

Kunda, M., McGregor, K., & Goel, A. (2010). Can the Raven's Progressive Matrices intelligence test be solved by thinking in pictures? Oral presentation given at 9th annual *International Meeting For Autism Research (IMFAR)*, Philadelphia, PA.

Can the
Raven's Progressive Matrices
Intelligence Test
Be Solved by
Thinking in Pictures?

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Conflict of Interest: None



vita

Visual Thinking
in Autism

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Our Team

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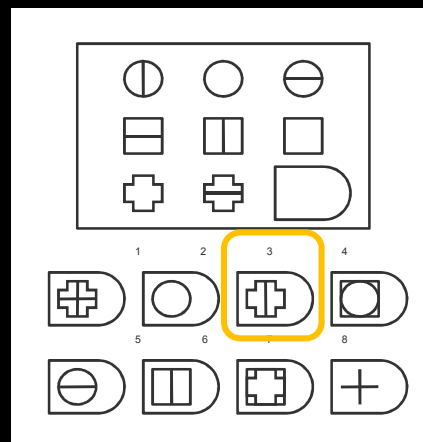
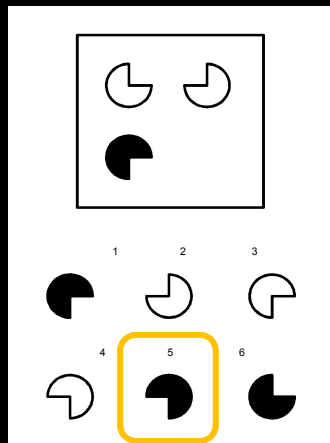
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What is the **Raven's** Test?

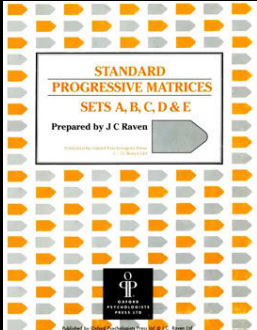
Why a **visual** solution strategy?

Is a purely visual strategy even possible?
(Our computational models say **yes!**)

So **what?**



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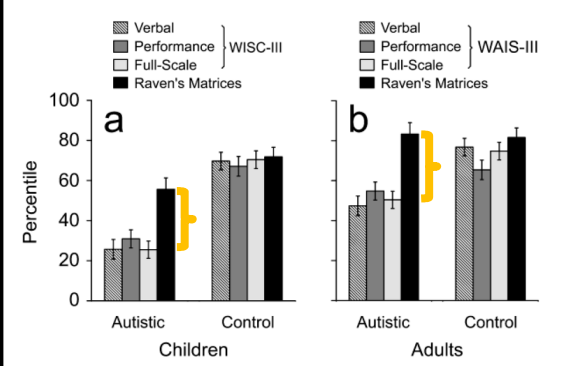


vs.

Wechsler Scales

- Information
- Similarities
- Vocabulary
- Arithmetic
- Digit Span
- Letter-Number Sequencing
- Block Design
- Picture Completion
- Digit Symbol-Coding
- ...

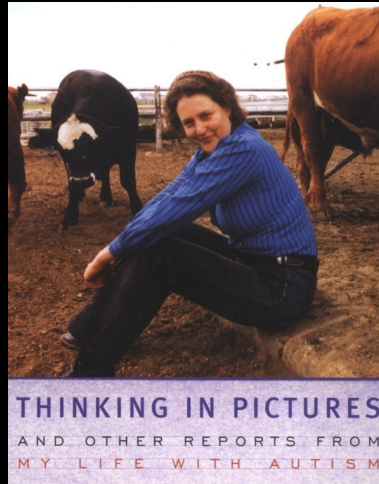
A puzzling discrepancy...



