

UNIVERSITY OF
PLYMOUTH



BRIC

BRAIN RESEARCH & IMAGING CENTRE

Why computers suck but you are great!

Prof. **Andy J. Wills**

*Brain Research and Imaging Centre,
University of Plymouth.*

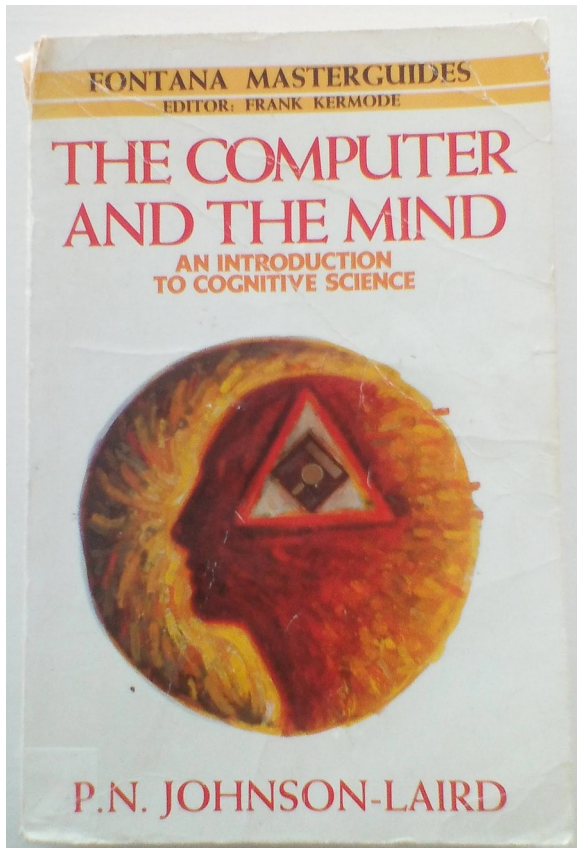
2nd Nov 2021. Exeter University.

Outline

Categorization of everyday objects by humans and machines.

- *General background / back story*
- *Beginners' guide to artificial neural networks (ANN)*
- *How good are ANNs at object categorization?*
- *How good are people at object categorization?*
- *Moravec's paradox and categorization research*
- *How do we do better?*

Background



- Computational models of categorization and perceptual learning

Wills & McLaren (1998, QJEP)

Wills et al. (2000, QJEP)

- Processes of category learning, and selective attention

Milton & Wills (2004, JEP:LMC)

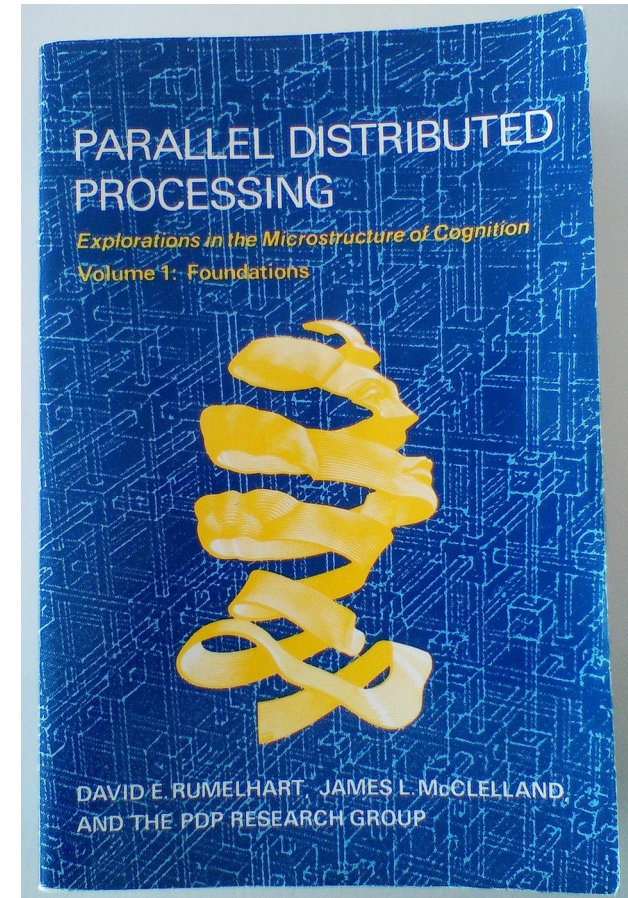
Wills et al. (2007, JoCN)

Wills & Pothos (2012, Psych. Bull.)

Wills et al. (2015, Cog. Psy.)

Le Pelley et al. (2016, Psych. Bull)

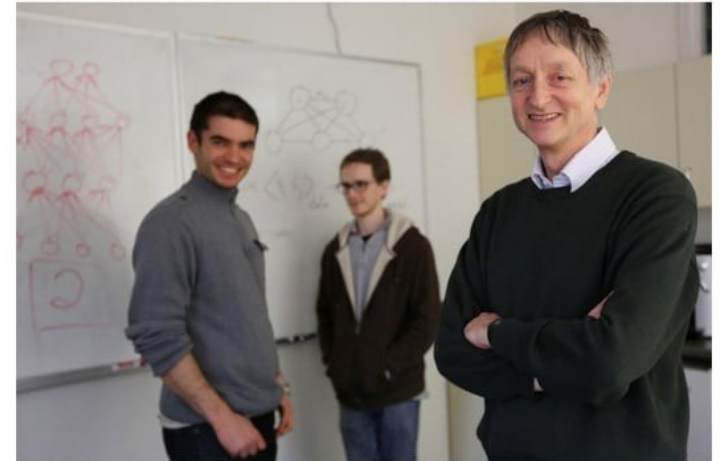
Schlegelmilch et al. (2021, Psyc. Rev.)



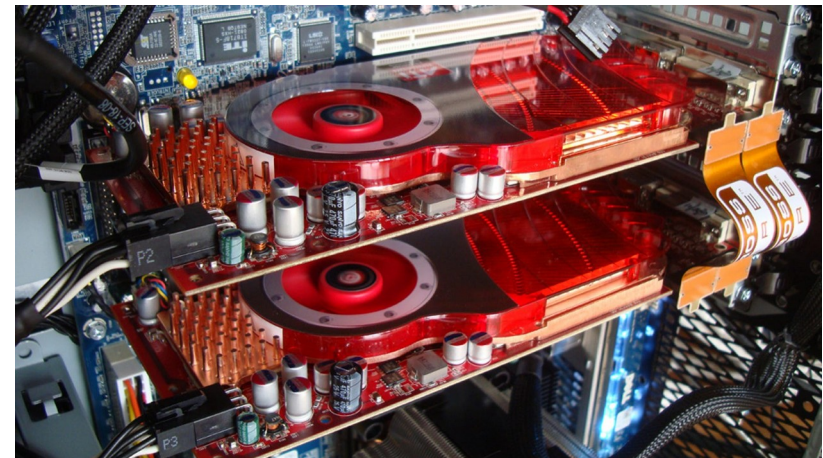
Background

- Can psychology aid the development of artificial intelligence?

- Can artificial intelligence aid the development of psychological theory?



