

1

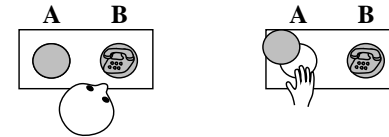
Neural network approaches to cognitive flexibility: A-not-B and other cases of perseveration

Yuko Munakata J. Bruce Morton
University of Colorado, Boulder University of Western Ontario

2

Flexibility

- A-not-B
10-months



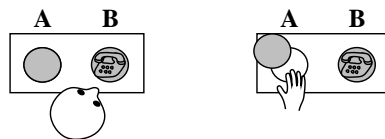
- Card-sorting
3 years

verbal query vs. action

3

Flexibility


- A-not-B
10-months



- Card-sorting
3 years

verbal query vs. action

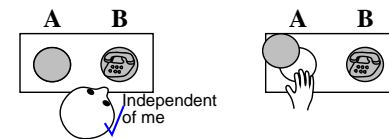
Red Truck Red Truck

"Where do trucks go?" 

4

Standard: Knowledge Intact


- A-not-B
10-months



- Card-sorting
3 years

verbal query vs. action

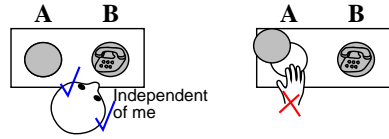
Red Truck Red Truck

"Where do trucks go?" ✓ 

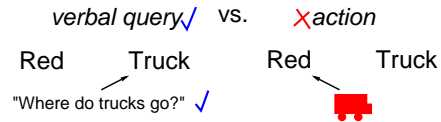
5

Standard: Deficits in Separable Systems

- A-not-B
10-months



- Card-sorting
3 years



6

Alternative: Nature of Knowledge Representations (I)

Knowledge not all-or-nothing.

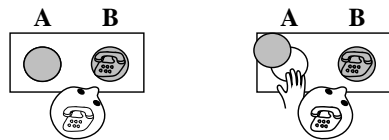
Graded representations, weaker or stronger:

- based on state of development, support from environment, extent of brain damage/differences, etc.
- in terms of number of relevant neurons firing, firing rates of those neurons, coherence of firing pattern.
- with some tasks requiring stronger reps than others.

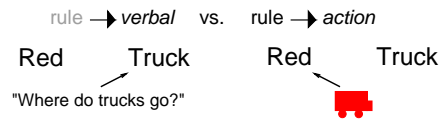
7

Alternative: Graded Representations

- A-not-B
10-months



- Card-sorting
3 years



8

Alternative: Nature of Knowledge Representations (II)

Knowledge not monolithic.

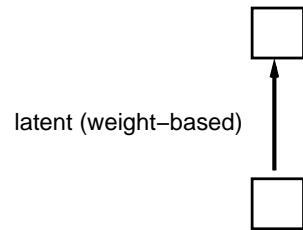
Distinct types of knowledge representations, active vs. latent:



9 Alternative: Nature of Knowledge Representations (II)

Knowledge not monolithic.

Distinct types of knowledge representations, active vs. latent:

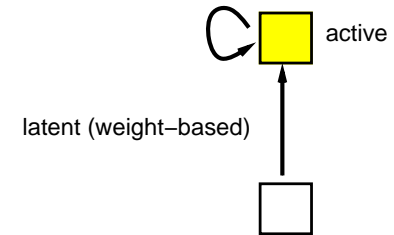


Latent reps: Develop early, posterior cortical/subcortical areas

10 Alternative: Nature of Knowledge Representations (II)

Knowledge not monolithic.

Distinct types of knowledge representations, active vs. latent:



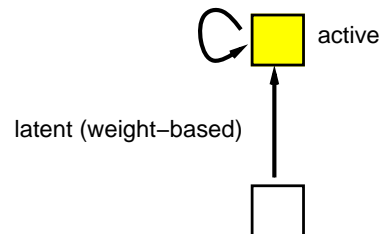
Latent reps: Develop early, posterior cortical/subcortical areas

Active reps: Develop late, prefrontal cortical regions

11 Alternative: Nature of Knowledge Representations (II)

Knowledge not monolithic.

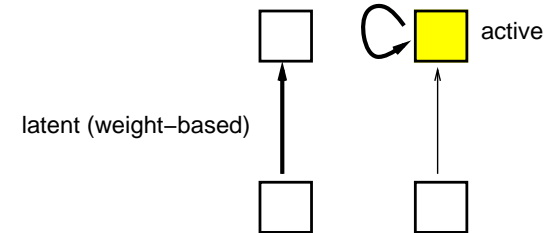
Distinct types of knowledge representations, active vs. latent:



12 Alternative: Nature of Knowledge Representations (II)

Knowledge not monolithic.

Distinct types of knowledge representations, active vs. latent:



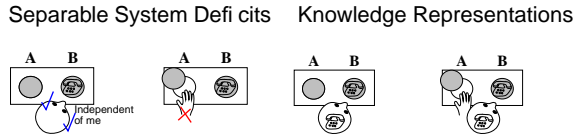
May compete in perseveration.

