



# INVESTIGATION COGNITIVE AVEC LES EFRPs (EYE-FIXATION-RELATED POTENTIALS)

Thierry Baccino  
CHART-LUTIN (EA 4004)  
Université de Paris VIII

# MESURES OCULAIRES

The screenshot shows a school website interface for 'Lycée Evaluation Belfort - BASSEAS Elsa'. The interface includes a navigation menu with items like 'Mon Ent', 'Configuration', 'Statistiques', 'Communication', 'Liens et applications', and 'Documents'. Below the menu are sections for 'Ma page d'accueil', 'IP Label performances', 'Messagerie', 'Encyclopédies', and 'Agenda'. The 'Agenda' section displays a calendar grid with colored blocks representing different classes. A 'PostIT [2]' window is visible at the bottom. Green heatmaps are overlaid on the page, indicating areas of high visual attention, primarily on the navigation menu, the 'Messagerie' section, and the 'Agenda' grid.



- Beethoven
- Bach
- Vivaldi
- Schubert
- Beatles
- Spice Girls
- Hanoi Rocks
- Rolling Stones
- Madonna
- Depeche Mode
- Elvis
- Still Crazy After All These Years
- Like a Virgin
- Hotel California
- Staying Alive
- Radio Ga Ga
- Macarena
- Rock Around the Clock
- Let It Be
- Memories



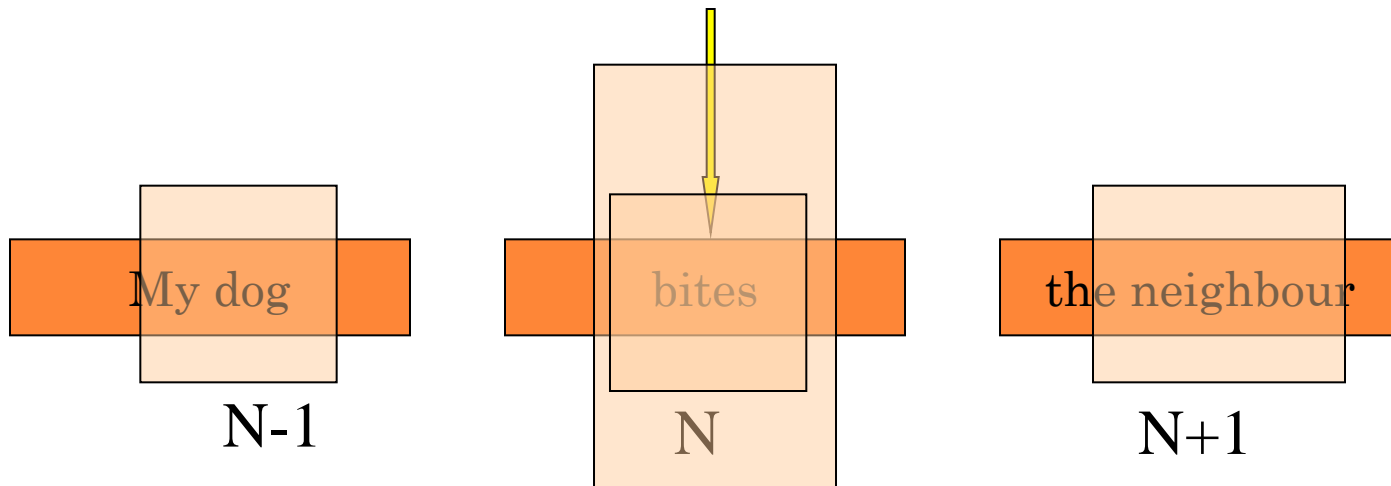
# PRELIMINARY QUESTIONS TO EFRPs

- Postulate:
  - Individual fixations are the « information units »?
  
- Questions: *Fixation properties*
  1. Completeness: does this information unit reflect only what is fixated?
    - *Or may be affected by previous or future processing?*
  2. Equivalence: does every fixation convey the same processing?
    - *Would it be possible to categorize fixations as attentional fixations, semantic fixations....?*



# 1. COMPLETENESS ?

- Not really true:
  - Parafoveal processing from:
    - Previous processing → Spill-over effects
    - Later processing → Parafoveal previewing



## 2. EQUIVALENCE BETWEEN FIXATIONS?

Plan du site Nous contacter

A propos de l'ANIL Nos partenaires Votre ADIL Recherche sur le site  OK

### Bienvenue sur le site de l'ANIL

L'Agence Nationale pour l'Information sur le Logement

#### Le guide du logement

- > Vous et les Professionnels
- > Accession à la propriété
- > Propriétaire occupant
- > Louer
- > Difficultés
- > Caution
- > Investissement locatif
- > **Instituts**

#### Calculez ...

Financement d'une opération, échéancier de prêt, frais annexes, révision de loyer, plus value, investissement locatif...

#### FAQ

Vous avez des questions ? Nous avons des réponses ...

