Abnormal neural correlates of audiovisual multisensory integration in autism spectrum disorders

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Background

- Individuals with autism spectrum disorders (ASD) exhibit abnormalities in multiple modalities of sensory functioning and in multisensory integration:
  - Evidence for both hyper- and hypo-sensitivity to auditory and visual stimuli.[1]
  - Temporal binding is disrupted in ASD.[2]
- Past research has shown evidence that individuals with ASD have a preserved capacity to integrate low-level auditory and visual input.[3, 4]
  - Specifically in the context of perceiving a "flash-beep" illusion,[5] wherein presentation of a single visual flash along with two temporally proximal auditory beeps results in the perception of an illusory second flash.
- However, differences have been found in the temporal window over which stimuli are integrated in ASD.[4]
  - Suggests that, though integration is occurring in ASD, the mechanisms by which it occurs may differ.
- Using electrophysiological recording, Mishra et al. (2007)[6] found that the occipital P120 and central P180 and N270 Event Related Potential (ERP) responses reflect the neural signatures of multisensory integration during the flash-beep illusion in healthy adults.
  - The neural correlates of audiovisual integration processes in ASD have not yet been investigated.
- The current project examines disruption in neural mechanisms subserving cross-modal integration in ASD using the flash-beep illusion.
  - Focused specifically on ERP responses when the illusion was and was not perceived in children with ASD and in typically-developing (TD) controls.
  - Allowed for the isolation of the illusion percept resulting from cross-modal integration.
- Hypothesis: individuals with ASD will perceive the illusion and likely show similar early sensory responses to stimuli, but will exhibit differences in later perceptual responses reflective of multisensory integration.

Methods

Study Design

- Participants were presented with trials in which several combinations of flashes and beeps were presented, including:
  - A 2-beep, 1-flash "flash-beep" condition.
    - Potentially eliciting illusion perception (Figure 1).
  - A 2-beep, 2-flash condition.
  - A 1-beep, 1-flash condition.
  - A 1-flash condition.
- Participants responded via button press regarding the number of flashes perceived.
  - Allowed "flash-beep" trials to be sorted into those in which illusion was ("Illusion") and was not ("No Illusion") perceived.

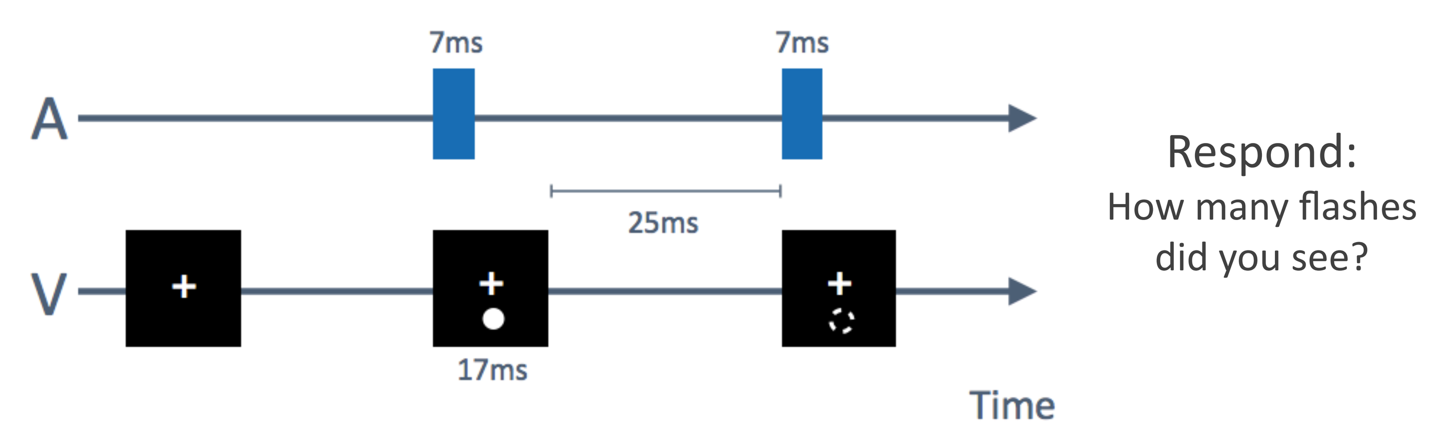

Figure 1: Trial design in the 2-beep 1-flash "flash-beep" condition. The top line ("A") shows the timing of auditory stimuli, while the bottom line ("V") shows the timing of visual stimuli. A fixation cross is presented at the beginning of each trial. A 7ms beep is then presented concurrently with a white circle below the fixation cross. The white circle "flash" is shown for 17ms. 25ms after the offset of the first flash, a second beep is presented without a flash. When the illusion is perceived, the participant reports seeing a second flash concurrent with the second beep.

