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The illusions of numerosity perception

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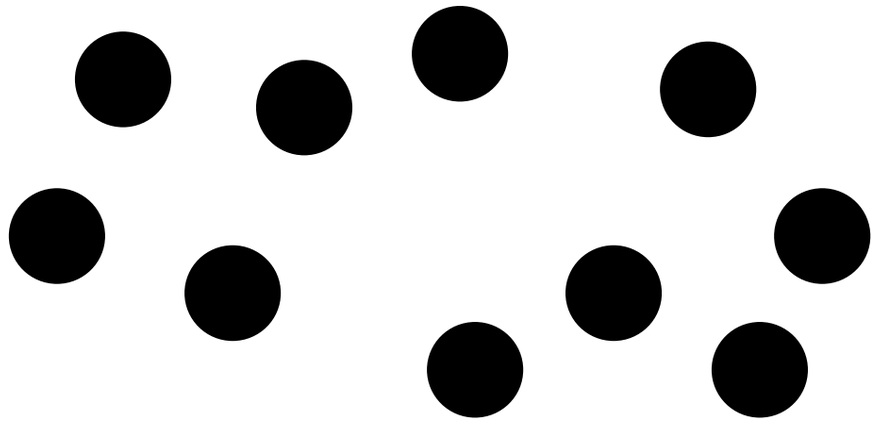
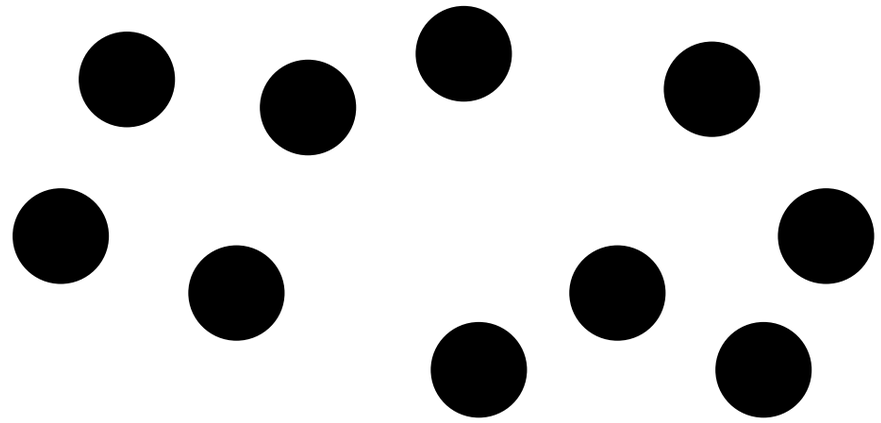


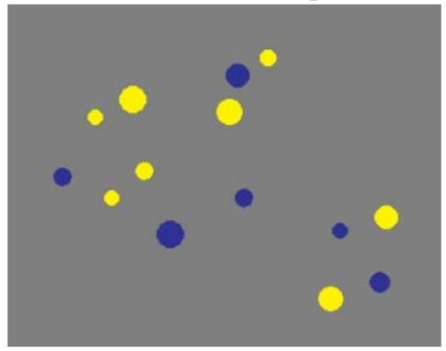
Numerosity perception refers to the spontaneous and universal ability to rapidly and approximately estimate the number of objects in a visual scene.

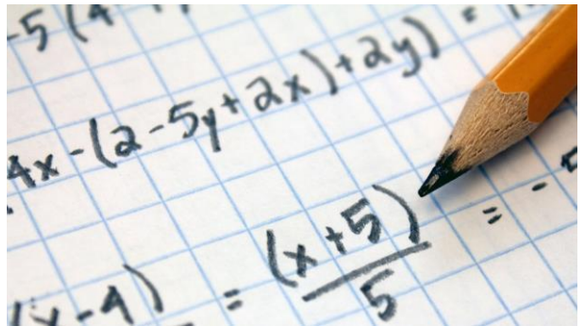


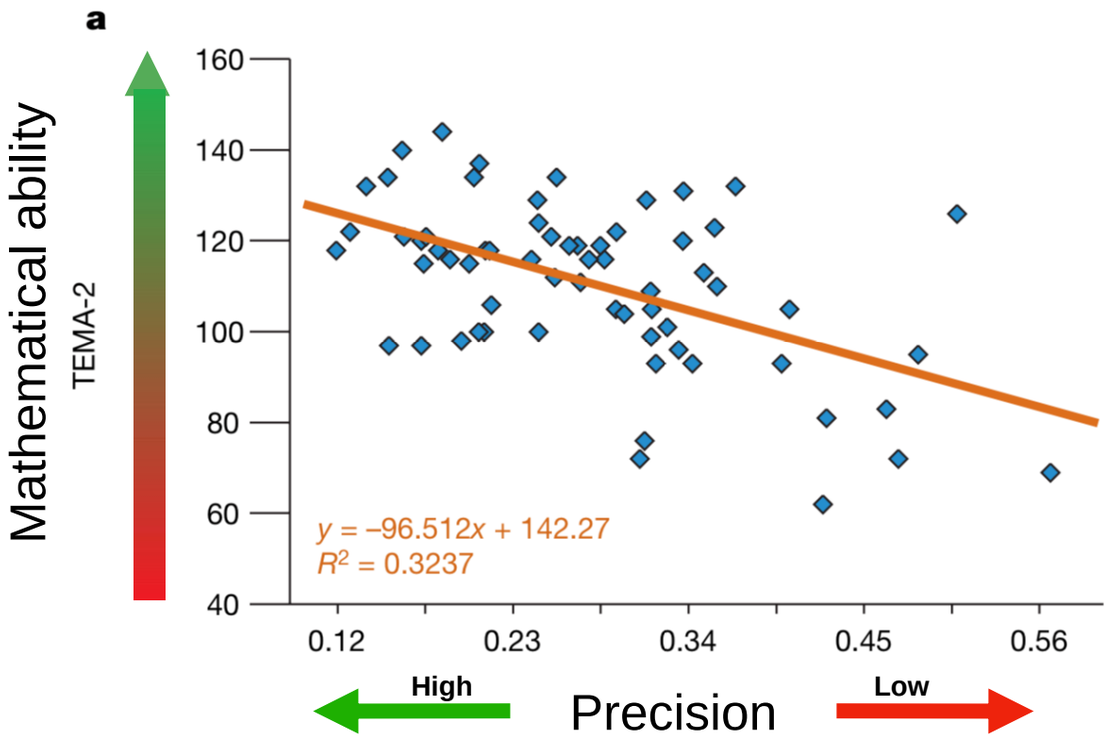
This phenomenon has been studied in many animal species and in humans and it has a very important role in perception, cognition, and decision making.

