Assessing and Training Analogical Responding in Young Children

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Importance of Analogy

Bee:Hive :: Bear:Den

- Ubiquitous aspect of daily language - key to understanding human language and cognition.

- Regarded by many psychologists as the core of intelligent behavior (Sternberg, 1985).

- Metric of intelligent behavior to predict academic success (GRE, Miller Analogy Test, LSAT).

- Problem-solving skills improved by employing analogy (Lipkens & Hayes, 2009).

Analogy and Psychology

Cognitive Scientists: "Mapping" information from one domain to another = "knowledge transfer" (Gentner, 1983).

- What does that mean at a psychological (functional analytical) level?

Behaviorists/Skinner: analogical language defined as the abstraction, via the extended tact, of a common physical property from two different types of environmental events.

- Skinner's definition seems *too simple* to capture the complexity and novelty of analogies and metaphors

RFT & Analogy

Deriving a relation between relations

A is to B as C is to D

A:B :: C:D

Analogies are the derivation of relations both within and across pairs

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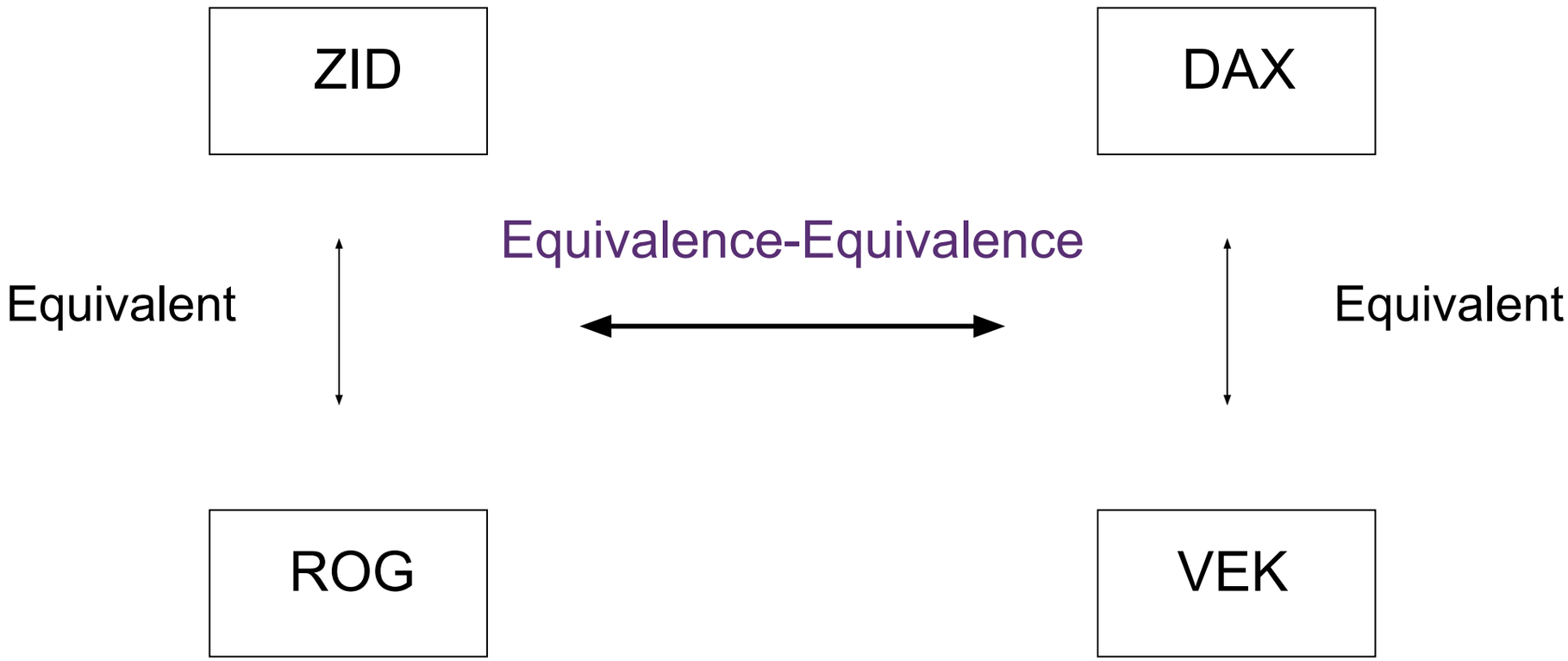
Apple is to Orange as Dog is to?

Sheep Book

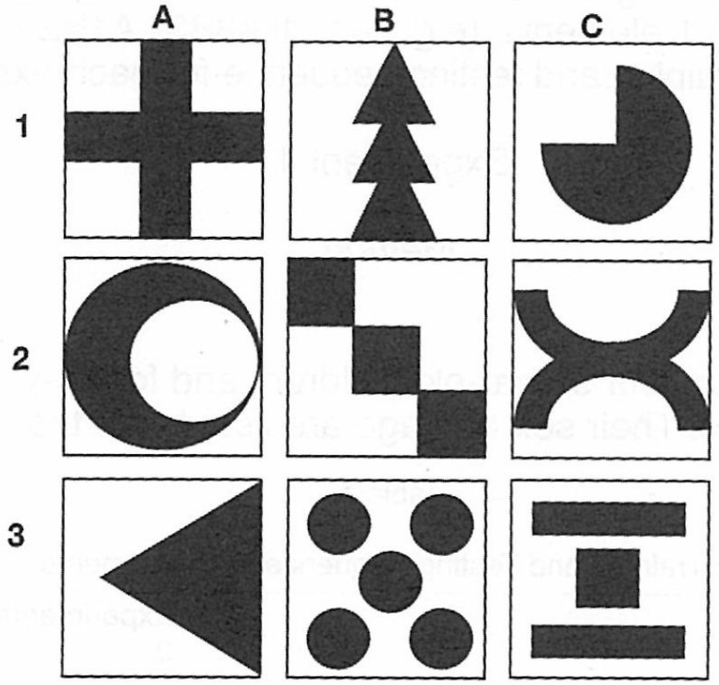
Barnes, Hegarty, & Smeets (1997)

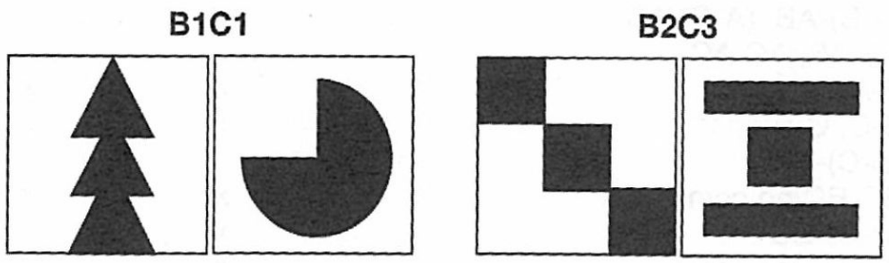
Proposed a Relational Frame model of analogical reasoning as **responding in accordance with equivalence-equivalence relations.**

This model captures a core property of analogy: the relating of derived relations

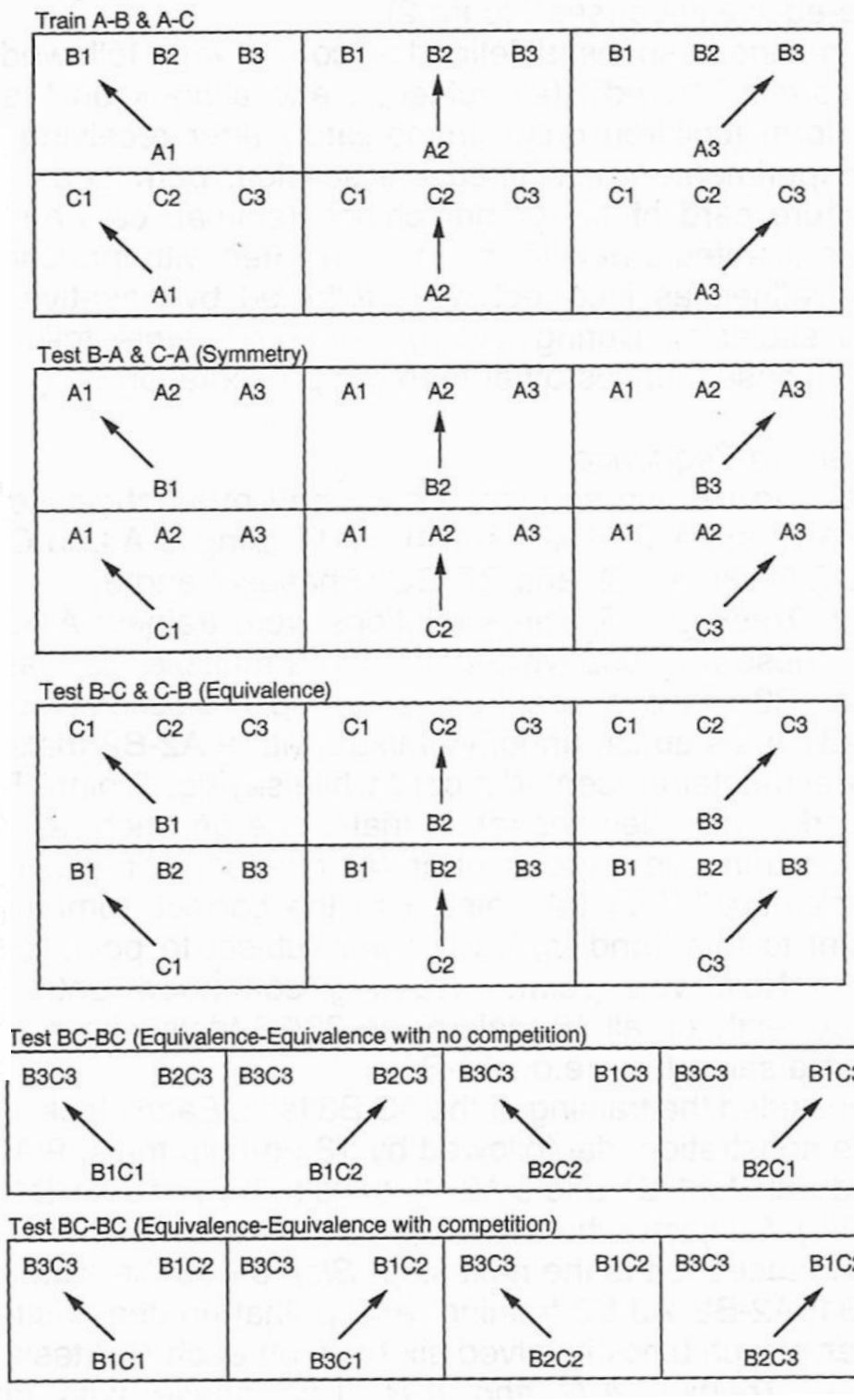


RFT & Analogy: Equivalence-equivalence model: *Carpentier et al., 2002*





Experimental stimuli used in Carpentier at al., (2002); Top = unitary stimuli, bottom = examples of BC compounds



Trained A-B and A-C matching (MTS).

