Vivre et grandir dans le noir

Compensations et substitutions sensorielles

Laurent Renier, PhD – Directeur du Département Déficiences Visuelles

Cécité

Déficience visuelle totale

28-35 millions d'aveugles dans le monde

- 0,2-0,5% de la population dans les pays industrialisés
- 1-3% dans les pays en voie de développement

37-52 millions de mal-voyants (x1,5)

=> Conséquences de la cécité?

Cécité

Déficience	Compensation
↓	↓
Incapacité	Compétence
↓	↓
Handicap	Avantage

Perplexité ↔ **Admiration/fantasme**

Vision

- Est le **sens dominant**
- Source de stimulation et de **motivation** pendant le développement
- Permet **l'imitation** comme source d'apprentissage
- Permet la **coordination** motrice (guide les mouvements)
- Contribue au sens de **l'équilibre**
- Permet d'appréhender **l'espace**
- Permet de nous **orienter**
- Conditionne nos **représentations mentales**

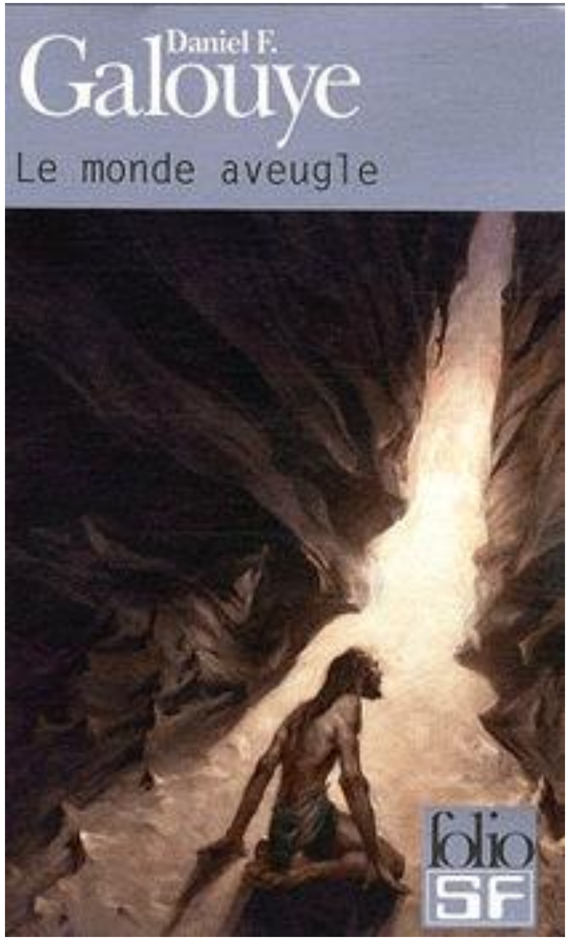
Conséquences de la cécité

- Développement *moteur*
- Développement de la *communication*
- Développement *cognitif* général
- Représentation *spatiale*

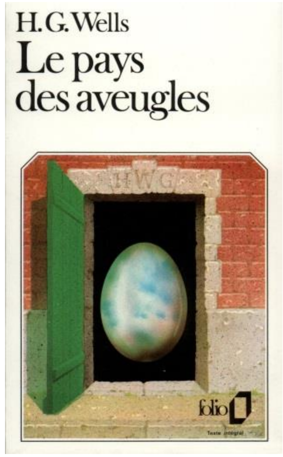
Retards d'acquisition
Déficits
Singularités - maniérisme

Compensations?

Cécité et littérature



« Ils vivent dans des cavernes plongées dans une totale obscurité. Ils ne connaissent que la nuit, la nuit la plus absolue et pleine de dangers terribles. Ils sont aveugles, tous. Au fil des générations leur ouïe et leur odorat se sont développés comme ceux des animaux. » ***Le Monde aveugle, Daniel F. Galouye, 1961.***



L'adaptation et la normalité sont des notions relatives.

Cécité et croyances

Le devin aveugle, **Tiresias**

3

L'AVEUGLE
CLAIR-VOYANT.
COMÉDIE.

SCÉNE PREMIÉRE.

LEONOR, LISETTE.

LISETTE.

EH bien, Madame, à quoi vous déterminez-vous?
On va voir arriver votre futur époux.
Damon revient enfin après deux ans d'absence.

LEONOR.

Faut-il encor... O Ciel! je frémis quand j'y pense.
Lisette, dans l'état où l'a mis son destin,
Pourrai-je me résoudre à lui donner la main?

LISETTE.

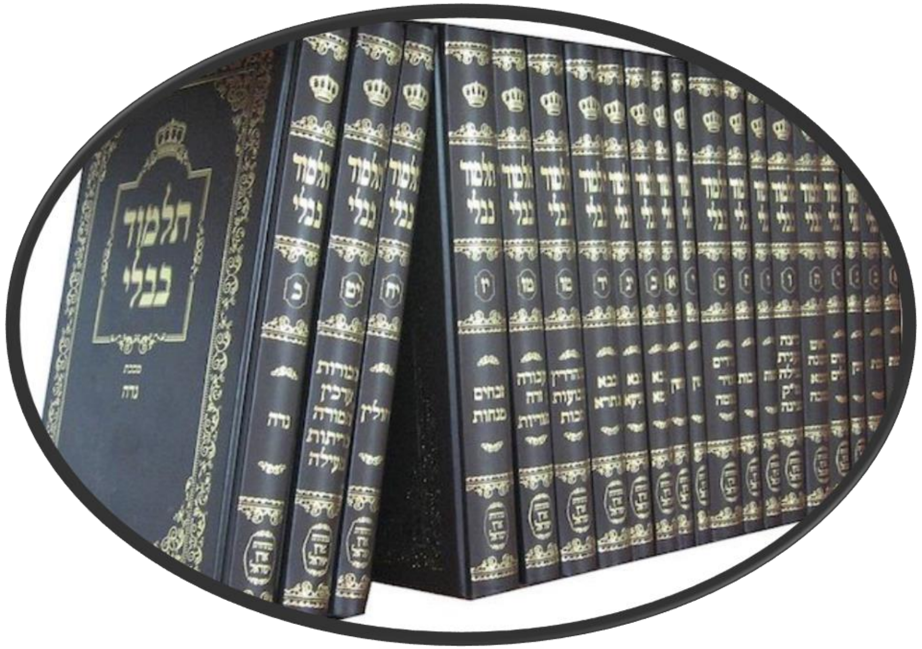
Comment vous en défendre? Un dédit vous engage.
Il l'exigea de vous avant ce long voyage,
Et que vous logeriez ici dans sa maison;

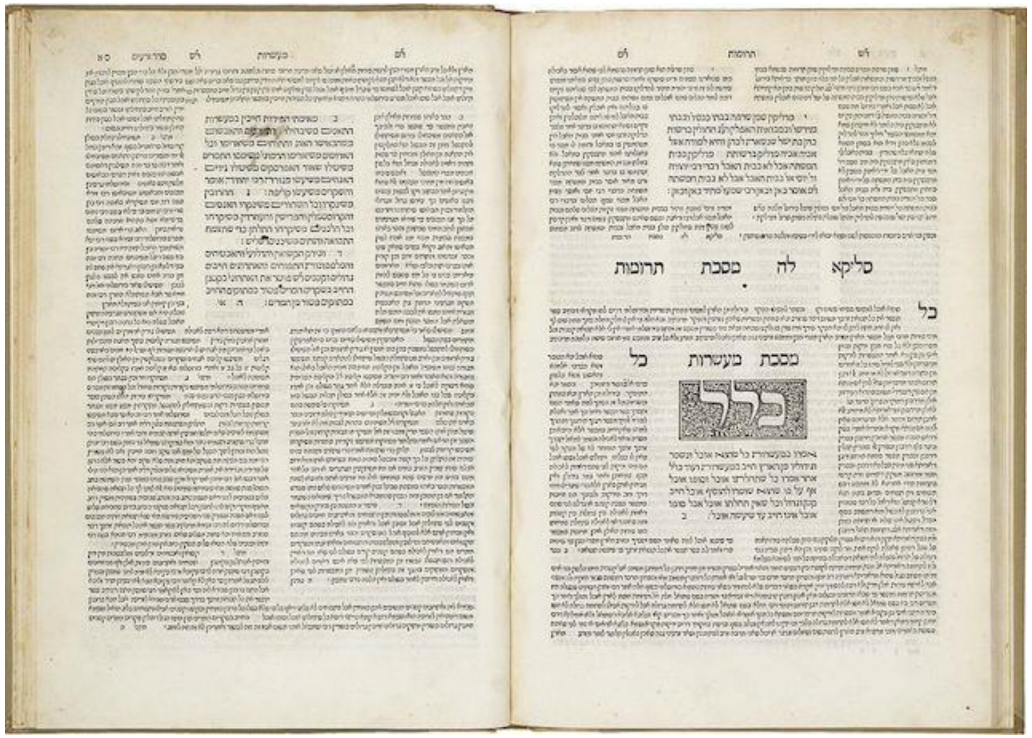
A 2 Nous

M. Legrand, 1716

L'oracle aveugle, Vikings

Cécité et histoire





« The traditions cited by Rabbi Sheshet are not subject to doubt as he is a blind man. » ***Talmud Yerushalmi, tractate Shabat 6b***

