Processes of overall similarity sorting

Andy J. Wills
University of Exeter
U.K.

Concat – NYU- Nov 2009

With thanks to…

Faculty
Stephen Lea
Tim Hodgson
Lisa Leaver

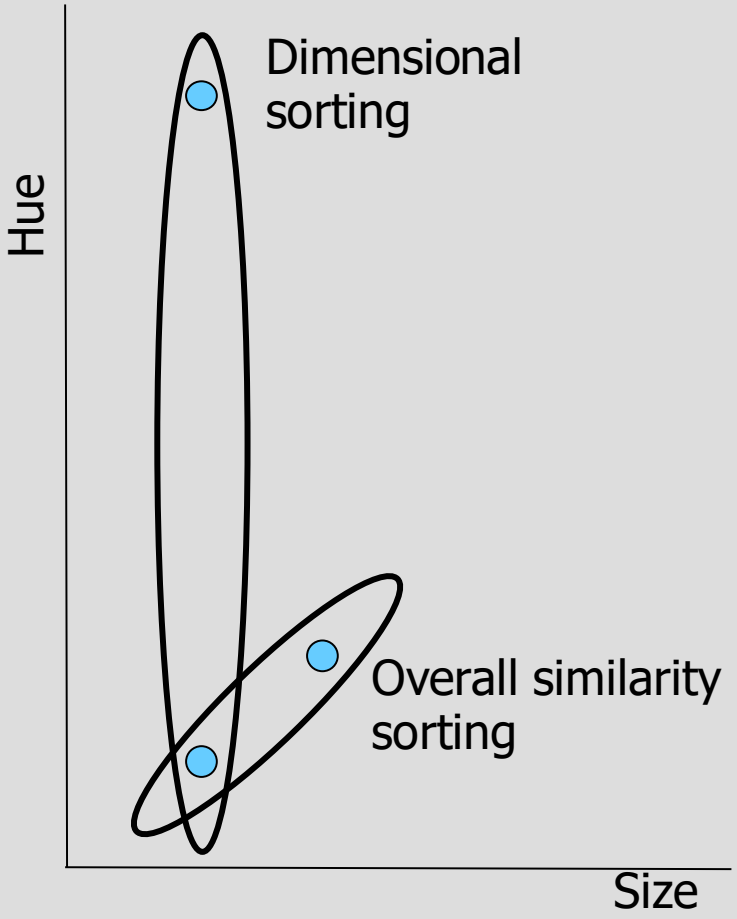
Post-docs (Cog/Neuro)
Fraser Milton
Chris Longmore

Post-docs(Comparative)
Britta Osthaus
Mark Suret
Catriona Ryan.

Research Assistants (Comparative)
Sue Chapman
Lou Millar

Funding
ESRC
European Commission

A classic result

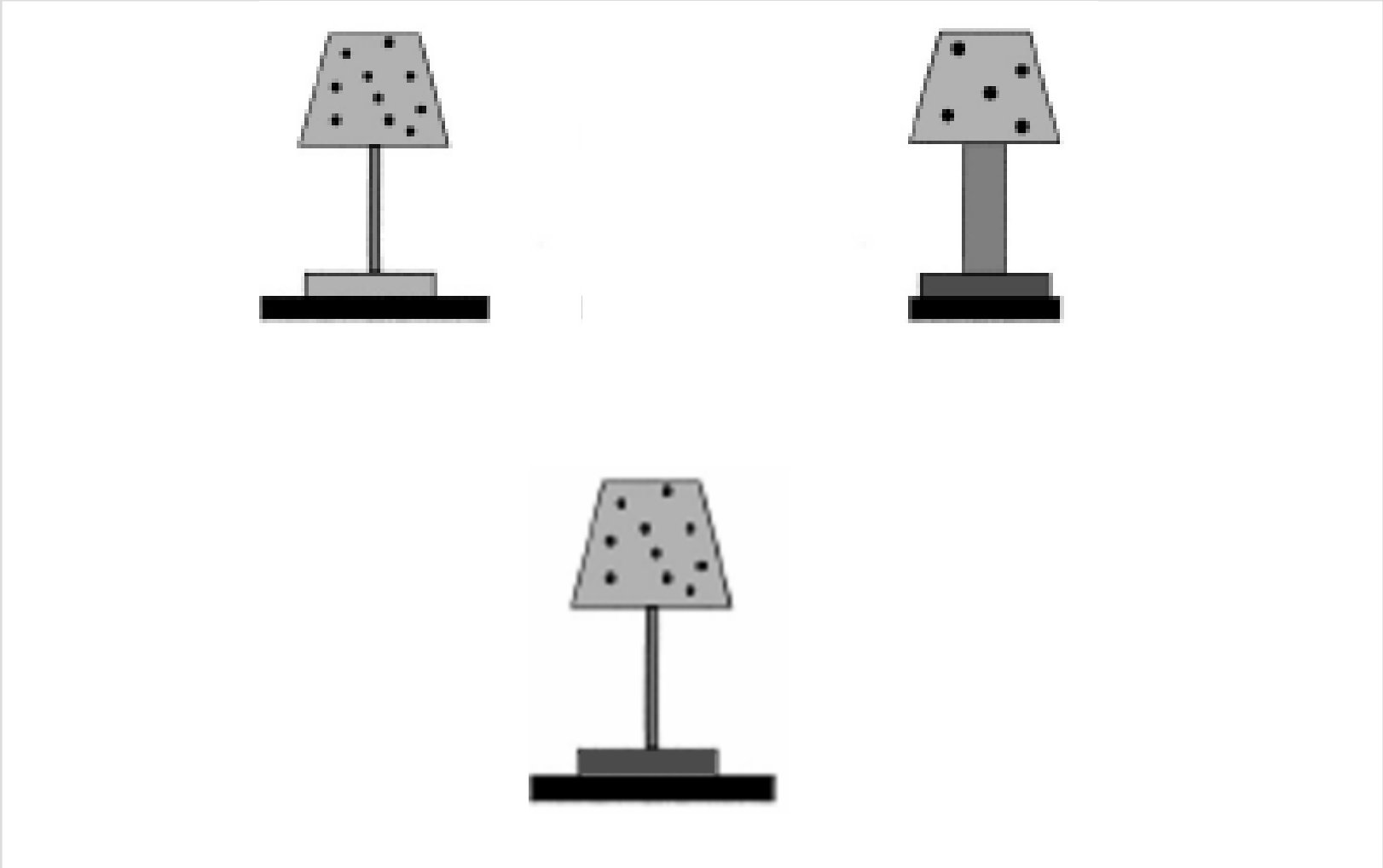


- Smith and Kemler Nelson (1984)
- Triad procedure
- Overall similarity classification is enhanced by:
  - Integrality
  - Time pressure
  - Cognitive load
  - Impulsivity
  - Youth

“Deliberative” thought

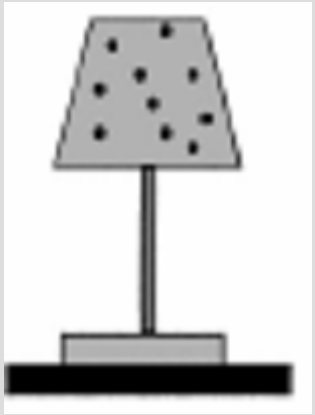
- Associative processes are automatic and based on overall similarity. Rule-based processes are strategic, and work on a subset of the features (Sloman, 1996) .
- “[The results of Smith & Kemler Nelson] are easily predicted by COVIS if the reasonable assumption is added that processing time for the verbal system is greater than processing time for the implicit system” (Ashby et al., 1998).
- “In similarity-based categorization, category membership is determined by overall similarity … Rule-based categorization is employed when specific features must be considered …This process is resource demanding” (Koenig et al., 2005).
- “conscious thought suffers from the low capacity of consciousness, making it less suitable for very complex issues. Unconscious thought does not suffer from low capacity”. Dijksterhuis (2006).