Ilya Sutskever, Alex Krizhevsky, Geoffrey Hinton

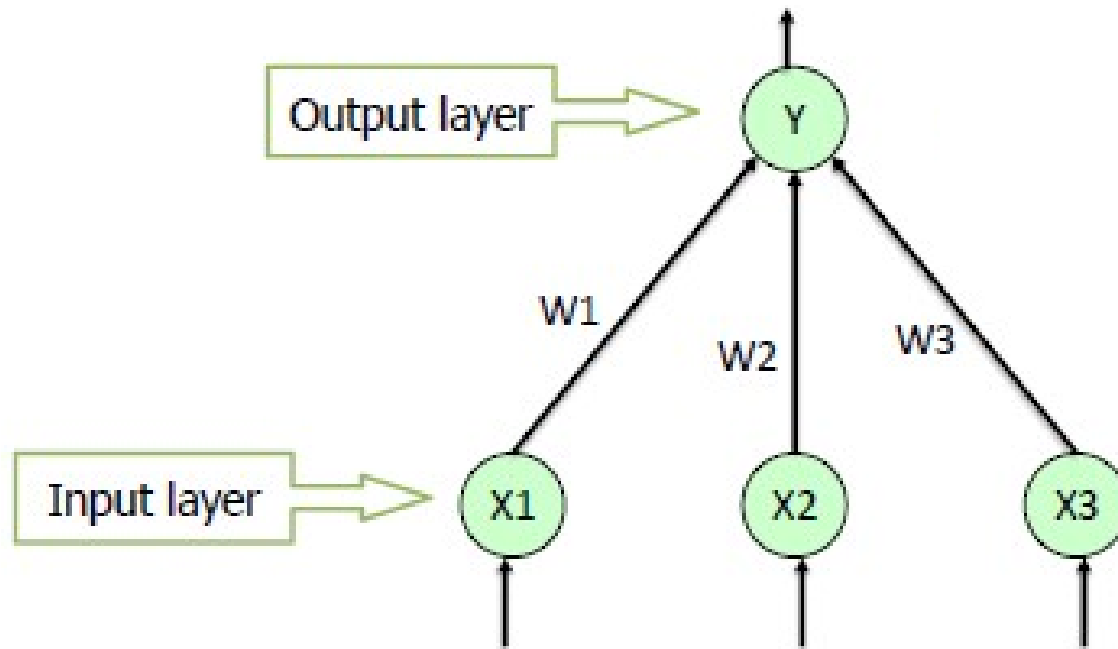


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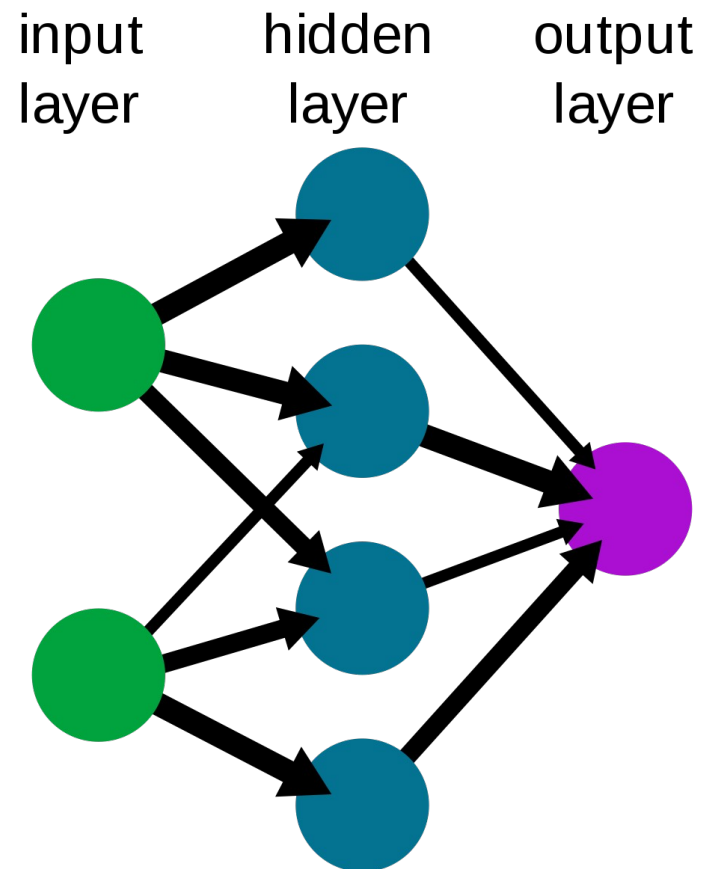
Categorization of everyday objects by humans and machines.

- *General background / back story*
- ***Beginners' guide to artificial neural networks (ANN)***
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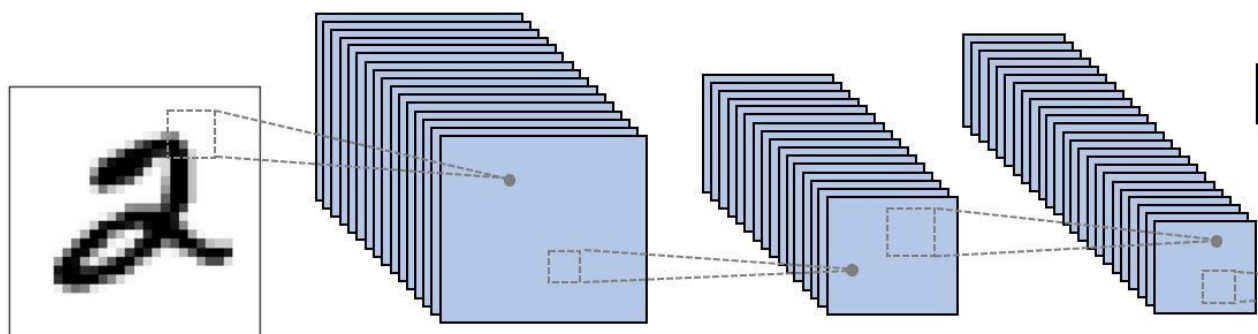
Shallow neural networks



Deep neural networks



Convolutional neural networks



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How good are they?

“recent advances from machine learning led to the discovery of hierarchical neural network models that achieved near-human-level performance level on challenging object categorization tasks”

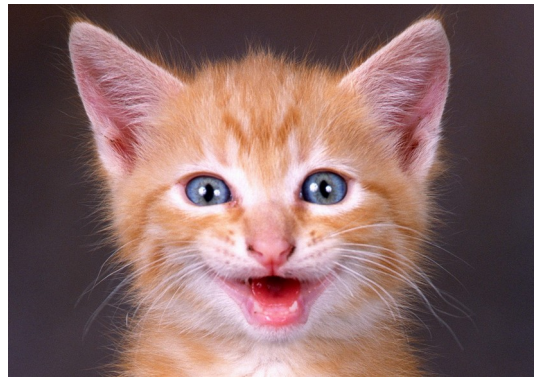
- Yamins & DiCarlo (2016)

Can you be more specific?

PNASNet:

- 96.2% Top-5 accuracy on ImageNet (Liu et al., 2018)

- (1) Hatstand
- (2) Orange
- (3) Battleship
- (4) Dandelion
- (5) Cat

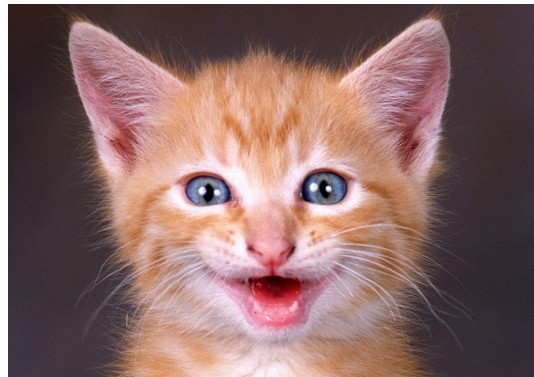


How about a sensible answer?

