The ventriloquist effect evokes changes in the early spatial processing of auditory stimuli as measured by the mismatch negativity

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Abstract

*The Ventriloquist Effect arises when synchronous auditory and visual events occur with spatial discrepancy and the location of the visual event biases the perceived location of the auditory event. (Alais, D., & Burr, D. (2004))

*The mismatch negativity (MMN) has been shown to be effective in tracking changes in spatial location of both auditory and visual stimuli by examining peaks of standard and deviant difference waves occurring within 200 ms after stimulus presentation by using a passive oddball paradigm. (Deouell et al. (2006)).

*To explore the effects of the Ventriloquist Effect on the auditory MMN, we present an audio visual MMN experiment in which we attempt to induce an auditory MMN by shifting only the location of the visual stimulus in the deviant condition.

*Auditory stimuli were presented by a software system for spatial audio reproduction that created two dimensional virtual acoustic scenes and employed head tracking for added robustness. In addition, auditory and visual only conditions were collected to serve as comparisons to the audio visual difference waves.

*An auditory MMN was successfully induced in the peripheral audio visual condition, supporting other findings that cross-modal processing can elicit changes in the early pre-attentive processing of stimuli.

Methods

Participants

17 students aged 20-25 were recruited. For all stimuli conditions. Subjects watched a silent movie and were instructed to fix their gaze forward. Only data collected from students that showed a significant ($p<0.05$) MMN in the audio only condition (>2 mV) was used for further processing . This resulted in 10 subjects.

Stimuli and Task

*Audio stimulus was a 30 ms recording of the word "pi" (70 dB SPL) delivered by headphones using SoundScape Renderer, a software framework for real-time spatial audio rendering. A Polaris headtracking system was also incorporated to increase robustness.

*Visual stimuli consisted of a 30 ms flash of a standard light bulb (300 $^{cd}/_{mm^2}$) that was hung at eye level at the corresponding testing positions.

*Audiovisual stimuli consisted of the two auditory and visual stimuli synchronized using optical and auditory sensors. In an effort to induce an auditory ventriloquist effect MMN, the auditory stimulus was held at a constant location at both the standard and deviant positions while only the visual position was shifted in the deviant condition.

*Each stimulus was presented in three different spatial standard/deviant locations thus resulting in the nine conditions listed in the table. Standard stimuli in each condition were delivered 600 times with no less than two stimuli presented before each deviant.

Data Acquistion and Analysis

*EEG was collected from 16 scalp sites according to the 10/20 International System for electrode placement.

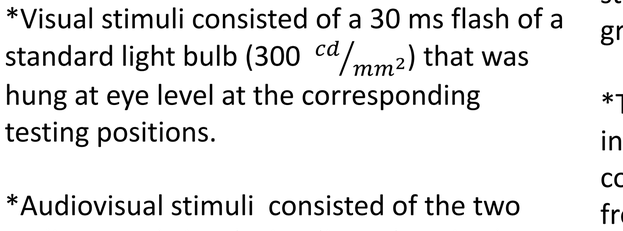
*Data was continuously digitized at 512 Hz with a 0.1-30 Hz band-pass filter. Impedances were kept below 10 $k\Omega$.

*Data was re-referenced offline to mastoids and band-pass filtered between 1-20 Hz. Epochs were 450 ms with a 50 ms pre-stimulus baseline. Baseline rejection was performed and epochs containing values outside of the ±70 mV range were rejected.

*MMN was calculated for each of the nine conditions by subtracting the grand mean standard condition from the corresponding grand mean deviant condition.

*To examine if the ventriloquist effect induced an auditory MMN in the audio visual condition, the visual MMN was subtracted from the audiovisual MMN and the result was compared to the corresponding audio only condition.

