Combination or Differentiation? Two theories of processing order in classification

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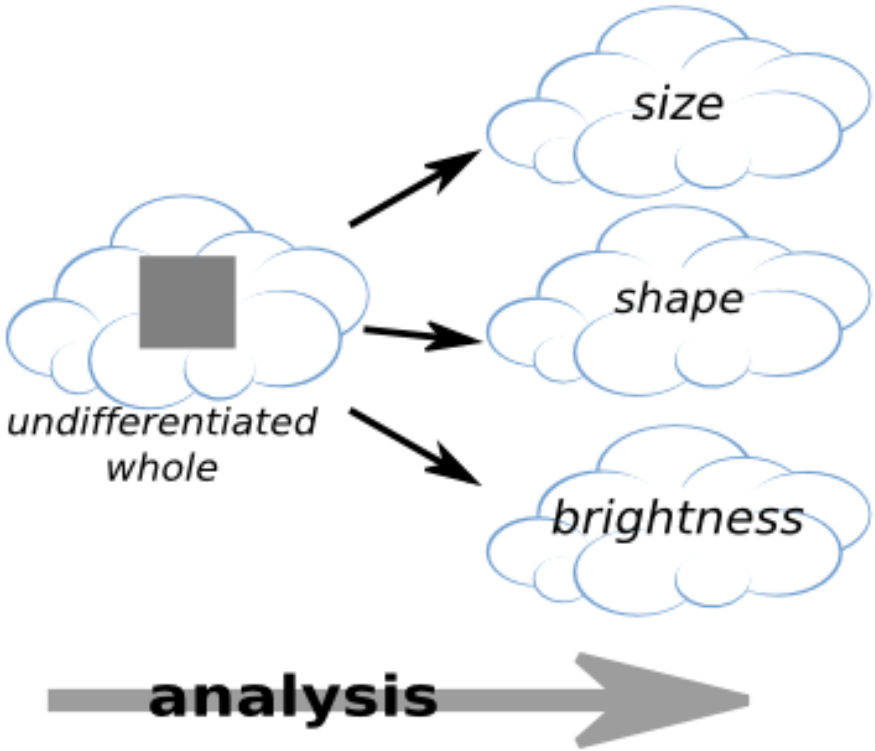
PSYCHOLOGY WITH PLYMOUTH UNIVERSITY

Differentiation Theory

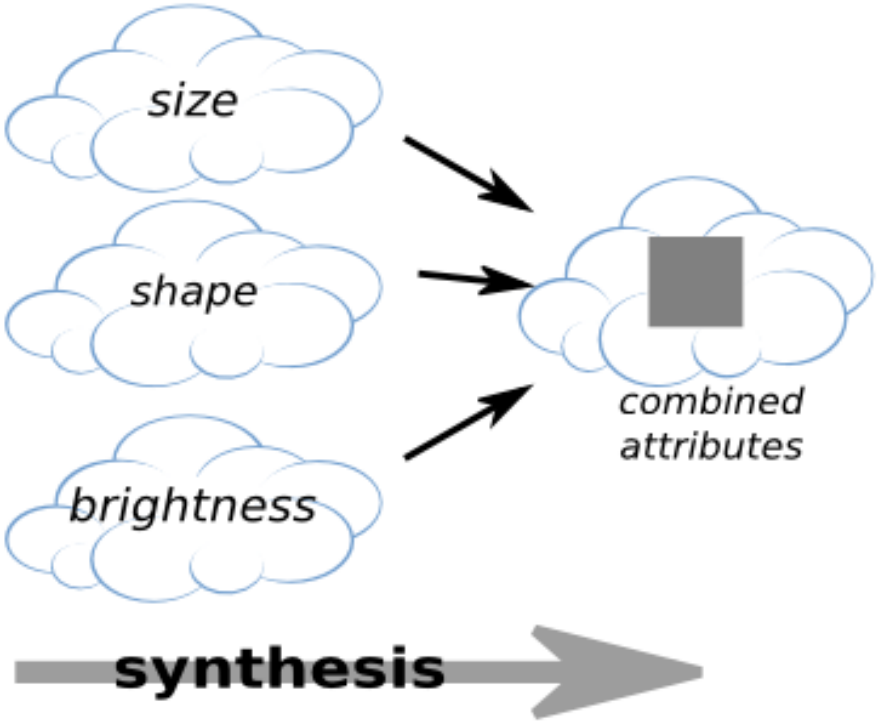
Classification starts with an undifferentiated whole, which can be broken down into its constituent attributes if time and cognitive resources allow.



e.g. Lockhead, 1972; Brooks, 1978; Ward, 1983; Kemler Nelson, 1984; J. Smith & Kemler Nelson, 1984; Ashby et al., 1998; E. Smith et al., 1998; Goldstone & Barsalou, 1998; Tracy et al., 2003; Couchman et al., 2010.

Combination Theory

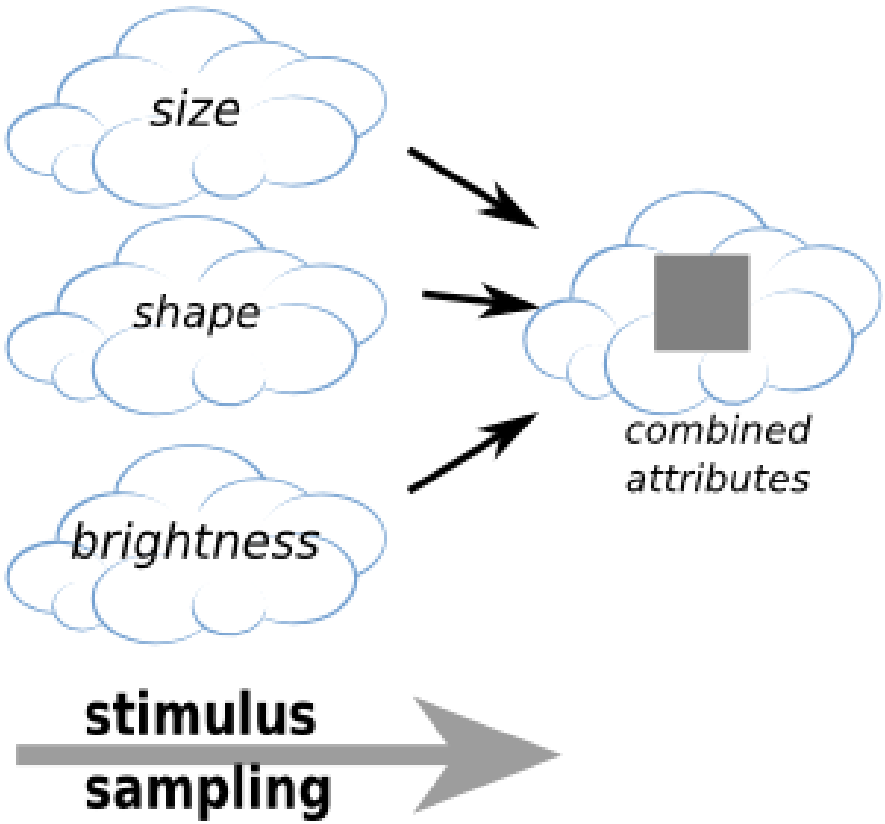
Classification starts with the attributes. Information from these attributes can be combined if time and cognitive resources allow.



e.g. Oden & Massaro (1978); Treisman & Gelade (1980); Lamberts (1995); Milton & Wills (2004).

