Geometric shape representations in human adults have syntactic structure

Barbu Revencu and Stanislas Dehaene

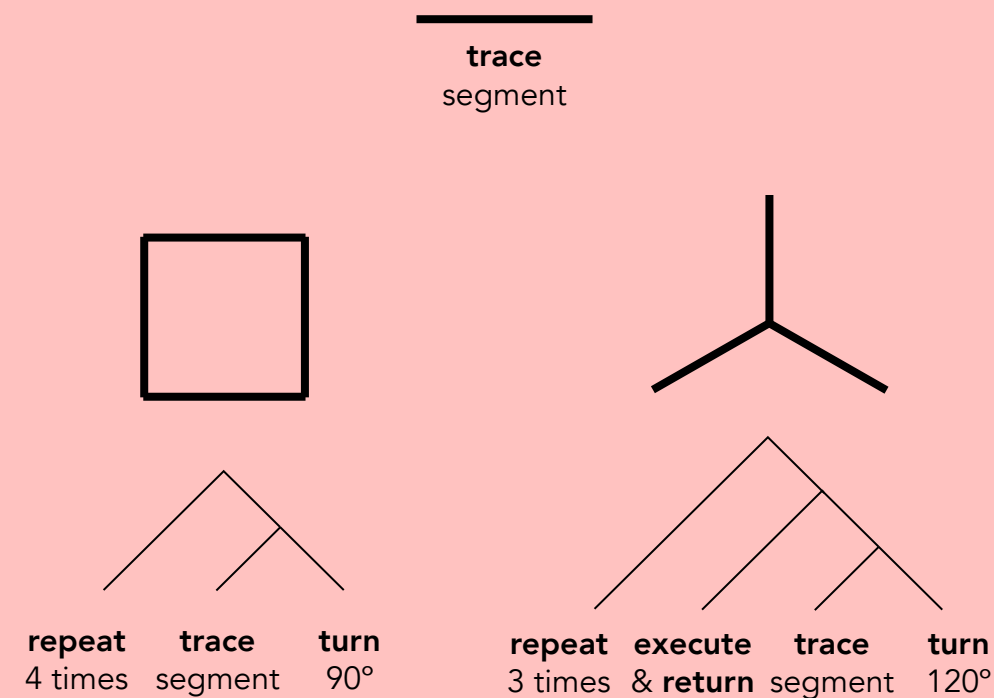NeuroSpin Cognitive Neuroimaging Unit | CEA | INSERM | Université Paris-Saclay

Background

We build on the recent proposal that **geometric shapes are represented in a language of thought (LOT)** consisting of a handful of primitives that combine to recreate the encoded shape (Sablé-Meyer et al. 2022)

trace
segment

repeat
4 times

trace
segment

turn
90°

repeat
3 times

execute
& **return**

trace
segment

turn
120°

Sablé-Meyer et al. (2022) found that adults' reaction times and error rates in match-to-sample tasks were **predicted by the minimum description length (MDL)** of the shape's LOT program

This **fuses two features of geometric shape representations** that are partly independent, format (LOT) and selection (MDL), and uses MDL data to argue for LOT—Highly indirect evidence