#### En savoir plus...

Les bases de données des spécialistes du logement

- > Les études de l'ANIL et des ADIL
- > L'actualité réglementaire
- > Questions / Réponses
- > **Jurisprudence**

#### Lumière sur ...

L'actualité en bref et les dernières publications

©Anil MARS 2001

Scanpath from an information seeking task

First Fixation

Last Fixation



# HOW TO DISENTANGLE DIFFERENT PROCESSES?

At least, two ways:

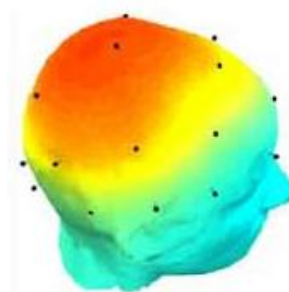
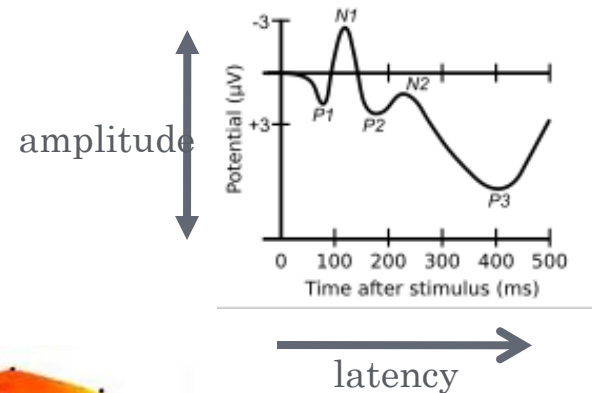
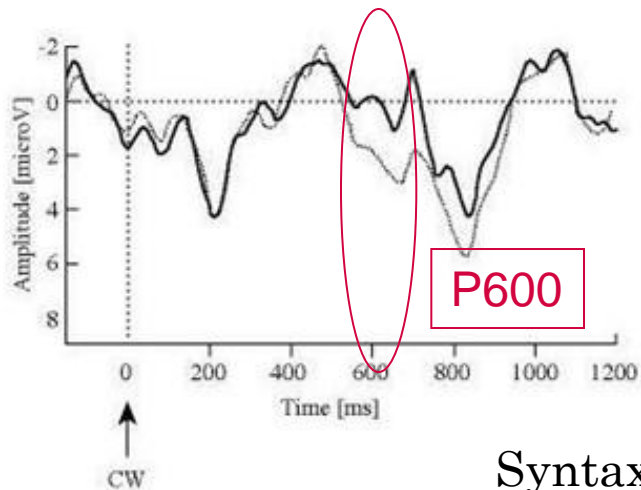
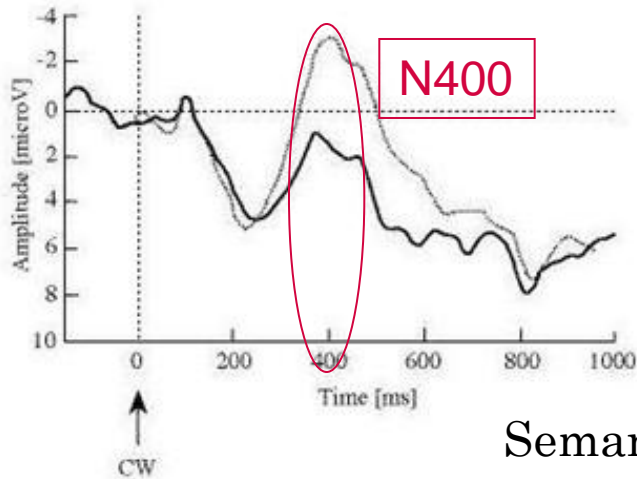
- **Statistical approach by crossing different variables:**
  - Fixation duration and saccade amplitude (Velichkovsky et al. 2002)
  - Fixation duration and number of progressive fixation (Kennedy et al, 1987)
  - MRA or Partial LS analyses crossing both qualitative and quantitative data (Marshall et al, 2002).
- **Physiological approach by integrating other measures:**
  - fMRI and EMs (Brown, Vilis & Everling, 2008; FIBER project – Cornelissen et al)
  - MEG and EMs (Hari, Helsinki)
  - EEGs and EMs – **EFRPs** (Baccino & Manunta, 2005; Hutzler et al, 2007;...)



# ERPs/EEGs: ADVANTAGES

## Advantages:

- Precise timing of activation/inhibition phases
- Correlation component/function
- Different measures of activity: latency, amplitude, scalp distribution,...



# EYE MOVEMENTS: ADVANTAGES

Puis, il est question depuis plusieurs années de lecture électronique ou numérique<sup>1</sup> pour désigner les documents affichés sur un écran ou un téléviseur, il paraissait logique également de s'interroger sur les spécificités de la lecture induites par de tels supports. Or, si les supports

Normal reader

Time	<u>Fixation duration</u> <ul style="list-style-type: none"><li>• Single Fixation/First Fixation</li><li>• Gaze Duration</li><li>• Progr./Regress. Fixations</li><li>• Refixations</li></ul>
Spatial	Saccade size Scanpath length...
Frequency	Number of fixations, regressions,...

