

# The types of stimuli that will cause a switch of attention and result in distraction



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## Introduction

How do we manage to become aware of stimulus input that is relevant, yet banish from awareness that which is not relevant? One mode requires the active participation of the observer. The observer chooses to “attend” to that which is deemed to be relevant and thus become conscious of it. This “selective” attentional process however comes at a cost. The observer will not be aware of what might be highly relevant information that occurs outside of the focus of attention. For this reason, a second mode allows high relevant input to “capture” attention. The observer then has no choice but to become aware of these so-called intrusions into consciousness. But, what types of input are deemed to be so potentially relevant that ongoing cognitive activities are interrupted?

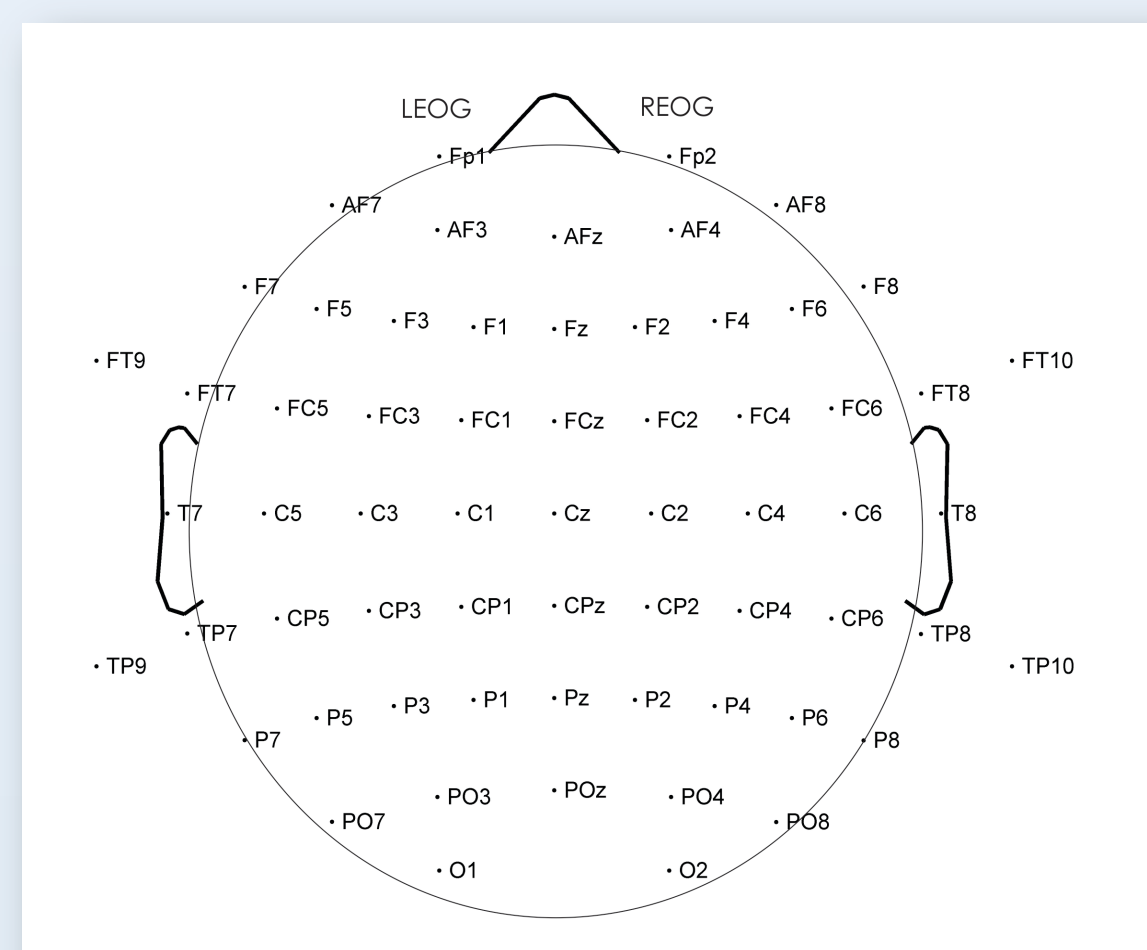
It is known that very frequently occurring, repetitive stimuli are highly unlikely to capture attention. It is more likely that rarely presented, novel stimuli will do so. Determining whether a stimulus captures attention is however methodologically very difficult. Many researchers employ the changes in the electrical activity of the brain to external stimuli (the so-called event-related potentials). An auditory “oddball” paradigm is often used in which the subject is presented with a unchanging frequently presented stimuli (the “standard”). At odd and unpredictable times, a feature of the standard is changed and a “deviant” is presented. The subject does not need to actively attend to the auditory stimuli. This is because the initial processing and extraction of the features of the stimuli takes place automatically (without the need for attention). The features of the deviant fail to match those of the standard. Thus, when the deviant is presented, it automatically elicits a negative wave after about 100 ms called the Mismatch Negativity (MMN). The observer is not however conscious of this detection of change. To do so would require that the observer attend to the auditory stimuli. The amplitude of the MMN varies with the extent of change. If it reaches a certain critical threshold, an interrupt signal is sent to the frontal lobes forcing a switch of attention away from ongoing current tasks and toward the incoming auditory stimuli. This is called “attention capture” or “distraction.” The switching of attention to the auditory stimuli allows the observer to become aware of what might be much more relevant information. The switching of attention to the potentially more relevant stimulus elicits a different event-related potential, a positive wave occurring at about 250 ms, called the P3a.

