pen

Spaced learning enhances perceptual expertise training.

Tim Curran[1], Chris D'Lauro[1], Lisa Scott[2], James Tanaka[3], David Sheinberg[4]

Perceptual Expertise Network

1. University of Colorado
2. University of Massachusetts
3. University of Victoria
4. Brown University

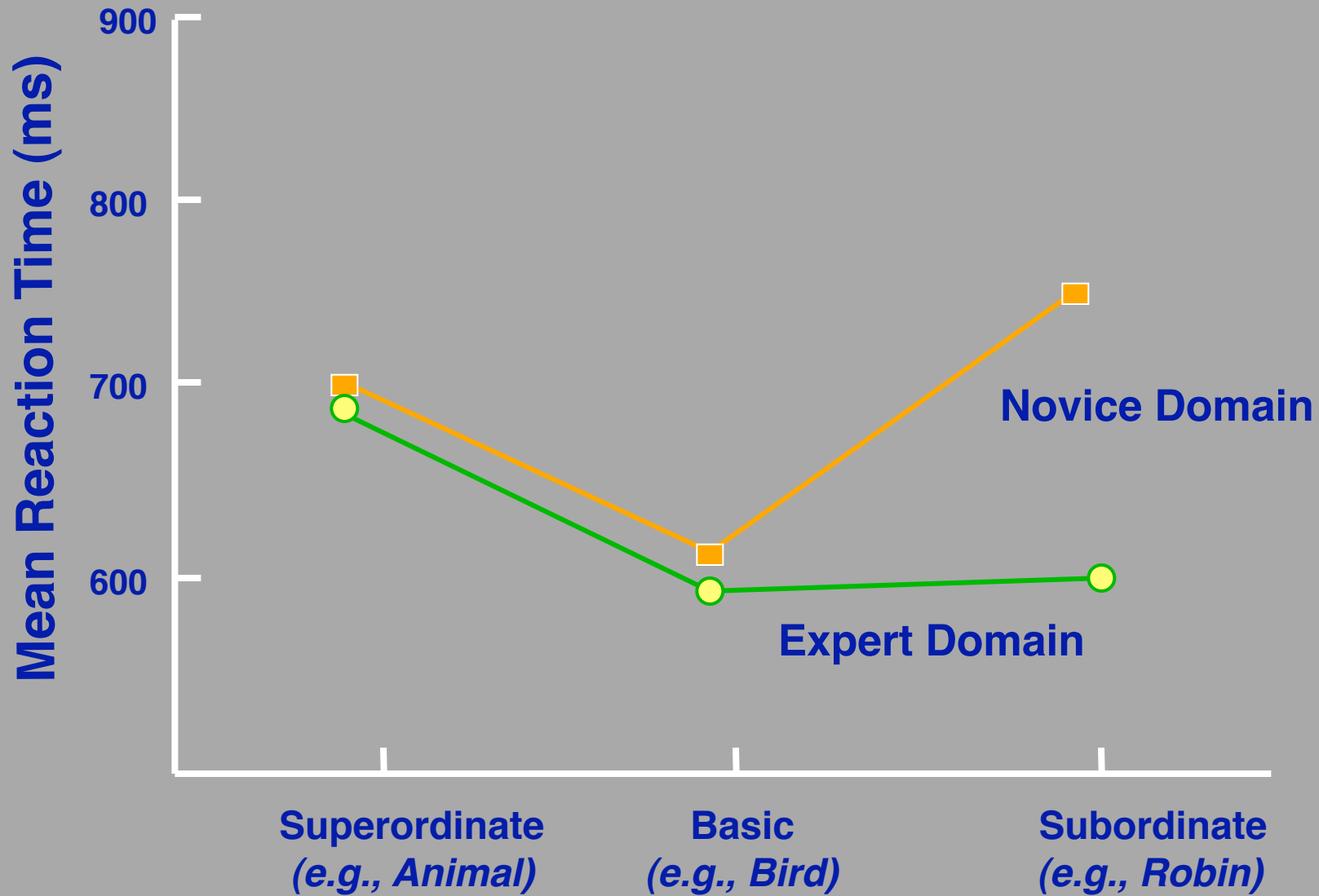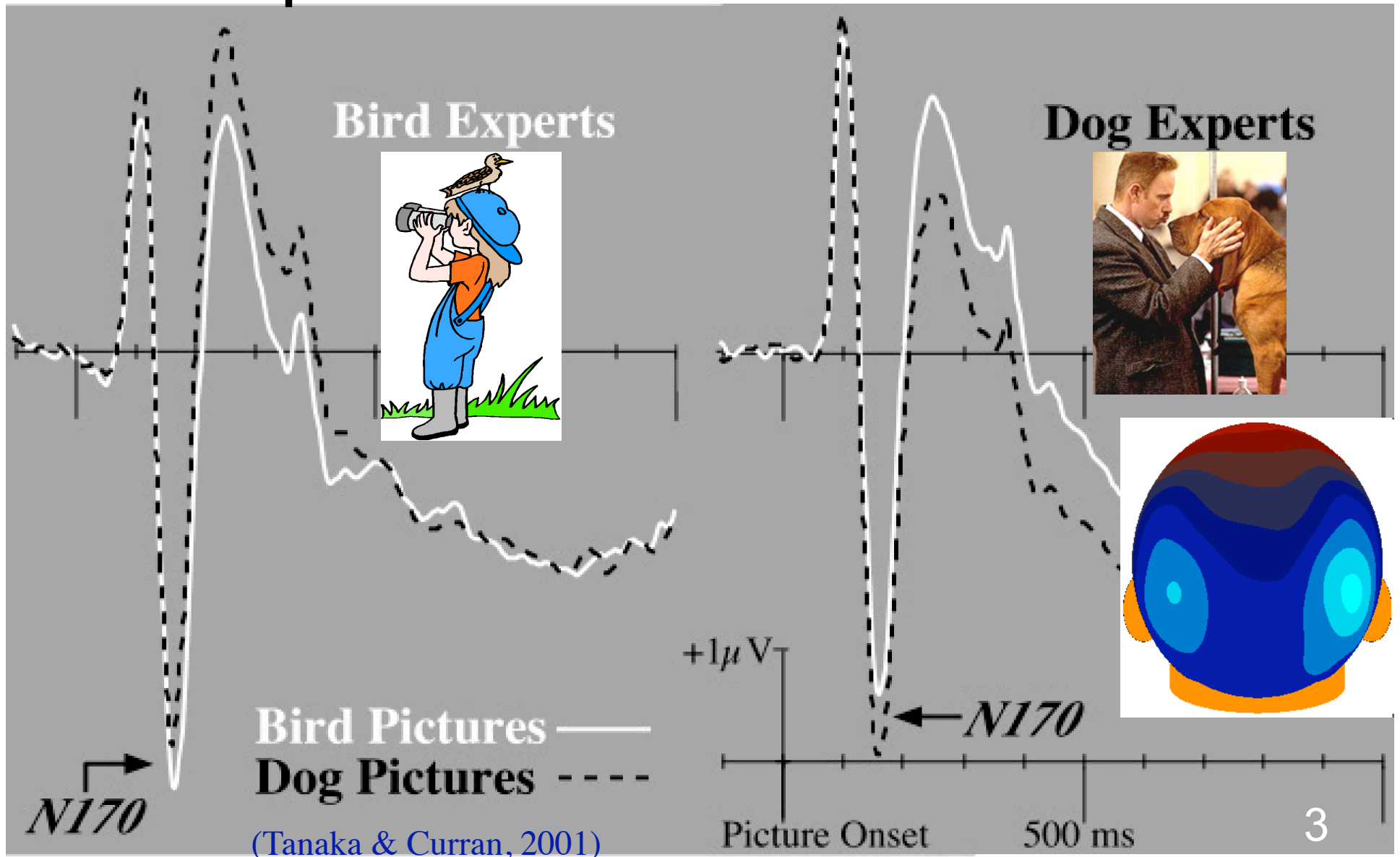# Levels of Categorization