13

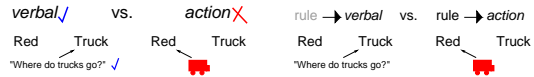
Overview

1. Compare alternative accounts of perseveration, dissociation:

- A-not-B
10-months



- Card-sorting
3 years

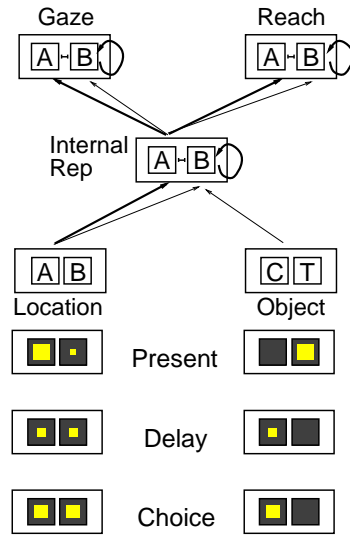


2. Challenge: Why do we sometimes perseverate when answers are right in front of us?

3. New directions: increasing flexibility, generalizing knowledge.

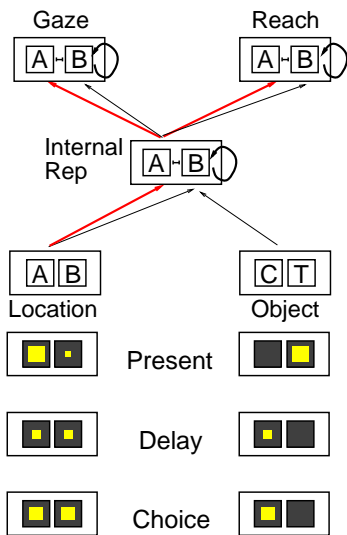
14

A-not-B Simulation (Munakata, 1998, *Developmental Science*)



15

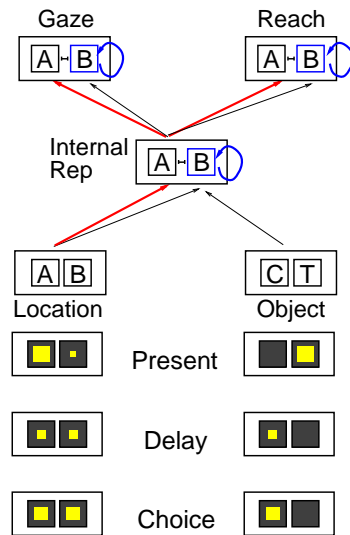
A-not-B Simulation (Munakata, 1998, *Developmental Science*)



Latent = weights
- increase w/co-activity (Hebbian)

16

A-not-B Simulation (Munakata, 1998, *Developmental Science*)

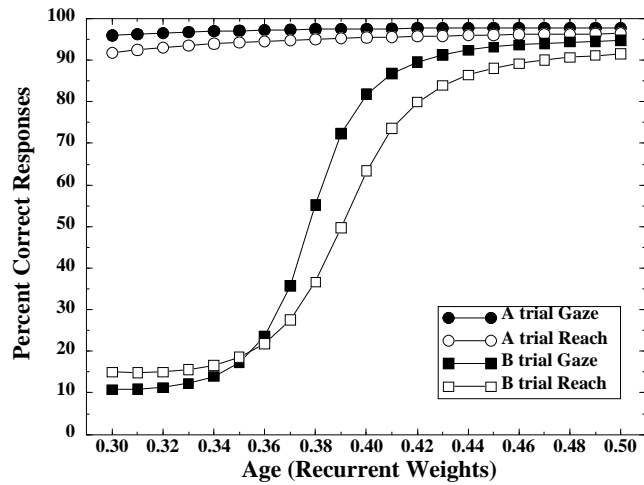


Latent = weights
- increase w/co-activity (Hebbian)

Active = unit activity
- recurrent weights increase w/age

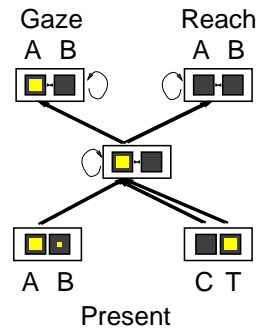
17

Simulation Results



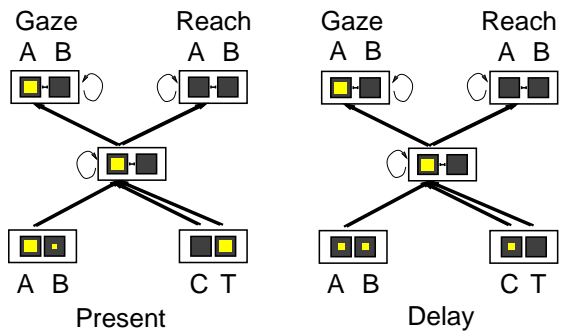
18

A trial activity



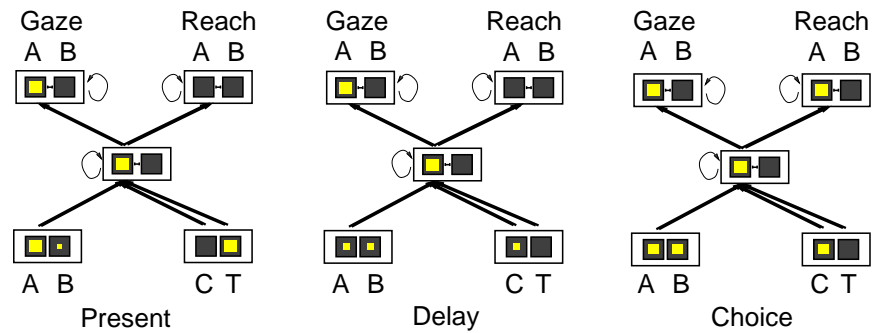
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A trial activity



