

Event-Related Potential Measures on the Occurrence of Auditory Intensity Change in Attention Capture

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Introduction

Detection of change in the environment is crucial for the survival and communication among mammalian species. The brain is capable of rapidly detecting acoustic change and taking appropriate action in response to the change. The auditory modality allows the observer to become aware of an otherwise unattended, but relevant input. An auditory increase in intensity (an increment) suggests an approaching threat, which will elicit a fast switch of attention from whatever the animal is doing and toward the auditory modality. A decrease in intensity (a decrement) suggests the threat as retreating further away. An otherwise unattended auditory stimulus can force an individual to switch attention from ongoing cognitive activity to the auditory channel. This is called *attention capture*.

Näätänen (1990) developed a model of how we become aware of an otherwise unattended auditory input in the environment. There are two modes. One mode is the transient detector system, that is responsible for the detection of intense stimuli. When the output of this system reaches a critical level, attention is forcefully switched to the auditory channel. A stimulus need not be obtrusive for it to capture attention, if it signals change from the past. The change detector system, detects a change in any stimulus feature, including frequency, location, duration and intensity. A decrease in intensity signals change, again from the past. If the output is large enough, attention is forcefully switched to the auditory channel.

In human participants, responses to external stimuli are often recorded by event-related potentials (ERPs). These ERPs are used to study attention capture and are recorded from the scalp of humans. The output of a change detector system is monitored by a negative-going ERP, the Mismatch Negativity (MMN). In the Näätänen model, when the output of the change detection is large, attention is switched to the auditory channel. This switching of attention is reflected by a later positivity, the P3a, seen on an EEG. The MMN and P3a are recorded using an oddball paradigm. In this paradigm, subjects are presented with a series of homogeneous auditory “standard” stimuli. At rare and unpredictable times, a feature of the standard is changed to form a “deviant”.

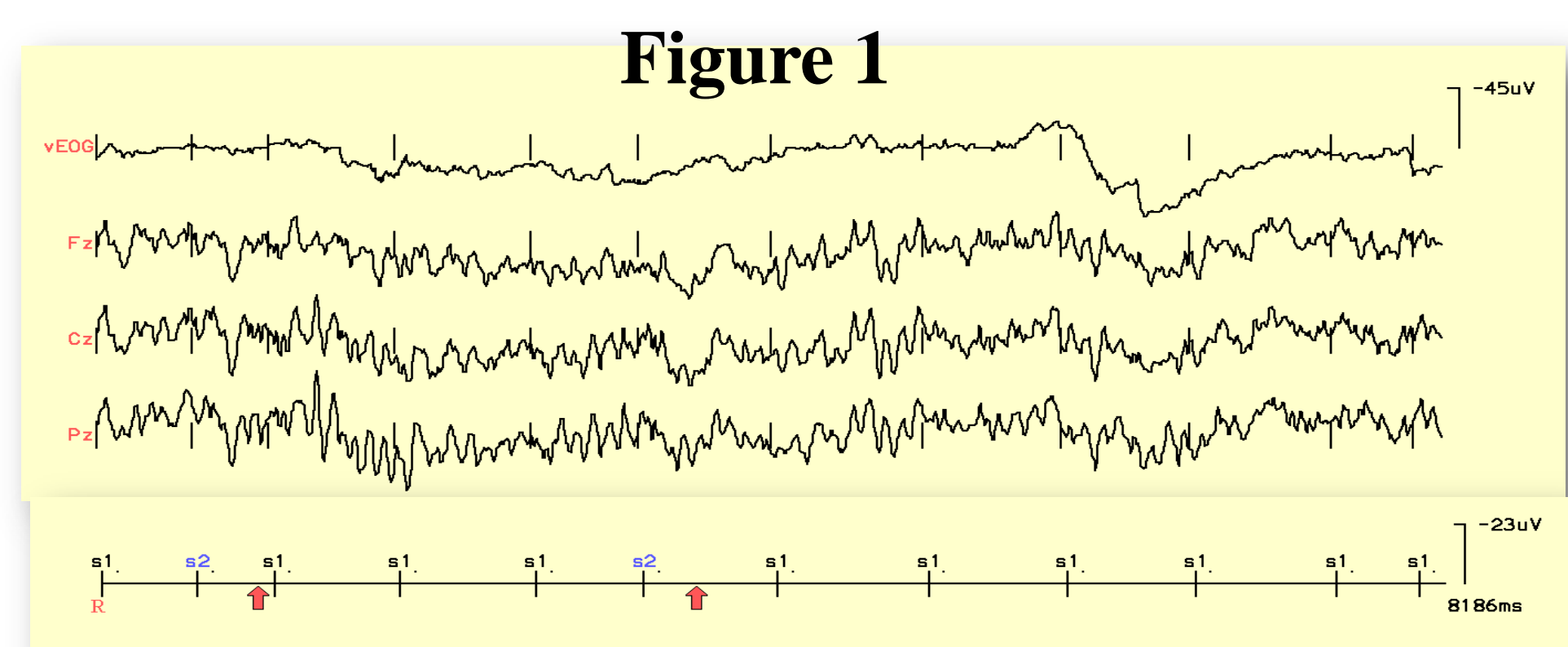


Figure 1 shows an EEG being recorded at different scalp sites. At the bottom of the Figure, an oddball paradigm is observed in which two different stimuli are presented, a frequently occurring standard, S1 and an infrequent deviant stimuli, S2.