Instantiating the theories

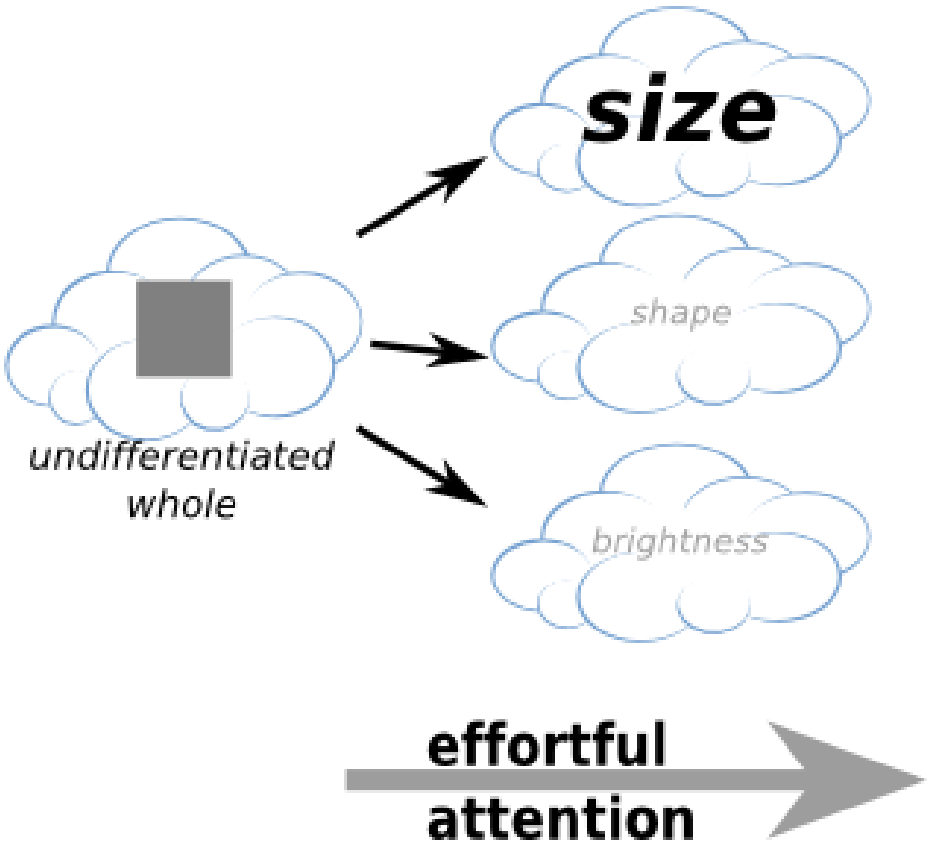
Combination Theory as *stimulus sampling*



(Estes; McLaren & Mackintosh; Lamberts)

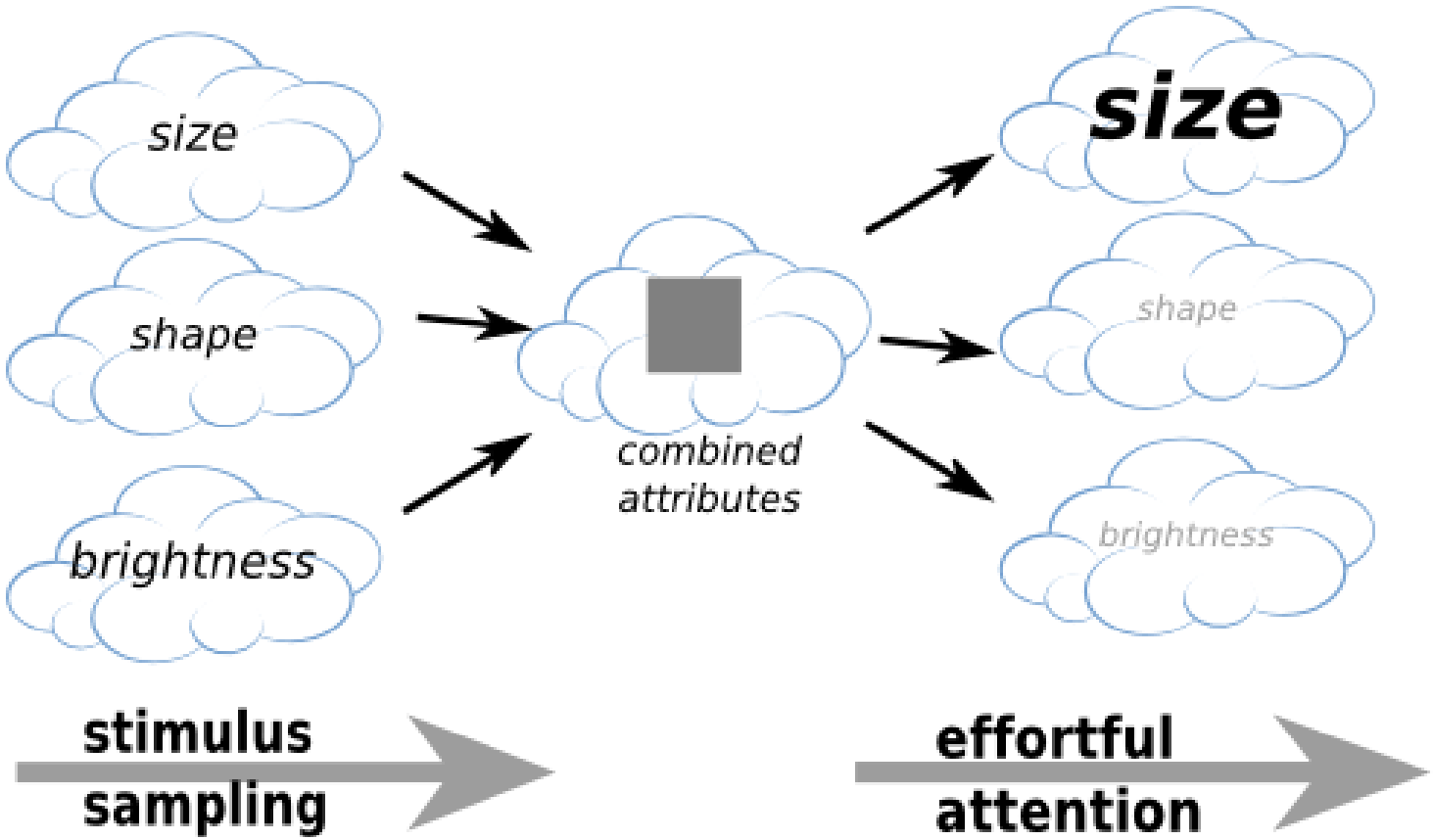
Instantiating the theories

Differentiation Theory as *effortful, time-consuming, selective attention*

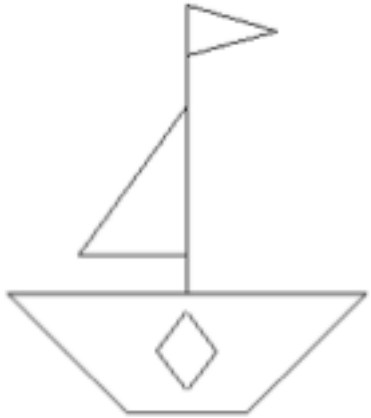


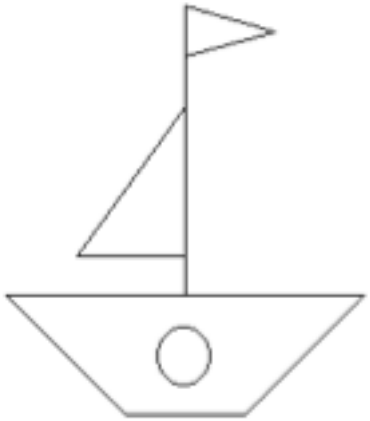
(e.g. Nosofsky & Kruschke)

