

# Developing Sensitive Measures of Statistical Learning for School-age Children

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## Background

In children (Saffran et al., 1996; Evans et al., 2009; Kidd & Arciuli, 2015; Arciuli & Simpson, 2011)

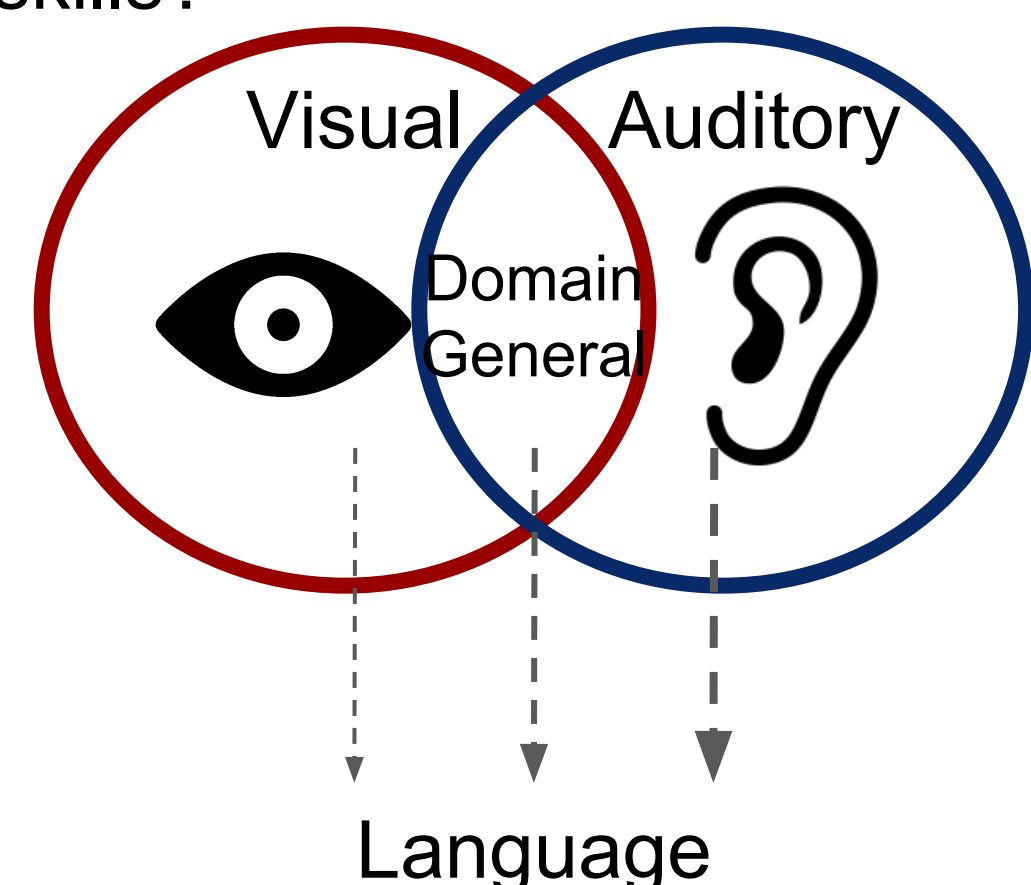
- Statistical learning (SL) is fundamental for first language acquisition.
- Variabilities in SL in both auditory and visual domains have been associated with children's vocabulary, grammar and reading abilities.

In adults (Siegelman & Frost, 2015; Frost, et al., 2015)

- SL ability in a given domain is a stable trait.
- But, an individual varies in SL abilities across domains.

## Current Study

- How do visual and auditory SL abilities each contribute to individual's language skills?
- Are SL abilities independent across domains in children?
  - If so, how are SL abilities from different domains associated with children's language skills?

