Auditory Brainstem Responses (ABR) in sight recovery individuals reveal crossmodal sensitive periods in humans

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Introduction

The auditory system does not develop and function in isolation, and other senses, such as vision, modulate its functional and structural organization (1, 2). This interplay is particularly manifest in the case sight is missing since early phases of the development. Recent findings in both human and non-human animal models have revealed that even a temporary visual deprivation occurring in the early phases of the development is sufficient to elicit functional changes within the auditory pathway (3). Studies in non-human animal models have revealed that in early development, the onset of visual input gates the critical period closure of basic auditory functions (4). The study of rare individuals whose sight was restored after a period of congenital blindness offers the unique opportunity to assess whether visual input in the earliest phases of life is a prerequisite for the full development of the other sensory functions. Here, we investigated whether a few months of delayed visual onset would affect the development of subcortical auditory responses, and whether plasticity effects could be observed at early developmental stages.

Methods

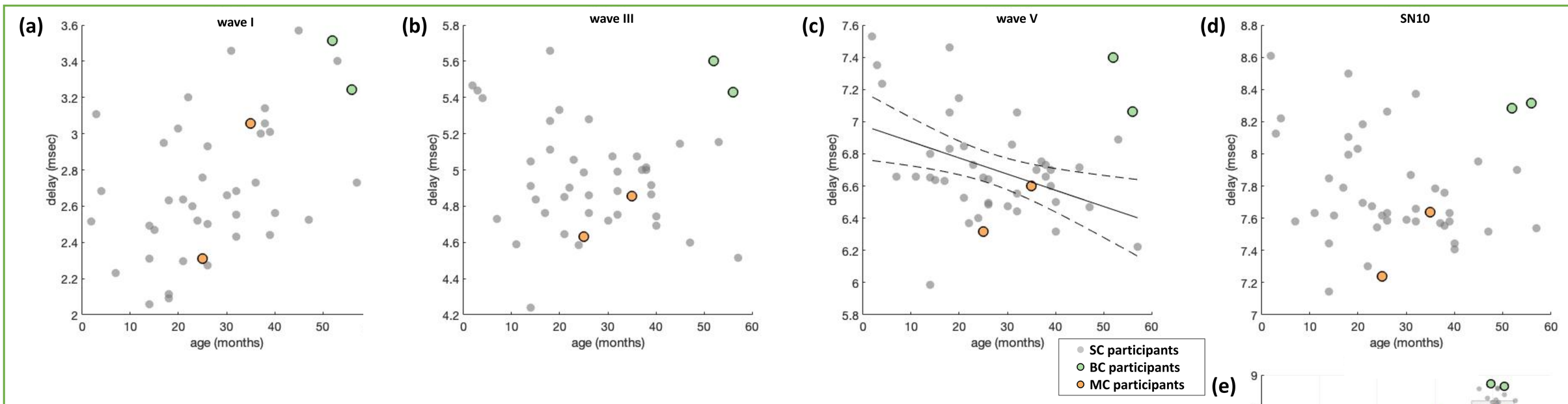
Participants:

We collected Auditory Brainstem Responses (ABRs) from two case studies, young children (both having about 4.5 years of age) who experienced a transient visual deprivation since birth due to congenital bilateral dense cataracts (BC), and who regained sight after surgery within the first two months of age. As controls we also tested 40 children (sighted controls, SC; 15 F; mean age = 26.38 months; st.dev = 13.39 months) with typical development, as well as two children who were treated (within the first two months of age) for congenital monocular cataracts (MC). We employed ABRs as they are widely used in the clinical practice to assess the functionality and the development of the subcortical auditory pathway and provide reliable data at the individual level (5).

Analyses:

- A semi-automated procedure was adopted to extract peak latencies for waves I, III, V, and SN10 with the supervision of an expert audiologist. Separately for each wave, latencies from the two ears were averaged.
- In SC group, we estimated the effect of age variable on wave latency by means of an independent regression.
- Then, bootstrap-based statistics were performed both at the single subject level (each BC vs. SC group and each MC vs. SC group) as well as at the group level (BC vs. SC and MC vs. SC) on latencies of main ABR waves.

Results



- ABR latencies in the SC group showed a clear age-related association. Consistently with existing literature (6), we found that the latency of the wave V decreased with age in the SC group (see Figure c)
- When considering ABR latencies and age as a covariate of no-interest, no differences were found for wave I between the SC and each subject of the BC group (see Figure a)
- For waves III, V and SN10, the absolute latencies of both BC participants were significantly delayed ($p_{bonf\text{-}corr}<0.05$; see Figures b, c, d).
- When considering ABR latencies in the MC group, no differences were found between them and the SC group for none of the tested wave latencies ($p_{uncor}>0.05$; see Figure a, b, c, d)
- Group-level comparisons confirmed the results found at single-subject level (see Figure e)

Conclusions

The observed latency delay of the ABRs found in both BC participants suggests a change in the auditory system maturation as a consequence of a limited-in-time visual deprivation at birth. Moreover, for all wave latencies, MC did not differ to SC, suggesting that a monolateral visual deprivation is not sufficient to alter the development of the auditory system. These findings suggest that in case patterned visual input has a delayed onset, the auditory system development is lagging behind the typical development. Overall, results support the idea of the presence of a visually-dependent sensitive period in the human auditory system.

References

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