Objectives

- The extent that the obtrusiveness of the standard affects attention capture. One in which the frequently occurring standard is an unobtrusive 80 dB stimulus and another in which the standard is an obtrusive 90 dB stimulus.
- The extent to which the intensity of a stimulus needs to decrease before attention can be captured and the observer is forced to become aware of it. To observe whether a large decrement of 20dB from a standard unobtrusive or obtrusive stimuli or a smaller decrement of 10 dB will elicit attention capture.

Method

- Ten young adults volunteered to participate in this study. They were engaged in a difficult visual search recognition task and *ignored* the auditory stimuli.
- In the background, they were presented every 450-550 ms with an irrelevant auditory oddball paradigm consisting of frequently ($p = .90$) presented “standard” loud auditory stimuli and two infrequently presented ($p = .05$) stimuli that decreased in intensity.
- In one condition, the standard is 80 dB SPL. The small decrement was 70 dB and the large decrement, 60 dB.
- In the other condition, the standard is 90 dB SPL. The small decrement was 80 dB and the large decrement 70 dB.
- Note that the identical 70 dB stimulus acted as a small decrement in one condition but a large decrement in the other. Note also that the same 80 dB stimulus acted as the standard in one condition and the deviant in another.
- An EEG was recorded from the scalp of each subject. Electrodes were placed over 32 different scalp sites.

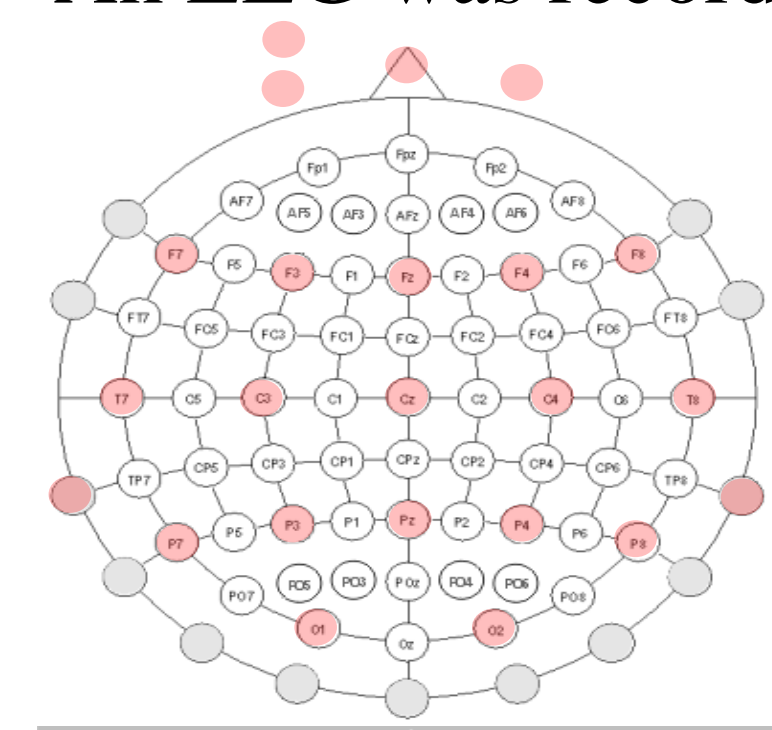


Figure 2. Standard EEG scalp placement system.