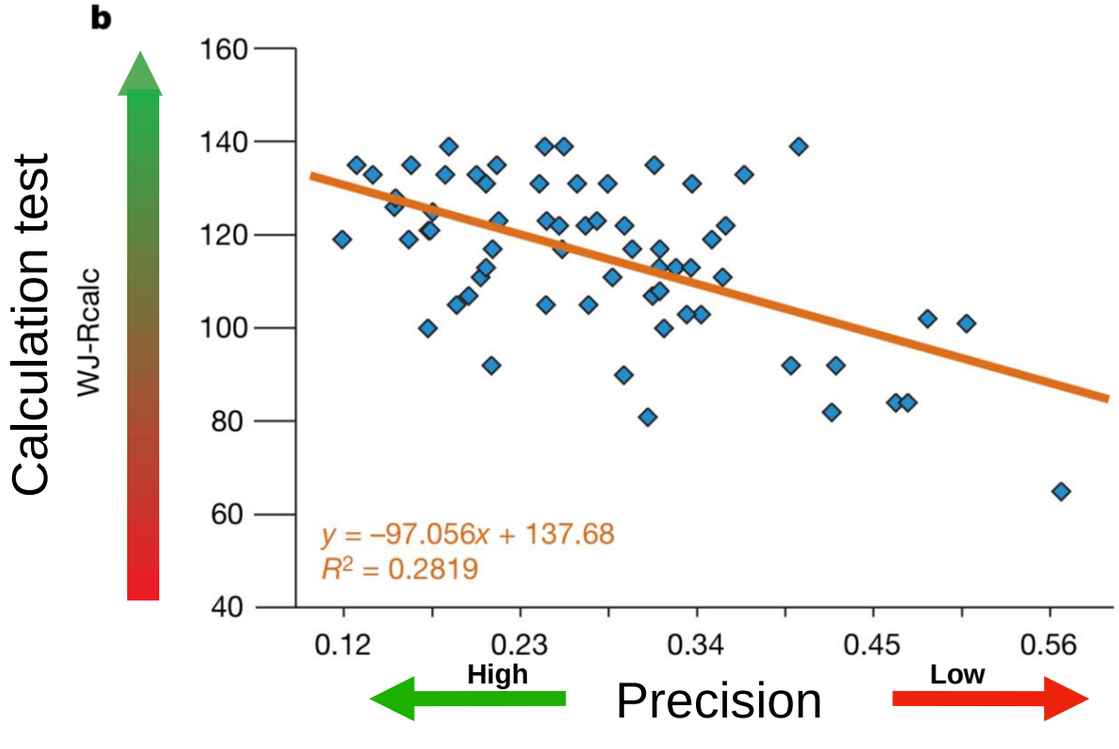
In the animal world, numerosity perception is
essential to spot the patch with more food
or to take rapid fight-or-flight decisions according to
the number of predators, conspecies or preys.

In humans, numerosity perception plays a key role in the development of more complex numerical abilities, mediating the acquisition of mathematical knowledge.





