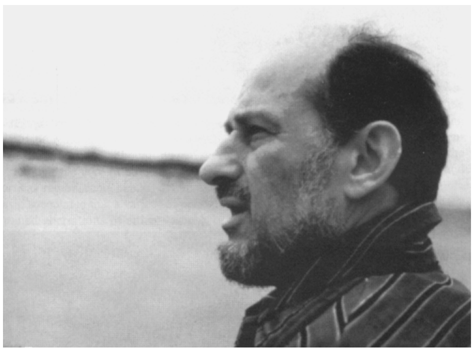
http://resodys.phpnet.org

Neuroscience
- neuropsychology
  - Analysis of reading deficits (subtypes, etc…)
  - Demonstration of specific precursors (phonology, others)
- Neurobiology, neuroanatomy
  - Description of atypical brain organisation
  - Questions about aetiology (genetic, hormonal…)
- Functional brain imaging
  - Description of atypical brain function
  - Role of environmental factors

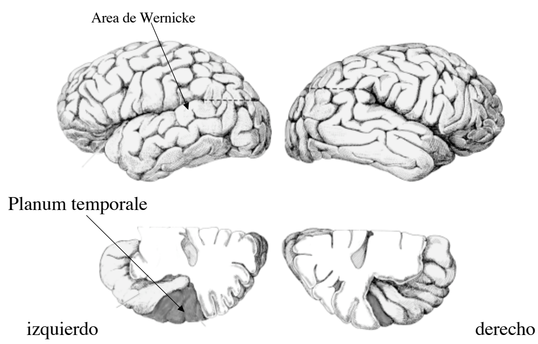
Overview

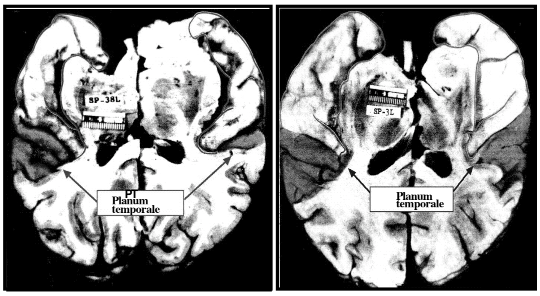
- Structural brain changes in dyslexia
- Imaging the reading brain
- Explaining dyslexia :
  - Visual deficit
  - Phonological deficit
  - Modern theories
    - Temporal processing deficit
    - Cerebellar impairment
  - Dyslexia as an information integration deficit

Structural brain changes



Norman Geschwind : 1926-1984

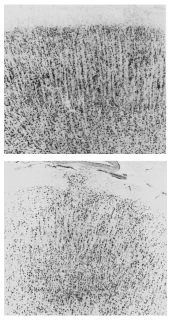




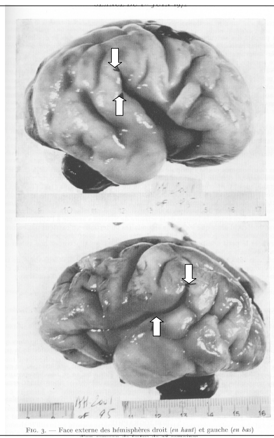
NOT DYSLEXIC

DYSLEXIC

Lack of planum temporale asymmetry in the dyslexic brain
Galaburda et al., 1979; 1985



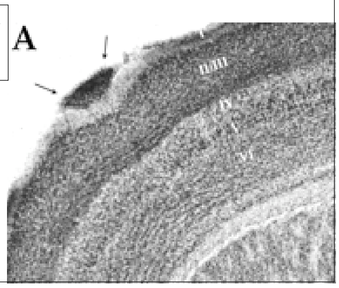
Ectopias on the dyslexic cortex (Galaburda et al., 1979, 1985)



Teszner et al., 1972 :
Planum asymmetry already present in pre-term fetuses

« Dyslexic » mice : genetically determined ectopias

2 genetically deviant strains (NZB et NXSM) produce spontaneous ectopias and maze learning deficits

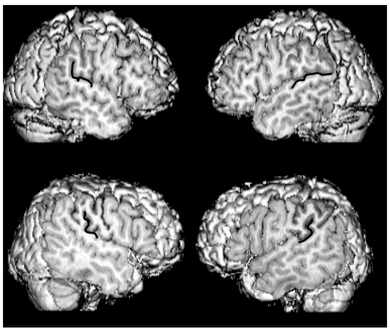


Jenner AR, Galaburda AM, Sherman GF, 2000.

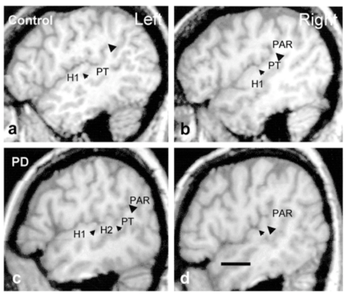
Robichon et al., 2000: Cortical asymmetry and dyslexia : no difference in planum temporale, only in parietal operculum

controls

dyslexics

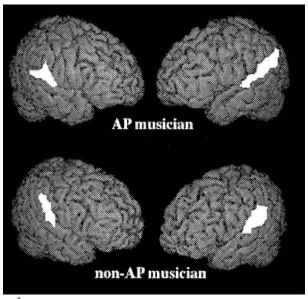


Leonard et al. (2001) : extreme leftward asymmetry of temporal and parietal cortices



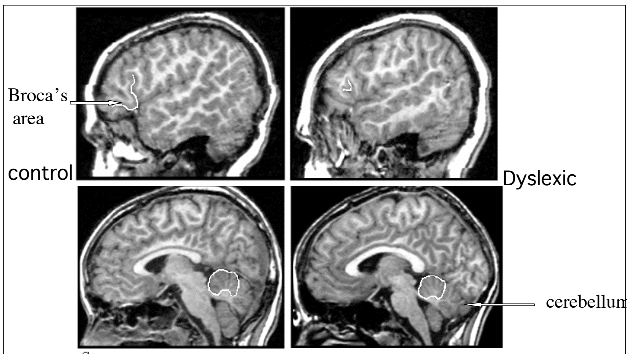
Planum asymmetry is larger in musicians with absolute pitch (AP)

GOTTFRIED SCHLAUG
The Brain of Musicians: A Model for Functional and Structural Adaptation
Ann NY Acad Sci 2001 930: 281-299.



Subject	δPT	PT size (mm^2)	
		Left	Right
AP musicians ($n = 27$)	−0.50 (0.27)[a]	1381 (449)	822 (236)
Non-AP musicians ($n = 24$)	−0.24 (0.14)	1350 (340)	1062 (267)
Nonmusicians ($n = 27$)	−0.28 (0.24)	1341 (306)	008 (285)

[a]Significant differences between AP musicians and non-AP musicians as well as between AP-musicians and nonmusicians.

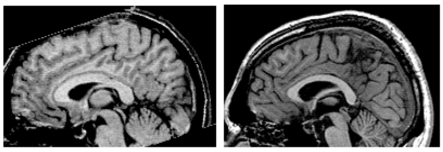


DOI: 10.1093/brain/awg026 *Brain* (2003), **126,** 482–494

Anatomical correlates of dyslexia: frontal and cerebellar findings

Mark A. Eckert,[1] Christiana M. Leonard,[1] Todd L. Richards,[2] Elizabeth H. Aylward,[2] Jennifer Thomson[3] and Virginia W. Berninger[3]

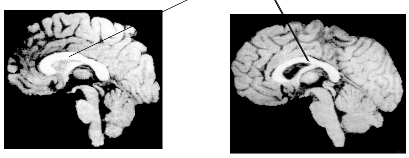
increased size of corpus callosum



dyslexic (2136) **control**

Anterior part of the callosum is larger in early-trained musicians

corpus callosum



MUSICIAN **NON- MUSICIAN**

(Schlaug et al., 1995)

MOTOR SYSTEMS NEUROREPORT

Corpus callosum: musician and gender effects

Dennis J. Lee,[1,2] Yi Chen[1] and Gottfried Schlaug[1,CA]

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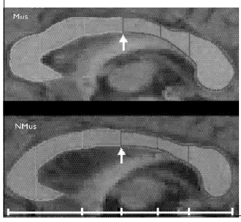


Table 2. Group morphometric data.

