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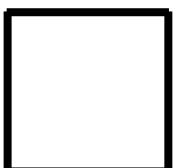
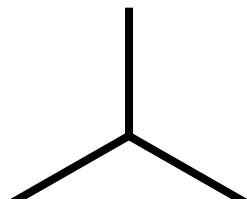
# Geometric shape representations in human adults have syntactic structure

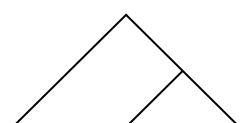
# Barbu Revencu and Stanislas Dehaene

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

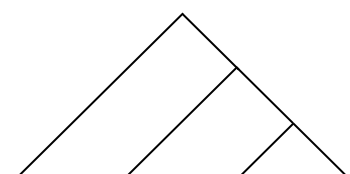
**trace**
segment







**repeat** 4 times **trace** segment **turn** 90°



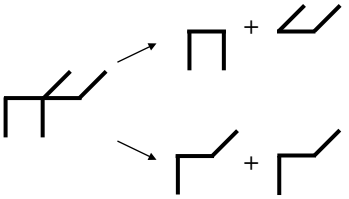
**repeat** 3 times **execute** & **return** **trace** segment **turn** 120°


PREREGISTERED

Different structured representations can be induced for the same shape

## Samples

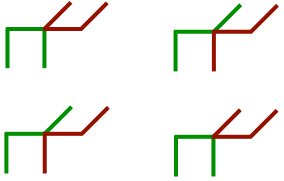
Shape Structure



## Targets

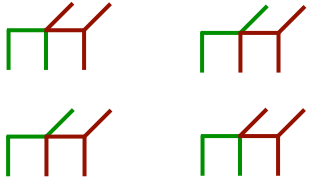
### Matches

Congruent Incongruent



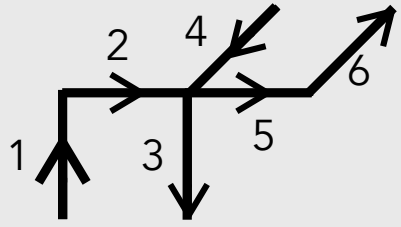
### Deviants

Modified congruent Modified incongruent

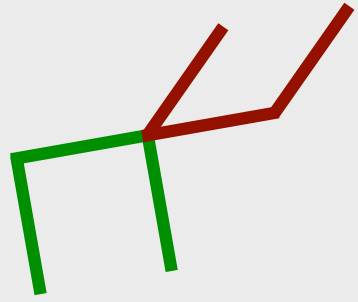


# Experiment 1: Structural Ambiguity

Sample: Encode




Target: Same shape?



# Background

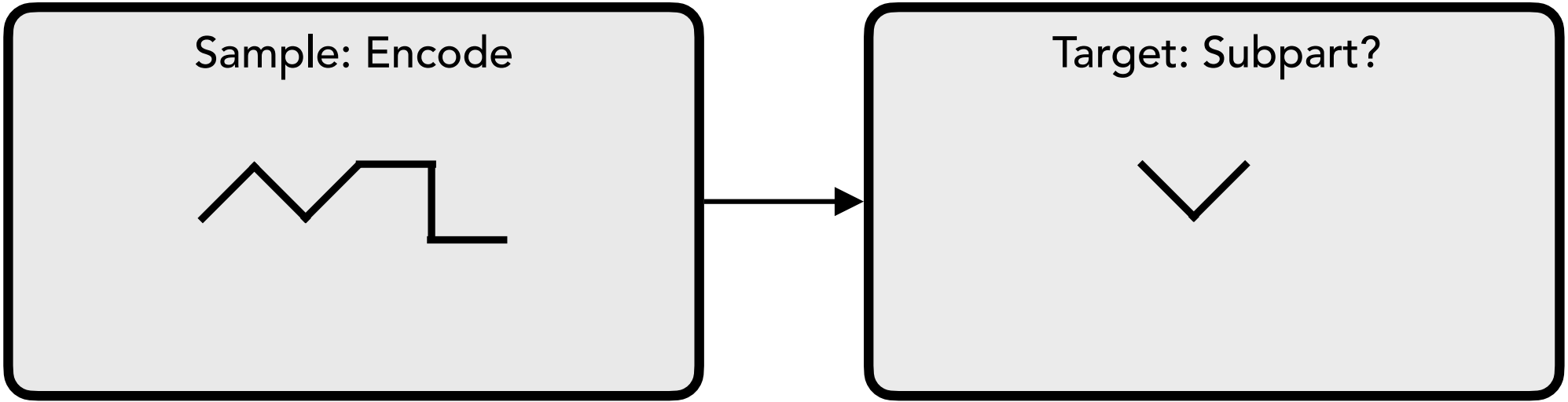
We build on the recent proposal that **geometric shapes are represented in a language of thought** (LOT) consisting of a handful of primitives that combine to recreate the encoded shape (Sablé-Meyer et al. 2022)