Results

Unobtrusive (80 dB SPL) Standard

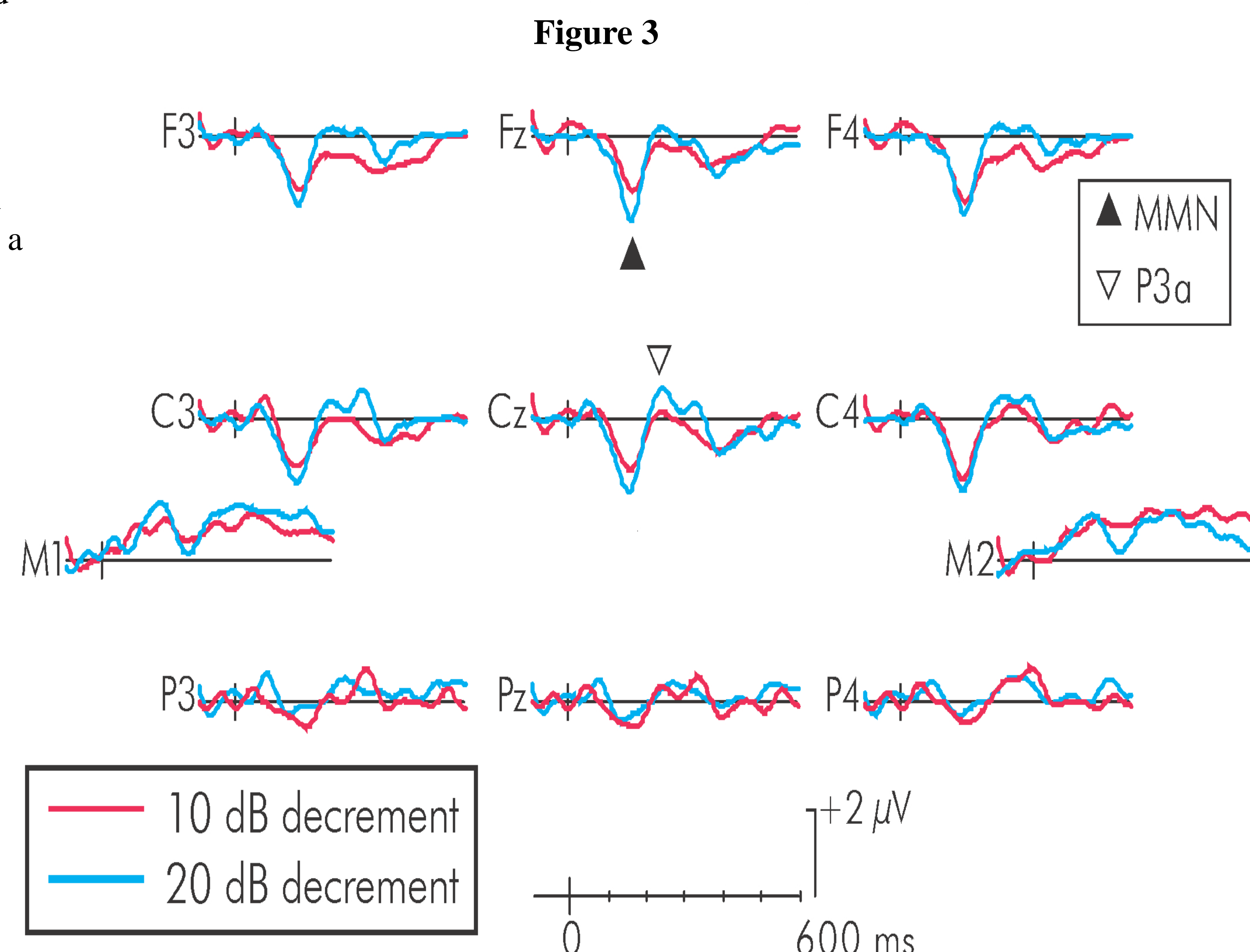


Figure 3 The figure illustrates the condition in which the standard was an unobtrusive 80 dB. A small amplitude response is apparent following the presentation of the frequently occurring standard. When the intensity of the standard was changed by lowering its intensity to 70 dB, an additional small negative amplitude was apparent at 150 ms. This is the MMN, reflecting the detection of change, even though the subject was not aware that the stimulus had occurred. When the intensity of the standard was lowered by 20 dB (i.e. was 60 dB), the MMN was larger. It was followed by a positivity occurring at 250 ms. This is the P3a. The P3a is reflective of a forced switching of attention, allowing the subject to become conscious of the auditory stimuli.