Métiers aveugles

Accordage de piano

Claude Montal,
1800-1865

Massages & shiatsu

Aveugles, musique & castes

Stevie Wonder

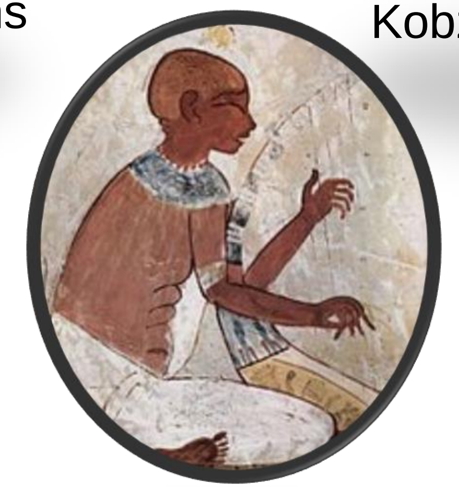
Ray Charles

Andrea Boceli

Gilbert Montagné

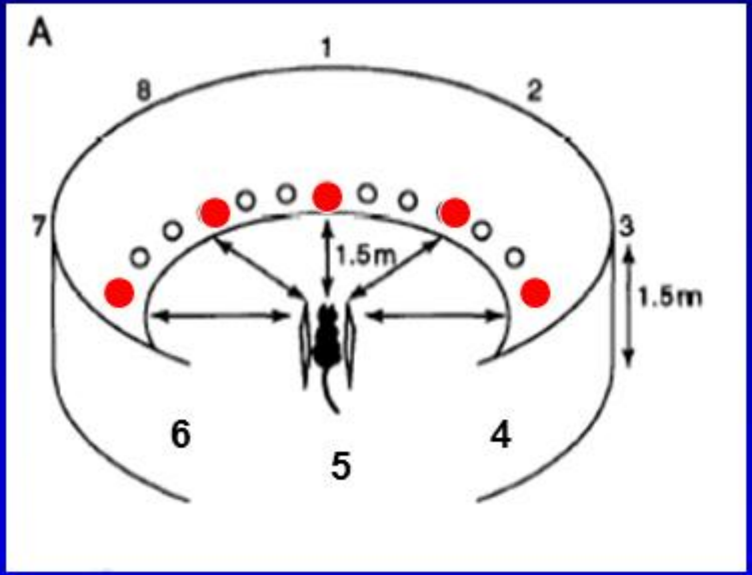
Chinese blind Musicians

Kobzars d'Ukraine

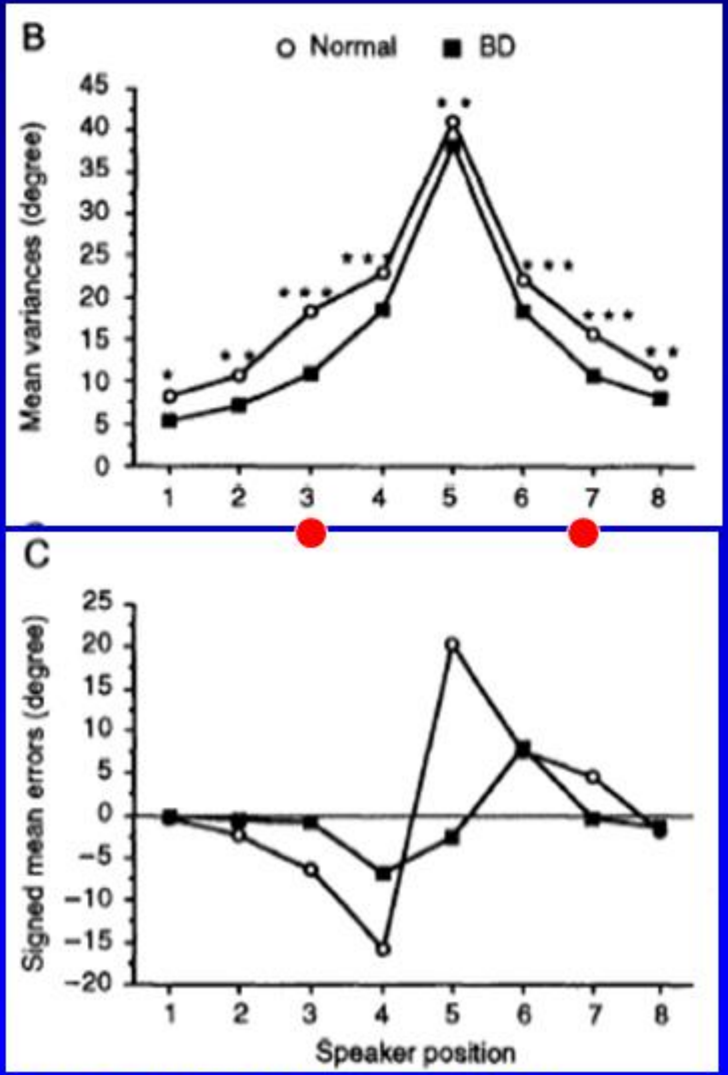


Fresque égyptienne

Plasticité intermodale : performances améliorées



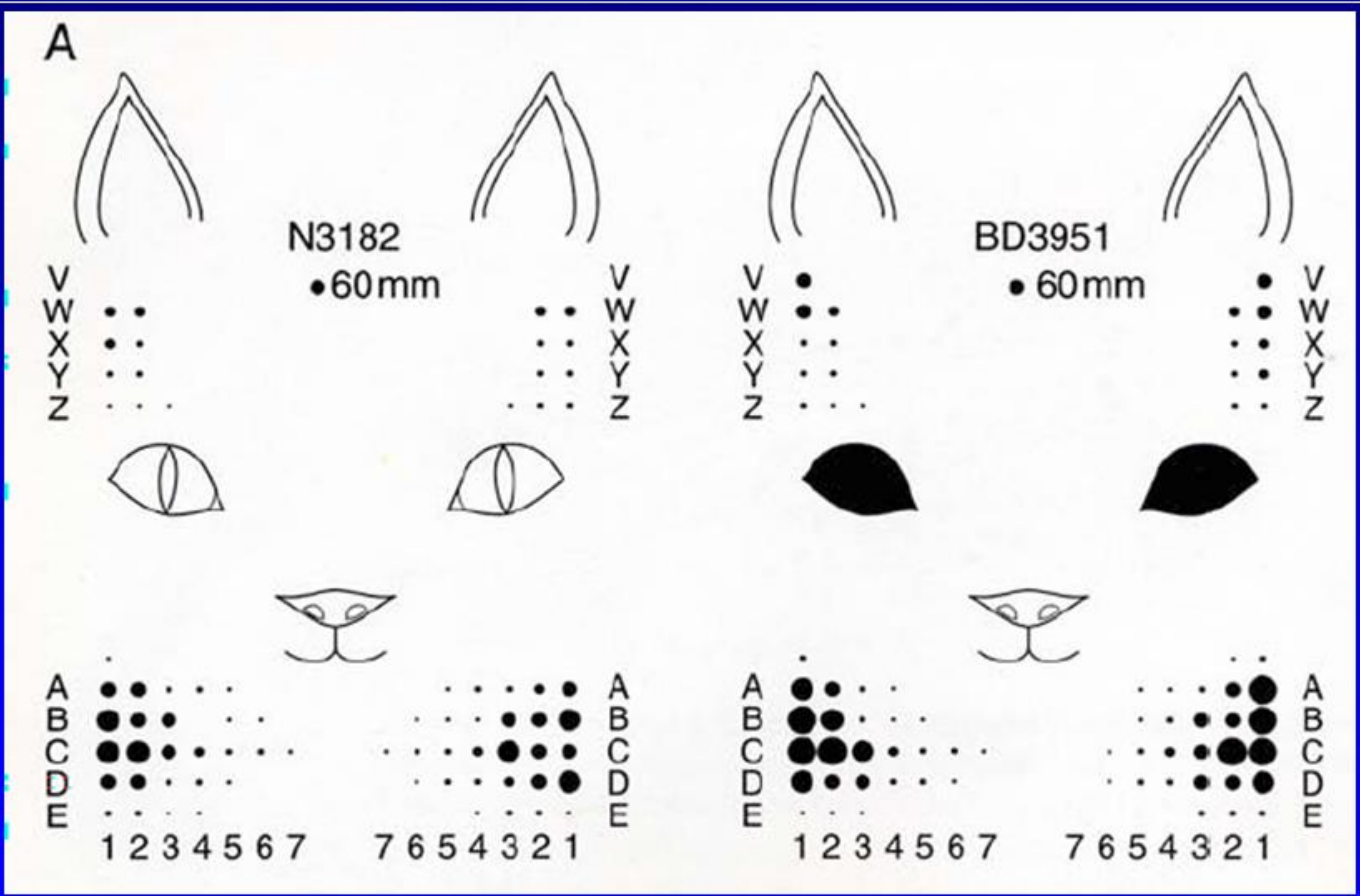
Rauschecker et al, *J. Neurosci*, 1993



B: P < 0.002; two-way ANOVA
C: P < 0.02; two-way ANOVA

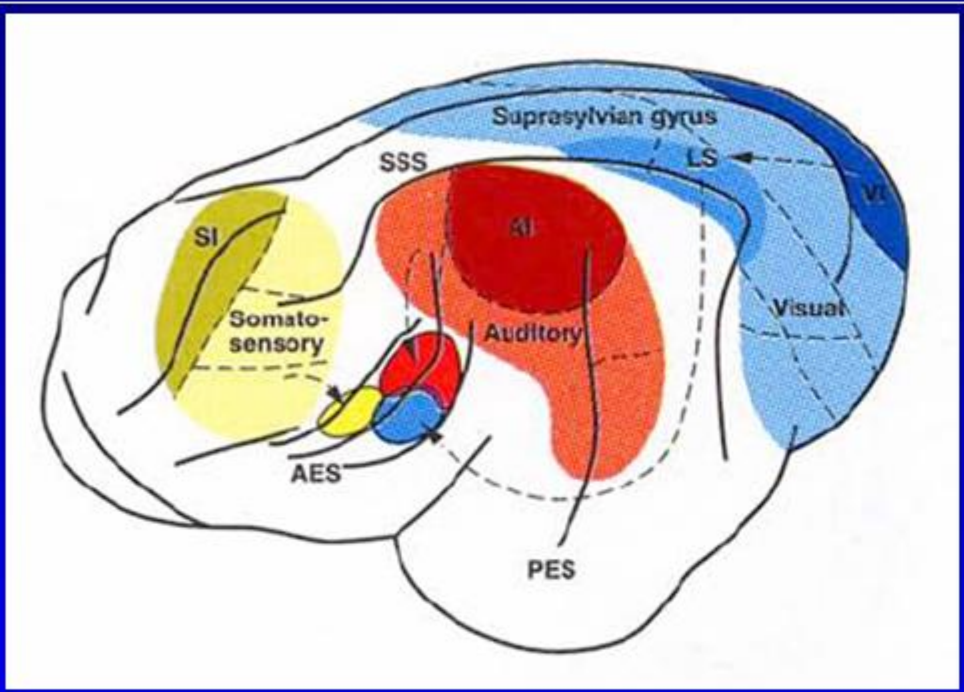
Adapté de : Rauschecker, TINS 1995; 18: 36-43.