PNASNet:

~73% Top-1 accuracy on ~300 ImageNet categories
(Barbu et al., 2019)

- (1) Cat
- (2) Orange
- (3) Battleship
- (4) Dandelion
- (5) Hatstand



Barbu et al. (2019)



Internet objects
72% correct



Objects in the real world
30 % correct

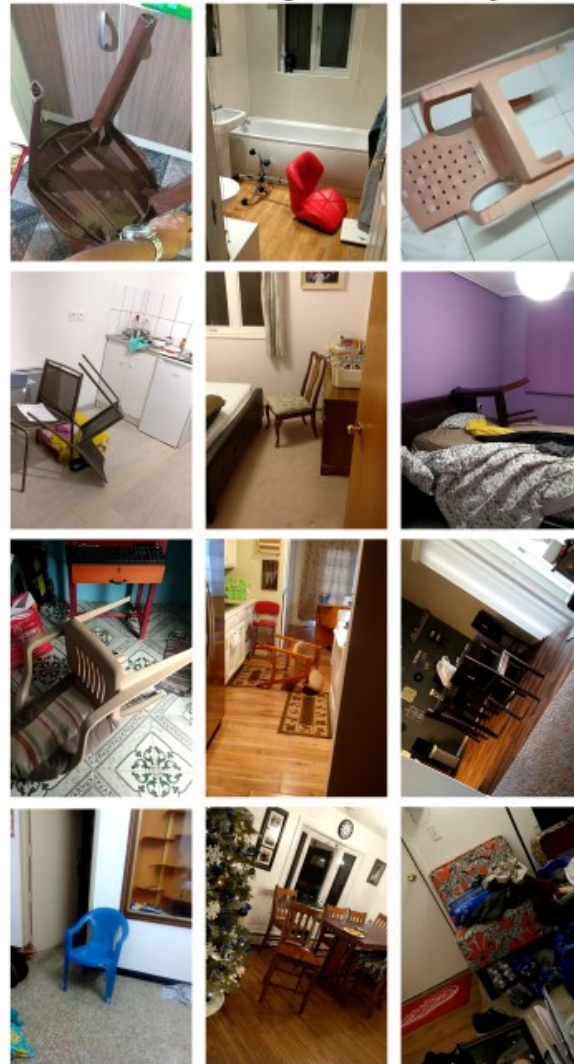


Outline

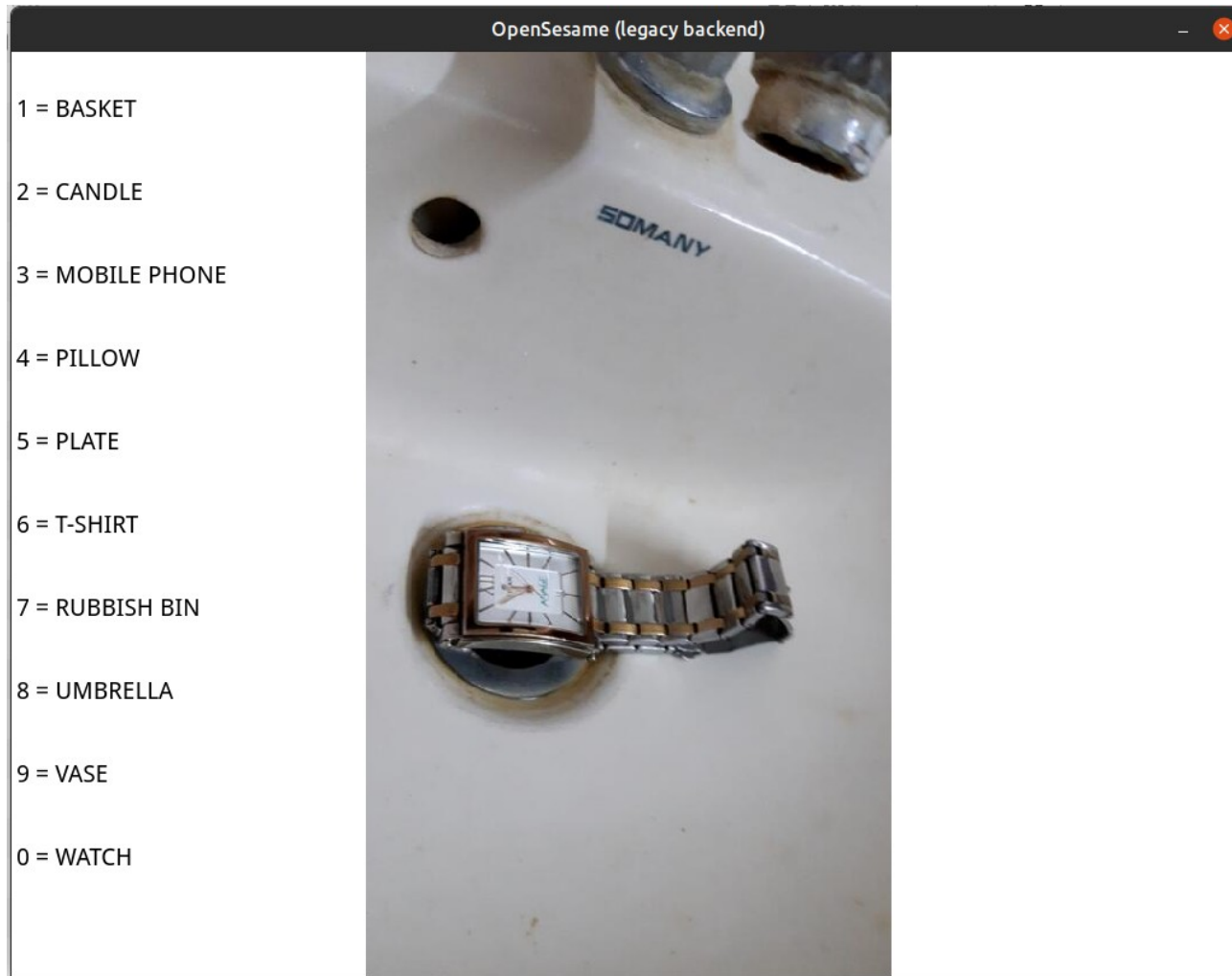
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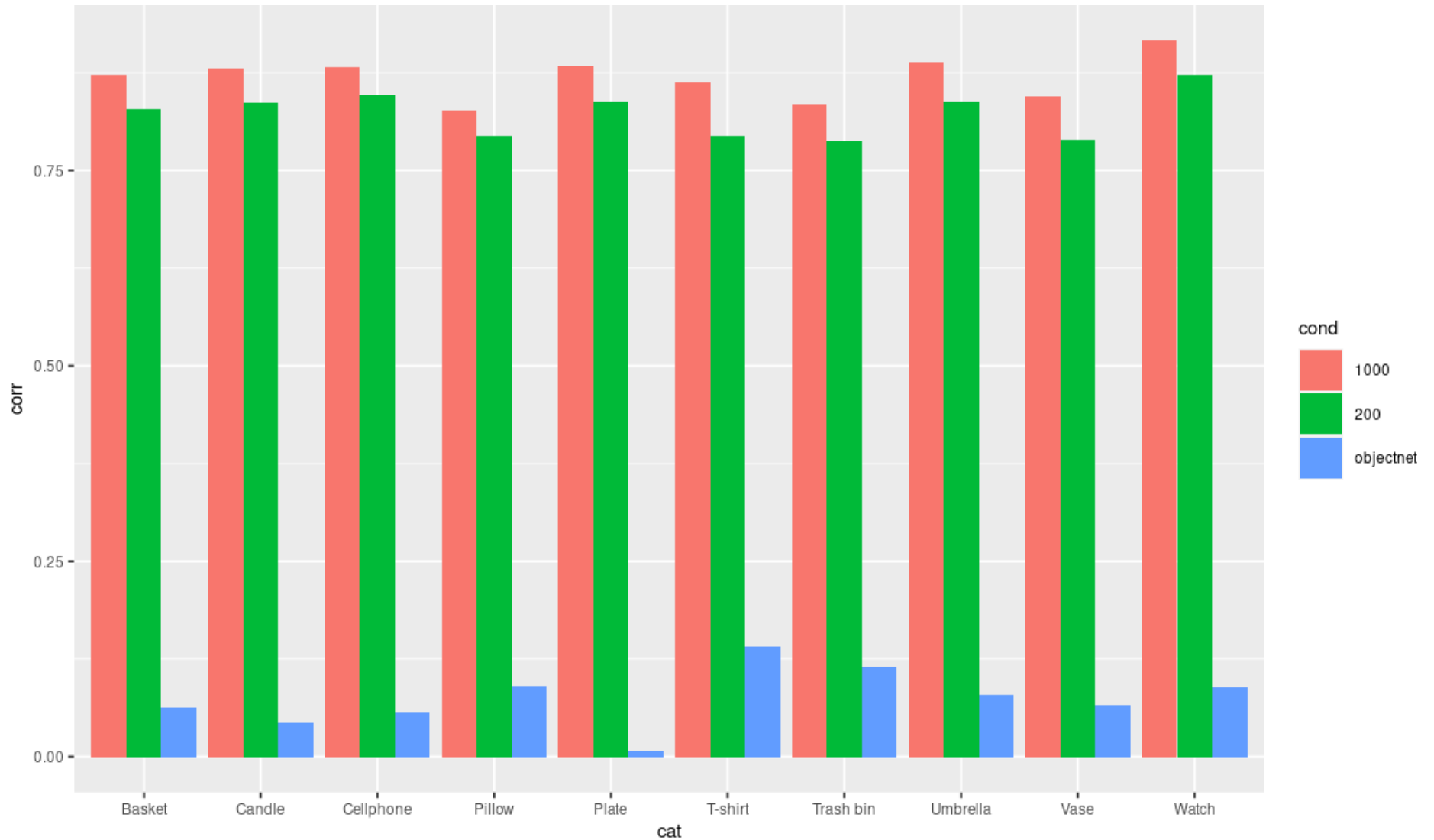
How good are people?