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

# Experiment 2: Subtree Facilitation

# Experiment 3: Movement Depth

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


Sample: Encode
Target: Subpart?

## Samples

Shape

Structure

Overlap

## Targets

### Matches

Same subtree



Different subtrees

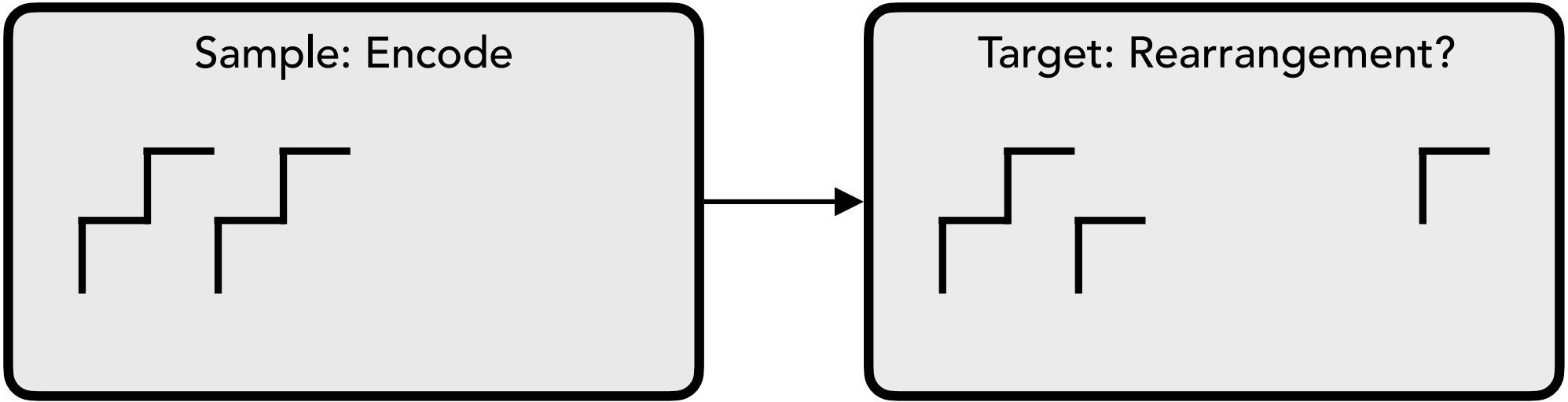


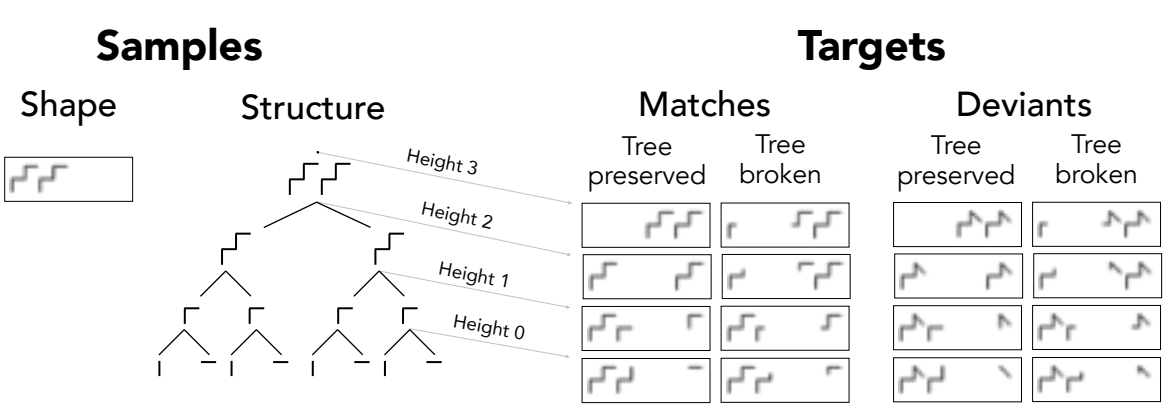