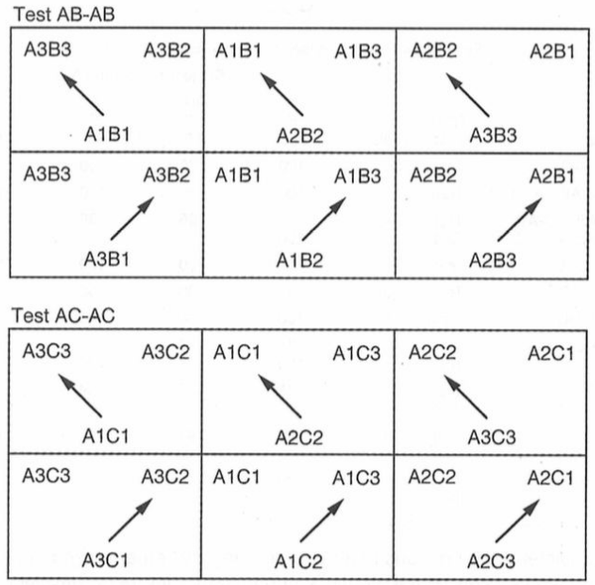
Test: symmetry B-A and C-A;

Test: equivalence B-C, C-B;

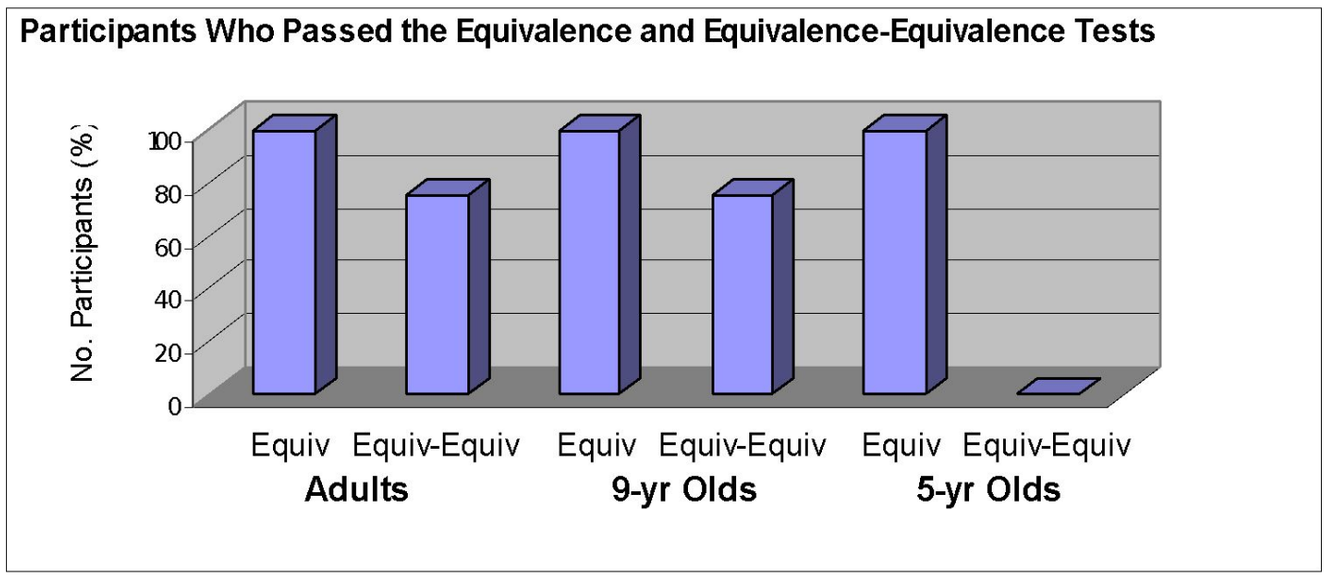
Test: equivalence-equivalenc BC-BC.

Carpentier, Smeets, & Barnes-Holmes, 2002

Most adults and 9-year-olds demonstrated equiv.-equiv., **5-year-olds did NOT demonstrate equiv.-equiv.** without first matching compounds with trained correct relations (e.g., A1B1-A3B3 before A1C1-A3C3).



Suggests a developmental divide



The Analogical Relations Assessment

- Ages 3-4, 4-5, 5-6, 6-7, 7-8

- The ARA allows assessment/training of five sub-stages testing for frames of 1) coordination and distinction, 2) comparison, 3) opposition, 4) temporality, and 5) hierarchy.

- Stage 1: non-arbitrary (physical) relations

- Stage 2: non-arbitrary analogy (relations between physical relations)

- Stage 3: arbitrary relations

- Stage 4: arbitrary analogical relations (relations between abstract relations).

The Analogical Relations Assessment

- Do participants' scores on the ARA correlate with IQ scores (SB5)?

- Identify how and when analogical responding emerges in young children

- Compare and correlate development of analogy with development of other relational skills
  - Examine analogy as embedded in the development of relational responding

- Identify deficit component relations required for emergence of analogical responding

- Determine if RFT-based training protocols are effective at training analogical relations when weak or absent

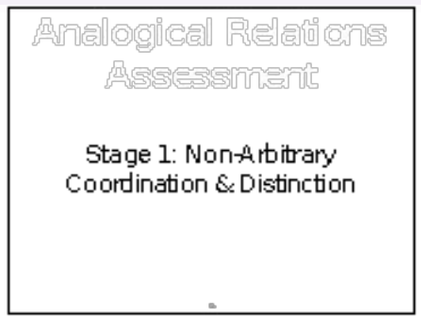
    - Predict that training weak/missing component relations:
      - Supports generative language
      - Will support acquisition of analogical reasoning

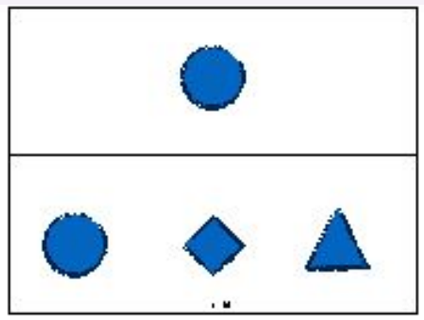
Evolution of the ARA

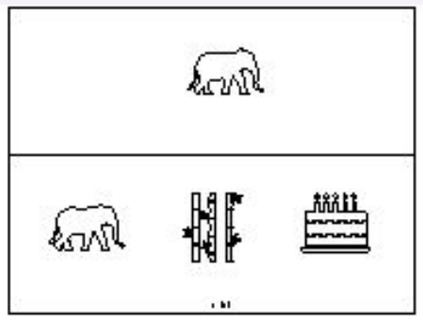
Pilot testing: Testing and refining the ARA with approximately 60 typically developing participants aged 3-7 & 15 adults

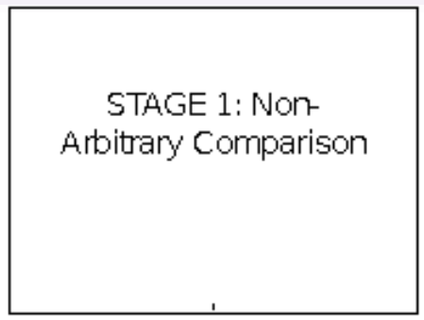
- 3-D stimuli → iPad
- Yes/No → Yes/No/I don't know
- Added priming task to Stage 1 and Stage 2 Opposition (also an issue for argumentative, adult pilots □)
- Stages 3 and 4 employed a format that potentially benefitted children with greater reading skills
    - Adapted the format to minimize reliance on reading: using single letter stimuli and incorporating both auditory and visual dimensions
- Added Stage 3: Formatting test
- Observe guessing responses