Experiment



Results

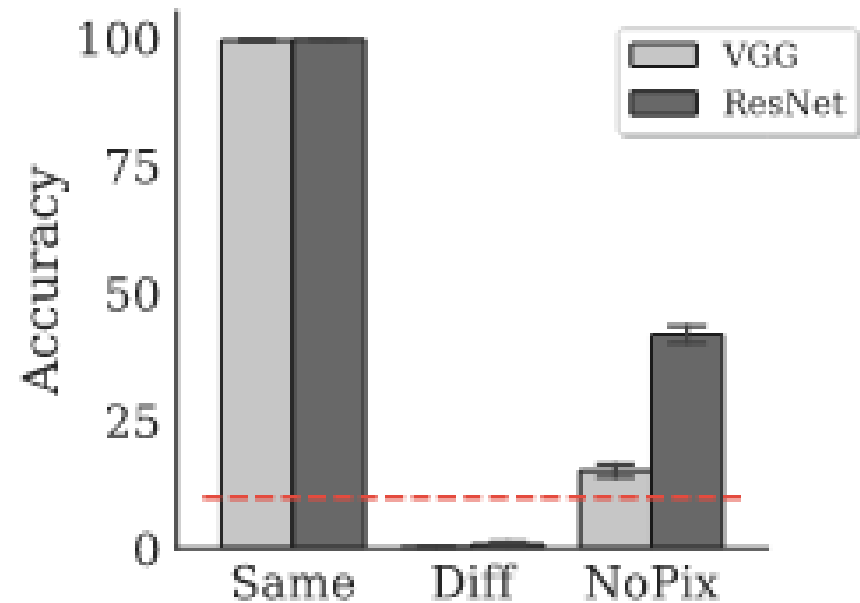


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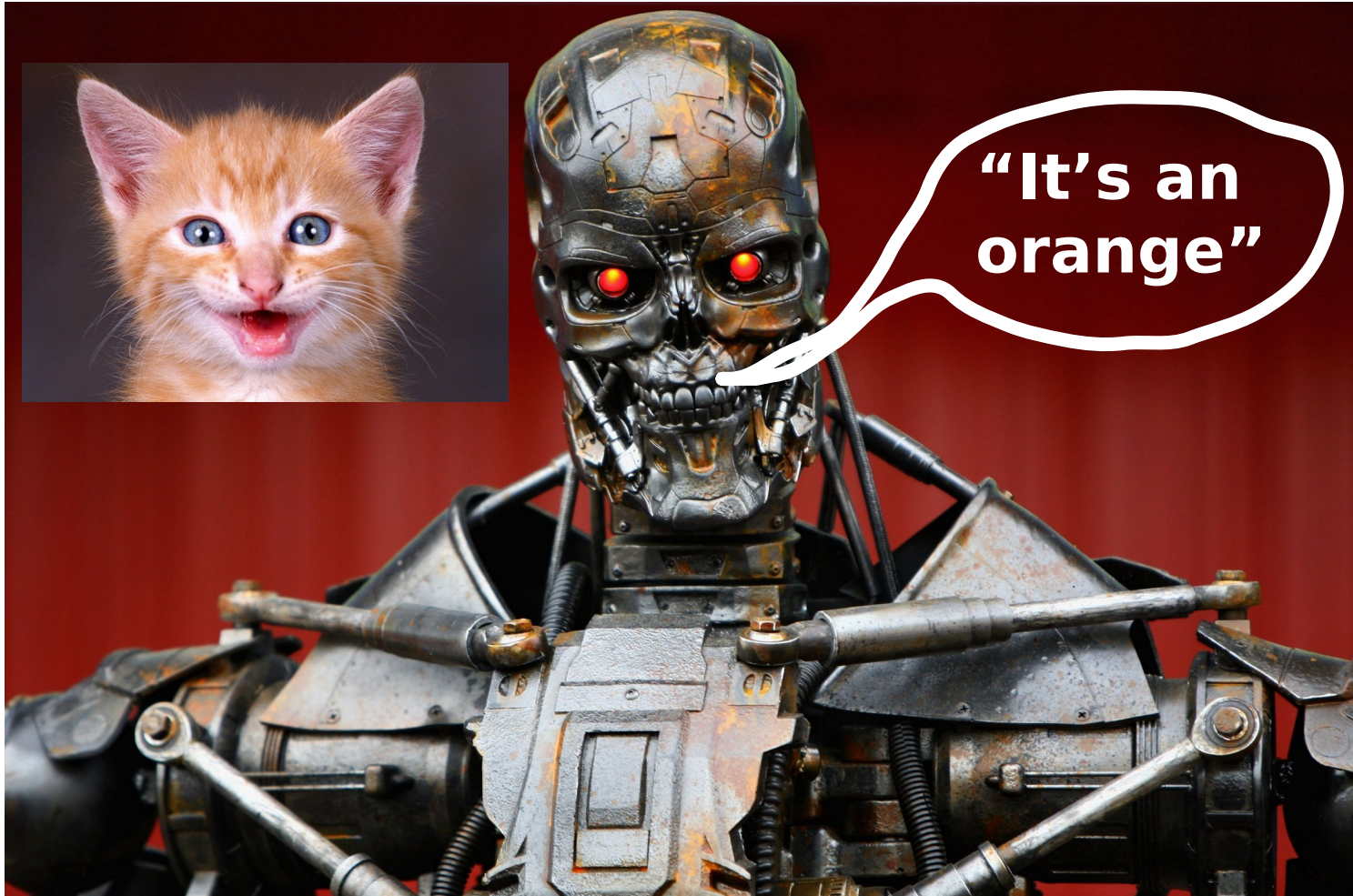
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Overly sensitive to tiny local features