Group	Absolute CC area (mm^2)		
	Total	Anterior	Posterior
Male musicians ($n = 28$)	665 ± 91	342 ± 44^a	323 ± 50^b
Male non-musicians ($n = 28$)	619 ± 70	323 ± 40^a	296 ± 37^b
Female musicians ($n = 28$)	591 ± 55	304 ± 30	286 ± 31
Female non-musicians ($n = 28$)	624 ± 75	322 ± 42	302 ± 39

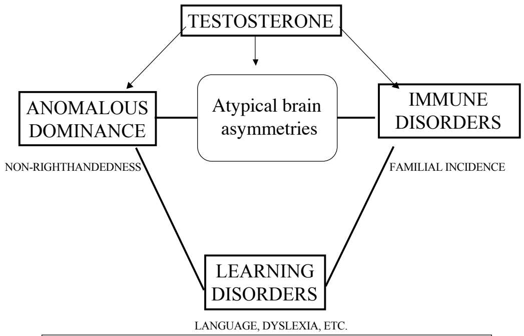
[a]Significant difference between male musicians and male non-musicians, $p < 0.05$.
[b]Trend for difference between male musicians and male non-musicians, $0.05 < p < 0.10$.

Neuroanatomical modifications in dyslexia : Which reality? Which meaning?

- A brain cortex with atypical asymmetry
  - But not where expected (parietal and frontal)
  - Not always in the expected direction
- Interhemispheric connections also modified :
  - Usually as an hypertrophy
  - Hypotrophy in some cases

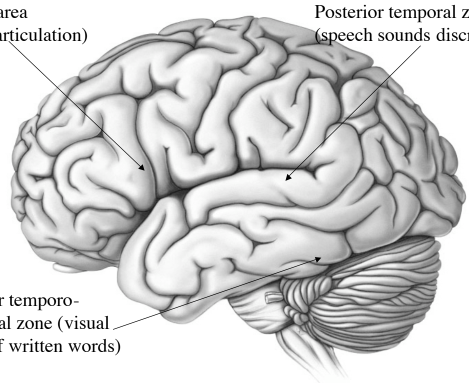
Neuroanatomical modifications in dyslexia : what do they mean?

- Observing an excess of neurons and connections : a debated issue
- Excess of neurons not necessarily linked to genetic factors (role of environmental factors, pre- or post-natal)
- Observed differences
  - Are not necessarily causal to anomalies at the behavioral level
  - Might only represent an indirect witness of maturational deviance



Imaging the reading brain

Functional imaging during reading and phonological tasks



The left hemisphere of the human brain and its reading-related cortical areas

Seminar

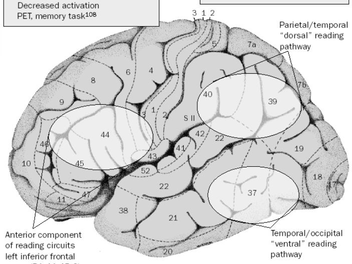
Developmental dyslexia

Jean-François Démonet, Margot J Taylor, Yves Chaix

Dysfunction of left inferior frontal area
Increased activation:
fMRI, hierarchically organised tasks with phonological process;[106]
PET, implicit and explicit word and pseudoword reading[107]

Decreased activation
PET, memory task[108]

Reduced activity in left parietal/temporal regions
PET, rhyming task;[108,109]
PET, pronunciation and decision making tasks;[110]
fMRI, hierarchically organised tasks with phonological process[106]
PET, reading[111]



Reduced activity in left inferior temporal/occipital area
MEG, letter perception[101]
PET, implicit and explicit word and pseudoword reading[107,112]

Lancet 2004; **363:** 1451–60

INSERM U455, Hôpital Purpan, IFR 96, Toulouse, France (J-F Démonet MD); **CNRS UMR 5549, Faculté de Médecine de Toulouse-Rangueil, IFR 96, Toulouse, France** (M J Taylor PhD); **and Unité de Neuro-Pédiatrie, Hôpital des Enfants, Toulouse, France** (Y Chaix MD)

Correspondence to: Dr J-F Démonet
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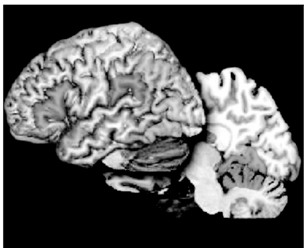
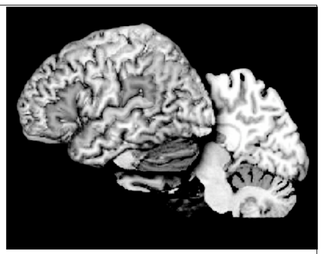


Anatomical areas activated during written language tasks and that exhibit significant differences from controls in studies of dyslexia



Anatomical areas activated during oral language tasks and that exhibit significant differences from controls in studies of dyslexia

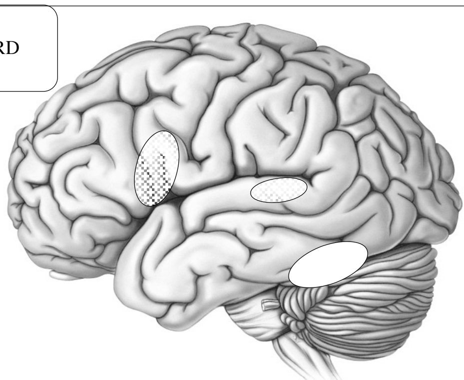
REVIEW ■

Neuroanatomical Markers for Dyslexia:
A Review of Dyslexia Structural Imaging Studies

MARK ECKERT

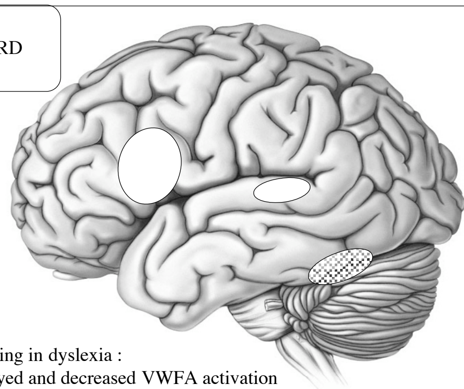
NEUROSCIENTIST. 10(3):000–000, 2004.

WORD



Normal reading : strong and transient early activation of visual word form area (VWFA)

WORD

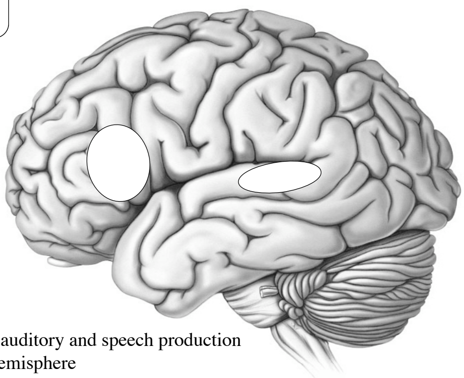


Reading in dyslexia :
Delayed and decreased VWFA activation
Early and increased Broca’s area activation

G H

Phonological awareness task : non-dyslexic child

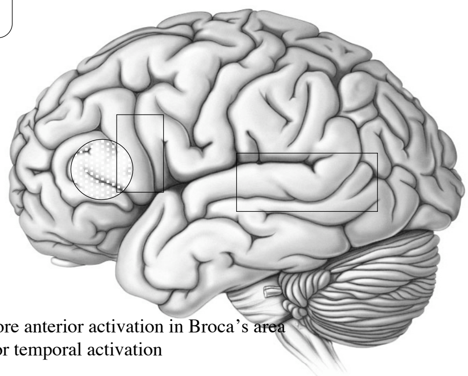
Do the letters rhyme?