The present study examines the types stimuli that will be likely to result in a switch of attention (i.e. attention capture), as indexed by the P3a.

## Method

**Subjects:** Ten young adults (18-26 years, 8 females) volunteered to participate in this study.

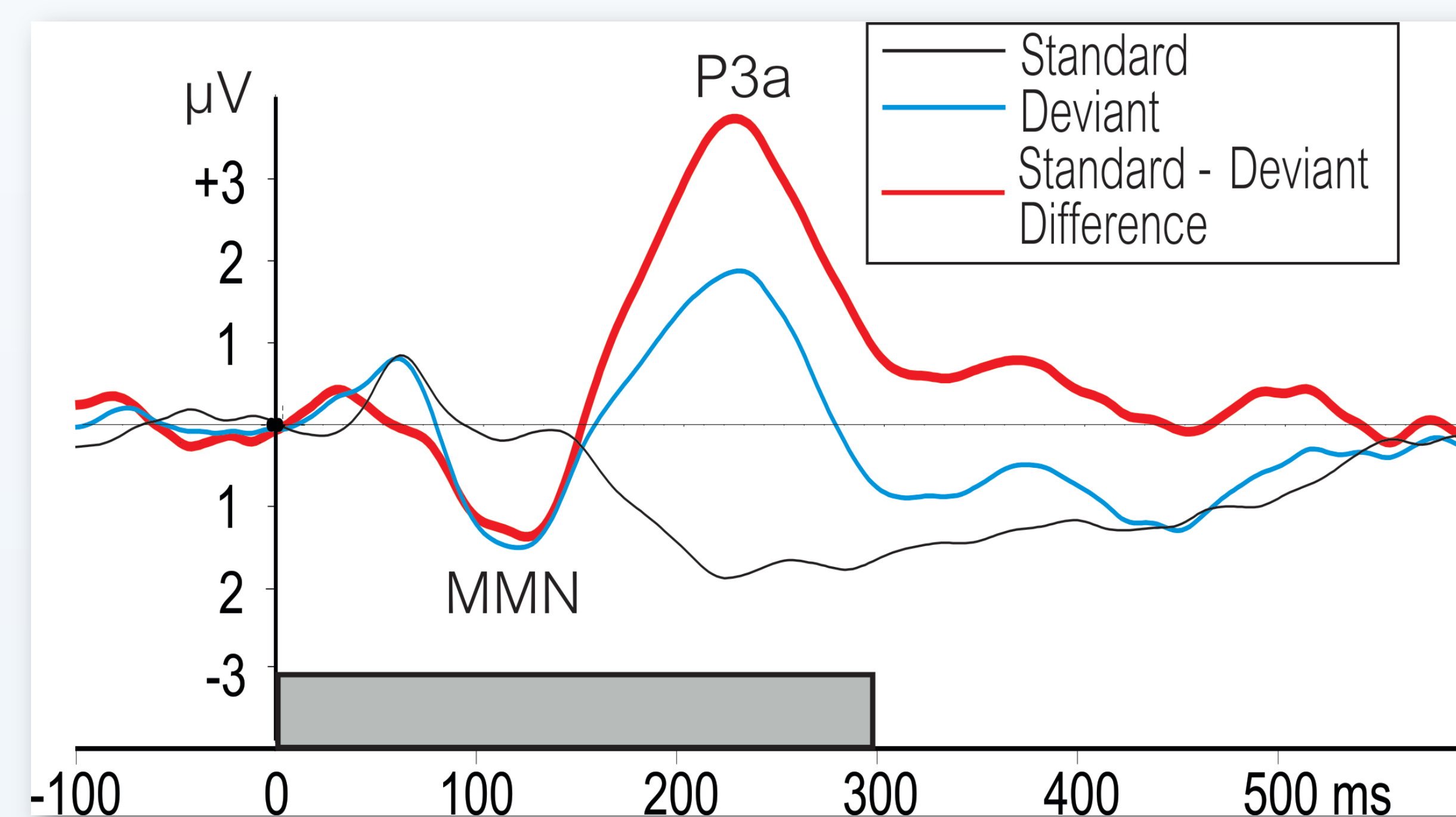
**Procedure:** Subjects were presented with an oddball paradigm consisting of a series of frequently occurring moderate intensity (80 dB SPL) 1000 Hz “standard” pure tones occurring on 92% of the trials. At rare (odd) and unpredictable times, a feature of the standard was changed to form the “deviant” stimulus, occurring on the remaining 8% of the trials. The duration of each stimulus was 300 ms. Four different “oddball” conditions each lasting about 10 minutes were presented in which the deviant was either: (a) 10 dB “increment” in intensity, (b) 20 dB “decrement” in intensity, (c) white noise burst, or (d) different environmental sounds with an average dB of 80 (e.g. buzz, musical instruments, animal sounds). Each condition was repeated 3 times to assure the replicability of the findings.