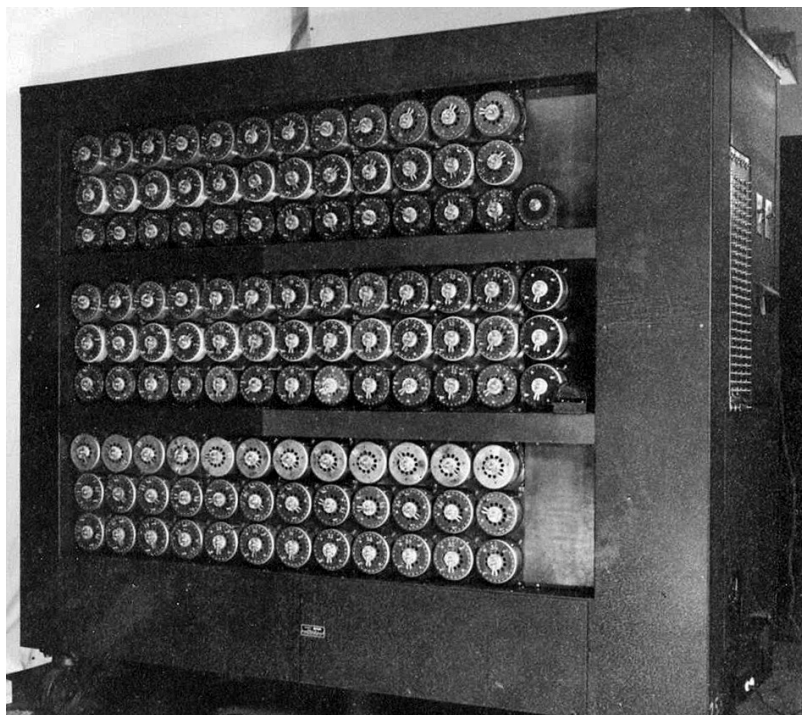
(c) Single diagnostic pixel

Why is this so hard?



