Mismatch negativity elicited by changes in sound location is moderated by location and probability of the deviant stimulus

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Abstract

There is considerable variability in the literature with regard to the latency (reported peaks between 100 and 200 ms) and distribution of mismatch negativity (MMN) elicited by occasional changes in the location of a stimulus. There are also no previous systematic studies of how MMN is affected by the actual locations of the standard and deviant stimuli, or of how deviant probability affects MMN.

In Experiment 1, we systematically examined how event-related potentials elicited by an occasional change in location of a short pure tone are affected by probability and deviant stimulus location. Difference waves showed an early MMN peaking between 100 and 140 ms after stimulus onset. Lower-probability deviants and larger changes in stimulus location elicited larger peaks. In addition, occasional stimuli from different locations within the same hemifield elicited patterns of activity consistent with different underlying generators, possibly reflecting the presence of cortical spatial maps.

In Experiment 2, we investigated whether there was a contribution of N1 to the components observed in Experiment 1. When we presented stimuli from 5 equally probable locations, we found that in contrast with the oddball design used in Experiment 1, there were no significant peaks in the difference waves.

We conclude that although occasional changes in the location of a pure tone elicit earlier peaks than MMN reported for other types of deviation, the topographical distribution and behaviour of the elicited electrical activity are consistent with an underlying mismatch-like process.

Purpose

To provide a systematic study of MMN elicited by occasional changes in sound location.

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Experiment 1: How is MMN to changes in sound location affected by location and probability of the deviant stimulus?

Method

8 right-handed adult subjects (mean age = 25)

Oddball paradigm: standard stimuli presented from 0 degrees
deviant stimuli presented from -90, -30, 30 or 90 degrees

Three 5000 trial blocks with percentage of each deviant varying between blocks (7.5 %, 5% or 2.5%)

50 ms pure tone stimulus (including 5ms cosine ramps), presented with SOA of 104 ms over headphones

Location of tones specified using head related transfer function co-efficients

Passive listening task – participants watched a silent film

64 sites, common average reference, bandpass filtered 0.5 to 20 Hz

Difference waves created (deviant – standard) for each deviant location and probability level

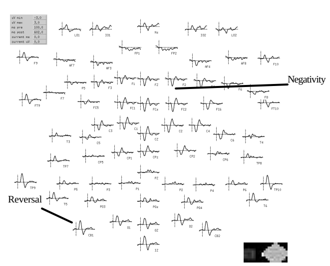

Figure 1: Group difference waves for a 2.5 % probable deviant stimulus presented from -90 degrees. The distribution of voltages across the head is typical for MMN, with a negativity at frontal sites, and a corresponding positivity at occipital and mastoidal sites

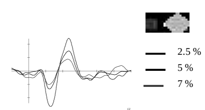

Figure 2: Group difference waves at a single site (CZ) showing that less probable deviants from -90 degrees elicit a larger MMN and subsequent positivity than more probable deviants

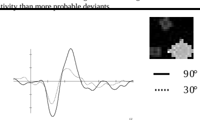

Figure 3: Group difference waves at a single site (CZ) showing that deviants from -90 degrees (blue) elicit a larger MMN and subsequent positivity than deviants from -30 degrees (red)

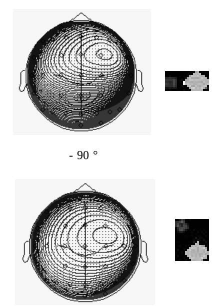

Figure 4: Topographic maps showing the patterns of electrical activity across the scalp at the point of maximal negative deflection of the group difference waves (2.5% probability condition) for deviant stimuli presented at -90 and -30 degrees. Different angles of presentation elicit slightly different distributions of electrical activity across the scalp, possibly indicating different underlying generators

Experiment 2: Is there any contribution of the N1 component to the waveforms seen in Experiment 1?

Method

9 right-handed adult subjects (mean age = 27.5 years)

Stimuli, procedure and data processing is identical to that from Experiment 1 except that stimuli were presented from -90, -30, 0, 30 or 90 degrees with equal probability (1000 stimuli from each location in random order)

Difference waves were created by subtracting ERPs elicited by stimuli presented from 0 degrees, from those presented at other locations as in Experiment 1

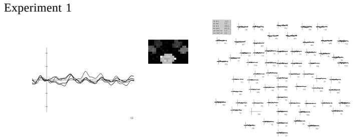

Figure 5: Group difference waves for all for location types. The distribution of voltages across the head shows that there are no significant components in the difference waves when the conditions necessary for eliciting MMN are removed, suggesting that there is no contribution of other components such as the N1 in the data from Experiment 1

Experiment 3: Does Experiment 1 replicate in the free field?

Method

10 adult subjects (mean age = 24 years)

Stimuli, procedure and data processing is identical to that from Experiment 1 except that stimuli were presented in the free-field

Difference waves created (deviant – standard) for each deviant location and probability level

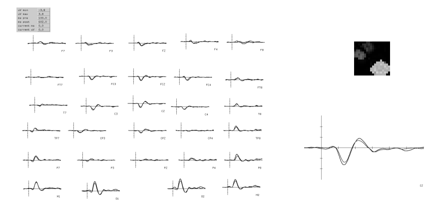

Figure 6: Group difference waves for a 2.5 % probable deviant stimulus presented from -90 degrees (blue) and -30 degrees (red). The distribution of voltages across the head is a gain typical for MMN, with a negativity at frontal sites, and a corresponding positivity at occipital and mastoidal sites. Further, the resulting waveforms are very similar to those seen in Experiment 1, indicating that the paradigm does indeed replicate in the free field

Conclusions

ERPs elicited by occasional changes in location of a repeating stimulus behave in a manner consistent with MMN: rarer deviants and larger changes in direction result in larger waveforms.

Rare events also generate a frontal P3a-like positivity, which may reflect an orienting of attention to the deviant stimulus.

Waveforms from Experiment 1 reveal preliminary evidence for spatial maps in auditory cortex.

Although the latency of the MMN component is earlier than might be expected, results from Experiment 2 indicate that there is no contribution of N1 in the ERPs seen in Experiment 1.

Experiment 3 shows that the paradigm used in Experiment 1 replicates well in the free field.