Activation of auditory and speech production areas in left hemisphere

G H

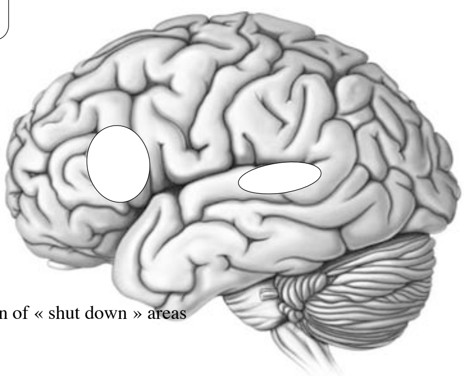
Dyslexic child



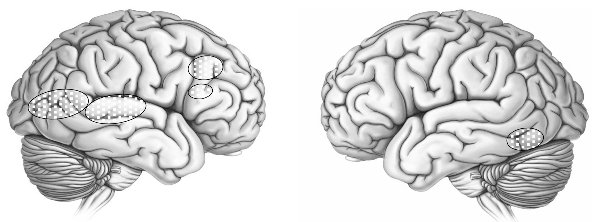
Weaker and more anterior activation in Broca’s area
Lack of superior temporal activation

G H

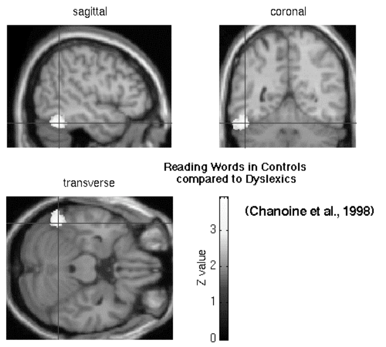
Dyslexic child after specific training (Fastforword®)

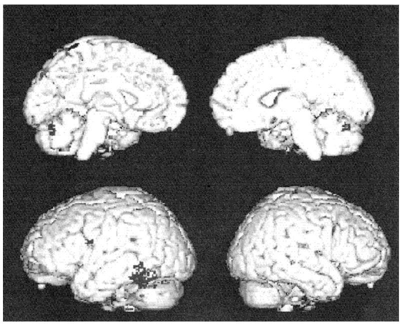


Re-activation of « shut down » areas
But also…

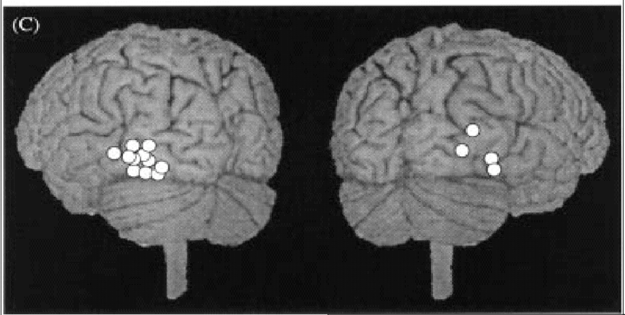


… new activation of previously unactvated regions (and unactivated in controls) : compensation? Re-organization?



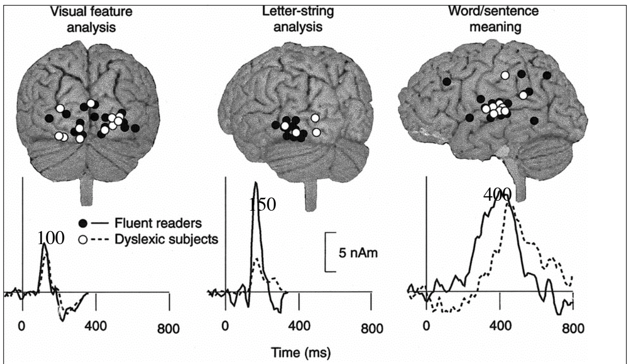


Areas of reduced activation in dyslexics relative to controls reading aloud words and non-words (Brunswick et al., 1999)



Type II activation (sources location): Strongest for visible words

- ~ 150ms after stimulus onset
- left predominant occipito-temporal
- correlates with time for word-reading
- increases with string length
- = letter-string specific



Magnetoencephalography (MEG) during word reading (Salmelin et al., 2000) : intact perceptual processing, decreased VWFA activation, delayed semantic- temporal activation

The main explanatory theories

Dyslexia as a visual deficit ⇩ Magnocellular theory

Dyslexia as a phonemic representation deficit ⇩ Phonological theory

2 « classical »

automatisation deficit ⇩ Cerebellar dysfunction theory

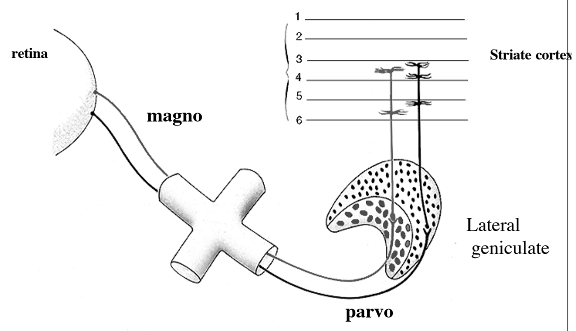
Time processing deficit ⇩ Temporal processing deficit theory

Stimulus integration deficit ⇩ Multiple stimulus integration theory

3 « modern »

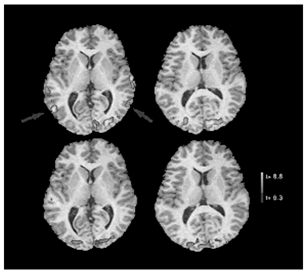
Explaining dyslexia (1) : visual errors and perceptual deficits

might dyslexia result from visual impairment?



Hypothesis: dyslexia results from a defect in the magno cellular system
- impaired contrast sensitivity
- excess of visual persistence

controls dyslexics



Dyslexics : failure to activate V5/MT « motion area »
(Eden et al., 1996)

Wobbles, Warbles and Fish – the Neural Basis of Dyslexia

John Stein, University Laboratory of Physiology, Oxford, UK

- Why reading is difficult – visual and auditory requirements depend on magnocellular neurones
- Dyslexia – diagnosis and incidence, overlap with other neurodevelopmental conditions
- Impaired visual magnocellular development ➡ unstable binocular control ➡ visual confusion
- Impaired auditory development ➡ phonological confusion
- Impaired motor development ➡ speech impediments, clumsiness, poor handwriting
- Heredity – dyslexia genes on Chromosomes 1,2,6,15,18
- Environment – immune system, nutrition –fish oils

The visual magnocellular system stabilises the eyes

Retinal motion, 'slip' → Feedback to eye control → Steady eye fixation →

Visual stability → Identify letter order → Orthographic skill

Conclusions 2

- Weak magnocellular function may result from:
  Genetic vulnerability
  Immunological attack
  HUFA deficiency
- However do not be downhearted! These weaknesses can be remedied: eye exercises, coloured filters, phonological training, **fish oil** supplements

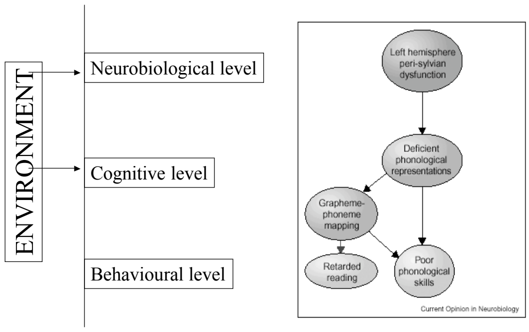
BUT remember Einstein, Churchill, Rodin were dyslexic!