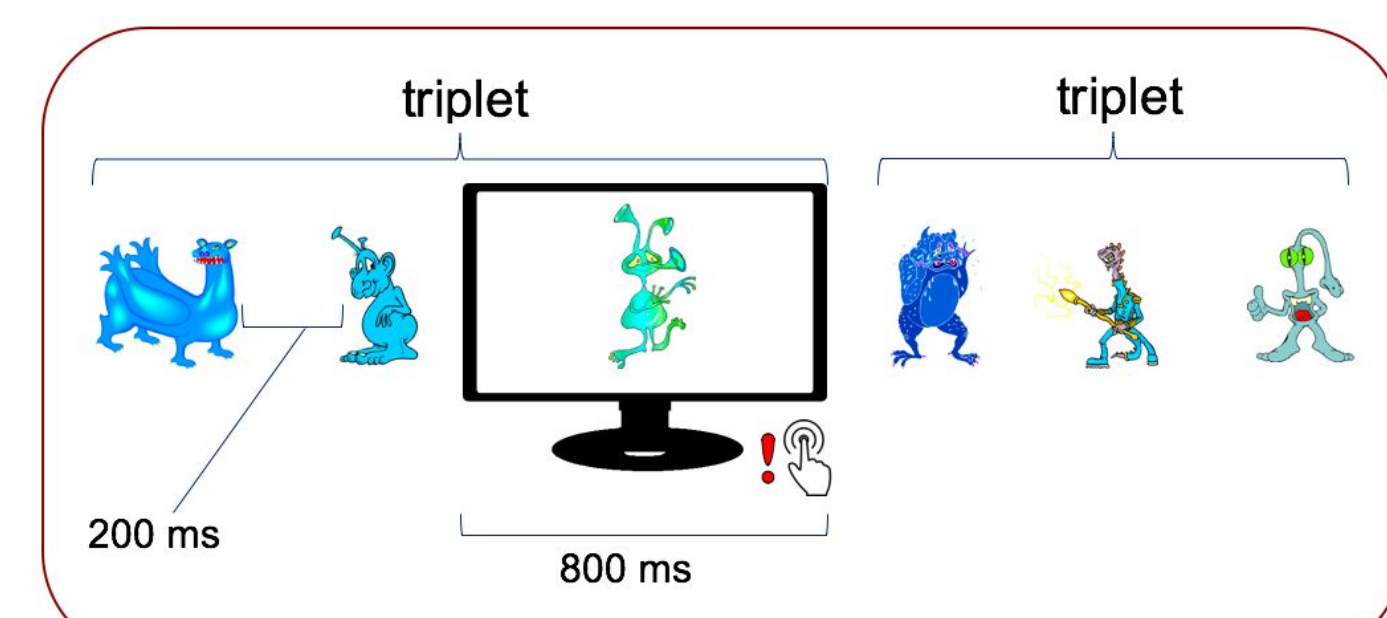


## Stimuli

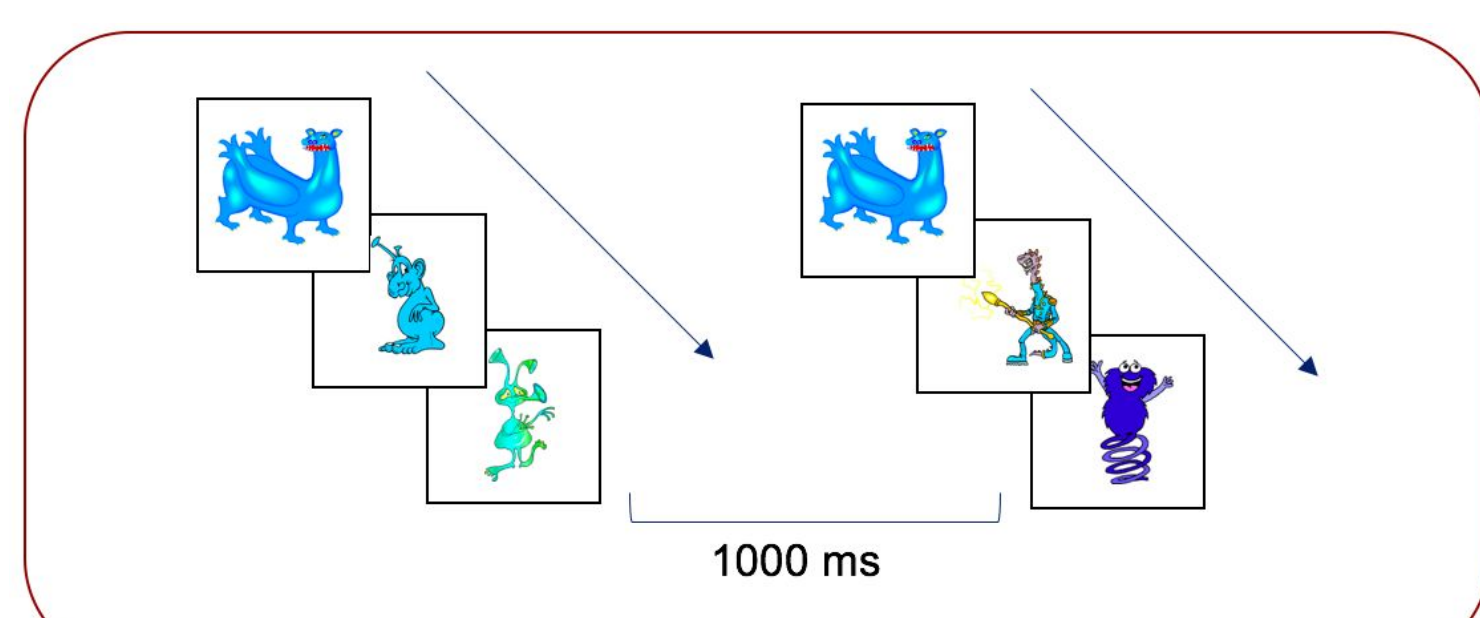
Visual and tone sequences were designed by concatenating four triplets of images or tones. Foils for the test phase preserved the relative positions of each element in the triplet, but combined them differently (i.e. if ABC, DEF, and GHI were triplets in the familiarization sequence, a valid foil would be AEI.)

