

# The influence of Natural Environments on Children's Cognitive Functioning

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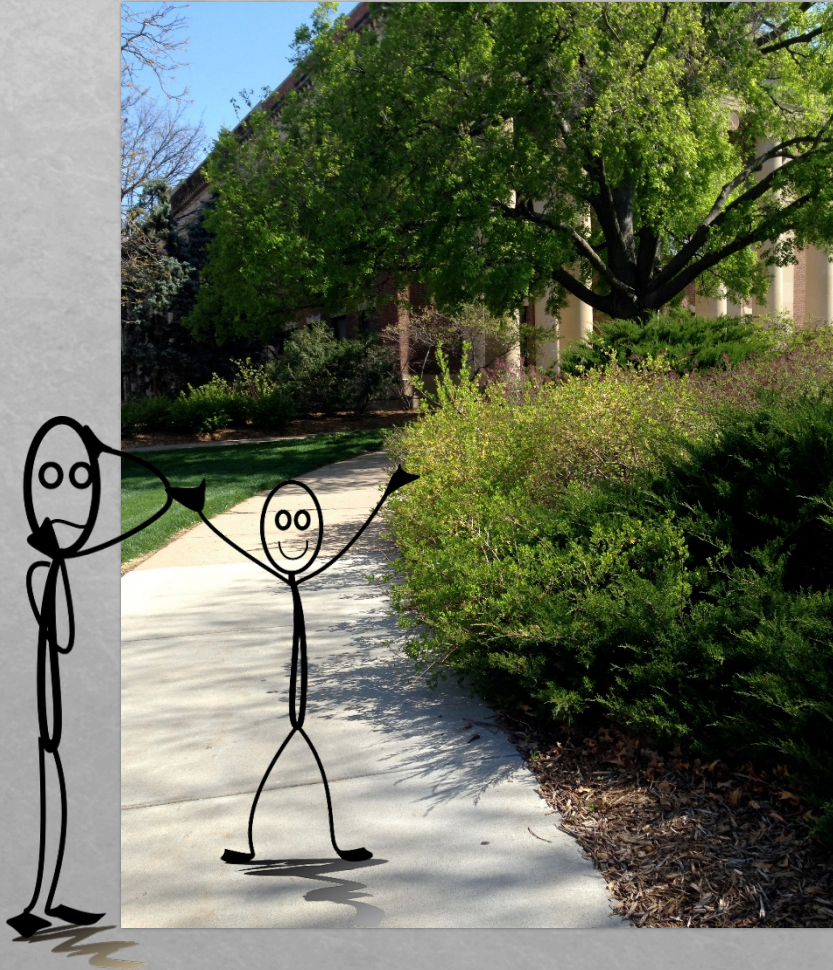
# Overview

- ◆ Background – Theory & Evidence
- ◆ Study 1: Nature vs. Urban Walk
- ◆ Study 2: Cognitive & Neuroelectrical activity  
Indoors vs. Outdoors

