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Feature Creation and Concept Learning: Empirical Evidence and Neural Modeling

Introduction

- We manipulate complex perceptual concepts with speed
- We learn new concepts from single exposures to exemplars
- These characteristics require complex features
- Feature creation capabilities are therefore a necessity

(Schyns, Goldstone & Thibaut, 1998)

How do we bridge the gap between available low-level features and the high-level features needed in a complex environment?

Purpose of this work

Demonstrate experimentally that, while learning new concepts, features are being automatically created. These features are intermediate structures, composites of the elementary inputs.

Concepts are composites of features. Features are shared by different concepts.

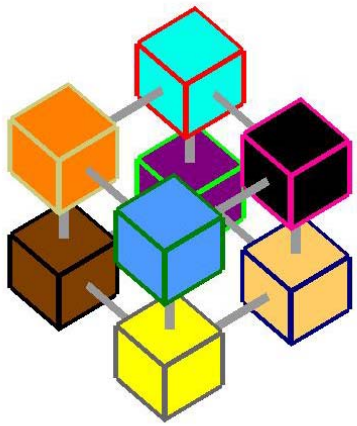
Show analog behavior of a neural network mimicking the experiment.

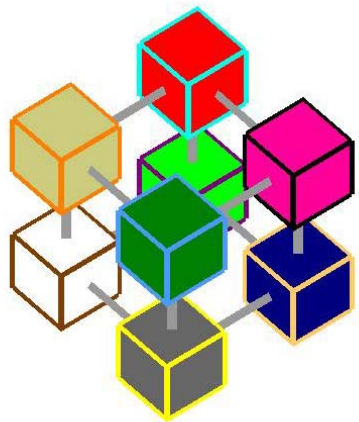
Experiment 1

Use a setup of 8 colored cubes to define four concepts (combinations of 4 cubes each) and demonstrate emergence of four features (2 cubes each). The experiment was carried out on 27 subjects. Training sessions continued until perfect learning was reached.

Experiment 1

- Materials
- Learning session
- Testing session
- Results





8 binary inputs lead to 2**8 configurations.

Different colors determine uniqueness of each cube. This allows presentation of the figure from different spatial perspectives, thus eliminating bias of representation.

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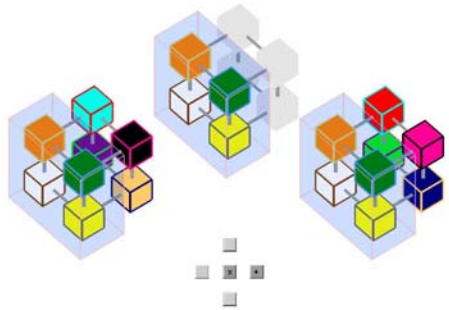

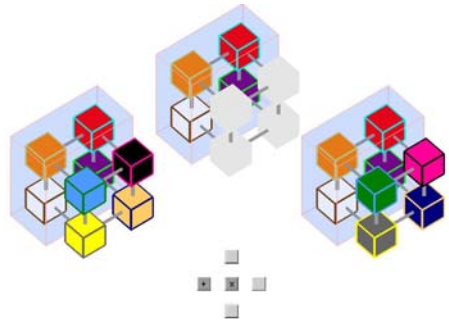

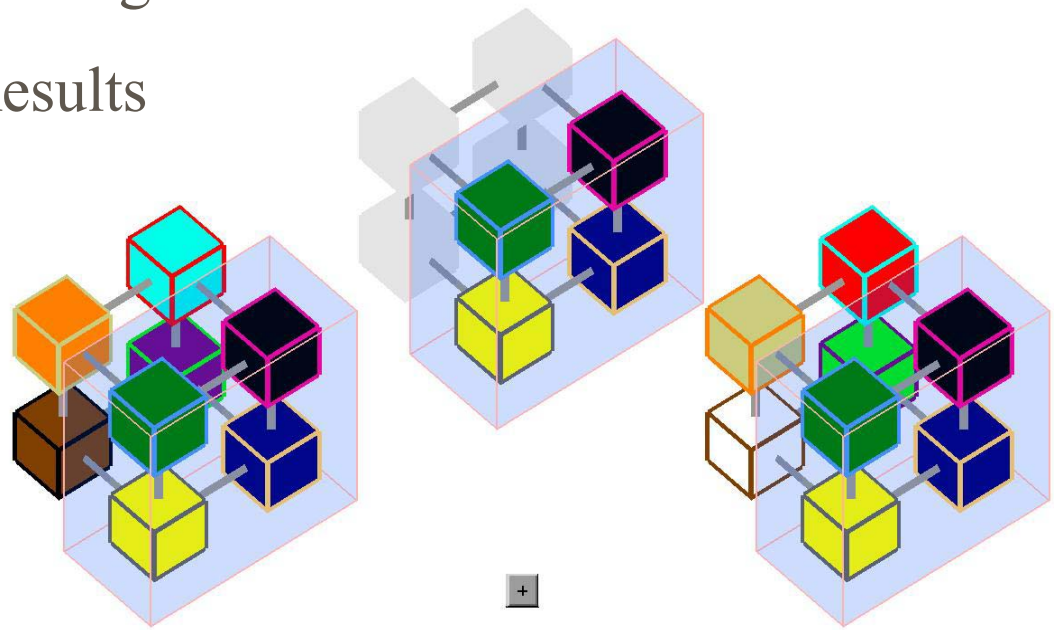

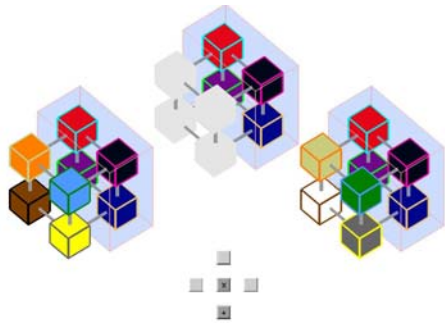

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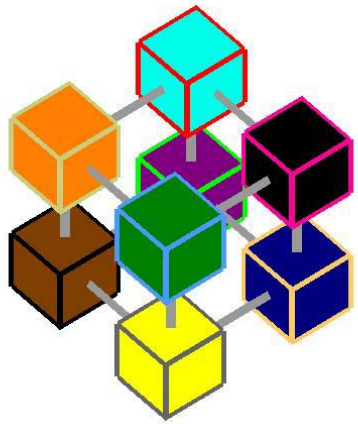