Group	Test	Autistic (Percentile)	Control (Percentile)
Children (a)	Verbal (WISC-III)	~25	~65
	Performance (WISC-III)	~30	~65
	Full-Scale (WISC-III)	~25	~65
	Raven's Matrices	~55	~70
Adults (b)	Verbal (WAIS-III)	~45	~75
	Performance (WAIS-III)	~55	~75
	Full-Scale (WAIS-III)	~45	~75
	Raven's Matrices	~80	~80

Dawson, M., Soulières, I., Gernsbacher, M., & Mottron, L. (2007). The level and nature of autistic intelligence. *Psychological Science*, 18, 657-662.

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Our Central Question

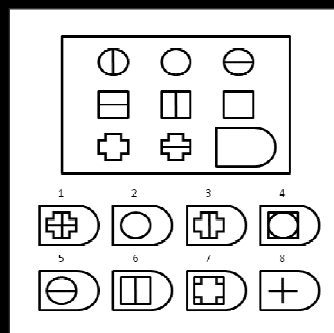
Do people with autism solve the Raven's test **visually**?

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But first...

Is using a visual strategy on the Raven's even possible?

What do we mean by a visual strategy anyway?



visual inputs

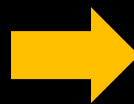


Figure1:
Shape: Circle
Texture: Line
Orientation: Vertical
Figure2:
Shape: Circle
Texture: Empty
Figure3:
Shape: Circle
Texture: Line
Orientation: Horizontal
...

verbal
representations

Carpenter, P. A., Just, M. A., & Shell, P. (1990). What one intelligence test measures: a theoretical account of the processing in the Raven Progressive Matrices Test. *Psychological Review*, 97(3), 404-31.

Bringsjord, S., & Schimanski, B. (2003). What is artificial intelligence? Psychometric AI as an answer. *IJCAI*, 18, 887-893.

Lovett, A., Forbus, K., & Usher, J. (2007). Analogy with qualitative spatial representations can simulate solving Raven's Progressive Matrices. *29th Annual Cognitive Science Conference* (pp. 449-454).

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Our visual method

Affine transformations

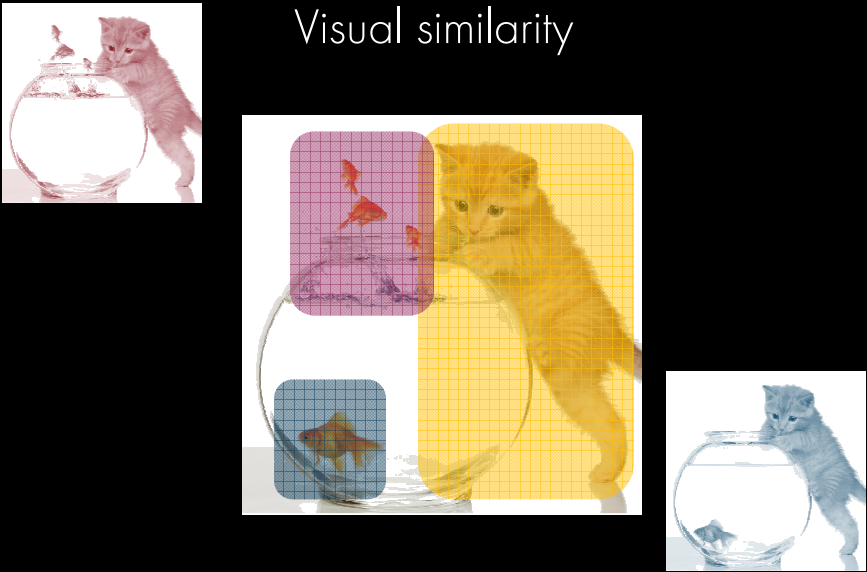
Visual similarity

Affine transformations



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Visual similarity



Tversky, A. (1977). Features of similarity. *Psychological Review*, vol. 84, pp. 327-352.

Visual algorithm

For each base transform T:

Apply T to Image A.