## Advantages:

- High spatial ( $< 0.5^\circ$ ) and temporal accuracy ( $> 1\text{Khz}$ ).
- Natural conditions of viewing.
- Pupil dilation.





# LIMITATIONS

## ○ Limitations EEG:

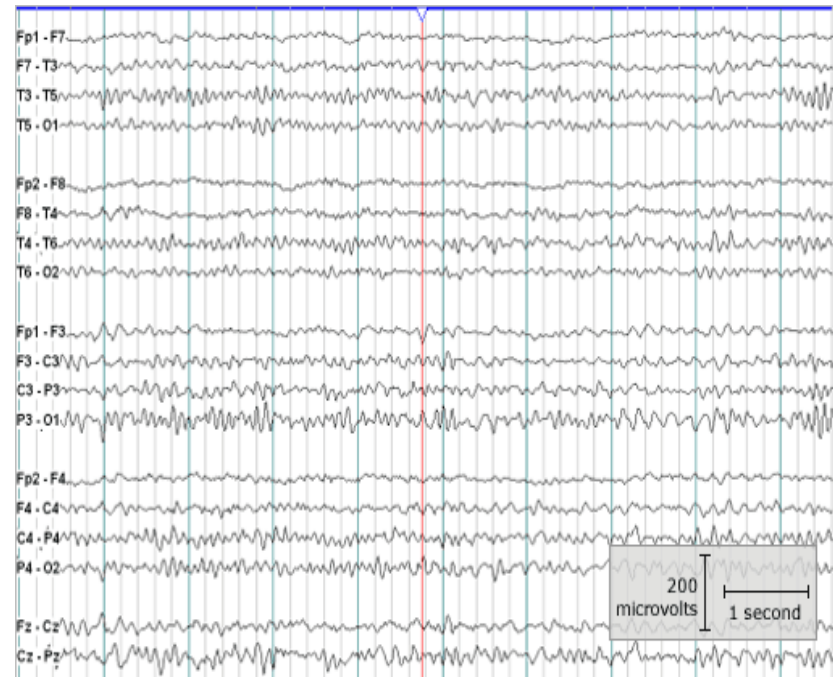
- Stimuli are presented with unnaturally long intervals ( $> 500\text{ms}$ ) → Late components analyses
- Stimuli are presented isolated at one fixed position → To remove out any saccade effects

## ○ Limitations Eye-Movements

- How to disentangle different processes (sequential or parallel) occurring during a fixation