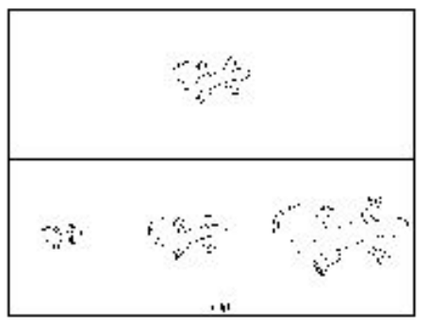
ARA Stage 1: Nonarbitrary Relations

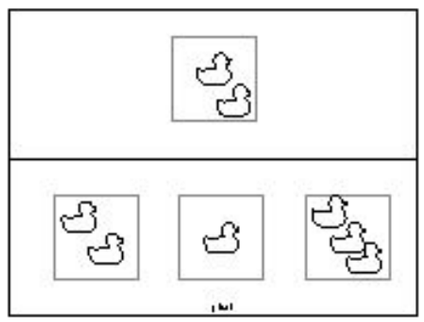


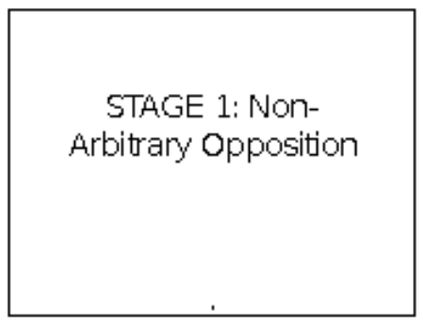


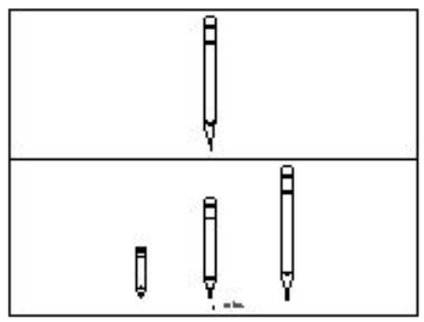


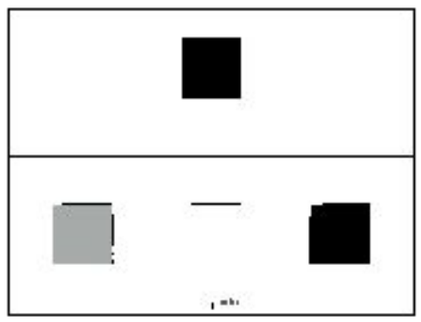


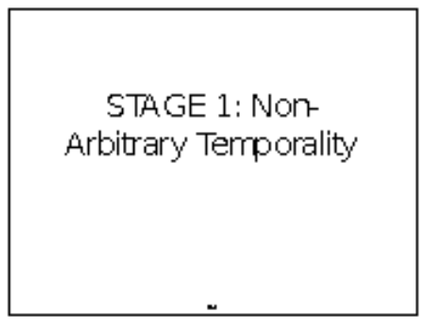


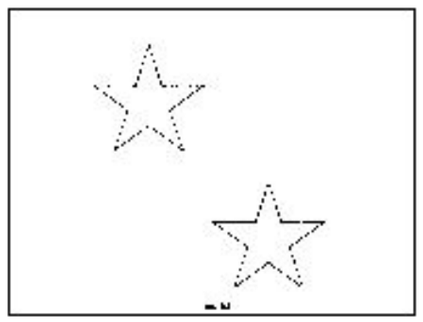


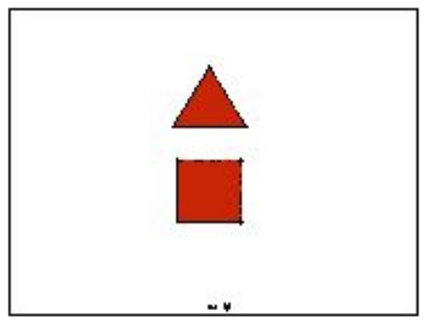


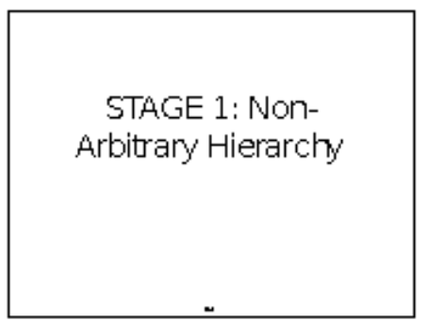


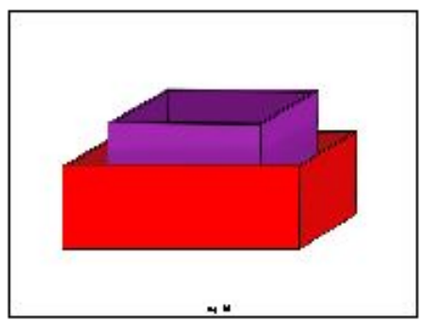


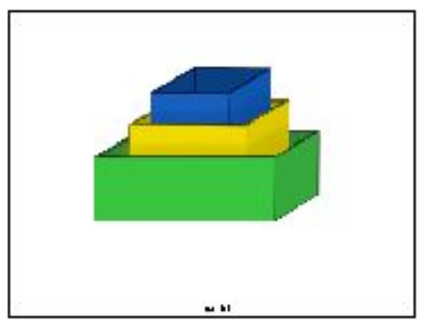


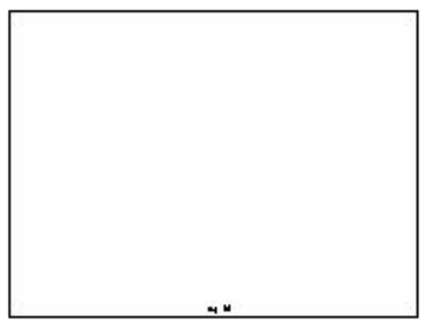




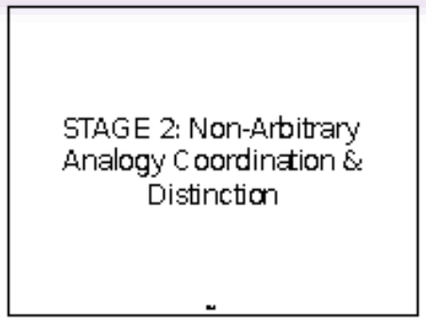


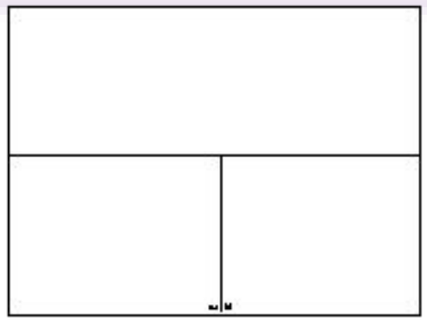


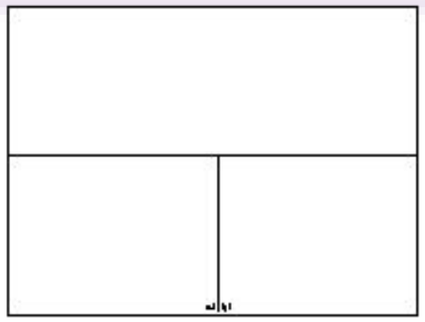


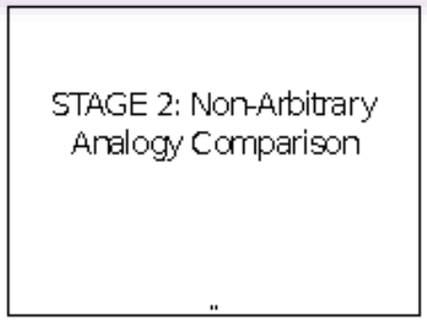


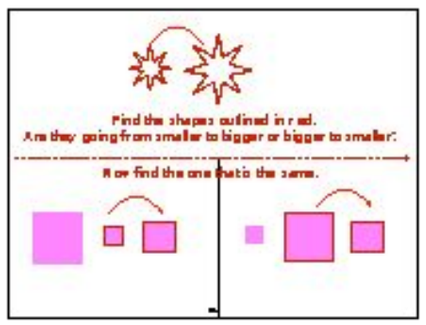
ARA Stage 2: Nonarbitrary Analogy

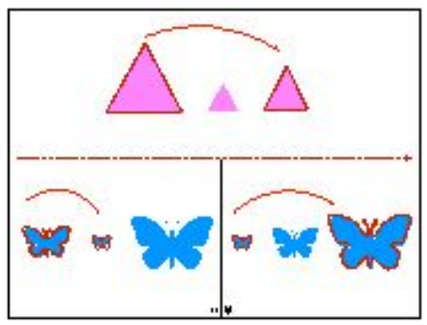


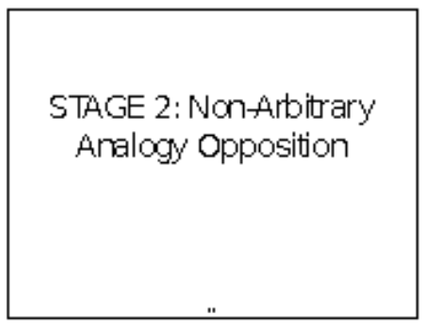


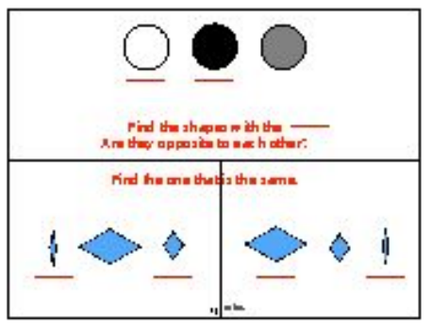


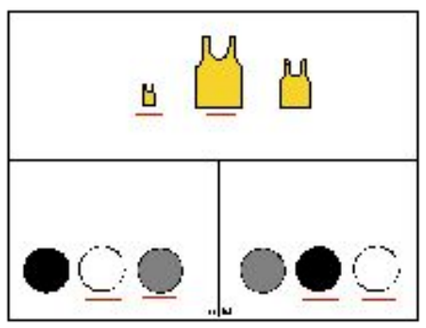


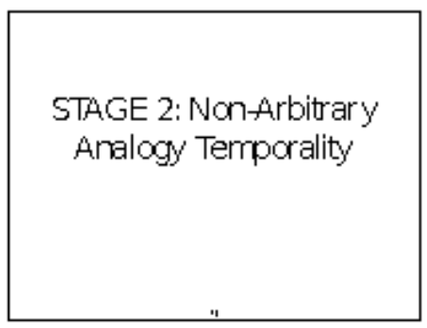


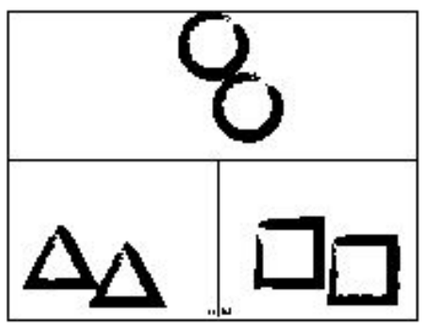


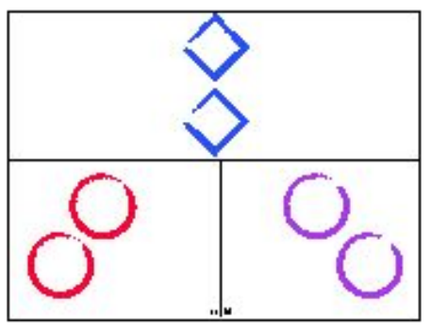


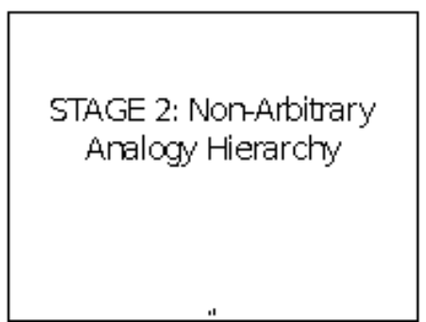


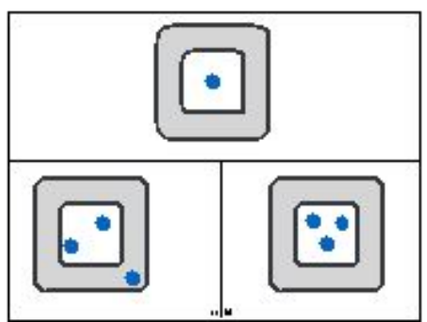