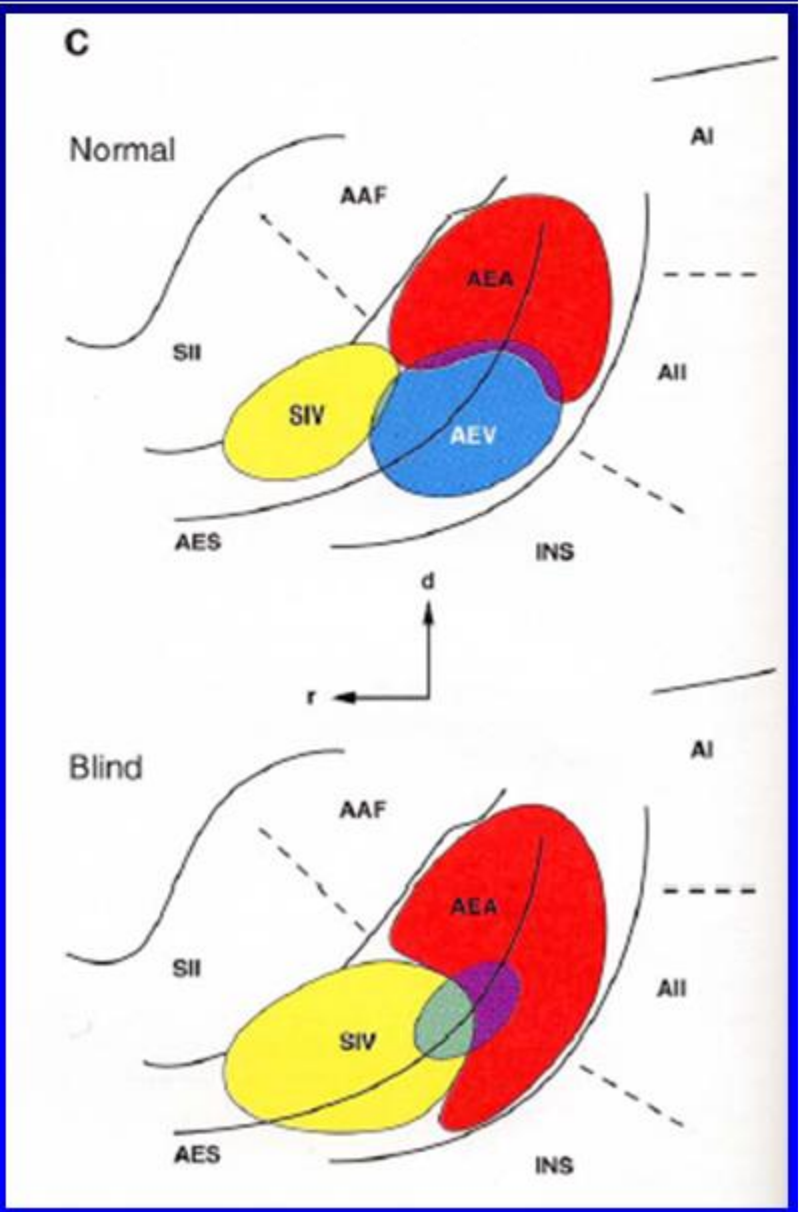
Plasticité intermodale : modifications physiques



Adapté de : Rauschecker, TINS 1995; 18: 36-43.

Plasticité intermodale : corrélats cérébraux

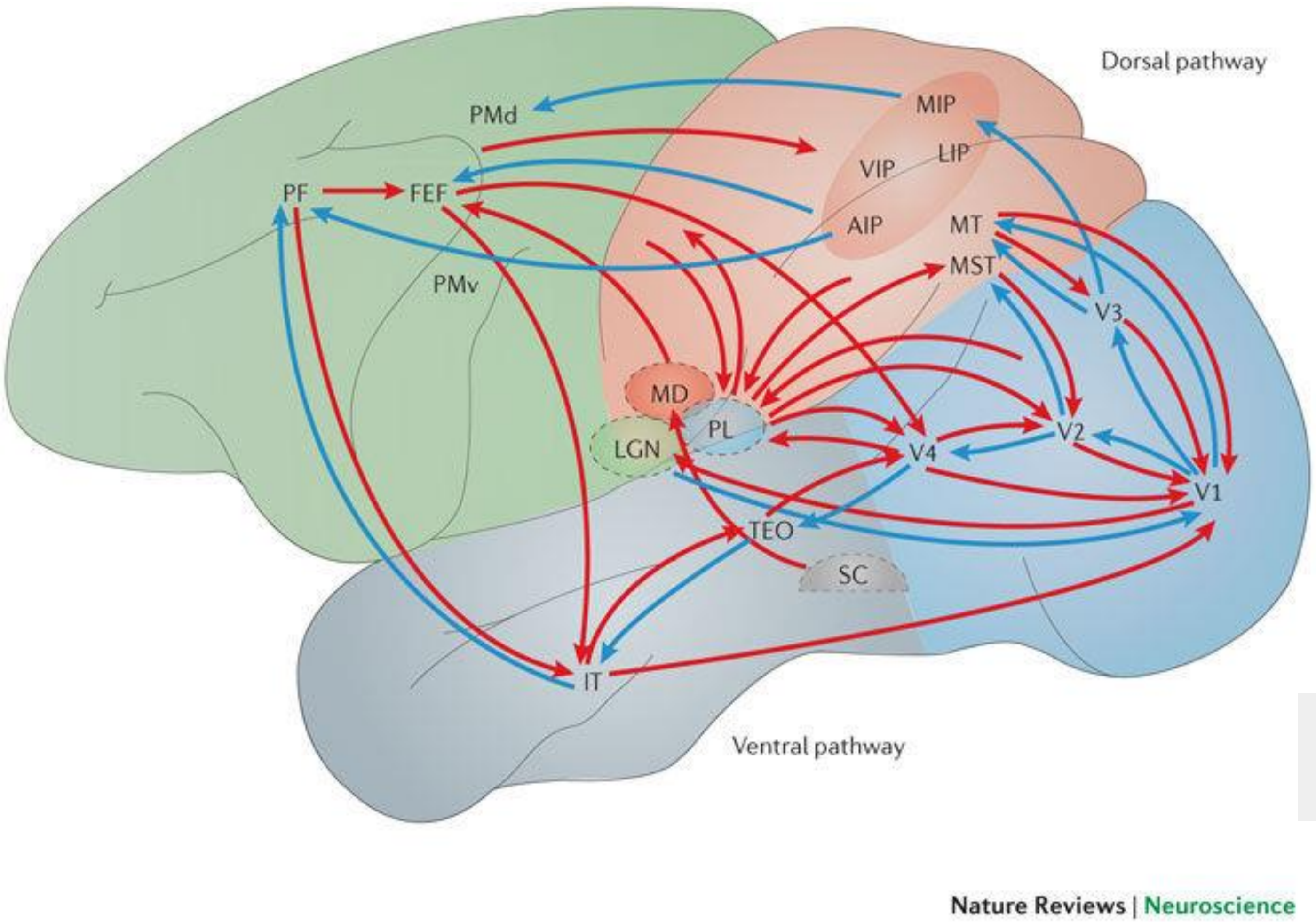




AES : anterior ectosylvian sulcus

Adapté de : Rauschecker, TINS 1995; 18: 36-43.