Modality	Label	Standard (0.8)	Deviant (0.2)
Auditory	A1	0°	20°/-20°
	A2	10°	-10°
	A3	-10°	10°
Visual	V1	0	20°/-20°
	V2	10°	-10°
	V3	-10°	10°
AudioVisual	AV1	A0° V0°	A0° V20°/-20°
	AV2	A10° V10°	A10° V-10°
	AV3	A-10° V-10°	A-10° V10°

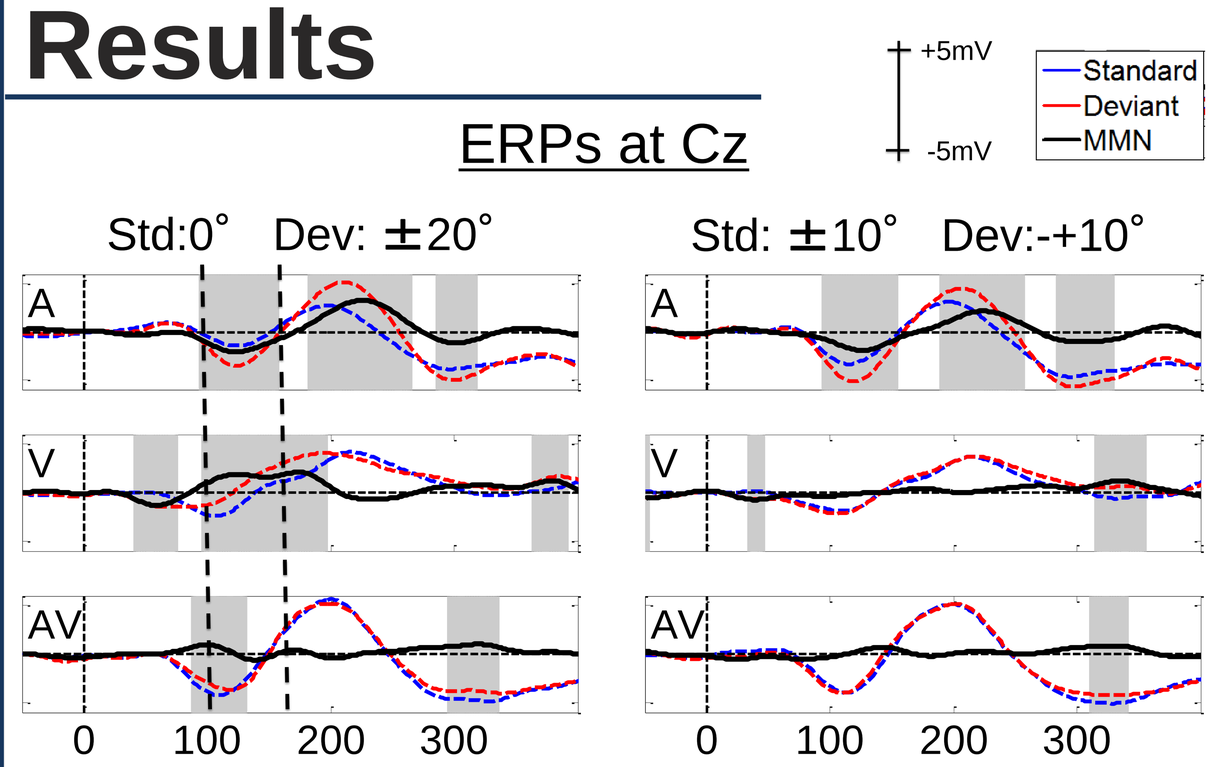


(Above): Table of standard and deviant spatial conditions over all modalities

(Left): Spatial layout of the AV1 experiment.