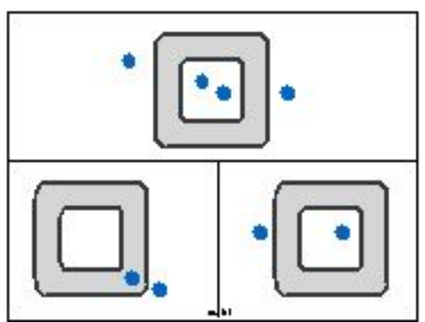


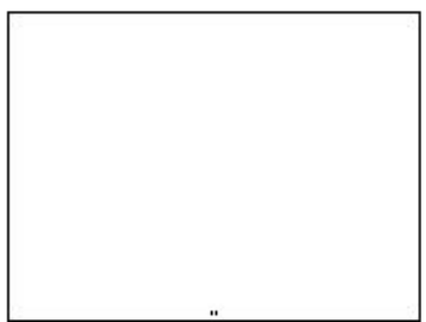




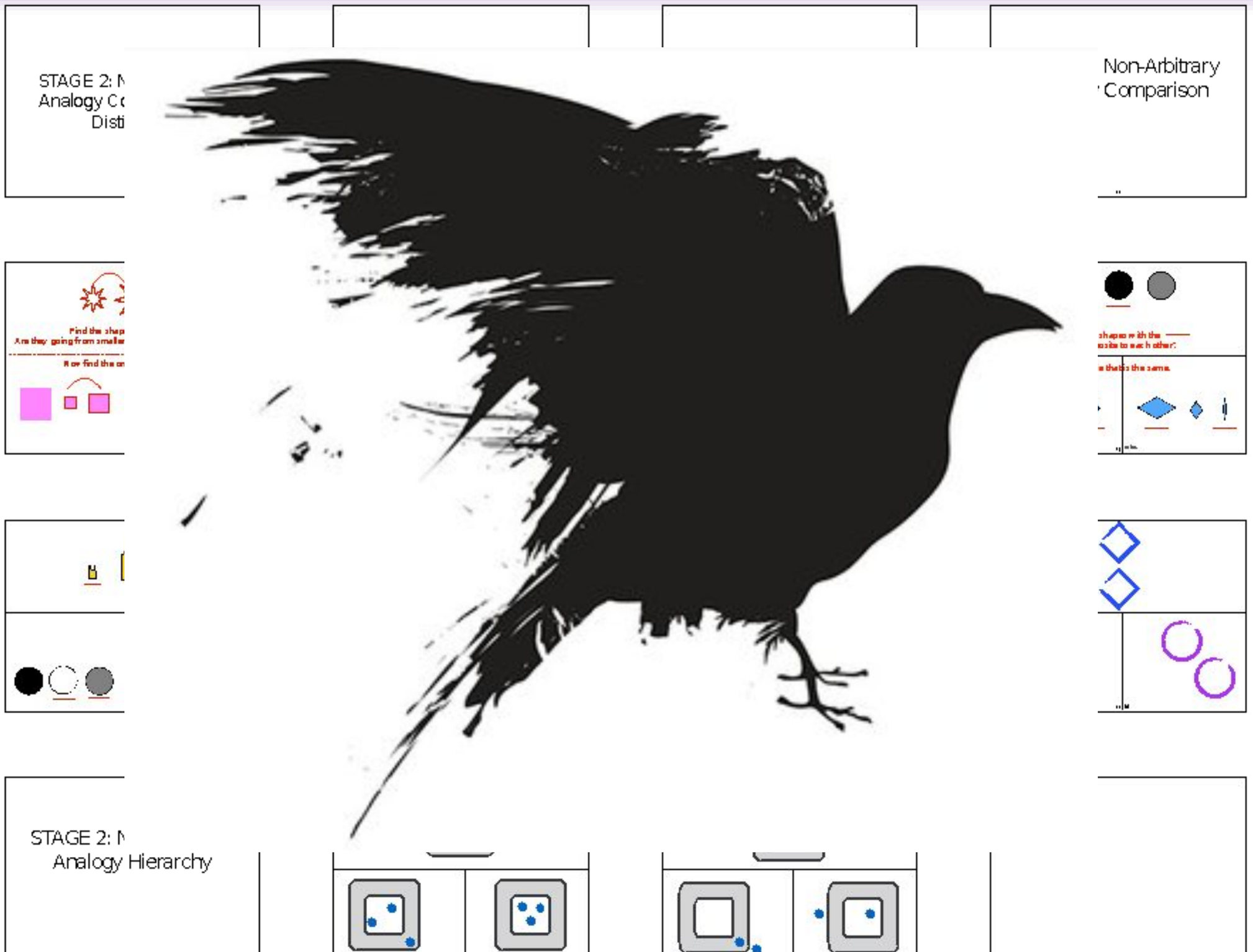








ARA Stage 2: Nonarbitrary Analogy



Stage 3: Arbitrary Relations I

STAGE 3: Arbitrary Relations

25

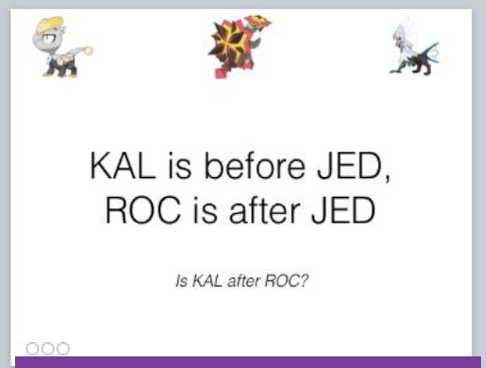
Coordination/Distinction

Opposition

Opposition

Comparison

Temporal

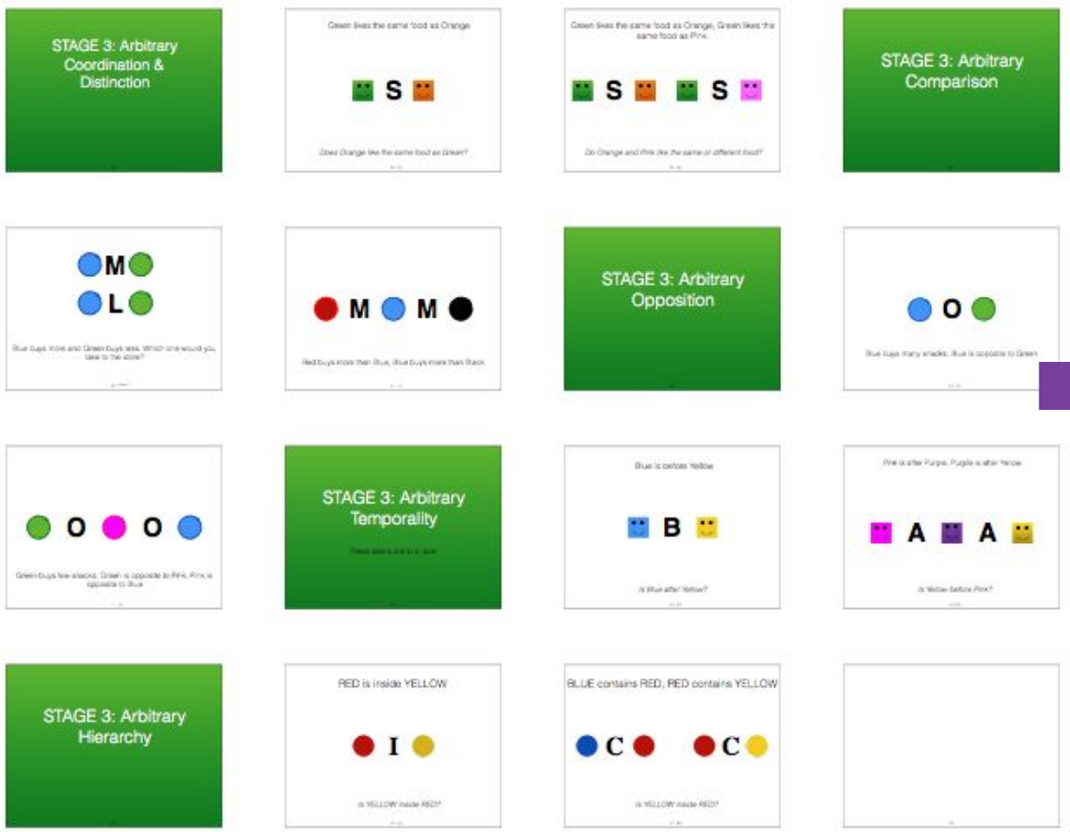


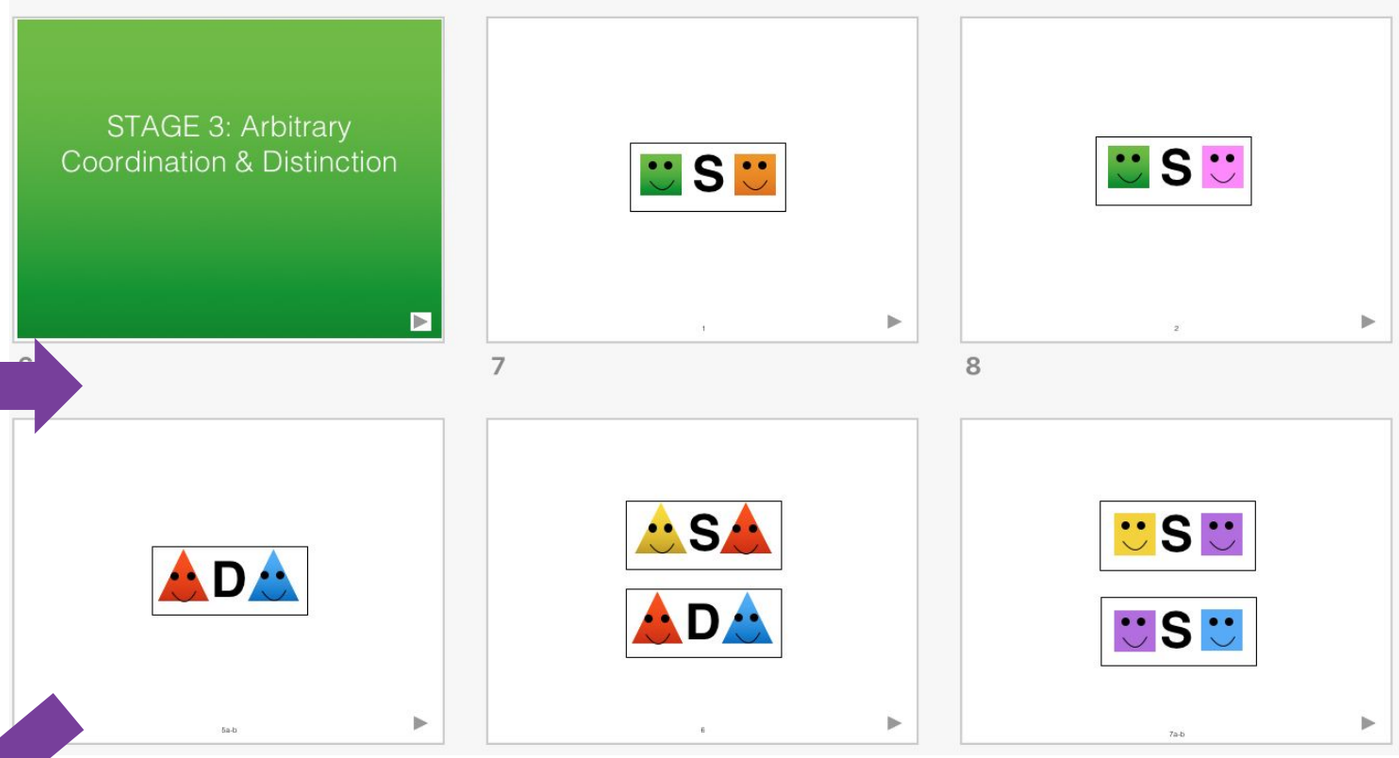
Temporal

Hierarchy

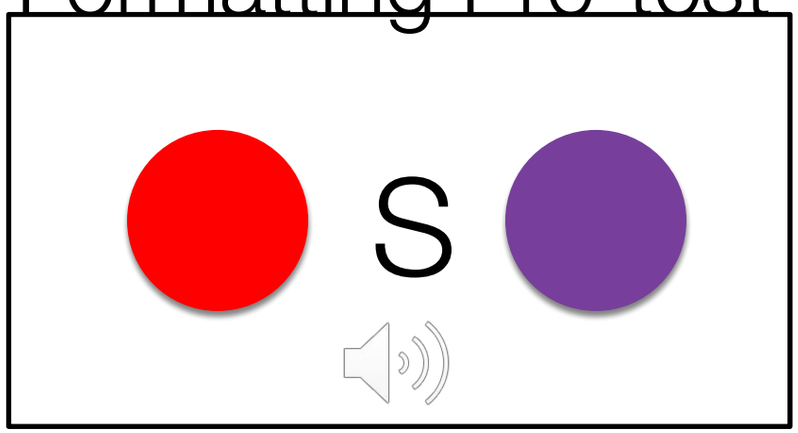
36

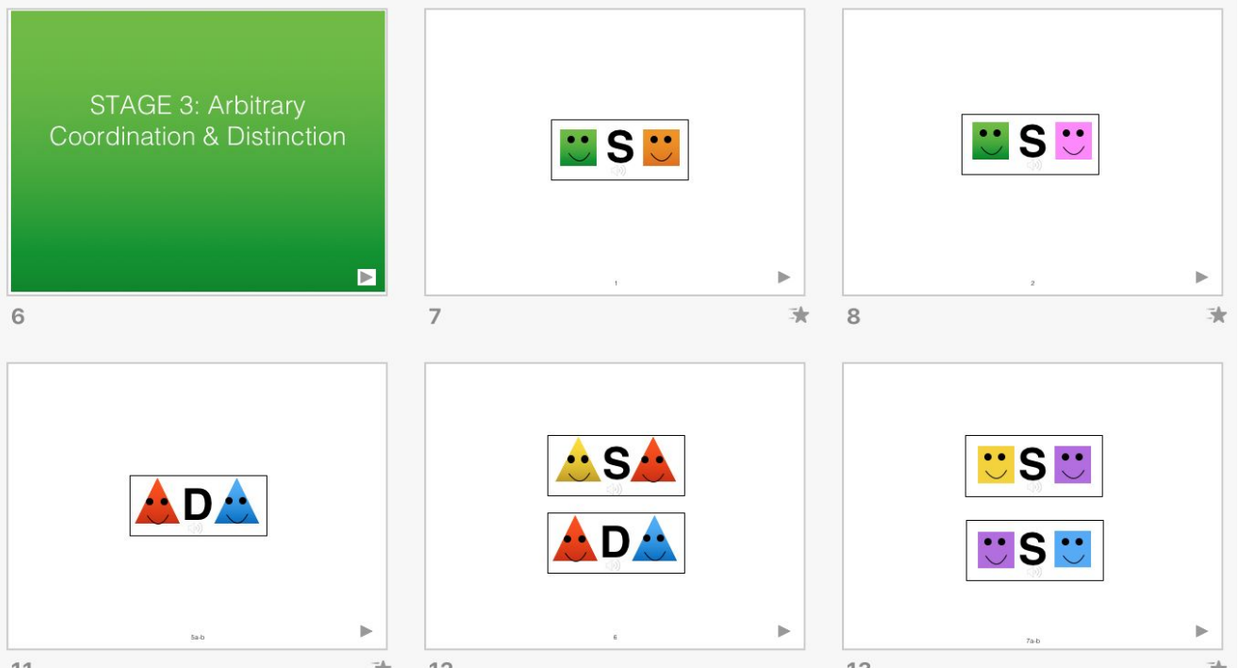
Stage 3: Arbitrary Relations II-IV





Formatting Pre-test





Stage 4: Arbitrary Analogical Relations I

STAGE 4: Arbitrary Analogy

37

BUZ is the same as DAX,
YIM is the same as HAL,
BUZ is different from YIM.

BUZ is the same as DAX,
YIM is the same as HAL,
BUZ is different from YIM.

BUZ DAX

DAX BUZ **BUZ YIM**

Coordination/Distinction

ZEB is the same as BAF,
BAF is opposite to MIC,
MIC is the same as COV.

Opposition

ZEB is the same as BAF,
BAF is opposite to MIC,
MIC is the same as COV.

ZEB BAF

BAF ZEB **BAF MIC**

Opposition

JUT is more than RIX,
JUT is less than MAF, RIX
is more than WEM.

JUT is more than RIX,
JUT is less than MAF, RIX
is more than WEM.