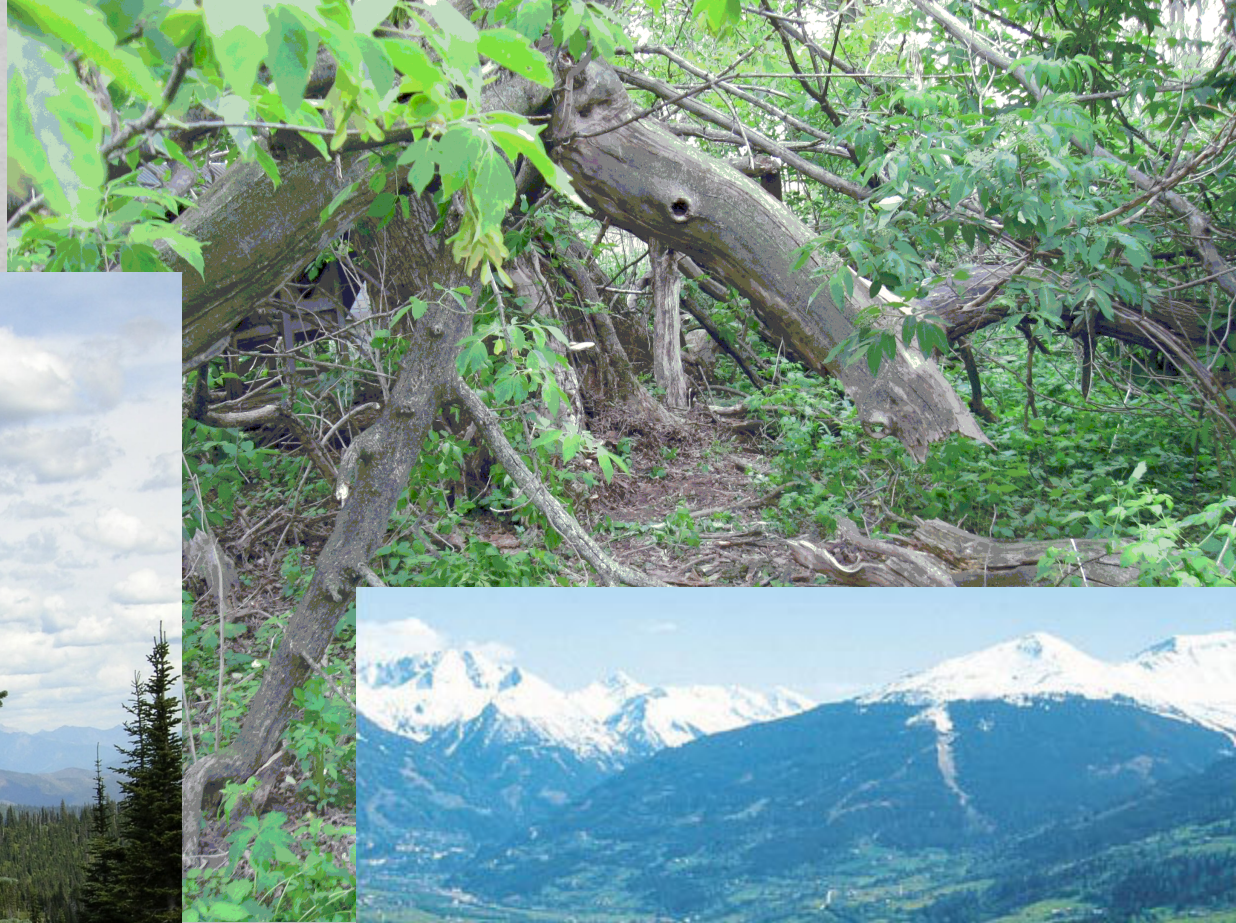
“Fresh Air & Sunshine”



# Natural Environments













# Attention Restoration Theory (ART)

- ◆ Based on work by William James
- ◆ Three basic premises
  1. two attention systems:
    - ◆ directed, effortful attention (executive attention)
    - ◆ involuntary, effortless attention “fascination”
  2. directed attention is susceptible to fatigue and restoration
  3. some environments are restorative



# Research on Children

# Nature views



For girls ages 7-12:

naturalness of view  
from apartment

concentration

impulse inhibition

delay of gratification

Taylor, Kuo, & Sullivan, 2002



# Faber Taylor et al. 2001

- ◇ Convenience sample of 96 parents of children with ADD/ADHD
- ◇ Nominated “best” and “worst” activities

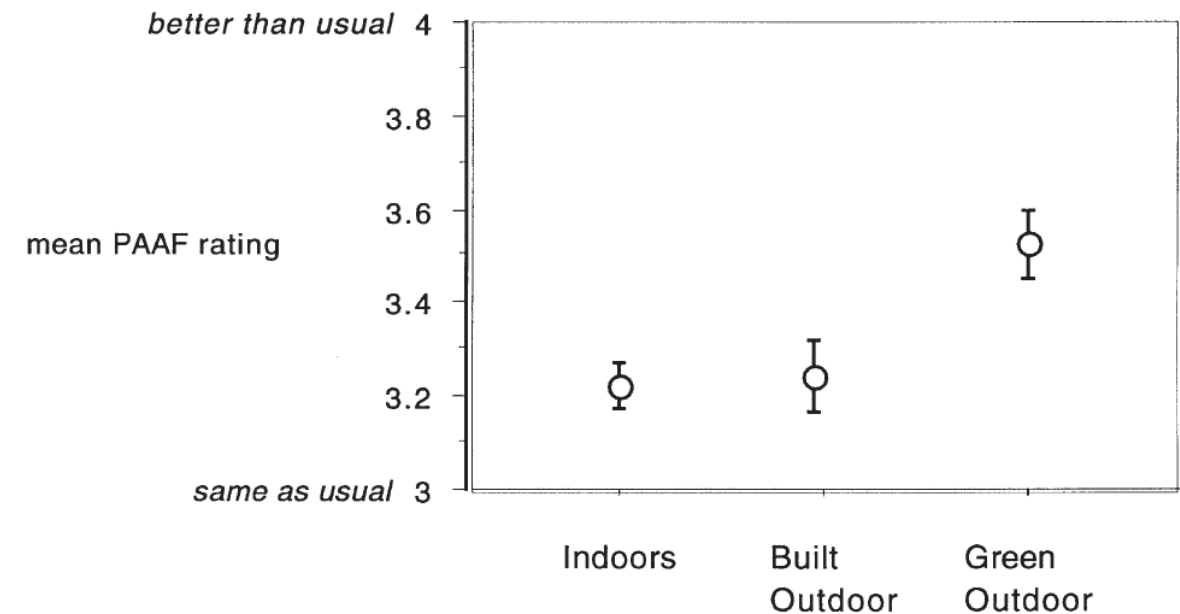
**TABLE 1**  
**Activities Nominated as Best and Worst for**  
**Attention Deficit Disorder Symptoms, Classified by Likely Setting**

