



Christine L. Lackner<sup>1</sup>, Karen Milligan<sup>2</sup>, Leanne Wilkins<sup>2</sup>, Flavia Spiroiu<sup>2</sup>, Paul Badali<sup>3</sup>, Louis A. Schmidt<sup>4</sup>, & Sidney J. Segalowitz<sup>1</sup>

<sup>1</sup>Brock University, <sup>2</sup>Ryerson University, <sup>3</sup>Integra, <sup>4</sup>McMaster University



## Background

Children with ADHD and/or learning disabilities often show difficulties appropriately allocating their attention. One way that attention allocation is indexed is through event-related potentials (ERPs) recorded during an auditory selective attention task.

Selective attention effects are reduced in children from lower SES backgrounds and in children with specific language impairment, a circumstance often associated with poorer attentional control [1, 2]. However, these effects can be somewhat normalized through intervention [3, 4, 5, 6]. These attention-related effects are complicated by the fact that amplitudes in the averaged ERP can differ across participants because of differences in the amplitude of the electrocortical generators or because of differences in the consistency of EEG phase angle (intertrial coherence – ITC), a potential form of electrocortical self-regulation.

Here, we examine whether training in MMA improves intertrial coherence markers of attentional control. MMA was developed by Paul Badali at Integra, the only children’s mental health centre in Canada dedicated to treating children and youth with learning disabilities and co-occurring mental health issues. MMA integrates mindfulness meditation, cognitive behavior therapy, and behavior modification into a 20-week martial arts group training program. Mindfulness meditation interventions have been used in the past to treat ADHD [7], but to our knowledge this is the first program that has been evaluated for youth with LDs and self-regulation challenges.

## Methods

### Participants:

18 male adolescents aged 13-16  
 15 with comorbid learning disability and ADHD  
 3 with a learning disability and no ADHD  
 11 treatment participants and 7 wait-list control participants  
 Tested at 6 week intervals

### Selective auditory attention task:

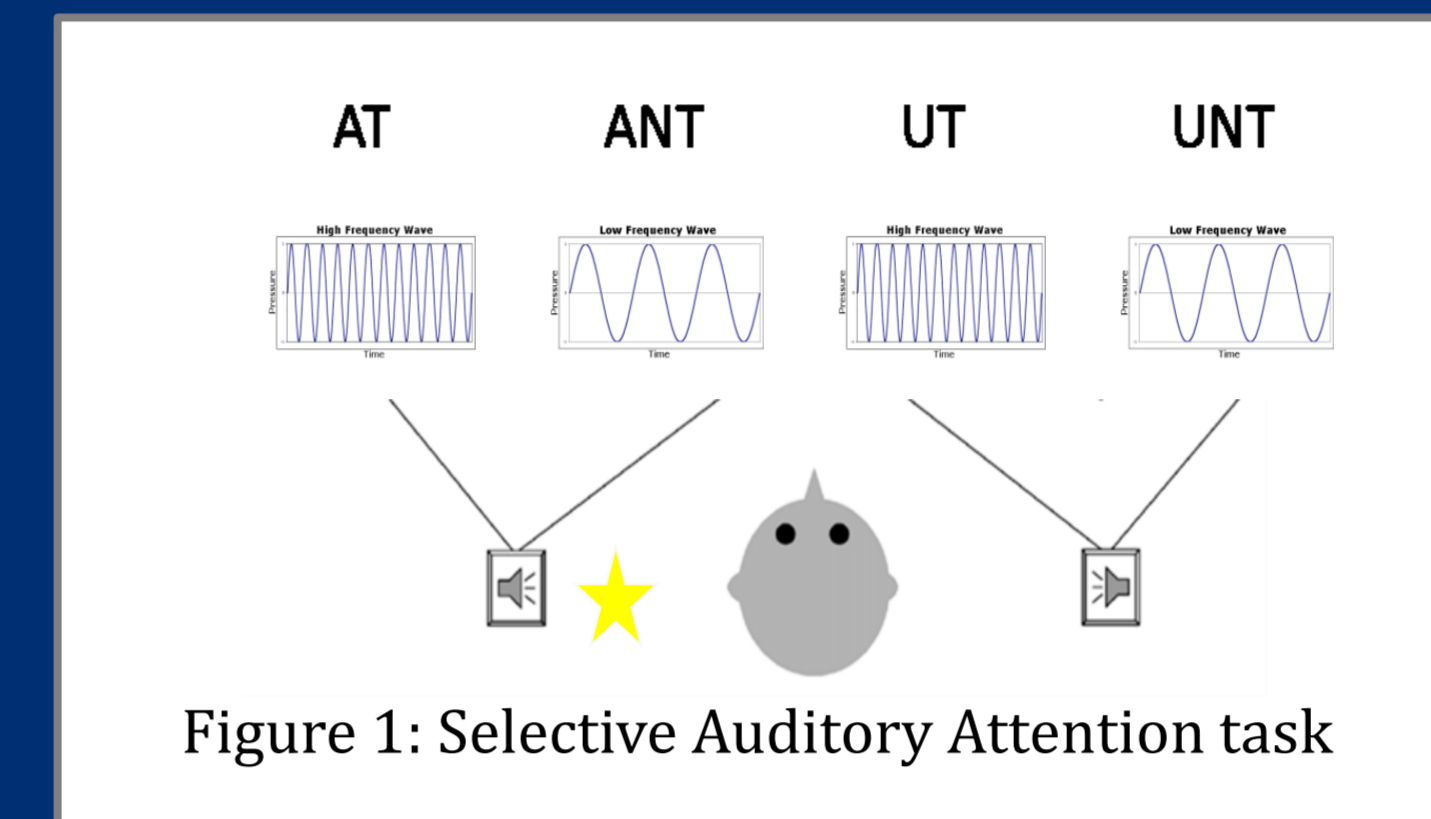
Two digitized sounds (200 ms beeps) presented dichotically  
 1000 Hz (88% probability, nontarget) and 2000 Hz (12% probability, target)  
 Approximate rate of 1 per second with a variable ISI of 600 to 800 ms randomized across ears  
 Instructed to attend to one ear only and to ignore all sounds presented to the other ear  
 Responded by pressing a number on a key pad when they heard the target tone in the attended ear  
 Four blocks of 200 trials each