Vision

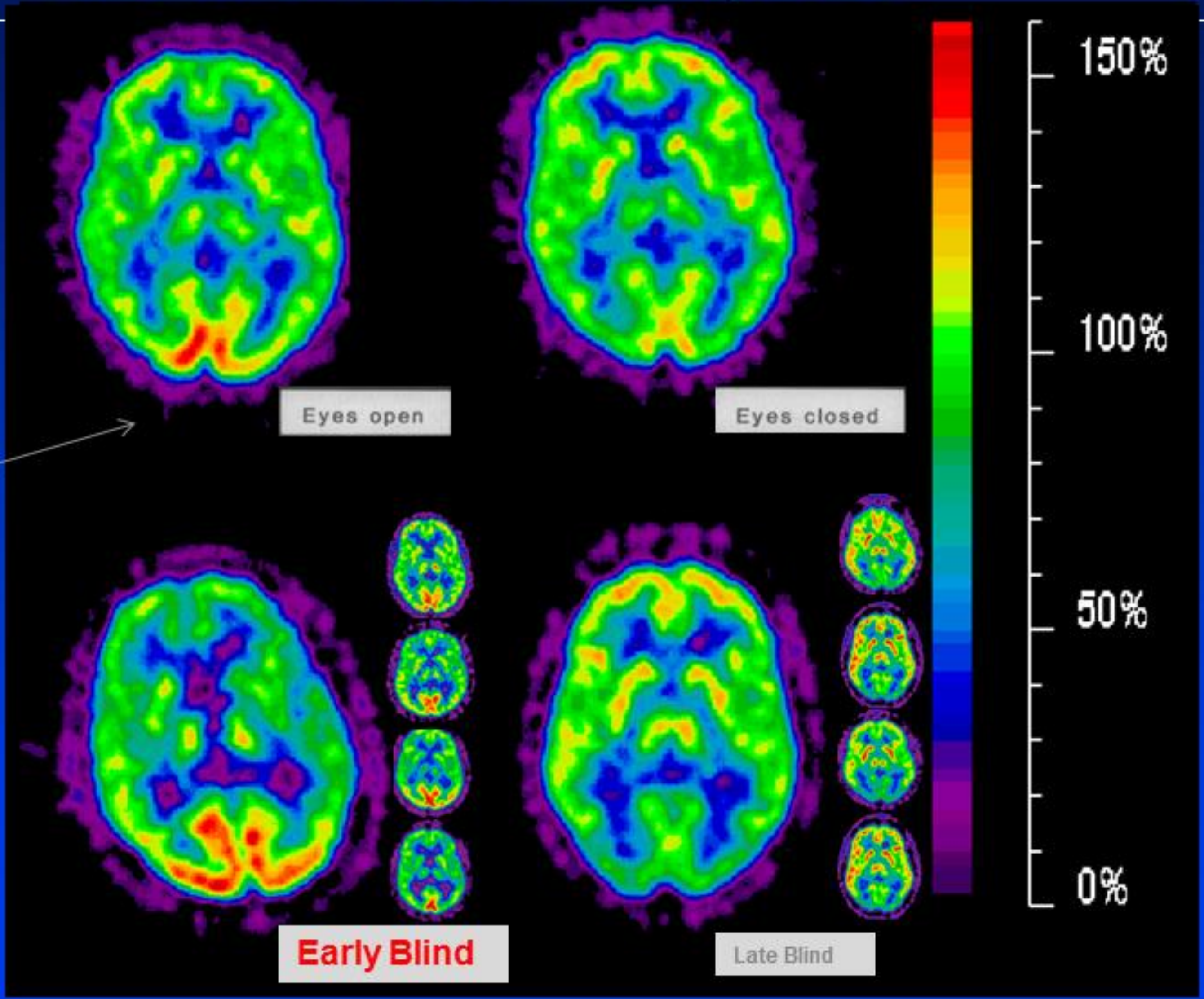


- 2/3 du cerveau impliqué dans la vision (± 60 000 000 000 de neurones)

Réorganisation cérébrale et plasticité nerveuse

Glucose utilization in human visual cortex is abnormally elevated in blindness of early onset

Adapted from Phelps et al., Science 1981.



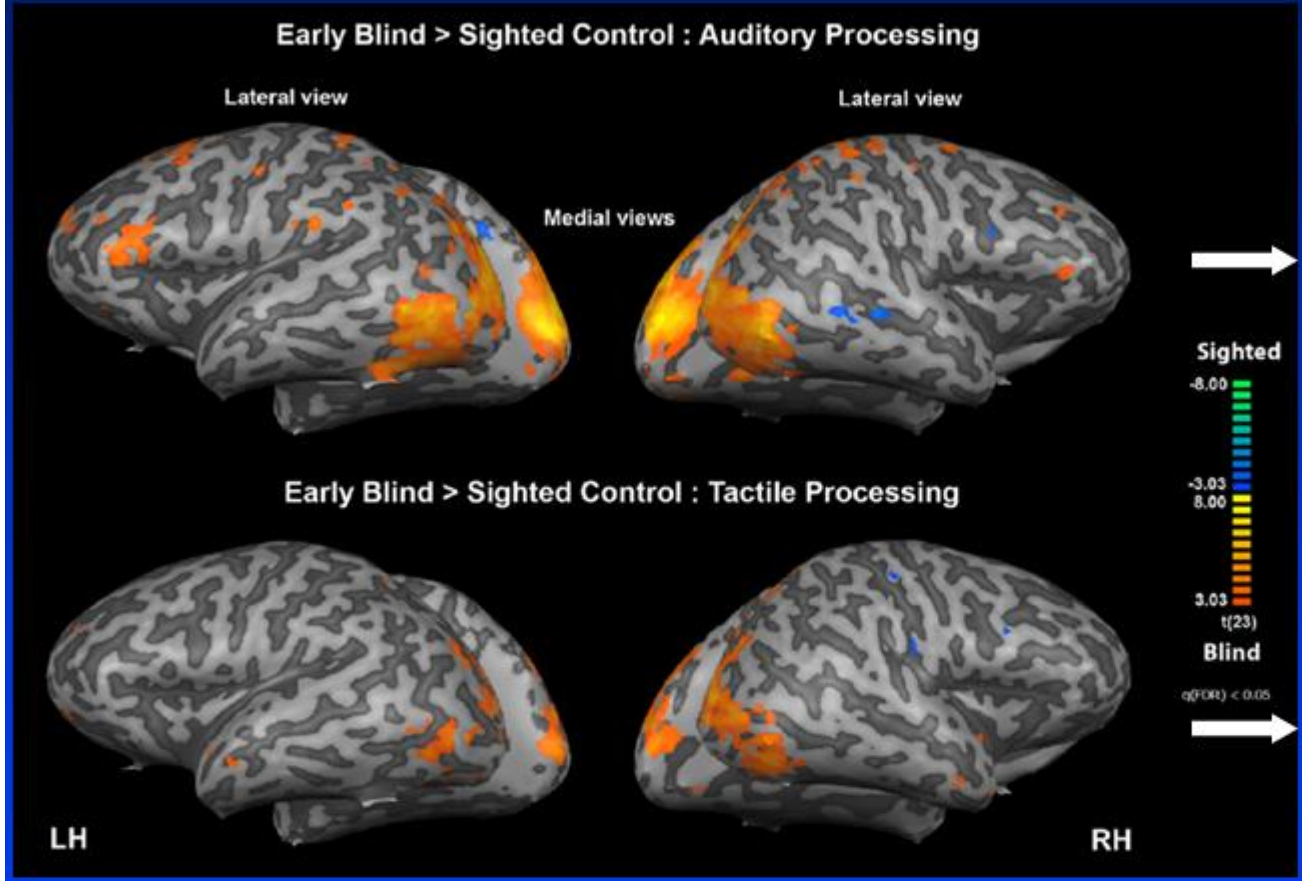
PET/FDG study of regional brain glucose metabolism

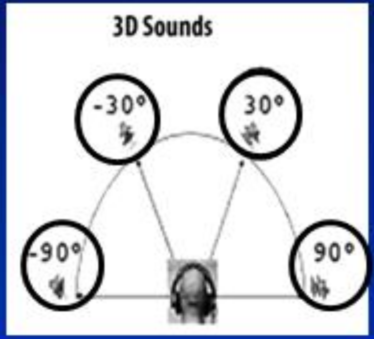
= an index of synaptic activity

Wanet-Defalque *et al.* *Brain Res.*, 1988; Veraart *et al.* *Brain Res.*, 1990; De Volder *et al.* *Brain Res.*, 1997.

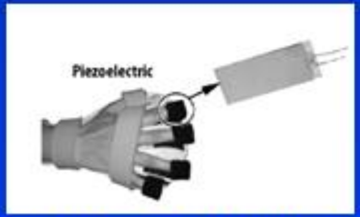
Preserved functional dorsal stream in the blind : processing auditory and tactile stimuli

Localization + Identification





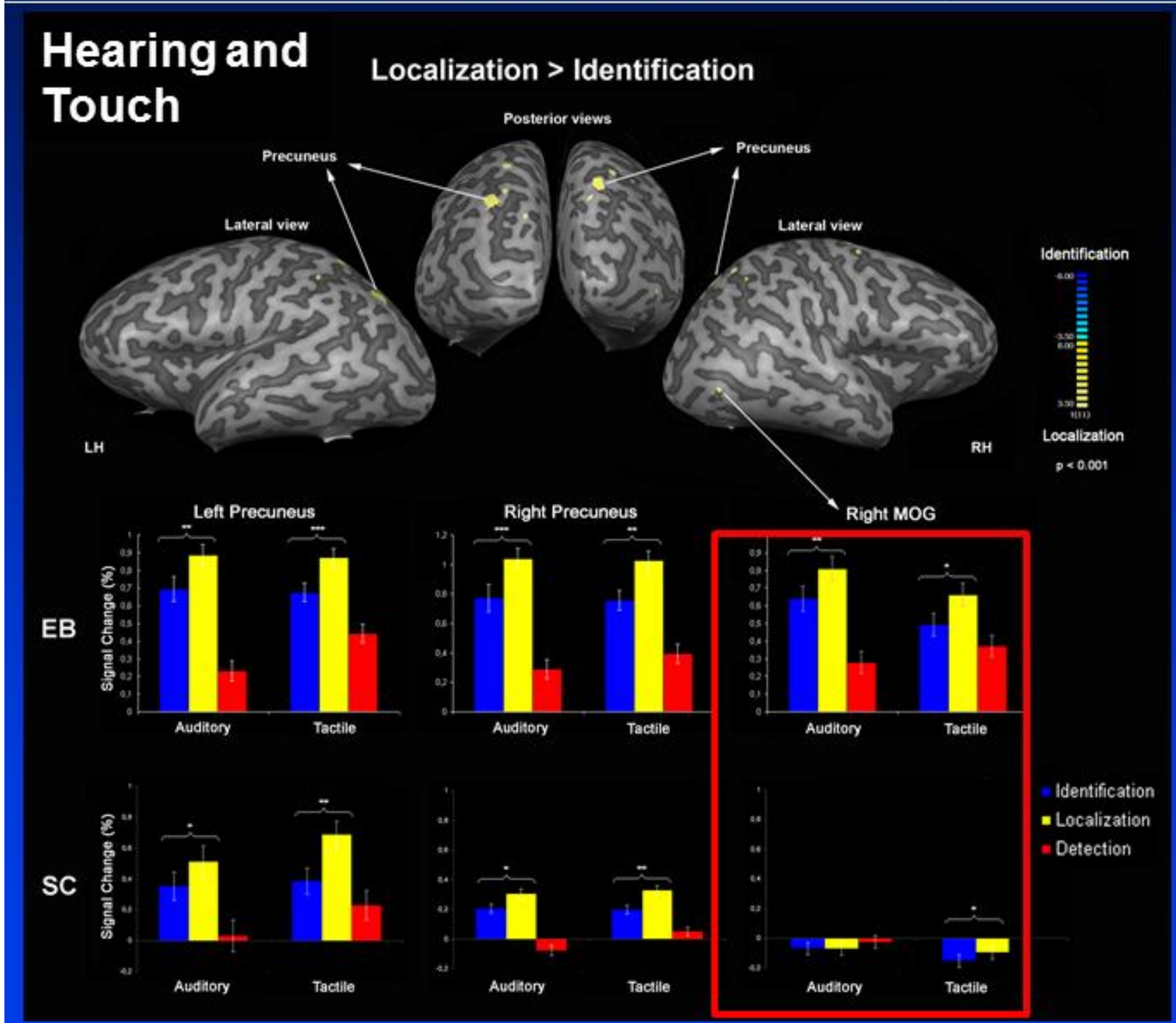
4 piano chords varying in pitch



4 pure tones of 40, 80, 160 and 320 Hz

Renier et al, *Neuron*, 2010.

