Mismatch negativity in a patient with frontal neglect

Martin Dietz[1]

1) Centre for Functionally Integrative Neuroscience, Aarhus University, Denmark

Introduction

The mismatch negativity (MMN) is a component of the auditory event-related potential observed as a negative deflection around 150 ms post-stimulus at fronto-central M/EEG scalp locations to a violation of a regular auditory sequence. Crucially, the MMN is thought reflect the earliest cognitive component of auditory processing observable in the ERP (Näätänen et al 2007). Spatial neglect is a condition commonly observed in patients with damage to the right hemisphere characterized neuropsychologically by the inability to attend to the side of the sensorium opposite to the lesion, typically in the visual (Driver & Mattingley 1998) but also the auditory modality (Pavani et al 2003).

We tested the hypothesis that a patient with positive neglect symptoms following damage to the right hemisphere would elicit an abnormal or absent MMN to changes in the location of a sound, specifically sounds in left auditory hemifield, with a preserved MMN to changes in frequency. For comparison, we present a group analysis from healthy subjects under the same spatial paradigm.

Methods

Single patient

EEG was acquired from a female patient, age 69, with damage to the right frontal lobe using 32 electrodes (*Brain Products GmbH*) referenced to the nose and sampled at 500 Hz, while listening to an auditory oddball paradigm. Standard tones consisted of 75 ms pure tones at 500 Hz with 5 ms rise and fall. Frequency deviants consisted of 550 Hz pure tones whereas sound location deviants were created by introducing an interaural timing delay of 800 microseconds between left and right stereo channels, respectively (Paavilainen et al 1989). Deviant tones were pseudo-randomized and each presented 180 times with a variable number of standards (3-5) between each deviant at a fixed SOA of 500 ms across the auditory sequence.

Normal subjects

For comparison, we acquired EEG from 12 healthy subjects, age 21-35, using 64 electrodes (*Brain Products GmbH*)) sampled at 1000 Hz, while listening to the same spatial paradigm, except for the frequency deviants which have been extensively quantified in healthy subjects elsewhere (Näätänen et al 2007). Two subjects were excluded due to excessive artefacts and a third due to an undetectable MMN.

Data were epoched to a peri-stimulus time window of -100 to 400 ms, down-sampled to 250 Hz, bandpass-filtered between 0.5 – 30 Hz, artefact rejected and averaged using robust averaging (Wager et al 2005) in SPM8 (http://www.fil.ion.ucl.ac.uk/spm/). Average difference waveforms were created for each subject between each deviant type and the standard, as well as the location deviants collapsed. Data were converted to scalp images by interpolating between channels and smoothed with a FWHM of 9 mm in the x-y direction and 20 ms in the temporal dimension.

Results

As anticipated, the single patient showed no MMN to spatial location deviants and there was no difference between right and left deviants at $p<0.05$, uncorrected. As further anticipated, there was a preserved MMN to changes in frequency peaking at 176 ms post-stimulus over

frontal locations, predominantly over the right frontal scalp. Using a two-sample *t*-test fixed-effects (FFX) analysis, the MMN was significant at the peak and cluster-level, $p<0.05$, family-wise error (FWE) corrected for multiple comparisons over all pixels and time points using random field theory (Worsley et al 1996, Kilner et al 2005). Importantly, all deviants occurred at the same probability and the same amount of trials.

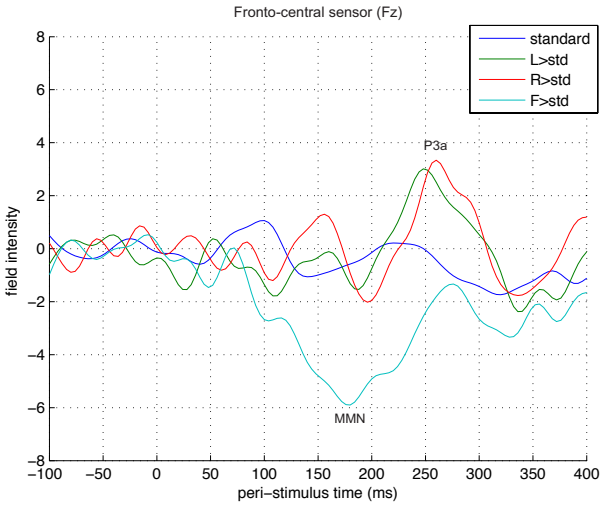

Figure 1. Single patient event-related responses (EER)

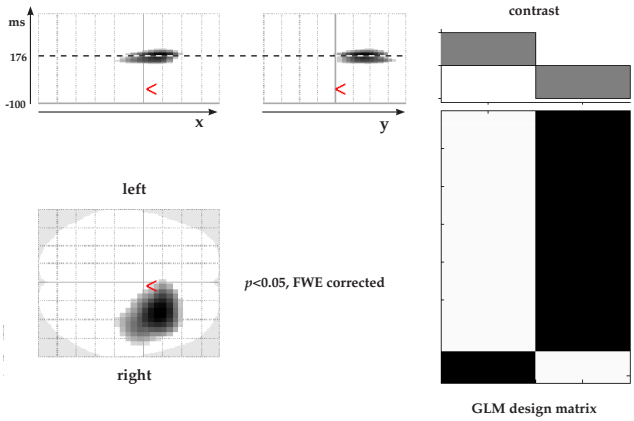

Figure 2. Single patient fixed-effect (FFX) analysis

For comparison, a random-effects (RFX) analysis over healthy subjects showed a clearly quantifiable MMN to location deviants peaking at 136 ms post-stimulus over frontal locations, predominantly over the right frontal scalp, $p<0.05$ FWE corrected. Furthermore, the left and right location deviants each produced a distinguished MMN, the left peaking at 136 ms, $p<0.05$ FWE corrected, and the right peaking at 128 post-stimulus, $p<0.001$, uncorrected.

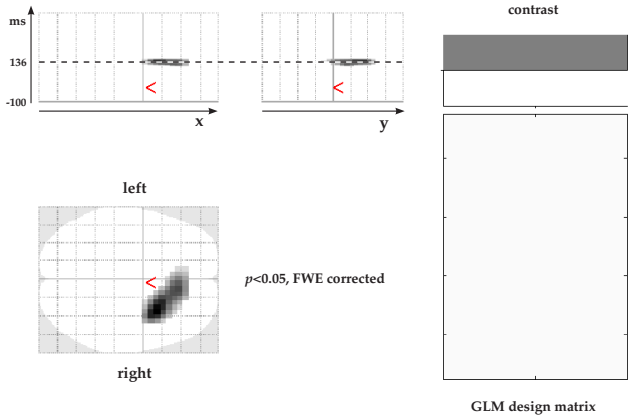

Figure 3. Random-effects (RFX) analysis

Conclusion

We hypothesized an absent MMN for changes in the spatial location of sound in a patient with frontal neglect. This was confirmed not only for deviants in the left auditory hemifield, but also in the right auditory hemifield which may point to a general impairment in the processing of spatial information in this patient. Further studies of auditory perception in neglect are planned to replicate findings from this single patient.

References

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