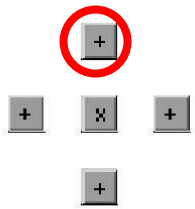

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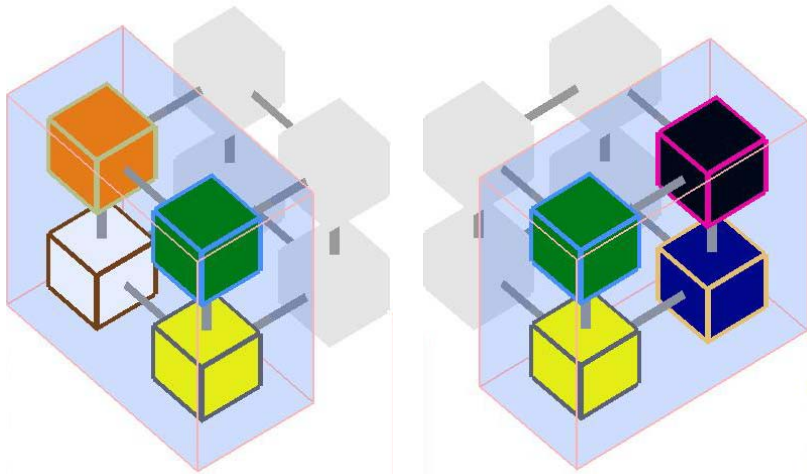

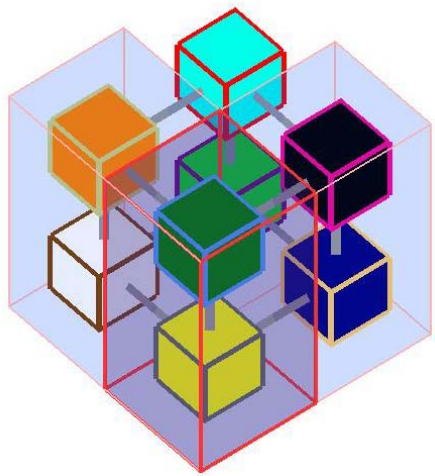

Test: recall colors of a concept. Order of recall should demonstrate the acquired features.

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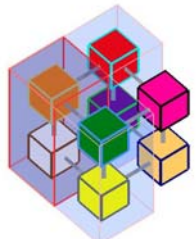

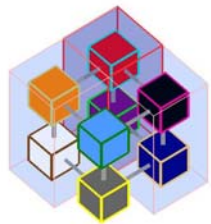

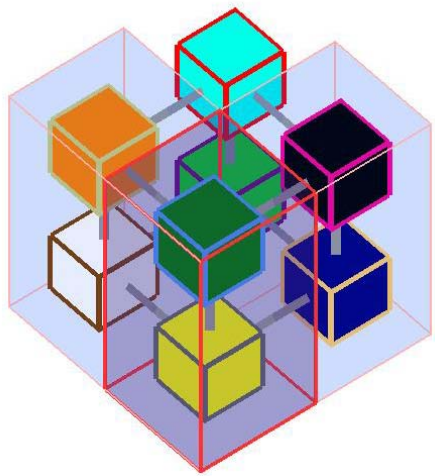

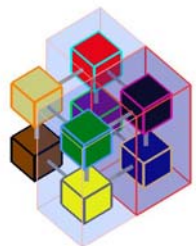

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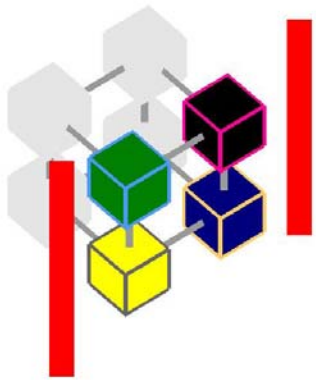
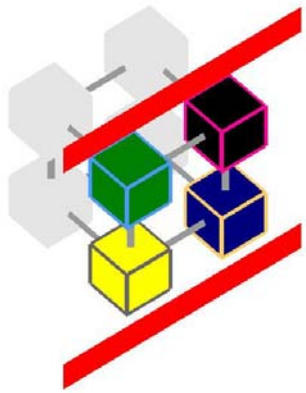
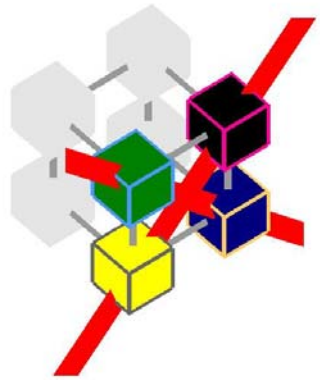