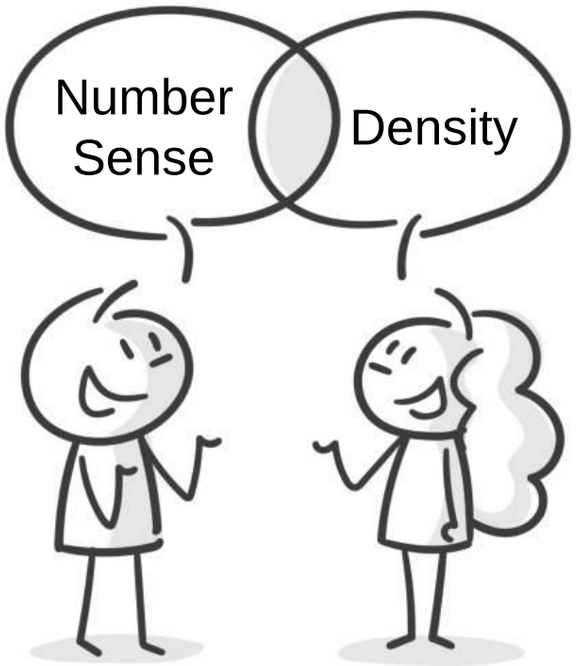




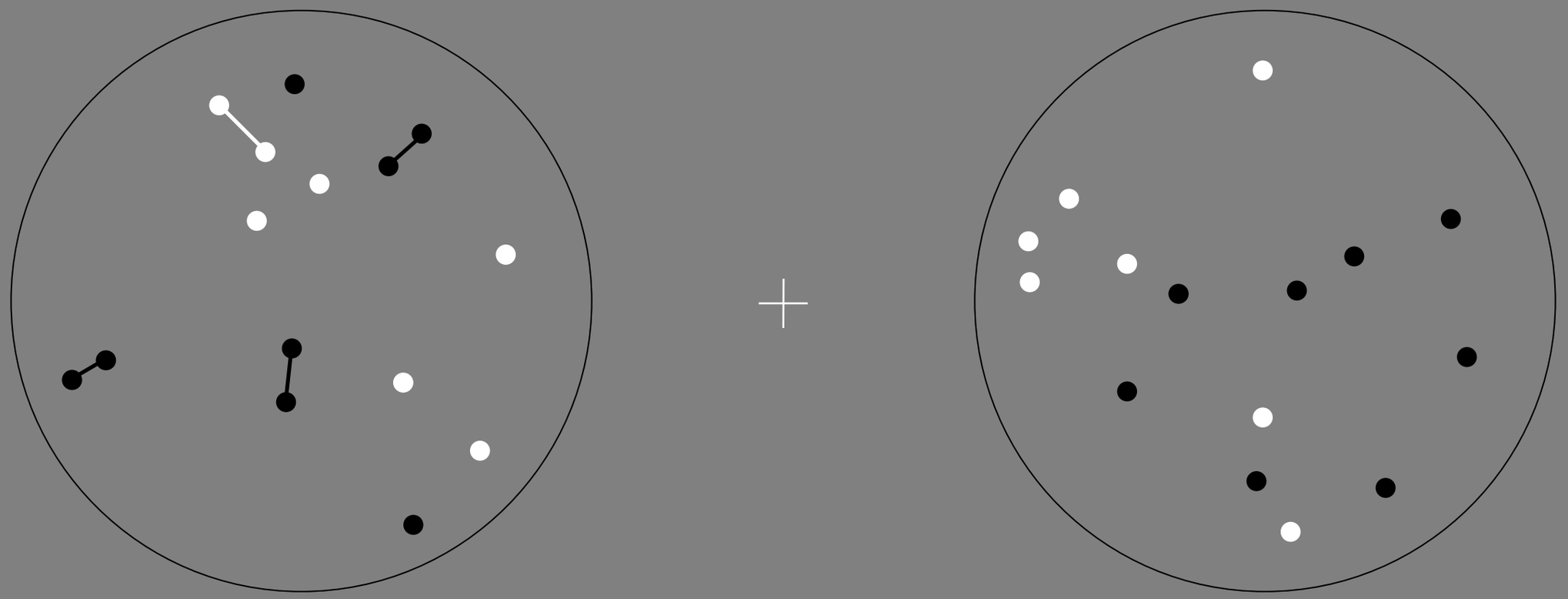
Halberda, J., Mazzocco, M. & Feigenson, L. Individual differences in non-verbal number acuity correlate with maths achievement. *Nature* 455, 665–668 (2008).

Numerosity mechanisms: Number sense vs Texture

Some maintain that the system calculates numerosity via texture density and area, while others maintain that more direct, dedicated mechanisms are involved

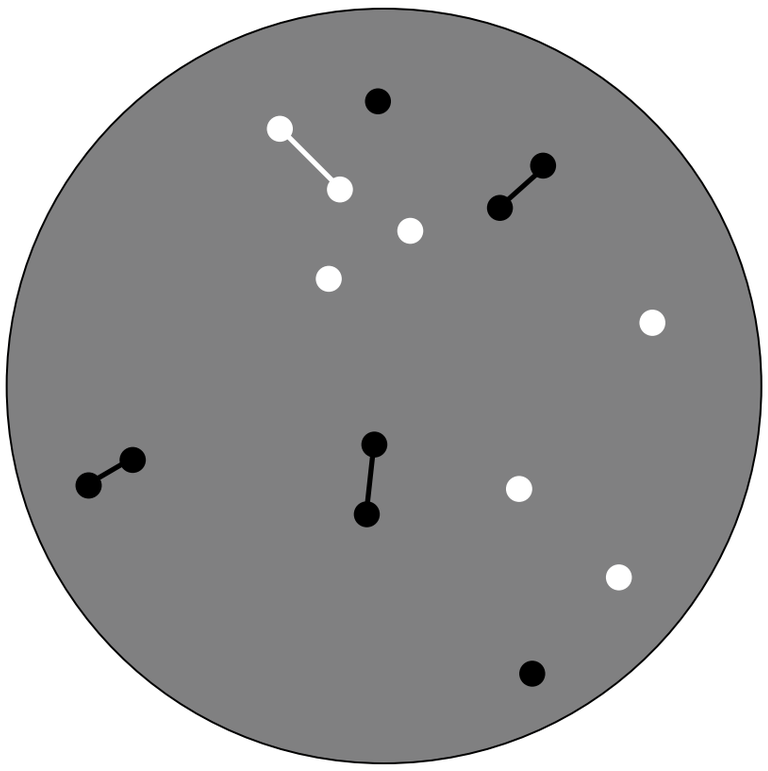


The next numerosity illusion has been a tool to distinguish between the two perception theories



Which was more numerous?