Preserved functional specialization for spatial processing in the Middle Occipital Gyrus of the early blind



- Stimuli / Task :
  - localization
  - identification
- one-back comparison task

Vision

See also Collignon, Lepore et al., *PNAS*, 2011

Weeks , Rauschecker et al., *J Neurosci.* 2000

Capacités auditives

Absolute pitch in blind musicians

Roy H. Hamilton,[1,2] Alvaro Pascual-Leone[1] and Gottfried Schlaug[1,CA]

[1]Department of Neurology, Beth Israel Deaconess Medical Center, 330 Brookline Avenue, Palmer I, Boston, MA 02215; [2]Harvard Medical School, Boston, MA, USA

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DOI: 10.1097/01.wnr.0000118981.36602.90

Absolute pitch (AP) is possessed by only a small percentage of musicians (typically $< 20\%$). From a sample of 46 early blind subjects, we identified 21 who had musical training, 12 of whom (57.1%) reported having AP, reflecting markedly increased prevalence compared to sighted musicians, despite the fact that mean age of commencement of musical training was significantly later among blind than sighted AP musicians in our database. MR images acquired in a subset of blind AP musicians revealed greater variability in planum temporale asymmetry compared with the increased left-sided asymmetry previously described in sighted AP musicians. This suggests that neural mechanisms underlying AP in blind musicians could differ from those in sighted musicians. *NeuroReport* 15:803–806 © 2004 Lippincott Williams & Wilkins.

Key words: Absolute pitch; Morphometry; Musicians; Blind; Planum temporale

Capacités auditives

Pitch discrimination in the early blind

People blinded in infancy have sharper listening skills than those who lost their sight later.

Do blind people develop superior abilities in auditory perception to compensate for their lack of vision? They are known to be better than sighted people at orientating themselves by sound, but it is not clear whether this enhanced awareness extends to other auditory domains, such as listening to music or to voices. Here we show that blind people are better than sighted controls at judging the direction of pitch change between sounds, even when the speed of change is ten times faster than that perceived by the controls — but only if they became blind at an early age. The younger the onset of blindness, the better is the performance, which is in line with cerebral plasticity being optimal during the early years.

Auditory spatial localization is enhanced in early-blind subjects[1–3], but the effect of blindness on performance in the non-spatial auditory domain is less clear: blind sub-

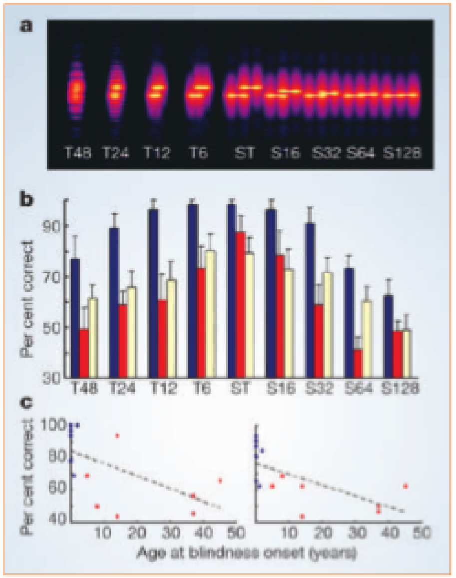


Figure 1 Judgement of direction of pitch change by early-blind,

($r = -0.49$, $P = 0.045$, one-tailed). Again, this finding held for both the spectral (Fig. 1c, right; $r = -0.65$, $P = 0.011$) and the temporal (Fig. 1c, left; $r = -0.60$, $P = 0.024$) parts of the data set.

Early-blind subjects were better than both late-blind and sighted subjects at determining the direction of pitch change, for different temporal as well as spectral levels. We conclude that compensatory auditory mechanisms following visual deprivation must extend beyond the spatial domain. Our finding that a large part of the variance (42%) could be accounted for by the age of blindness onset may explain why conflicting results are found when early- and late-blind subjects are pooled together[4,6]. Moreover, it is in agreement with the idea that cerebral plasticity is more efficient at early developmental stages.

Frédéric Gougoux*, Franco Lepore*, Maryse Lassonde*, Patrice Voss*,

Open access, freely available online PLoS BIOLOGY

A Functional Neuroimaging Study of Sound Localization: Visual Cortex Activity Predicts Performance in Early-Blind Individuals

Frédéric Gougoux[1], Robert J. Zatorre[2], Maryse Lassonde[1], Patrice Voss[1], Franco Lepore[1,3*]

1 Centre de Recherche en Neuropsychologie et Cognition, Département de Psychologie, Université de Montréal, Montréal, Québec, Canada, 2 Neuropsychology/Cognitive

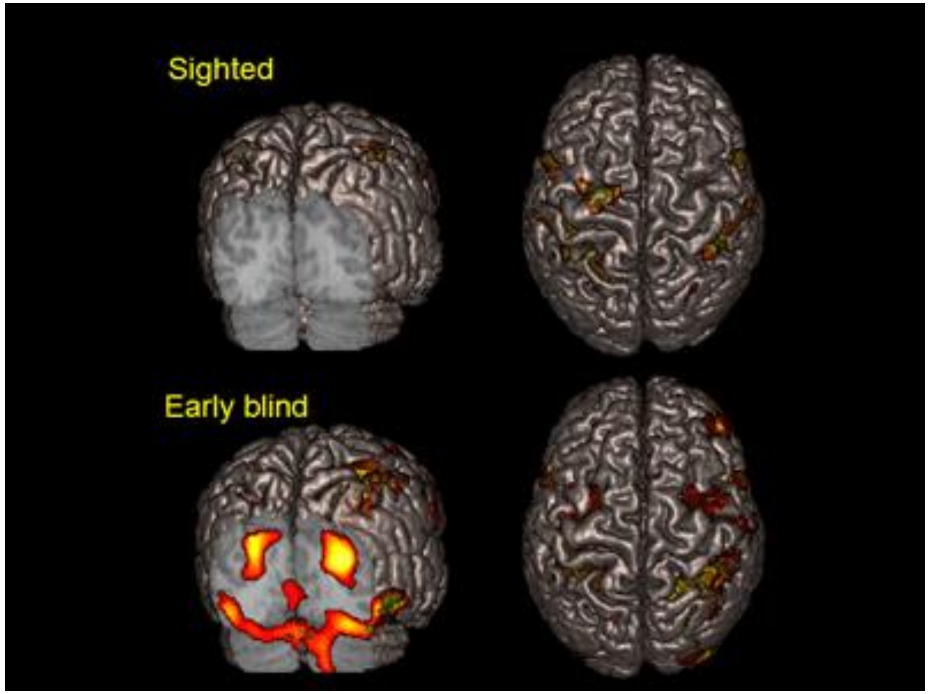
Capacités tactiles

letters to nature

Involvement of visual cortex in tactile discrimination of orientation

Andro Zangaladze*, Charles M. Epstein, Scott T. Grafton & K. Sathian

Department of Neurology, Emory University School of Medicine, WMRB-6000, PO Drawer V, 1639 Pierce Drive, Atlanta, Georgia 30322, USA



Activation of the primary visual cortex by Braille reading in blind subjects

Norihiro Sadato*†, Alvaro Pascual-Leone*, Jordan Grafman‡, Vicente Ibañez*, Marie-Pierre Deiber*, George Dold§ & Mark Hallett*

* Human Motor Control Section, and ‡ Cognitive Neuroscience Section, Medical Neurology Branch, and § Research Service Branch, National Institute of Neurological Disorders and Stroke, National Institutes of Health, Bethesda, Maryland 20892-1428, USA

Capacités mnésiques

ing Group http://www.nature.com/natureneuroscience

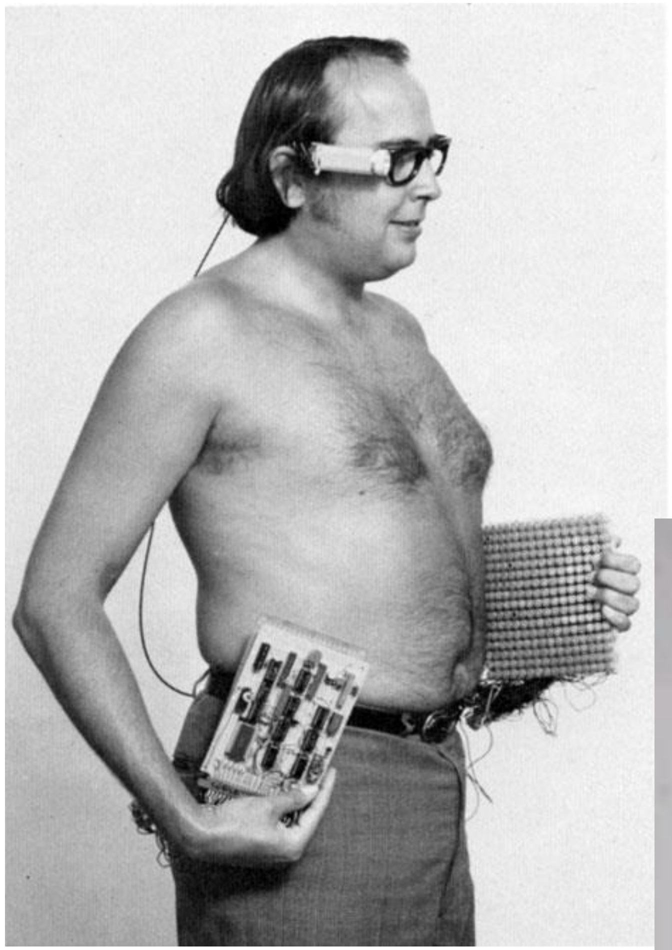
Early 'visual' cortex activation correlates with superior verbal memory performance in the blind