Adjacent & Congruent

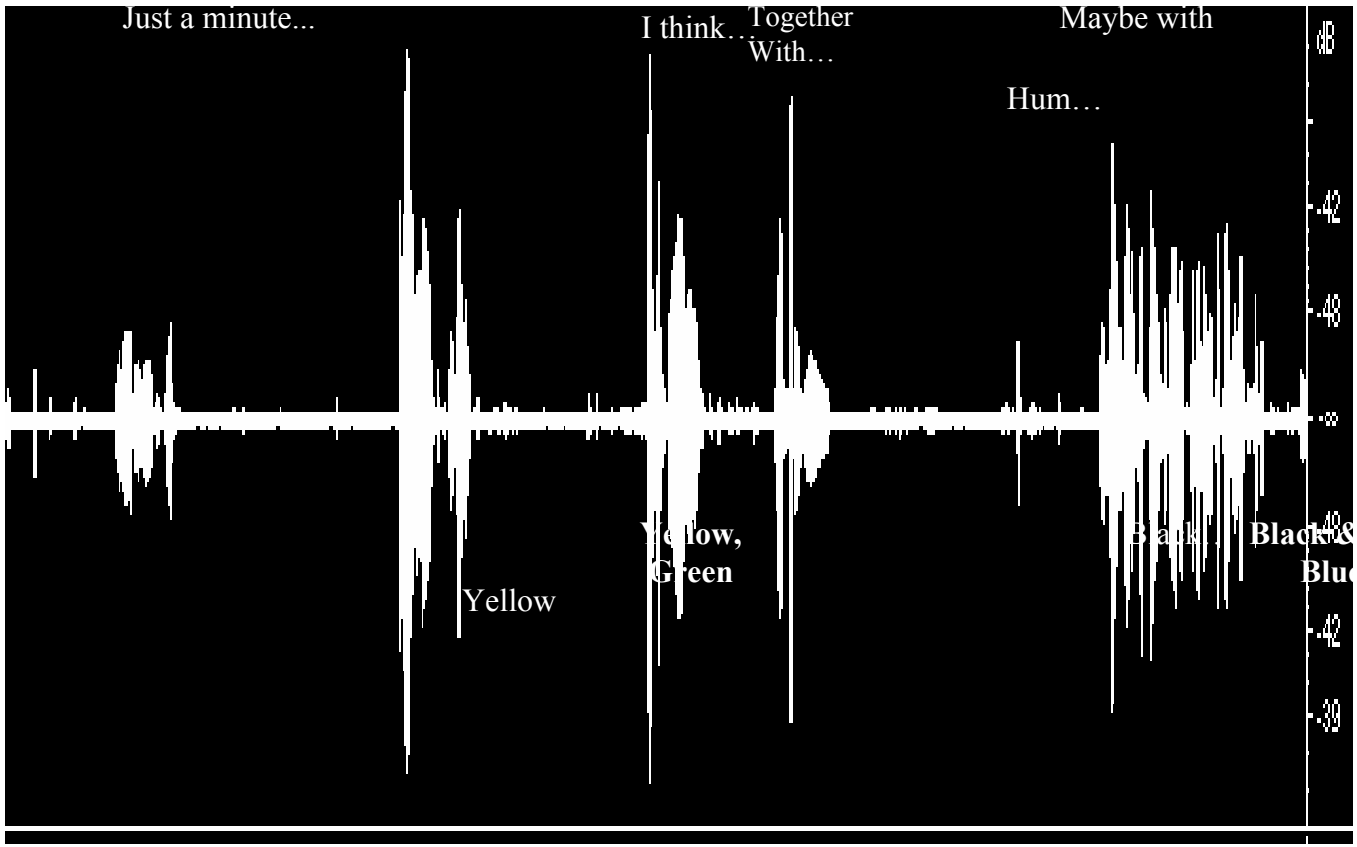


Adjacent & Incongruent



Diagonal & Incongruent

Free recall of a concept



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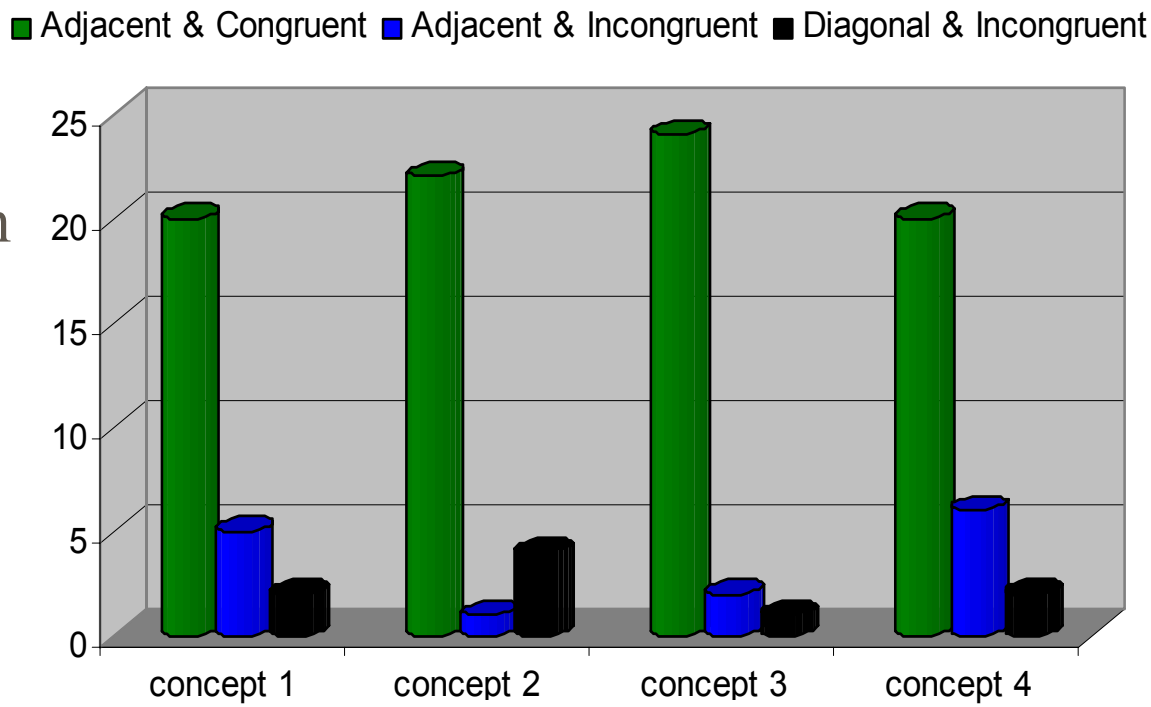
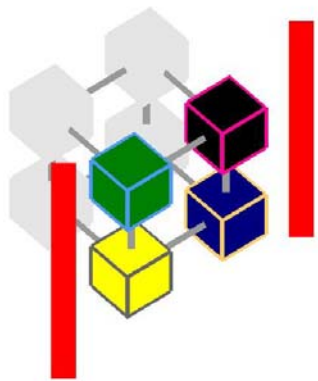
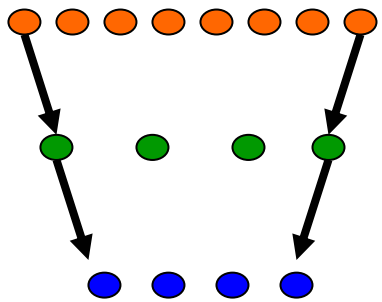




