Getting into Shapes: Exploring a Comparable Spatial Deductive Reasoning Bias in Children and Adults

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INTRODUCTION

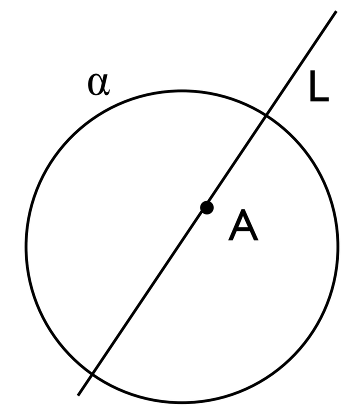
Recent work in cognitive science suggests that human spatial reasoning relies on an interplay between topological and geometric representations. People appear particularly sensitive to topological properties, such as connectedness and enclosure, but their ability to manipulate spatial configurations also depends on the types of geometric transformations involved:

Counterexample search in topological reasoning

Adults proved able to spontaneously search for topological counterexamples in the majority of spatial inferences:

Point A is inside circle α.
Point A is on line L.

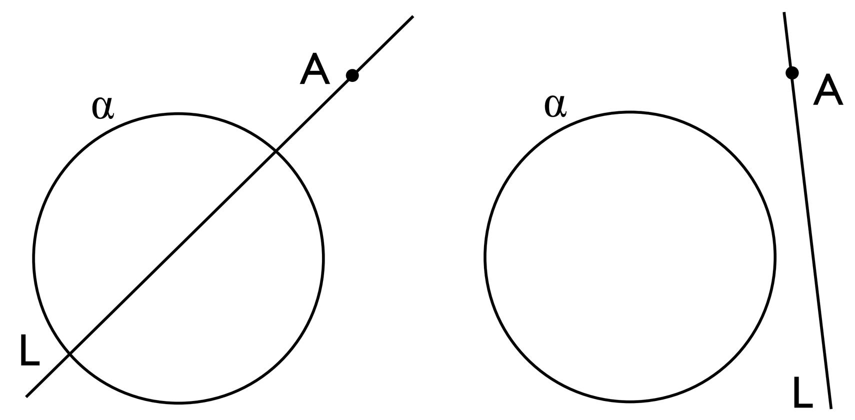
Line L intersects circle α.



Valid inference! (No counterexamples exist)

Point A is outside circle α.
Point A is on line L.

Line L intersects circle α.



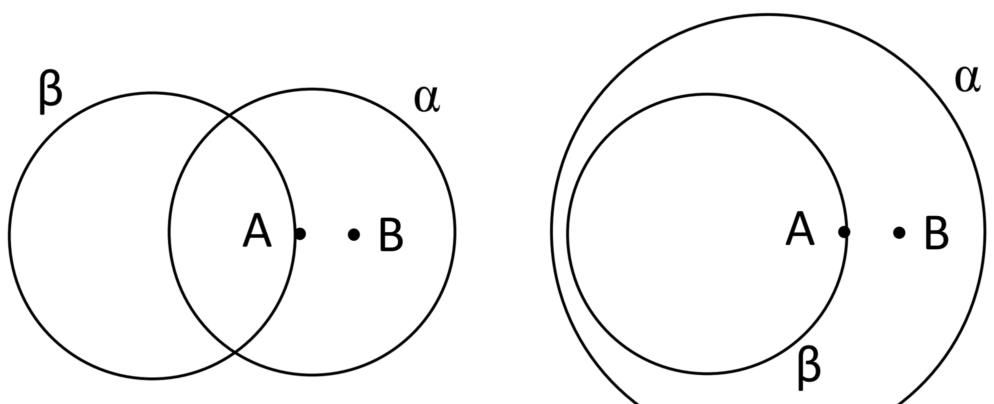
Invalid inference! (Counterexample(s) exist)

A biased inference in adults

Adults were systematically unable to identify topological counterexamples in spatial inferences when doing so required scaling rather than translating:

Point A is inside circle α.
Point A is on circle β.
Point B is inside circle α.
Point B is outside circle β.