<i>Likely Setting</i>	<i>Best</i>	<i>Worst</i>
Green (e.g., fishing, soccer)	85% (17)	15% (3)
Ambiguous (rollerblading, playing outside)	56% (43)	44% (34)
Not Green (video games, TV)	43% (53)	57% (69)

NOTE: Numbers in parentheses are *ns* for each group.

# Faber Taylor et al. 2001

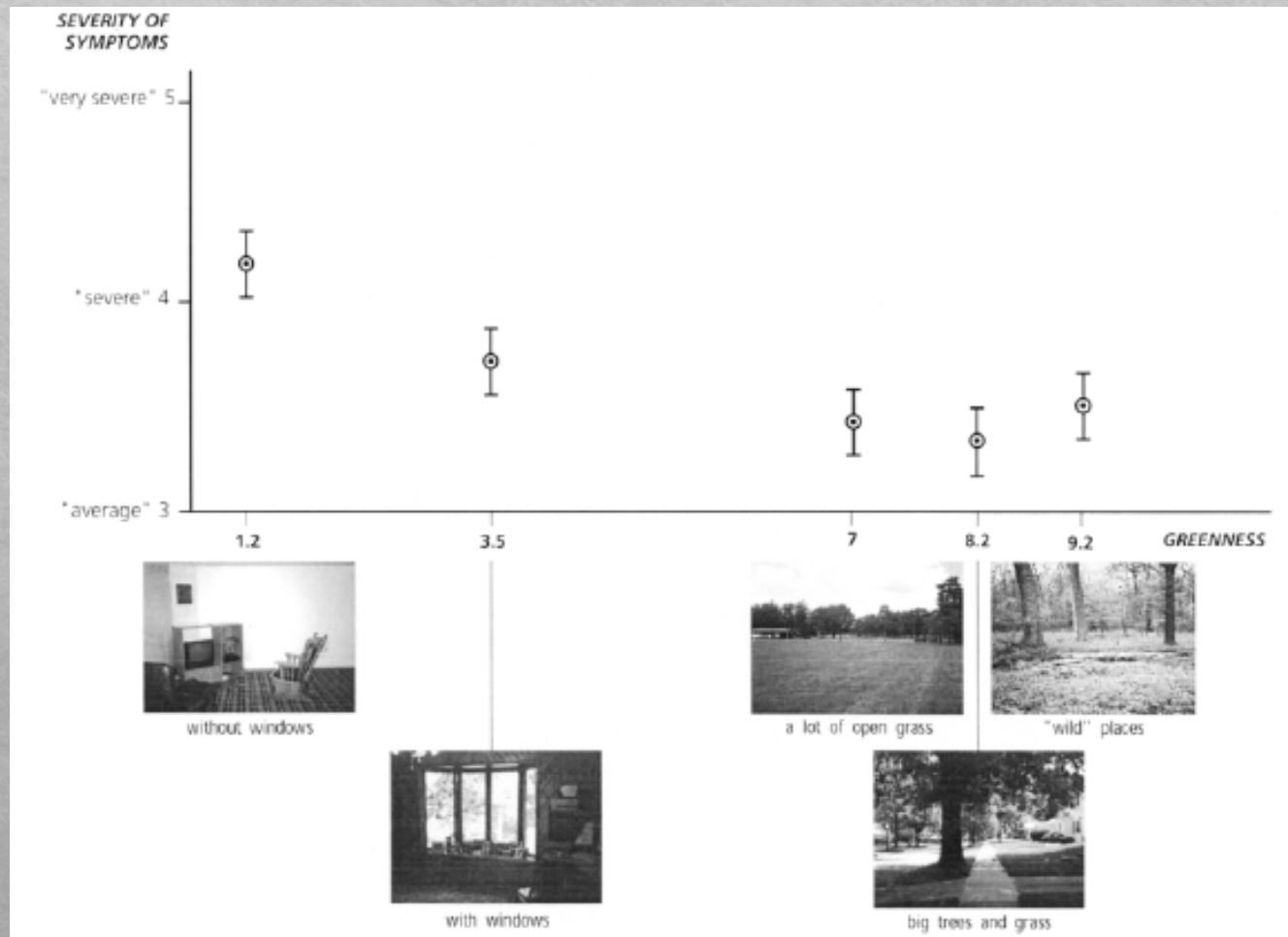
- ◆ Parents rated attentional functioning after activities in 3 types of settings