15



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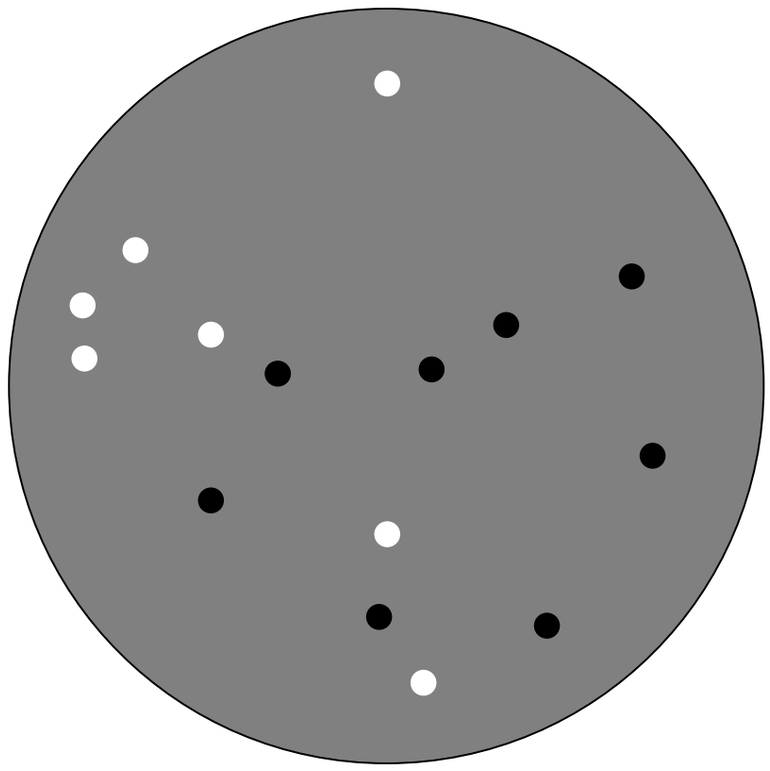
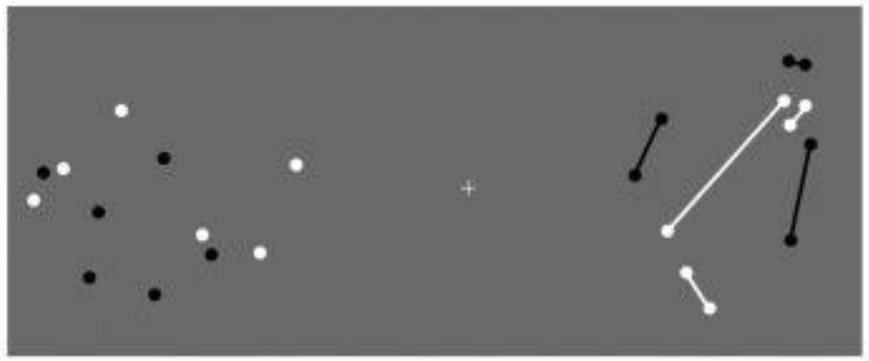
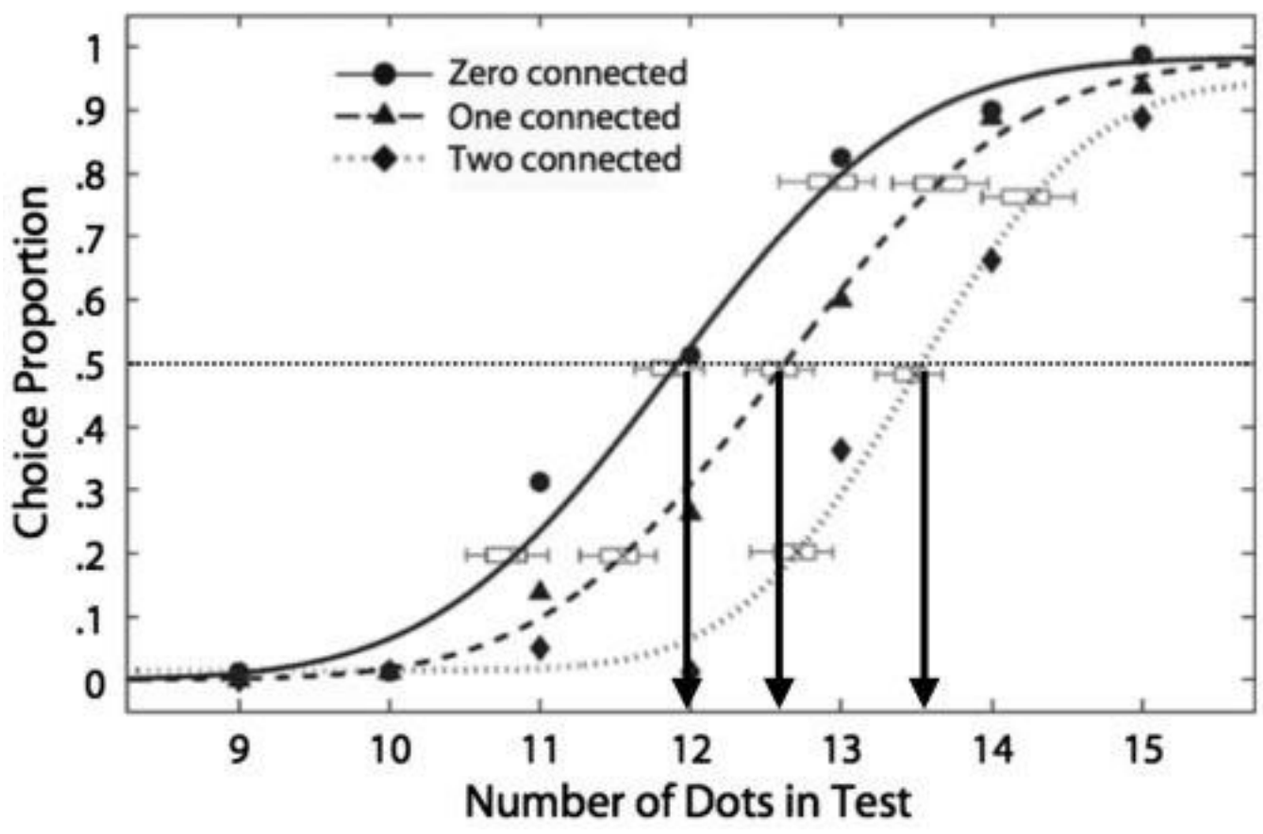


When a few dots are connected in pairs by task-irrelevant lines, although more elements are added to the scene (more density), people underestimate the numerosity of those collections.



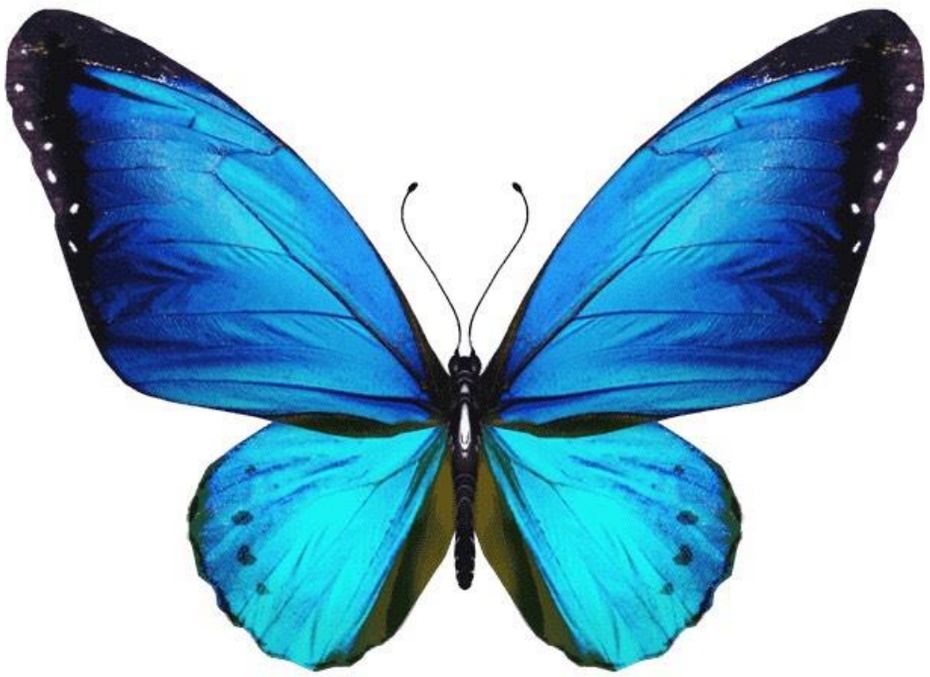


Connectedness effect on numerosity perception.