We report more **direct evidence for tree structure in geometric shape representations** from three online experiments with adults
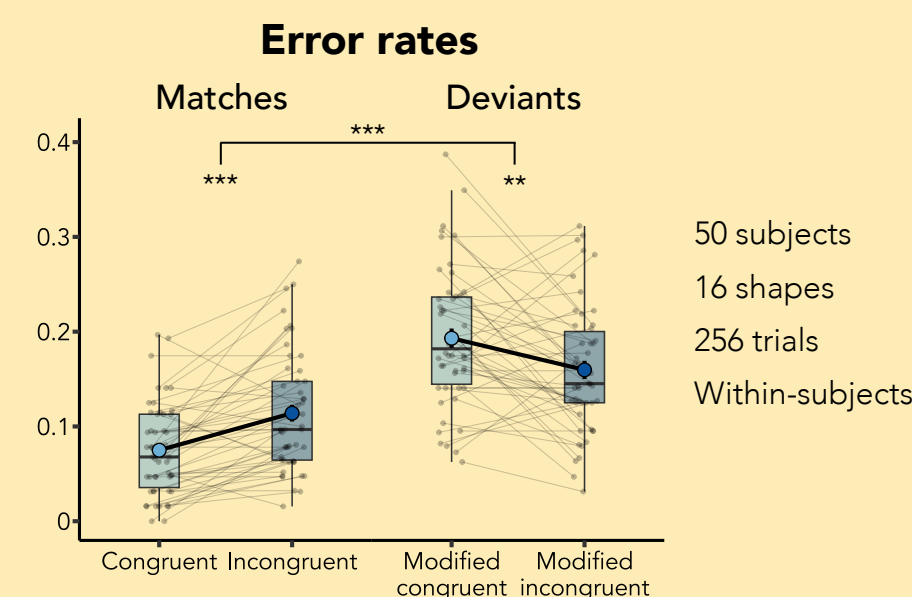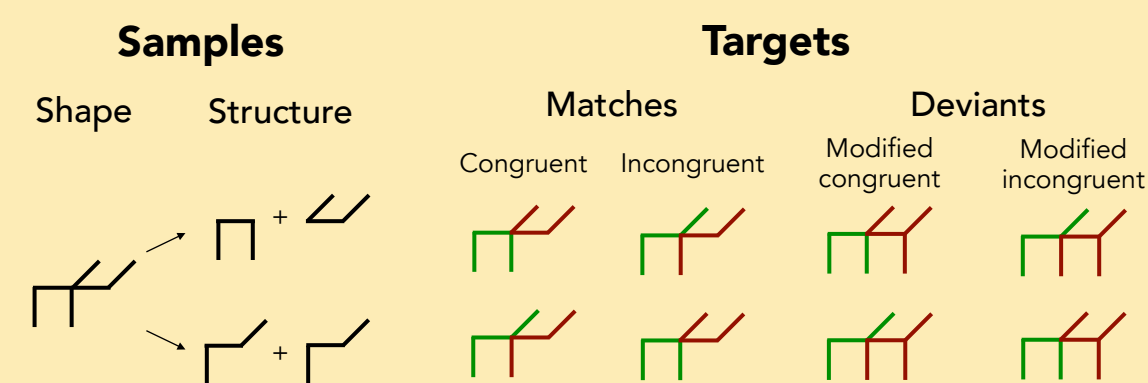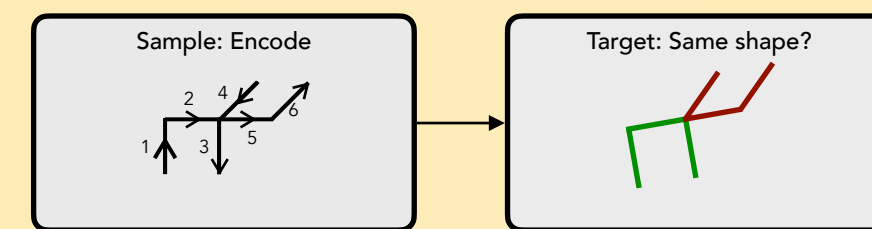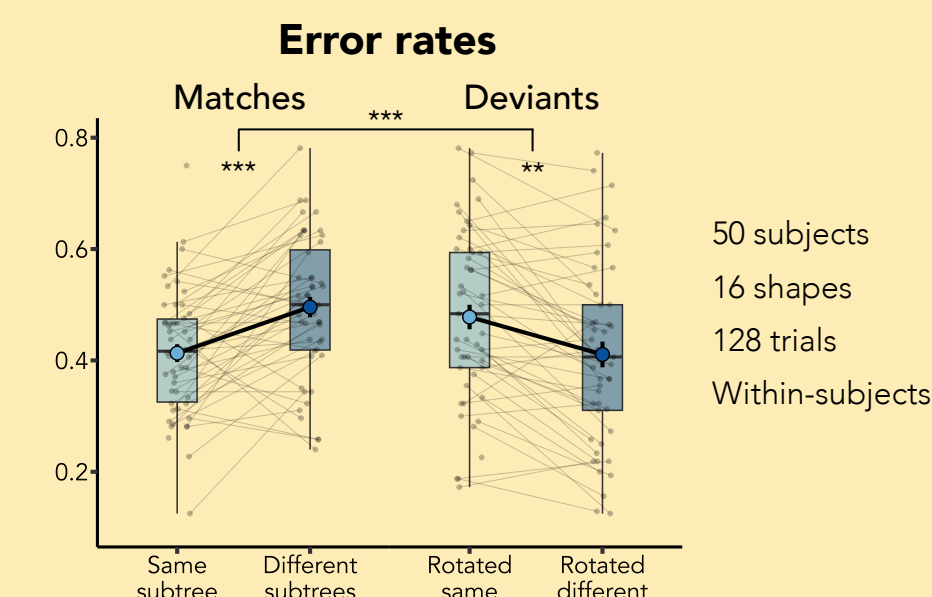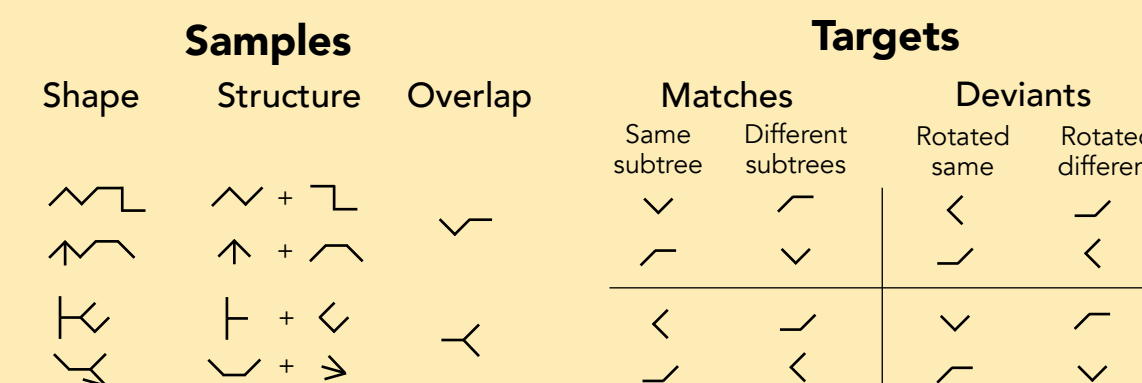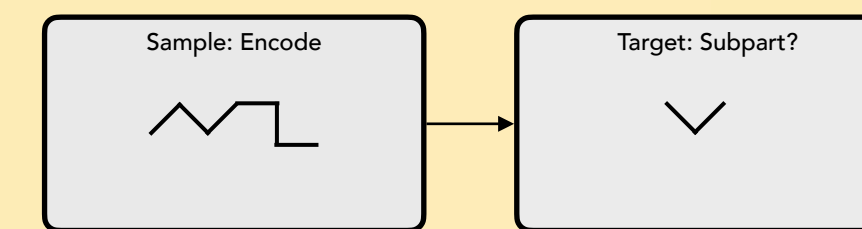
PREREGISTERED