**Figure 1: Mean Postactivity Attentional Functioning Ratings for Indoor, Built Outdoor, and Green Outdoor Activities**



# Faber Taylor et al. 2001



**Figure 2: Mean Severity of Attention Deficit Symptoms for Five Play Settings**

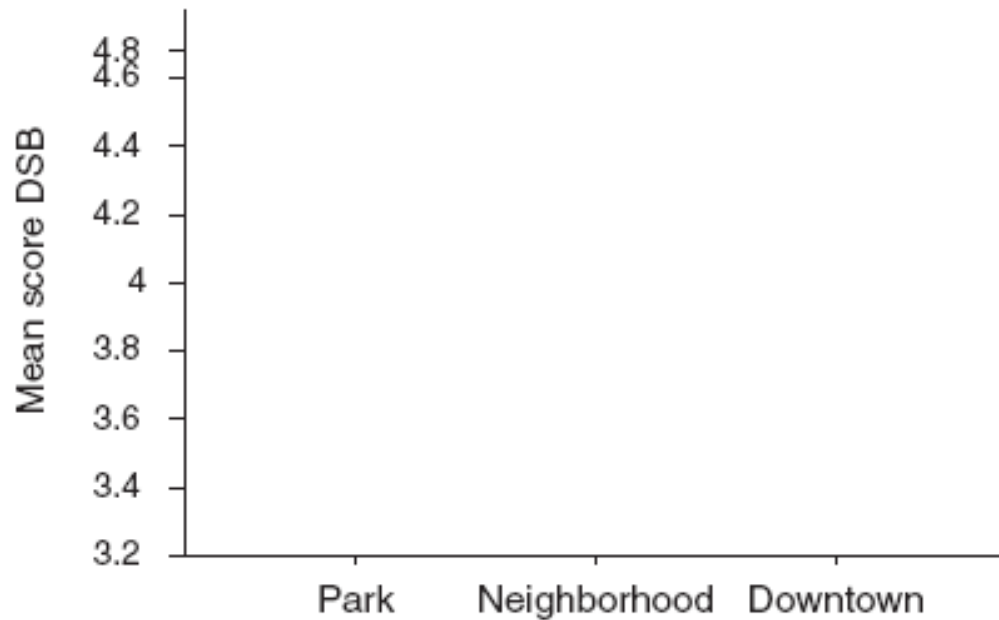
# Kuo & Faber Taylor (2004)

- ◆ 452 online surveys of parents
- ◆ Reported activities, settings, and social contexts
  - ◆ Rated attention symptoms
- ◆ The same activities reduced symptoms significantly more when they were conducted in green settings than when they were conducted in indoor settings or in built outdoor settings



# Nature Walk Study

**Mean Postwalk Scores on Digit Span Backwards for Park, Neighborhood, and Downtown Conditions**



Taylor & Kuo, 2009, Figure 1

# Adult research

- ◆ Non-ADHD adults improved on backwards digit span and executive portions of the attention network task following
  - ◆ a nature walk (Experiment 1)
  - ◆ viewing scenes of nature (Experiment 2)

Berman et al., 2008



# Adult research

- ◆ self-report more positive emotion and decreased stress (Gran & Stigsdotter, 2003; Mayer et al. 2009; Ulrich et al. 1991; Van den Berg et al. 2003)
- ◆ increased ability to reflect on a problem (Mayer et al. 2009)
- ◆ hypothalamic-pituitary-adrenal (HPA) axis function (Ward Thompson et al., 2012)
- ◆ parasympathetic nervous system response (Hartig, et al., 2003; Laumann et al., 2003; Parsons et al., 1998)
- ◆ mobile electroencephalogram (EEG): suggested lower frustration, engagement, and arousal, and higher meditation in green space (Aspinall et al., 2013)



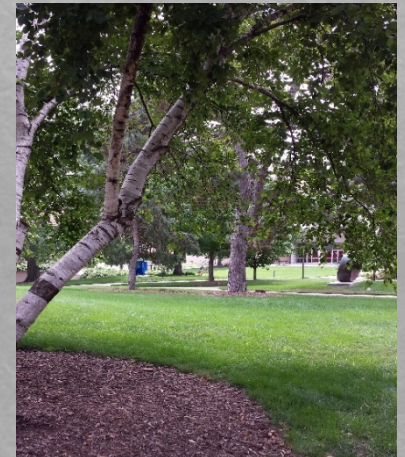
# Study 1: Schutte, Torquati, & Beattie (2015)