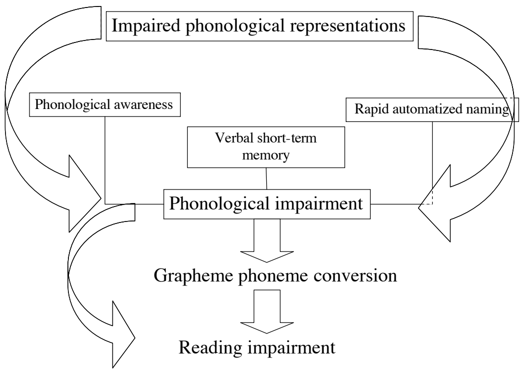
Problems with the magnocellular theory

- Nearly as much negative than positive evidence
- Does not explain easily phonological impairment
- Magnocellular deficit found mainly in phonological (not surface) dyslexia
- +++ lack of evidence for visual deficits before learning to read (≠ phonlogy)

⇨ Visual problems might be consequences, not causes, of dyslexia

Explaining dyslexia (2) : the dominant phonological theory





DOI: 10.1093/brain/awg076 *Brain* (2003), **126**, 841–865

Theories of developmental dyslexia: insights from a multiple case study of dyslexic adults

Franck Ramus,[1,5] Stuart Rosen,[2] Steven C. Dakin,[3] Brian L. Day,[4] Juan M. Castellote,[4,6] Sarah White[1] and Uta Frith[1]

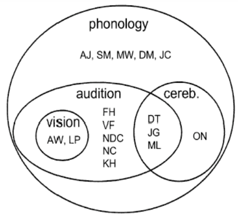
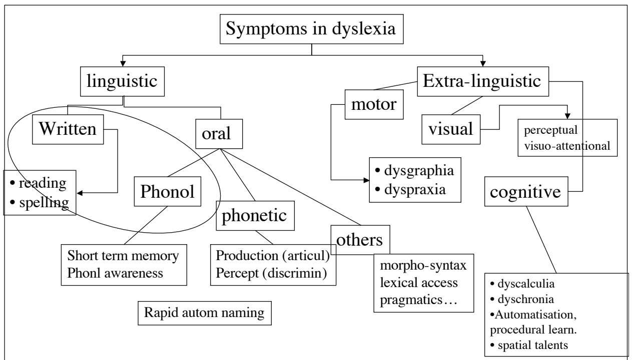


Fig. 4 Distribution of phonological, auditory, visual and cerebellar disorders in the sample of 16 dyslexic adults. Initials refer to individual dyslexic subjects.

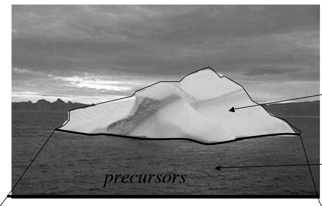


Any coherent model of dyslexia MUST take account of the possible occurrence of all associated symptoms

Conclusion : phonological theory of dyslexia

- By far the most often referred to and the best documented theory
- The highest level of correlation with reading achivement
- Major practical interest for early diagnosis before learning to read as well as remediation efficacy
- Deficit present the large majority of cases
- But **major problem** : only focuses on reading, neglecting associated symptoms

Reading impairment in dyslexia : the iceberg's visible part



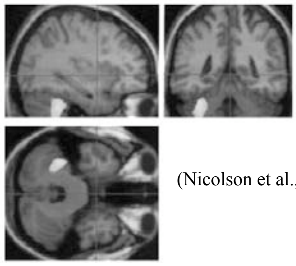
Explaining dyslexia (3) :
automatisation and motor symptoms

Cerebellar dysfunction

Developmental dyslexia: the cerebellar deficit hypothesis

Roderick I. Nicolson, Angela J. Fawcett and Paul Dean

Surprisingly, the problems faced by many dyslexic children are by no means confined to reading and spelling. There appears to be a general impairment in the ability to perform skills automatically, an ability thought to be dependent upon the cerebellum. Specific behavioural and neuroimaging tests reviewed here indicate that dyslexia is indeed associated with cerebellar impairment in about 80% of cases. We propose that disorders of cerebellar development can in fact cause the impairments in reading and writing characteristic of dyslexia, a view consistent with the recently appreciated role of the cerebellum in language-related skills. This proposal has implications for early remedial treatment.



(Nicolson et al., 1999)

Difference in activation between 6 dyslexics and 6 controls during learning of a motor sequence of the fingers: underactivation of the right cerebellum

EVIDENCE FOR A NEUROANATOMICAL DIFFERENCE WITHIN THE OLIVO-CEREBELLAR PATHWAY OF ADULTS WITH DYSLEXIA.

Andrew J Finch, Roderick I Nicolson and Angela J Fawcett

(Department of Psychology, University of Sheffield, UK)

Cortex, (2002) 38, 529-539

VIEWPOINT
DYSLEXIA AND THE CEREBELLAR DEFICIT HYPOTHESIS

Alan A. Beaton

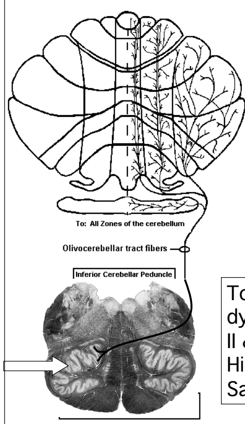
(Department of Psychology, University of Wales, Swansea, U.K. SA2 8PP)

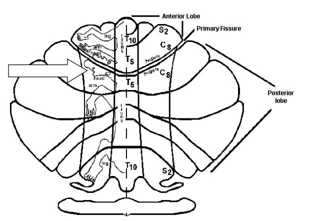
VIEWPOINT
CEREBELLAR ABNORMALITIES IN DEVELOPMENTAL DYSLEXIA: CAUSE, CORRELATE OR CONSEQUENCE?

Dorothy V.M. Bishop

(Department of Experimental Psychology, University of Oxford, Oxford)

Cortex, (2002) 38, 491-498 Cortex, (2002) 38, 479-490



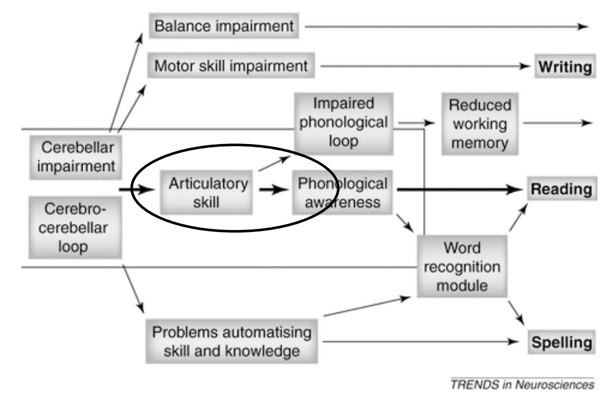


Finch et al., 2002

Total neuronal area (Purkinje) larger in dyslexics in the posterior cerebellum (crus II & paramedian lobule)
Higher proportion of large/small cells
Same tendency in olivary nucleus

Finch et al., 2002

- anterior lobe : non difference in large/small cells proportion
- Dentate nucleus : no change



Evidence for an Articulatory Awareness Deficit in Adult Dyslexics

Sarah Griffiths, and Uta Frith*

UCL, Institute of Cognitive Neuroscience, 17 Queen Square, London WC1N 3AR, UK

Table 1. Mean scores and Sds for dyslexic and control groups on standardized tests of intelligence and literacy

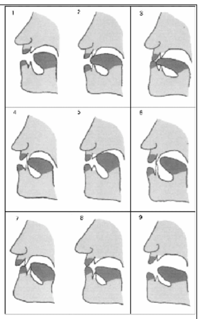
	Dyslexics (N = 17)		Controls (N = 17)		F
	Mean	S.D.	Mean	S.D.	
Age (years)	21.67	3.18	21.36	5.70	0.04
VESPAR spatial reasoning test†	11.06	1.25	11.65	0.86	2.56
VESPAR verbal reasoning test†	10.82	1.47	12.00	0.87	8.10**
WRAT reading†	97.94	6.46	113.53	6.53	48.99***
WRAT spelling†	93.00	13.92	113.24	8.24	26.60***

† = standard score.
Group differences significant at **$p<0.01$.
***$p<0.001$.