JUT RIX

RIX JUT **RIX WEM**

Comparison

REQ is before LAK, LAK
is before TUT, VOD is
after TUT.

Temporal

REQ is before LAK, LAK
is before TUT, VOD is
after TUT.

REQ LAK

TUT VOD **LAK REQ**

Temporal

ZIN is inside TEF, ZIN
contains NOS, TEF is
inside WAK.

ZIN is inside TEF, ZIN
contains NOS, TEF is
inside WAK.

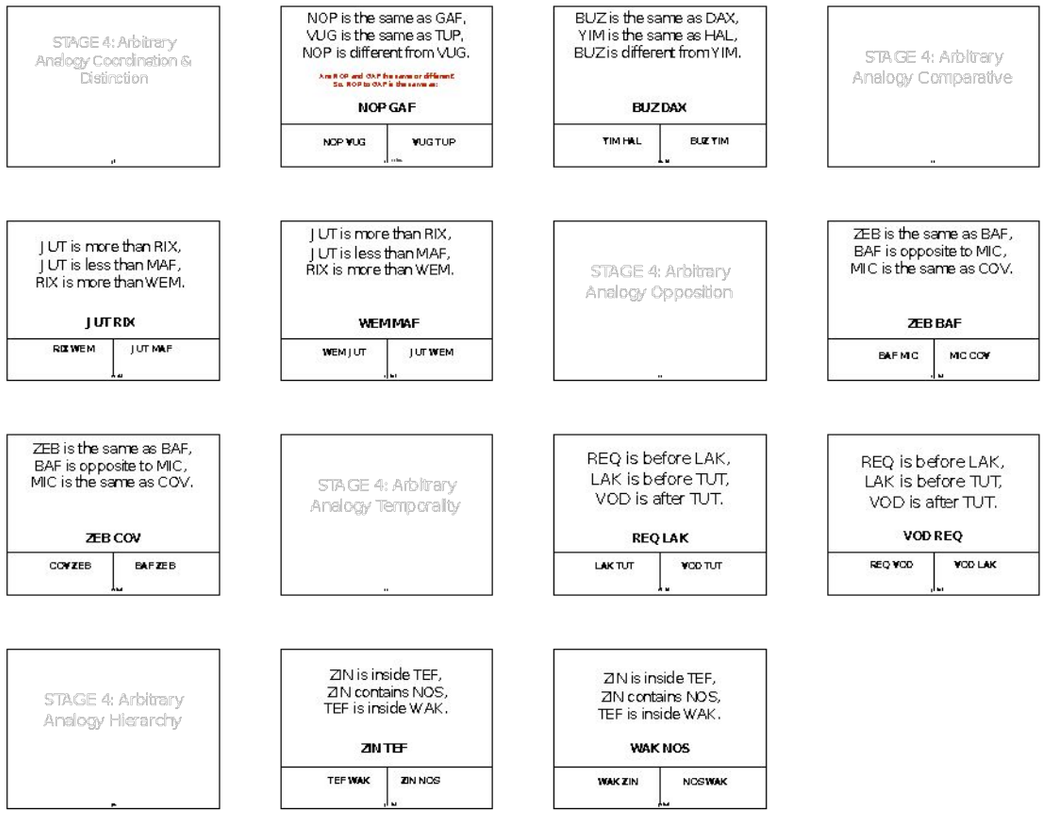
ZIN TEF

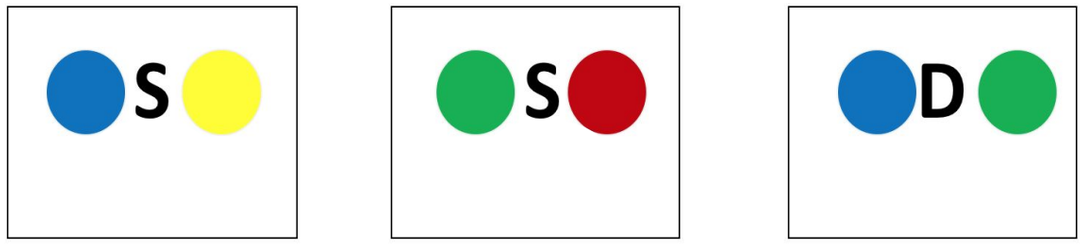
TEF WAK **ZIN NOS**

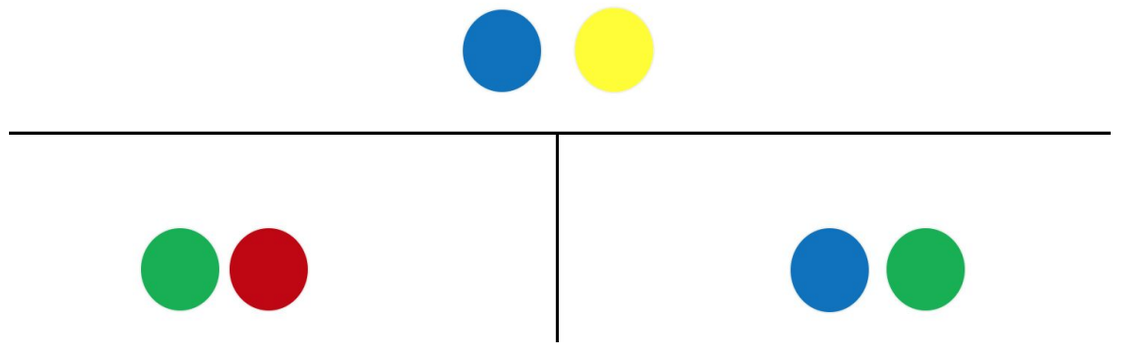
Hierarchy

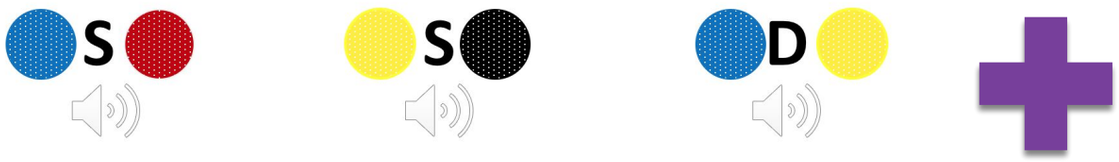
48

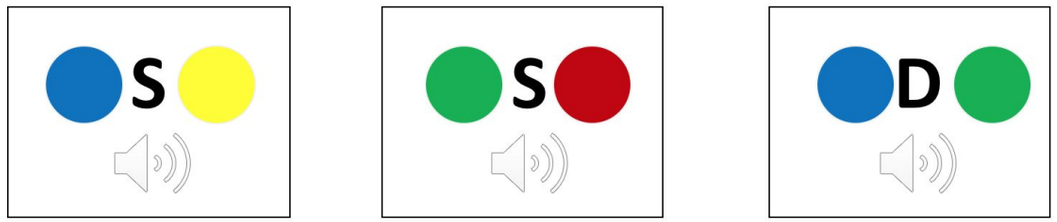
Stage 4: Arbitrary Analogical Relations II-IV



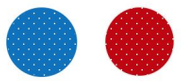


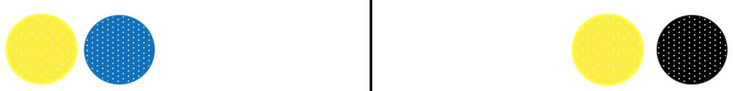






Are and the same or different?





Probe 1

Study 1: SB5 & ARA Correlations

	Age	SB5 Raw	ARA Total	ARA S1	ARA S2	ARA S3	ARA S4	ARA S1-3	ARA S2-3
Age									
SB5 Raw	.901**								
ARA Total	.866**	.887**							
ARA S1	.640**	.564**	.720**						
ARA S2	.730**	.789**	.843**	.710**					
ARA S3	.815**	.723**	.812**	.443*	.659**				
ARA S4	.719**	.806**	.901**	.500*	.659**	.649**		.687**	.854**

** Correlation is significant at the 0.01 level (2-tailed)

* Correlation is significant at the 0.05 level (2-tailed)

N = 25: Female: 15; Male: 10

Age Range = 36 - 89 months

Spearman's rank correlation coefficient between total scores on the ARA and the SB5 is statistically significant at the .01 level, with a correlation of .887

Study 1: SB5 & ARA Correlations

	Age	SB5 Raw	ARA Total	ARA S1	ARA S2	ARA S3	ARA S4	ARA S1-3	ARA S2-3
Age									
SB5 Raw	.901**								
ARA Total	.866**	.887**							
ARA S1	.640**	.564**	.720**						
ARA S2	.730**	.789**	.843**	.710**					
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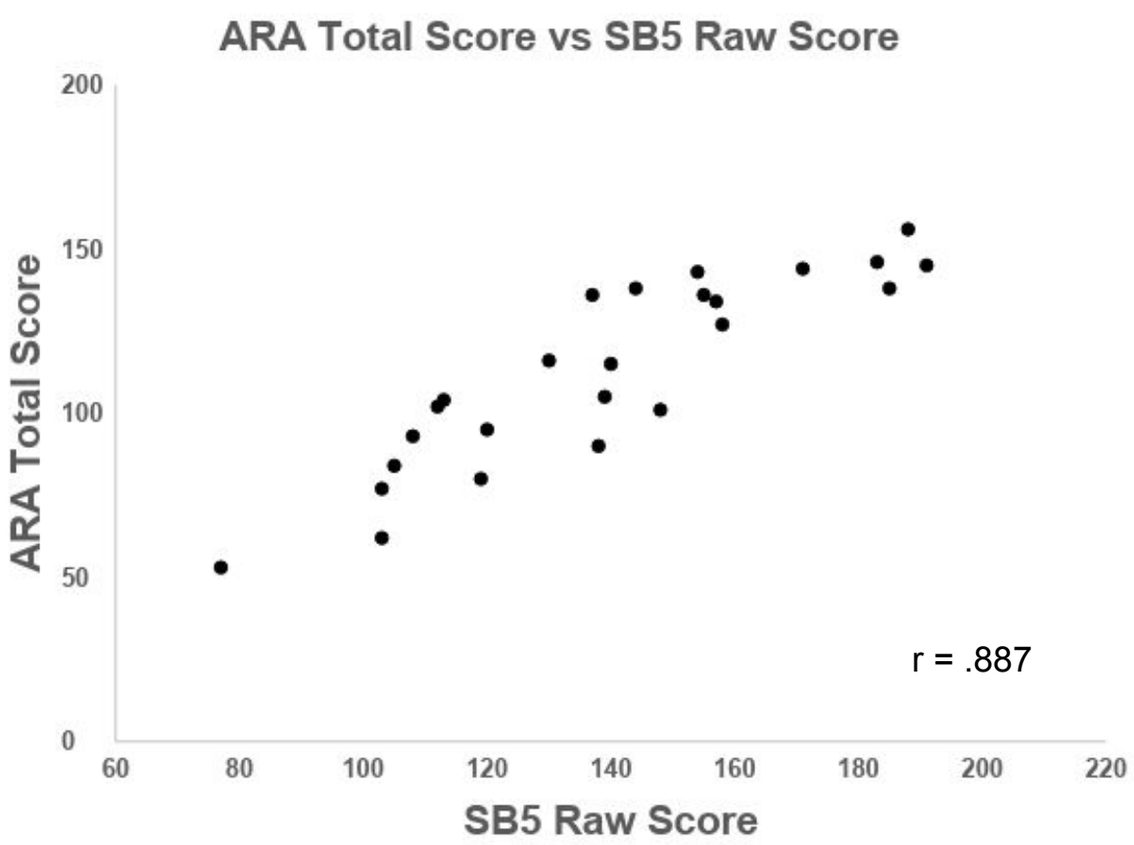
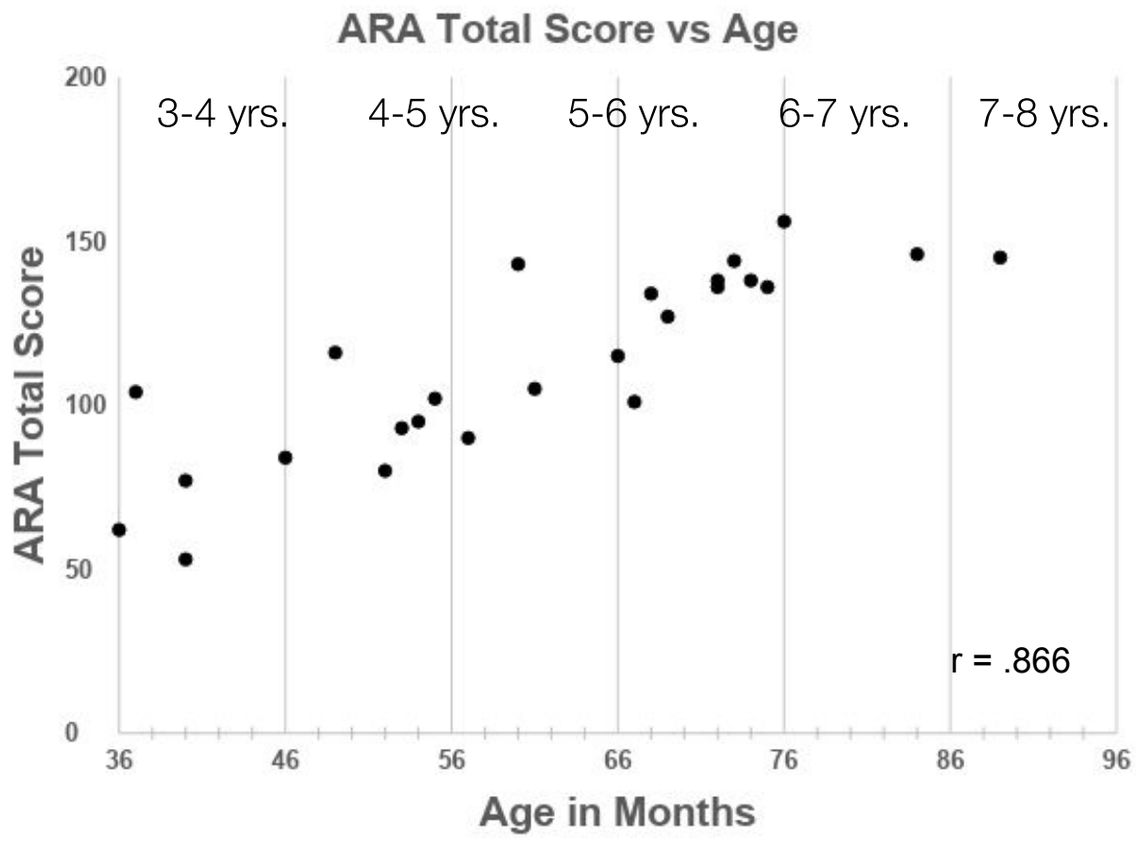
Correlations: SB5 & ARA