Methods

Participants

- Age range: 10-13
- ASD subjects: high-functioning, confirmed diagnosis with ADI-R and ADOS.
- TD subjects: no prior history of learning or psychiatric disorders.

	N	Sex	Age (yrs)	WASI Full Scale IQ
ASD	18	1 female	12.08 (1.29)	116.56 (16.27)
TD	20	4 female	12.17 (1.28)	114.32 (13.40)

ERP Extraction

P120 (100-160), P200 (140-270ms), and N200 (150-250) peak amplitude were extracted for electrodes over occipital, parietal, and central scalp according to 10-20 conventions (Figure 2) for illusion and no-illusion conditions.

ERP Data Analysis

Peak P120, P200, and N200 amplitudes were compared across illusion and no-illusion conditions using a 2x2 repeated measures analysis of variance (ANOVA) with illusion perception as a within-subjects factor and ASD diagnosis as a between-subjects factor.

Data Acquisition

- EGI 128-channel net
- Impedances < 40 kOhms
- Segmented 500ms post stimulus onset (from first beep)
- Sampled at 1000Hz
- Artifact detection
- Bad channels replaced
- Average reference
- 100ms baseline correction

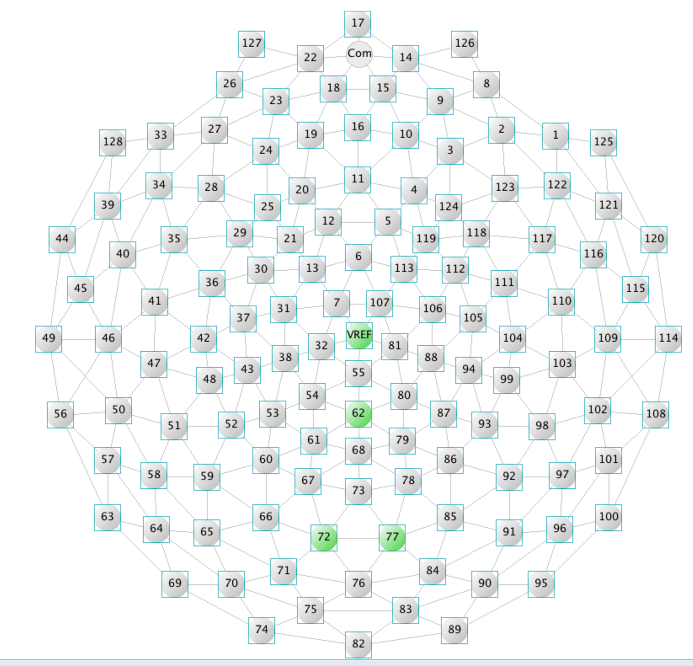

Figure 2: Electrodes for ERP component extraction shown in green.