Find translation (tx, ty) which yields best match between T(A) and B, according to:

$$\text{similarity}(A, B) = \frac{f(A \cap B)}{f(A \cup B)}$$

Find image composition operand X as follows:

Calculate similarity according to:

$$\text{similarity}(A, B) = \frac{f(A \cap B)}{f(A \cap B) + \alpha f(A - B) + \beta f(B - A)}$$

With: 1) $\alpha = 1, \beta = 1$
 2) $\alpha = 1, \beta = 0$
 3) $\alpha = 0, \beta = 1$

Choose maximum similarity value.

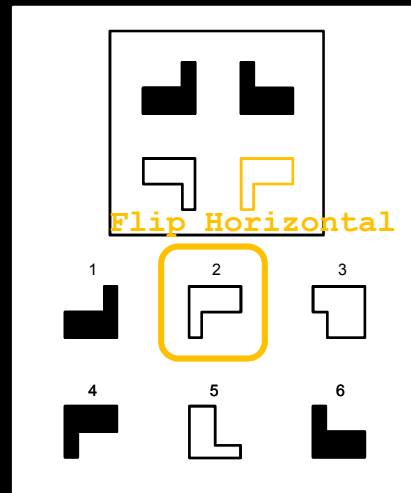
If maximum is (1), then $X = 0$.
 If maximum is (2), then $X = B - A$, and \oplus refers to image addition.
 If maximum is (3), then $X = A - B$, and \oplus refers to image subtraction.

The best-fit similitude transformation can then be specified as:

$$[T_{\max} + (tx, ty)](A) \oplus X = B$$

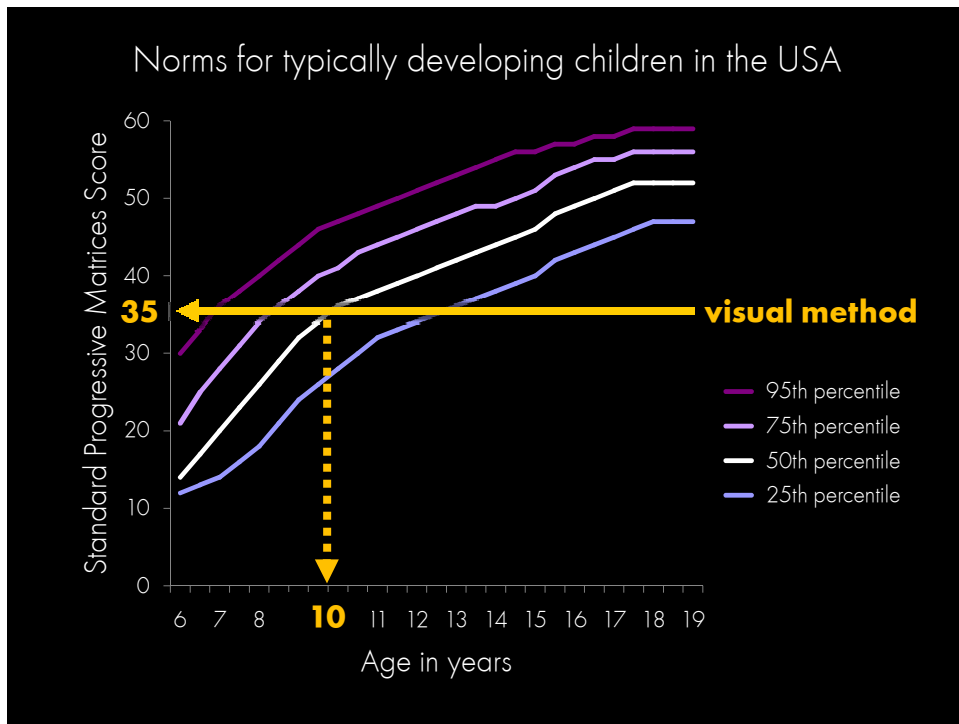
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Visual algorithm illustration



Results

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So what?

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Our work shows **sufficiency** of these particular visual representations, not **necessity**.

We have shown that one **could** use a purely visual strategy on parts of the Raven's test.

Whether one **does** is still an open question.