

Audiovisual feature association in the human auditory cortex: an ERP study

Julien Besle & Marie-Hélène Giard
"Mental Processes and Cerebral Activation"
Inserm U280, Lyon, France

Introduction

The Mismatch Negativity (MMN) is a component of the Event-Related Potentials (ERPs) that is automatically generated in the auditory cortex by any incoming sound that differs from a particular acoustic regularity. It is computed by subtracting the ERPs elicited by frequent standard sounds from ERPs elicited by infrequent sounds deviating from the standard on some feature (e.g. frequency) and is considered as the electrophysiological reflect of the representation of that feature in Auditory Sensory Memory (ASM).
The present experiment was designed to study the influence of visual information on the MMN. In a preceding study (Besle et al., *Exp. Brain Res.*, in press), we have shown that the difference wave elicited by audiovisual events deviating from standards on both auditory and visual features differs from the sum of the MMN elicited by auditory deviants and the visual analogue of the MMN elicited by visual deviants in the visual cortex, suggesting that information from one modality can influence the representation of features of the other modality.

However, due to the overlap of auditory and visual potentials in ERPs, it was not possible to clearly determine which sensory memory was altered. Here we report an experiment in which only the auditory MMN process was involved (using stimuli deviating only on their auditory dimension) in order to ascertain an influence of visual information on the representation in ASM.
We presented standard A (80%) and deviant A' (20%) sounds in three conditions: **"No Visual"** condition: auditory events were presented without visual event (except the desynchronized visual distractive stimulus) → **A'-MMN**
"Visual" condition: auditory standards and deviants were associated to always the same visual event. → **A'V-MMN**
"Equiprobable Visual" condition: auditory standards and deviants were indifferently associated to 4 different visual events. → **A'Veq-MMN**

Hypotheses:

- if visual information is integrated to the representation of an event in ASM, then the same auditory deviation should elicit different MMNs whether the event is audiovisual ("visual" condition) or auditory-only ("no visual" condition)
→ **A'V-MMN vs A'-MMN**
- on the other hand, when the visual feature is not consistently associated to the auditory standard feature ("equiprobable visual" condition), the MMN elicited by auditory deviants should be the same as in the "no visual" condition, and should therefore differ from the "visual" condition since no standard AV representation could be formed.
→ **A'Veq-MMN vs A'V-MMN**

Material

320 deviant trials randomly delivered among 1600 standard trials over 8 blocks of about 2 minutes, in each of the 3 conditions.