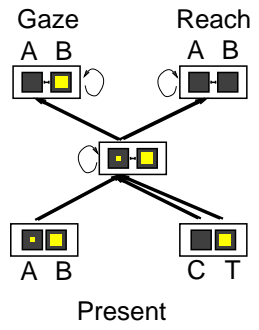
20

A trial activity



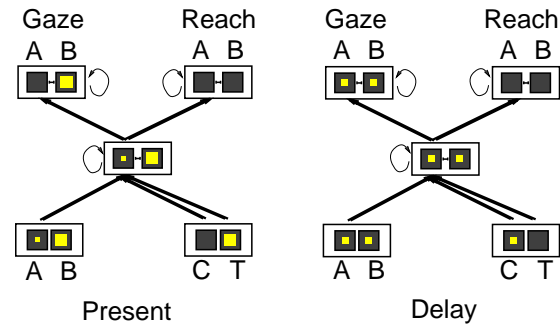
21

B trial activity



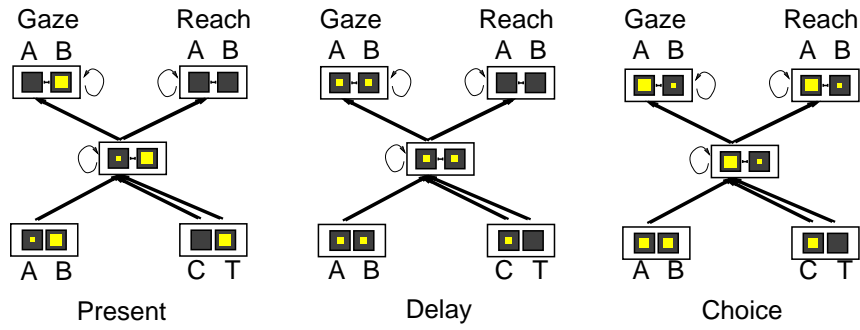
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B trial activity



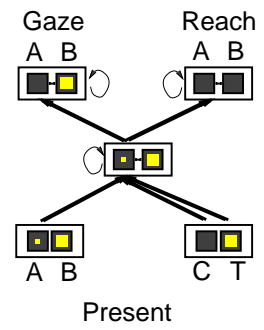
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B trial activity



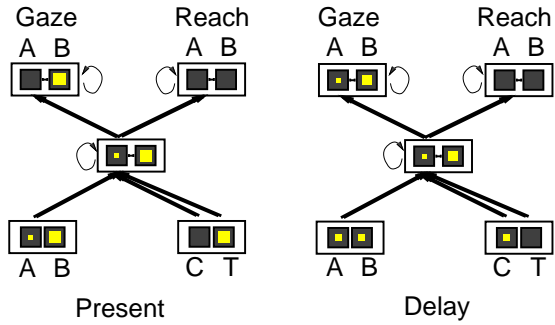
24

Gaze-reach dissociation



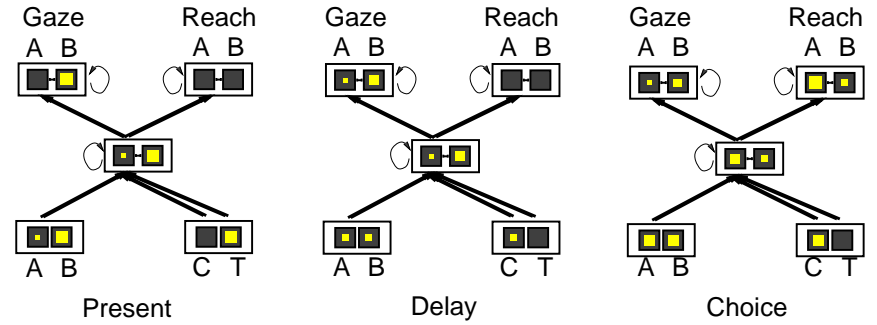
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Gaze-reach dissociation



26

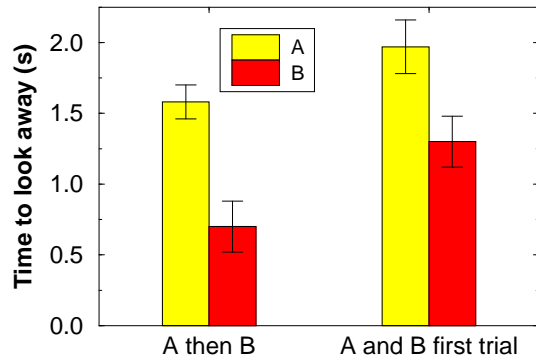
Gaze-reach dissociation



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Simulation Predictions

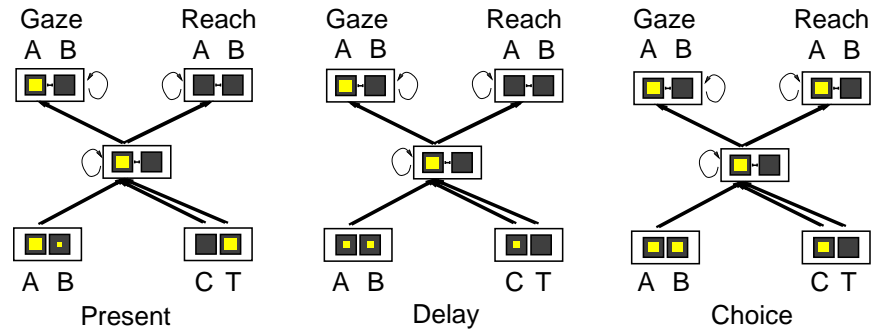
- Infants will look away more quickly after B trials than after A trials (Munakata, Yerys, & Hutaff (in prep)):