### Deviants

Rotated same

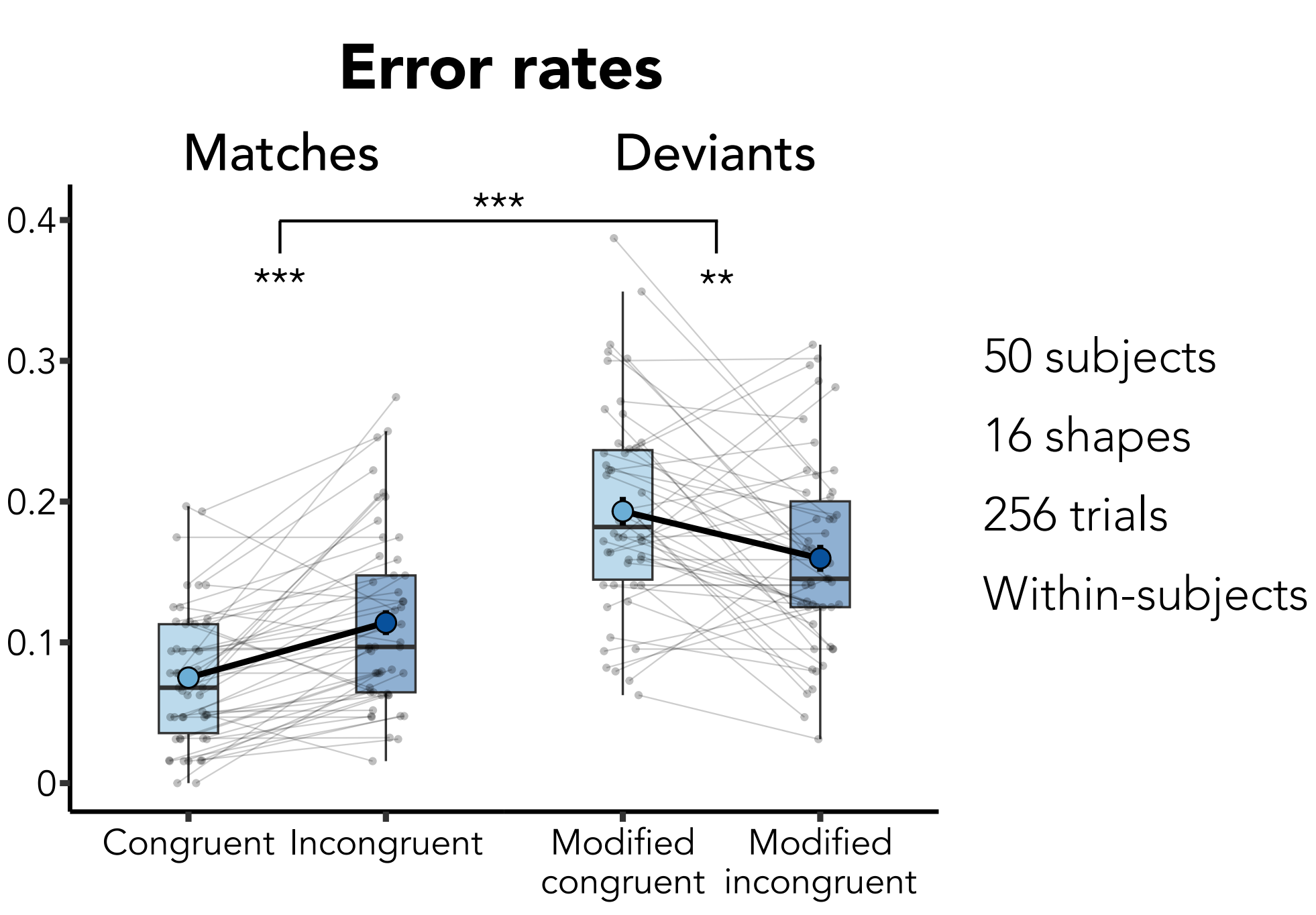


Rotated different

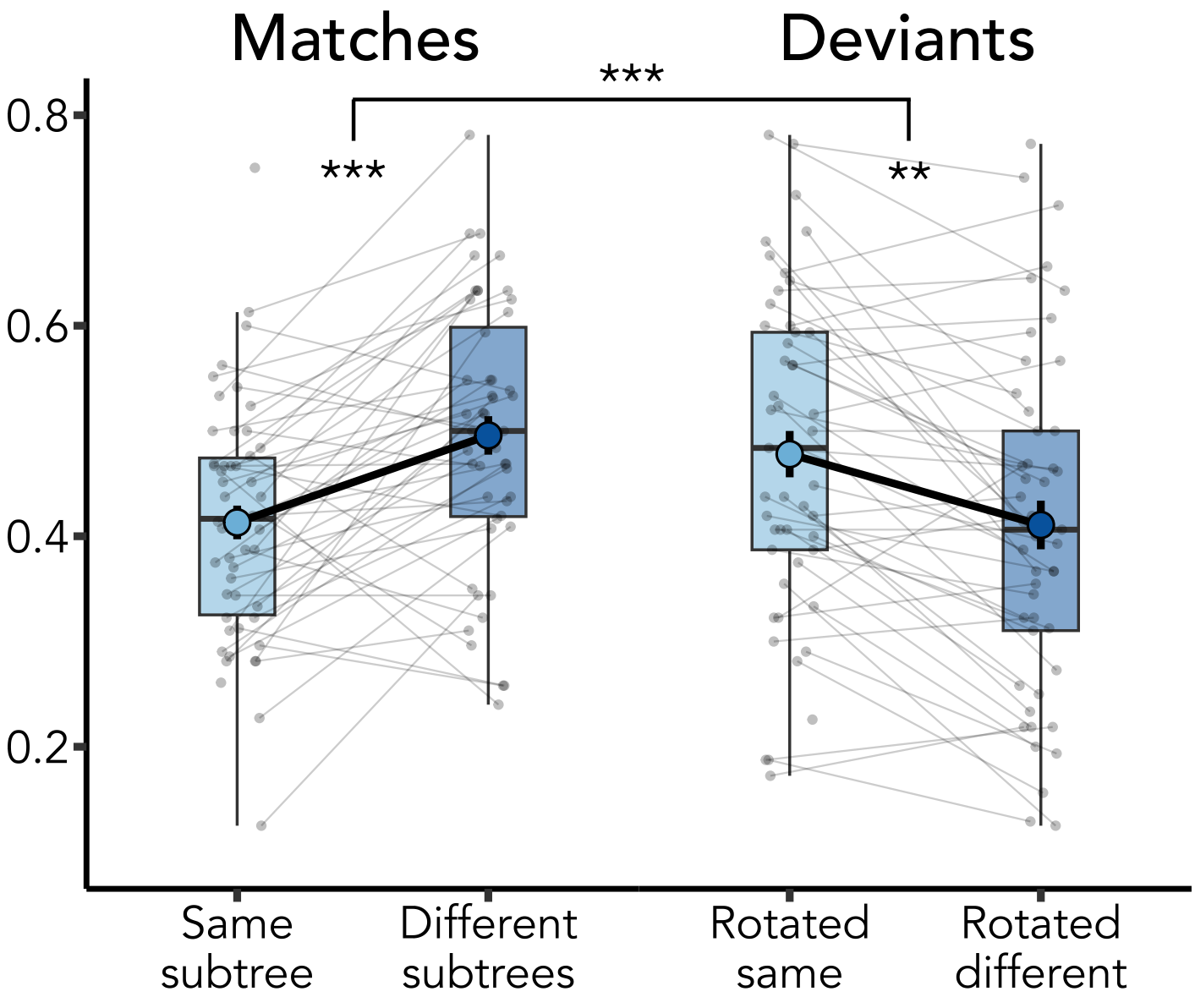

Sample: Encode
Target: Rearrangement?