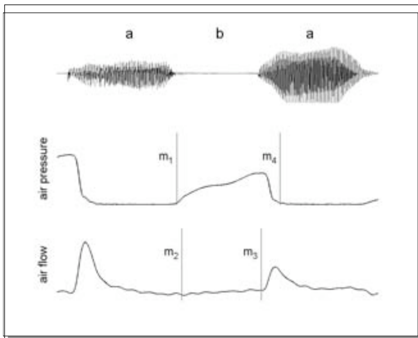
Table 2. Mean scores and Sds for dyslexic and control groups on tasks tapping phonological processing and articulatory awareness

Task	Dyslexics (N = 17)		Controls (N = 17)		F
	Mean	S.D.	Mean	S.D.	
Phoneme substitution (max = 10)	9.71	0.77	10.0	0.00	2.47
Digit span (standard score)	9.06	2.49	13.82	2.92	26.23***
Spoonerisms (max = 40)	27.88	8.37	34.18	5.14	6.98**
RAN digits (secs/50 items)	21.82	5.48	15.65	4.76	12.31***
RAN objects (secs/50 items)	36.03	9.10	29.36	5.67	6.58***
Articulatory awareness (max = 10)	5.06	1.98	7.24	1.52	12.88***

Group differences significant *$p<0.05$.
**$p<0.01$.
***$p<0.001$.



DYSLEXIA 8: 14–21 (2002)
DOI: 10.1002/dys.201



duration of the closing phase ($m_2 - m_1$)

* duration of the full closure phase ($m_3 - m_2$)

* duration of the release phase ($m_4 - m_3$)

Articulatory aspects of developmental phonological dyslexia

Muriel LALAIN, Noël NGUYEN and Michel HABIB
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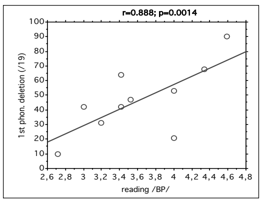
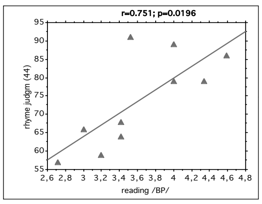
29 av. Robert Schuman, 13621 Aix-en-Provence, France
{lalain,nguyen,habib}@lpl.univ-aix.fr



Suppression 1er phonème



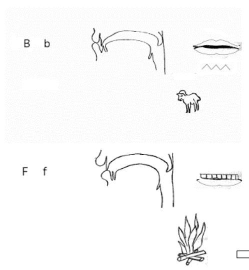
Jugement de rimes

Significant correlation between judges' evaluation and performance on phonological tasks

Lalain et al., 2002

Training the audio-articulatory loop to reduce phonological deficit

19 children : 7 to 11 y-old. Classical severe phonological dyslexia



- Example of plate used in intensive articulatory training
- Along with IBM « Speech-viewer™ » software

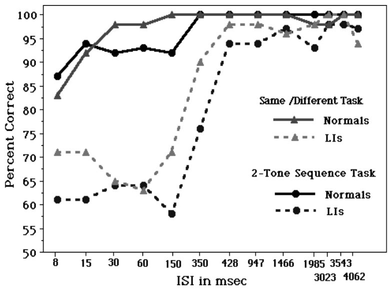
⇨ Modest overall improvement

Conclusion : the motor (cerebellar) theory of dyslexia

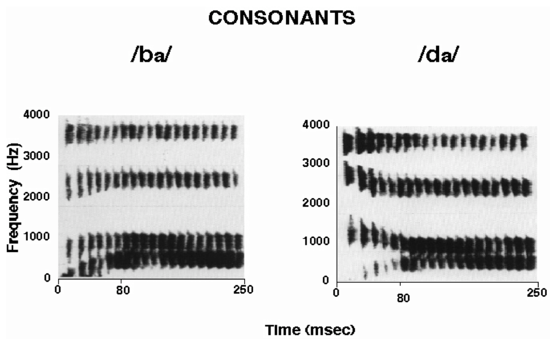
- Is coherent with associated motor and coordination deficits
- May be integrated into a motor theory of speech perception
- Does not explain visual symptoms
- Accounts for a limited number of cases
- Does not result in significant remediation applications

Explaining dyslexia (4) : time processing

Tallal's temporal processing deficit hypothesis



Tallal et al., 1973-76



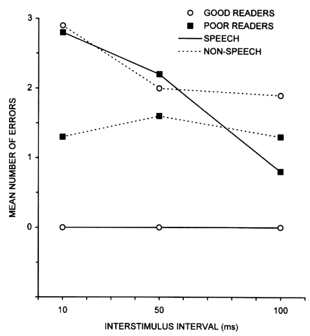
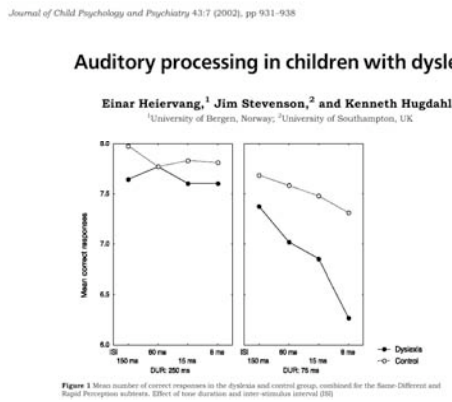


FIGURE 1. Mean number of errors by good and poor readers as a function of ISI on speech (/ba/–/da/) and nonspeech discrimination. (Reprinted from Mody et al., 1997.)

Mody et al., 1997 : le déficit de discrimination auditive chez le dyslexique est spécifique à la parole par rapport à la « non-parole » Pour la non-parole, les mauvais lecteurs ne sont pas significativement différents des témoins

Autre argument : si au lieu de ba/da on teste sa/sha, la différence témoins/dyslexiques disparaît


Journal of Child Psychology and Psychiatry 43:7 (2002), pp 931-938

Auditory processing in children with dyslexia

Einar Heiervang,[1] Jim Stevenson,[2] and Kenneth Hugdahl[1]

[1]University of Bergen, Norway; [2]University of Southampton, UK

The relationship between auditory temporal processing, phonemic awareness, and reading disability

Lesley Bretherton[a,*] and V.M. Holmes[b]