ARA Total Score vs SB5 Raw Score

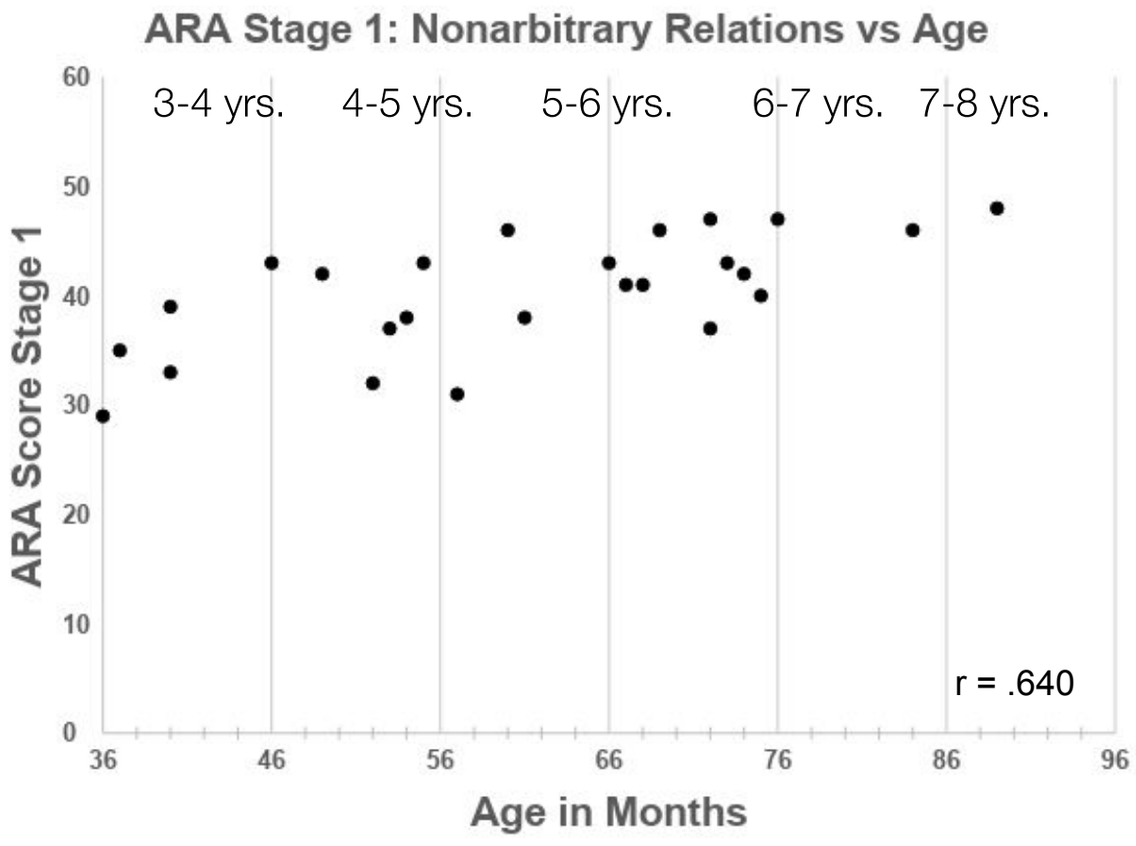


ARA Total Score vs Age

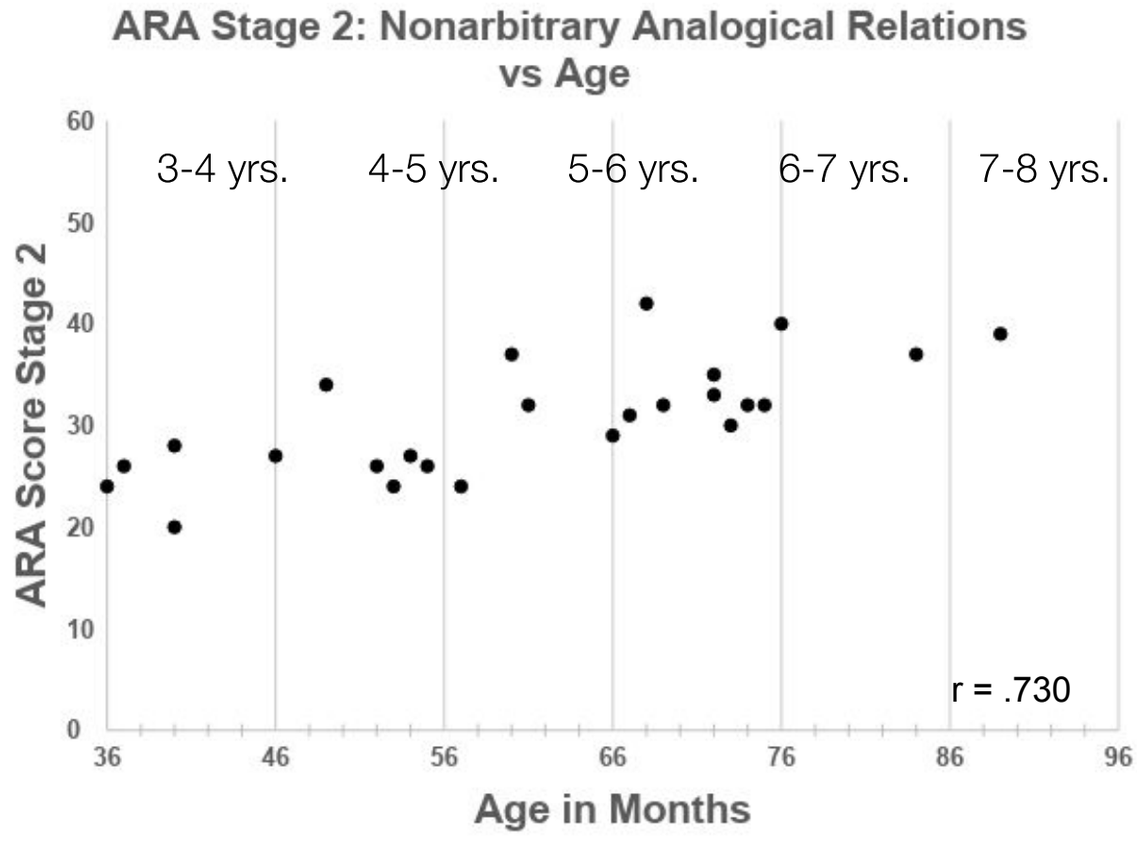


Stages 1 & 2 vs Age

ARA Stage 1 vs Age

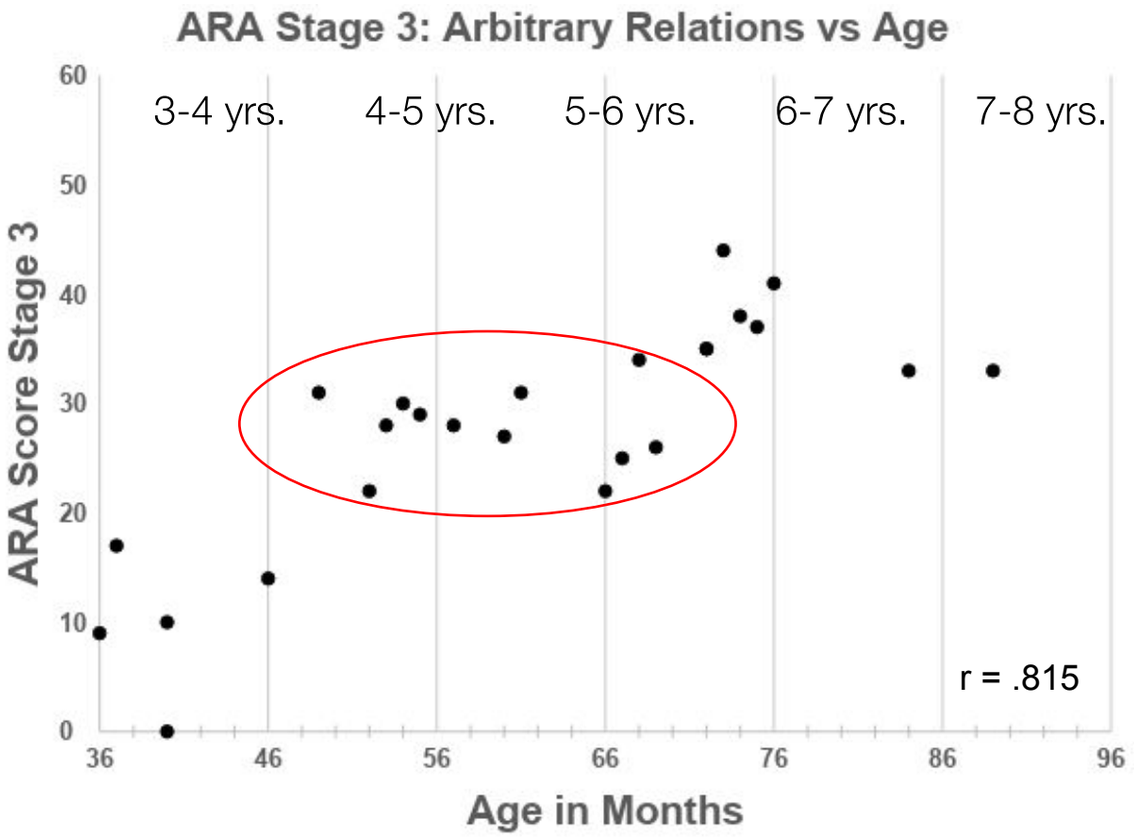


ARA Stage 2 vs Age

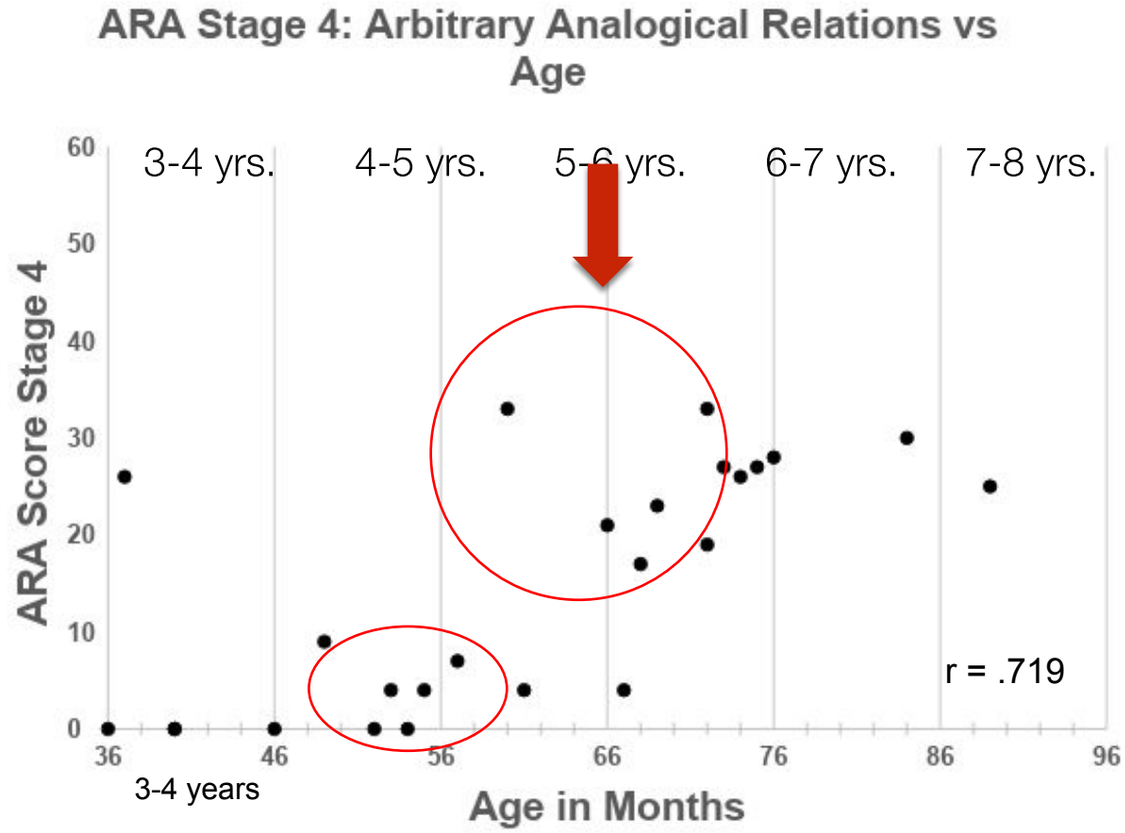


Stages 3 & 4 vs Age

ARA Stage 3 vs Age



ARA Stage 4 vs Age



Discussion

- Data suggest that the ARA is a reliable tool for assessing simple relations and relations within relations among young children.

- Emergence: mean % correct across all substages in Stage 4
  4-5-year-olds: 8%
  5-6-year-olds: 34%
  6-7-year-olds: 53%

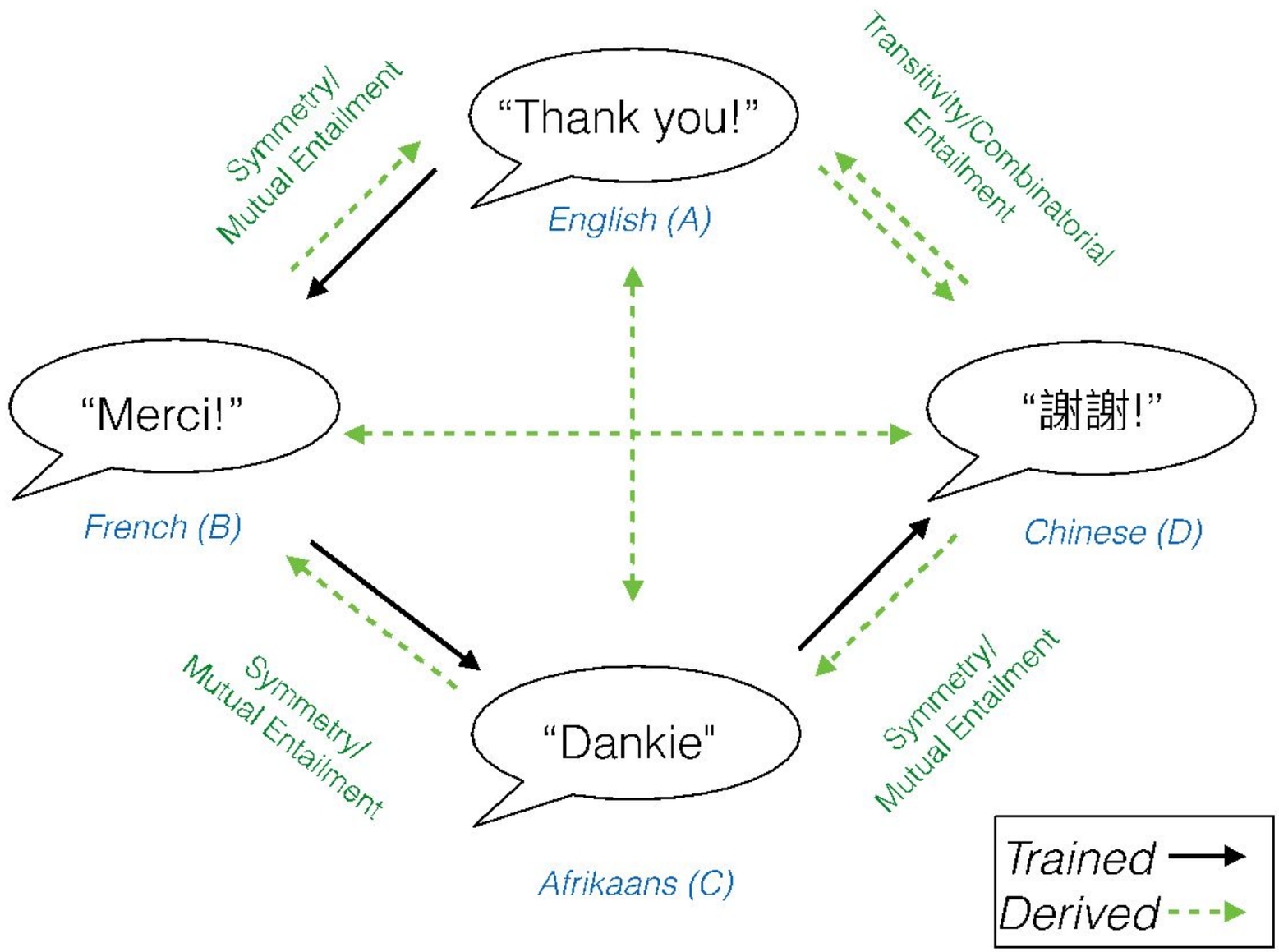
- Carpentier et al. suggested a developmental divide in the acquisition of analogical ability at approximately age of 5 years.

- These data support the findings of the Carpentier et al. studies (2002; 2003); 5-year-old children required more matching compounds tx before they successfully matched compounds involving derived stimuli.

Next: Training

- Use ARA data to design training procedures
- Implement multiple exemplar training (MET) to train a particular analogical repertoire in typically developing children, aged 5-6, identified as having a deficit in that repertoire.