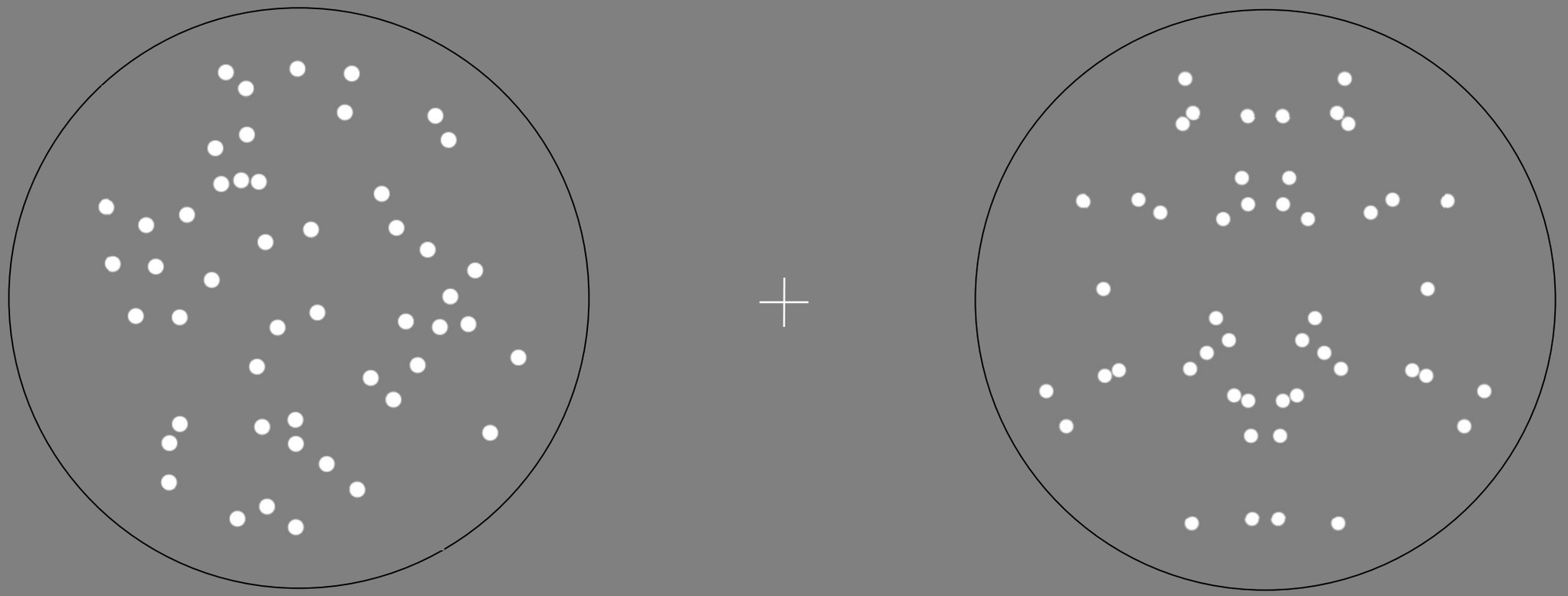
The pattern on the right appears less numerous. Psychometric functions showing proportion of choice test stimulus as more numerous then the reference (containing 12 unconnected dots). Test stimuli could contain zero, one, or two pairs of connected dots. The rightward shift of psychometric functions compared with the zero-connected indicates underestimation of the test when dots were connected.

He, Zhang, Zhou & Chen (2009). Connectedness affects dot numerosity judgment:Implications for configure processing. *Psychonomic Bulletin & Review*, 16, 509-517.

Symmetry



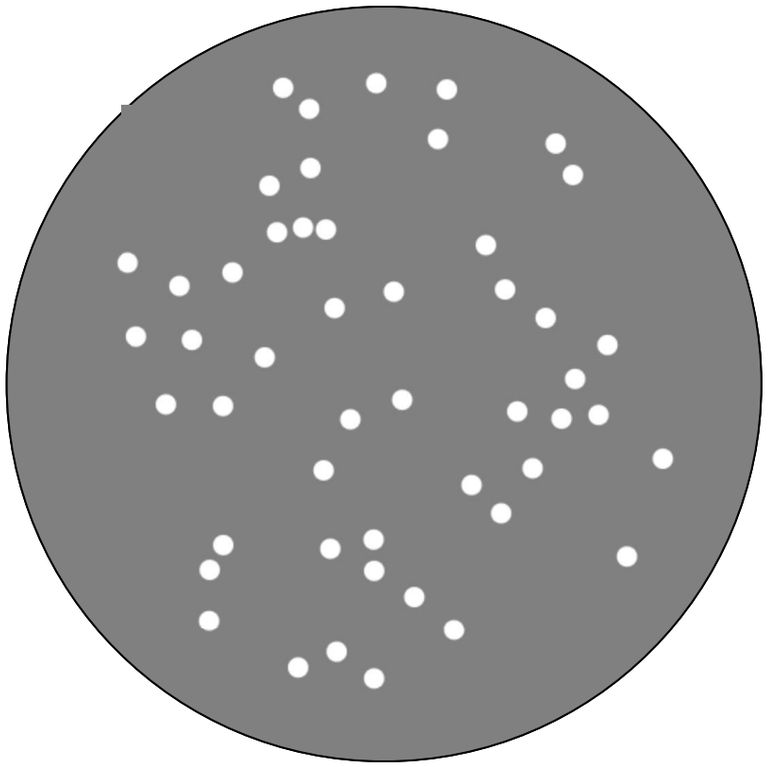
The Law of Symmetry is the gestalt grouping law that states that elements that are symmetrical to each other tend to be perceived as a unified group. This rule suggests that objects that are symmetrical with each other will be more likely to be grouped together than objects not symmetrical with each other.