J. Experimental Child Psychology 84 (2003) 218–243

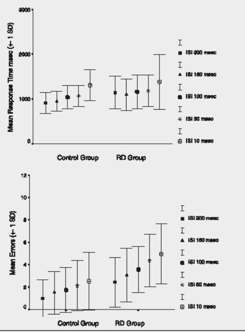


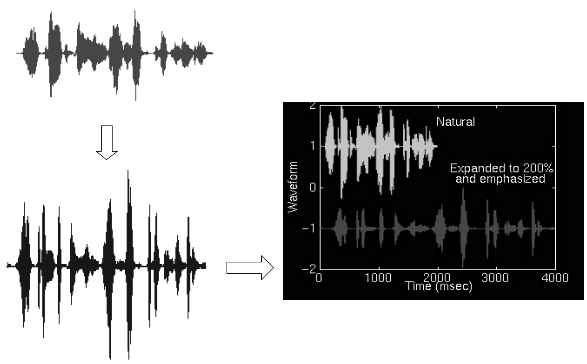
Table 3
Error rates and response times on the phoneme isolation tasks and error rates for phoneme deletion and reversal for the tone-order subgroups and the control group

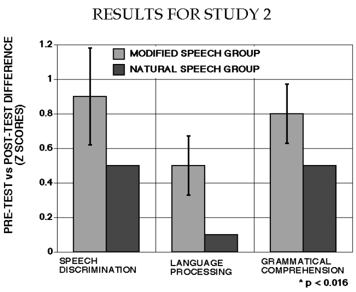
Task	Average tone		Poor tone		Control	
	M	*SD*	*M*	*SD*	*M*	*SD*
Beginning sound isolation						
Number of errors	2.6	2.2	2.1	2.4	0.9	0.9
Response time (ms)	1358	417	1295	522	1019	349
End sound isolation						
Number of errors	4.9	3.2	4.3	3.8	0.9	1.0
Response time (ms)	1822	104	1785	396	1407	407
Deletion (Number of errors)						
Beginning sound	6.4	2.4	6.1	3.9	1.6	2.1
End sound	5.5	3.5	6.3	4.1	1.8	2.7
Reversal (Number of errors)	10.2	2.5	10.3	2.4	4.1	2.8

Table 4
Mean error rates for the tone subgroups on the phonological tasks as a function of category of initial phoneme

Task	Stop consonant				Nasal/fricatives			
	Average tone		Poor tone		Average tone		Poor tone	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Isolation								
Beginning sound	1.1	1.3	1.0	1.0	1.6	1.2	1.1	1.6
End sound	2.1	1.9	2.0	2.2	2.8	1.7	2.3	1.9
Deletion								
Beginning sound	3.1	1.2	3.3	2.0	3.2	1.4	2.9	2.1
End sound	2.6	1.8	2.8	2.2	2.9	2.0	3.4	2.0
Reversal	5.2	1.2	5.2	1.1	5.1	1.5	5.2	1.5

" In this study, deficient order judgement on a nonverbal auditory temporal order task (tone task) did not underlie phonological awareness or reading difficulties."





Merzenich et al., 1996; Tallal et al., *Science*, 1996

Special Forum on Fast ForWord

Looking Back: A Summary of Five Exploratory Studies of Fast ForWord

Ronald B. Gillam
The University of Texas at Austin
Diane Frome Loeb
The University of Kansas, Lawrence
Sandy Friel-Patti
The University of Texas at Dallas

"The collective results of our studies suggest that improvements in language abilities after FFW training did not result from changes in temporal processing. It is possible that similar improvements in language may be obtained from a variety of interventions that are presented on an intensive schedule, that focus the child's auditory and visual attention, that present multiple trials, that vary task complexity as a function of response accuracy, and that reward progress."

American Journal of Speech-Language Pathology • Vol. 10 • 269–273 • August 2001

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[†§]

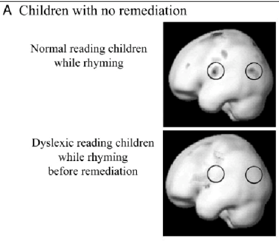
[†]Program in Neuroscience and [§]Department of Psychology, Stanford University, Stanford, CA 94305; [¶]Department of Psychology, University of California, Los Angeles, CA 90210; [‖]Scientific Learning Corporation, Oakland, CA 94612; [††]Center for Molecular and Behavioral Neuroscience, Rutgers University, Newark, NJ 07102; and [‡‡]Keck Center Integrative Neuroscience, University of California, San Francisco, CA 94143

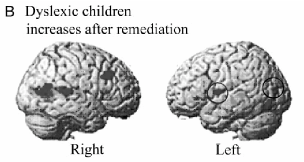
Contributed by Michael M. Merzenich, January 3, 2003

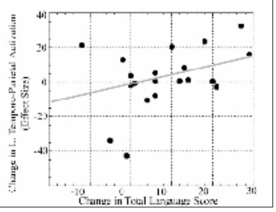
Table 2. Behavioral measures of reading and language

	Dyslexic-reading children				Normal-reading children			
	Pretraining	Posttraining	T-stat	*P*	1st scan	2nd scan	T-stat	*P*
Reading: WJ-RMT								
Word ID	78.2 (56–95)	86.0 (72–99)	3.9	0.0005	109.0 (95–120)	108.3 (97–126)	0.6	0.6
Word Attack	85.5 (72–102)	93.7 (82–109)	6.8	0.0001	112.3 (99–132)	109.4 (99–125)	1.1	0.3
Passage Comp	83.3 (51–103)	88.9 (77–107)	2.9	0.005	112.8 (104–120)	110.3 (100–122)	1.8	0.03
Language: CELF-3								
Receptive	92.5 (69–120)	101.3 (75–122)	3.6	0.001	118.6 (108–135)	121.8 (108–139)	1.5	0.2
Expressive	95.0 (61–125)	102.2 (80–150)	2.8	0.006	112.3 (102–125)	113.8 (92–139)	0.5	0.6
Rapid Naming	79.1 (35–97)	86.5 (67–103)	2.8	0.006	106.8 (94–121)	104.3 (82–124)	0.9	0.4

Range is given in parentheses. T-stat for paired *t* test. *P* value: one tailed for dyslexics, two tailed for controls. WJ-RMT, Woodcock–Johnson Reading Mastery Test; CELF, Comprehensive Evaluation of Language Fundamentals.







Magnitude of change in area 39 vs/ improvement in oral language

	Jamais	Rarement	Parfois	Souvent	Très souvent
1- Il (Elle) se souvient difficilement des jours / m ois / année que nous sommes.					
2- Il (Elle) confond les moments de la journée matin / après-midi / soirée.					
3- Un événement qui est survenu le matin, il (elle) peut le placer la veille.					
4- Pour un événement qui est survenu il y a quelques jours, il (elle) peut dire : "il y a très longtemps".					
5- Il lui est difficile de comprendre les relations existantes entre les membres de la famille : grands-parents, tantes, neveux, beau-frère.					
6- Il (Elle) a du mal à comprendre les notions de hier, demain ou après-demain.					
7- Il (Elle) a des difficultés à li re l'heure sur un cadran.					
8- Il (Elle) se trompe lorsque il (e lle) doit évaluer la durée d'un film, la durée d'une activité, voire même la durée d'une nuit de sommeil.					
9- Vous avez besoin de lui donner des indices pour qu'il (elle) se repère dans une semaine (lundi : école ; mercredi : activités extra-scolaires ; dimanche : repos …).					

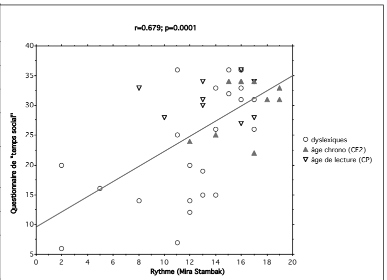


Figure 3 : corrélation ches 23 enfants dyslexiques et 20 témoins (appariés en âge de lecture : CP ou selon l'âge chronologique : CE2) entre la performance à un test d'imitation de rythmes et le résultats d'un questionnaire de « temps social » (Daffaure et al., 2002).