Intelligent machines

1939

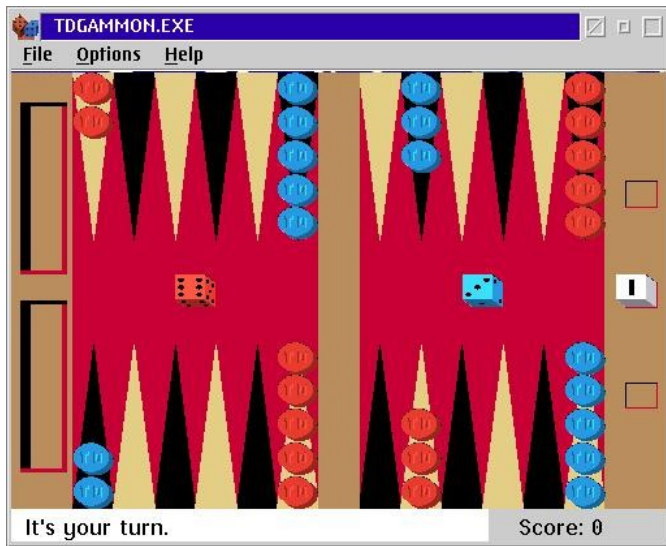


1972

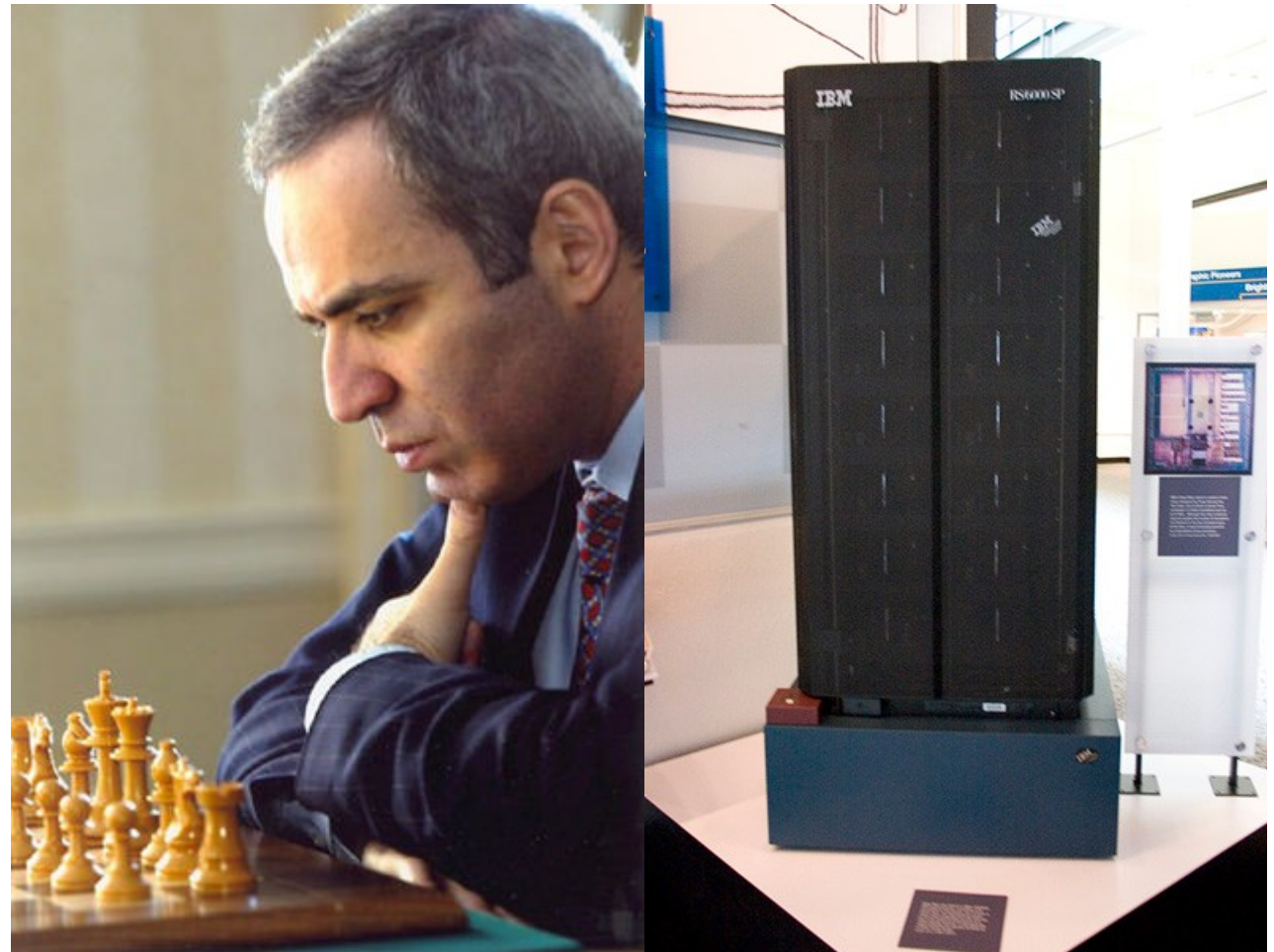


Intelligent machines

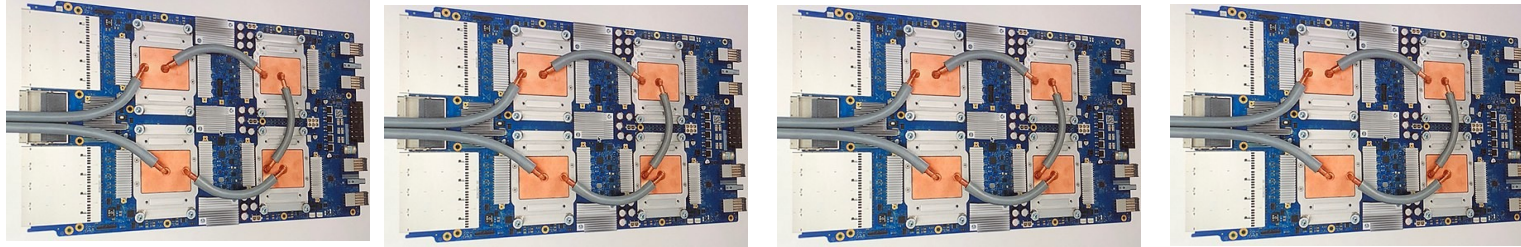
1992



1997



Intelligent machines



2017



Moravec's paradox (1988)

"It is comparatively easy to make computers exhibit adult level performance on intelligence tests or playing checkers, and difficult or impossible to give them the skills of a one-year-old when it comes to perception and mobility"



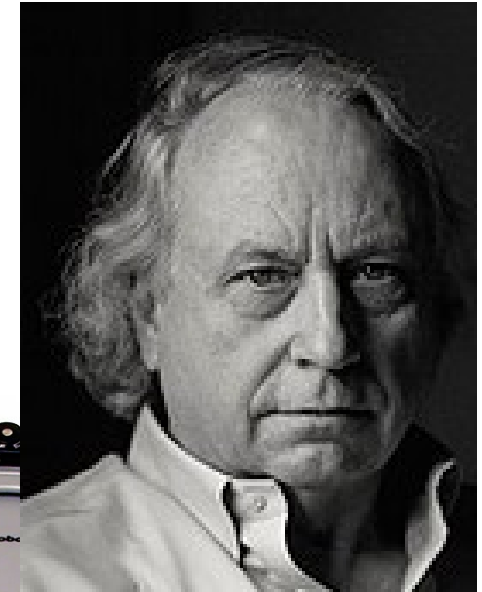
Rodney Brooks

In early AI research, intelligence was characterized as

"the things that highly-educated male scientists found challenging"

while

"things that children of four or five years could do effortlessly, such as visually distinguishing between a coffee cup and a chair...were not thought of as activities requiring intelligence"