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Simulation Predictions

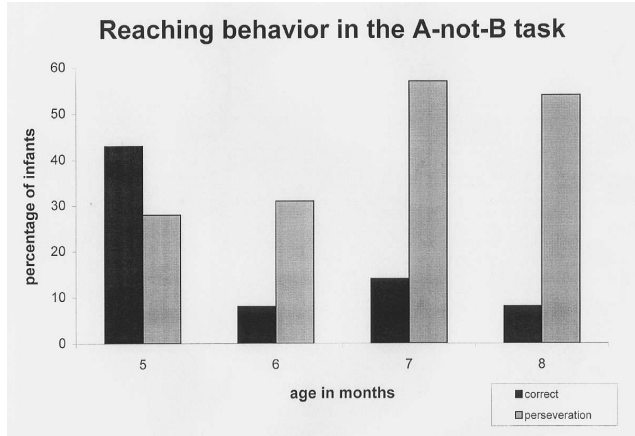
- Infants will show U-shaped developmental curve in A-not-B:



29

Simulation Predictions

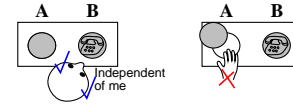
- Infants will show U-shaped developmental curve in A-not-B (Clearfield, Thelen, et al.):



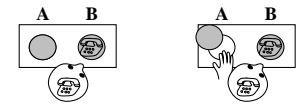
30

Evaluation: A-not-B

Separable System Deficits



Knowledge Representations



Not:

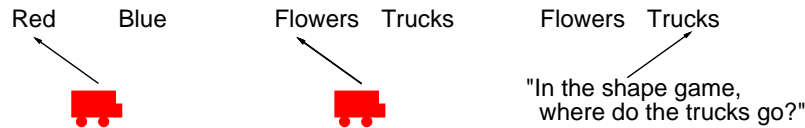
- knowledge fine (lookaway)
- reaching problem (U-shaped curve)

Stronger reps to overcome conflict, to drive less frequent response.

31

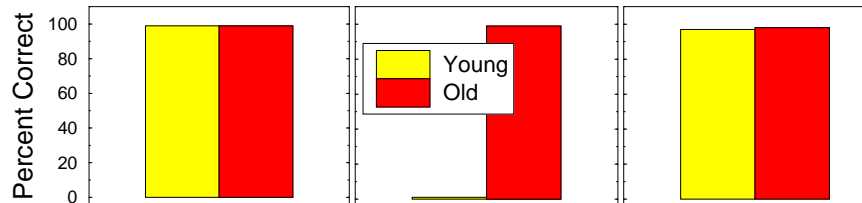
Dissociations in card-sort

Zelazo et al.



Simulation

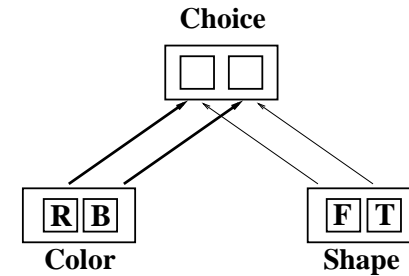
Morton & Munakata (2002), *Developmental Psychology*



32

Card-sorting Simulation

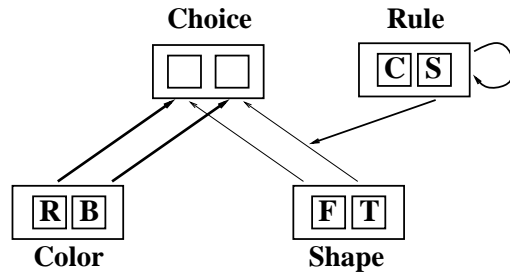
Morton & Munakata (2002), *Developmental Psychology*



33

Card-sorting Simulation

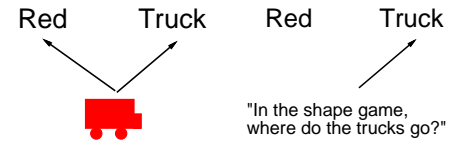
Morton & Munakata (2002), *Developmental Psychobiology*



34

Conflict

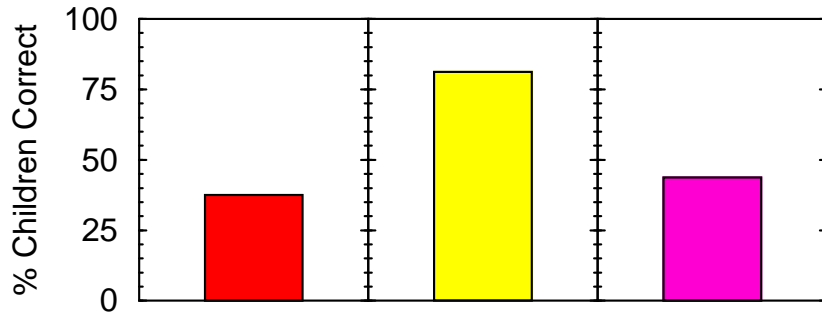
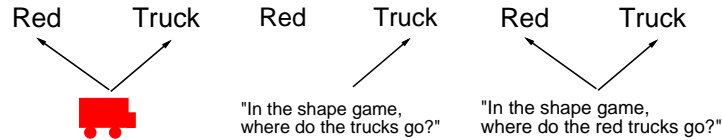
Munakata & Yerys (2001), *Psych Science*



35

Conflict

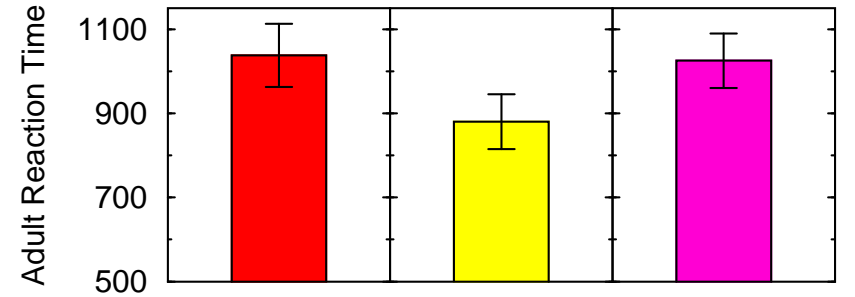
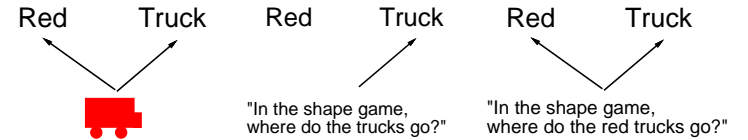
Munakata & Yerys (2001), *Psych Science*