### Visual Statistical Learning (VSL)

Familiarization (Target detection task) Two-forced choice test



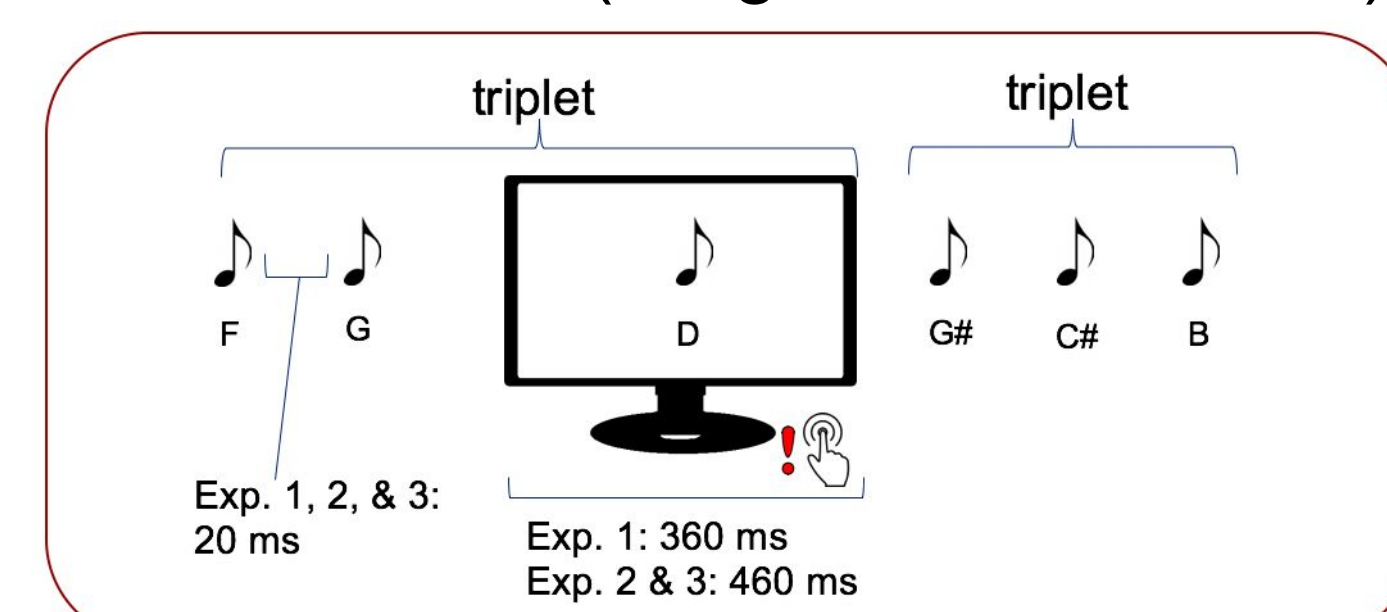
4 triplets, each presented 24 times: 4'48"



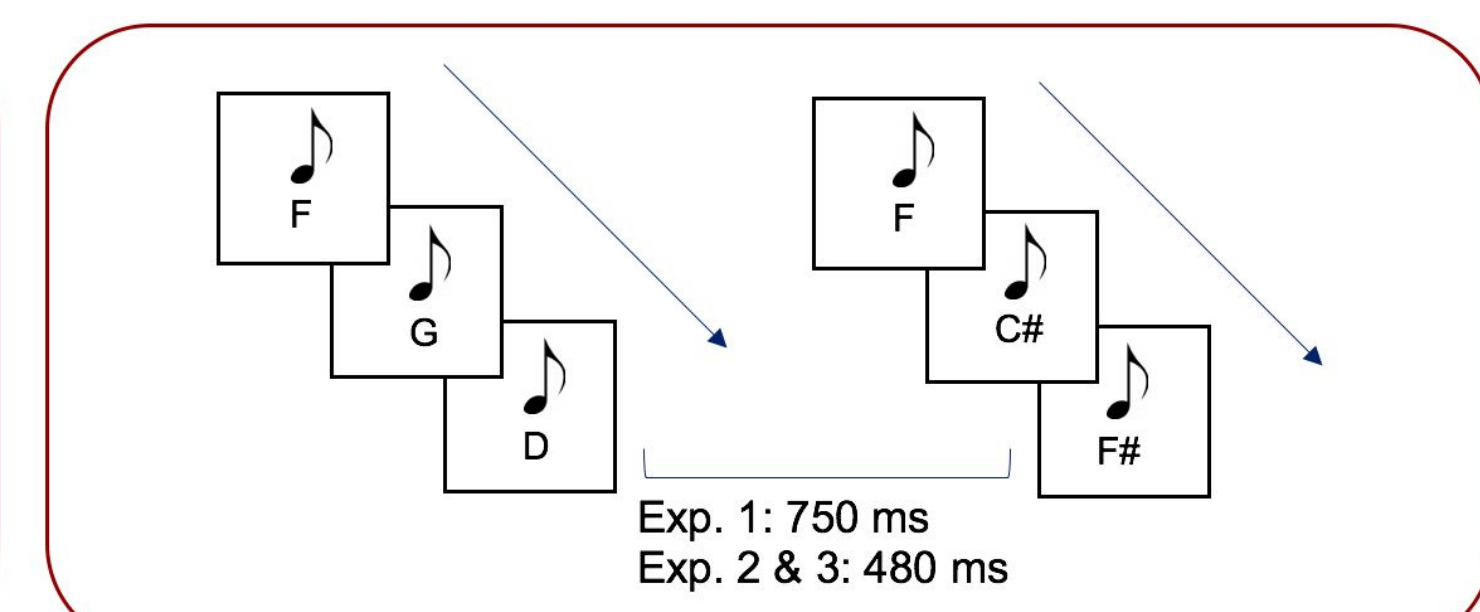
Exp. 1: 64 test items, Exp. 2 & 3: 32 test items