Circle α intersects circle β.

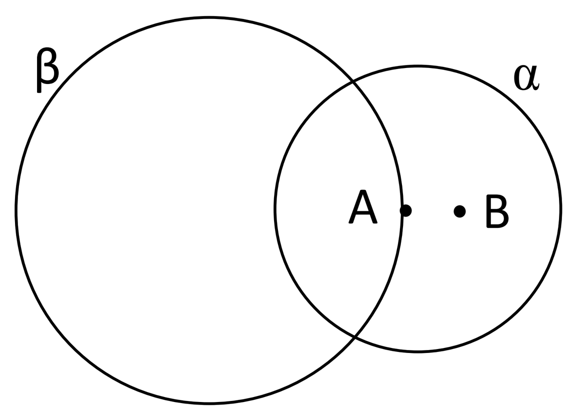


From this initial configuration, scaling is required to find a counterexample.

Locking property of a set of geometrical premises

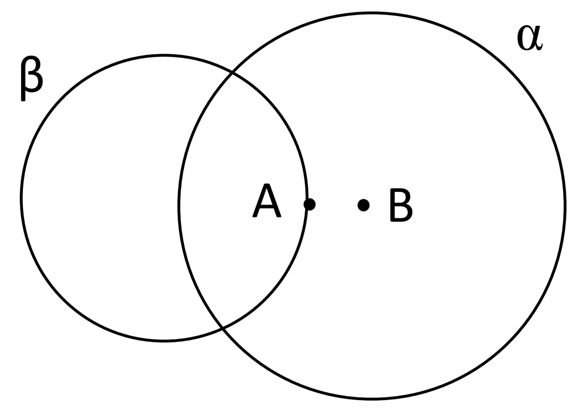
The property of a geometrical situation where there exist representations from which no translation will produce a topologically different configuration (i.e., a locked configuration):

Locked Configuration



~ 70% of all drawings

Non-Locked Configuration



~ 30% of all drawings

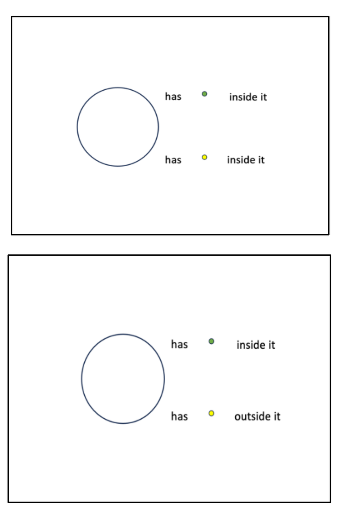
Adults tended to draw locked configurations

ADAPTATION OF THE TEST IN CHILDREN

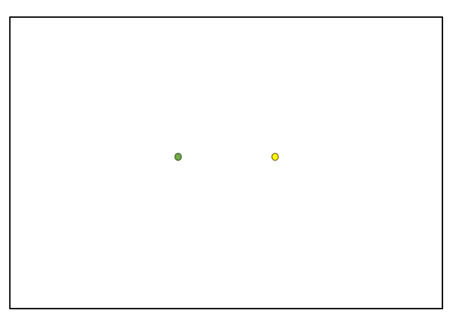
Methodology

46 8-10-year-old children and 38 adults were asked to draw two circles based on spatial premises provided on flashcards:

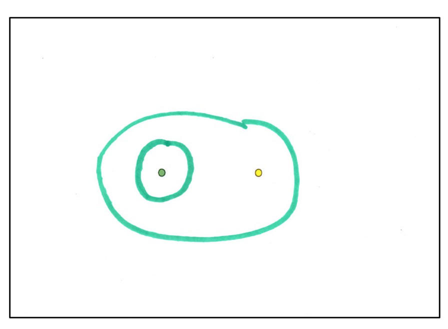
Flashcards for an invalid inference



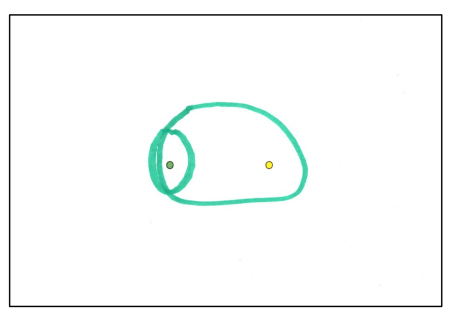
Worksheet for one inference



Example of a participant's initial drawing



Example of a participant's second drawing



They were then asked to assess whether an alternative configuration (i.e., a counterexample, differing in topological structure) could exist, explaining their reasoning with an additional drawing.

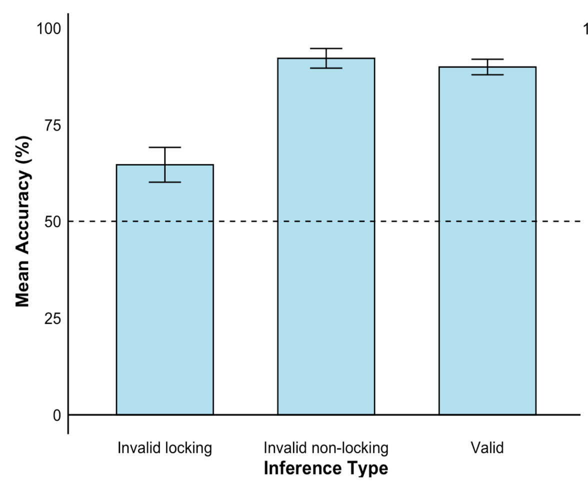
Participants were presented with 12 of these inferences in a random order:

- Six were valid**:** the conclusion necessarily follows from the premise
- Six were invalid**:** the conclusion does not always follow from the premises, or in other words, there are counterexamples
- Three of the invalid inferences had the Locking Property**,** while three did not.

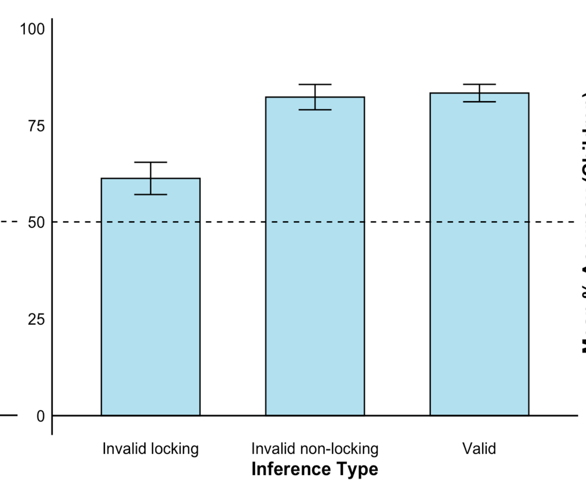
Results

Both groups performed similarly across inference types, including within the invalid inferences with the locking property

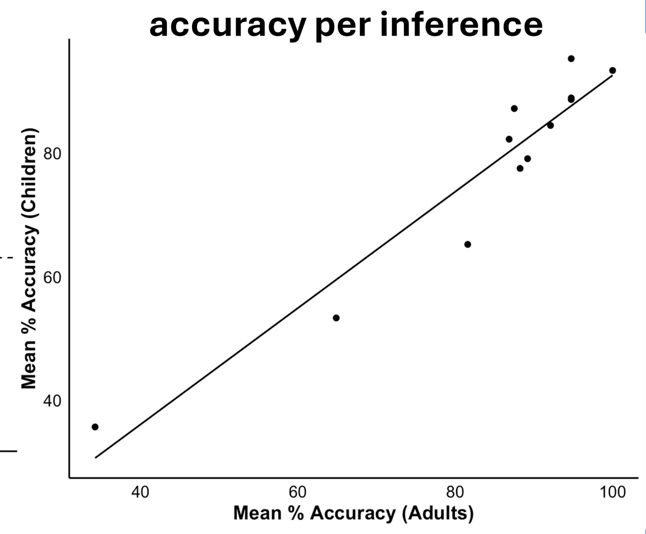
Mean accuracy by inference type in adults