36

Conflict

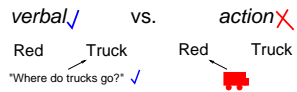
Morton & Munakata (in prep)



37

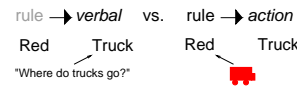
Evaluation: Card-sorting

Separable System Deficits



Action deficits cannot fully account for sorting errors.

Knowledge Representations



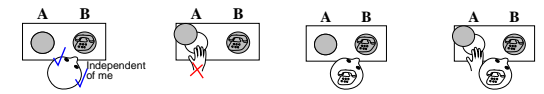
Stronger reps needed to overcome conflict, whether verbal or action.

38

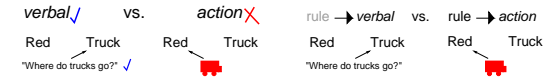
Overview

1. Compare alternative accounts of perseveration, dissociation:

- A-not-B



- Card-sorting



2. Challenge: Why do we sometimes perseverate when answers are right in front of us?

3. New directions: increasing flexibility, generalizing knowledge.

39

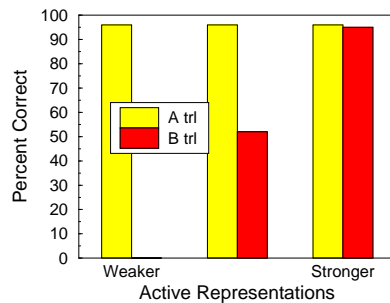
Perseveration with Visible Solutions

Aguiar & Baillargeon (2000)



Simulation:

Stedron, Sahni, & Munakata (2005), Journal of Cog Neuroscience



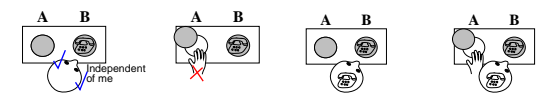
Common mechanisms for working memory and attention.

40

Overview

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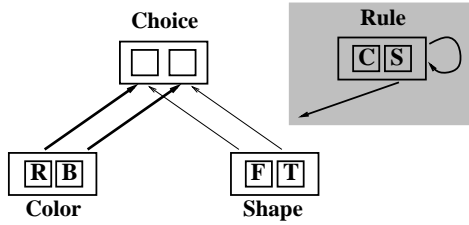
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41

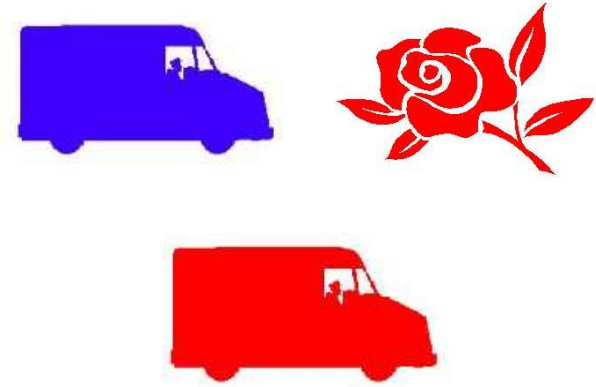
Improving Children's Switching

Teach through scaffolding: With weak active reps, more effective to build up latent reps.



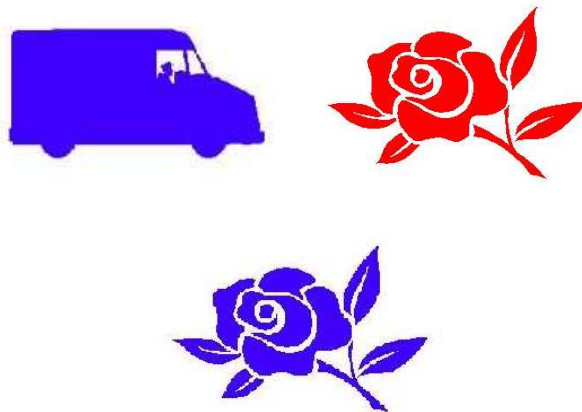
42

Improving Children's Switching



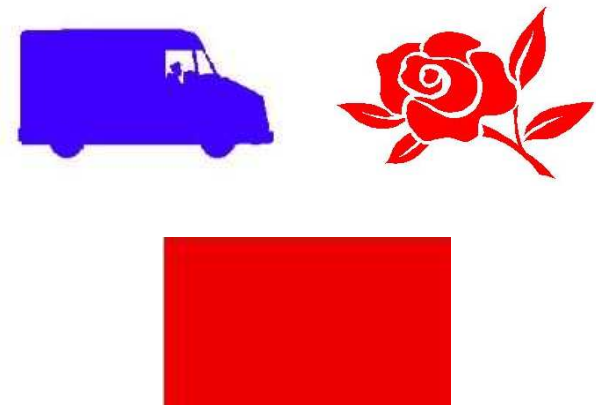
43

Improving Children's Switching



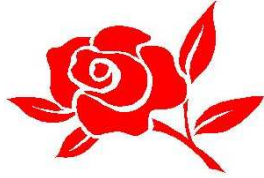
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Improving Children's Switching