Results

ERPs at Cz

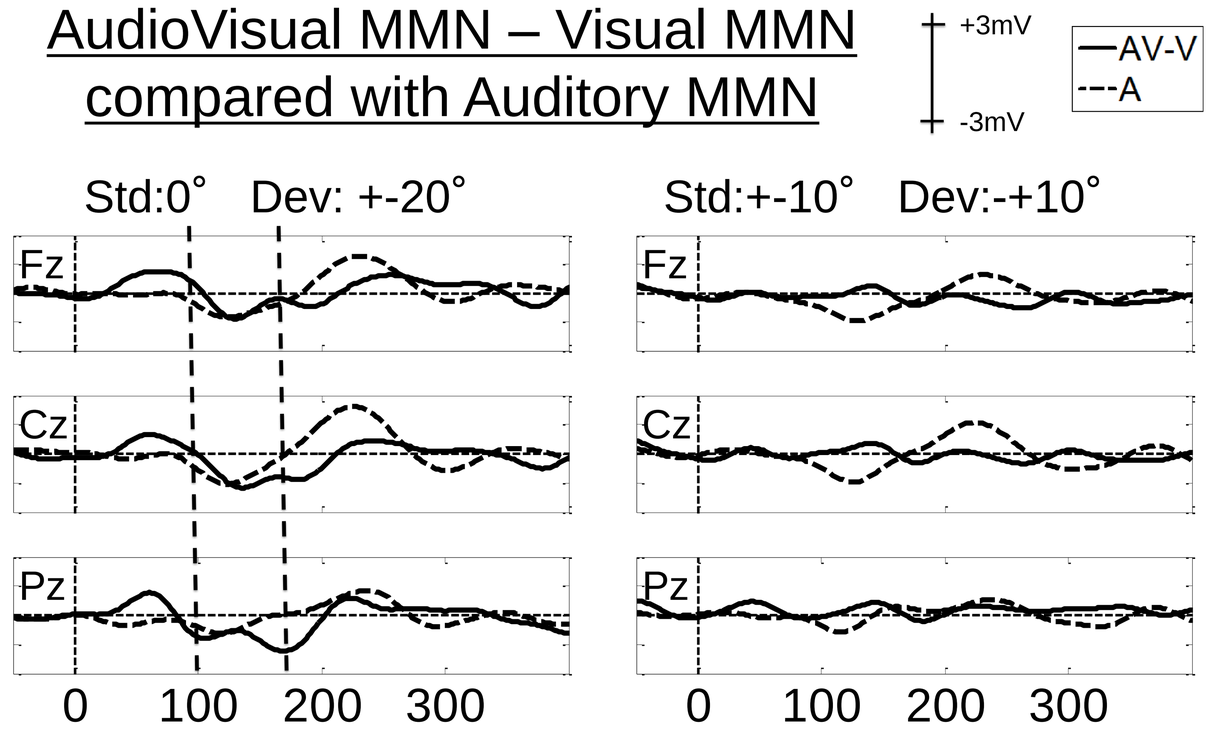


*Stimuli of all modalities produced standard N1-P2 responses.

*Auditory only difference waves for both spatial conditions resulted in significant (highlighted in gray, $p<0.05$) MMN between 97ms and 130 ms.

*The V1 and AV1 (Std: 0, Dev:±20) conditions were the only spatial conditions that succesfully captured a significant MMN for the visual and audiovisual modalities.

AudioVisual MMN – Visual MMN compared with Auditory MMN



*For the AV1 (Std: 0, Dev:±20) condition only, at the three electrode positions shown, there were no significant differences between the AV-V and A MMN within the time window of the significant auditory only MMN (97ms and 130ms).

Conclusion

*The results imply that an auditory MMN can be produced by shifting the spatial location of a visual stimulus. However, this can only occur if a significant visual and audiovisual MMN is elicited by the experimental setup.

*This result supports other findings that cross-modal processing can elicit changes in the early pre-attentive processing of stimuli.

References

Alais, D., & Burr, D. (2004). The ventriloquist effect results from near-optimal bimodal integration. *Current biology*, *14*(3), 257-262.

Deouell, L. Y., Parnes, A., Pickard, N., & Knight, R. T. (2006). Spatial location is accurately tracked by human auditory sensory memory: evidence from the mismatch negativity. *European Journal of Neuroscience*, *24*(5), 1488-1494.