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Event-Related Potentials of Children Aged 6-12 during Naïve Optics Educational Video Game Play Show Positive Wave Amplitudes at Pz.

Joseph E. Schroer[1], Doris Bergen[1], Robin Thomas[2], Xintian Tu[1], George Woodbury[2], Miami University, Ohio

[1]Department of Educational Psychology, [2]Psychology Department

Introduction

Spatial Reasoning

The development of spatial reasoning has received recent attention from the National Research Council (2006, 2009, 2012), National Teachers of Mathematics (NCTM, 2010), and and Common Core Standards, with criteria beginning in Kindergarten.

Naïve Optics is one element of spatial reasoning. Naïve Optics includes the law of reflection where the angle of incidence equals the angle of reflection. Mishkin et. Al (1983) demonstrate posterior parietal activation in Macaques for spatial relationships. Visuo-Spatial Working Memory (VSWM) also includes the region of the superior frontal sulcus (DLPFC) (Courtney et. Al., 1998).

Videogames have been shown to increase spatial reasoning abilities (i.e., Uttal et. al., 2013). Guevara et. al. (2015) suggest that VSWM efficacy is mediated by DLPFC and Parietal coupling in Alpha and Beta frequencies for adolescents. Little research has focused on this development in children.

Purpose

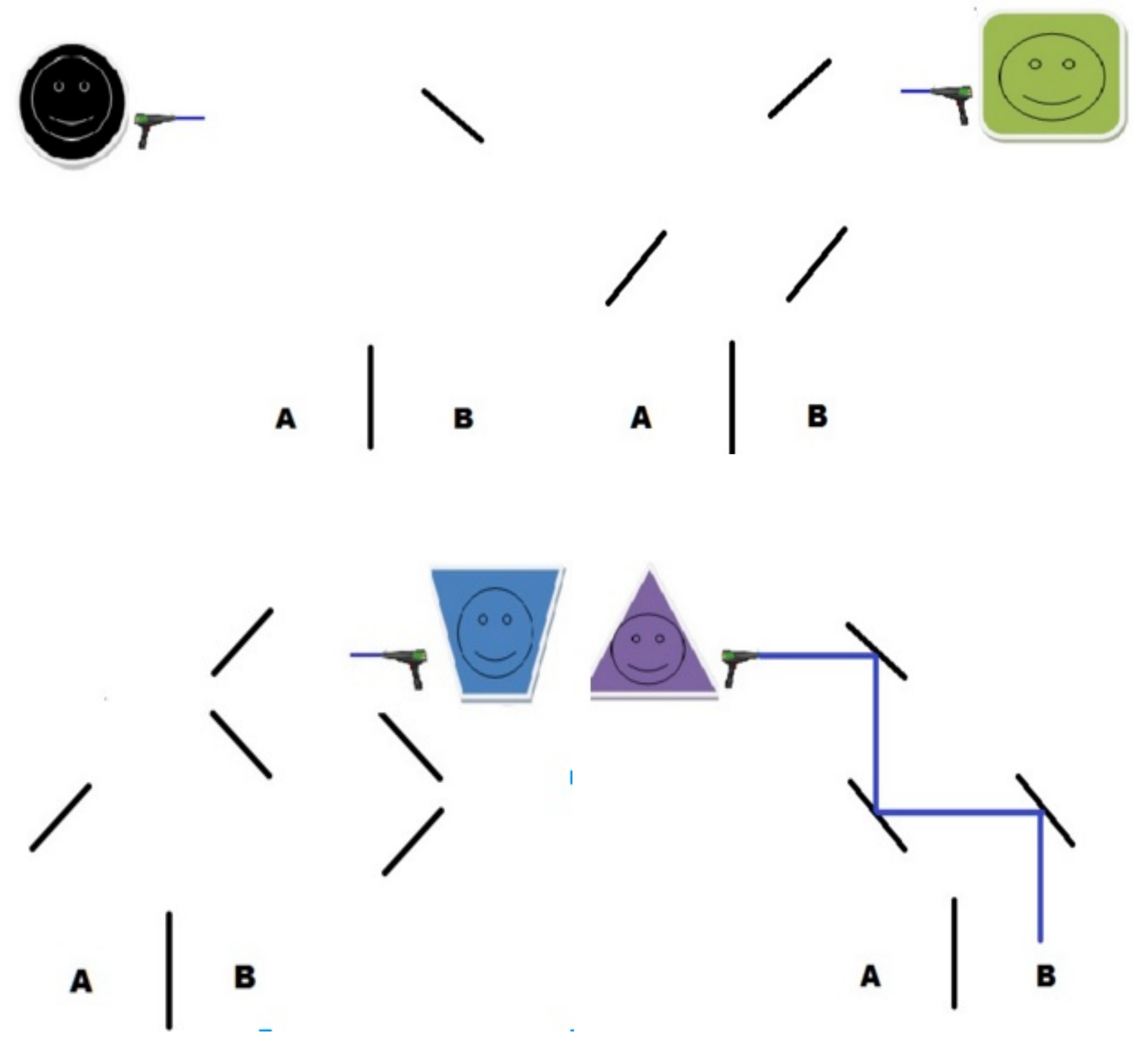
The main purpose of this research is to explore the hypothesized “spatial triangle” of Naïve Optic spatial reasoning skills in children using ERP research.