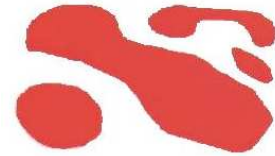
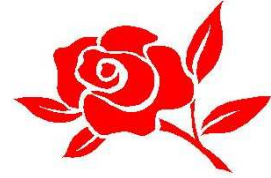
45

Improving Children's Switching



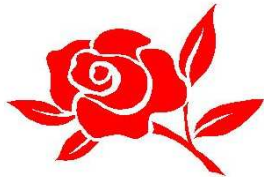
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Improving Children's Switching



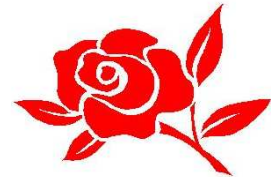
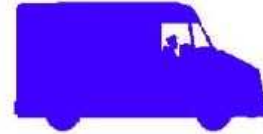
47

Improving Children's Switching



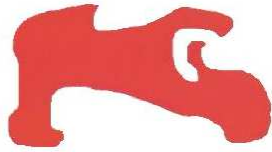
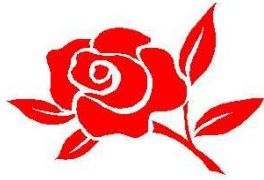
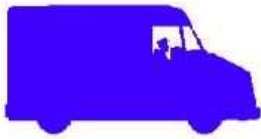
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Improving Children's Switching



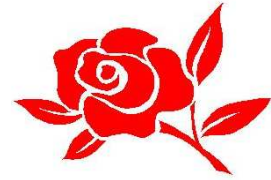
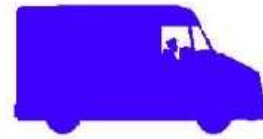
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Improving Children's Switching



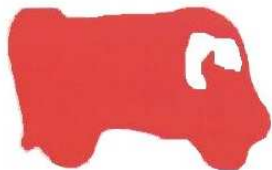
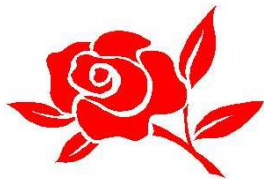
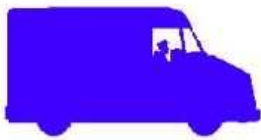
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Improving Children's Switching



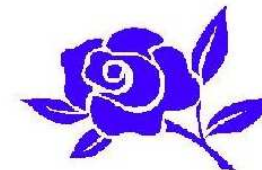
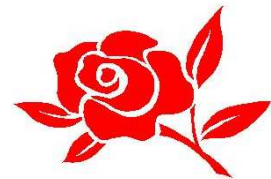
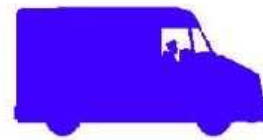
51

Improving Children's Switching



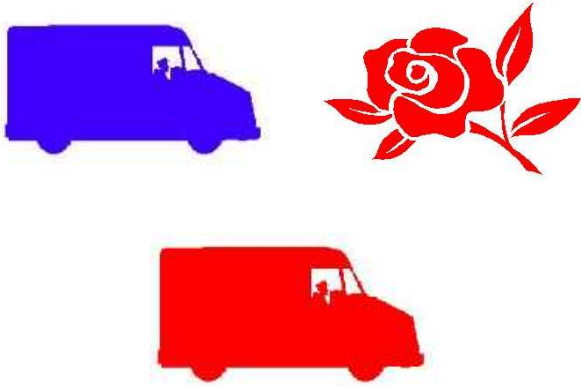
52

Improving Children's Switching



53

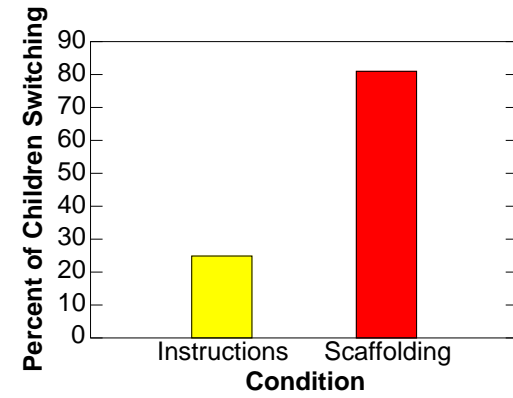
Improving Children's Switching



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Improving Children's Switching

Brace, Morton, & Munakata (in prep)