Stimulus sampling, then effortful selective attention

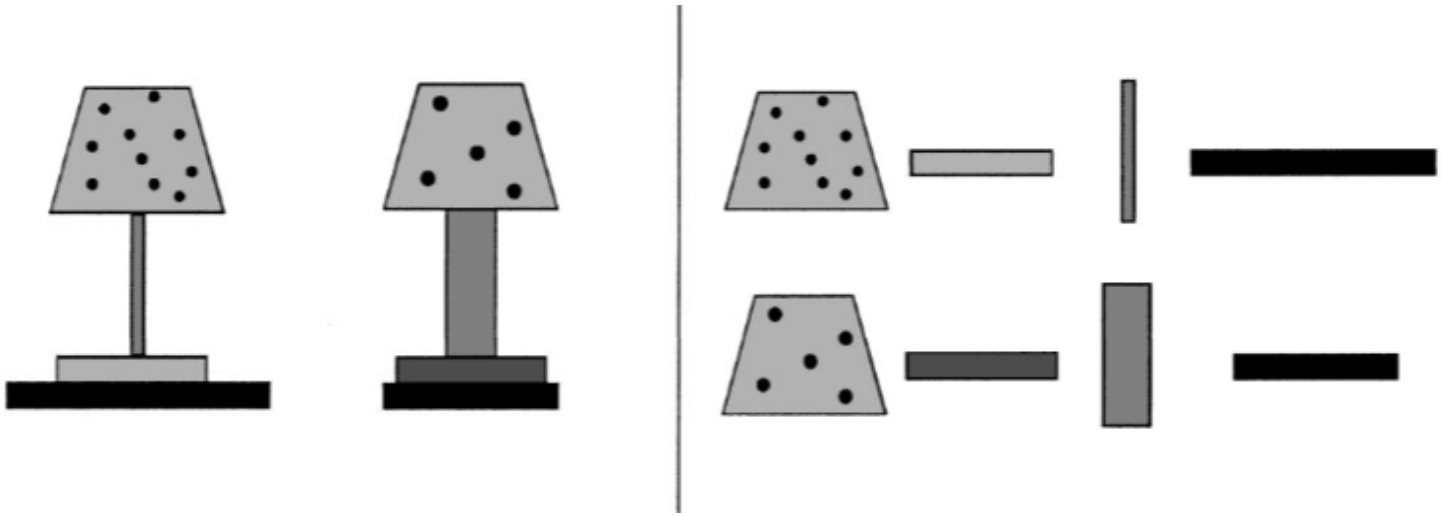


Match-to-standards procedure





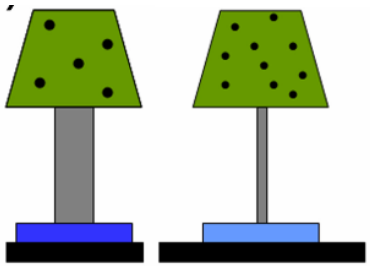
Spatial integration



	UD	OS
Spatially integrated	23	12
Spatially separated	11	24

Milton, F., & Wills, A.J. (2004). *JEP:LMC, 30*, 407-415.
Exp. 4 (N = 24/cond) & Exp. 5 (N = 36/cond) are relevant; Exp. 5 is illustrated here.