### Auditory Statistical Learning (ASL)

Familiarization (Target detection task) Two-forced choice test



4 triplets, each presented 48 times  
Exp. 1: 3'39", Exp. 2 & 3: 4'36"

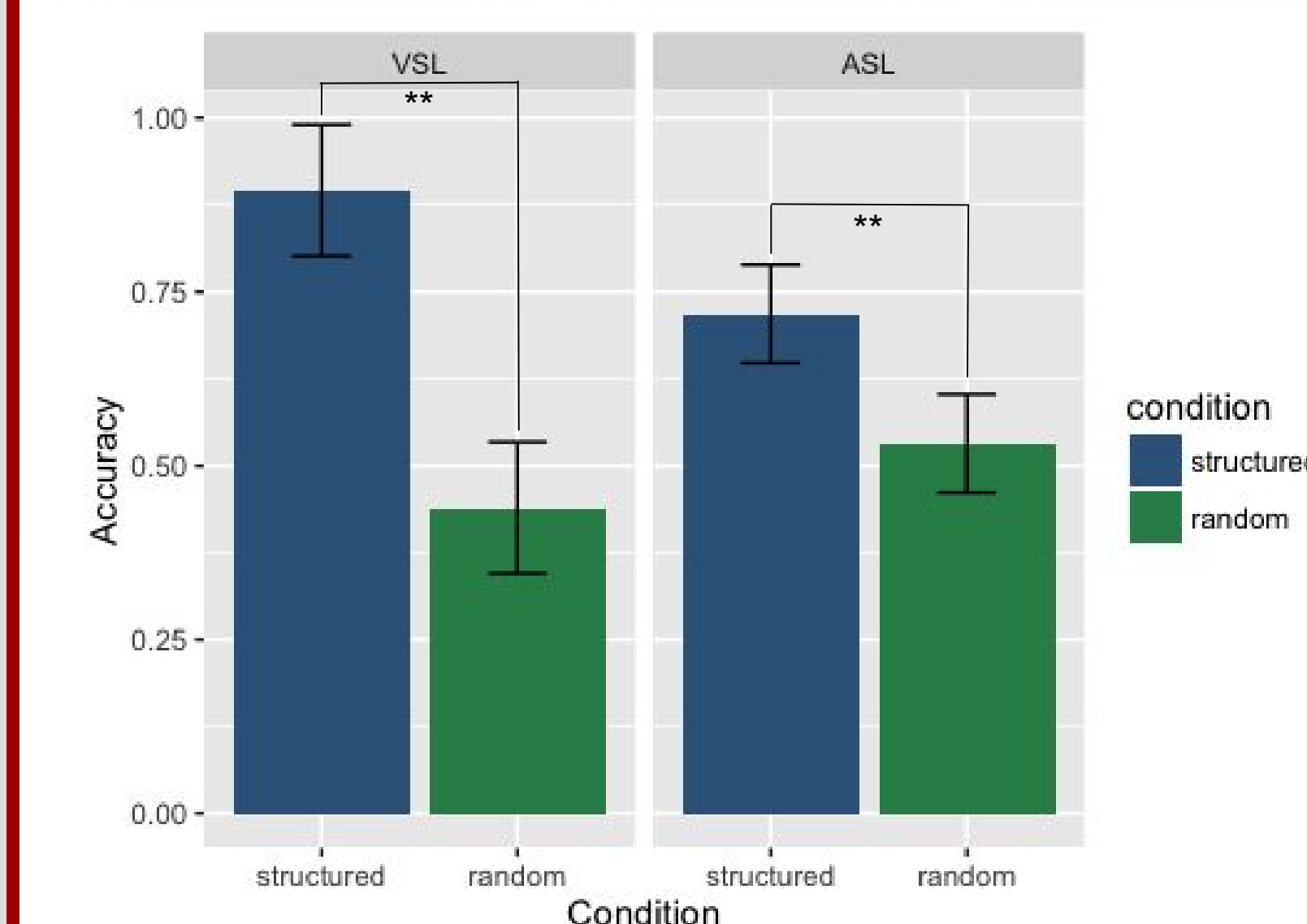


Exp. 1, 2, & 3: 32 test items

## Expt. 1: Validating the task design

Participants: 15 right-handed adult native English speakers

Visual			Auditory		
n	mean age	M : F	n	mean age	M : F
8	25.7	4 : 4	7	21.3	3 : 4



Decreased RT across trials:

- VSL:  $t = -3.064$ ,  $p = 0.0026$
- ASL:  $t = 1.05$ , n.s.