# EYE-FIXATION-RELATED POTENTIALS (EFRPs): EYE-TRACKING BASED

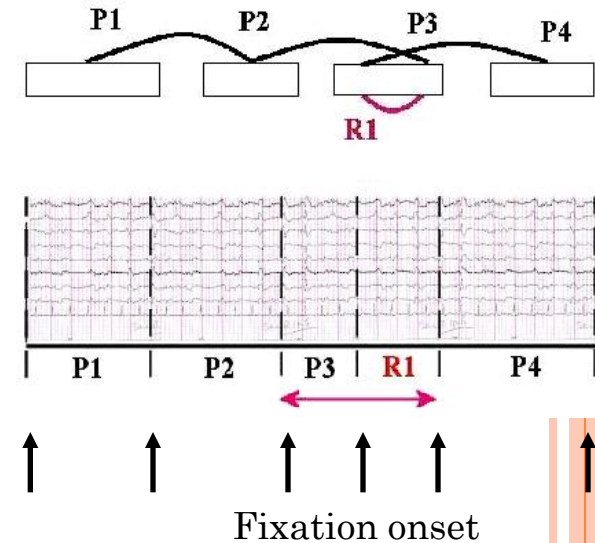
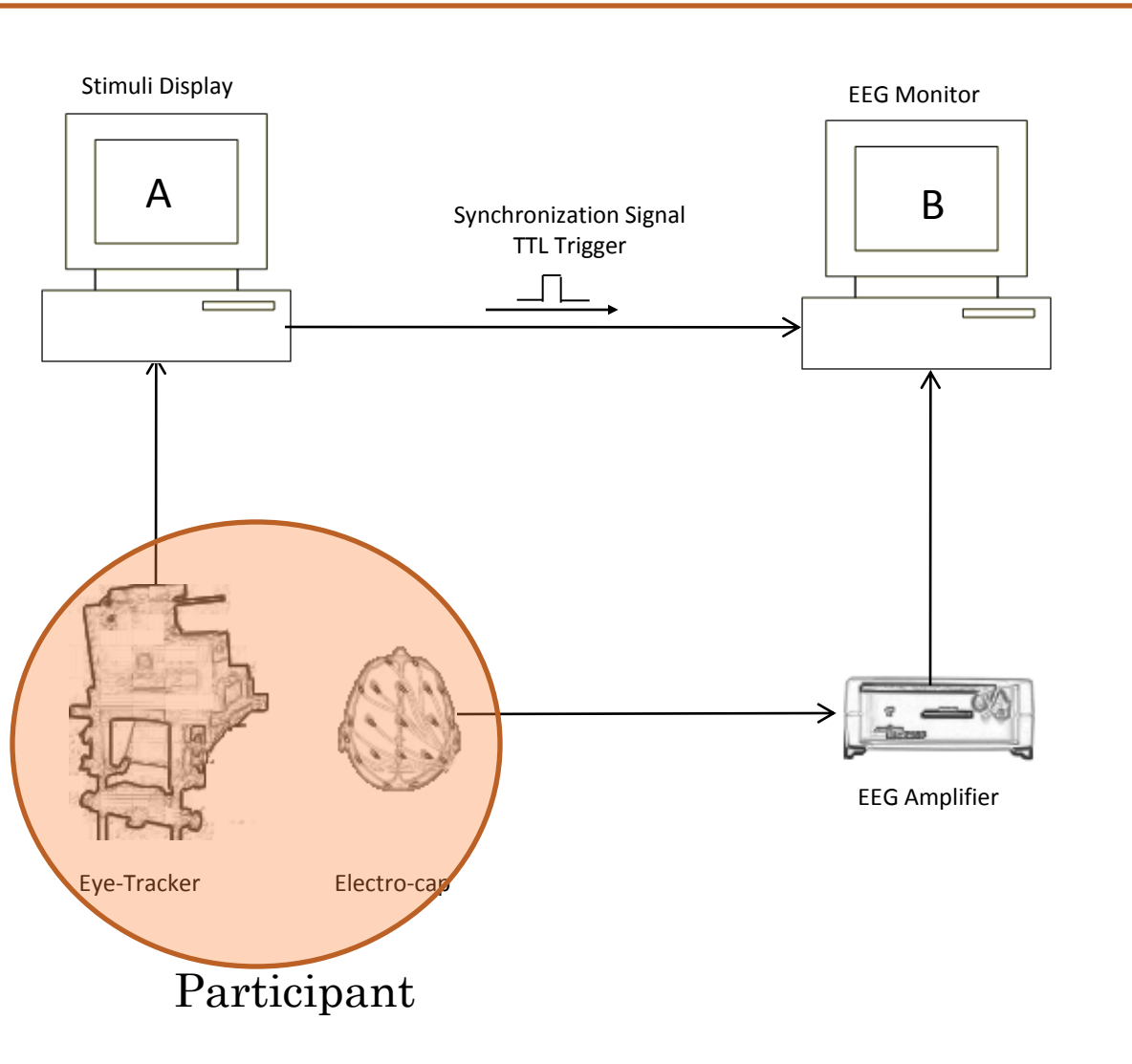


Overcome difficulties related to:

- Measuring ERPs/EMs in two separate sessions
- EOG does not provide accurate fixation locations



# EFRPs TECHNIQUE

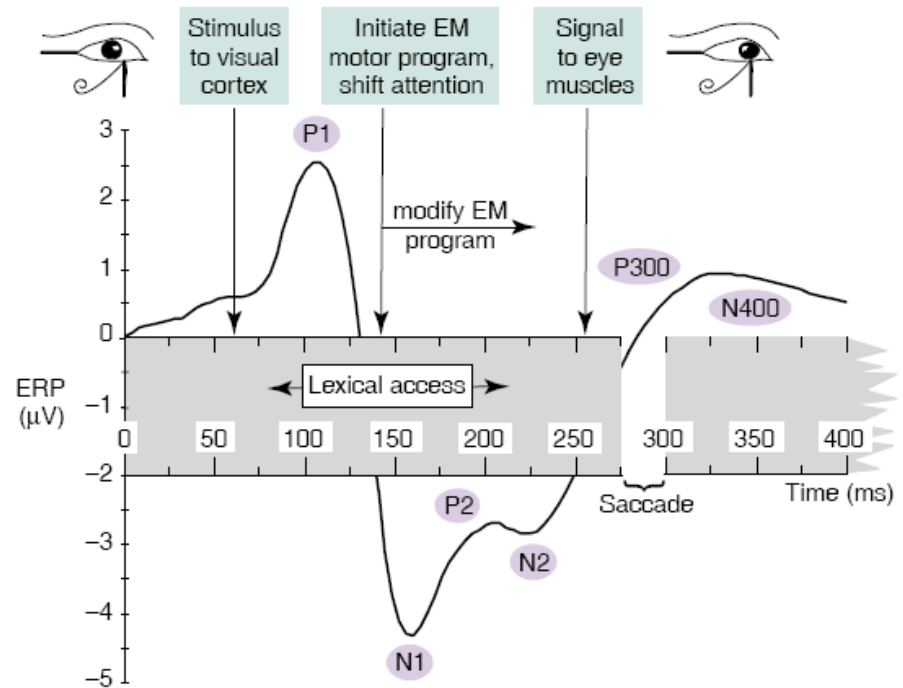


EFRPs will result from the segmentation of the continuous EEG with markers such as fixation onset and offset.