Corrélation entre reproduction de rythmes et questionnaire de « temps social »

Reading and Writing: An Interdisciplinary Journal **15:** 179–206, 2002.

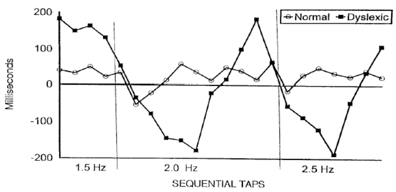
Timing precision and rhythm in developmental dyslexia

PETER H. WOLFF
Children's Hospital and Harvard Medical School, Boston MA 02115, USA

Dyslexics are poor at maintaining a regular pace in tapping task and at following a changing pace

Outcome measure	Dyslexic students Mean (SD)	Normal readers Mean (SD)
A. Absolute difference (ms) tap onset and metronome signal		
Stable rate – 2Hz		
Right finger	130 (53)	41 (10)**
Both finger	86 (41)	28 (14)**
B. Rate change: 1.5 to 2 HZ to 2.5 Hz		
Right finger	6.1 (1.1)	1.3 (14)**

**$p < 0.01$ Mann-Whitney U-Test.

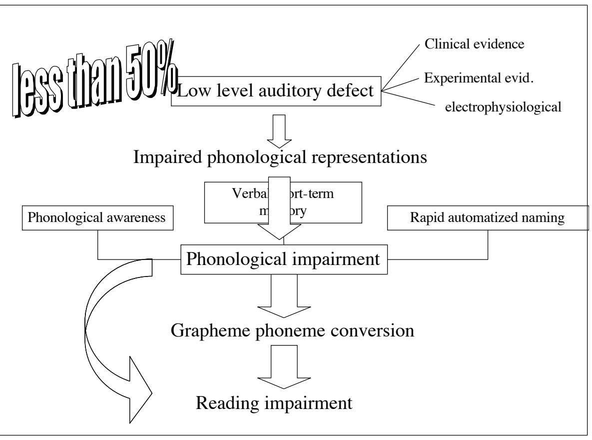


Conclusion : the temporal processing theory of dyslexia

- Is coherent with several unexplained features in dyslexics
- Can account for auditory and visual symptoms
- Has led to remediation applications, variably appreciated, however
- Not compatible with studies showing different results according to the linguistic nature or not of the stimuli
- Generally no correlation between temporal processing deficit and phonological deficit

Explaning dyslexia (5) : multiple stimuli integration deficit

Dyslexics fail to process integrated stimuli



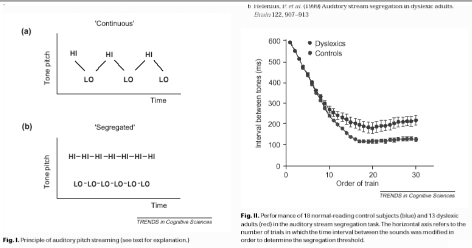
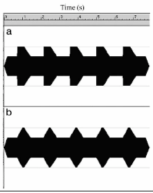


Fig. I. Principle of auditory pitch streaming (see text for explanation.)

Impaired processing of rapid stimulus sequences in dyslexia

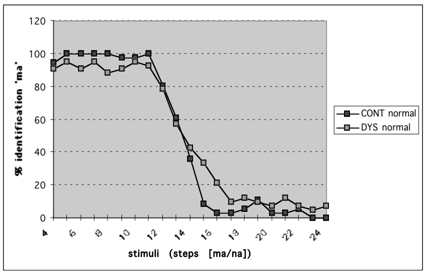
Riitta Hari and Hanna Renvall



Amplitude envelope onsets and developmental dyslexia: A new hypothesis

Usha Goswami*[†], Jennifer Thomson*, Ulla Richardson*, Rhona Stainthorp[‡], Diana Hughes[§], Stuart Rosen[¶], and Sophie K. Scott[||]

Categorical perception in dyslexia
[ma/na] continuum



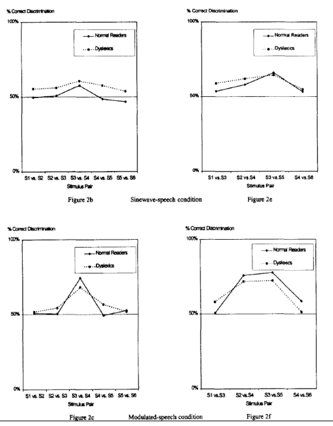
Perceptual Discrimination of Speech Sounds in Developmental Dyslexia

Willy Serniclaes
Laboratoire de Statistique Médicale
Ecole de Santé Publique
Université Libre de Bruxelles
Brussels, Belgium

Liliane Sprenger-Charolles
CNRS - LEAPLE
and
Université René Descartes
Paris, France

Experiments previously reported in the literature suggest that people with dyslexia have a deficit in categorical perception. However, it is still unclear whether the deficit is specific to the perception of speech sounds or whether it more generally affects auditory function. In order to investigate the relationship between categorical perception and dyslexia, as well as the nature of this categorization deficit, speech specific or not, the discrimination responses of children who have dyslexia and those of average readers to sinewave analogues of speech sounds were compared. These analogues were presented in two different conditions, either as nonspeech whistles or as speech sounds. Results showed that children with dyslexia are less categorical than average readers in the speech condition, mainly because they are *better* at discriminating acoustic differences between stimuli

384 *Journal of Speech, Language, and Hearing Research* • Vol. 44 • 384–399 • April 2001



Sine-wave speech

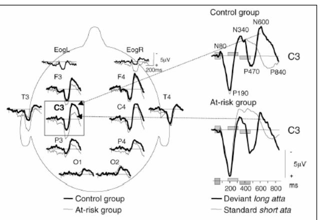
Natural speech

DEVELOPMENTAL NEUROPSYCHOLOGY, 22(1), 407–422

Brain Responses to Changes in Speech Sound Durations Differ Between Infants With and Without Familial Risk for Dyslexia

Paavo H. T. Leppänen
Department of Psychology
University of Jyväskylä

Ulla Richardson



6 month-old infants with familial risk of dyslexia, compared to controls not at risk : decreased ERP activation by a rare deviant stimulus (/ata/ vs /atta/)

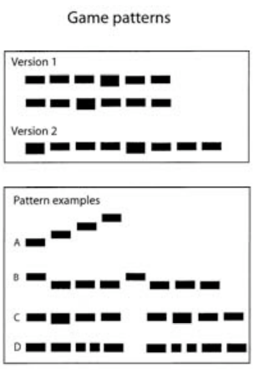
Plastic neural changes and reading improvement caused by audiovisual training in reading-impaired children

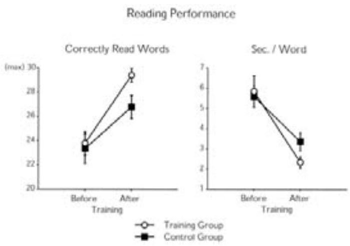
T. Kujala*[†], K. Karma[‡], R. Ceponiene*, S. Belitz*, P. Turkkila[‡], M. Tervaniemi*, and R. Näätänen*[§]

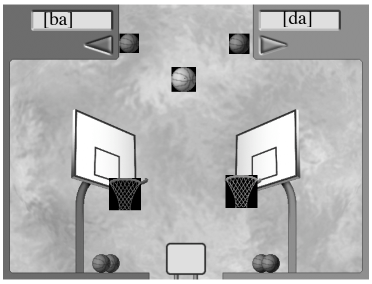
*Cognitive Brain Research Unit, Department of Psychology, P.O. Box 13, University of Helsinki, FIN-00014 Helsinki, Finland; [‡]Sibelius Academy, Department of Music Education, FIN-00251 Helsinki, Finland; and [§]BioMag Laboratory, Meilahti, P.O. Box 340, 00029 HUS, Finland

This study aimed at determining whether audiovisual training without linguistic material has a remediating effect on reading skills and central auditory processing in dyslexic children. It was found that this training resulted in plastic changes in the auditory cortex, indexed by enhanced electrophysiological mismatch negativity and faster reaction times to sound changes. Importantly, these changes were accompanied by improvement in reading skills. The results indicate that reading difficulties can be ameliorated by special training programs and, further, that the training effects can be observed in brain activity. Moreover, the fact that the present training effects were obtained by using a program including no linguistic material indicates that dyslexia is at least partly based on a general auditory perceptual deficit.