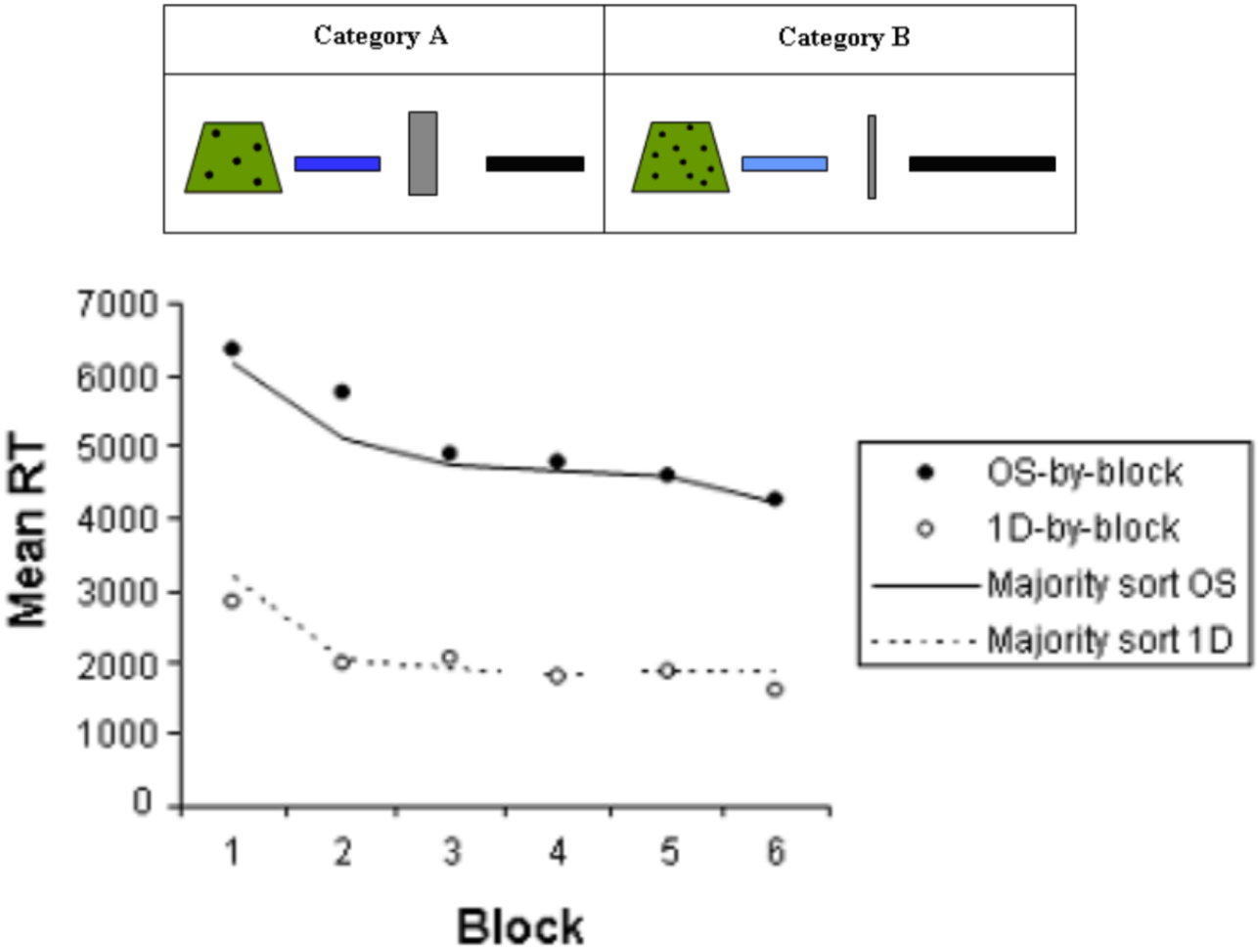
Instructions to respond meticulously



	UD	OS	Other
Meticulous	.23	.75	.02
Neutral	.58	.36	.06

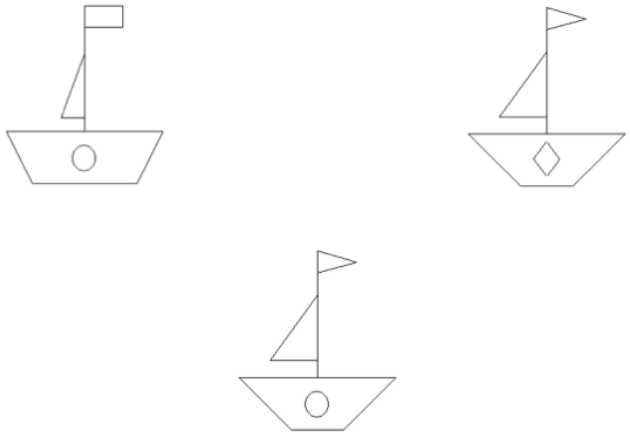
Wills, A.J., Milton, F., Longmore, C.A., Hester, S., & Robinson, J. (2013). *QJEP, 66*, 299-318. (Exp. 4. N = 14/cond).

Reaction time



Milton, F., & Wills, A.J. (2009). *Proc. Cog. Sci. Soc.* (single experiment, N = 15/cond).

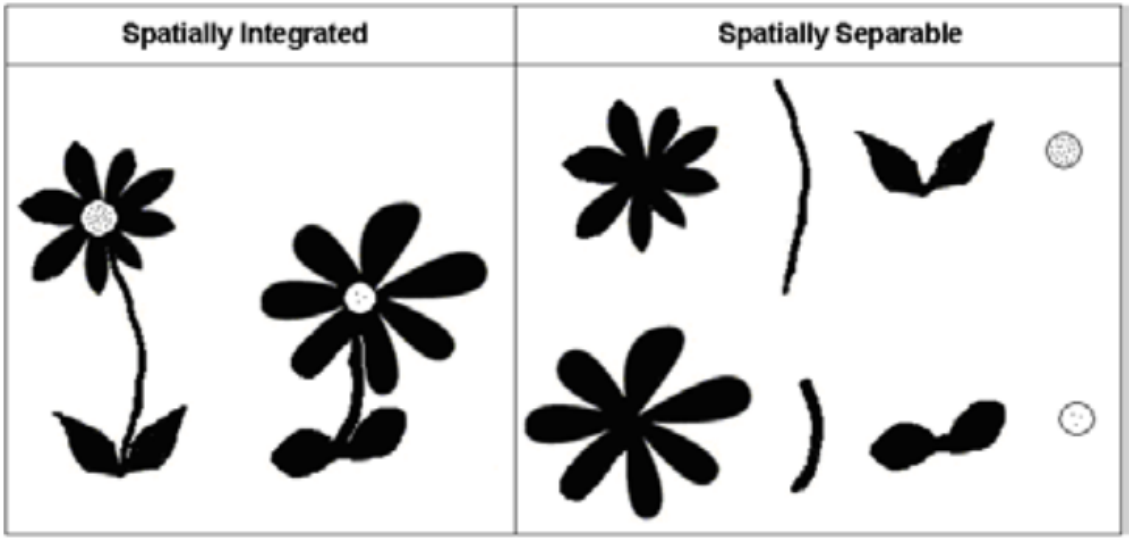
Time pressure



	UD	OS	Other
1024 ms	.61	.18	.22
4096 ms	.29	.58	.13

Milton, F., Longmore, C.A., & Wills, A.J. (2008). *JEP:HPP, 30*, 407-415.
Exp. 1 (N = 12/cond), Exp. 2 (N = 14/cond) & Exp. 4 (N = 14/cond) are relevant.
Exp. 2 is illustrated.

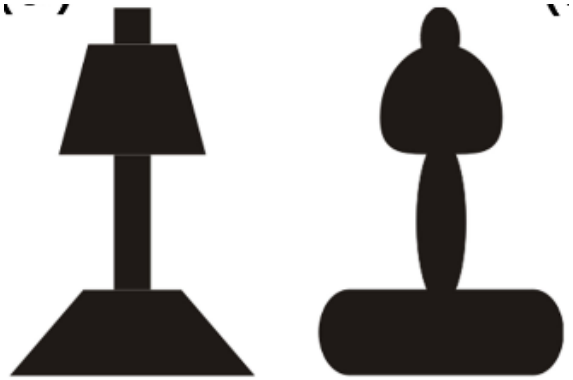
Time pressure x spatial separability



p(OS)	5000 ms	1000 ms
Spatially integrated	.41	.05
Spatially separated	.78	.06

Milton, F., Viika, L., Henderson, H., & Wills, A.J. (2011). *Proc. Cog. Sci. Soc.* Single experiment. N = 12/cond.

Concurrent load

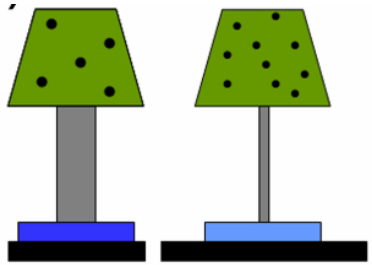


23 ... 87 ... 19 ...

	UD	OS	Other
Load	.52	.14	.35
No load	.34	.63	.03

Wills, A.J., Milton, F., Longmore, C.A., Hester, S., & Robinson, J. (2013). *QJEP, 66*, 299-318. Exp. 1A (N = 21/cond), Exp. 1B (N = 21/cond) & Exp. 2 (N = 18/cond) are relevant. Exp. 1A is illustrated.

Working memory capacity



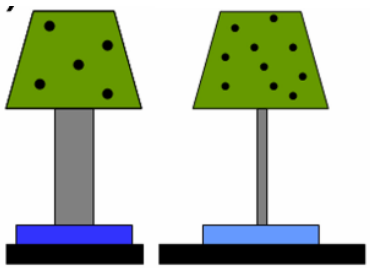
...then measure OSPAN.