Superordinate

Basic

Subordinate

Animal

Bird

Robin

YES   **NO**

(Tanaka & Taylor, 1991)

Category Verification Results

Mean Reaction Time (ms)

900

800

700

600

Novice Domain

Expert Domain

Superordinate
(e.g., Animal)

Basic
(e.g., Bird)

Subordinate
(e.g., Robin)

3

(Tanaka & Taylor, 1991)

Expertise Effects on the N170

(Tanaka & Curran, 2001)

N170 Correlates with Degree of Expertise

N170 Amplitude (μV) to Cars

□ RH ($r = -0.36$)
◇ LH ($r = -0.34$)

(both p < .05)

Novices ⟶ Experts

Car expertise ($\triangle d'$)

5

Gauthier, Curran, Curby & Collins (2003)
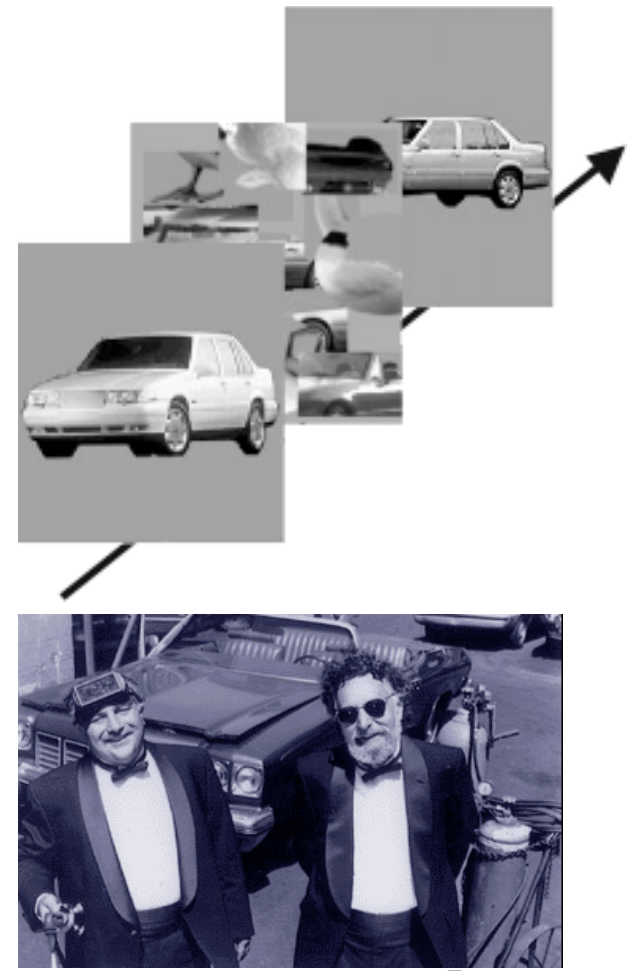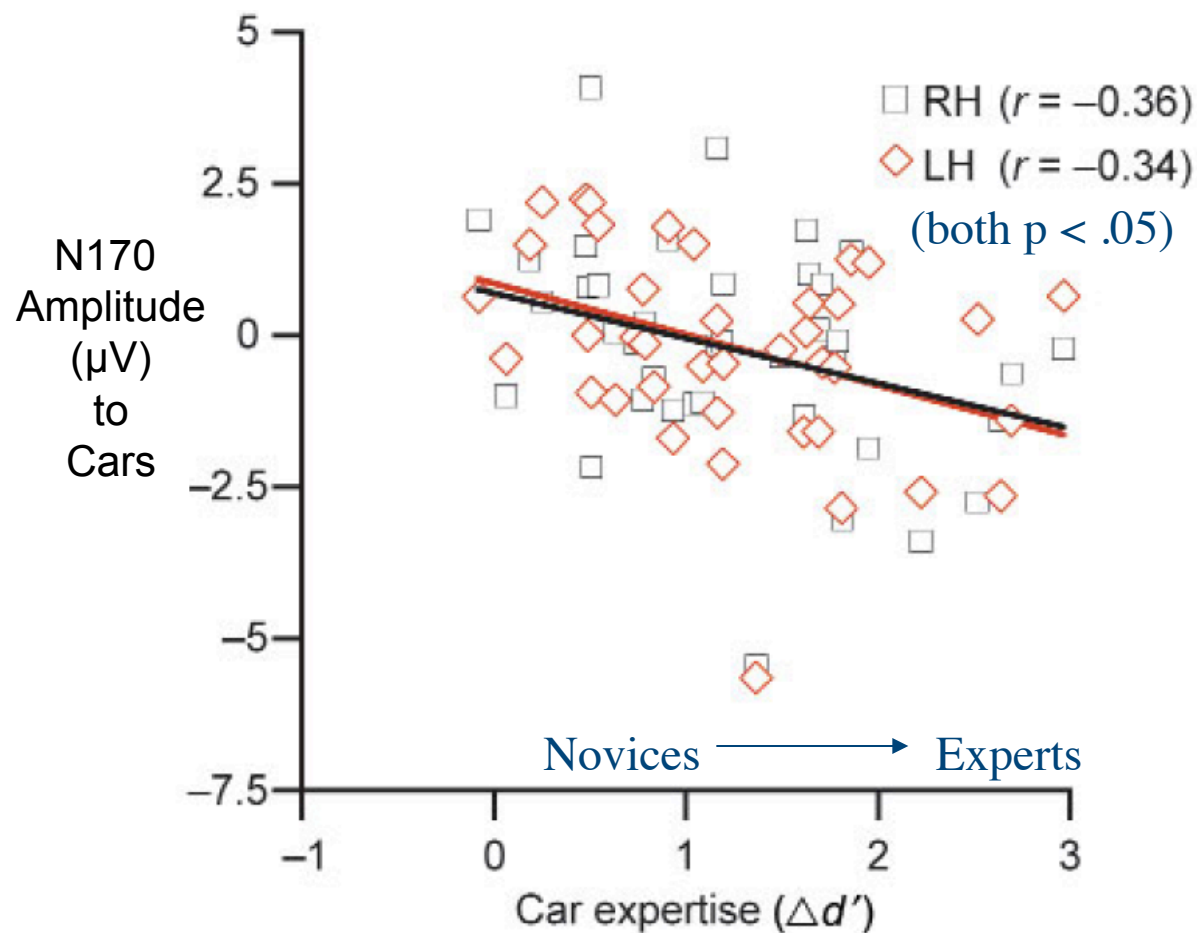
Can laboratory training help us understand the dynamics of the learning processes contributing to perceptual expertise?

Training Bird "Experts"

Owls
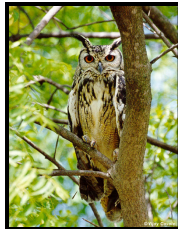### (Family 1)

AND

Wading Birds
(Family 2)

Boreal

Barn

Elf

Burrowing

American Bittern

Black Crowned Night Heron

Great Egret

Hawk

Eagle

Screech

Flammulated
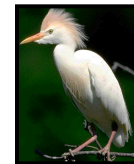
Cattle Egret
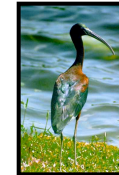
Glossy Ibis