Amir Amedi[1,2,5], Noa Raz[1,5], Pazit Pianka[3], Rafael Malach[4] & Ehud Zohary[1,2]

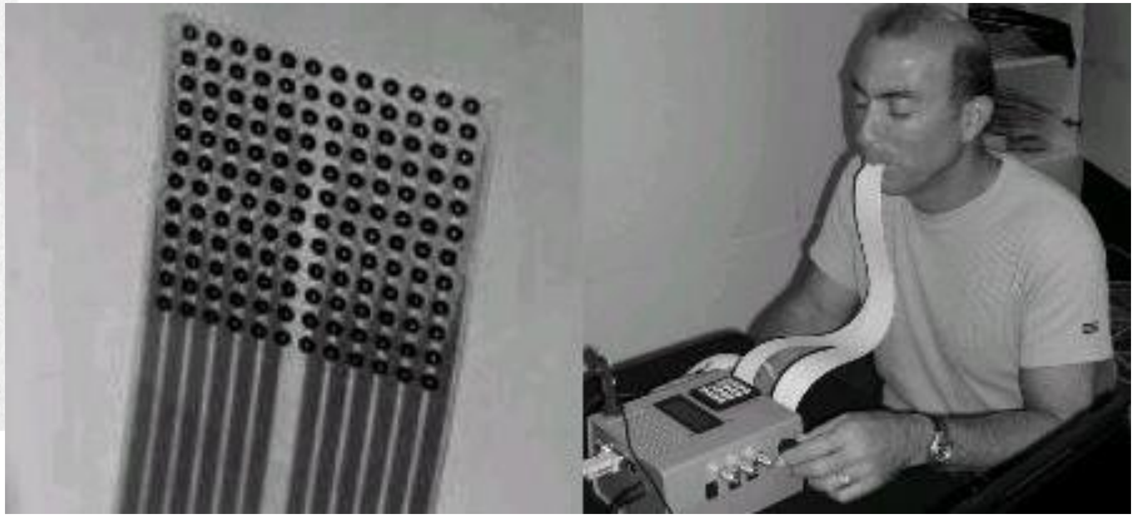
The visual cortex may be more modifiable than previously considered. Using functional magnetic resonance imaging (fMRI) in ten congenitally blind human participants, we found robust occipital activation during a verbal-memory task (in the absence of any sensory input), as well as during verb generation and Braille reading. We also found evidence for reorganization and specialization of the occipital cortex, along the anterior–posterior axis. Whereas anterior regions showed preference for Braille, posterior regions (including V1) showed preference for verbal-memory and verb generation (which both require memory of verbal material). No such occipital activation was found in sighted subjects. This difference between the groups was mirrored by superior performance of the blind in various verbal-memory tasks. Moreover, the magnitude of V1 activation during the verbal-memory condition was highly correlated with the blind individual's abilities in a variety of verbal-memory tests, suggesting that the additional occipital activation may have a functional role.

"The traditions cited by Rabbi Sheshet are not subject to doubt as he is a blind man." –Talmud Yerushalmi, *tractate Shabat 6b*

Substitution sensorielle



TVSS, 1969

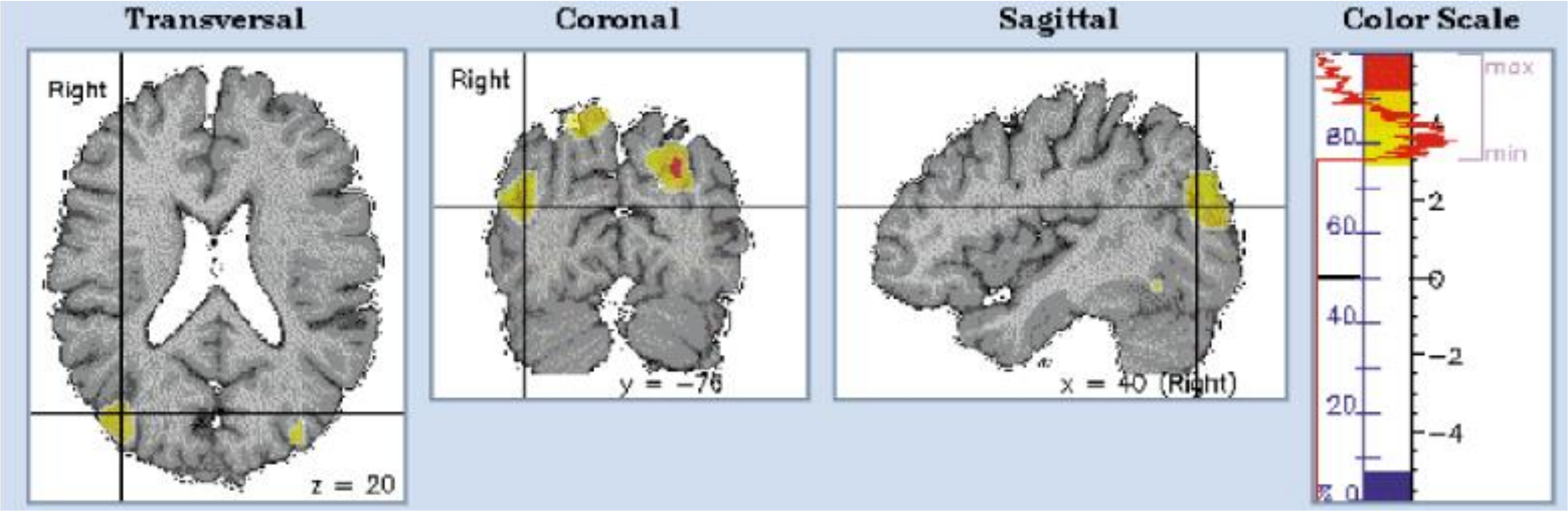


NeuroImage **13,** 632–645 (2001)
doi:10.1006/nimg.2000.0731, available online at http://www.idealibrary.com on IDEAL®

Occipital Activation by Pattern Recognition in the Early Blind Using Auditory Substitution for Vision

Patricia Arno,* Anne G. De Volder,† Annick Vanlierde,* Marie-Chantal Wanet-Defalque,* Emmanuel Streel,* Annie Robert,‡ Sandra Sanabria-Bohórquez,* and Claude Veraart*

**Neural Rehabilitation Engineering Laboratory and ‡Public Health School, Université Catholique de Louvain, B-1200 Brussels, Belgium; and †Positron Tomography Unit, Université Catholique de Louvain, Louvain-la-Neuve, Belgium*

