Tutorial at Diagrams 2018 -- Monday June 18th: 14:00-15:30
http://www.diagrams-conference.org/2018/

Were "Super-Turing" diagrammatic reasoning competences ancient products of biological evolution?

Alternative, shorter title:
Evolved "diagrammatic" spatial intelligence.

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- **Introduction.**
  -- Audience Composition
  -- Audience views
  -- The current state of AI
  -- What's missing?
  -- Links to
  -- psychology, neuroscience, philosophy, biology, computer science,
  mathematics,...
- **What is mathematics?**
  How does it differ from other disciplines?
  Kant: three features.
  -- non-empirical,
  -- not analytic (not based solely on logic + definitions),
  -- concerned with
  -- necessity/impossibility/possibility (but not "possible world semantics")
  -- see Cathy Legg's talk, and several others in this conference.
- **Links with work of Immanuel Kant, and (possibly) Alan**

Turing.
Also Piaget, especially his last two books on children reasoning about Possibility and Necessity

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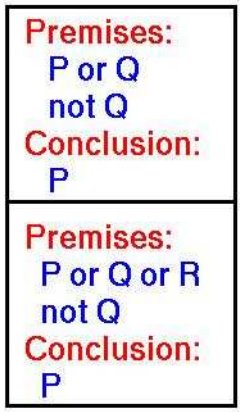
- **The case of propositional/Boolean logic**

Figure Logic: Which inference is valid, and why?



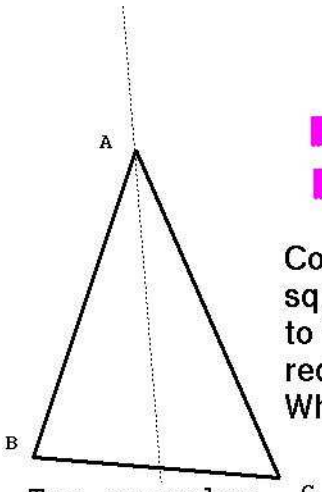
By starting from the truth tables for "or" and "not" you can reason about which possible combinations of truth values for P and Q (and R in the second example) will make the premises true and ask whether the conclusion can be false in any of those cases.
If it is impossible for all the premises to be true while the conclusion is false, then the inference is valid.

Here exhaustive analysis of a discrete finite collection of possibilities suffices (though for more atomic propositions the set of possibilities increases exponentially.

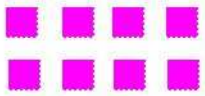
What about continuously varying sets of possibilities? Finite exhaustive analysis is no longer possible. WHAT MECHANISMS ALLOWED ANCIENT MATHEMATICIANS TO MAKE THEIR AMAZING DISCOVERIES?

- **Background: Evolution and mathematics**
- **Some examples:**

EXAMPLES



Two examples
in one diagram.

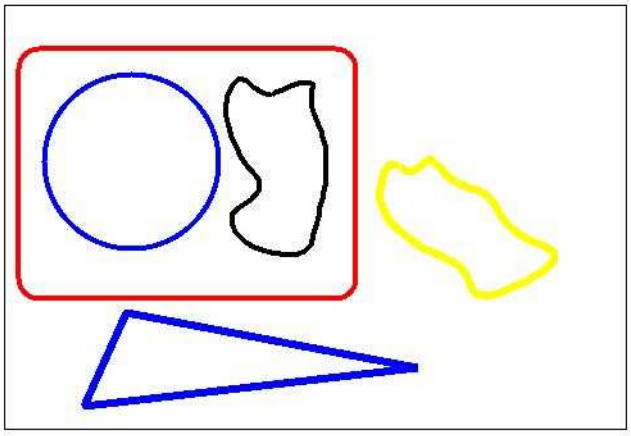


Could the same squares be moved to form a different rectangle?
What if I add a square?

Why are linked rings so useful for many purposes?