# EFRPs TECHNIQUE

## Advantages:

- **Precise time line** of activation/inhibition sequence of EEGs occurring during any fixation → allowing to investigate **early components** (attention, stress, perception, ..).
- **Natural conditions** of presentation → allowing to use saccadic movements.
- **Categorizing fixations** by using components analyses (PCA, ICA)



# DISSOCIATION BETWEEN SPATIAL AND NON-SPATIAL PROCESSES

**Goal: Disentangling specific processes - spatial and non-spatial processes with EFRPs (i.e, at fixation level)**

**N=12**

**Within-Factors:            2 Spatial X 2 Object**

- **Spatial: Match/Non-Match**
- **Object: Match/Non-Match**

**40 items by condition**



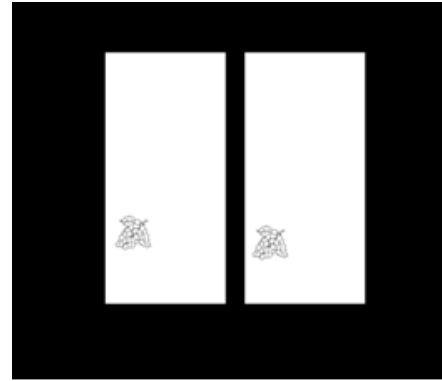
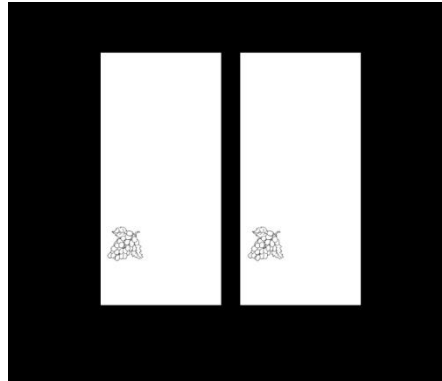
# DISSOCIATION BETWEEN SPATIAL AND NON-SPATIAL PROCESSES

Space

Match

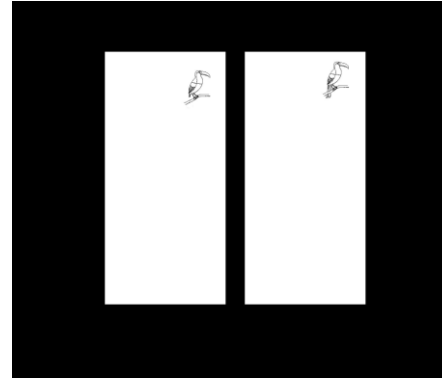
Non-Match

Match



Object

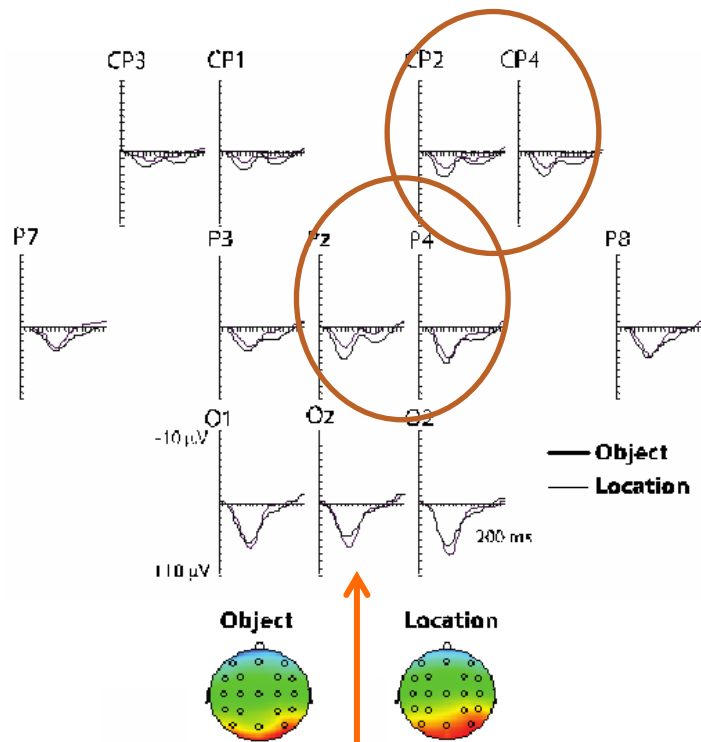
Non-Match



Task: To press a mouse button whether the drawings were the same or not.