- ◇ Typically developing 4- to 8-year-olds
- ◇ Spatial working memory (SWM) task
  - ◇ More accurate following nature walk
- ◇ Continuous performance task (attention)
  - ◇ Shorter reaction time following nature walk

**Urban Walk**



**Nature Walk**





# Study 2: Torquati, Schutte, & Kiat

Compare Cognitive &  
Neuroelectrical activity  
Indoors vs. Outdoors





## *Central hypotheses:*

- ◆ Behavioral measures of executive functions (EFs) will demonstrate more optimal performance when exposed to a natural environment
- ◆ Neuroelectrical activity over regions of the brain associated with EFs (frontal and parietal regions) will indicate more optimal functioning when exposed to a natural environment
- ◆ P300

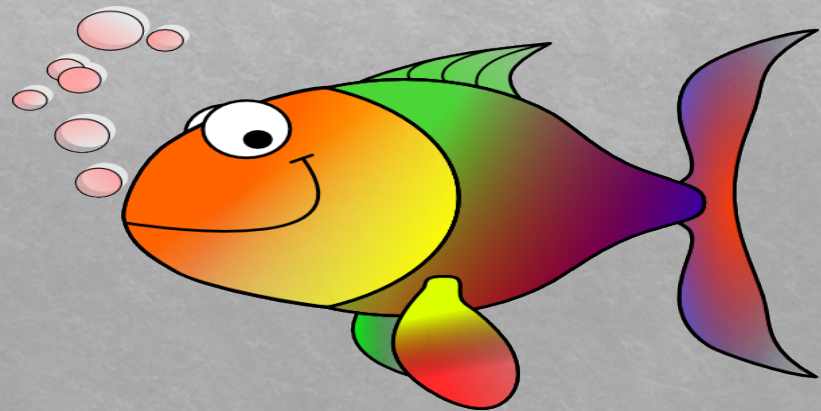
# Methods

- ◆ Sample:
  - ◆ 10 6- to 11-year-olds
  - ◆ 10 11- to 16-year-olds
- ◆ Two sessions:
  - ◆ Indoor lab
  - ◆ Outdoor classroom with many natural elements such as mature trees, shrubs, and grass
- ◆ Continuous EEG (Electrical Geodesics, Inc.)
  - ◆ School-age: high-density 128-channel electrode net
  - ◆ Adolescents: high-density 256-channel electrode net



# Measures

- ◊ Working memory: Digit span backwards & Spatial working memory task
- ◊ Inhibitory control: Go-no go
- ◊ Sustained attention: Continuous performance task