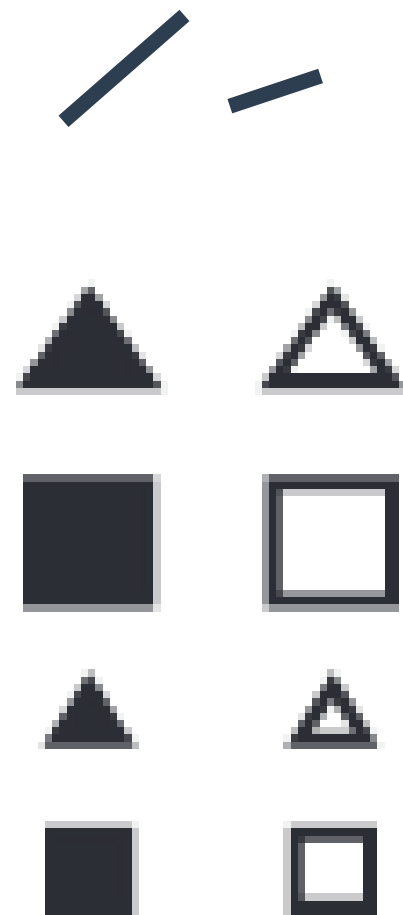


Categorization research as problem solving research

- **Geometrically simple, abstract stimuli.**

- **A world of two categories.**

- **Simple, plausible and effective rules.**



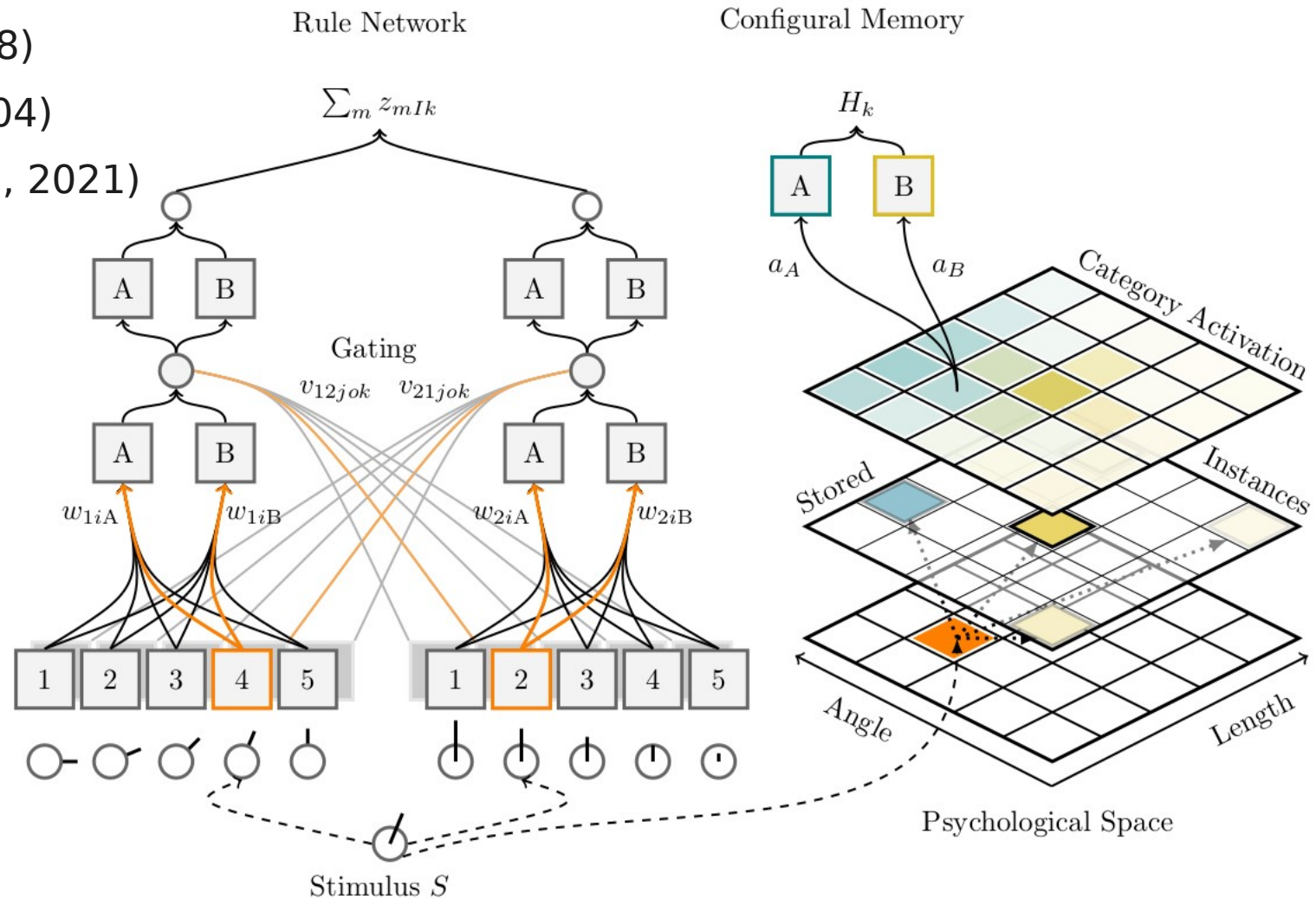
Formal models of categorization

Psychological Review

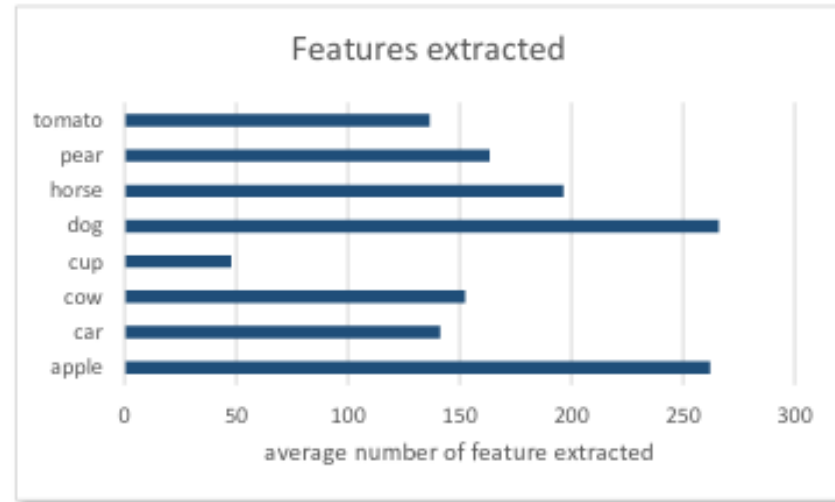
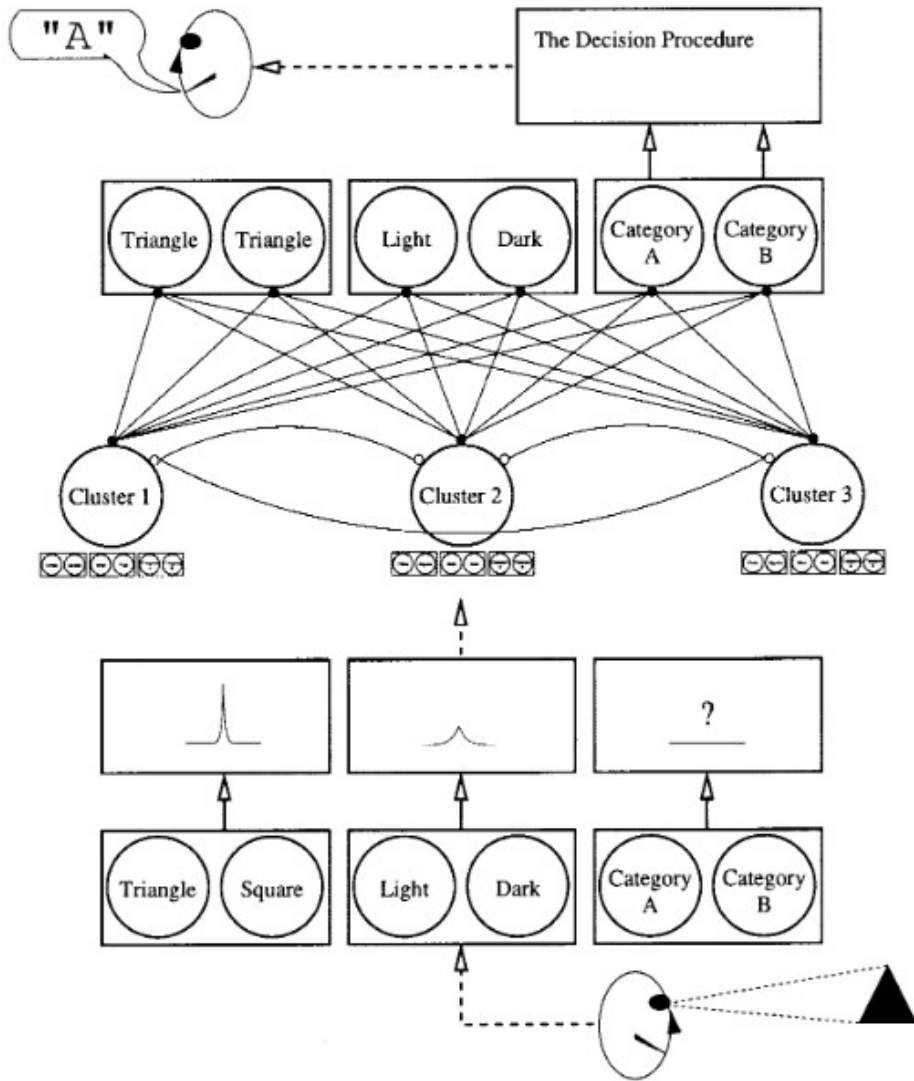
COVIS (Ashby et al., 1998)

SUSTAIN (Love et al., 2004)

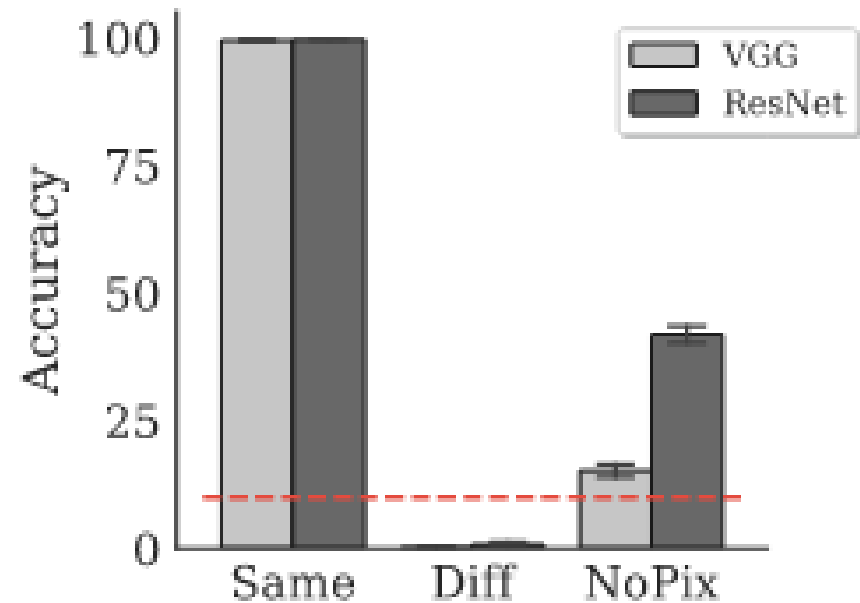
CAL (Schlegelmilch et al., 2021)