Which was more numerous?

We observe a similar underestimation effect with symmetric stimuli

50



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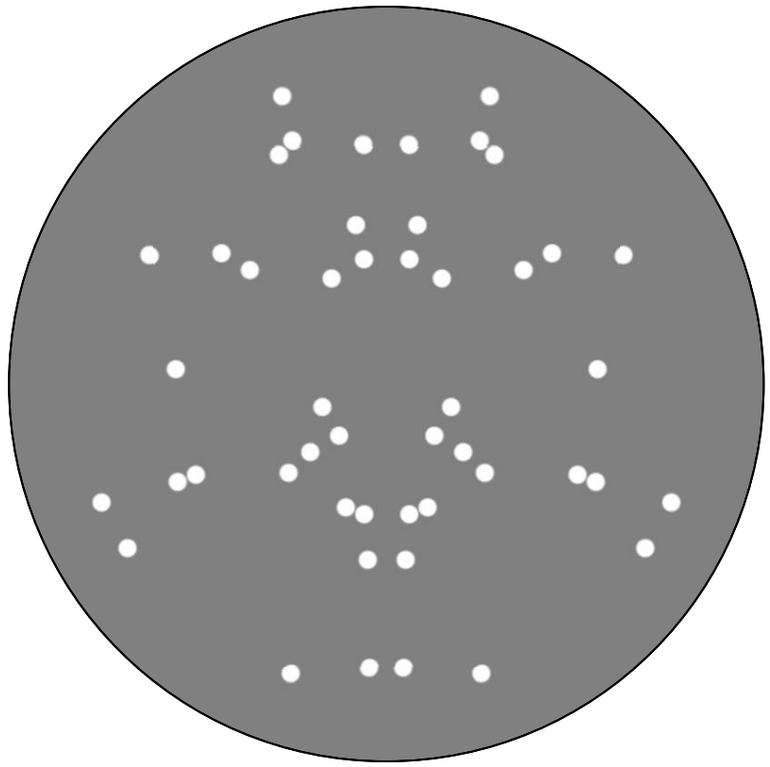
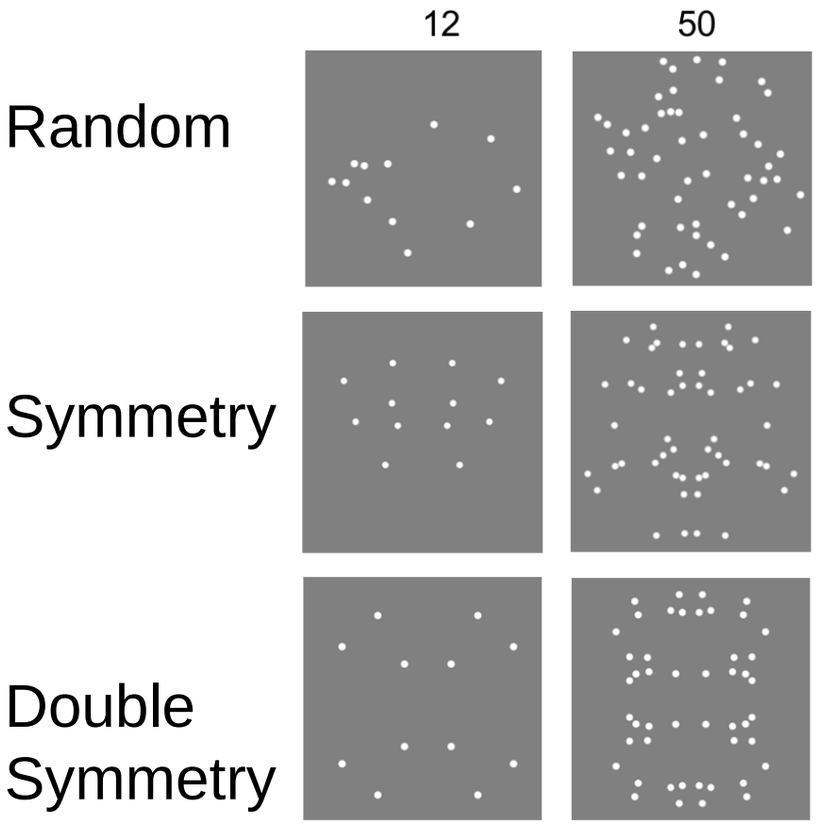
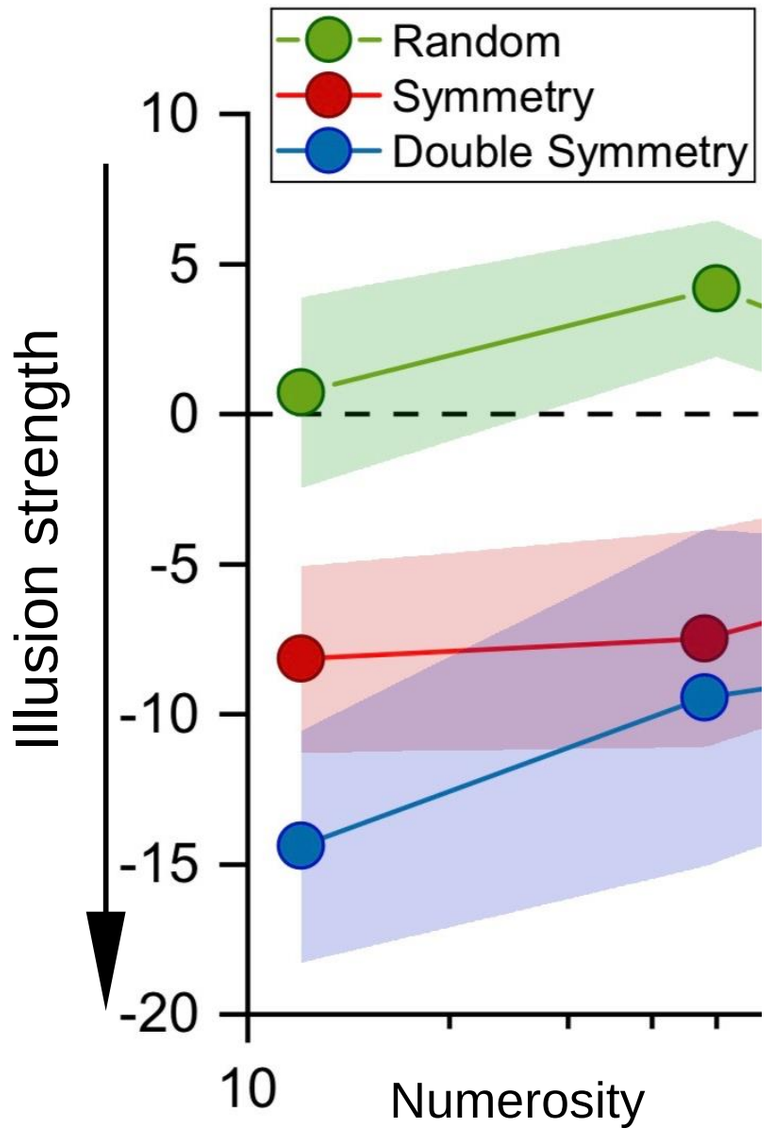