Continuous deformation:

If one circle is inside another on the same plane can one of them be continously be deformed until they suddenly overlap i.e. occupy exactly the same points?



More continuous deformation:

What difference does it make if the figures are on the surface of a sphere

Or on the surface of torus?

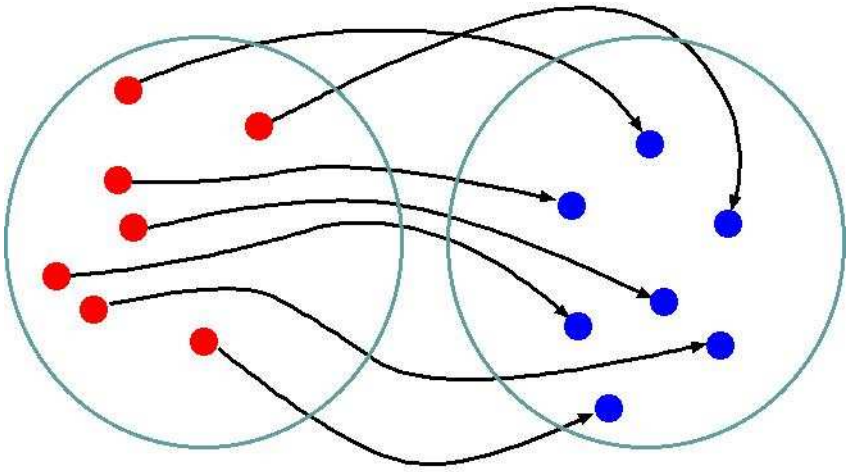
- **WHY WAS KANT RIGHT ABOUT ARITHMETIC?**

  The concept of number essentially involves 1-1 correspondence: a topological relationship.

Understanding cardinals requires grasping that 1-1 correspondence is transitive and symmetric, and therefore produces equivalence classes.

Very few psychologistss or neuroscientists understand the implications.

Piaget did, but failed to propose adequate explanatory mechanisms.



How do we come to know that this relationship is necessarily transitive and symmetric?
... and can therefore generate equivalence classes?

Spatial/diagrammatic reasoning can help us understand this, but we have to see that individual diagrams represent an infinity of distinct cases!

Compare the logicist explanations (Peano, Frege, Russell, etc.) whose psychological plausibility is zero.

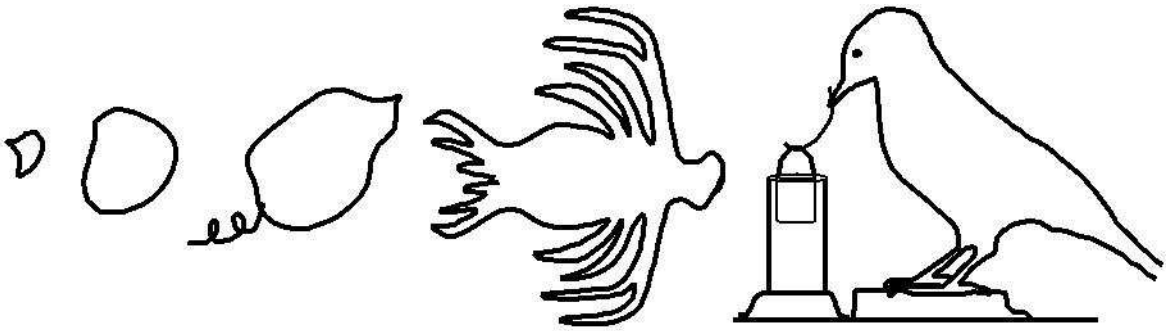
NB There are pseudo numerical, much simpler competences whose inadeqacies most psychological and neural research ignores.
-- They merely involve pattern recognition in small clusters.

Challenge for my view: What neural mechanisms, or sub-neural mechanisms can support these capabilities.