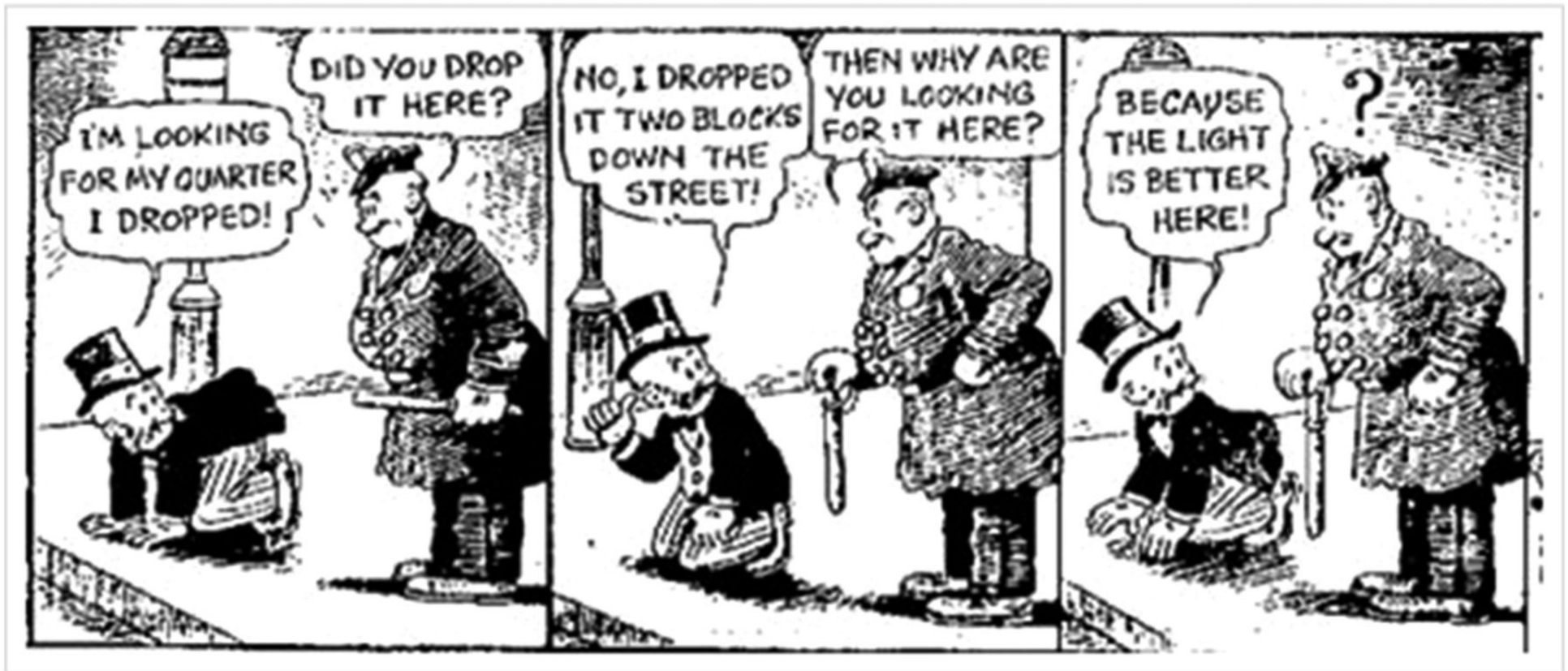
Carmantini et al. (2014)



Overly sensitive to tiny local features



(c) Single diagnostic pixel



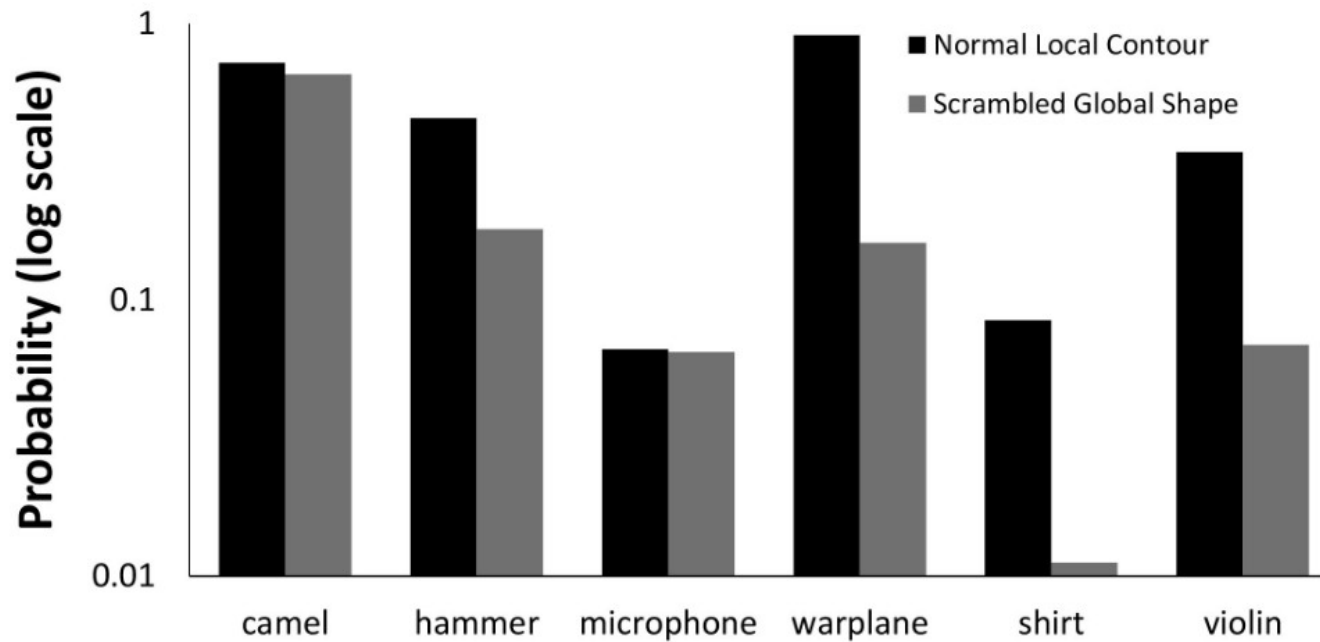
Fisher & Smith (1942, June). *Mutt & Jeff*. Syndicated comic strip

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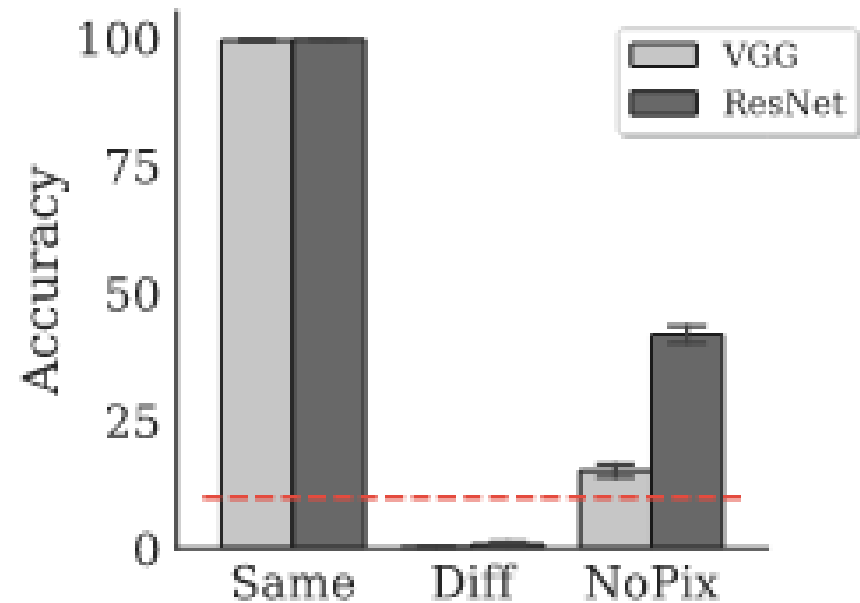
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Insufficiently sensitive to shape



Overly sensitive to tiny local features



(c) Single diagnostic pixel

Possible areas for improvement

- **Take the neuroscience more seriously (Tsvetkov et al., 2020)**
- **Bias the learning rule against simple solutions (Dagaev et al., 2021)**

Any questions?