- Test participants on analogical relational reasoning on a particular set of stimuli and then train them on that set of stimuli if they fail in a multiple baseline design across participants and relations.

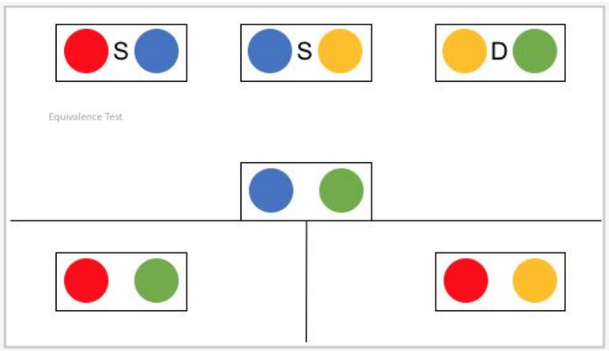
Thank you!


Symmetry/
Mutual Entailment
"Thank you!"
English (A)
Transitivity/Combinatorial
Entailment
"Merci!"
French (B)
"謝謝!"
Chinese (D)
Symmetry/
Mutual Entailment
"Dankie"
Afrikaans (C)
Symmetry/
Mutual Entailment
Trained
Derived

RFT & Analogy

- Barnes, Hegarty, & Smeets, 1997
- Stewart, Barnes-Holmes, Roche, & Smeets, 2001
- Stewart, Barnes-Holmes, Roche, & Smeets, 2002
- Carpentier, Smeets, & Barnes-Holmes, 2002
- Carpentier, Smeets, & Barnes-Holmes, 2003
- Carpentier, Smeets, Barnes-Holmes, & Stewart, 2004
- Stewart, Barnes-Holmes, & Roche, 2004
- Barnes-Holmes, Barnes-Holmes, Commins, Walsh, Stewart, Smeets, Whelan, Dymond, 2005
- Likens & Hayes, 2009
- Matos & de Lourdes Passos, 2010
- Ruiz & Luciano, 2011
- Miguel, Frampton, Lantaya, LaFrance, Quah, Meyer, Elias, & Fernand, 2015
- Ruiz & Luciano, 2015

Pilot Study 1



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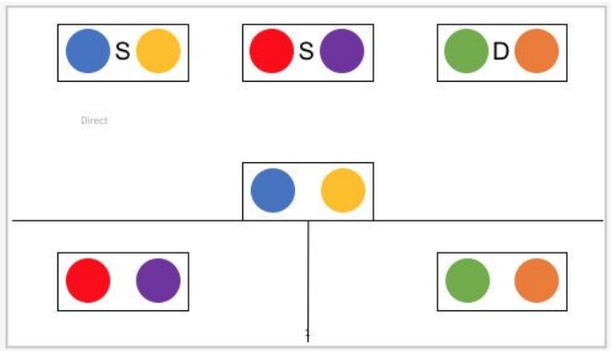

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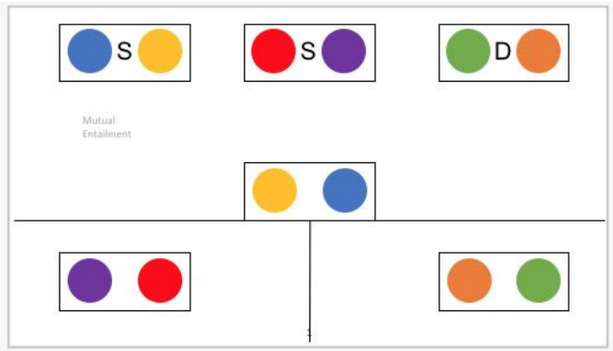