Accuracy:

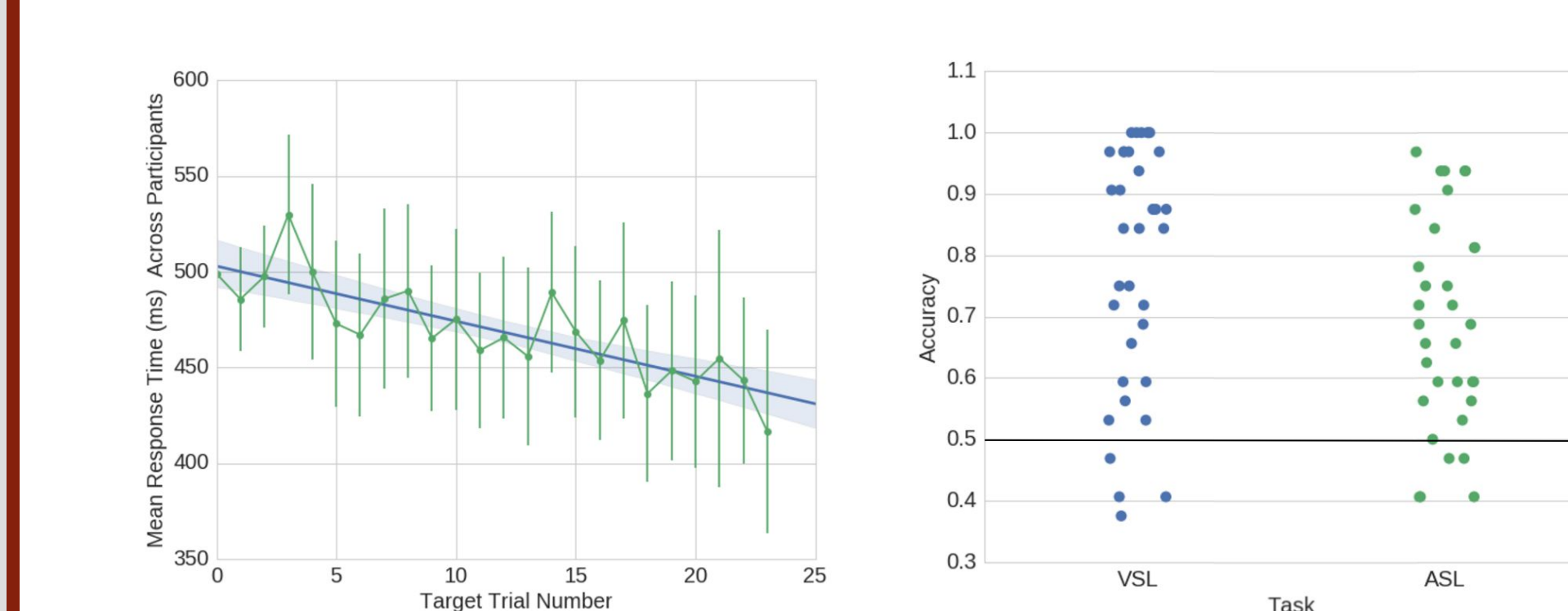
- VSL: structured (0.89) > random (0.44) ( $p = 0.0013$ )
- ASL: structured (0.72) > random (0.53) ( $p = 0.0039$ )

\*\* =  $p < 0.01$

## Expt. 2: SL and language skills in adults

- Participants: 33 right-handed adult native English speakers, mean age: 24.2 years old, 10 males and 23 females.
- Standardized Assessments: IQ: KBIT-II; Sentence comprehension: WJ-III NU ACH Reading Fluency; Passage comprehension: WRMT<sup>TM</sup>-III.