Neural Network Modeling

Neural Network Modeling

- Modeling Framework
- Multi Layer Perceptron
- Attentional Constraint
- Model Prediction



- Feed Forward networks
- Eight input elements (p)
- Four hidden neurons (h)
- Four output neurons (a)
- Train by changing weights to minimize the error $(a-t)^2$

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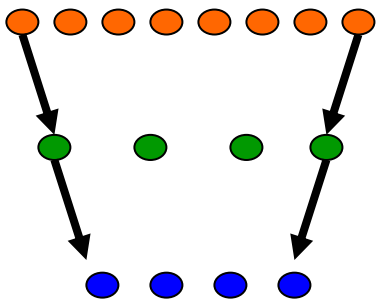

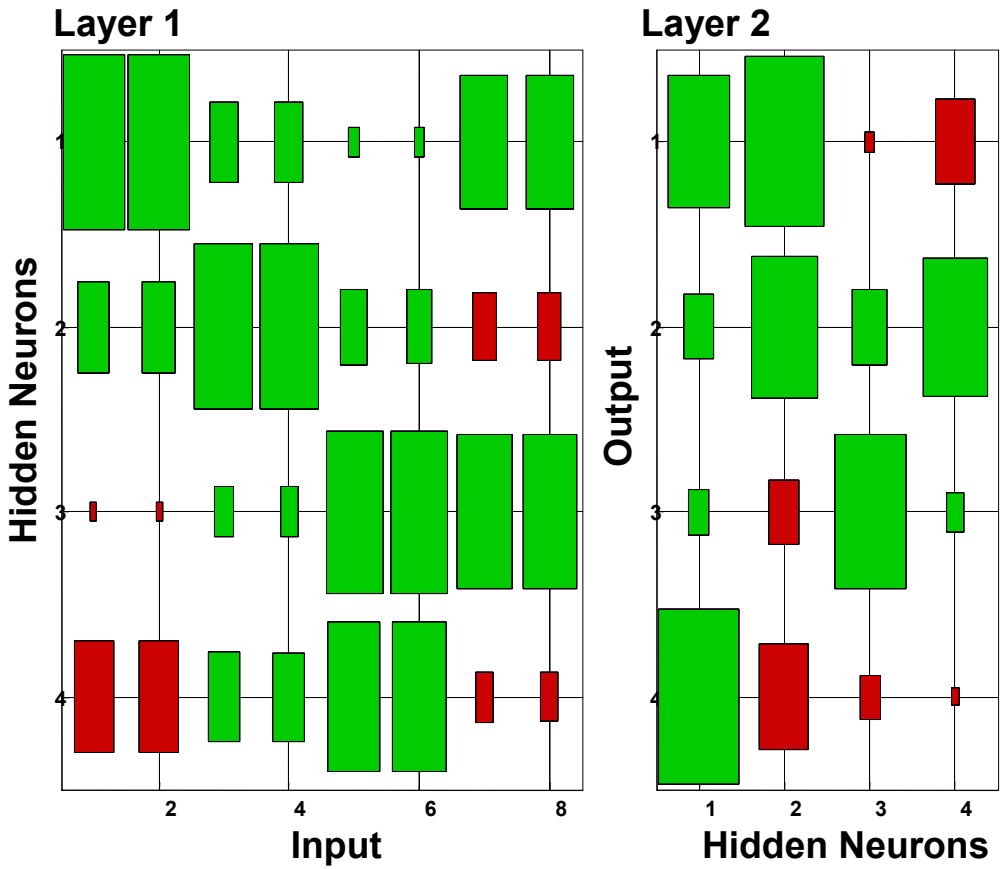

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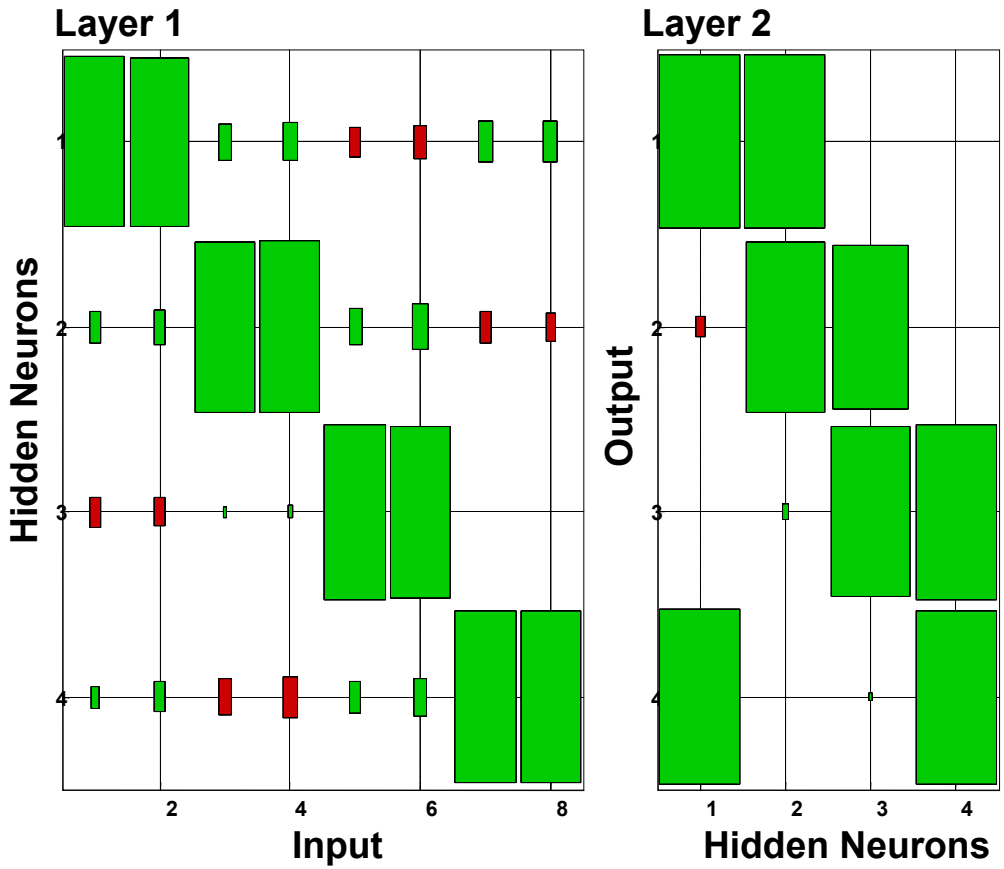
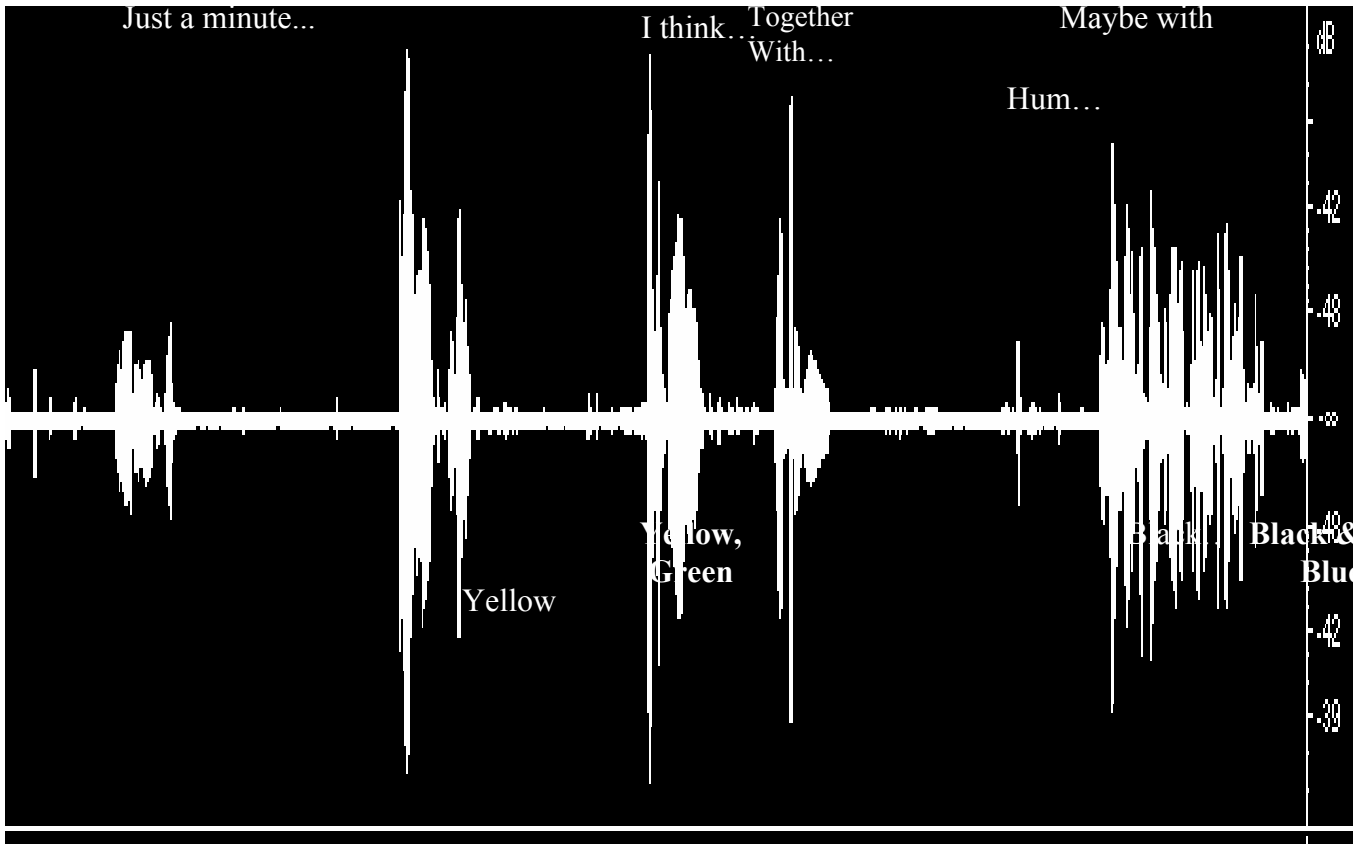
change weights to minimize the error