Samples
Targets
Shape
Structure
Matches
Deviants
Tree preserved
Tree broken
Tree preserved
Tree broken
Height 3
Height 2
Height 1
Height 0

# Error rates


Matches
Deviants
***
***
**
0.4
0.3
0.2
0.1
0
Congruent
Incongruent
Modified congruent
Modified incongruent
50 subjects
16 shapes
256 trials
Within-subjects

# Error rates

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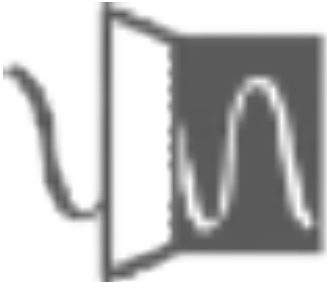
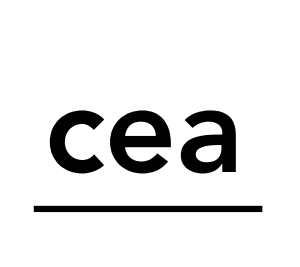
Within-subjects



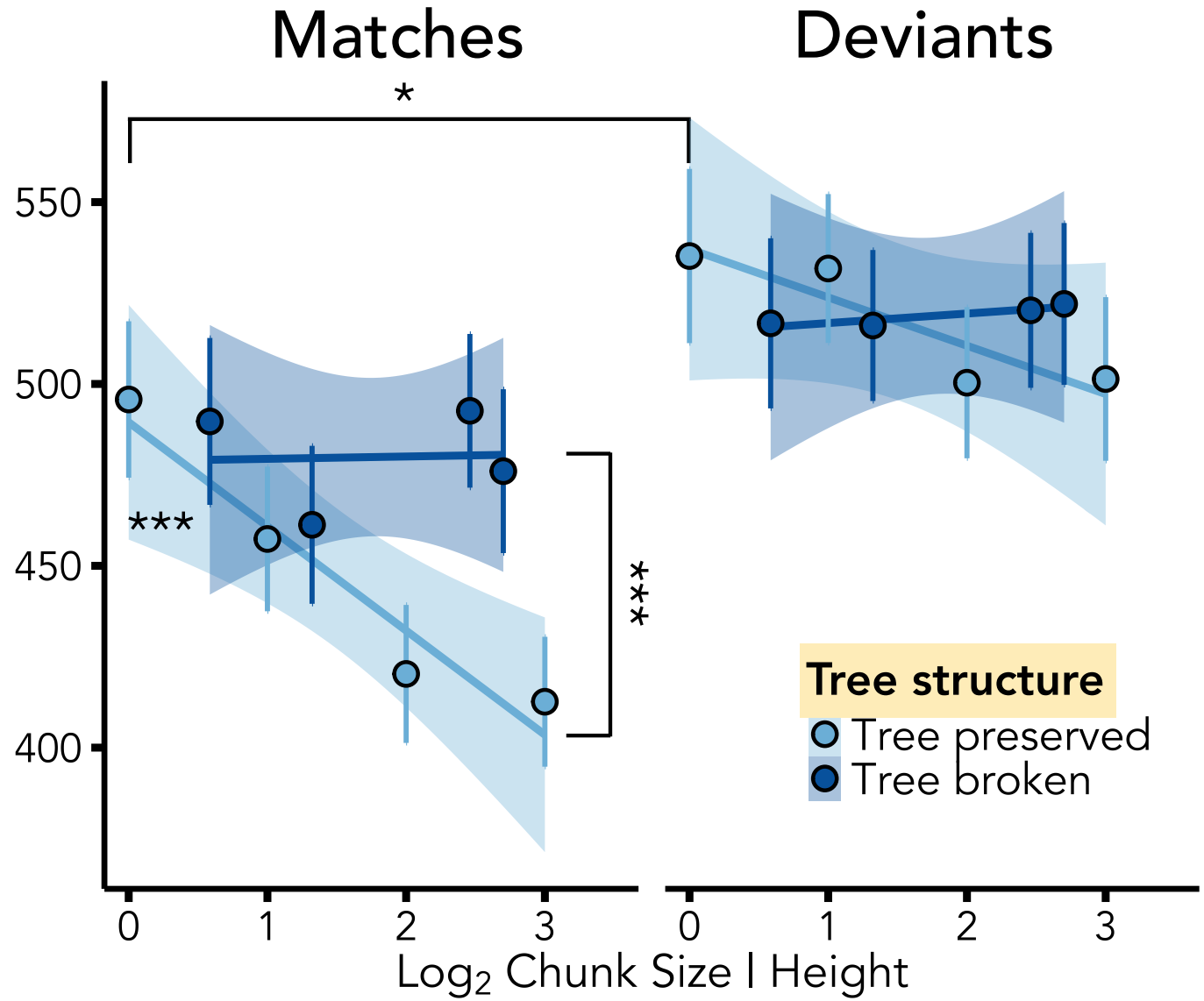
# NeuroSpin


cea

Inserm

# Fyssen

# Reaction times




36 subjects

8 shapes

256 trials

Within-subjects


erc

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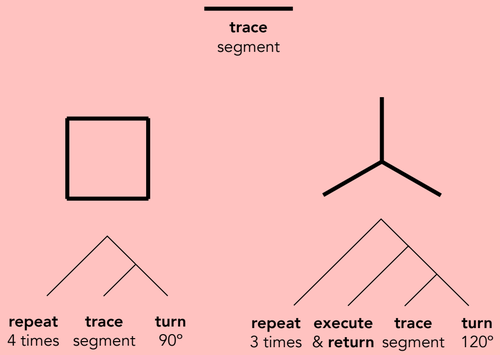


