Cross-modal matching of numerosity is subserved by the left parietal cortex in the developing brain

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INTRODUCTION

The involvement of the fronto-parietal circuit in tasks requiring allocation of covert attention is well known in the adult brain [1]. Less is known about the fronto-parietal interplay in the developing brain during the allocation of attention to visual objects. The aim of the present study was to investigate the involvement of the entire fronto-parietal network in 6-month old infants during a task of lateralized visual attention.

MATERIALS AND METHODS

Participants: Twenty-four 5-to-6-month old infants (mean age=5.7, SD=.44). Five infants were discarded due either to technical issues or because they attended to less than 50% of trials in at least one condition (19 participants, 10 females).

Data processing: NIRS data were analyzed with the Homer2 package [2]. Channels with very low intensity were pruned, motion artifacts were identified and corrected applying a combination of spline and wavelet techniques, physiological noise was reduced by applying PCA (85%) and a band-pass filter (0.01-1 Hz) was applied. Before block-averaging, trials with a looking time < 1s were removed.

Metric: The integral of the mean hemodynamic response between 4 and 11 s was computed for both oxy- (HbO) and deoxy-hemoglobin (HbR).

Statistical analysis: Mixed ANOVAs separately for the frontal and parietal regions, with gender as between-subject factor and number of visual targets (1 vs. 3), congruency (congruent vs. incongruent), hemisphere (left vs. right) and channel (from 1 to 4) as within-subject factors.

Data acquisition: The bilateral fronto-parietal brain responses to the stimuli were monitored with an ISS Imagent™ system equipped with 4 detectors and 16 sources (16 channels) (Fig.2).

Paradigm: Auditory (i.e., either 1 or 3 beep sounds) and visual (i.e., either 1 or 3 lateralized visual targets) stimuli that could be congruent or incongruent in numerosity (Fig.1).

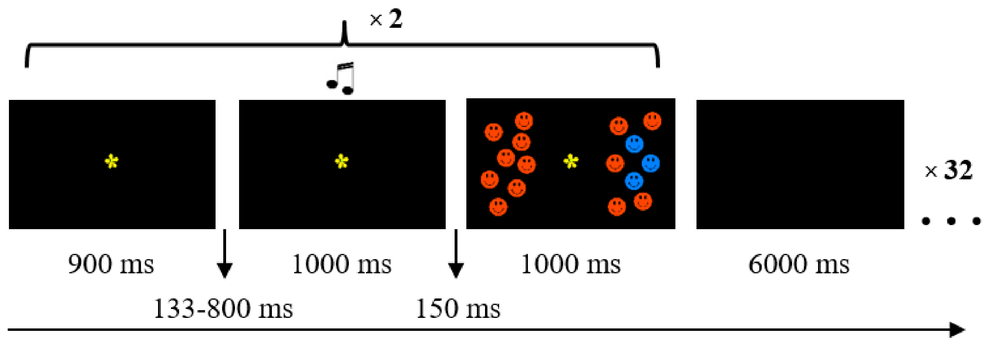

Fig. 1: A central attractor was presented before and maintained throughout each trial to favor the allocation of the infant's eyes at the center of the screen. To match auditory (i.e., either 1 or 3 beep sounds) and visual (i.e., either 1 or 3 lateralized target visual stimuli) information, infants were required to orient their attention to the lateralized visual targets. During the experiment infants were videotaped.

RESULTS AND DISCUSSION

- No differences between male and female.
- Main effect of hemisphere ($F(1,17)=4.98$, $p=.039$) for HbO in the frontal region.
- The most lateral-anterior frontal channel showed the main difference between the two hemispheres ($t=-3.353$, $p=.004$).
- Interaction congruency*hemisphere ($F(1,17)=10.02$, $p=.006$) in the parietal region (increase in the left hemisphere and decrease in the right hemisphere for incongruent stimuli and opposite pattern for congruent stimuli).
- The most left-anterior parietal channel showed the main difference between activation for congruent and incongruent stimuli ($t=-2.282$, $p=.035$) (Fig.3).
- The most left-anterior parietal channel showed a significant difference with the activation of the symmetric channel in the congruent condition ($t=-2.231$, $p=.039$).
- For HbR no statistically significant differences but a tendency in the parietal region for the interaction congruency*hemisphere ($F(1,17)=3.34$, $p=.085$).