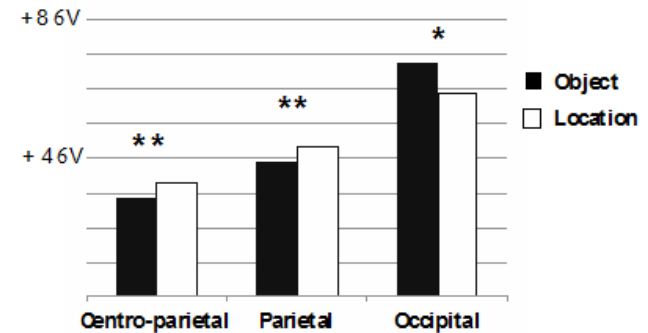


# RESULTS (EFRPs) – TASK EFFECT



EFRPs were analyzed during the first four fixations. Eye-fixations evoked P1 and N1 components that were maximal at the occipital, parietal, and centro-parietal recording sites. The mean latencies of P1 and N1 were 68 ms and 122 ms, respectively

## Task (P1 Amp)



Object: Larger P1 at occipital cortex

Location: Larger P1 at parietal and centro-parietal cortex

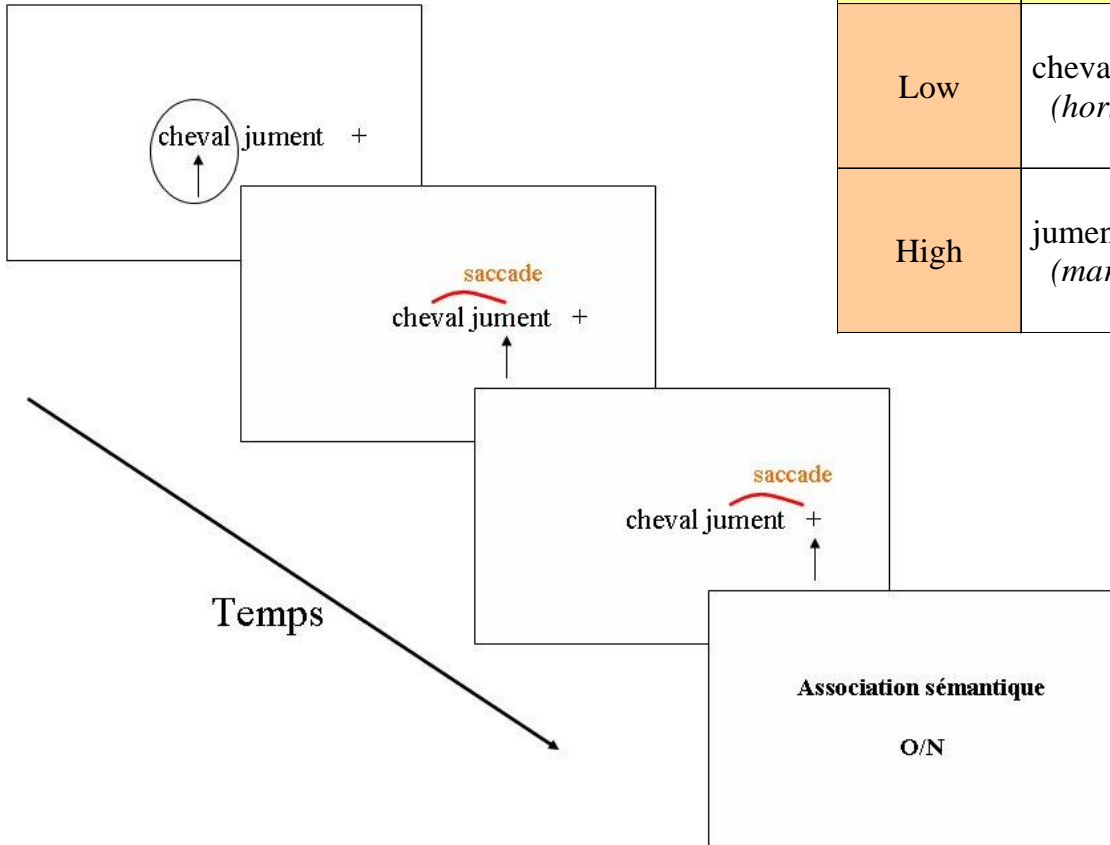
### Visual System:

Ventral Pathway (What): occipito-temporal cortex (involved in recognition of object features...)

Dorsal Pathway (Where): parietal cortex (involved in spatial processing of objects...)

# PARAFOVEAL/FOVEAL EFFECTS

Associated Strength	Semant. Asso.	Non-Word	Semant Non-Asso.
Low	cheval – jument (horse-mare)	cheval – tvsqrd (horse-tvsqrd)	cheval – chaise (horse-chair)
High	jument – cheval (mare-horse)	jument – tvsqrd (mare-tvsqrd)	jument – chaise (mare-chair)



- N=20
- *Fixation Duration (single) on 1st word*

Baccino, T., & Manunta, Y. (2005). Eye-Fixation-Related Potentials: Insight into Parafoveal Processing. *Journal of Psychophysiology*, 19(3), 204-215.