$$\text{sum}_i(\mathbf{a}_i-\mathbf{t}_i)^2+\mathbf{w}^2$$



Free recall of a concept



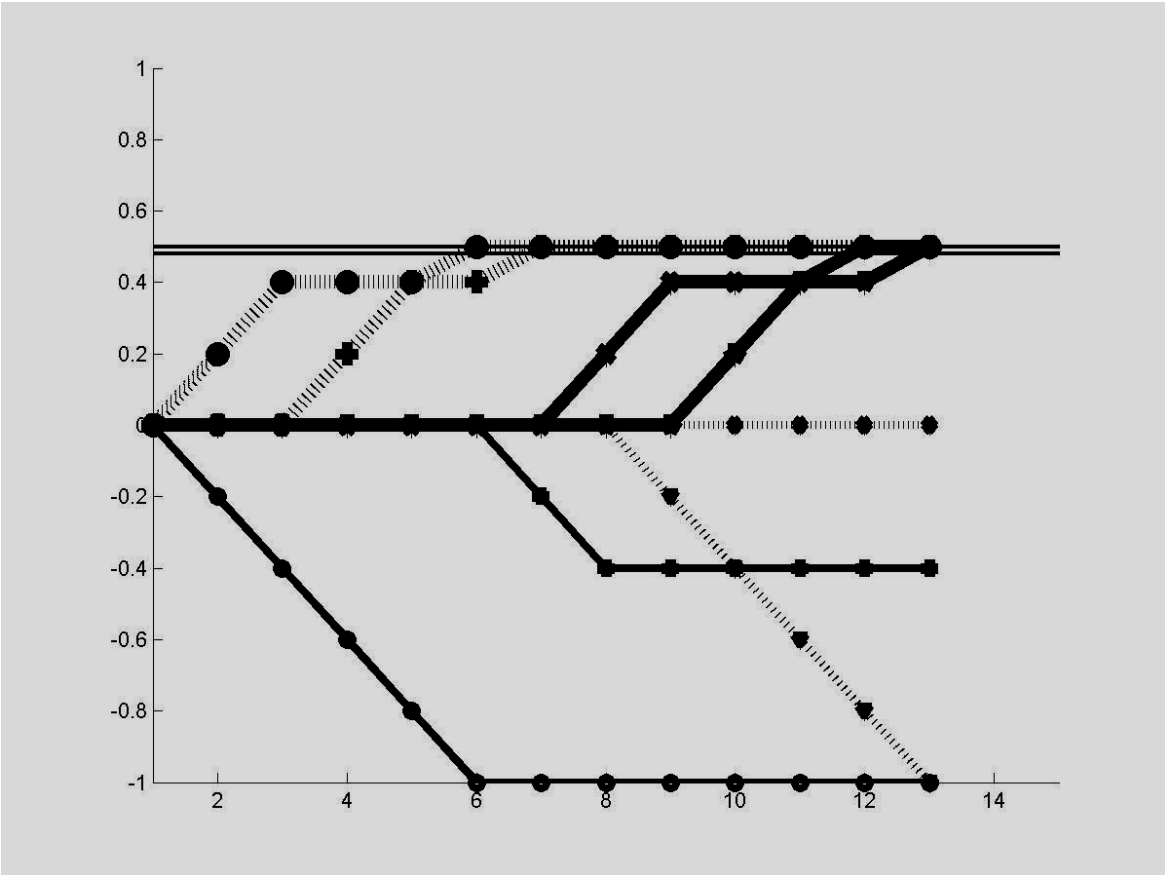
Free recall of a concept

Modeling with the neural network by testing it under sub-threshold conditions, mimicking mental search: Winning Input Activation.

Start with zero input activations. Search for ε update that maximally reduces error of desired output. Choose winner and update only it. Similarly choose loser as one who maximally increases error and deactivate it.

Proceed until unit activations reach 0.5.

Free recall of a concept



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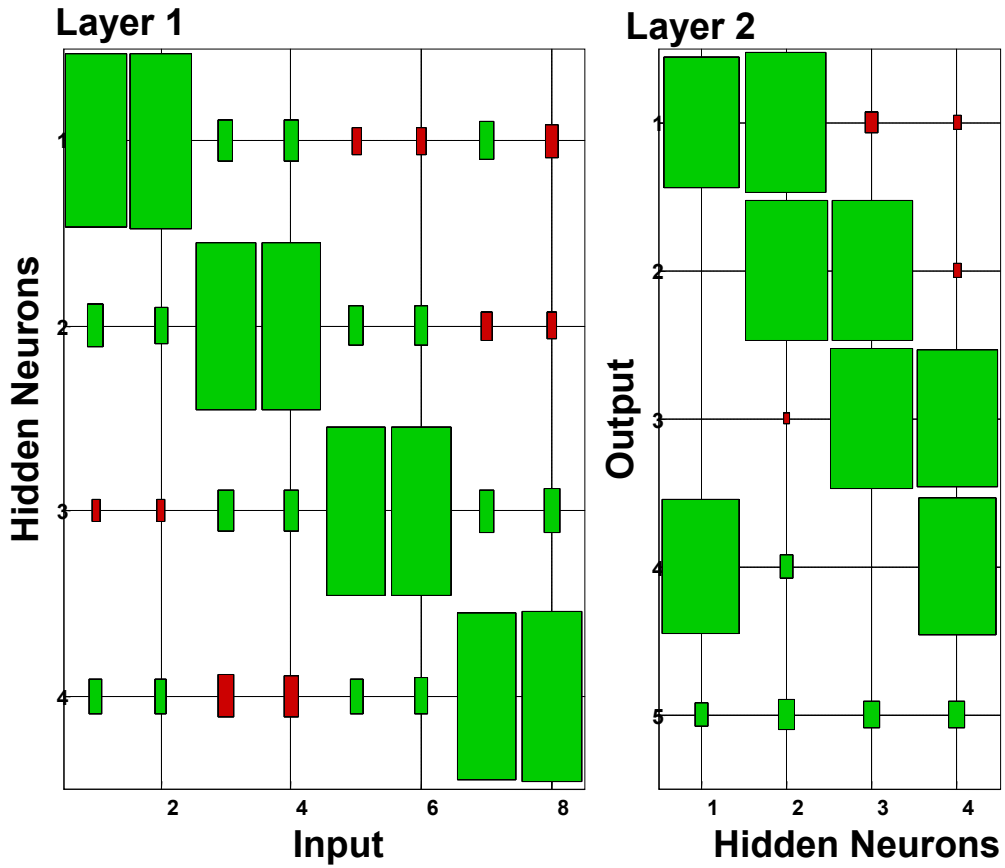
Learn four concepts



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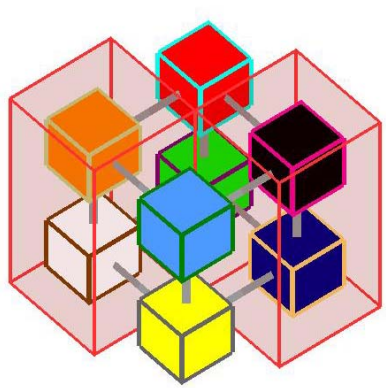
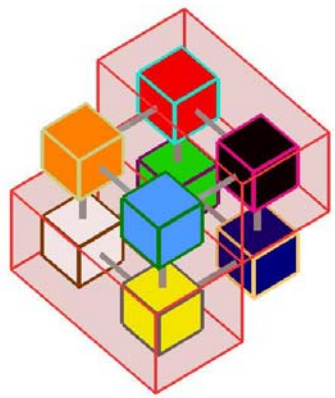
Learn four concepts