Experiment 1: Structural Ambiguity

Different structured representations can be induced for the same shape

Sample: Encode → Target: Same shape?

Samples
Shape Structure

Targets
Matches
Congruent Incongruent

Deviants
Modified congruent Modified incongruent

Error rates

Matches   Deviants

***   ***   **

Congruent Incongruent Modified congruent Modified incongruent

50 subjects
16 shapes
256 trials
Within-subjects

Experiment 2: Subtree Facilitation

Subparts are easier to recognize when they belong to the same subtree

Sample: Encode → Target: Subpart?

Samples
Shape Structure Overlap

Targets
Matches
Same subtree Different subtrees

Deviants
Rotated same Rotated different

Error rates

Matches   Deviants

***   ***   ***   **

Same subtree Different subtrees Rotated same Rotated different

50 subjects
16 shapes
128 trials
Within-subjects

Experiment 3: Movement Depth

Shapes are easier to reconfigure when they are split higher up in the tree

Sample: Encode → Target: Rearrangement?

Samples
Shape Structure

Height 3
Height 2
Height 1
Height 0

Targets
Matches
Tree preserved Tree broken

Deviants
Tree preserved Tree broken

Reaction times

Matches   Deviants

*

***   ***

550
500
450
400

0 1 2 3 0 1 2 3
Log₂ Chunk Size | Height

Tree structure
○ Tree preserved
● Tree broken

36 subjects
8 shapes
256 trials
Within-subjects