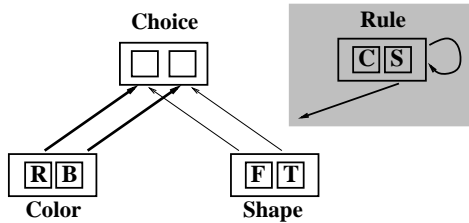


55

Improving Children's Switching

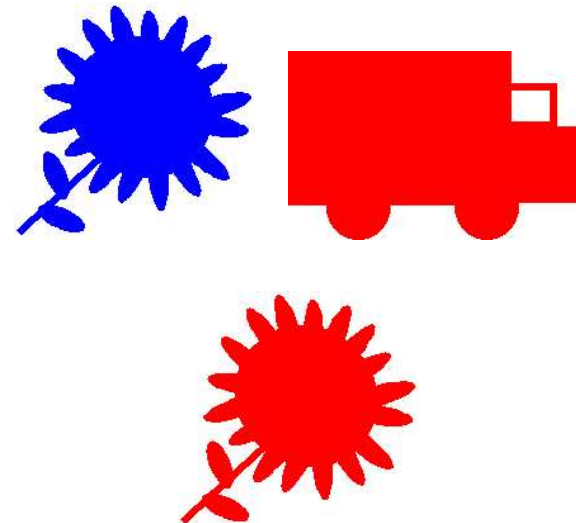
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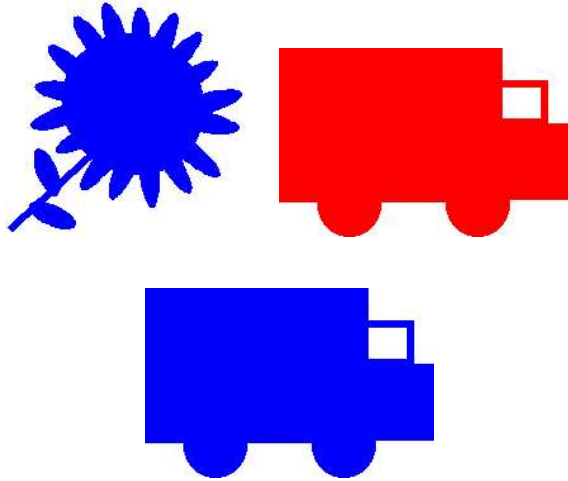
56