Match-to-standards procedure



OS and UD sorting

1 1 1 1



0 0 0 0

Overall similarity

1 1 1 1
0 1 1 1
1 0 1 1
1 1 0 1
1 1 1 0

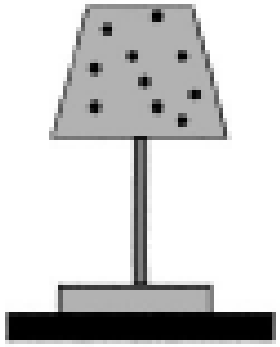
0 0 0 0
1 0 0 0
0 1 0 0
0 0 1 0
0 0 0 1

Unidimensional

1 1 1 1
1 0 0 0
1 0 1 1
1 1 0 1
1 1 1 0

0 0 0 0
0 1 1 1
0 1 0 0
0 0 1 0
0 0 0 1

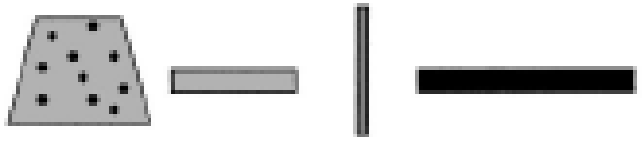
Spatial integration effect



OS 9

UD 9

Spatially integrated



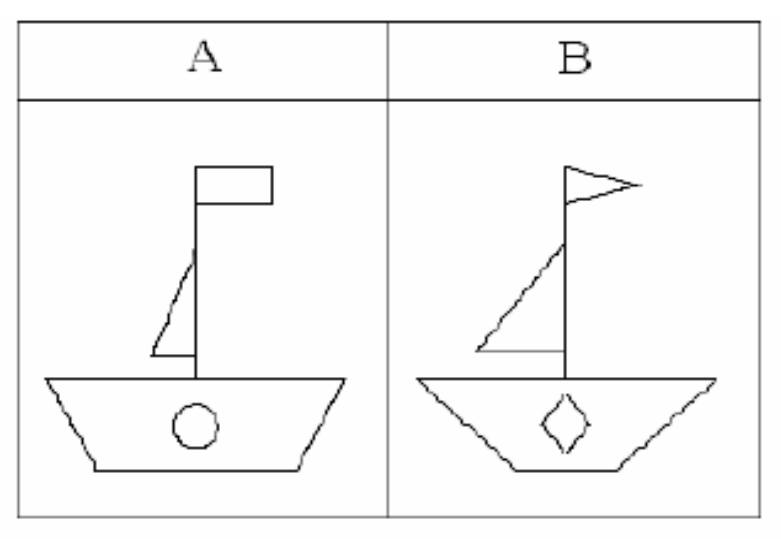
OS 13

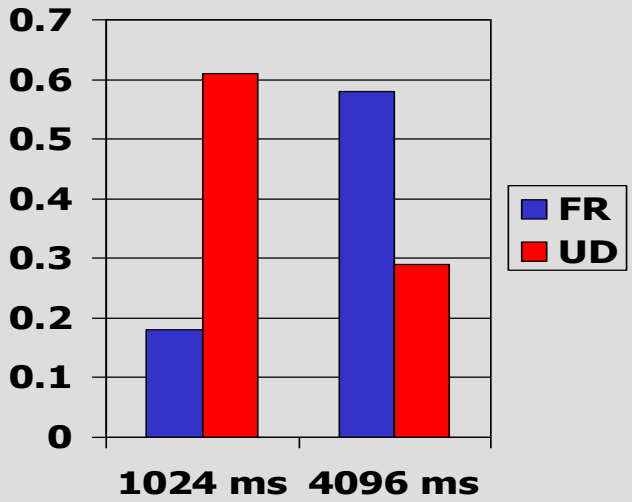
UD 5

Spatially separate

Milton & Wills (2004)

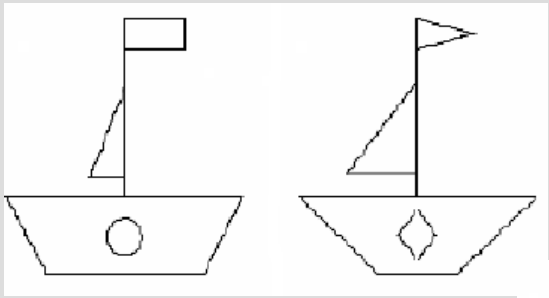
Presentation time





- Milton, Longmore & Wills (2008)

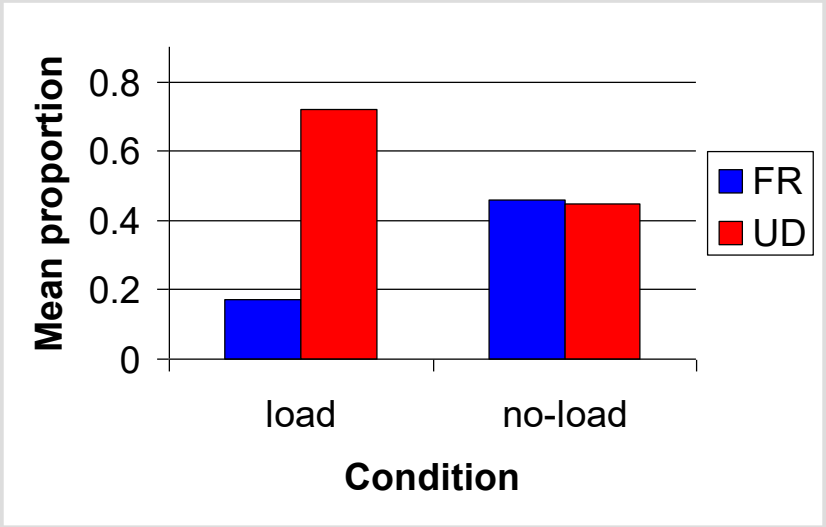
Concurrent load



"6 .. 4 .. 9 .. 2 .. 8 .. 1"

A or B?