Congruent condition

Incongruent condition

Learn a 5th concept in **limited** time





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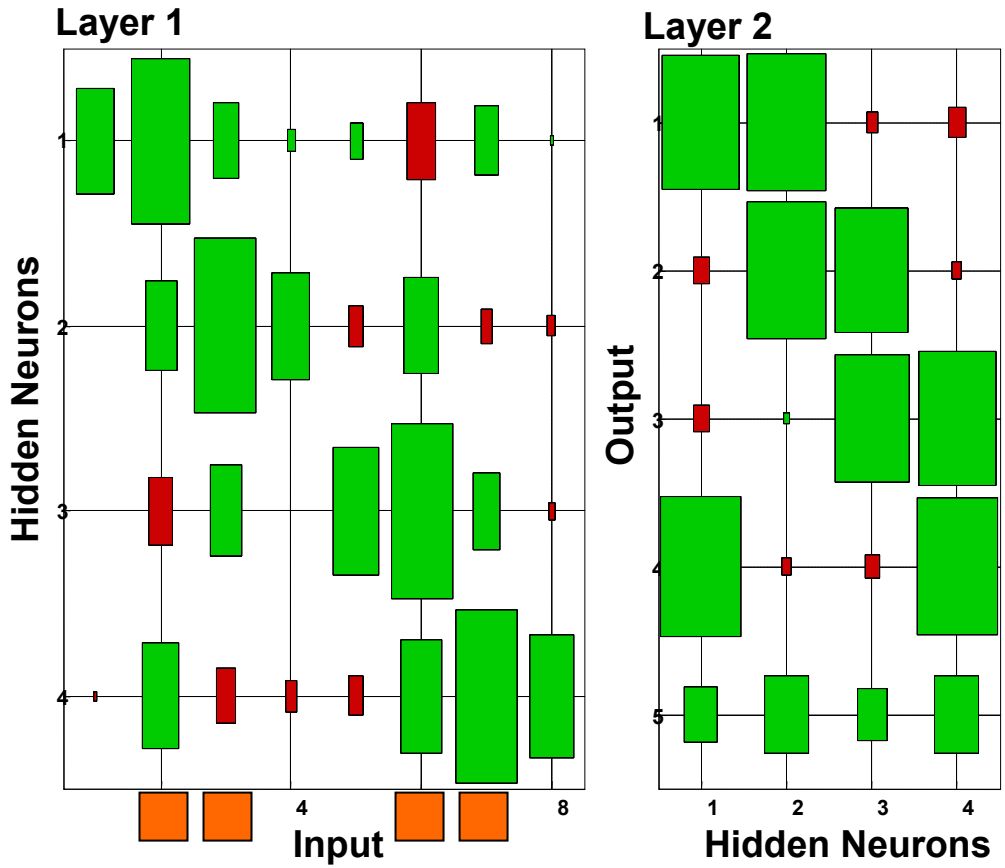

Incongruent condition

Neural Network Modeling

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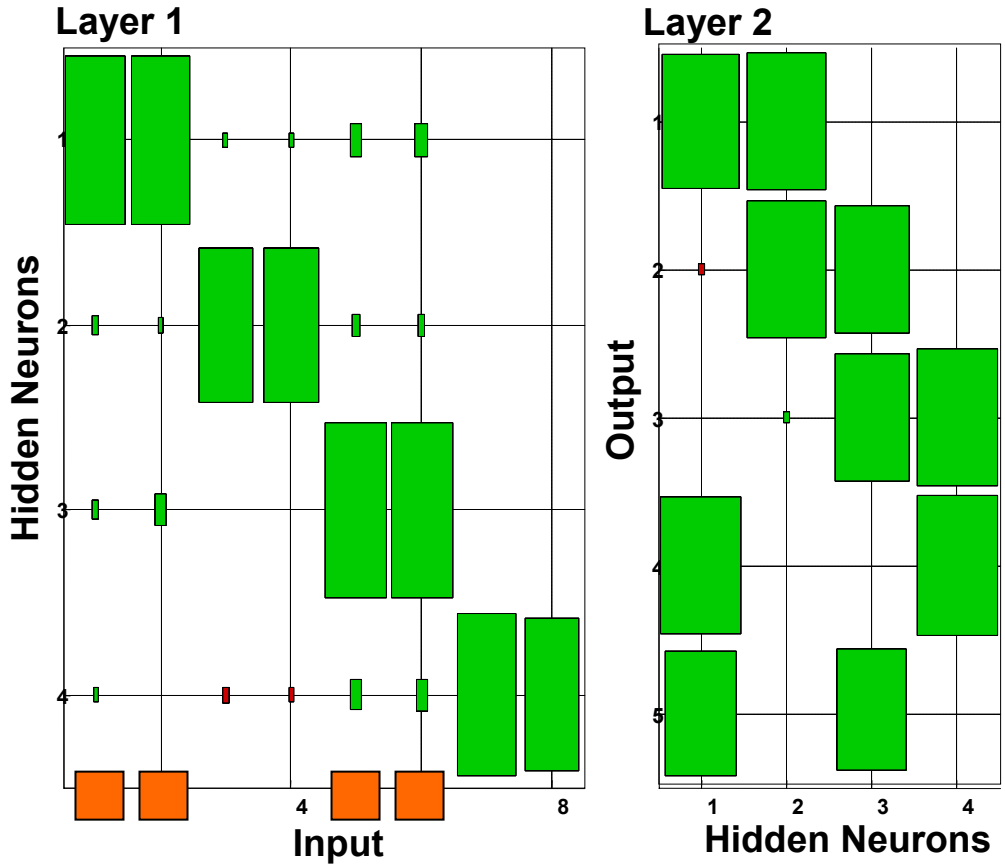
Extracted features facilitate future concept learning