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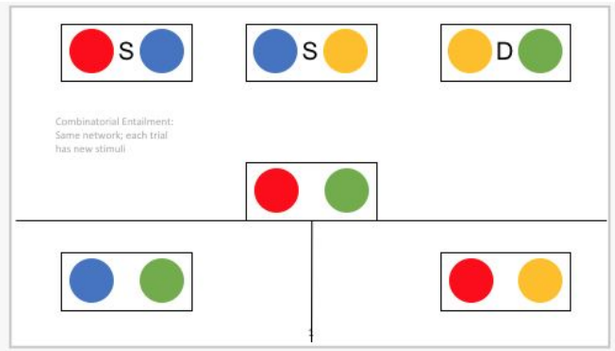

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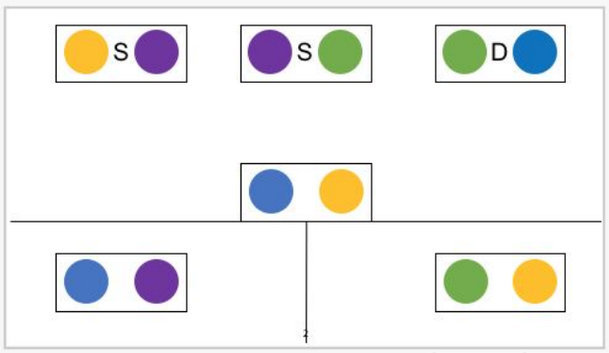

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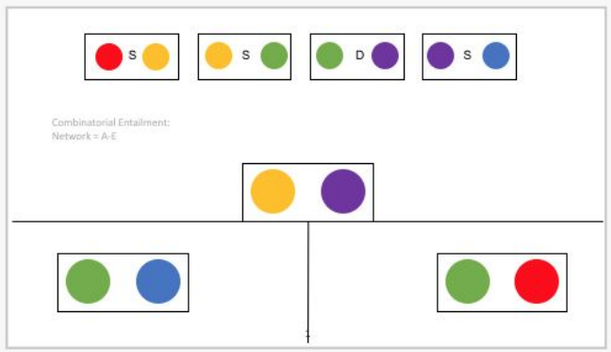
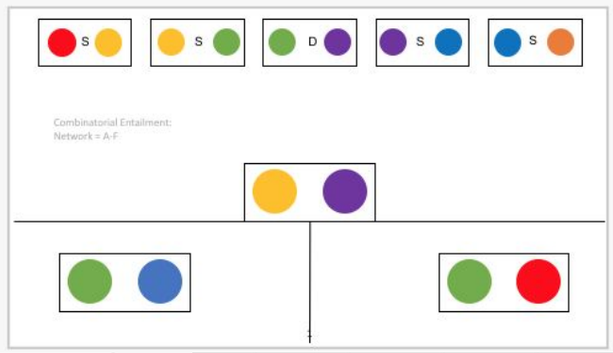




Equivalence Test			
Trial	**Relational Network**	**Correct**	+ -
1	Red is the same as blue; what's the same as red?	Blue	+ -
2	Blue is the same as yellow, what's the same as yellow?	Blue	+ -
3	Red is the same as blue, blue is the same as yellow; what is yellow to blue?	Same	+ -
4	Red is the same as blue, blue is the same as yellow; is red the same as yellow?	yes	+ -
5	Red is the same as blue, blue is the same as yellow; what is yellow to red?	Same	+ -
6	Blue is the same as yellow, yellow is different to green; is blue the same as green?	no	+ -
7	Blue is the same as yellow, yellow is different to green; what is green to blue?	Different	+ -
8	Red is the same as blue, blue is the same as yellow, yellow is different to green; what is red to yellow?	Same	+ -
9	Red is the same as blue, blue is the same as yellow, yellow is different to green; what is red to green?	Different	+ -
10	Red is the same as blue, blue is the same as yellow, yellow is different to green; is green the same as red?	no	+ -

	Equiv	Direct	ME		Same network diff colors		A-E	A-F
P#	% cor	% cor	% cor	Age	% cor	Post A-E & A-F	% cor	% cor
8	80	60	50	4.58	40%		40%	40%
11	80	50	40	4.83	0%		0%	0%
12	40	60	100	6.83	60%		80%	40%
4	60	100	100	7.5	40%		100%	40%
6	70	90	90	7.9	20%	0%	40%	80%
3	100	100	100	9.25	60%	100%	20%	40%
9	60	100	90	9.92	80%		20%	40%
7	70	100	100	10.4	40%	100%	80%	100%
10	100	100	100	13.2	100%		100%	100%
1	100	100	100	Adult	40%		80%	80%
2	100	100	100	Adult	80%		100%	100%
5	100	100	100	Adult	100%		100%	80%
				Mean:	60%		68%	70%

Pilot Study 2

#	Same-Different
1	S means the same
	What does S mean?
2	D means different
	What does D mean?
3	Point to same
4	Point to different
5	*What does this (S) mean?*
6	*What does this (D) mean?*

#	Red is the same as blue
1	Is red the same as blue?
2	Is blue the same as red?
3	What is red to blue?
4	What is blue to red?
5	Are red and blue the same or different?
6	Is red different to blue?
7	Is blue different to red?
8	What is the same as red?
9	What is the same as blue?
10	What does S mean?

#	Red is different to blue
1	Is red different to blue?
2	Is blue different to red?
3	What is blue to red?
4	Are red and blue the same or different?
5	Is red the same as blue?
6	What is different to blue?

#	Red S Blue, Blue S Yellow
1	Is red the same as blue?
2	Is blue the same as yellow?
3	Is red the same or different to yellow?
4	What is yellow to red?
5	Is yellow the same as red?
6	Is yellow different to red?
7	What is red to yellow?
8	What is the same as yellow? (2 R)

#	Red S Blue, Blue D Yellow
1	Is red the same or different to blue?
2	Is blue the same or differnet to yellow?
3	What is red to yellow?
4	Is yellow the same or different to red?
5	Is red the same or different to yellow?
6	What is yellow to red?
7	Is yellow different to red?
8	What is different to yellow? (2 R)

#	CE Equivalence Prompts S S S
1	Is blue the same or different to red?
2	Is yellow the same or different to blue?
3	Is green the same or different to yellow?
4	What is red to yellow?
5	Is green the same or different to blue?
6	What is yellow to red, same or different?
7	What is red to yellow?
8	What is red to green?
9	What is green to red?

#	CE Equivalence Prompts S S D
1	Is blue the same or different to red?
2	Is yellow the same or different to blue?
3	Is green the same or different to yellow?
4	What is red to blue?
5	What is yellow to green?
6	Is blue the same or different to green?
7	What is green to blue?
8	What is red to green, same or different?
9	What is green to red?

#	Red S Blue, Blue D Yellow
1	What is red to blue, same or different?
2	What is blue to red?

#	Red S Blue, Blue D Yellow
1	What is blue to yellow, same or different
2	What is yellow to blue?

#	CE Analogy w/ Equiv Prompt (Viz + Voc)
1	Is red the same or different to green?
2	Is blue the same or different to green?
3	Is red the same or different to yellow?
#	CE Analogy #1
Correct	Left: blue to green

#	CE Analogy w/ Equiv Prompt (Viz + Voc)
1	Is blue the same or different to yellow?
2	Is blue the same or different to purple?
3	Is green the same or different to yellow?
#	CE Analogy #2
Correct	Left: blue to purple

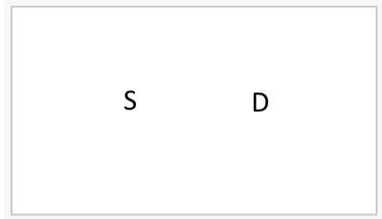
#	CE Analogy w/ Equiv Prompt (Viz + Voc)
1	Is green the same or different to red?
2	Is orange the same or different green?
3	Is red the same or different to blue?
#	CE Analogy #3
Correct	Right: Red to blue

#	CE Analogy w/ Equiv Prompt (Viz + Voc)
1	Is blue the same or different to purple?
2	Is green the same or different to blue?
3	Is purple the same or different to red?
#	CE Analogy #4
Correct	Left: green to blue

#	CE Analogy w/ Equiv Prompt (Viz + Voc)
1	Is blue the same or different to orange?
2	Is purple the same or different to blue?
3	Is orange the same or different to yellow?
#	CE Analogy #5
Correct	Right: Orange to yellow

#	CE Analogy w/ Equiv Prompt (Viz)
1	Right: purple to green
2	Right: blue to yellow
3	Left: red to green
4	Left: orange to purple
5	Right: orange to yellow

#	CE Analogy No Prompt
1	Right: orange to green
2	Left: blue to yellow
3	Left: green to red
4	Right: blue to yellow
5	Left: orange to purple



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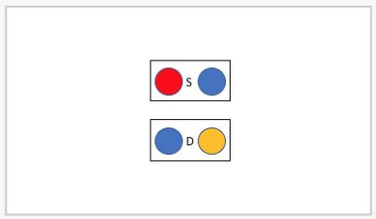

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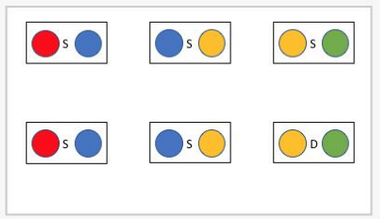

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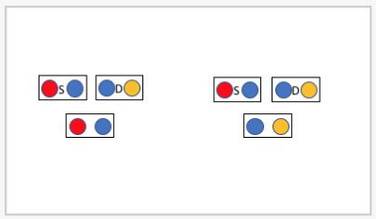

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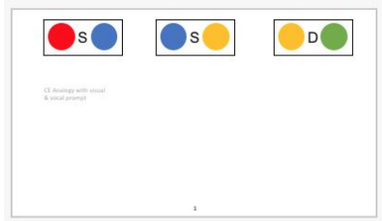

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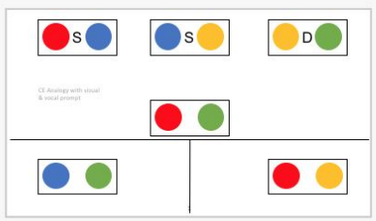

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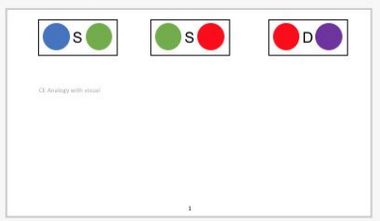

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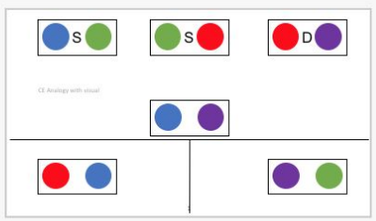

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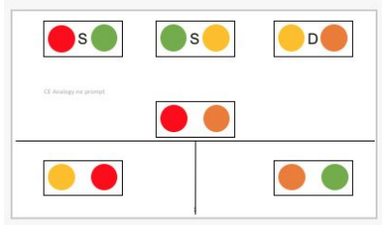

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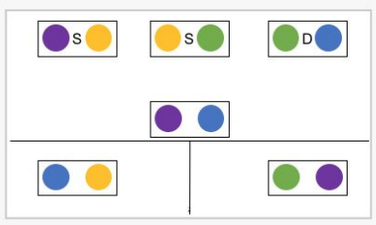

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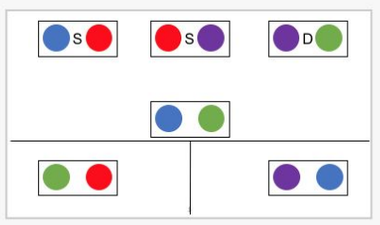

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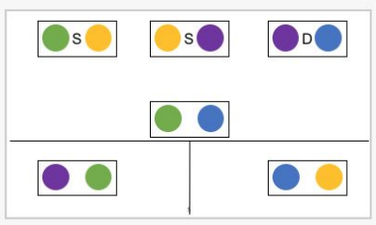

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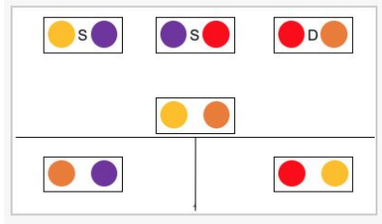

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