The secondary purpose of this research was to identify the frequency coordination of areas of the brain associated with the learning of spatial reasoning abilities while learning the concept of the law of reflection. We hypothesized Pz, P3b (36),F4 and F3 site alongside alpha and beta frequency coupling during the pre and posttest blocks.

Methodology

Participants

Seventeen participants aged 6-12 (11 boys, 6 girls) completed an educational videogame law of reflection task consisting of a pre-test, practice, and posttest.



Technical Considerations

A 64-channel geodesic sensor net was used to collect electrical signals. Artifact detection, Bandpass filtering from 0.1-55Hz, baseline correction, re-reference to the average, and segmenting the data were performed using Netstation v.4.5. The videogame, “When Visitors Attack” was performed and trial data were collected using E-Prime v. 2.0.

SPSS v. 22 was utilized for statistical analysis of ERP and behavioral data. Matlab 2015a was used for frequency analysis and topomap creation.

Results

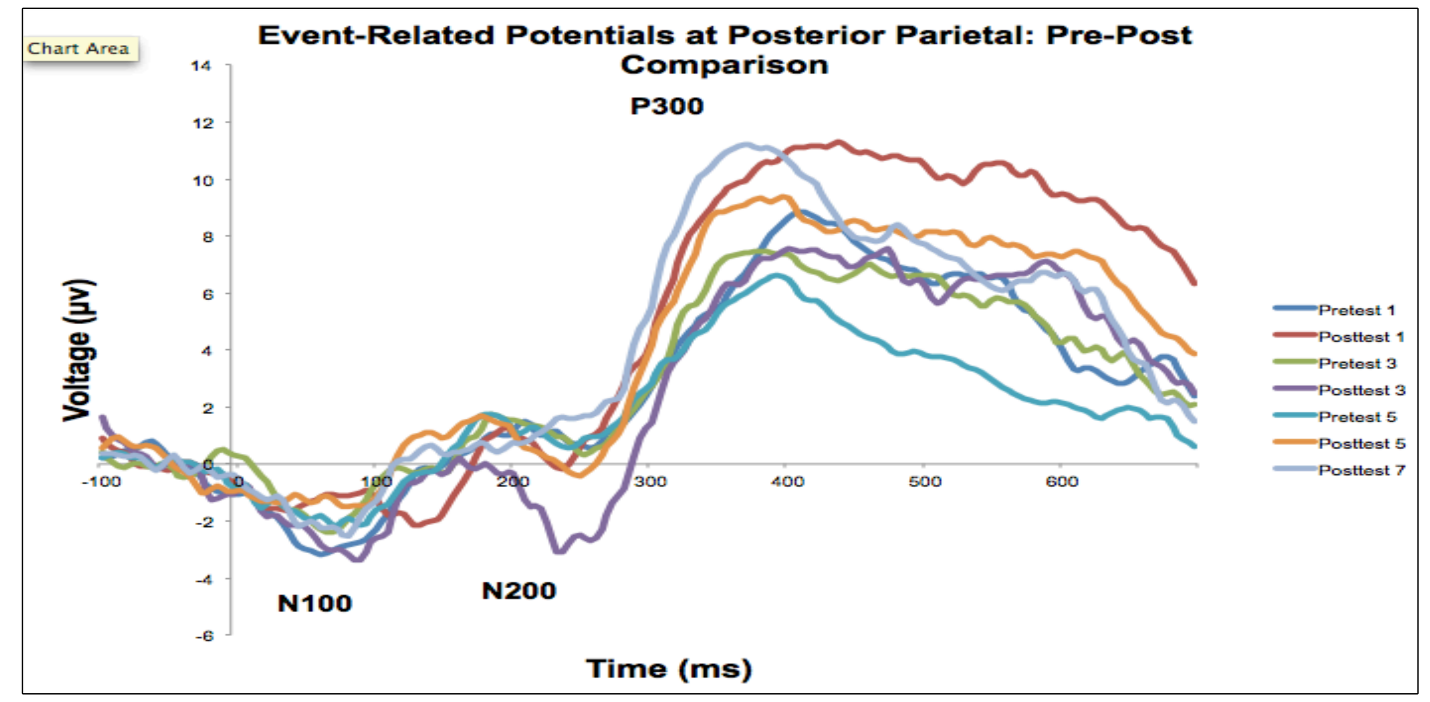


Figure 1: ERPs during each trial at Posterior Parietal

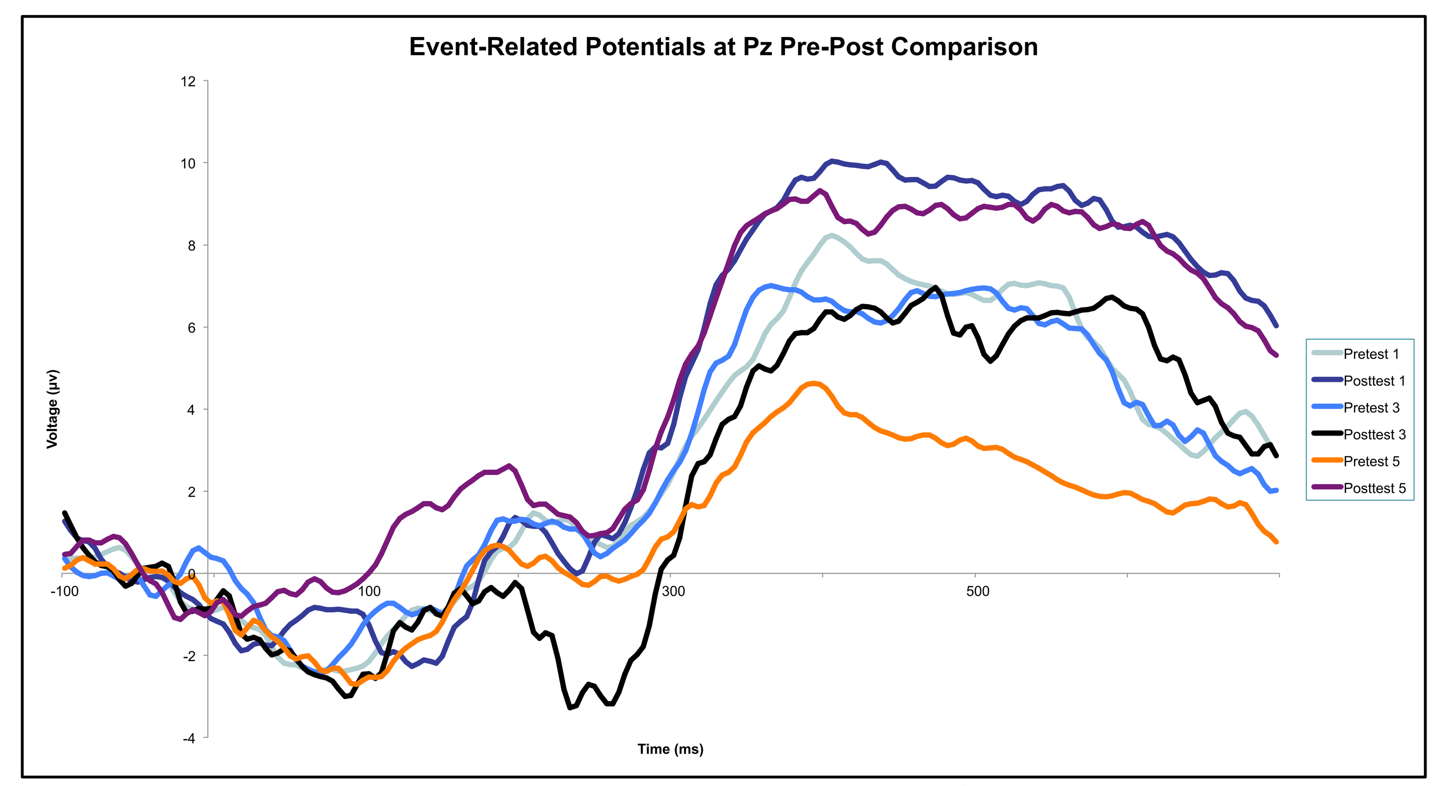


Figure 2: ERPs during each trial at Pz

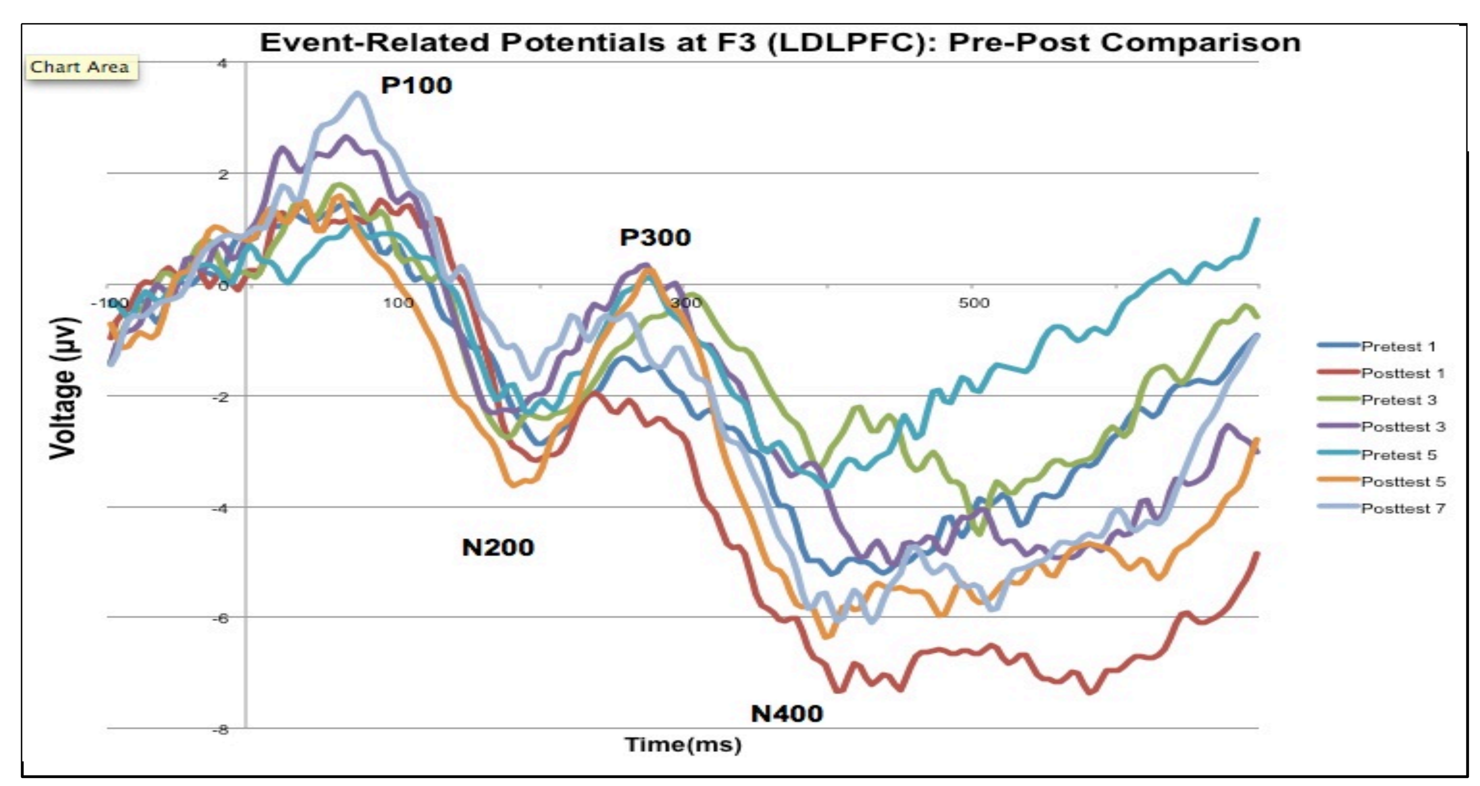
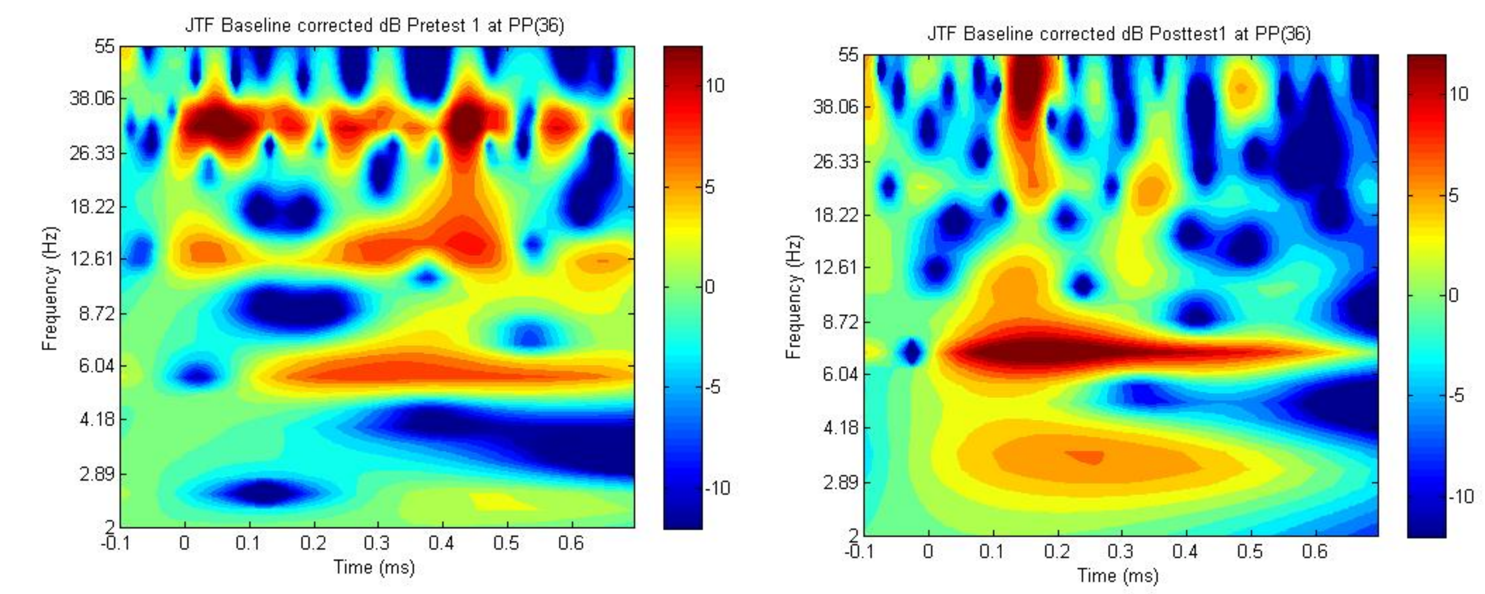
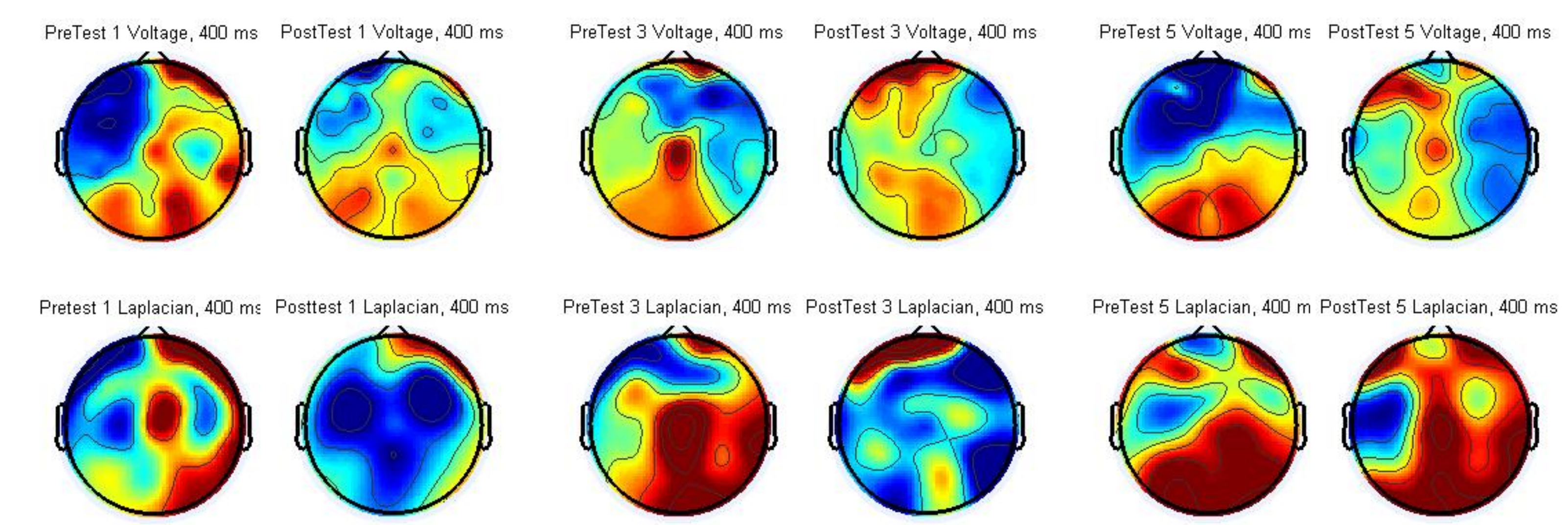