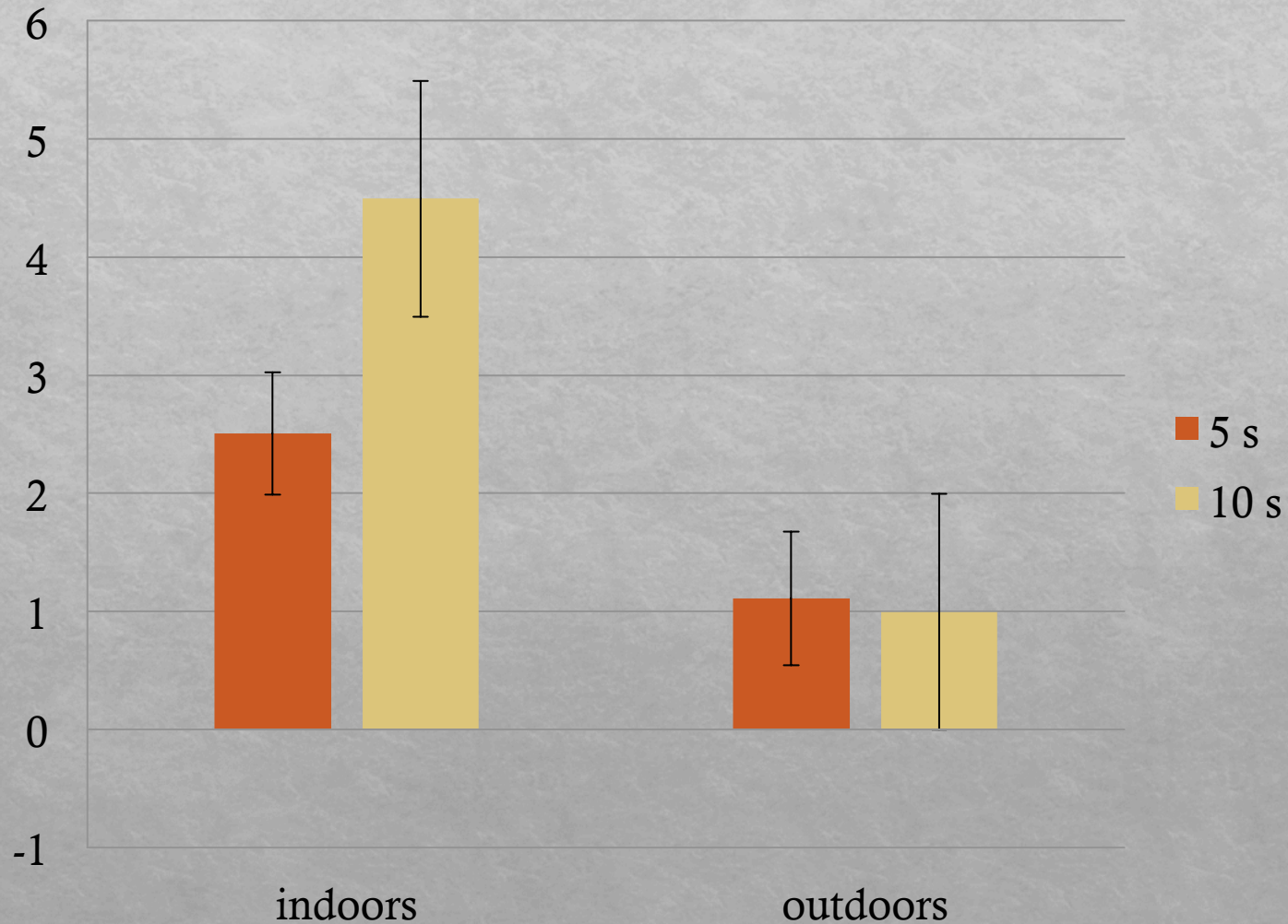


# Behavioral Results: School age

- ◆ Digit span backwards: No difference
- ◆ Spatial working memory:
  - ◆ more accurate outdoors
- ◆ Attention: No difference
- ◆ Inhibitory Control: No difference



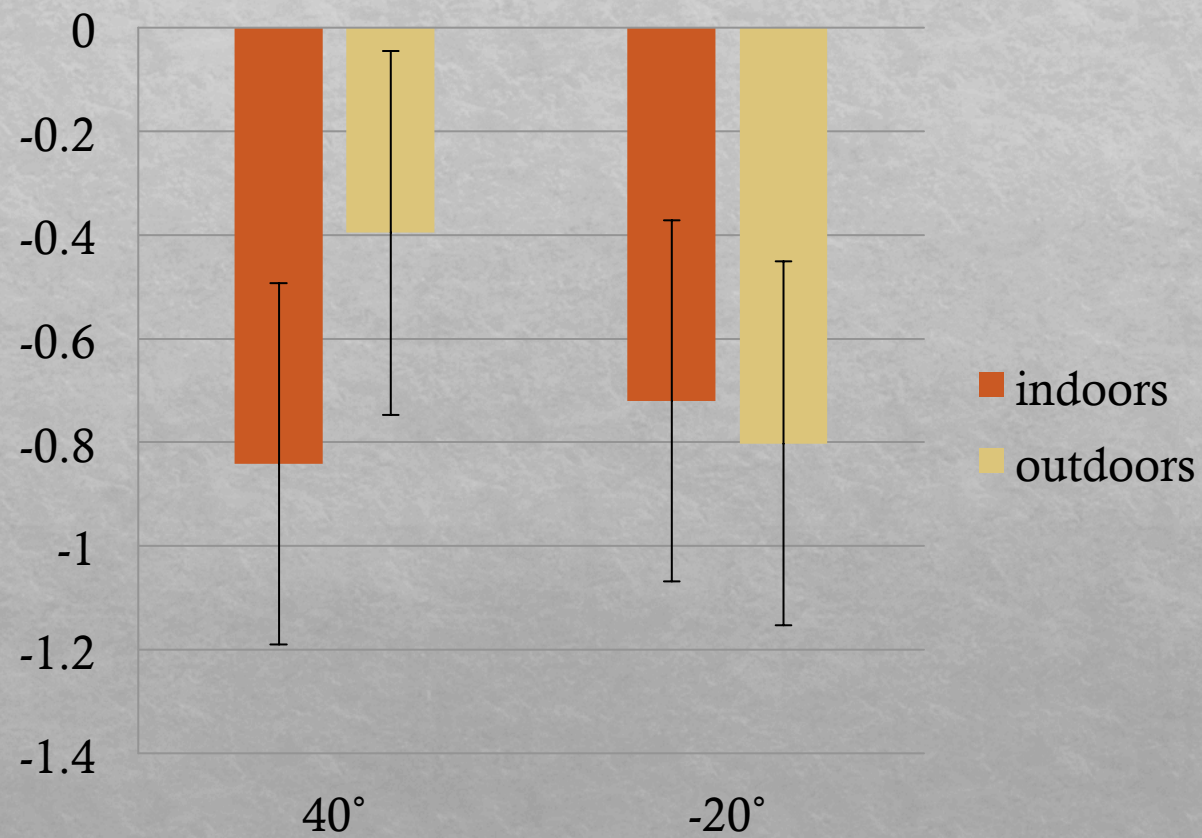
# Comparison of Constant Directional Error Indoors vs. Outdoors