$2 \times 3 + 1 = 17$ BED

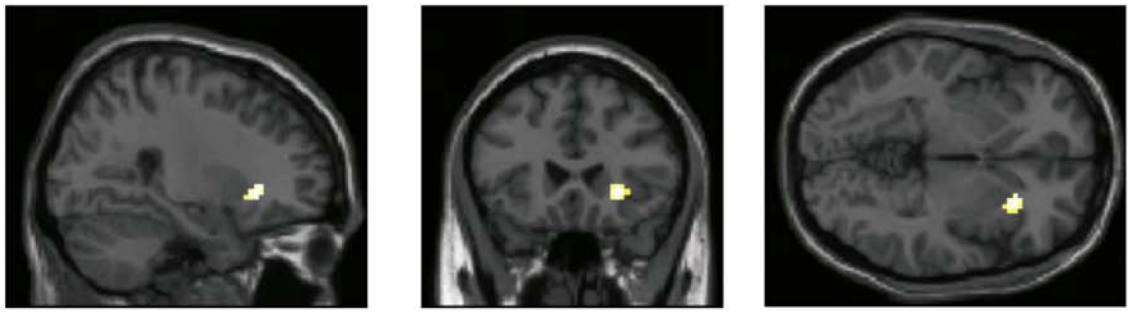
	span	N
UD sorters	2.39	31
OS sorters	3.73	15

Wills, A.J., Milton, F., Longmore, C.A., Hester, S., & Robinson, J. (2013). *QJEP, 66*, 299-318. (Exp.3).

Neuroimaging



$OS_{sorters} - UD_{sorters}$



Milton, F., Wills, A.J., & Hodgson, T.L. (2009). *NeuroImage, 46*, 319-326.
(single experiment, $N_{OS} = 17, N_{UD} = 10$, BA47 illustrated).

Pre-exposure x time pressure

p(OS)	NPE	PE
300 ms	.03	.07
4096 ms	.22	.34

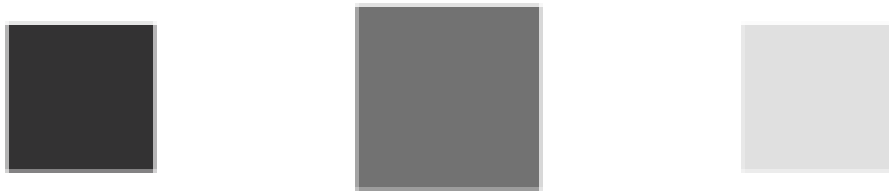
Wills, A.J. & Milton, F. (in prep.).

(single experiment, N = 20/cond).

Evidence for Differentiation Theory?

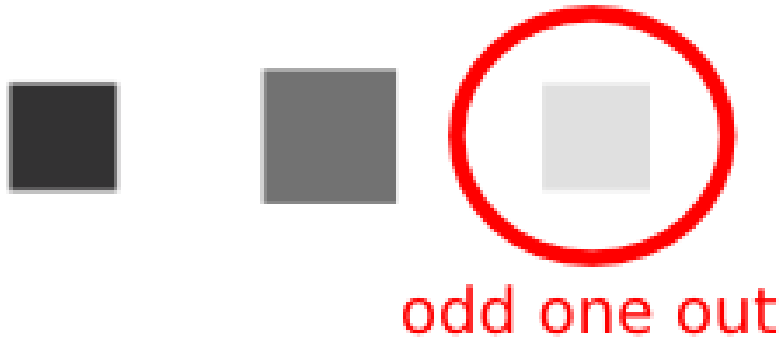
- Ward (1983) - triad task - time pressure
- Smith & Kemler Nelson (1984) - triad task - time pressure, concurrent load, instructions.
- Milton, Longmore & Wills (2008) - triad task - time pressure.
- Kemler Nelson (1984) - criterial-attribute task - incidental training
- Smith & Shapiro (1989) - criterial-attribute task - concurrent load

Triad task

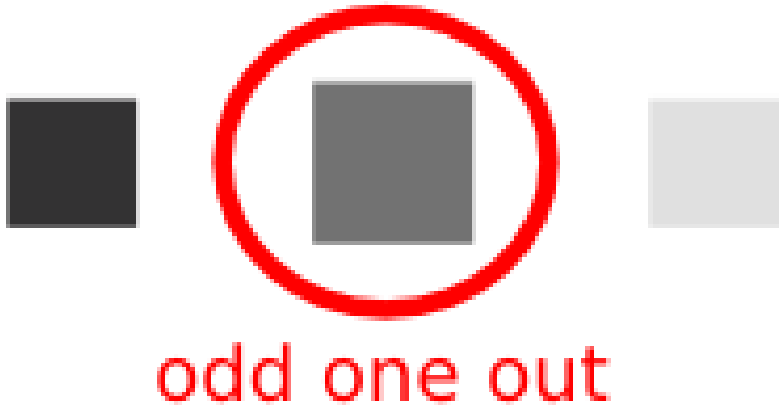


Triad task: Assumed strategies

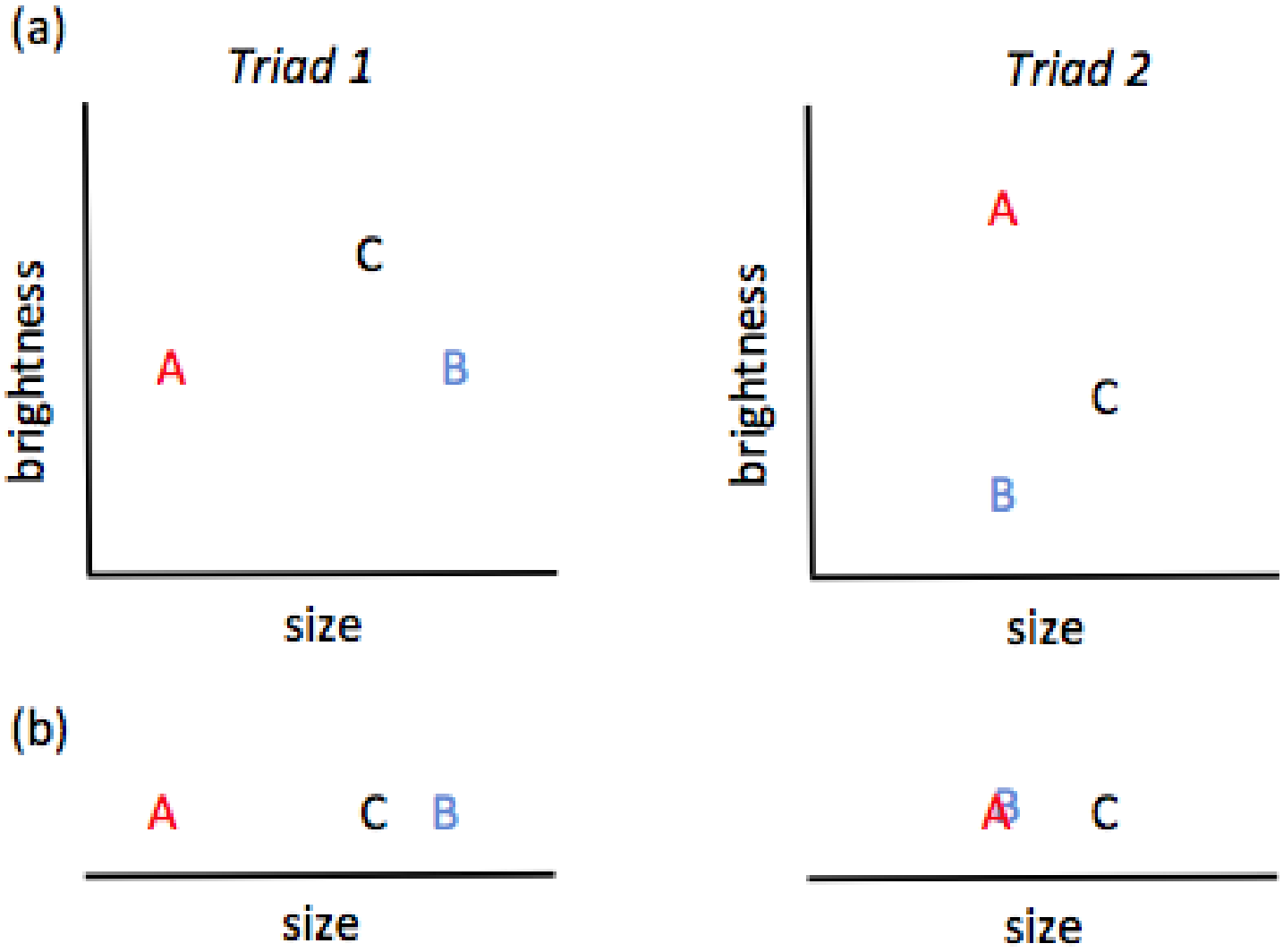
Overall similarity (Differentiation Theory: Fast)