We observe a similar underestimation effect with symmetric stimuli

The numerosity perception of symmetric stimuli is underestimated



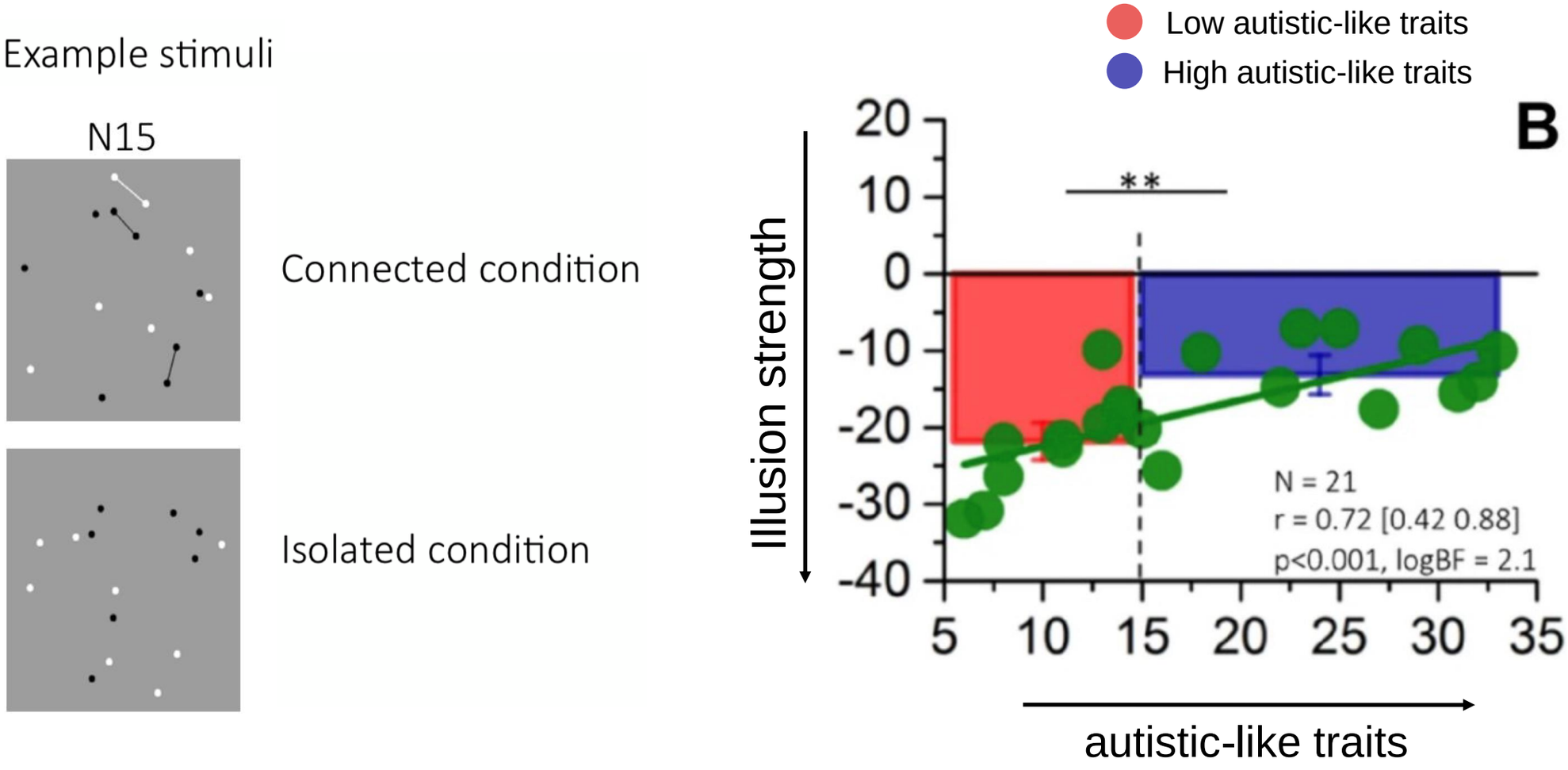


The numerosity of symmetrical arrays is significantly underestimated, espycially at low numerosities, while this effect is reduced at higher numerosities

Paula A. Maldonado Moscoso, Giovanni Anobile, David C. Burr, Roberto Arrighi & Elisa Castaldi, *Symmetry as a grouping cue for numerosity perception*, Under Review