# Comparison of Constant Distance Error Indoors vs. Outdoors







# ERP Results

- ◆ N1: Early perceptual response
- ◆ P3b: Later processing, comparing stimulus to memory (same/different? Action needed?)



# Go-No Go: School-age (128 net)

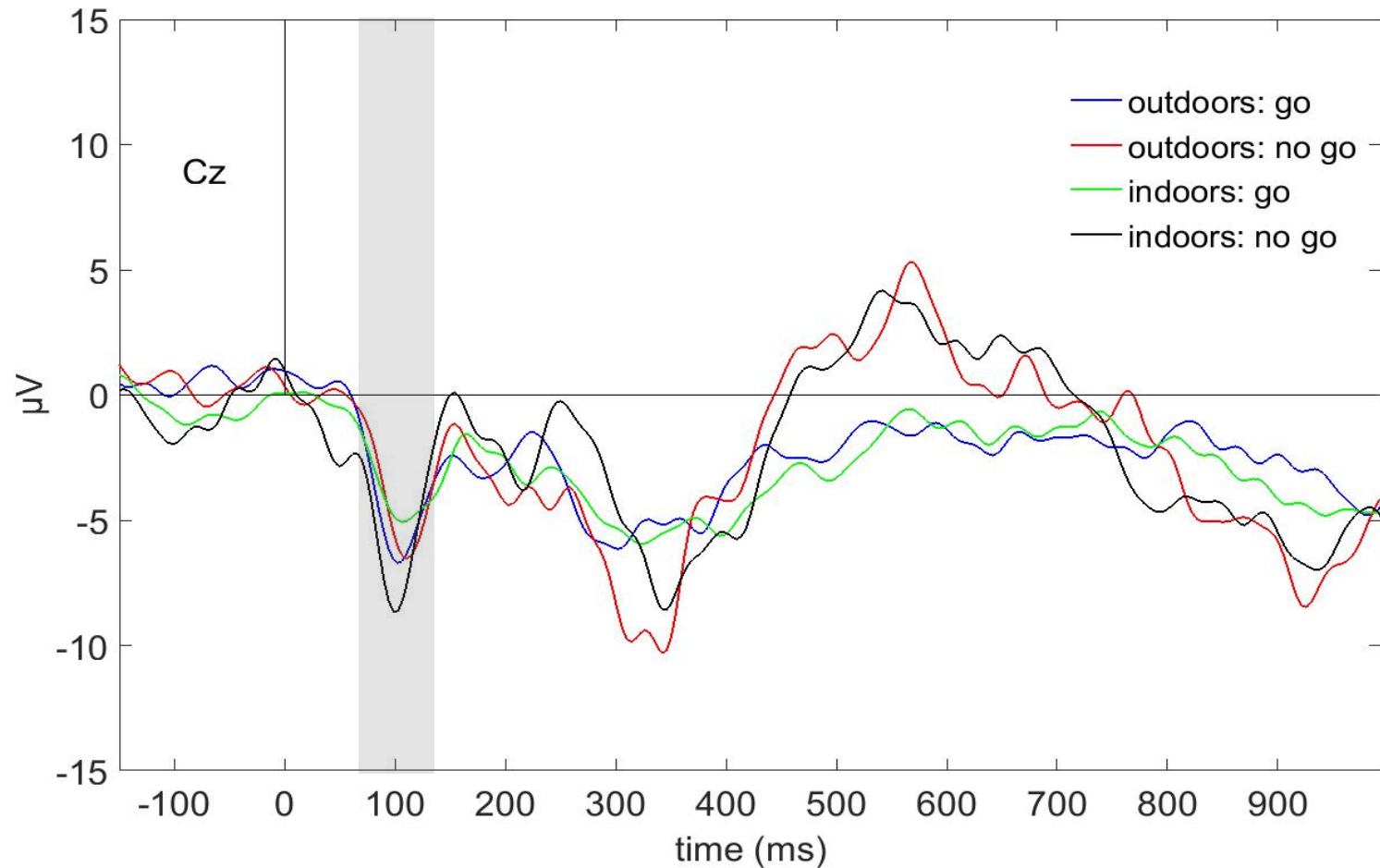


Figure 1 displays grand average ERP waveforms and topographic maps for the N100 and P300 components, comparing indoor and outdoor environments.