Dimensional identity (Differentiation Theory: Slow)

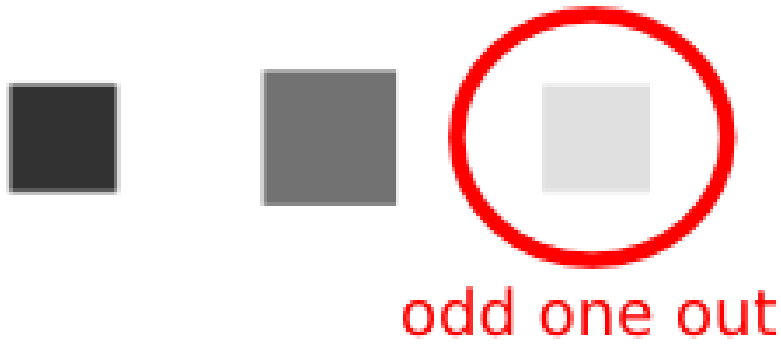


Triad task: Abstract structure

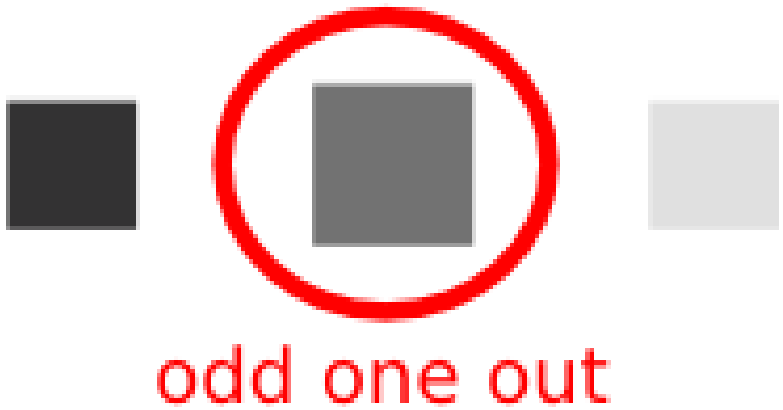


Triad task: Single-dimension responding

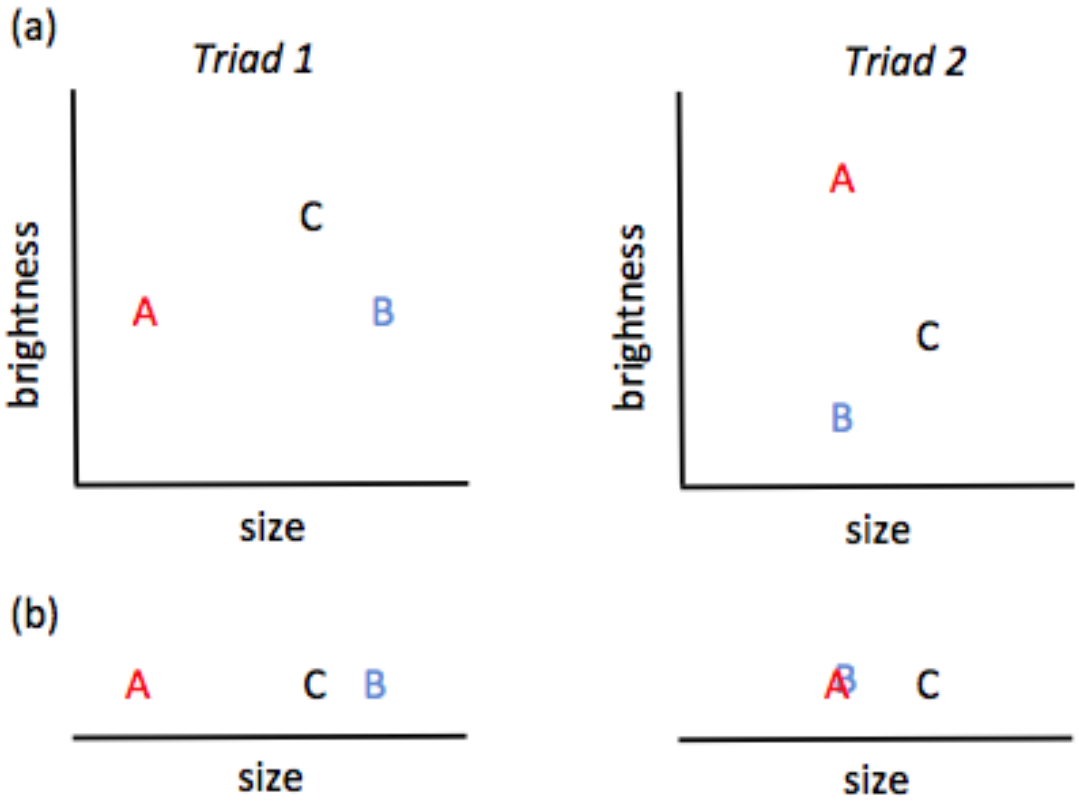
Overall similarity? Or brightness?



Dimensional identity? Or size?

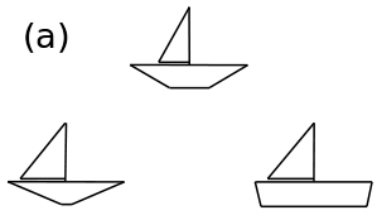


Triad task: Abstract structure



	Triad 1	Triad 2
ID	C	C
OS	A	A
UD(size)	A	C
UD(brightness)	C	A

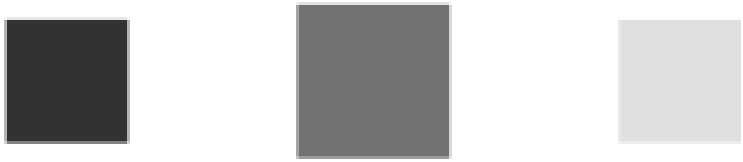
Milton, Longmore & Wills (2008): Re-analysis



	Traditional			Response-set		
Condition	BC ("OS")	AB ("ID")	AC ("Hap.")	UD	OS	ID
640 ms	.43	.33	.24	.74	.22	.04
1024 ms	.49	.32	.19	.76	.24	.00
2048 ms	.44	.43	.13	.76	.10	.14
3072 ms	.35	.52	.13	.44	.20	.36
7500 ms	.38	.53	.09	.28	.36	.36

Wills, A.J., Inkster, A.B., & Milton, F. (2015). *Cognitive Psychology, 80*, 1-33. (N = 30/cond).