Results

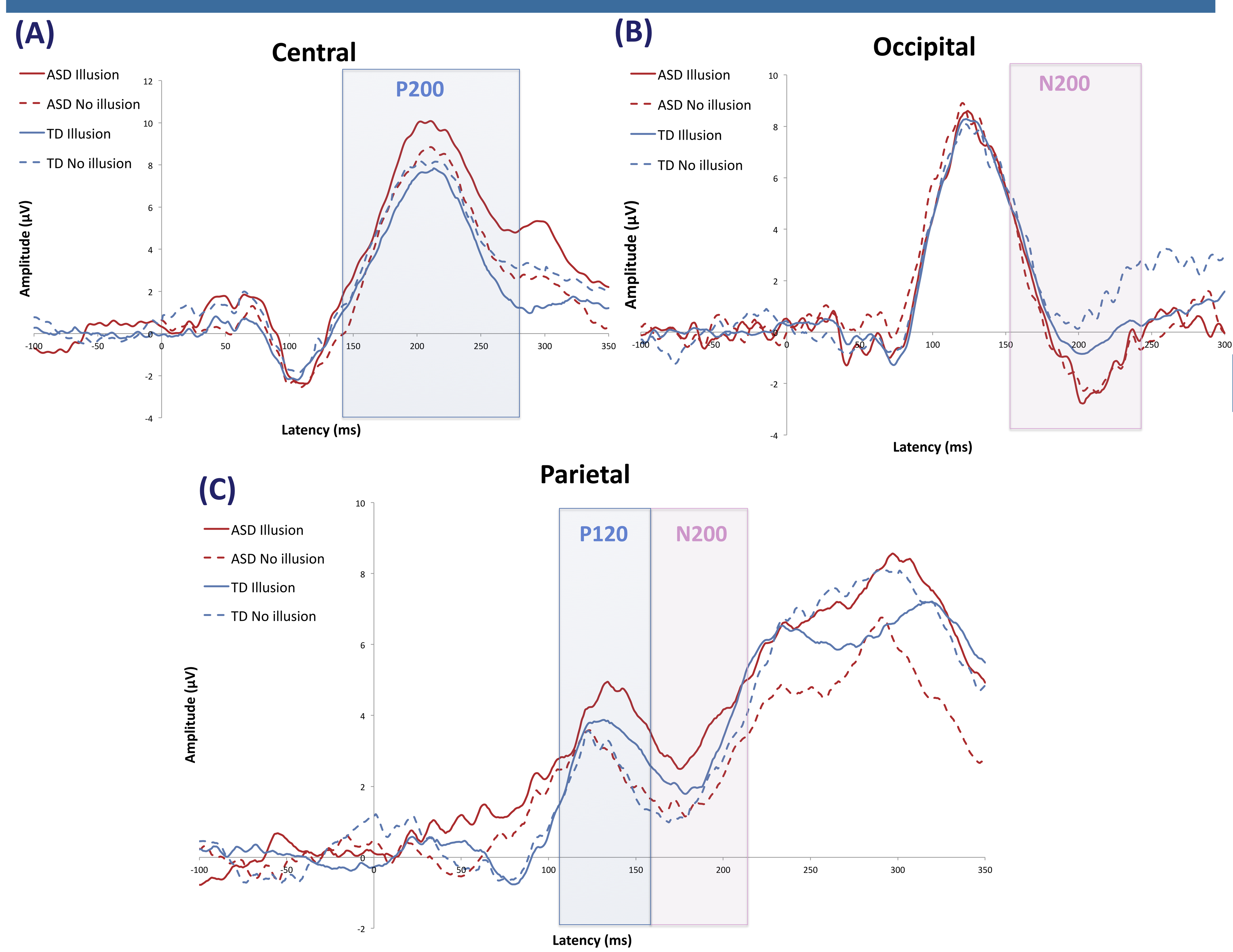

Figure 3: ERP results. (A) P200 response in electrode Cz shows a significant interaction effect between illusion perception and group. (B) N200 response, averaged across electrodes 72 and 77 over visual cortex. Given its later latency and presence over the posterior scalp, this potential was interpreted as an N200c. ASD participants showed a stronger N200c than TD participants. (C) ERP responses in electrode Pz. For both groups, peak P120 amplitude was greater when the illusion was perceived, and N200 amplitude was greater when the illusion was not perceived. Given the early latency and more central distribution of the N200 component, as well as the accompanying P300, it was interpreted as an N200b.

Results

P120 Amplitude

- Higher peak P120 amplitude was found over parietal cortex when the illusion was perceived ($F(1, 36) = 5.351$, $p < .05$) across groups.

N200 Amplitude

- Early N200 response over parietal cortex (N200b) was stronger when the illusion was not perceived in both groups ($F(1, 35) = 4.986$, $p < .05$).
- Later N200 response over occipital cortex (N200c) was significantly stronger in participants with ASD irrespective of condition ($F(1, 34) = 6.181$, $p < .05$).

P200 Amplitude

- P200 response over frontocentral cortex was modulated by both group and condition, with ASD participants showing a stronger response when the illusion was perceived and TD participants showing a stronger response when the illusion was not perceived ($F(1, 35) = 6.529$, $p < .05$).

Conclusions

- All participants displayed a heightened early sensory response (P120) when they perceived the illusion.
  - P100 has been shown to be modulated by visual attention.[7]
  - Suggests that participants perceive the illusion when they are more initially attentive to the flash and that early processing is similar for ASD and TD participants.
- Illusion perception also elicited a stronger parietal N200b response across subjects, indicating that the illusion was perceptually novel to both groups (despite the physical stimulus equivalence between the illusion and no-illusion conditions).
- ASD participants allocated a greater degree of attention to process the stimuli than TD participants overall, as reflected in a stronger N200c response in the ASD group.
- Differences in later P200 response suggests that multisensory integration is the result of greater higher-order perceptual processing for individuals with ASD, while greater higher-order perceptual processing is associated with lack of integration for TD individuals.

Implications and Future Directions

- These results contribute to a better understanding of the neural basis of sensory processing and multisensory integration differences in ASD.
  - Individuals with ASD exhibit preserved basic sensory processing (P100) but abnormal later perceptual processing during multisensory integration.
  - Contributes to a broader knowledge of neural differences in ASD.
- Future research could compare the illusion perception condition with the 2-flash 2-beep condition, in which the perceptual outcome is the same though the physical stimulus input differs.
- Future studies examining oscillatory activity during illusion perception could further elucidate the neural substrates of multisensory integration in ASD.

References

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