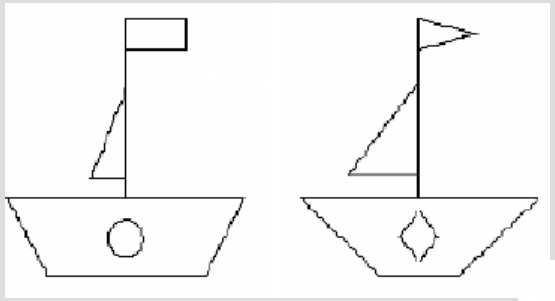
9

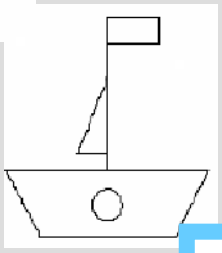


Milton, Longmore and Wills (2008)

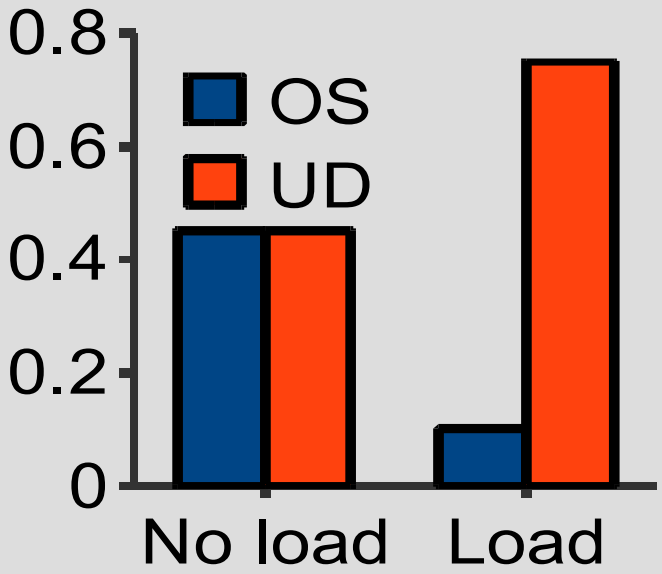
Concurrent load

"...11...48 ... 9 ... 87 ... 45 ... 78 ... 23 ... 91 .. 43 ... 82 ..."



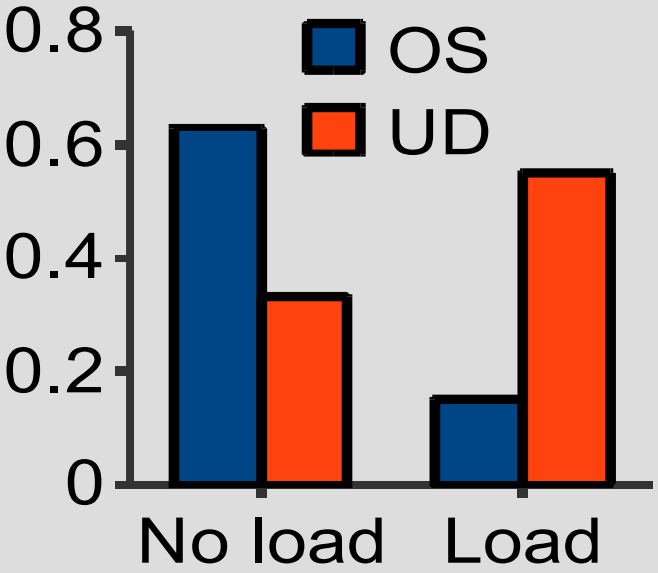


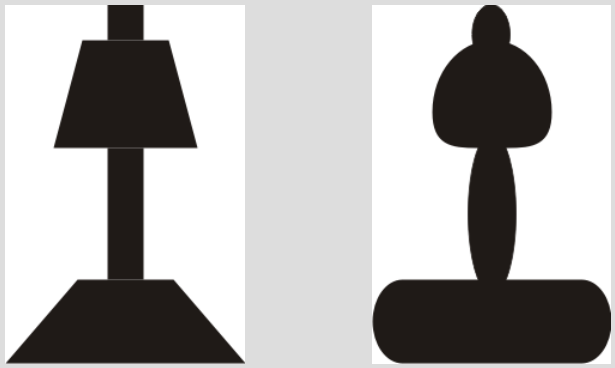
A or B?



Longmore, Milton & Wills (in preparation)

Concurrent load

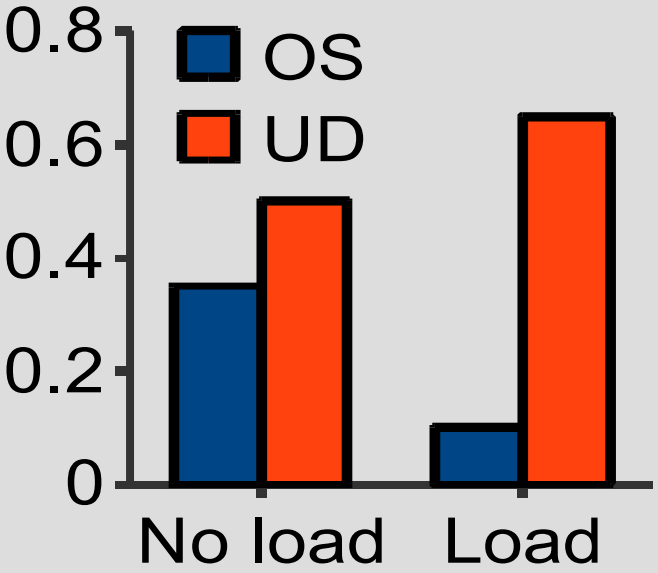


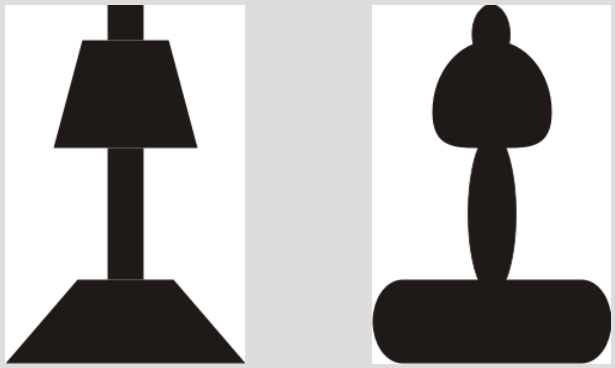


1500ms

Longmore, Milton & Wills (in preparation)