**EEG (Electroencephalogram) Recording:** In order to monitor the extent of processing of the unattended auditory stimuli, the subject’s EEG was recorded from 32 different scalp sites.

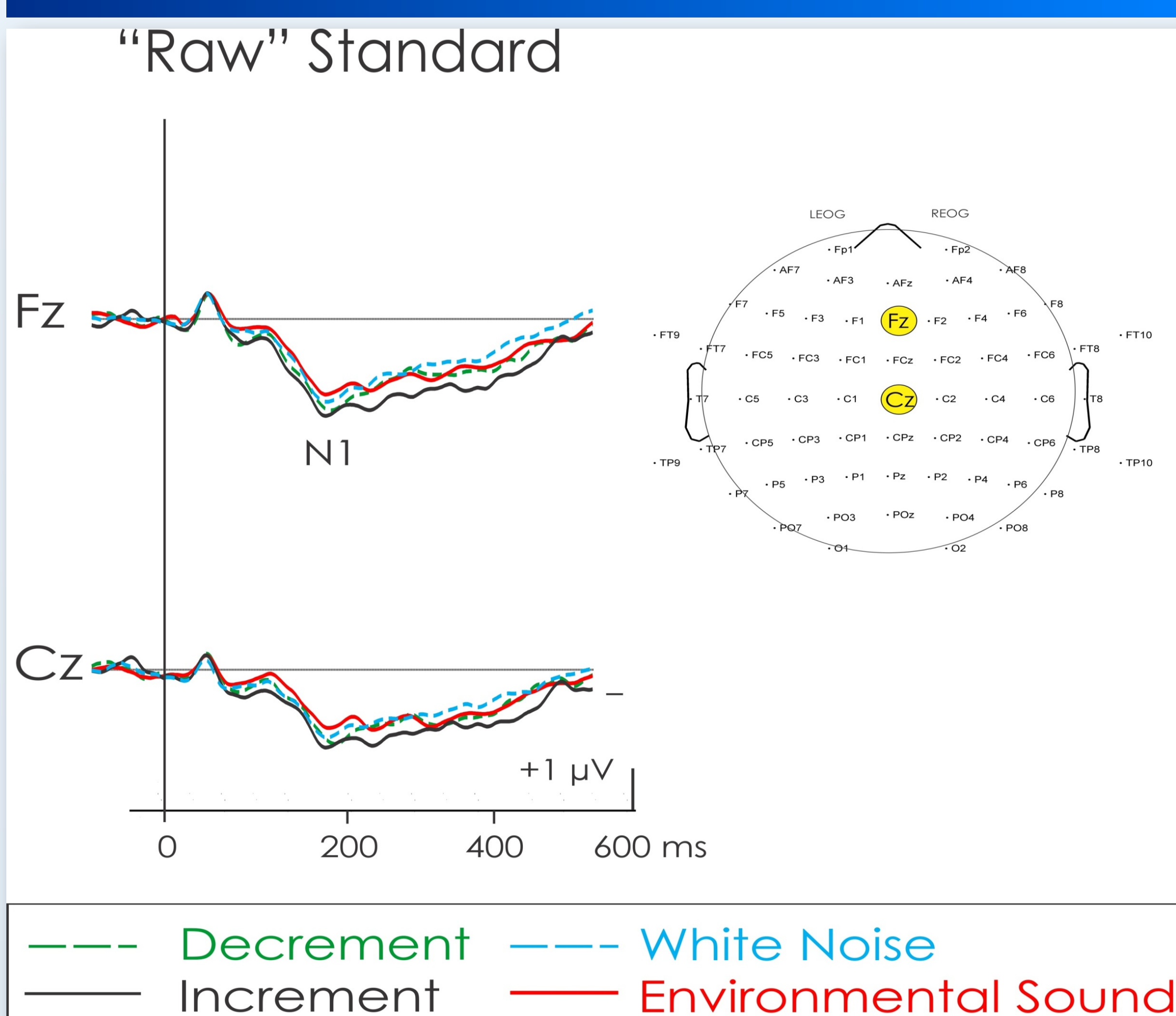
Subjects were asked to watch a sub-titled video and thus *ignore* the auditory stimuli. In actual fact, what the subject is doing is incidental. Because subjects were not actively attending to the auditory stimuli, they should not have been conscious of them.