Generalization



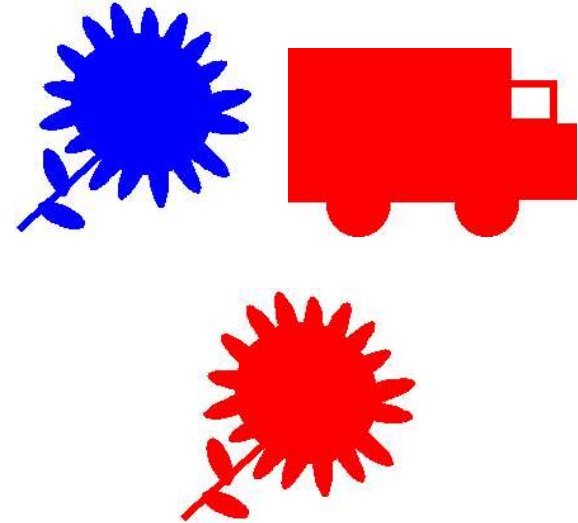
57

Generalization



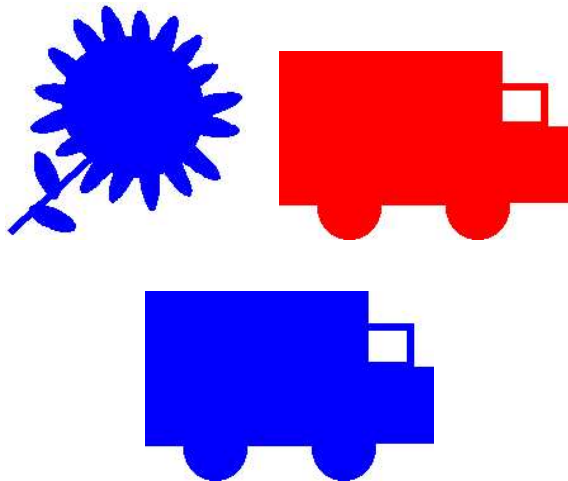
58

Generalization



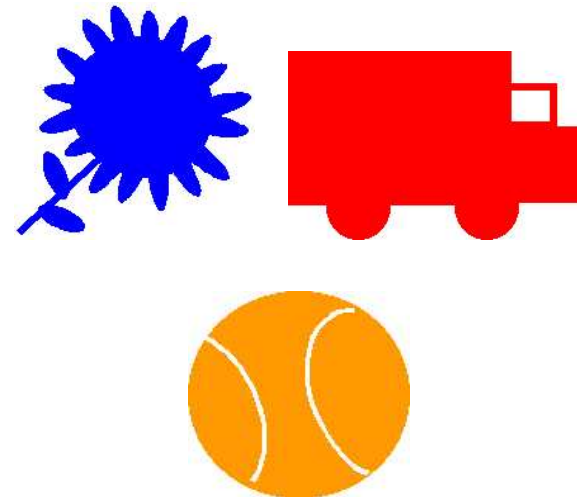
59

Generalization



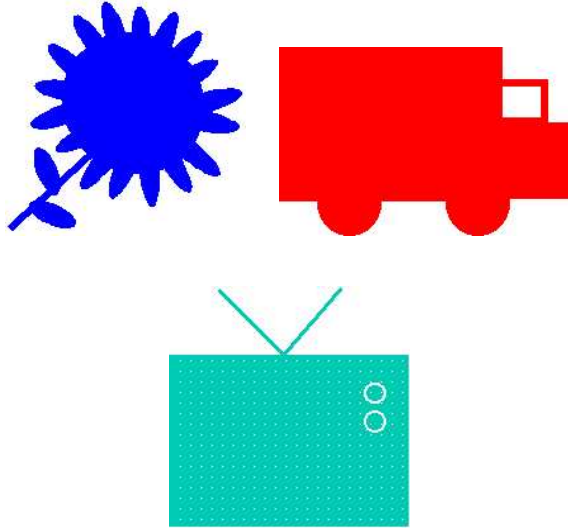
60

Generalization



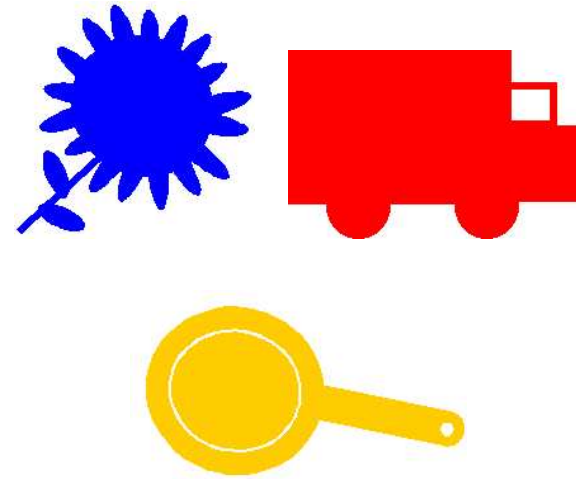
61

Generalization



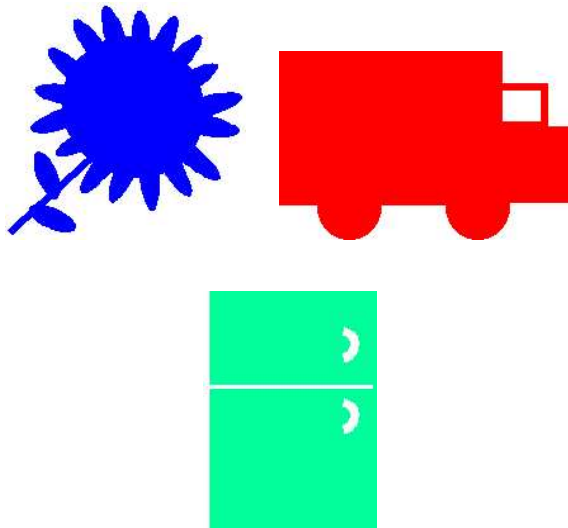
62

Generalization



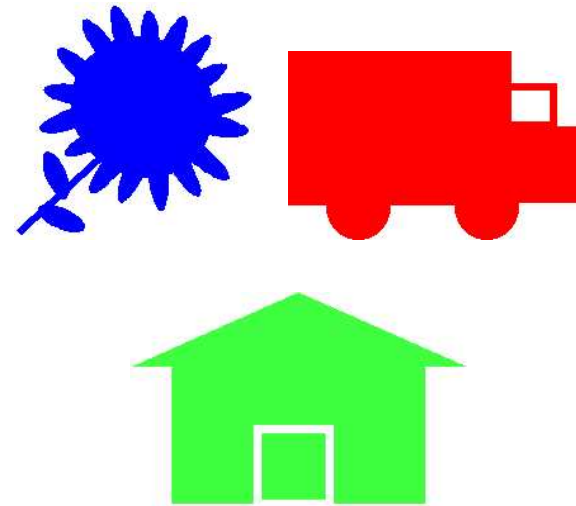
63

Generalization



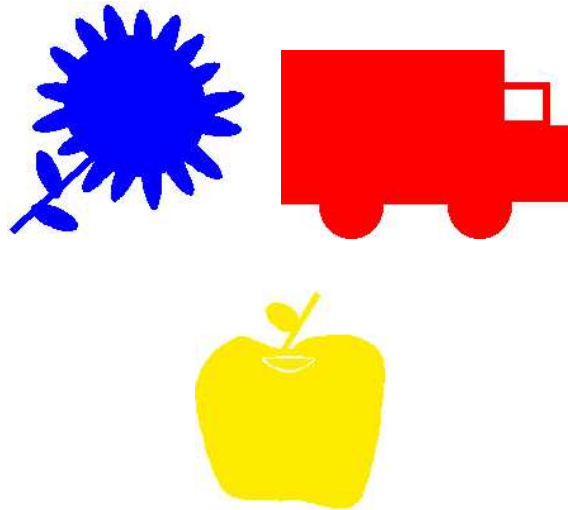
64

Generalization



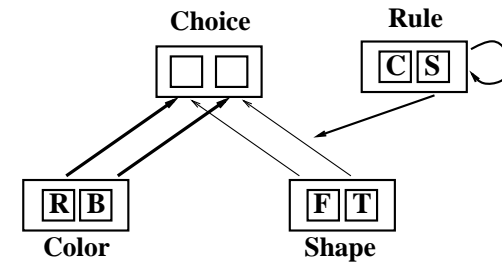
65

Generalization



66

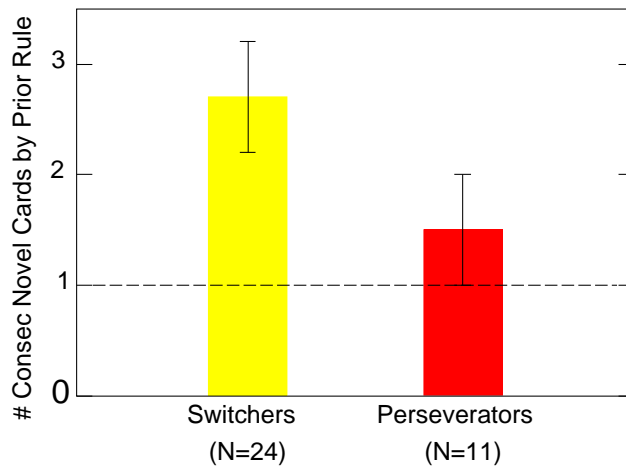
Generalization



67

Generalization by 3.5-year-old Children

Kharitonova, Chien, Colunga, & Munakata (in progress)



68

Overview

1. Compare alternative accounts of perseveration, dissociation:

Separable System Deficits Knowledge Representations

- A-not-B

10-months
- Card-sorting

3 years

verbal ✓ vs. action ✗

Red Truck vs. Red Truck

"Where do trucks go?" ✓ vs. "Where do trucks go?"

2. Challenge: Why do we sometimes perseverate when answers are right in front of us? Common mechanisms for working memory and attention.

3. New directions: increasing flexibility, generalizing knowledge.