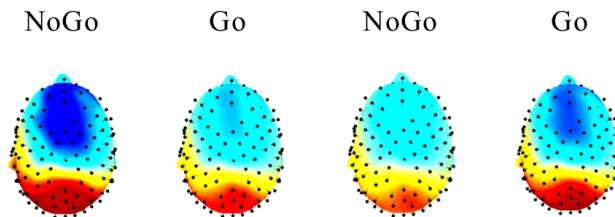
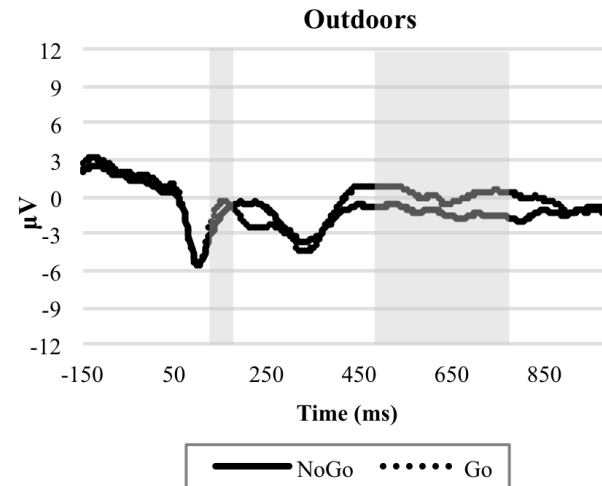
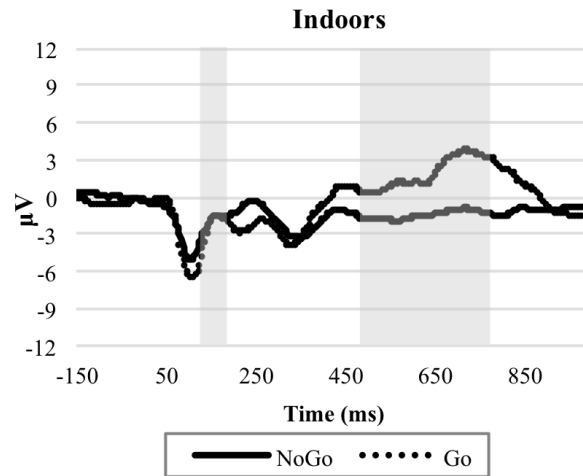
**Top Panel:** Grand average ERP waveforms (µV) for the N100 component (left) and P300 component (right). The x-axis represents Time (ms) from -150 to 850. The y-axis represents voltage in µV from -12 to 12. Two conditions are shown: NoGo (solid line) and Go (dotted line). Shaded gray areas indicate the time windows for the N100 (approx. 100-200 ms) and P300 (approx. 400-600 ms) components.

**Bottom Panel:** Topographic maps showing the spatial distribution of the N100 (left) and P300 (right) components. The maps are arranged in a 2x4 grid, with columns for NoGo and Go conditions, and rows for Indoor and Outdoor environments. The color scale ranges from -3 (blue) to 3 (red) µV.

**Legend:** Solid line = NoGo; Dotted line = Go.



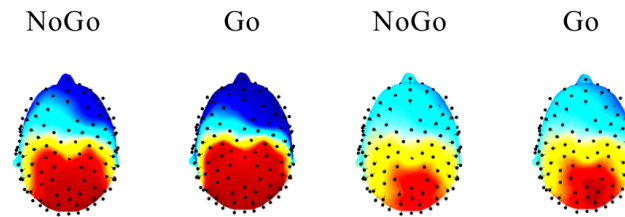
# Continuous Performance Task (CPT)



Indoors

Outdoors

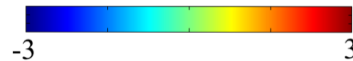
N100 (98 ms peak)



Indoors

Indoors

P300 (562 ms peak)



# Summary

- ◆ Better performance on spatial working memory outdoors
- ◆ No differences in performance on Go No-go or CPT indoors vs. outdoors BUT significant differences in neuroelectrical activity
- ◆ Imaging results suggested that completing the attention and inhibitory control tasks outdoors required fewer cognitive resources than indoors
- ◆ N1 - Go-no go and CPT for school-age children
  - ◆ Larger (more negative) N1 indoors on “No go” trials
- ◆ P3b
  - ◆ Larger (more positive) P3b indoors on “no go” trials



# Implications

- ◆ Implications for educational practices (e.g., recess, nature classrooms)
- ◆ Developmental implications
  - ◆ Short-term impact or long-term developmental effect?
  - ◆ Cumulative effects of depleted/fatigued attention



# Thank you!

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