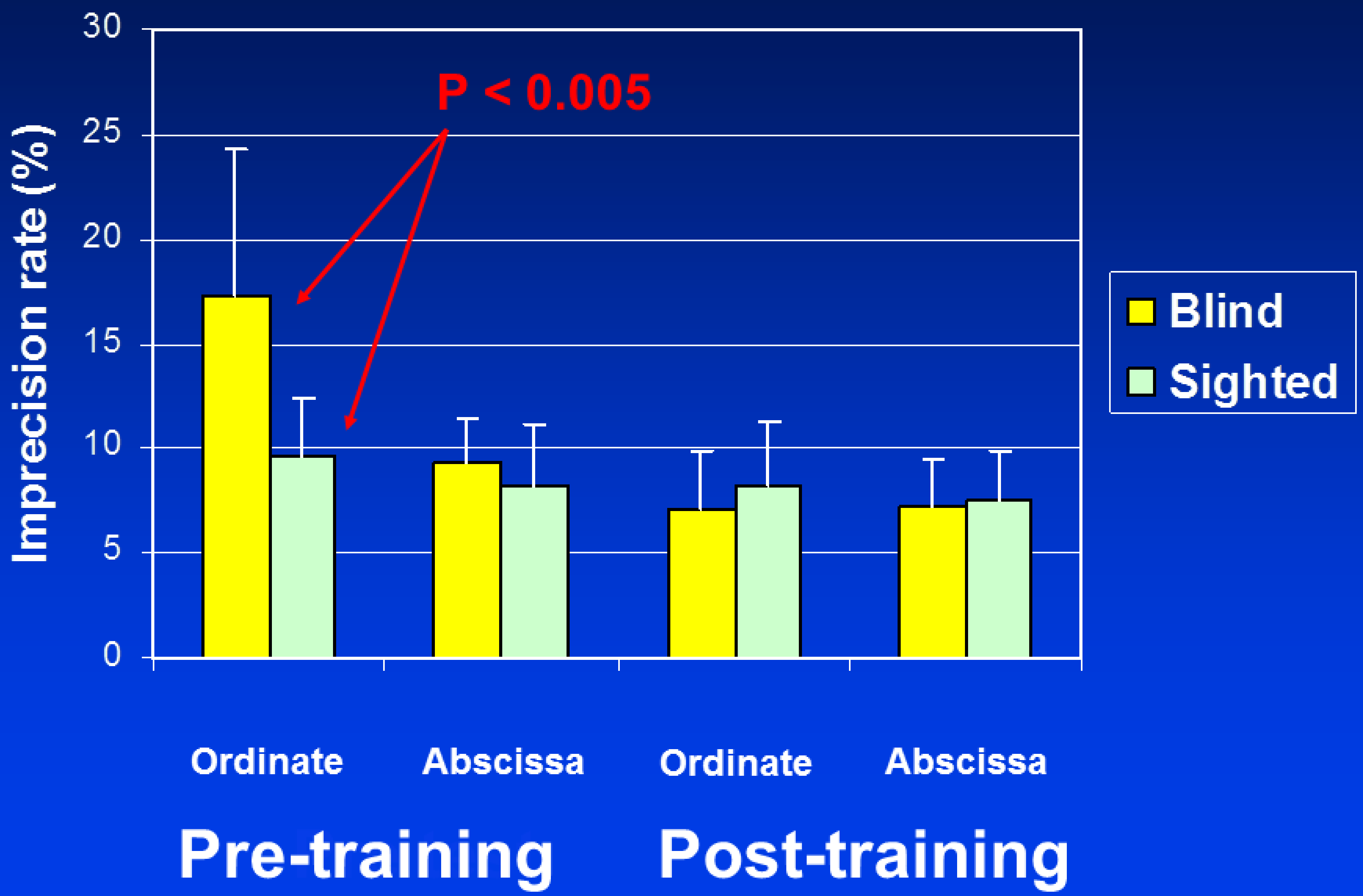


Localisation spatiale

Capelle, Veraart et al, 1998

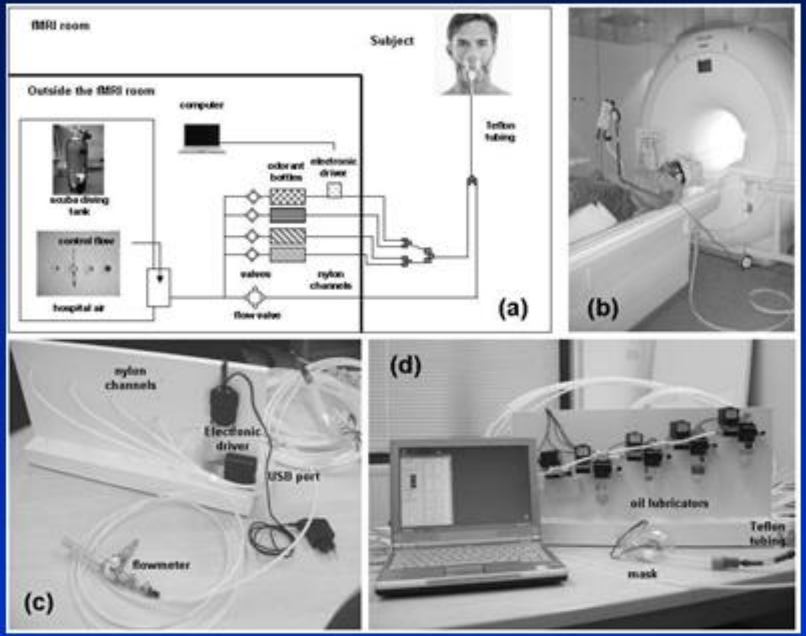
Renier & De Volder, Disab Rehab, 2010

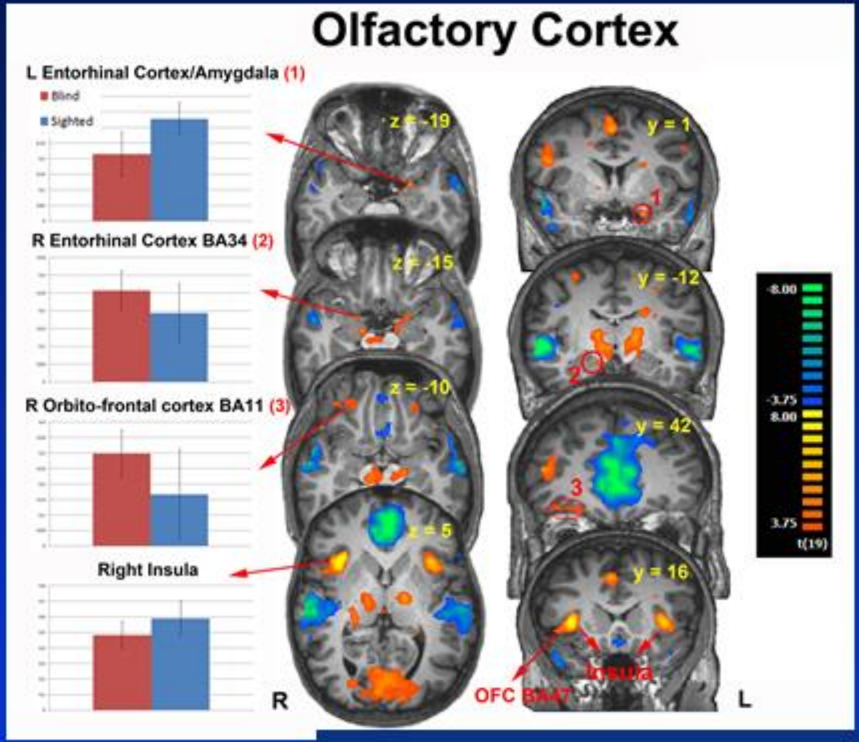
Results



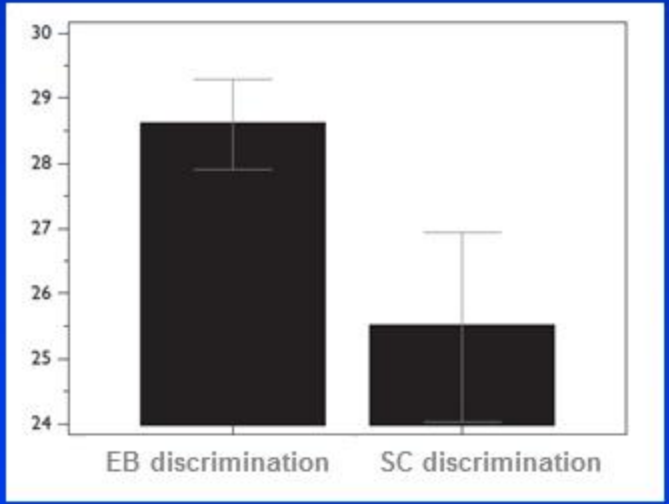
P < 0.005
Imprecision rate (%)
30
25
20
15
10
5
0
Blind
Sighted
Ordinate
Abscissa
Ordinate
Abscissa
Pre-training
Post-training

Olfactory processing in the occipital cortex of the blind





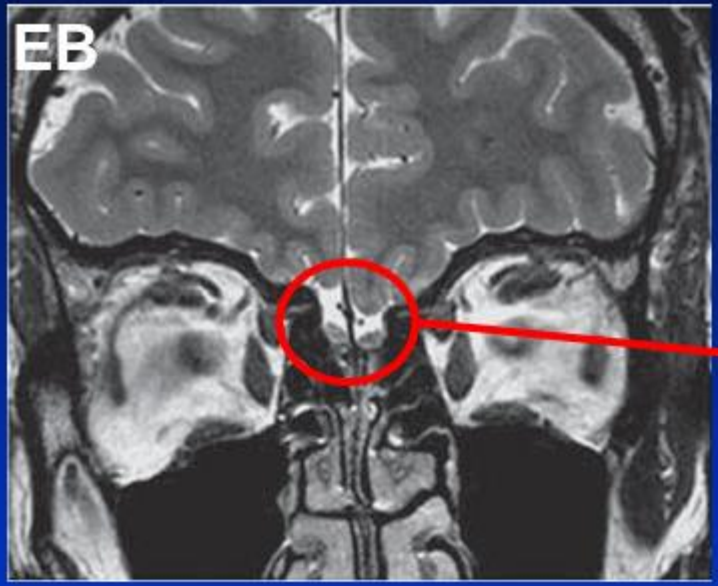
Behav. Res. Methods, 2010.

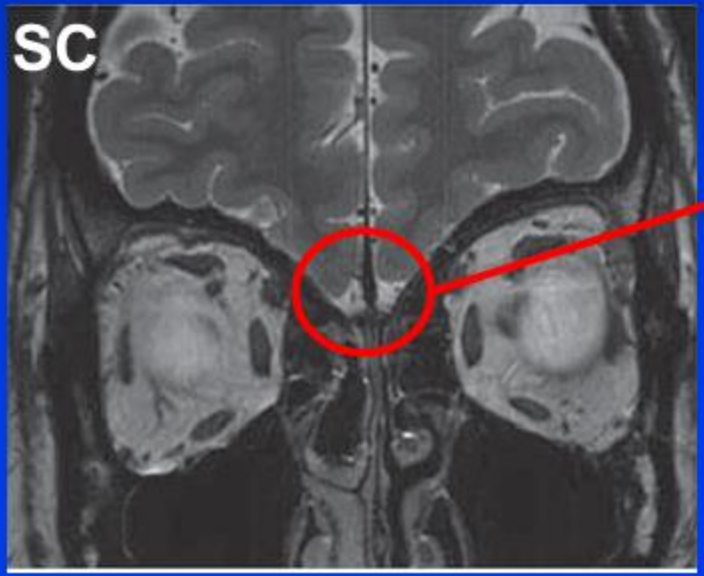


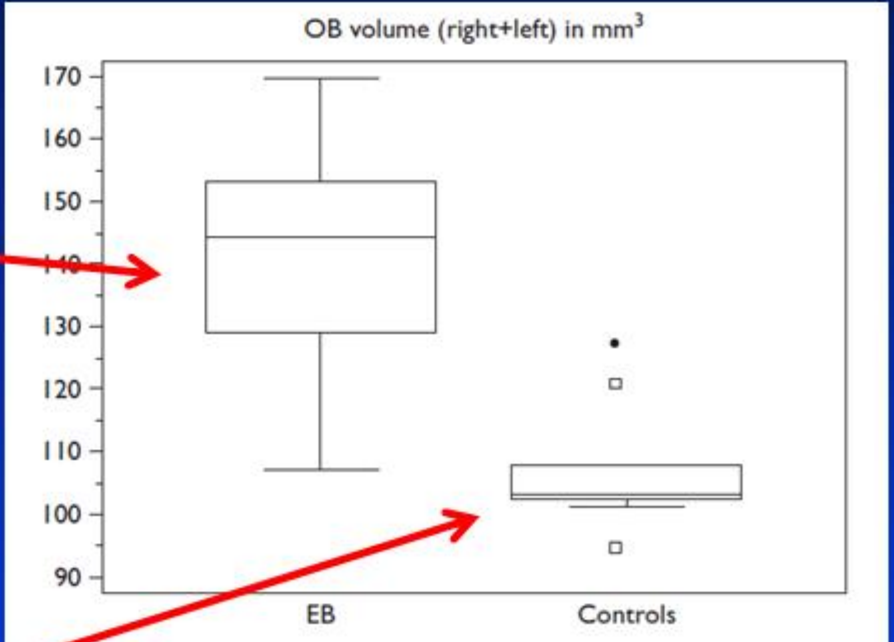
Lower detection threshold and better discri-minatrion abilities *Cuevas et al., JVIB, 2010.*

See also Beaulieu-Lefebvre et al., *Brain Res Bull.*, 2011.