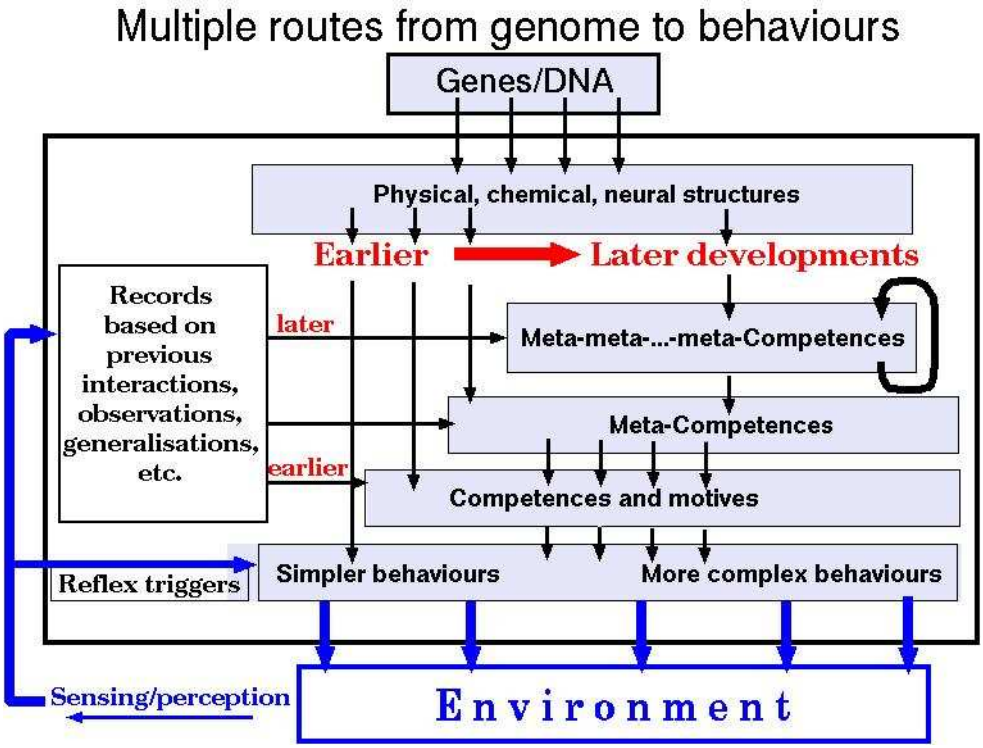
NOBODY KNOWS, AND ALMOST NOBODY IS ASKING.

If there's time we can come back to the problem of finding biological precursors.

- **WHAT TRANSITIONS IN INFORMATION PROCESSING DID EVOLUTION PRODUCE?**
  Why?



- **WHAT SORTS OF PROCESS ARE INVOLVED IN GENE EXPRESSION?**
  THE META-CONFIGURED GENOME
  (Work with Jackie Chappell (2007))



WHICH PARTS INCLUDE ROLES FOR MATHEMATICAL COGNITION?

- **REQUIREMENTS FOR AN ALTERNATIVE TO TURING MACHINERY?**
  -- Replace the Turing Machine tape
  With what? 1-D, 2-D, 3-D, 4-D elements?
  -- Replace the Turing Machine engine
  -- Some quarter-baked thoughts
  For more on this see

  http://www.cs.bham.ac.uk/research/projects/cogaff/misc/super-turing-geom.html
  http://www.cs.bham.ac.uk/research/projects/cogaff/misc/super-turing-phil.html

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- **CONCLUSION: none of the "standard" methods of philosophy, psychology, and neuroscience can answer the key questions.**

  WE NEED NEW MORE POWERFUL EXPLANATORY MECHANISMS

THEY MUST EXIST BECAUSE THEY ARE NEEDED FOR KNOWN FORMS OF INTELLIGENCE, IN HUMANS AND OTHER INTELLIGENT ANIMALS.

Some initial, half-baked (quarter-baked) thoughts about this can be found in
http://www.cs.bham.ac.uk/research/projects/cogaff/misc/super-turing-geom.html
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