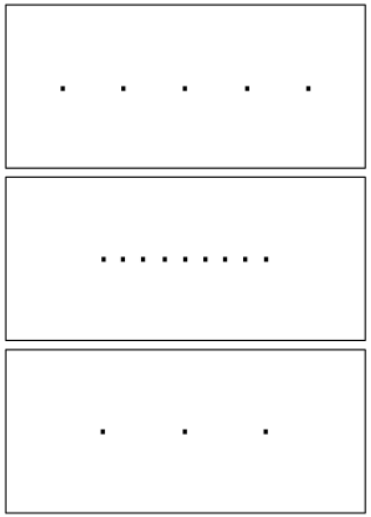
Smith & Kemler Nelson (1984): Replication



	Traditional			Response-set		
Condition	BC	AB	AC	UD	OS	ID
1000 ms	.34	.55	.11	.38	.13	.49
5000 ms	.12	.85	.03	.10	.00	.90

Wills, A.J., Inkster, A.B., & Milton, F. (2015). *Cognitive Psychology, 80*, 1-33. (Exp. 2, N = 40/cond).

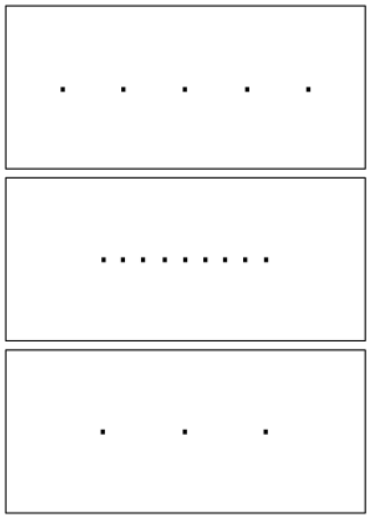
Ward (1983): Replication 1



	Traditional			Response-set		
Condition	BC	AB	AC	UD	OS	ID
2000 ms	.66	.20	.14	.29	.67	.04
5000 ms	.58	.32	.10	.40	.42	.18

Wills, A.J., Inkster, A.B., & Milton, F. (2015). *Cognitive Psychology, 80*, 1-33. (Exp. 3A, N = 54/cond).

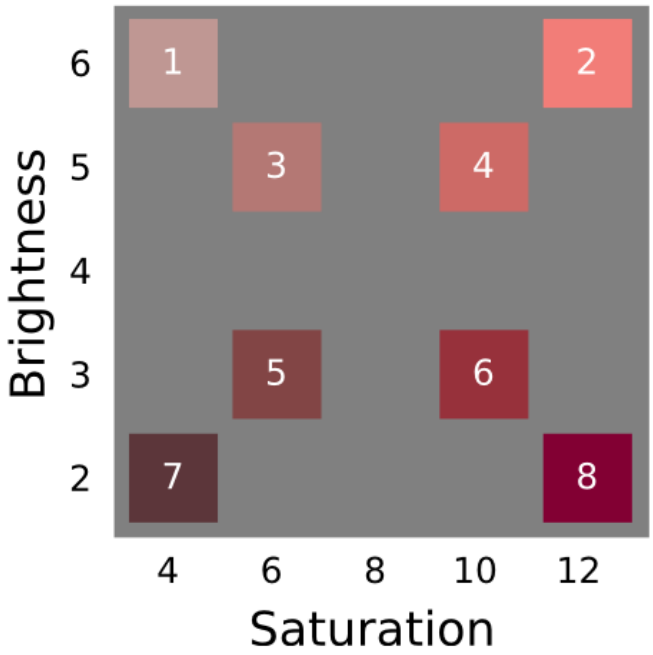
Ward (1983): Replication 2



	Traditional			Response-set		
Condition	BC	AB	AC	UD	OS	ID
< 2000 ms	.63	.13	.24	.09	.88	.03
> 5000 ms	.58	.32	.10	.21	.56	.22

Wills, A.J., Inkster, A.B., & Milton, F. (2015). *Cognitive Psychology, 80*, 1-33. (Exp. 3B, N = 40/cond).

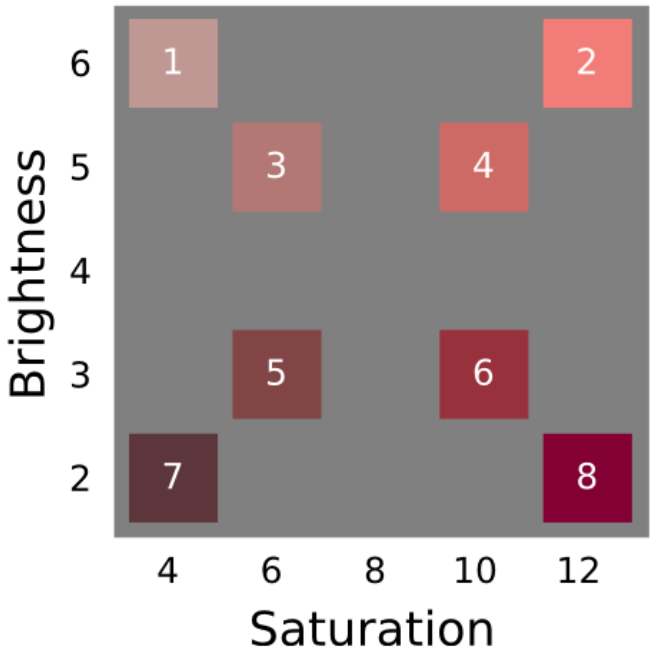
Time pressure with integral stimuli



	Resp.-set			Resp.-set by block		
	UD	OS	ID	UD	OS	ID
100 ms	.04	.96	.00	.12	.88	.00
2000 ms	.00	1.00	.00	.02	.98	.01

Wills, A.J., Edmunds, C., Williams, G. & Milton, F. (in prep.)
Exp. 1 ($N_{100ms} = 28, N_{2000ms} = 17$)

Time pressure with integral stimuli (replication)



	Resp.-set by block		
	UD	OS	ID
100 ms	.14	.85	.01
2000 ms	.01	.99	.00

Wills, A.J., Edmunds, C., Williams, G. & Milton, F. (in prep.)
Exp. 2 ($N_{100ms} = 35, N_{2000ms} = 15$)

Time pressure with integral stimuli (generality)

	Resp.-set by block		
	UD	OS	ID
100 ms	.14	.86	.00
2000 ms	.06	.93	.00

Wills, A.J., Edmunds, C., Williams, G. & Milton, F. (in prep.)
Exp. 3 ($N_{100ms} = 43, N_{2000ms} = 18$)

Criterial attribute procedure

Training items

Group 1: MUFA MUFY MUSA MOFA

Group 2: VOSY VOSA VOFY VASY

Classification by criterial attribute

Group 1: MUFA MUFY MUSA MOFA

Group 2: VOSY VOSA VOFY VASY

Classification by overall similarity (e.g. of MUSA)

Group 1: MUFA (3), MUFY (2), MUSA (4), MOFA (2)

Group 2: VOSY (1), VOSA (2), VOFY (0), VASY (1)