### Integra Mindfulness Martial Arts (MMA) treatment program:

20 weekly 90 minute sessions  
 Each session began with a brief sitting meditation and a lesson on a therapeutic skill (e.g., everything changes, nothing stays the same)  
 Followed by a yoga warm-up and mixed martial arts practice  
 Given worksheets and CDs which guide them through a meditation to complete at home

### EEG Recording and analysis:

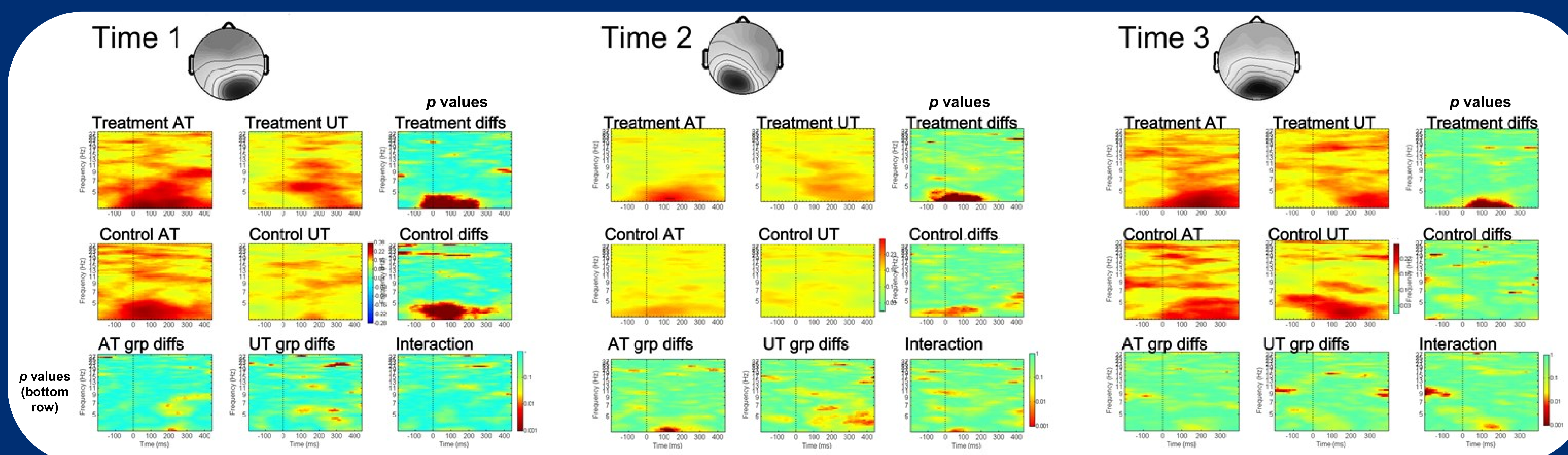
64 channel BioSemiTM gel net  
 Data referenced offline to the average of all sites, pruned to exclude any periods of off-task time (e.g., breaks) and any excessively noisy channels and subjected to an extended infomax independent components analysis (ICA; [8, 9]). Data were filtered (1-30 Hz) and all independent components representing eye movements, heart rate, or other muscle activity were removed.  
 Independent components were clustered based on time-frequency decompositions as well as topographies  
 Focal analyses conducted on 600 ms segments of IC data using native EEGLAB permutation based statistics  
 Each time frequency data point has its own set of associated test statistics and *p* values and so they are not reported here. See bottom right of each figure for *p* value colour bars.



## Conclusions

- MMA training successfully maintained ITC recorded during a selective auditory attention task over repeated task administration, compared to controls
- Effects restricted to early time windows and the theta frequency range
- Results consistent with finding that occipital theta ITC is increased to attention-grabbing pseudo words as compared to real words [12]
- MMA participants therefore benefitted by maintaining consistent attention to tones over each testing session
- Posterior IC effects, although we are currently investigating these effects in other, more traditionally related to self-regulation, networks (e.g., PFC)
- Frontal midline theta thought to reflect alternate activities of ACC and superficial PFC, [13] while the interpretation of posterior theta is less clear

## Results



Treatment, but not control participants, maintained higher ITC to AT than UT stimuli across the three testing sessions, while control participants appeared to habituate to the task

Many of these effects are significant at the *p* < .001 level

## References

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