Concurrent load



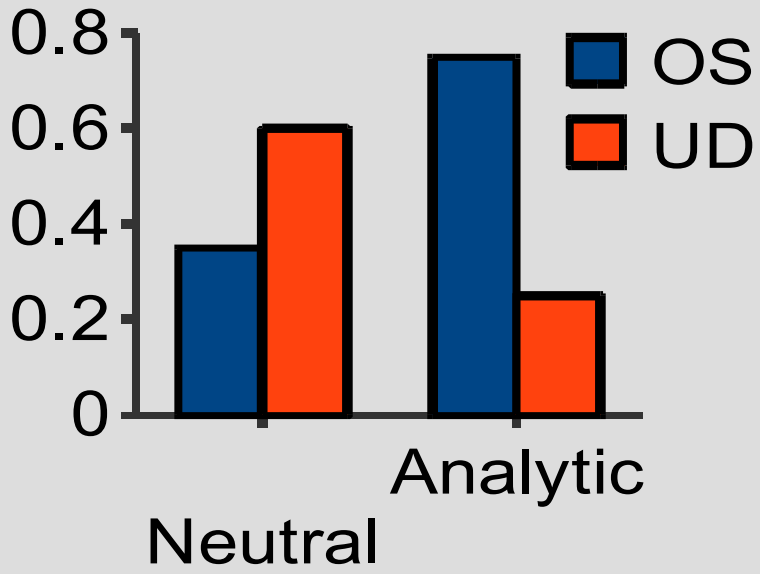


300ms

Longmore, Milton & Wills (in preparation)

Instructions

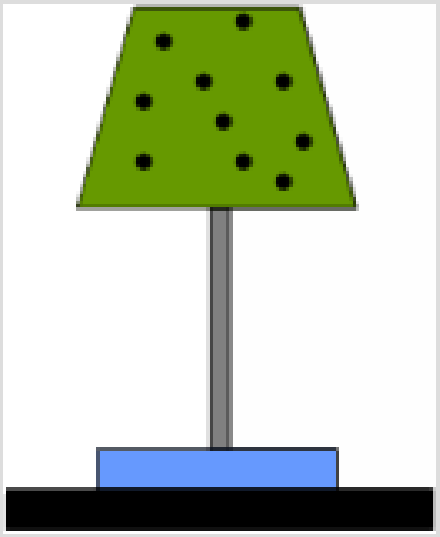
- The pictures you are about to see are quite complex. You should take particular care in your evaluation of how they differ. Study each image in detail. BE METICULOUS! BE CAREFUL!!

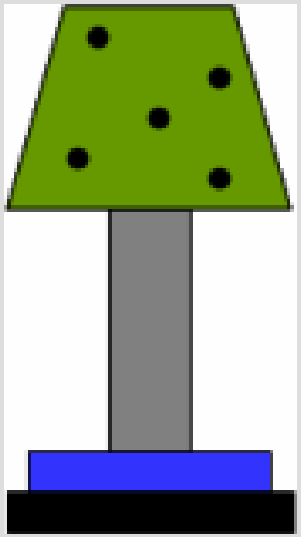


Longmore, Milton & Wills (in preparation)

Working memory capacity

- Operation span (OSPAN)
- OS sorters' mean span: 3.7
- UD sorters' mean span: 2.3

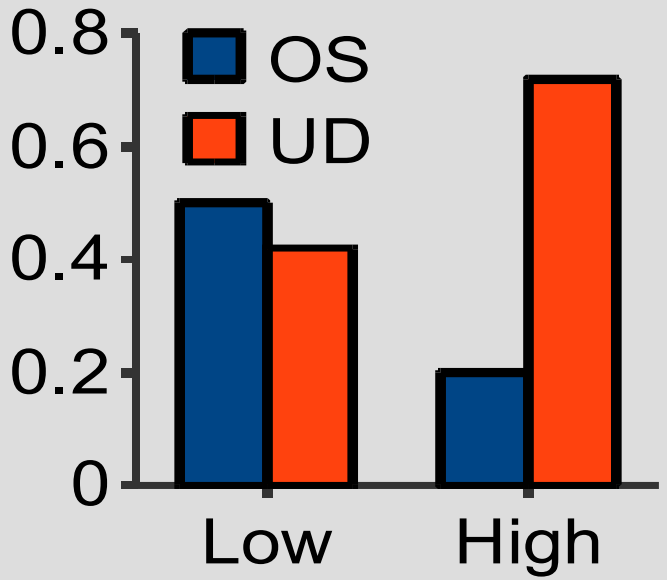




Longmore, Milton & Wills (in preparation)

Impulsivity

- Barrett Impulsivity Scale
- Median split



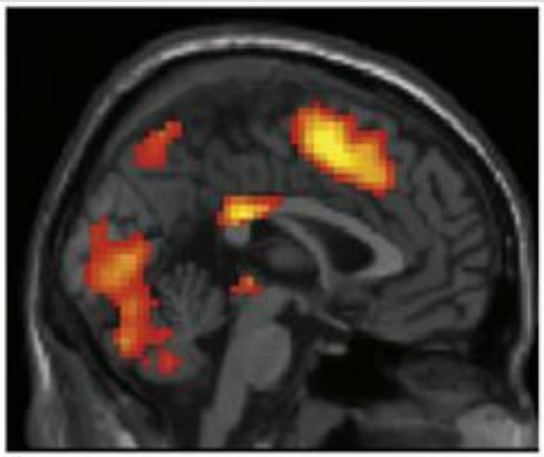
Longmore, Milton & Wills (in preparation)

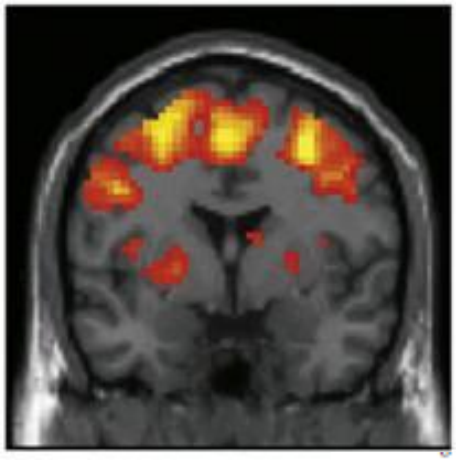
Neuroscience

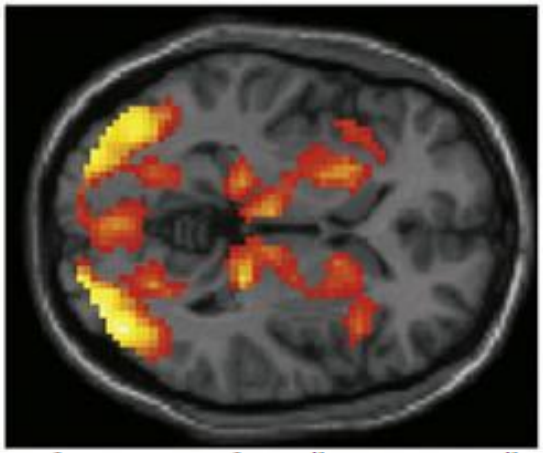
“Generally, it seemed that the authors did not meet the burden of defending the idea that FR responding is an effortful, explicit, analytic thing… They are arguing counter to the excellent literature on the cognitive neuroscience of category learning. There, it seems clear that prefrontal areas do unidimensional, rule-based things. It seems clear that the basal ganglia or the tail of the caudate do multidimensional, information-integration things”.