The brain’s response to the auditory stimuli (the ERP: Event-Related Potential) was recorded separately for the standard and the deviant stimuli. Processing of the deviant is best observed in a difference wave, computed by subtracting the processing of the deviant from the processing of the standard. Processing that is common to the standard and deviant stimuli will be removed by the subtraction process. If the processing of the standard and deviant was identical, the resulting difference wave would be a straight line.

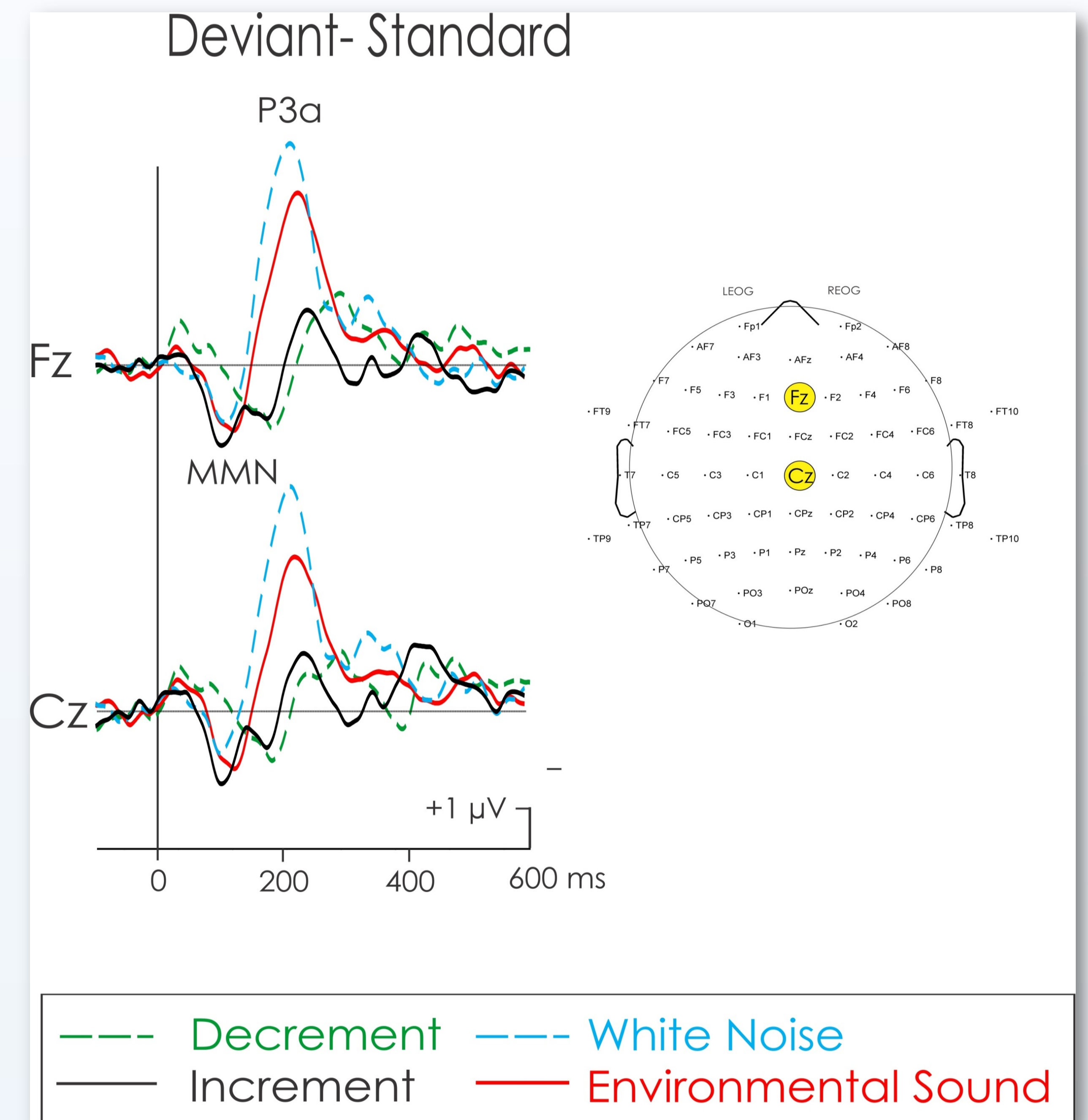


**Figure 1. ERPs to the standard (traced in black) and deviant (blue) stimuli.** At time 0, a 300 ms stimulus (in grey at the bottom) is presented. The standard elicits a small response. Processing until about 100 ms is similar for the standard and the deviant. At about 100 ms, there is a larger negativity (measuring about 1  $\mu$ V). This is the Mismatch Negativity (MMN) reflecting a detection of change (i.e., a mismatch from what was expected to be presented... the standard and what actually was presented... the deviant). While the MMN signals detection of change, it does not reflect a *conscious* detection. This only occurs at about 250 ms with the appearance of the optional P3a. The P3a signals that the subject has ceased ongoing cognitive activities (in this case, watching a video), and attention is forcibly switched to what potentially might be much more relevant, i.e. the features of the deviant stimulus. In the vast majority of cases, the intruding stimulus is found to be not relevant, and attention is switched back to the task at hand.

## Results



**Figure 2. ERP responses to standard stimuli given EEG readings.