Obtrusive (90 dB SPL) Standard

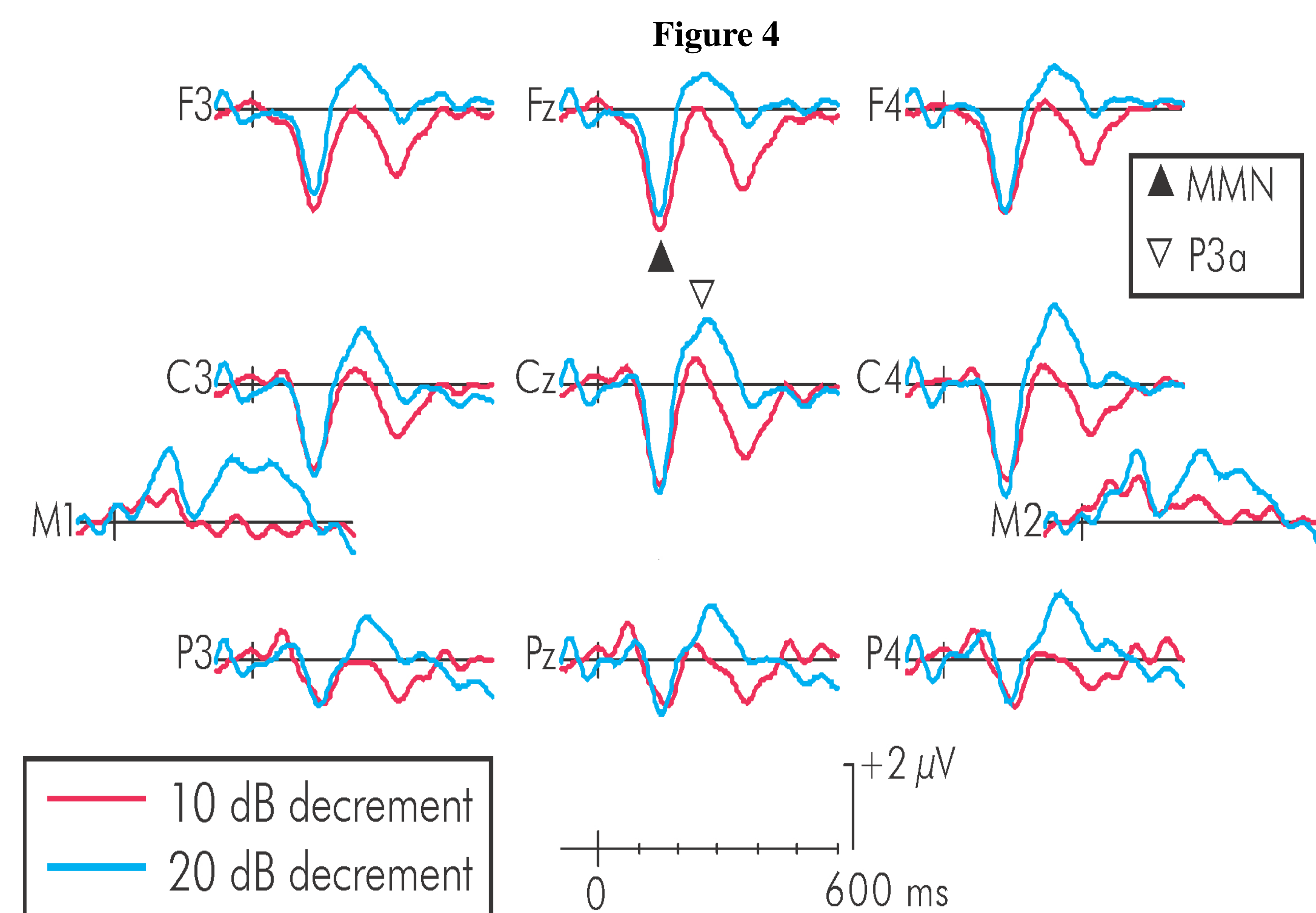


Figure 4- The figure illustrates the condition in which the standard was an obtrusive 90 dB. A small amplitude response was elicited by the frequently occurring standard even though it was a very loud 90 dB. When an infrequent 80 dB stimulus occurred (a 10 dB decrease in intensity), a MMN was elicited at 150 ms. This MMN to a 10 dB decrease in intensity was however larger to the same 10 dB decrement when the standard was 80 dB. When the infrequent 70 dB stimulus occurred (a 20 dB decrease in intensity), a very large MMN was elicited. This MMN was larger than that observed for the 20 dB decrement when the standard was an unobtrusive 80 dB. It was followed by a P3a at 250 ms. This P3a was larger than the P3a when the standard was 80 dB.

Conclusion

Detection of change to a frequently occurring auditory stimulus is critical for survival. The detection of change is reflected by a negativity, the MMN. In this study, even a small 10 dB decrease in intensity elicits the MMN. The MMN is however larger when the frequently occurring stimulus is a very loud and obtrusive 90 dB. If the extent of change is large (in this study, a 20 dB decrease in intensity), a later P3a will be elicited, signalling that the subject has switched attention from the ongoing visual task and toward the auditory channel. The subject will thus become aware of the contents of the auditory channel even if their intent was not to become aware of it. Hence, in both standard conditions, a larger decrement of 20 dB elicited a larger negativity, the MMN and a subsequent positivity, the P3a.

A much larger P3a is elicited when change occurs to a frequently occurring obtrusive 90 dB stimulus. An obtrusive stimuli of 90 dB will elicit a larger response in P3a than an unobtrusive stimuli of 80 dB. These results suggest that a participant will be much more likely to be forced to switch attention to an obtrusive stimuli. For humans, an obtrusive stimuli of 90 dB is equivalent to a fire alarm. Therefore, having an individual being forced to switch attention to a threat faster (of a fire alarm) is crucial for survival.

Acknowledgements

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