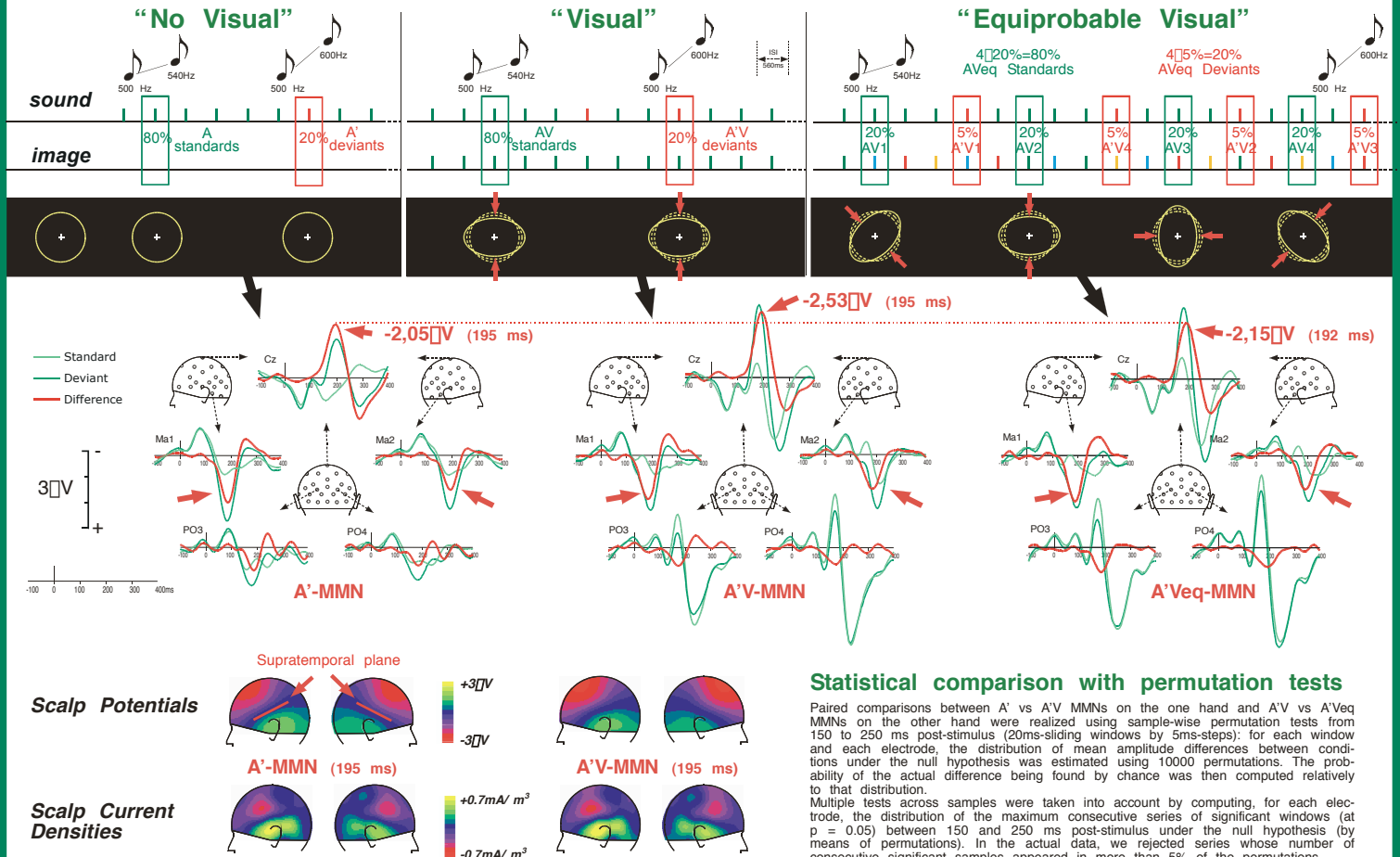
Auditory standards (A) and deviants (A') were exchanged on half of the blocks

ERPs were recorded at 36 electrode sites on the scalp of 16 subjects.

Visual stimuli: deformation of a circle either in the horizontal, the vertical or one of the two oblique directions.

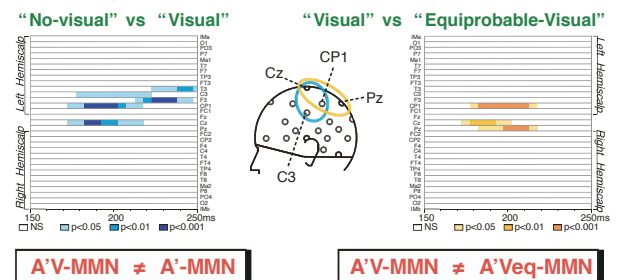
Auditory stimuli: rich tones shifting in frequency either from 500 to 540Hz or from 500 to 600Hz.

Distractive task: respond to infrequent, desynchronized disappearances of the fixation point.



Statistical comparison with permutation tests

Paired comparisons between A' vs A'V MMNs on the one hand and A'V vs A'Veq MMNs on the other hand were realized using sample-wise permutation tests from 150 to 250 ms post-stimulus (20ms-sliding windows by 5ms-steps): for each window and each electrode, the distribution of mean amplitude differences between conditions under the null hypothesis was estimated using 10000 permutations. The probability of the actual difference being found by chance was then computed relatively to that distribution. Multiple tests across samples were taken into account by computing, for each electrode, the distribution of the maximum consecutive series of significant windows (at $p = 0.05$) between 150 and 250 ms post-stimulus under the null hypothesis (by means of permutations). In the actual data, we rejected series whose number of consecutive significant samples appeared in more than 5% of the permutations.



Discussion

Although the MMNs that were elicited in the 3 conditions had similar topographies and the same timing, the MMN elicited by auditory deviants in the "visual" condition had a larger amplitude than the MMNs elicited by the same auditory deviants in both the "no-visual" and the "equiprobable-visual" conditions. This shows that, when auditory standards are consistently associated to a given visual feature, this visual feature is stored in ASM (i.e. in the auditory cortex). In other words, audiovisual events are represented in ASM in an integrated fashion. The lack of visual effect in the "equiprobable visual" condition further supports this conclusion: in this condition, the association of a visual and an auditory feature was not consistent and no audiovisual representation of the standard could be formed.