PNAS | August 28, 2001 | vol. 98 | no. 18 | 10509–10514







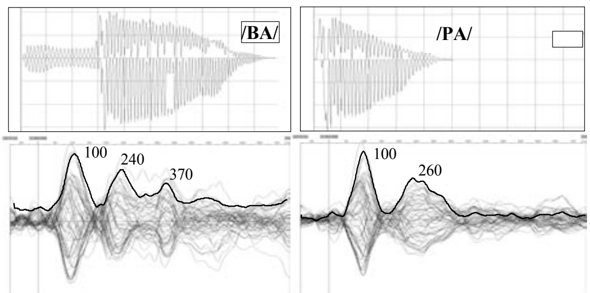
Intermodal training with « Play-on® » (Danon-Boileau & Barbier, 2000)

Danon-Boileau, L., & Barbier, D. (2000). Play-On: Un logiciel d'entraînement à la lecture. Paris: Audivi-Media.

auditory evoked potentials (AEP) following perception of ba/pa contrasts

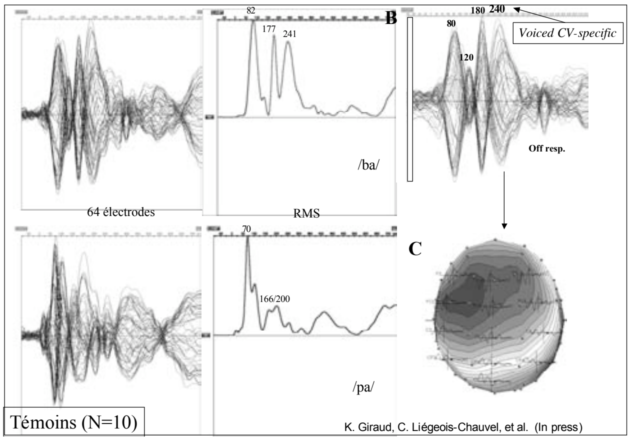
- /ba/ stimulus recorded from a female native French speaker ; /pa/ stimulus created by extracting the initial low frequency activity
- five 8-minute blocks of 450 trials of one of two stimuli, followed by the same number of blocks and presentations of the other stimulus.
- 14 male French-speaking adult dyslexics (23-49, mean 32.7) and 10 adult male controls (20-38, mean 26,5)
- All dyslexics with a long history of difficulties in academic achievement, needs for specific speech therapist intervention, and persistent spelling difficulties
- Raven PM38 : normal intellectual function

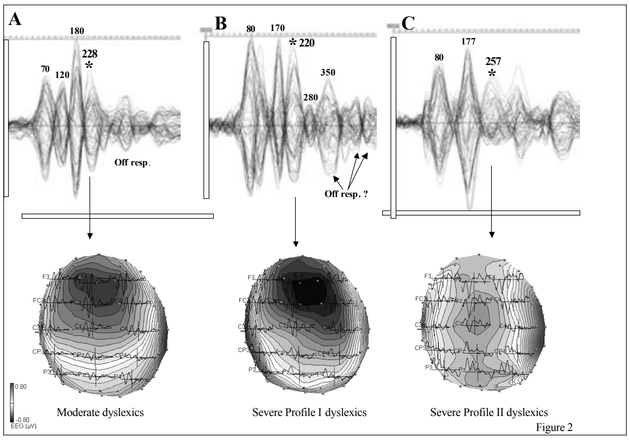
Corrélats électrophysiologiques du déficit de discrimination dans la dyslexie
K. Giraud, C. Liégeois-Chauvel, et al. (In press)



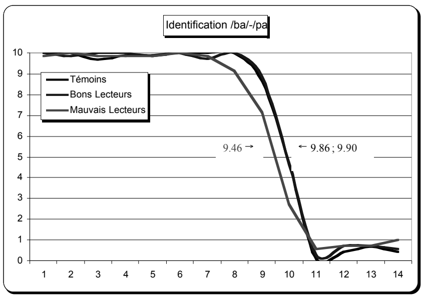
"Moderate" Dyslexics (N=7)				"Severe" Dyslexics (N=7)			
Subject	R.A. (yrs;mths)	Phono Score (/20)	Spell (%)	Subject	R.A. * (yrs;mths)	Phono Score(/20) n.s.	Spell*. (%)
HC	14;1	13	60	AB	9;11	15	54
ED	13;3	14	75	AS	9;8	9	33
JR	12;10	15	81	CG	9;5	15	54
DR	12;10	17	63	PH	8;11	10	44
NR	12;2	14	60	FL	8;8	13	67
MD	11;2	15	63	CM	8;6	16	56
HJ	10;2	12	69	SC	7;2	7	15

14 dyslexic adults : reading, phonological, and spelling performances

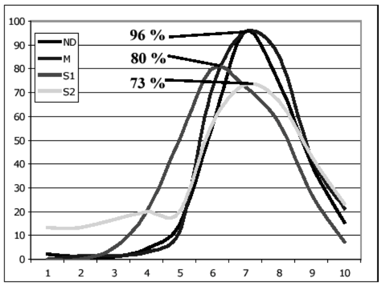




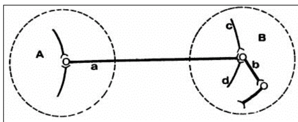
Categorical perception in adult dyslexics (K. Giraud et al., In press)



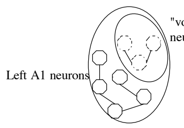
Discrimination (/ba/-/pa/)



Categorial perception /ba/-/pa/ (discrimination curves): severe dyslexics score significantly below controls and moderate dyslexics



Hebb's synapse: if axon **a** fires when neuron **B** is being activated by c and d, then the connection between **A** and **B** will be increased



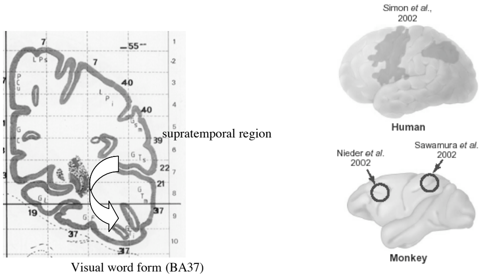
Learning voiced/unvoiced contrast : segregation of relevant neuron clusters

- An input synapse to a given neuron that is activated slightly before the neuron fires is strengthened, whereas a synapse activated slightly after is weakened
- This window of plasticity ranges from -40 to +40 msec
- This mechanism would cause multiple neurons in the primary auditory cortex that fire nearly simultaneously to bind together

Hebbian learning : main principles

Conclusion : the multiple stimuli integration deficit theory

- Explains both basic (low-level) auditory or visual deficits and more high-level, including multimodal, deficits
- Can account for auditory and visual symptoms
- Has led to remediation applications (recent, to be confirmed)
- Explains different results according to the linguistic nature or not of the stimuli
- Explains extra-linguistics deficits observed in dyslexics (dyscalculia, dyspraxia…)



Learning grapheme-phoneme conversion : the fundamental defect in dyslexia

Learning numerical value of quantities : the fundamental defect in dyscalculia

Hebbian learning : further speculations