### SL Task Performance



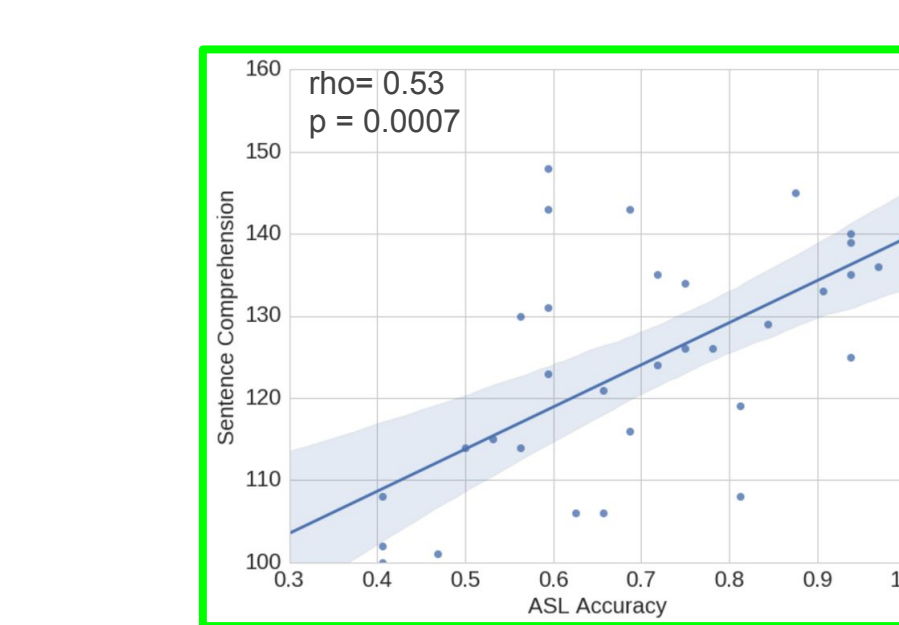
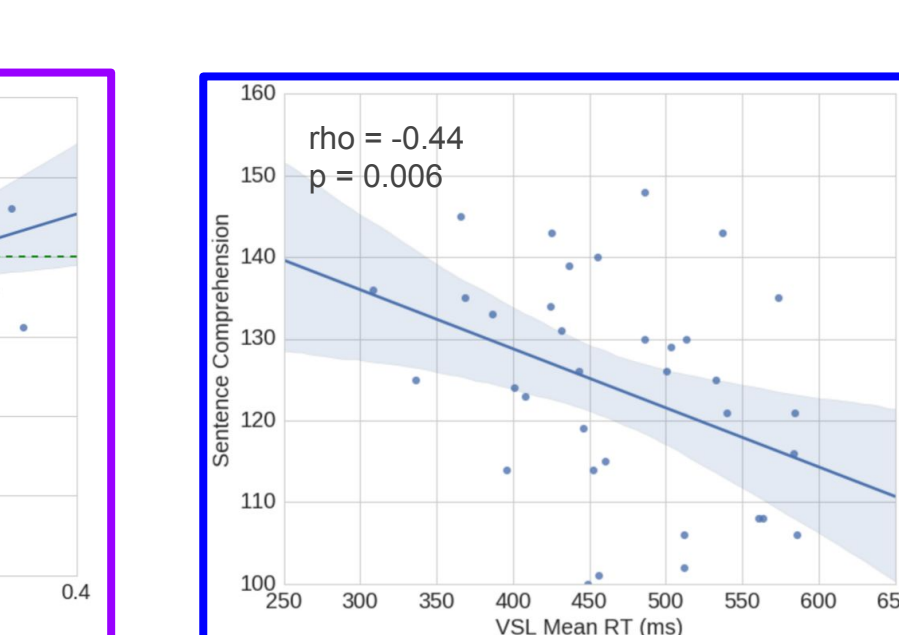
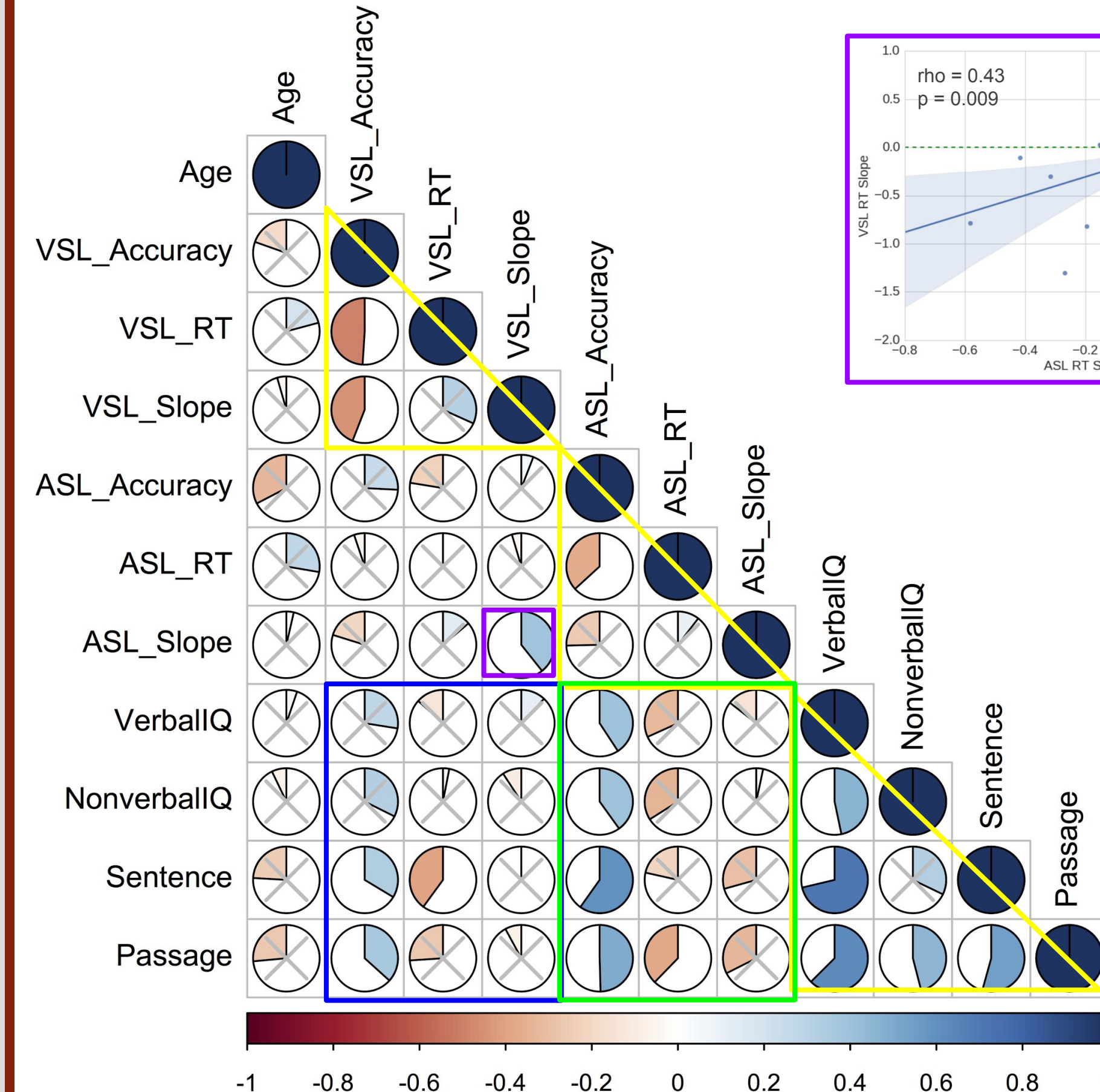
Decreased RT across trials:

- VSL:  $z = -3.325$ ,  $p = 0.001$
- ASL: n.s.
- VSL Slope vs. ASL Slope: not different ( $p = 0.13$ )

Accuracy:

- VSL: 0.79 ( $> 0.5$ ,  $p < 0.001$ )
- ASL: 0.69 ( $> 0.5$ ,  $p < 0.001$ )
- VSL > ASL ( $p = 0.017$ )

### Individual Differences



Controlling for IQ:

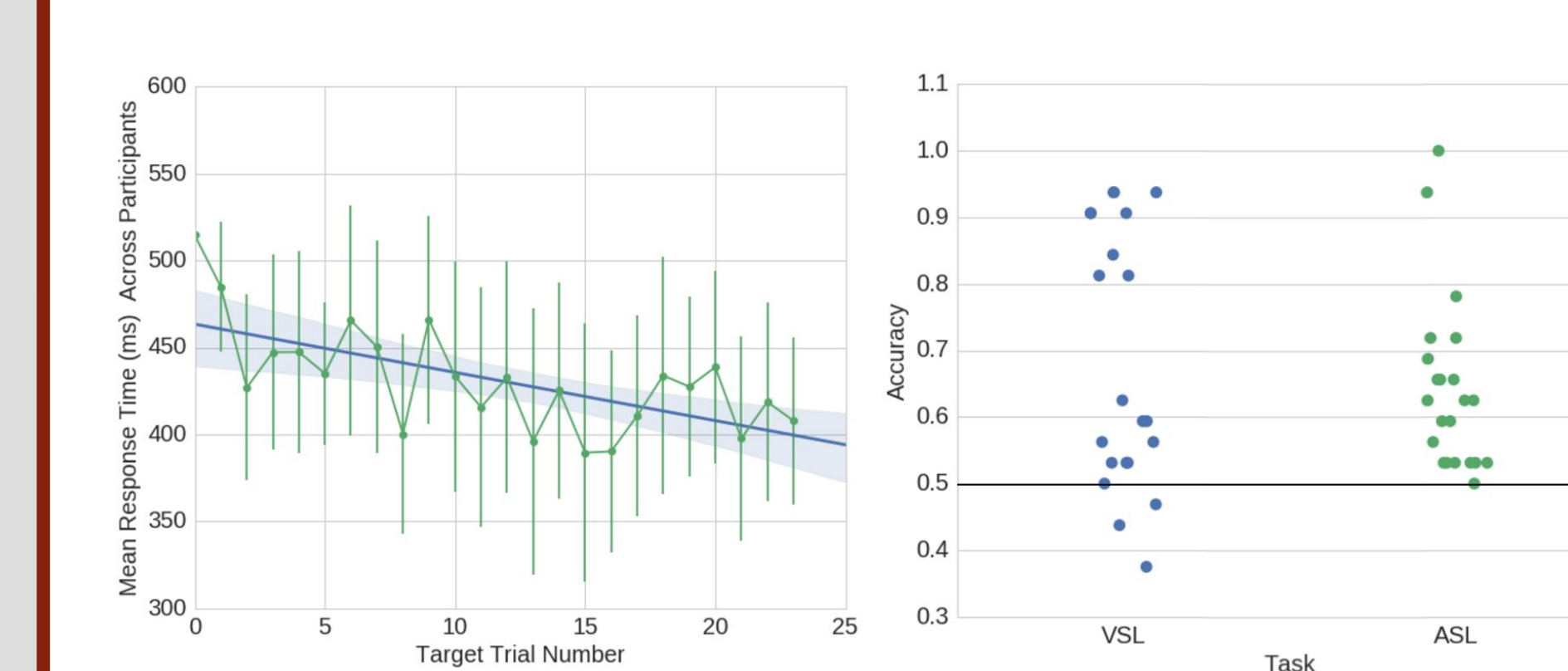
- VSL and ASL RT slopes are correlated.
- VSL RT and ASL Accuracy are both correlated with sentence comprehension.

## Expt. 3: SL and language skills in children

- Participants: 23 right-handed native English-speaking children (8-16 years old). Mean age = 11.3 years. 11 males and 12 females.
- Standardized Assessments: IQ: KBIT-II nonverbal; Syntax: TROG-2; Reading: TOWRE; Sentence Comprehension: WJ-III NU ACH Reading Fluency

\* The time intervals between SL and language tests range from 0.76 to 4.12 years, which are partialled out in all correlation analyses below.