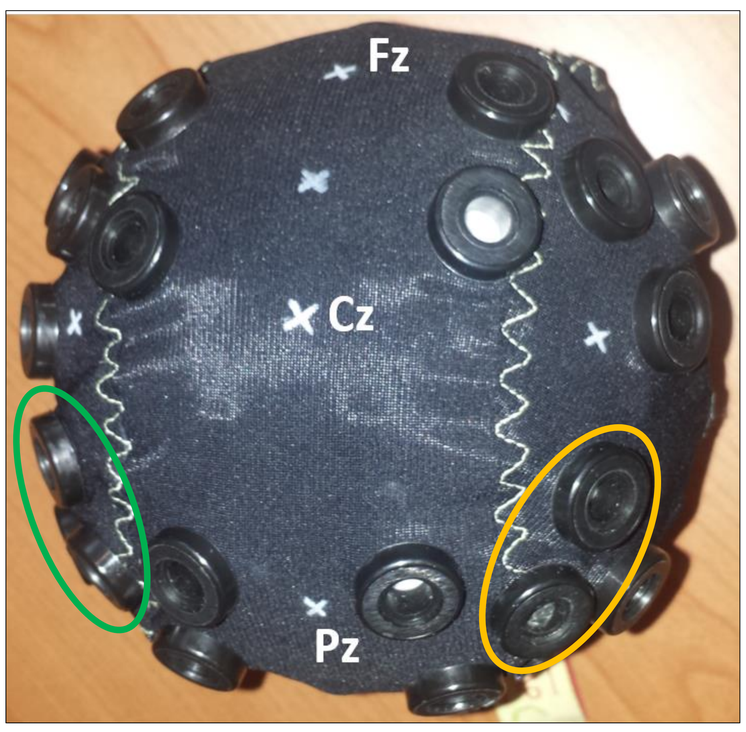

Fig. 2: The optodes in the parietal region were placed around P3 and P4 locations of the 10/10 System, whereas in the frontal region optodes were placed around FC3 and FC4.

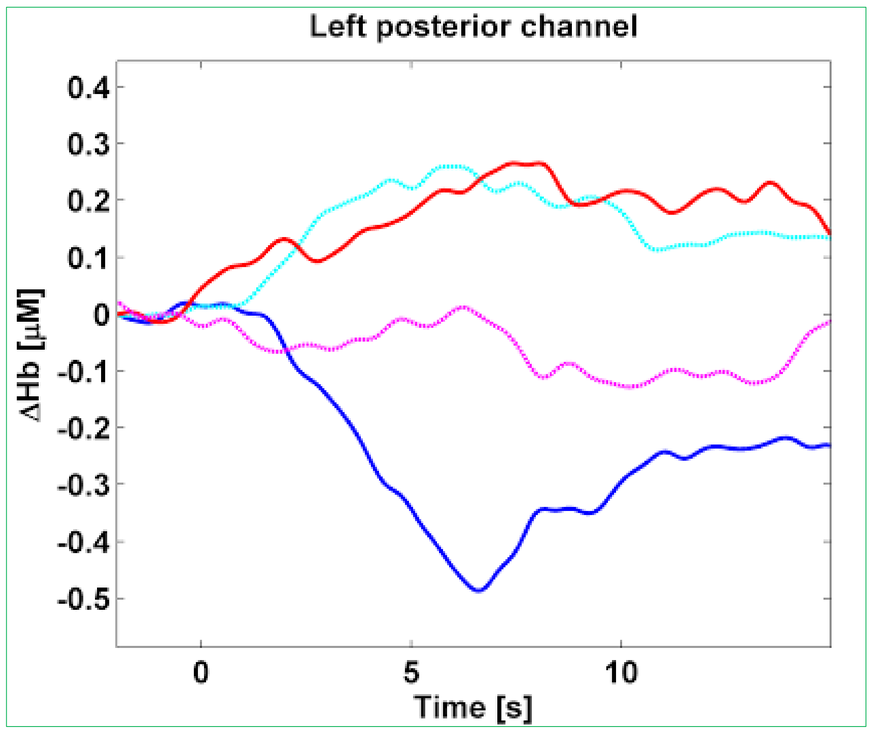

Fig. 3: Group average hemodynamic responses in the most left anterior parietal channel (left) and in the most right anterior parietal channel (right) for incongruent (red HbO, magenta HbR) and congruent condition (blue HbO, cyan HbR).

Conclusion

Our results suggest that 5-6 months old infants are able to match the numerosity of auditory and visual stimuli. These results confirm and extend previous evidence that such ability is present in young infants [3;4]. In addition, our data showed that both frontal and parietal regions are involved in the task, with the left parietal area likely more involved during the matching phase of the task.

REFERENCES

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ACKNOWLEDGES

This work was supported by Grant STPD 11B8HM from the University of Padova.