# RESULTS: 0-300MS

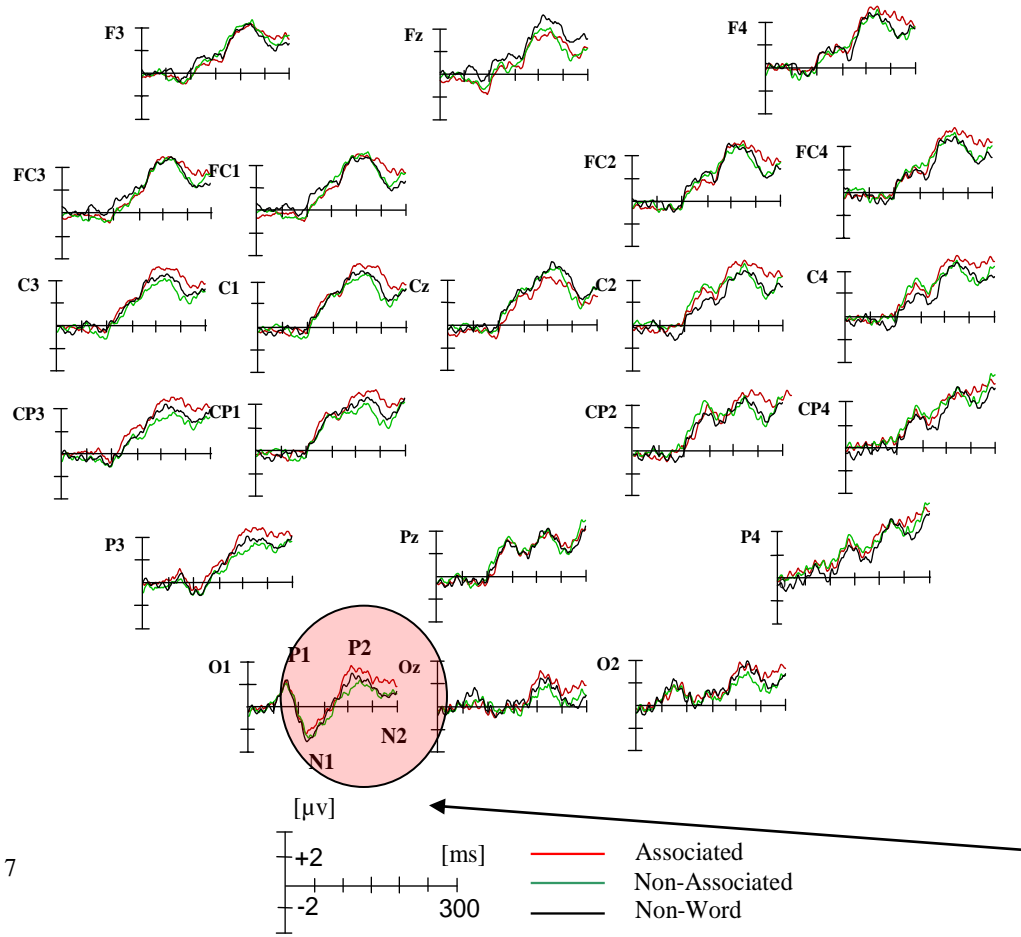


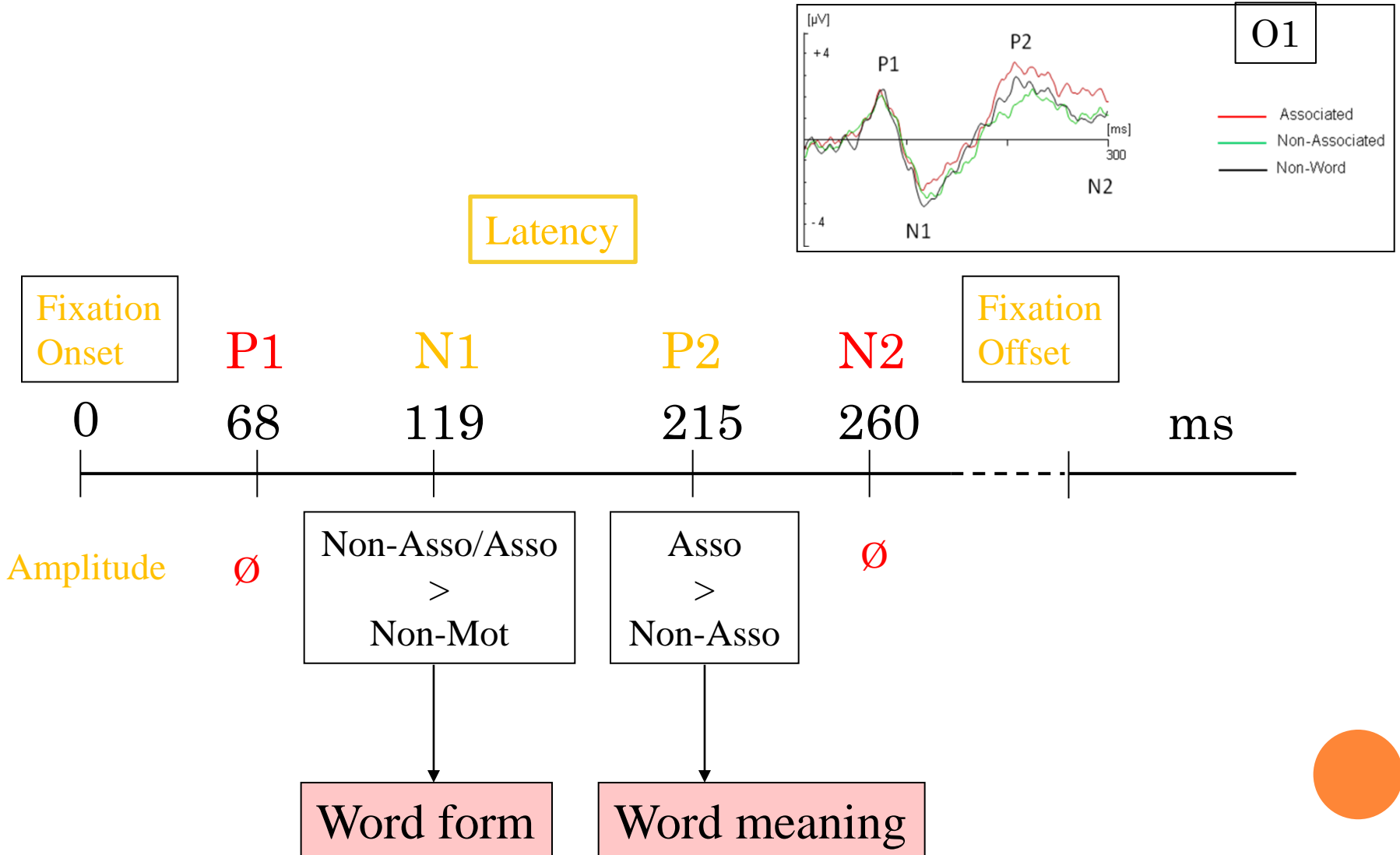
Figure 7

Greater activation on occipital region (electrode O1).

- **P1:  $\emptyset$**
- **N1: Asso/Non-Asso > Non-mots (near sig.)**
- **P2: Asso > Non-Asso**
- **N2:  $\emptyset$**

Grand Average according to electrode and association (Asso, non-Asso, non-Mot)

# TIME LINE OF COGNITIVE PROCESSES OCCURRING DURING A FIXATION



# AND FROM 2005, A GROWING NUMBER OF EXPERIMENTS USING EFRPs

- Reading
  - Baccino & Manunta (2005). Eye-fixation-Related Potentials: Insight into Parafoveal Processing. *Journal of Psychophysiology*, 19(3), 204-215.
  - Dimigen et al. (2006). Measuring ERP effects of word predictability during left-to-right reading. *Journal of Cognitive Neuroscience*, 12-21.
  - Simola, J., Holmqvist, K., & Lindgren, M. (2009). Right visual field advantage in parafoveal processing: Evidence from eye-fixation-related potentials. *Brain and Language*, 111(2), 101-113.
  - Barber, H. A., Ben-Zvi, S., Bentin, S., & Kutas, M. (2010). Parafoveal perception during sentence reading? An ERP paradigm using rapid serial visual presentation (RSVP) with flankers. *Psychophysiology*, 1-9.
  - Baccino, T. (2011). Eye Movements and concurrent ERP's: EFRPs investigations in reading. In S. Liversedge, Ian D. Gilchrist & S. Everling (Eds.), *Handbook on Eye Movements*. Pp.857-870, Oxford University Press.