### SL Task Performance



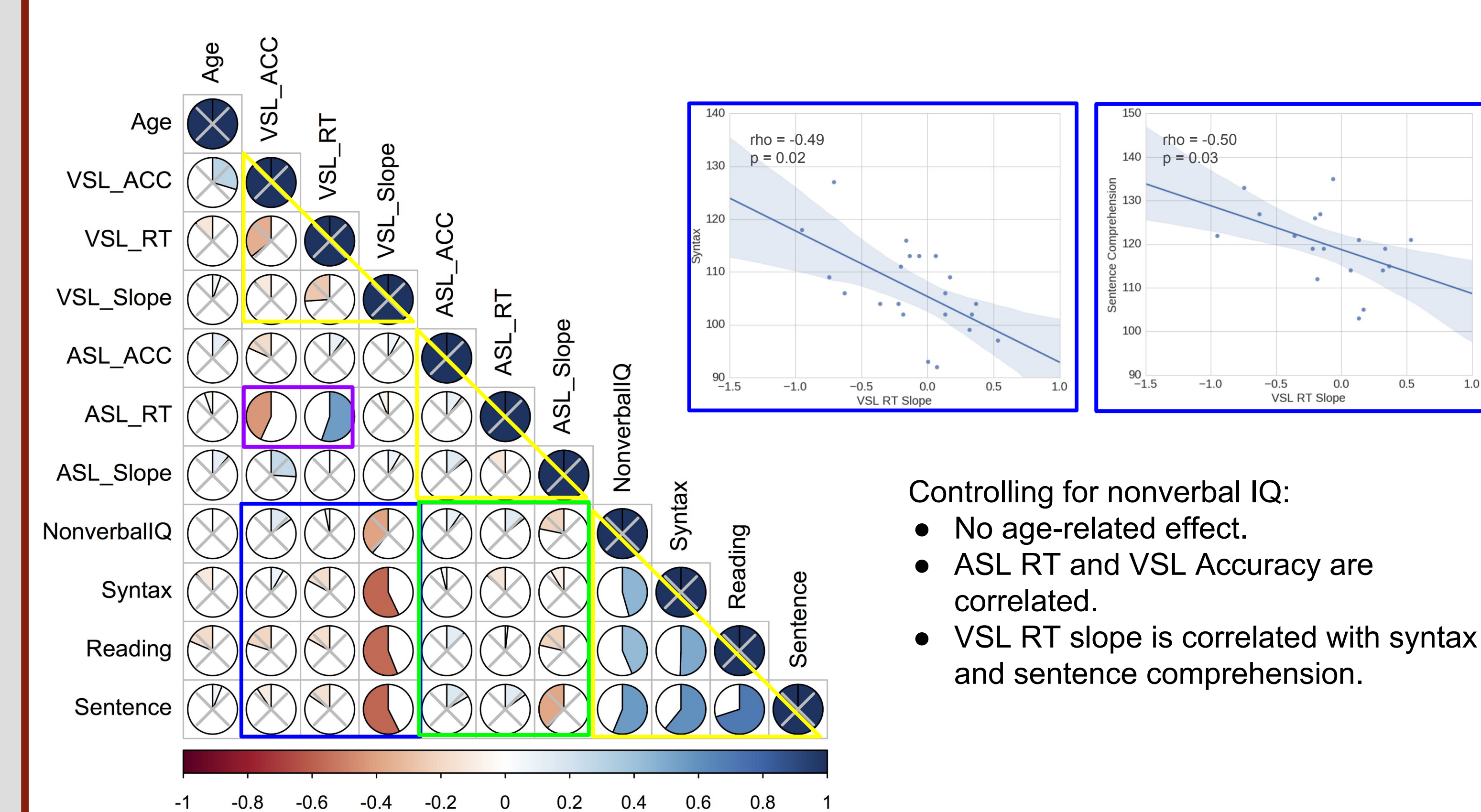
Decreased RT across trials:

- VSL:  $z = -2.51$ ,  $p = 0.012$
- ASL: n.s.
- VSL Slope vs. ASL Slope: not different ( $p = 0.15$ )

Accuracy:

- VSL: 0.68 ( $> 0.5$ ,  $p < 0.001$ )
- ASL: 0.64 ( $> 0.5$ ,  $p < 0.001$ )
- VSL vs. ASL: no difference ( $p = 0.64$ )

### Individual Differences



Controlling for nonverbal IQ:

- No age-related effect.
- ASL RT and VSL Accuracy are correlated.
- VSL RT slope is correlated with syntax and sentence comprehension.

## Conclusion

- Across tasks and age groups, statistical learning performance is significantly above chance.
- Response time during learning is a sensitive measure for statistical learning abilities.
- Test accuracy in auditory and visual SL is not correlated. However, there is response time evidence for shared mechanisms during online learning.
- ASL and VSL performance is related to individual language skills, independent of general intelligence.
- Further neuroimaging studies may reveal important differences between tasks and age groups.

### Reference:

1. Arciuli & Simpson, Dev Sci., 2011.
2. Evans et al., J Speech Lang Hear Res., 2009.
3. Frost et al., Trends Cogn Sci., 2015.
4. Kidd & Arciuli, Child Dev., 2015.
5. Saffran et al., Science, 1996.
6. Siegelman & Frost, J Mem Lang., 2015.