Neurocognitive Effects of Computerized Training on Structured Sequence Processing

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Introduction

- Structured sequence processing (SSP) is a domain-general mechanism used to learn patterns of stimuli unfolding in time.
- SSP is important for the development of social, motor cognition (Cleermans et al., 1998) and grammatical language knowledge (Conway et al., 2010, 2011).
- Furthermore, recent research suggests that certain language and communication disorders may be caused, in part, by disturbances to core domain-general SSP abilities (Conway et al., 2010; 2011).
- Given its vital role in learning and language functions, it could be beneficial to develop an intervention aimed at improving SSP.
- However, it is unknown whether SSP can be improved using computerized training techniques, or if any gains would transfer to language abilities.

Objectives

- The long term goal is to use a novel cognitive training technique to improve SSP and language processing.
- The first step is to test the feasibility of such an intervention in healthy typically-developing adults.
- Event-related potentials (ERP), may allow researchers to understand the neural mechanisms that underlie training-related effects.
- ERP is a portion of ongoing electroencephalography (EEG), time-locked to the presentation of a stimulus or event of interest.

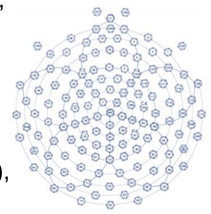


Figure 1. ERP- Electrical Geodesic System, 128 channel sensor net

Overview of Procedure

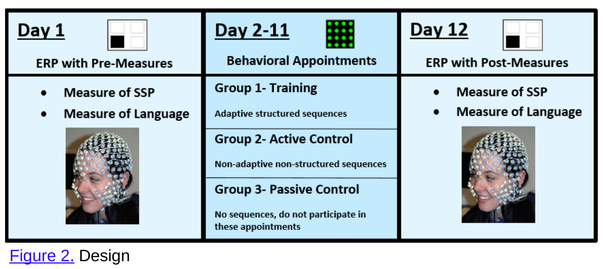


Figure 2. Design

Participants

- N=24 (Ages 18-22, 14F, 10M).
- 3 conditions: Training (n=8), Active Control (n=7), Passive Control (n=9).

Measure of SSP

- 5-item sequences of black squares appearing 1 at a time, in 1 of 4 possible quadrants on the screen (Fig 3).
- Task was designed to resemble artificial grammar learning (AGL) paradigms in which participants implicitly learn statistical regularities embedded in the sequences and then reproduce them to demonstrate knowledge and recognition of the patterns (Fig 4).
- The motivation behind this design was to create a non-linguistic task that would parallel the sort of complex syntactic processing found in natural language.

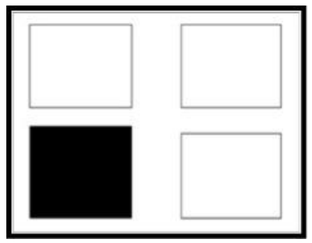


Figure 3. Measure of SSP

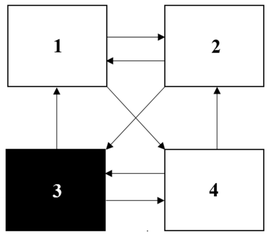


Figure 4. Rule structure of the measure of SSP

- 4 blocks: Practice Phase (2 seqs), Learning Phase-(8 grammatical seqs, 5x),Test Phase (8 grammatical-trained 2x, 8 gram-untrained 2x, 16 ungram 2x).
- **ERP time-locked to the presentation of a stimulus that made the sequence ungrammatical & was compared to a stimulus in a similar position in a sequence that was grammatical.**

Training Task

- 4x4 grid; Sequence of colored lights occurring one at a time (Fig 5).
- Task was to reproduce the sequence by pressing the circles in the correct order on a touch-screen monitor.

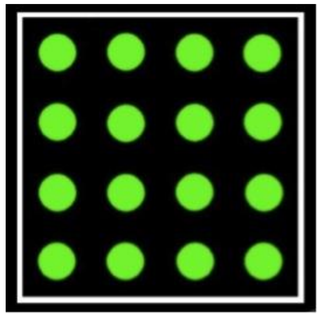


Figure 3. Behavioral Training

- (Unknown to participants) Sequences not determined randomly but conformed to certain underlying structural regularities.

SSP Components of Interest

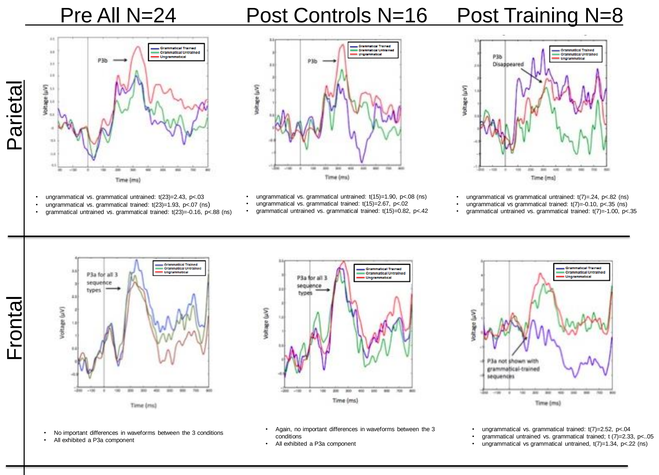
P3b (measured from parietal sensor)

- Reflects the evaluation of incoming information & the updating of contextual representations (Ferdinand et al., 2008).
- Associated with learning and working memory (WM) (Dolu et al., 2005).

P3a (measured from frontal sensors)

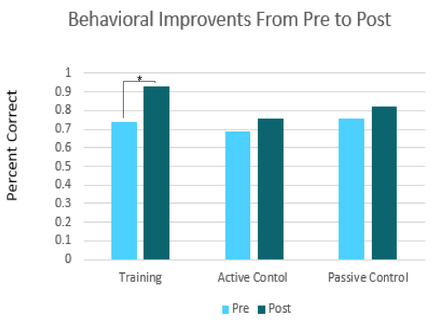
- Evoked from "novel" stimulus paradigms (Courchesne et al., 1975).
- Linked with a stimulus context that requires attentional focus (Comerchero & Polich, 1999).

Preliminary SSP Results



Preliminary Behavioral Results

- **Improvement to accuracy on SSP following training [t(1,10)=4.87, p=.001].**



Preliminary Results Summary

- Pre-measures show a P3b for ungrammatical sequences and all 3 groups show a P3a for all sequence types.
- At post-measure, the control groups show no change to these components.
- In contrast, at post-measure, the P3b disappears for ungrammatical sequences **only for the training group** and the P3a emerges for new sequences relative to old sequences.
- Topomaps show a very different distribution of electrical activity during the sequence learning task between the control groups and the training group, especially in frontal regions of the scalp.
- Behavioral results indicate an improvement to accuracy for the training group only.

Conclusions

- Disappearance of the P3b ➔possibly indicative learning and/or enhancement of WM.
- Appearance of the P3a for novel sequences of any type ➔possible shift in attention necessary to process these new sequences more completely.
- The ERP and topomap data together suggest that the SSP training regimen induced a functional reorganization, leading participants to rely heavily on frontal regions of the brain that are known to be important for executive functions, controlled attention, sequencing, and language processing.
- Overall, the ERP and behavioral preliminary findings demonstrate the feasibility of improving SSP.
- There may be broader implications for improving language processing in typical and atypical developing individuals (are currently analyzing the language data).
- The next step includes collecting baseline measures of SSP and language processing in individuals with autism spectrum disorder, followed by a training pilot study with this group.

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