Perceptual styles: Connectedness

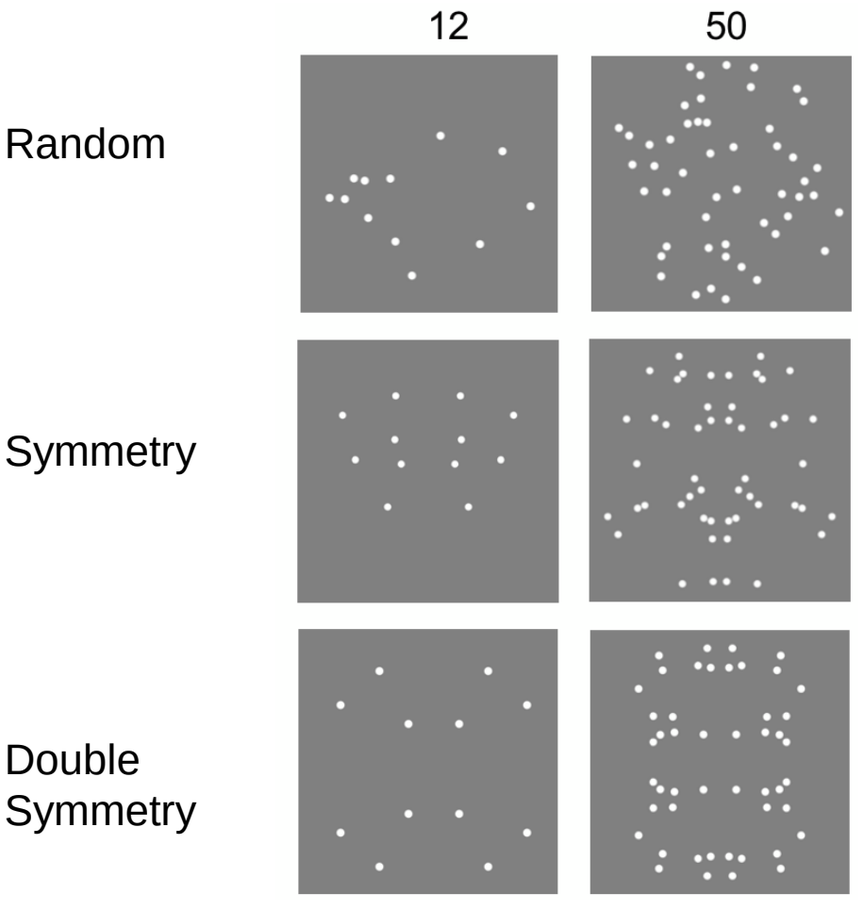
The underestimation bias correlated strongly with autism-spectrum quotient, being weaker for participants with high autistic traits. As connecting dots probably activates global grouping mechanisms, causing dot-pairs to be processed as an integrated whole rather than as individual dots, the results suggest that these grouping mechanisms may be weaker in individuals self-reporting high levels of autistic-like traits.

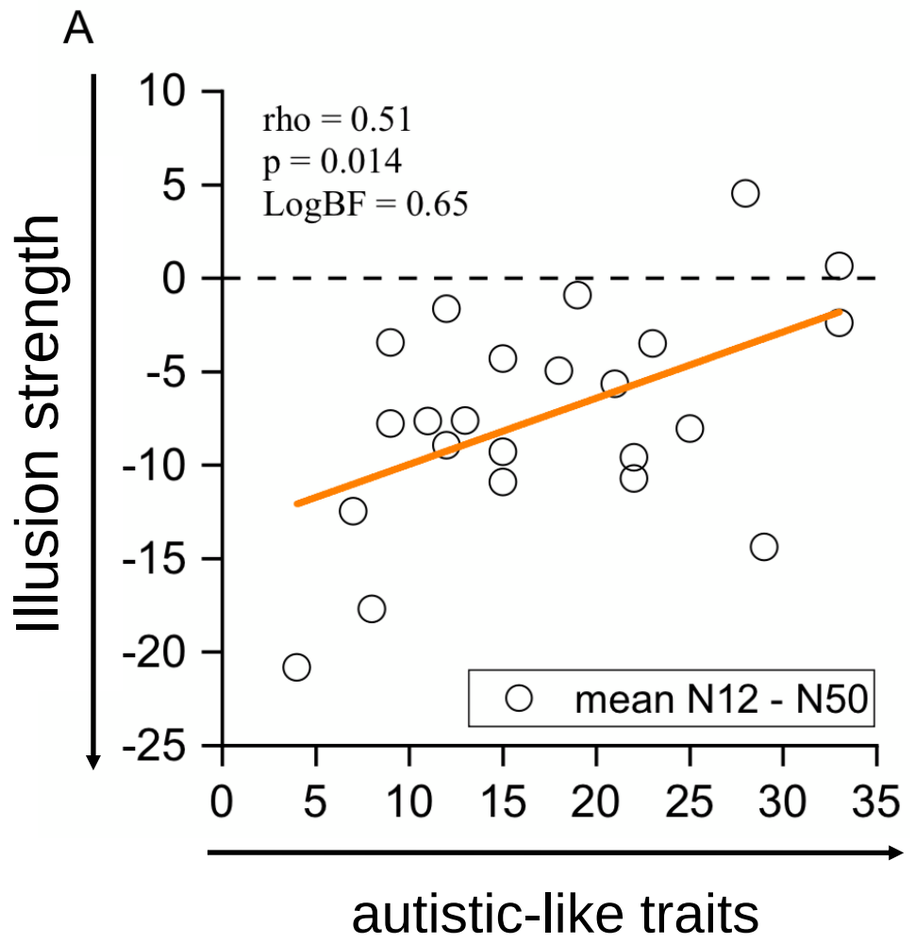


Antonella Pomè, Camilla Caponi, David Charles Burr, Grouping-Induced Numerosity Biases Vary with Autistic-Like Personality Traits, Journal of Autism and Developmental Disorders (2022) 52:1326–1333

Perceptual styles: Symmetry

The magnitude of the symmetry-driven underestimation is inversely correlated with autistic personality traits





Paula A. Maldonado Moscoso, Giovanni Anobile, David C. Burr, Roberto Arrighi & Elisa Castaldi, *Symmetry as a grouping cue for numerosity perception*, Under Review

Conclusions:

Here we discussed a demonstration that visual illusions could be used as a tool to:

- Investigate perceptual mechanisms
- Distinguish between different theories of perception
- Give informations about perceptual styles