** Across the 4 different conditions, the standard stimulus was always physically identical. Only the deviant changed (e.g. there was either an increase in intensity – an increment, or a decrease in intensity – a decrement, white noise, or an environmental sound). It is possible, however, that the processing of the constant stimulus varied across the 4 conditions. The figure above indicates that this was not the case. The processing of the standard was essentially identical across the 4 different conditions.



**Figure 3. ERP responses to the deviant stimuli.** The figure above represents the difference in processing between the deviant and the standard. All deviant stimuli elicit a downward (or negative-going) deflection with the MMN occurring at about 100 ms. This is a reflection of the fact that the acoustic change has been detected within the auditory cortex of the brain. A later P3a is apparent following the presentation of the white noise and the environmental sounds. The subject is thus forced to become conscious of these sounds. Only a very small P3a is apparent following the decrement or the increment. Presumably, the subject would not be much less conscious of these deviant stimuli.

## Conclusion

Stimulus change will always elicit a MMN. Stimulus change per se however will not necessarily result in attention capture as reflected by the P3a. Thus, subjects will not necessarily be conscious of any change. The increment and decrement deviants reflect a change in only the intensity for the standard. All the other features remained the same. The white noise deviant reflects a change of many features – mainly its pitch and its intensity. Similarly, the environmental sounds are created by changing many features of the standard. Thus, more novel stimuli (those that incorporate many changes in the features of the stimulus) are more likely to result in a switch of attention. Unfortunately, they are also more likely to result in distraction.

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