Congruent condition

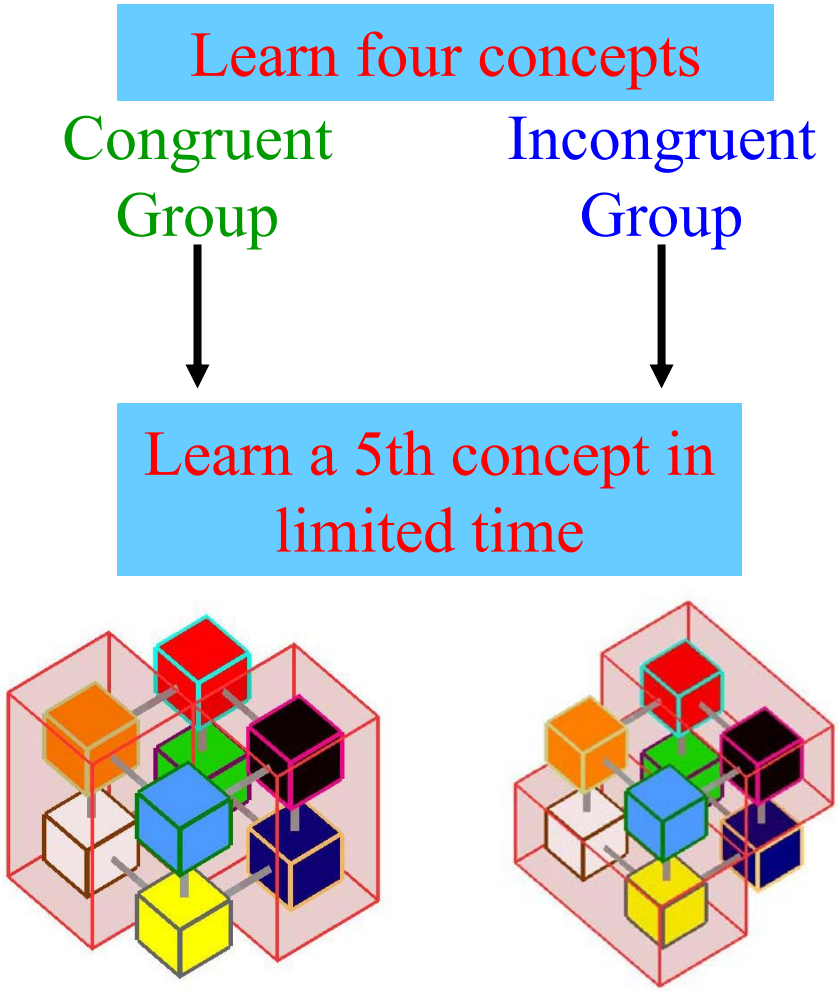
Experiment 2

Experiment 2

- Learning session
- Testing session
- Results

Test the model's prediction

that learning future concepts based on the features previously extracted will be significantly facilitated



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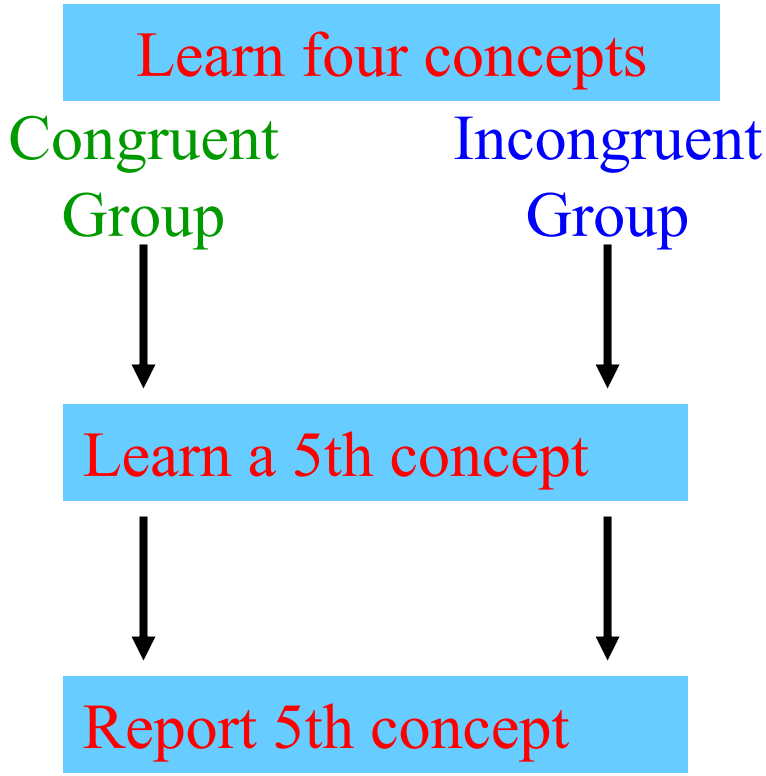

"White, Orange, Black & Blue"

Experiment 2

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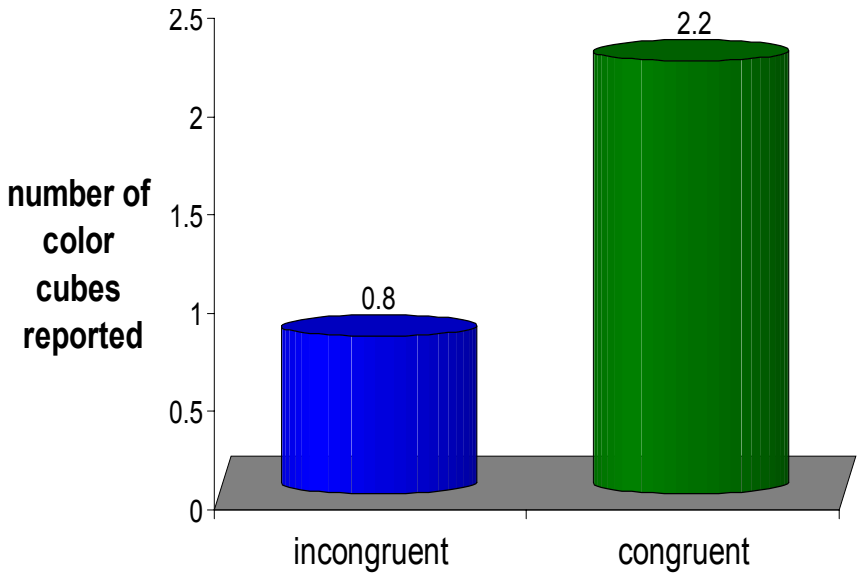

Summary

•Purpose of this work was to demonstrate feature creation within the learning process of new concepts.

•Experiment 1 - demonstrated feature creation. Features are shared between different concepts.

•Neural Network Modeling- description & prediction

•Experiment 2 - feature creation facilitates future learning.