- Anonymous JEP:LMC reviewer

Conjunction analysis





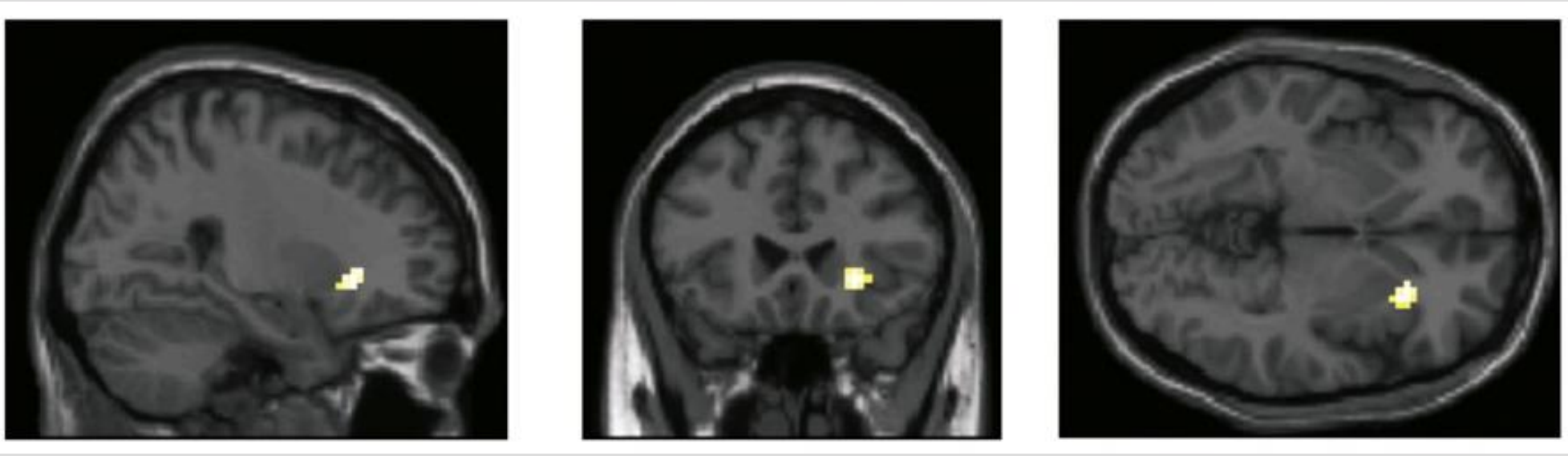


Region	Cluster size	BA	Talairach coordinates			z-score
			x	y	z	
Right posterior cerebellum	9629	–	33	−56	−12	>8.00
Right middle occipital gyrus		19	42	−78	7	7.83
Left middle occipital gyrus		19	−33	−84	18	7.76
Anterior cingulate	115	23	0	−28	24	6.23
Right sub-lobar thalamus	1145	–	21	−29	4	6.07
Left sub-lobar thalamus		–	−12	−20	9	5.88
Left brainstem		–	−6	−20	−1	5.47
Left dorsolateral frontal cortex	66	46	−42	30	23	5.17
Left dorsolateral frontal cortex		46	−48	25	26	3.24
Left sub-lobar insula	25	13	−36	−2	11	4.82
Right anterior cerebellum	29	–	6	−39	−26	4.21
Right anterior cerebellum	12	–	0	−59	−27	3.94
Left brainstem	14	–	6	−39	−26	3.76
Right middle prefrontal cortex	7	10	42	41	12	3.37

Note. BA = Brodmann's area. Indented rows indicate voxels in the same cluster as the non-indented row above them.

Milton, Wills & Hodgson (2009)

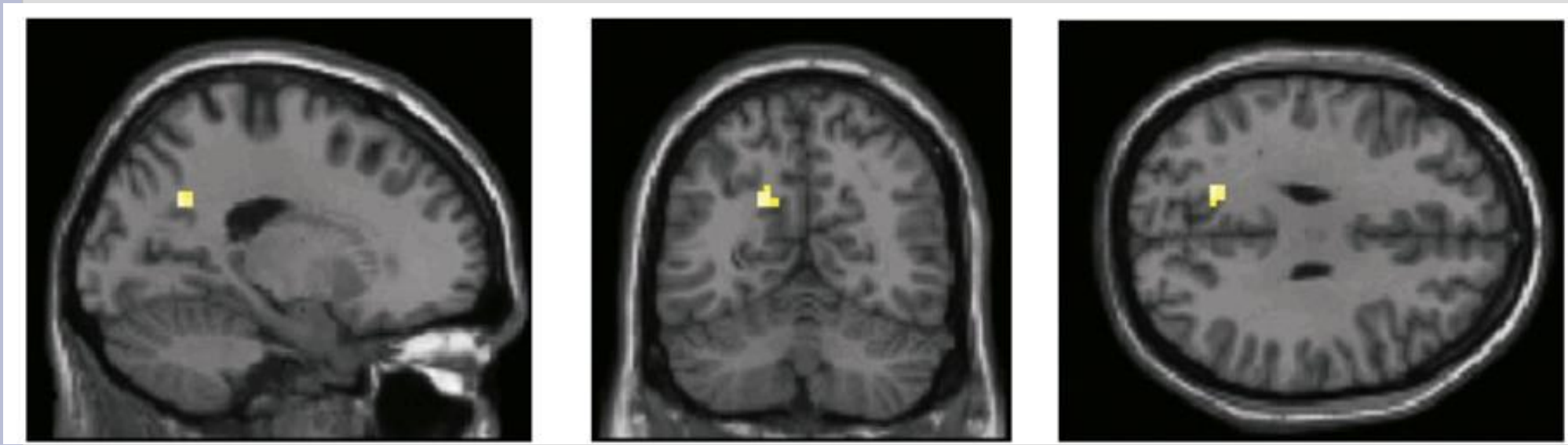
OS - UD



Includes: ventrolateral frontal cortex

Milton, Wills & Hodgson (2009)