- Attention and picture processing
  - Hutzler, F., Braun, M., Vö, M. L.-H., Engl, V., Hofmann, M., Dambacher, M., et al. (2007). Welcome to the real world: Validating fixation-related brain potentials for ecologically valid settings. *Brain Research*, 1172, 124-129.
  - Kretzschmar, F., Bornkessel-Schlesewsky, I., & Schlewsky, M. (2009). Parafoveal versus foveal N400s dissociate spreading activation from contextual fit. *NeuroReport*, 20(18), 1613-1618.
  - Rama, P., & Baccino, T. (2010). Eye-fixation related potentials (EFRPs) during object identification. *Visual Neuroscience*, 27, 1-6.
  - Graupner, S.-T., Pannasch, S., & Velichkovsky, B. M. (2011). Saccadic context indicates information processing within visual fixations: Evidence from event-related potentials and eye-movements analysis of the distractor effect. *International Journal of Psychophysiology*, 80(1), 54-62.
  - Dimigen, O., Sommer, W., Hohlfeld, A., Jacobs, A. M., & Kliegl, R. (2011). Coregistration of eye movements and EEG in natural reading: Analyses and review. *Journal of Experimental Psychology: General*, 140(4), 552-572.

# Thanks for your attention!

- And come to visit us in Paris at LUTIN
  - <http://www.lutin-userlab.fr/accueil/>