Mean accuracy by inference type in children



Correlation between adults' and children's mean percentage accuracy per inference

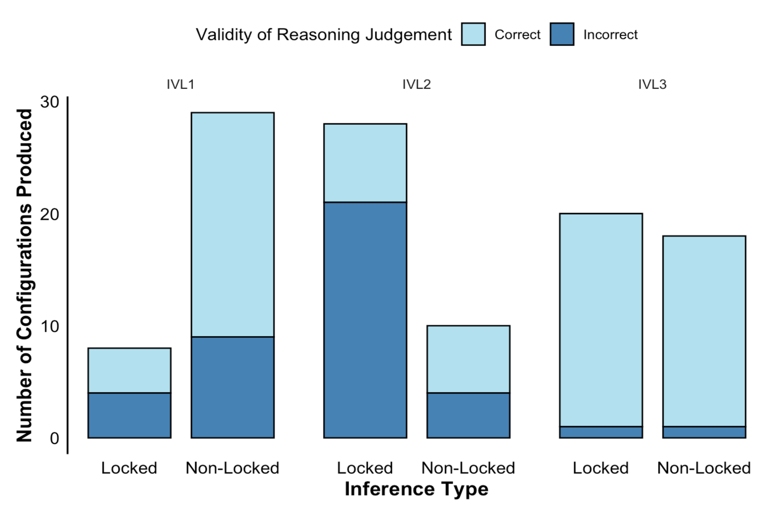


Both groups exhibited consistent preferences in how they initially represented the configurations.

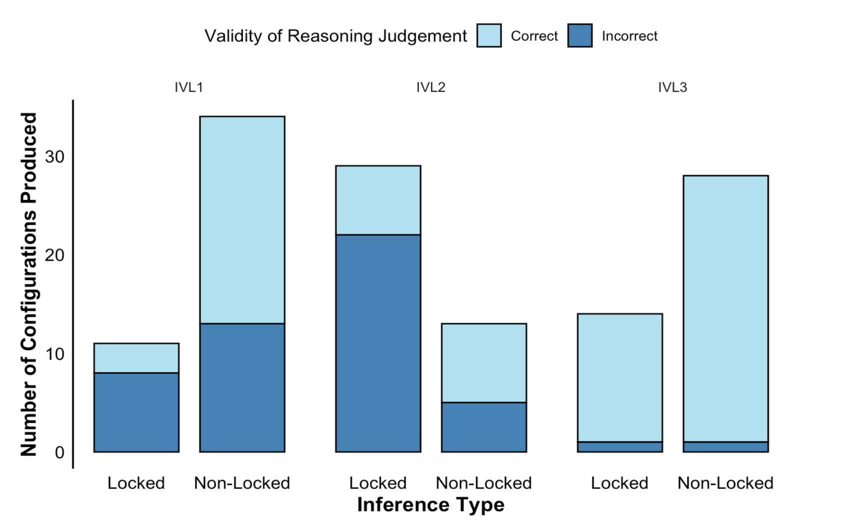
In one inference where producing a counterexample required scaling rather than translation, participants tended to fail the reasoning task.

Number of correct and incorrect locked and non-locked configurations produced for each inference

Adults



Children



DISCUSSION

Both children and adults showed a spatial deductive reasoning bias, suggesting that it emerges independent to formal geometry education. Instead, it may reflect early-emerging intuitive reasoning processes. While initial configurations (locked vs non-locked) influenced performance, this pattern did not generalize across all similar inferences, implying the involvement of additional, yet unidentified, cognitive mechanisms. For example, difficulties in transforming between enclosure and connectedness topological relations may contribute to lower accuracy, especially when combined with a bias toward translation over scaling. These findings suggest that spatial deductive reasoning relies on a complex interaction between both early-emerging topological sensitivity and geometric intuition, and may be subject to inherent limitations, independent of formal education.

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