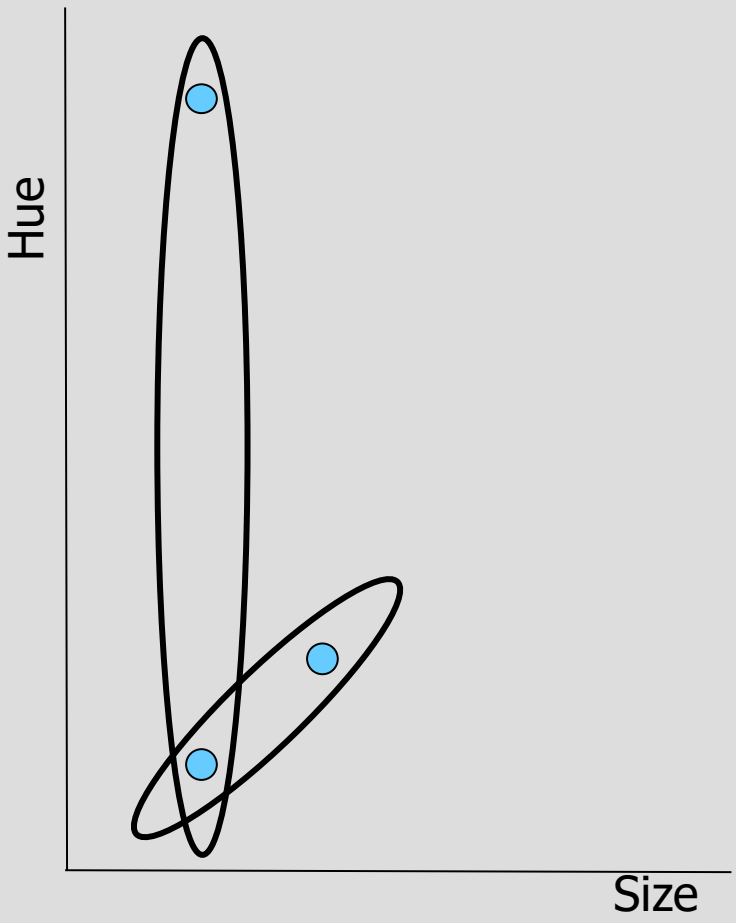
UD - OS

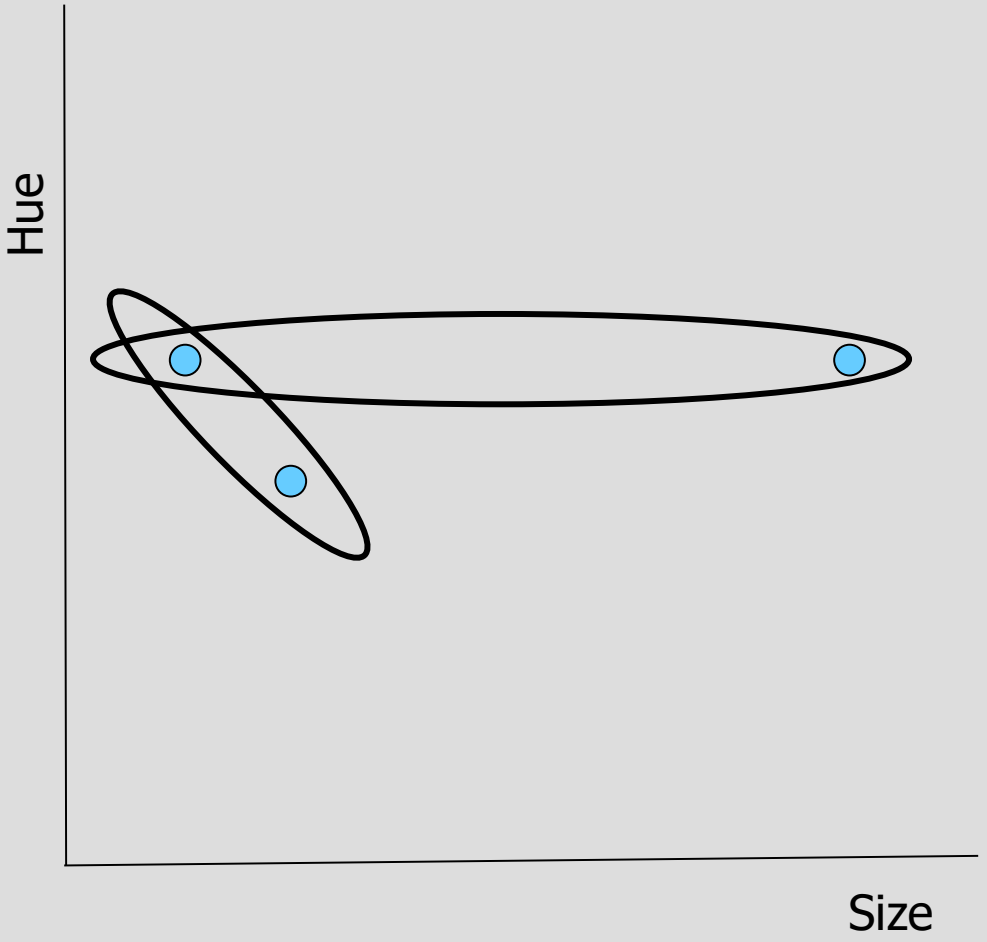


Includes: superior parietal lobe

Milton, Wills & Hodgson (2009)