Figure 3: ERPs during each trial at F3.

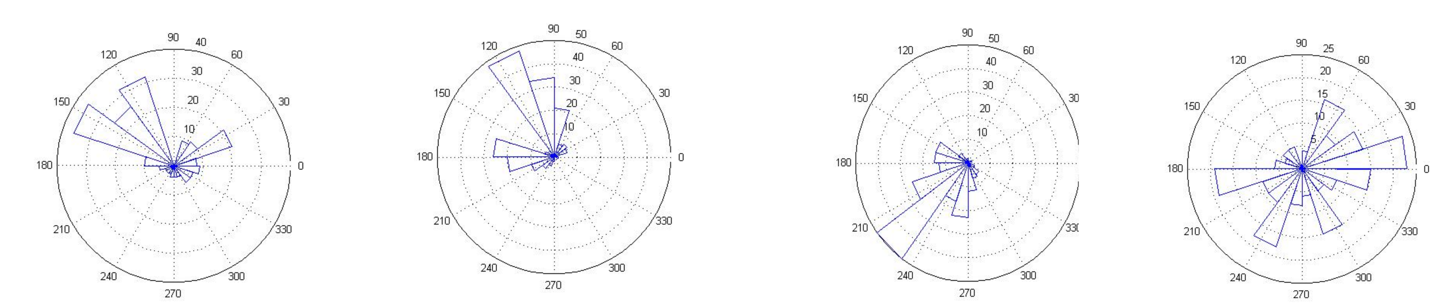
Time-Frequency Plots



TopoMap and Surface Laplacian Transform



PreTest1-Posttest1 PreTest3-Posttest3 PreTest5-Posttest5



Phase Coherence F3-F4 Alpha Pre1 | Phase Coherence F3-F4 Alpha Post1 | Phase Coherence F3-F4 Beta Pre1 | Phase Coherence F3-F4 Beta Post1

Discussion

While participant scores were found to be significantly different- demonstrating concept learning- paired sample t-tests of P3 at Pz, and 36 reveal only one marginally statistically significant difference between the Pre and Posttest grand average ERPs; Pre-Post 5 reflection $t(15)=-4.17$, $p=.094$. T-tests of P3 and N4 at F3 and F4 reveal no statistically significant differences. There were several Pre-Post correlations at Pz and the Posterior Parietal locations.

The Laplacian transforms demonstrate greater positive parietal activity during both Pre-Posttest as the number of mirrors increases and with training. Phase coherence analysis reveals greater coherence and correlation between F3 & F4 in Alpha(8-12 Hz) pre ($r=.33$) to posttest ($r=.63$), but decreased beta (13-35 Hz) frequency coherence F3-F4 from pre($r=.68$) to post($r=.15$) as children know the task. The more negative amplitude of N4 during Pretest suggests a greater level of inductive reasoning (semantic integration stage; Liang et. al., 2010).