"Critical" test items

VUFA MOSY

Criterial attribute procedure

Classification by non-criterial attribute

Training items

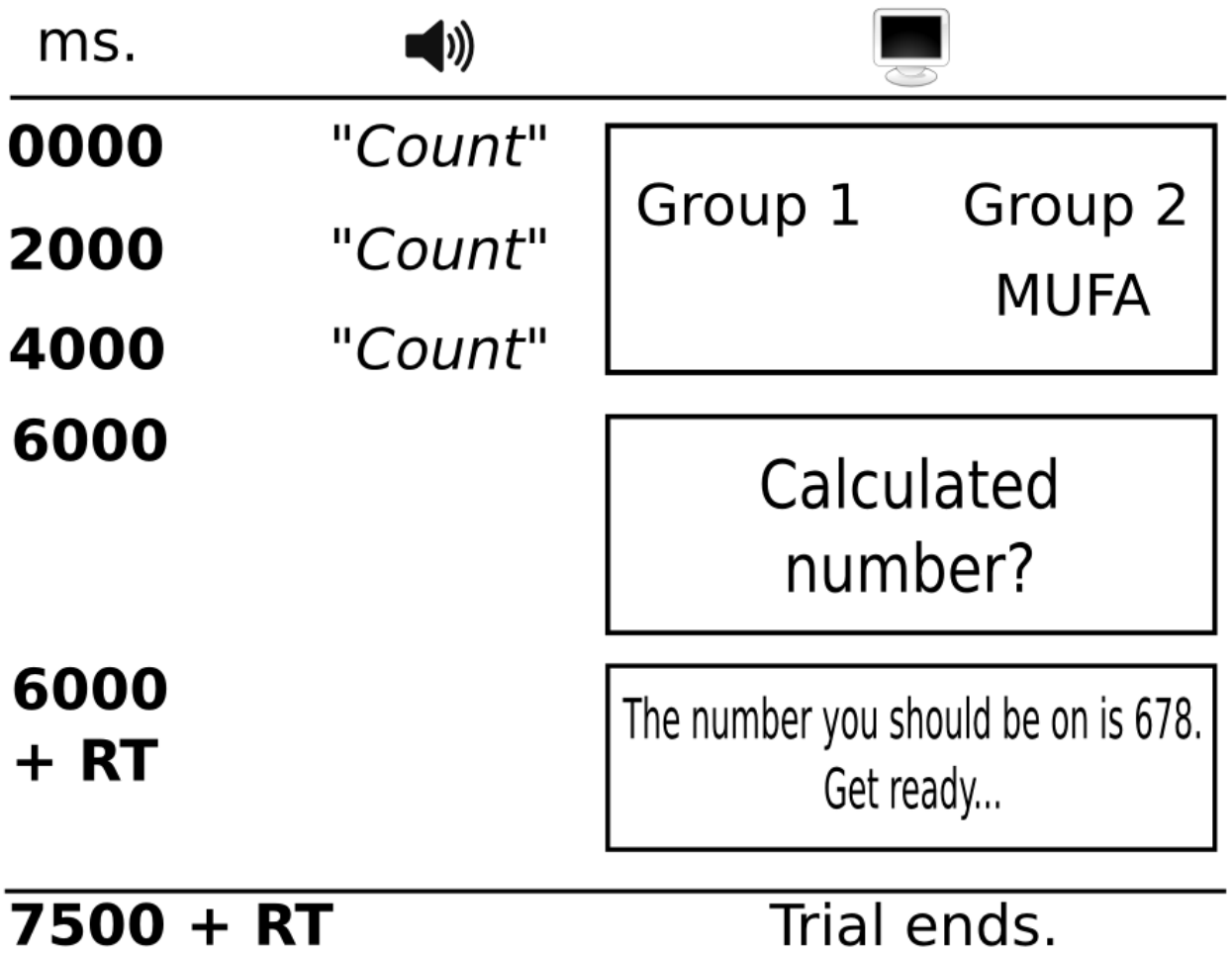
Group 1: MUFA MUFY MUSA MOFA

Group 2: VOSY VOSA VOFY VUSY

"Critical" test items

VUFA MOSY

Smith & Shapiro (1989): Replication

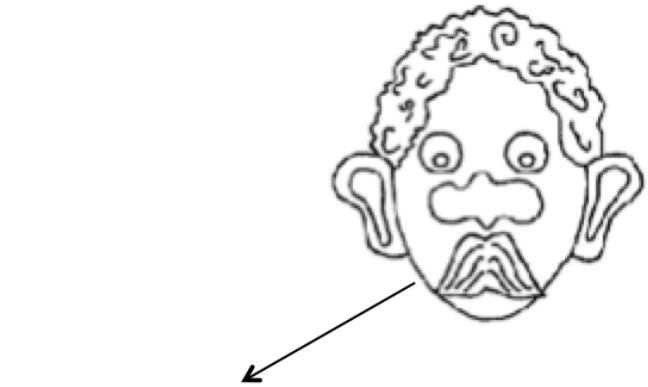


Smith & Shapiro (1989): Replication

	Traditional		Response-set		
Condition	OS	CA	OS	CA	NCA
Concurrent load	.53	.47	.00	.48	.52
Full attention	.27	.73	.00	.74	.26

Wills, A.J., Inkster, A.B., & Milton, F. (2015). *Cognitive Psychology, 80*, 1-33. (Exp. 5, N = 40/cond).

Kemler Nelson (1984): Intentional training



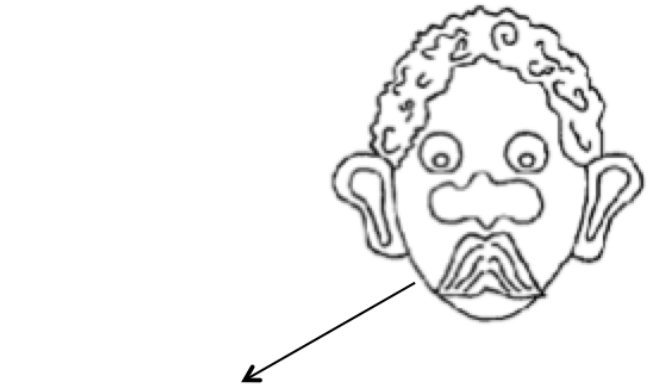
Group 1 – Doctor

Group 2 – Policeman

Kemler Nelson (1984): Incidental training

Seen Before?

Kemler Nelson (1984): Test phase



Group 1 – Doctor

Group 2 – Policeman

Kemler Nelson (1984): Replication 1

	OS	CA	NCA
Intentional	.07	.68	.25
Incidental	.03	.44	.53

Wills, A.J., Inkster, A.B., & Milton, F. (2015). *Cognitive Psychology, 80*, 1-33. (Exp. 4A, N = 50/cond).

Experiment 2

1. Removed OS-ambiguous items from test.
2. Extended incidental training to equate pass rates.

	OS	CA	NCA
Intentional	.09	.63	.28
Incidental	.15	.33	.52

Wills, A.J., Inkster, A.B., & Milton, F. (2015). *Cognitive Psychology, 80*, 1-33. (Exp. 4B, N = 37/cond).

Conclusion

Combination Theory provides a sufficient account of numerous results within the match-to-standards, triad, and critierial-attribute, procedures.

Contrary to widely-held beliefs, there seems to be no need to invoke the idea that classification begins with the analysis of an undifferentiated stimulus "whole" (**Differentiation Theory**).