Evoked olfactory responses in the OC in EB subjects *Cuevas et al., B-ENT, 2011.*



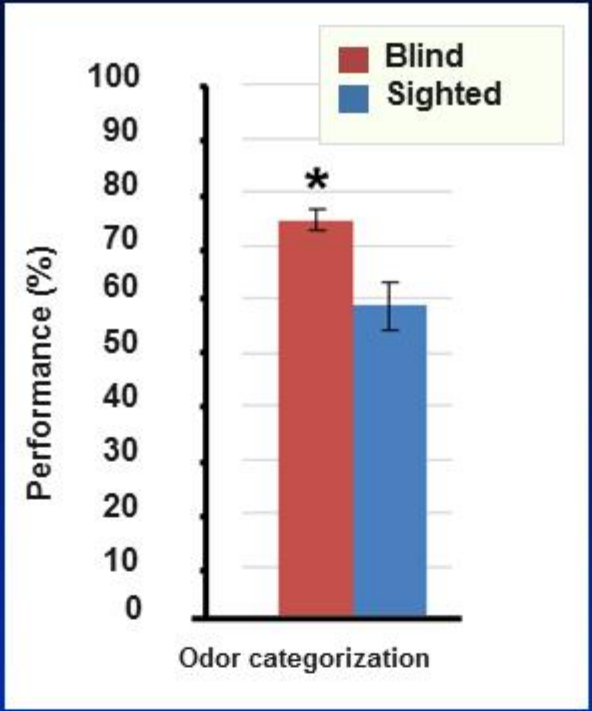




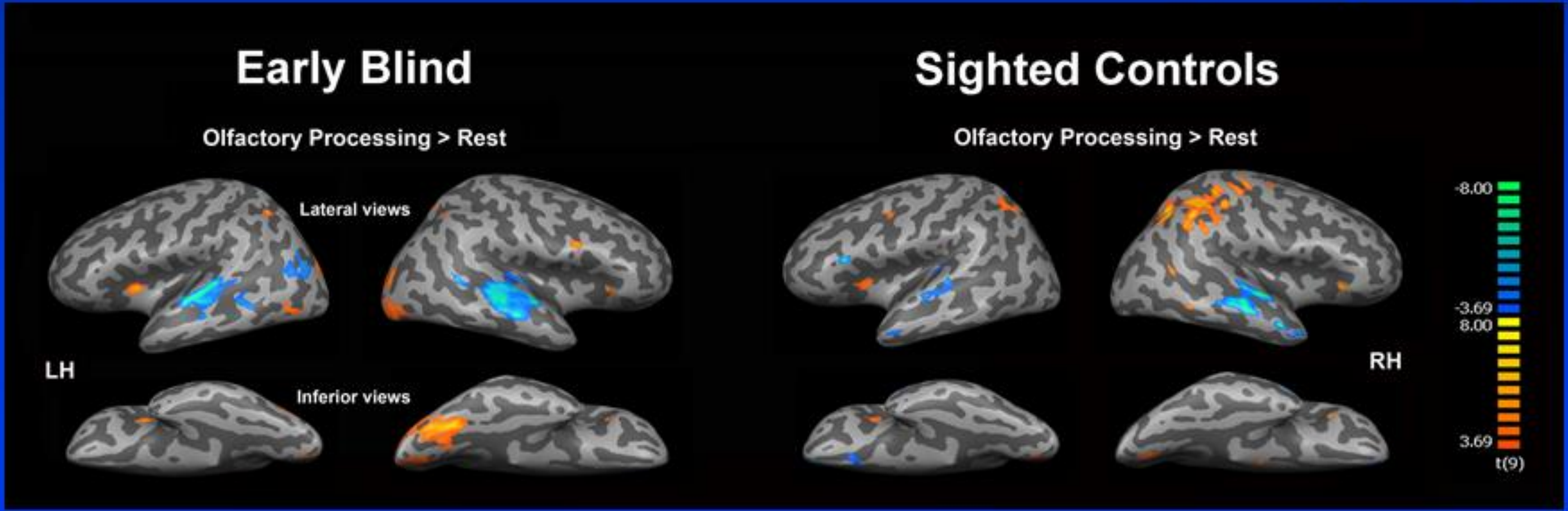
Box and whisker plots of total (right + left) olfactory bulb (OB) volume between EB subjects and controls.

Rombaux et al., *Neuroreport*, 2009

How blind people « see » odors

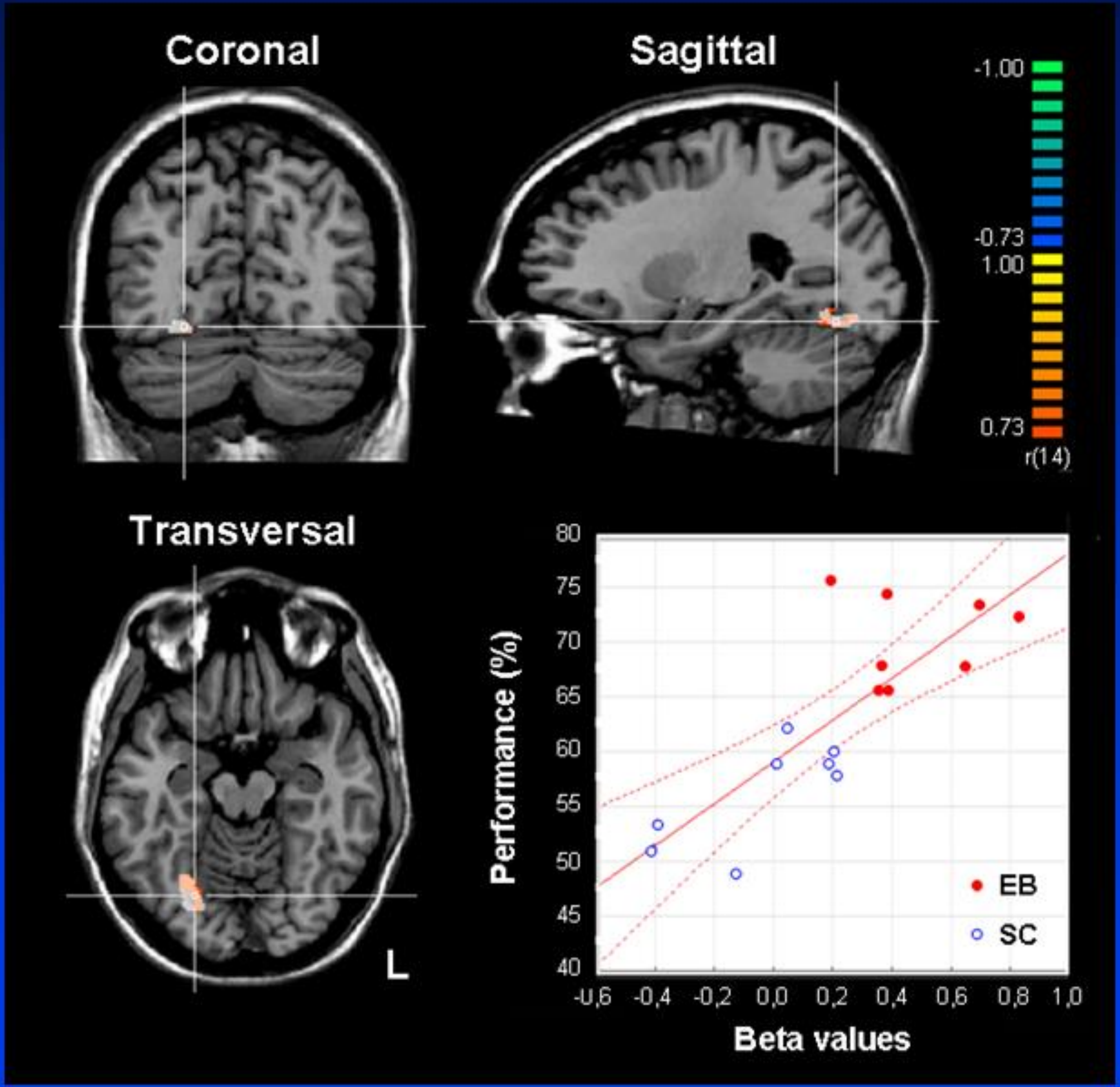


Cuevas et al., *Neuropsychologia*, 2009.

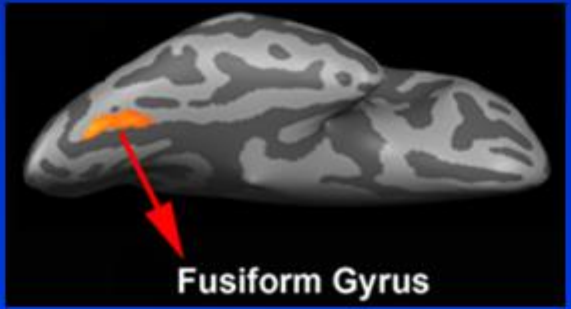


Renier, Cuevas et al, PLOS One, 2013, See also Kupers, Ptito et al., Neuropsychologia, *2011*.

Role of the right fusiform gyrus in olfactory processing



- Covariance analysis (whole brain) $p<0.001$



- Correlation analysis in the right fusiform gyrus (0.80)

Perspectives

Développer les capacités olfactives et gustatives par l'entraînement

Former un nez

Œnologues/ sommeliers, zytologues/biérologues

Développer les compétences rares et précieuses des personnes aveugles de sorte qu'en dépit de leur déficience sensorielle et de leur troubles (éventuels) associés ils puissent bénéficier d'une meilleure *intégrations* sociale et professionnelle.

John Bramblitt – blind painter

Merci