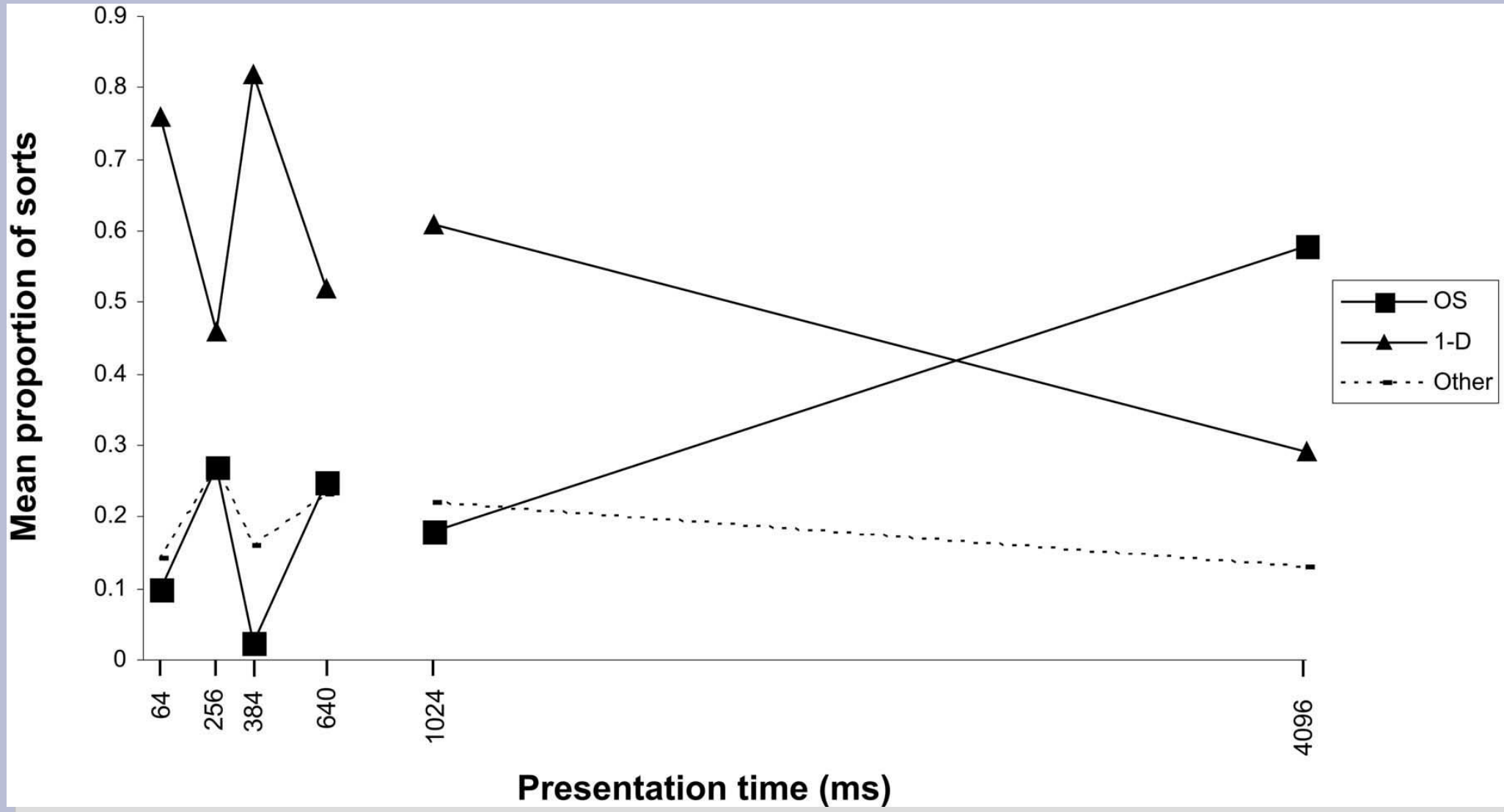
Triad task – issues of analysis





Thompson (1994); Raijmakers et al.,(2004)

Back to time pressure



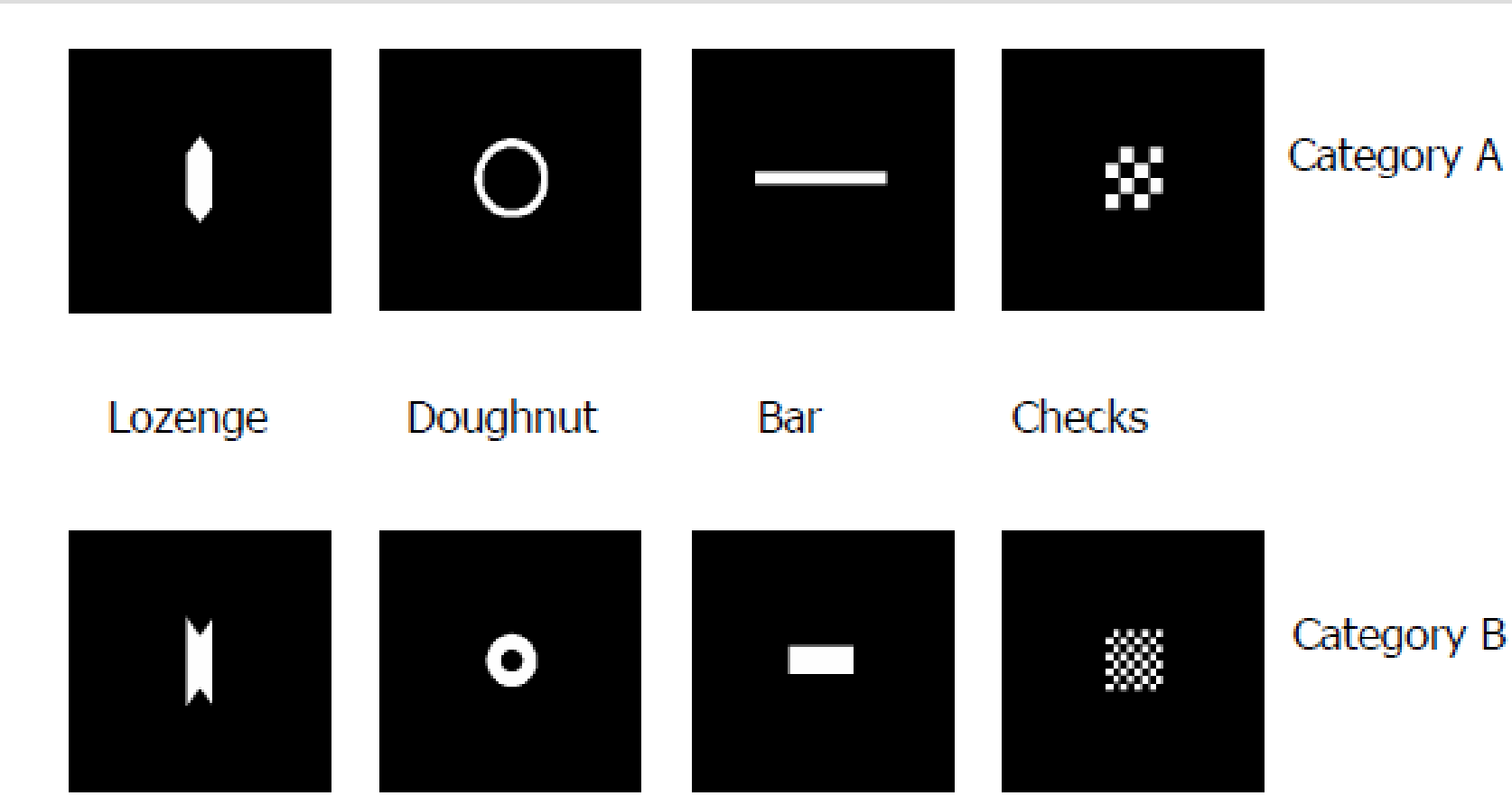
- Milton, Longmore & Wills (2008)

Comparative cognition

"While humans are presumably capable of either rule-based or associative categorization, most authors would assume that in other animals only the associative learning mechanism is available .. We would therefore expect [on the basis of the ruled-based = unidimensional account] … that, in animal cognition overall similarity sorting would be the usual finding".