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PREREGISTERED

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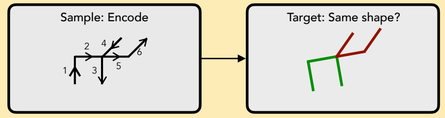


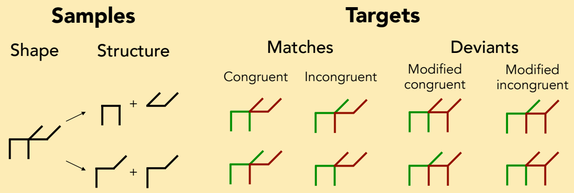


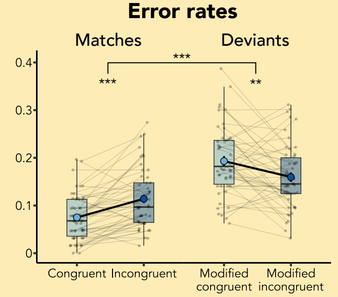


50 subjects
16 shapes
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Within-subjects

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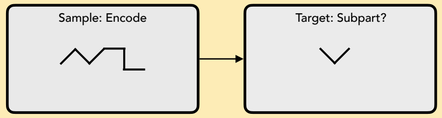
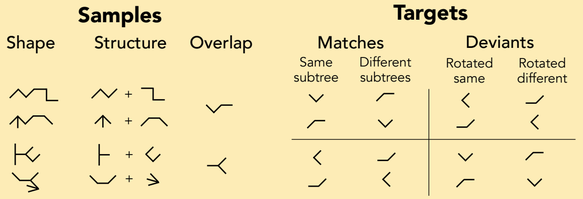
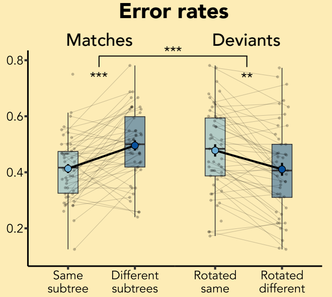
Subparts are easier to recognize when they belong to the same subtree

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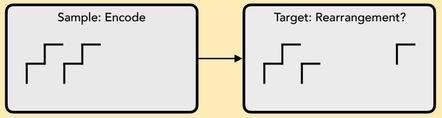