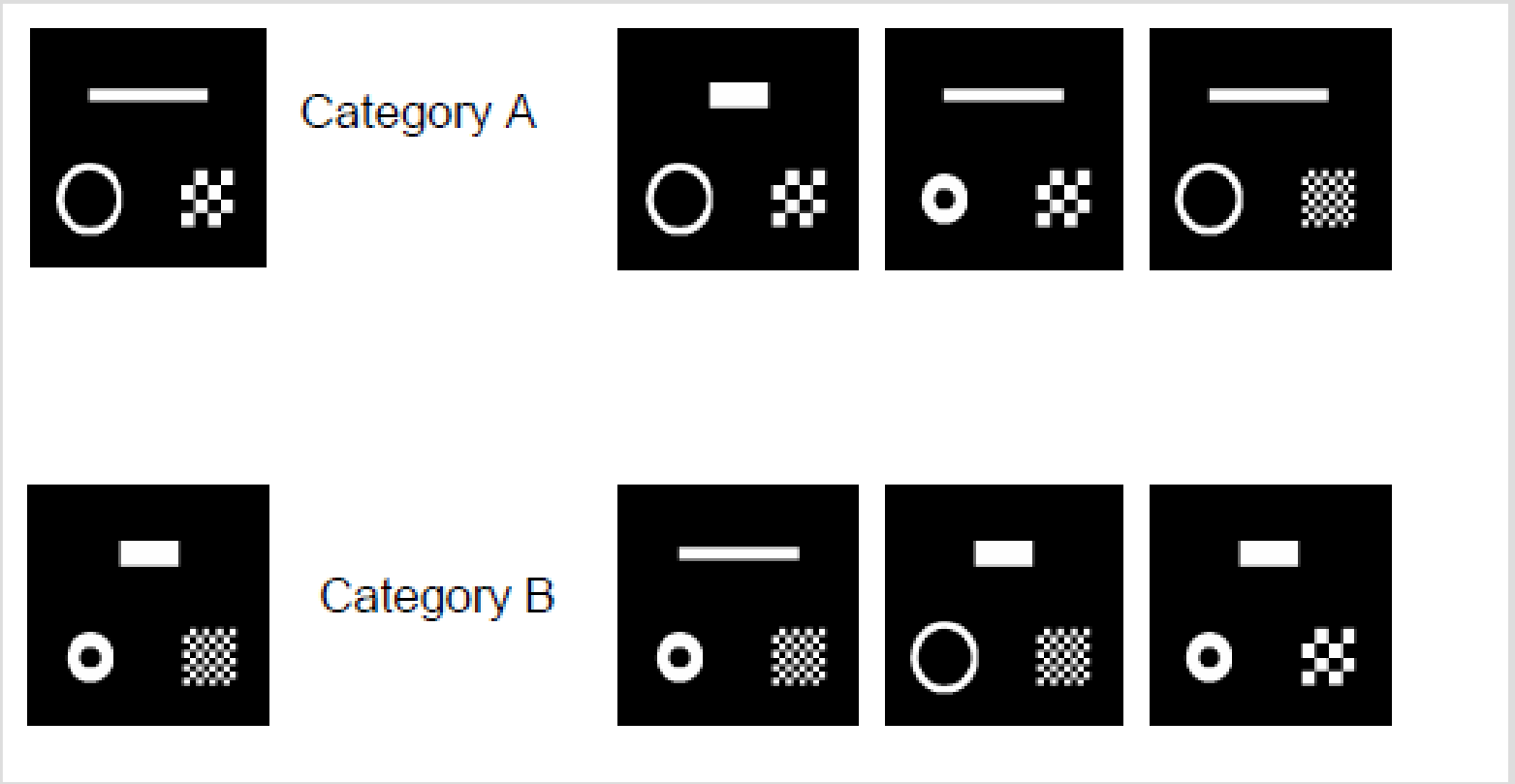
- Lea & Wills (2008, p. 116)

Free sorting in pigeons



Wills, Lea, Leaver, Osthaus, Ryan, Suret, Bryant, Chapman & Millar (in press)

Free sorting in pigeons



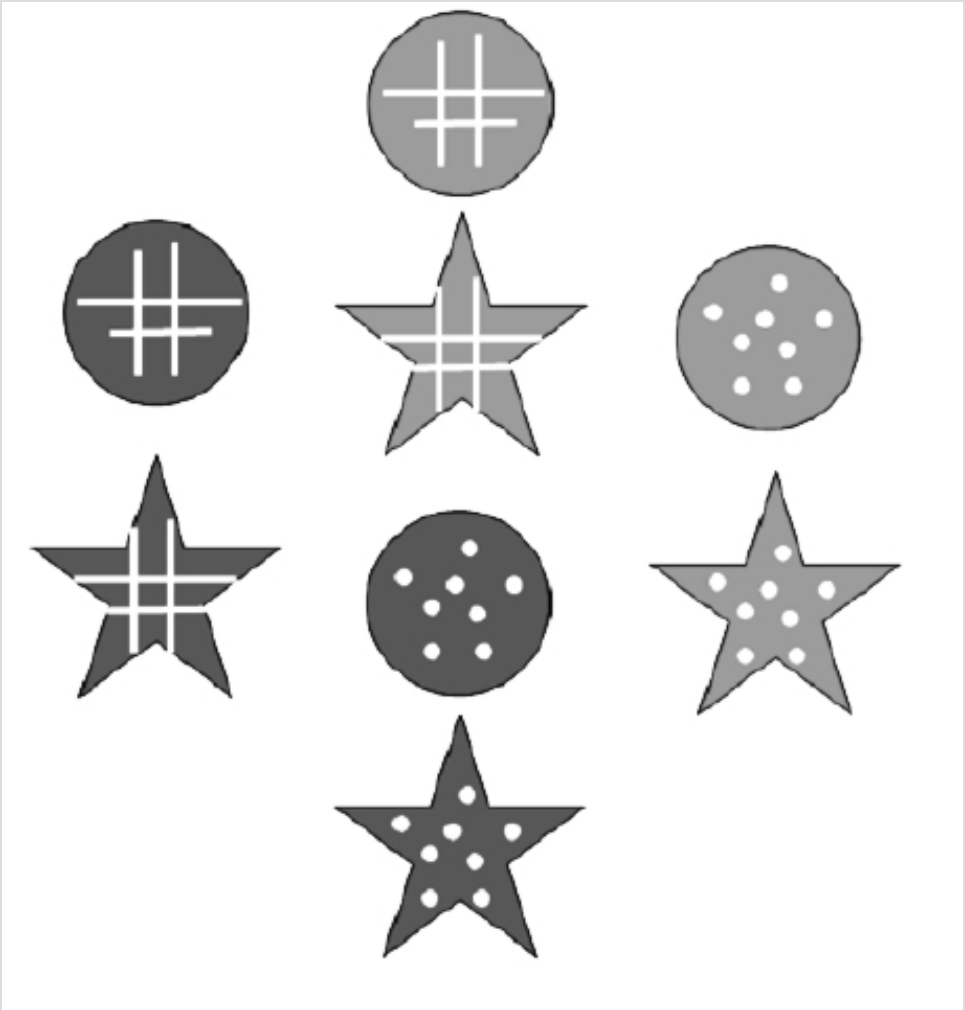
Wills, Lea, Leaver, Osthuas, Ryan, Suret, Bryant, Chapman & Millar (in press)

Free sorting in pigeons

Pigeons – 4 UD, 4 OS
Humans – 3 UD, 7 OS

Wills, Lea, Leaver, Osthuas, Ryan, Suret, Bryant, Chapman & Millar (in press)

Free sorting in pigeons



Pigeons – 5 UD, 1 OS

Humans – 7 UD, 2 OS

Squirrels – 4 UD, 0 OS

Wills, Lea, Leaver, Osthuas, Ryan, Suret, Bryant, Chapman & Millar (in press)

Closing thoughts

- Deliberative thought typically uses more information and/or uses it more consistently, than non-deliberative thought.
  - Some studies (e.g. triads) might be best interpreted as cases of increased consistency of a small amount of information…
  - …whilst MTS might be a case of increased information breadth.
- Nevertheless, it is possible to observe non-deliberative OS sorting:
  - In a brief time window between fully perceiving the stimulus and beginning to analyze it.
  - Presumably, in pigeons and squirrels
  - Presumably, in highly practiced situations.