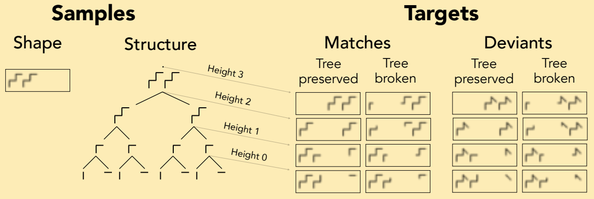


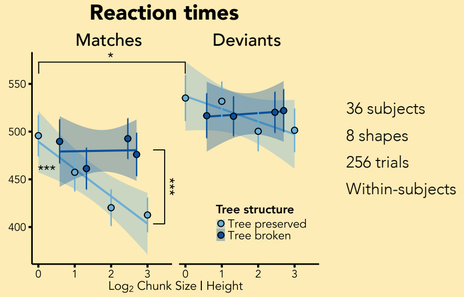


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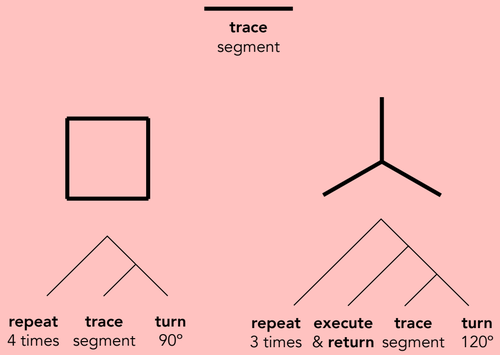


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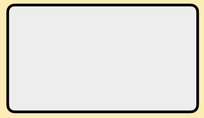

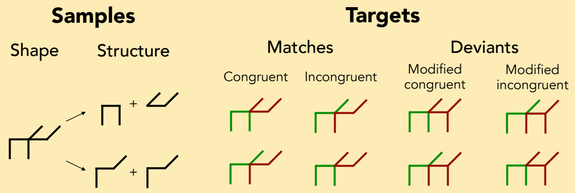


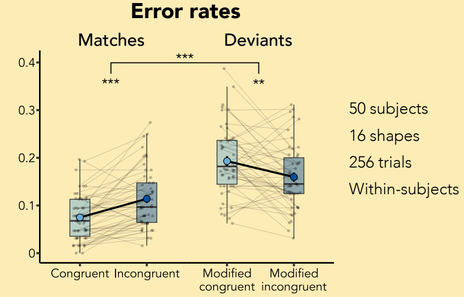


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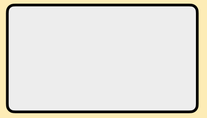

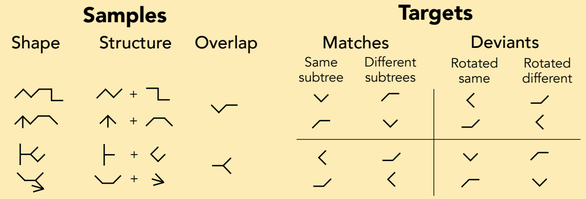


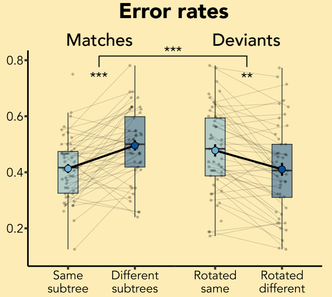


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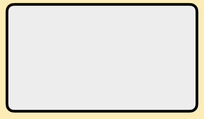

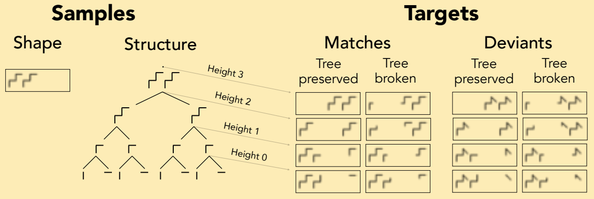


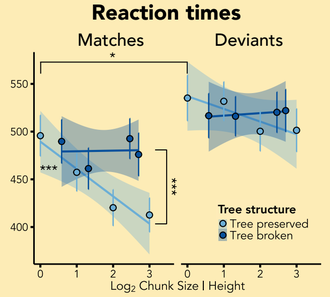


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