Green Heron

Barred
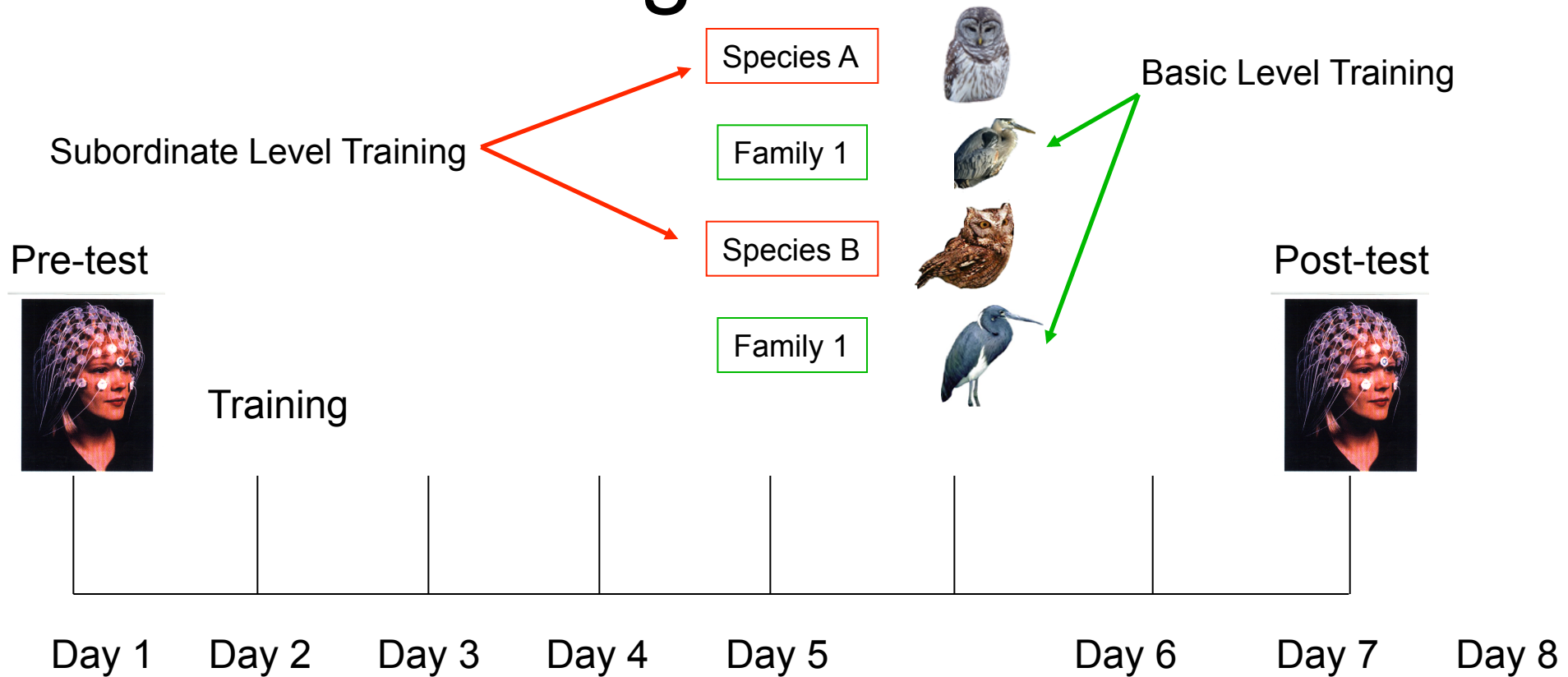
Great Grey

Great Blue Heron **Least Bittern**

Limpkin

Reddish Egret

7

(Tanaka, Curran, Sheinberg, 2005; Scott, Tanaka, Sheinberg, Curran, 2006)

Training Methods

Species A

Family 1

Subordinate Level Training

Species B

Family 1

Basic Level Training

Pre-test

Post-test

Training

Day 1   Day 2   Day 3   Day 4   Day 5   Day 6   Day 7   Day 8

6 days of training over 2 weeks

8

(Scott, Tanaka, Sheinberg & Curran, 2006)

Subordinate Matching Task
(Pre- and Post- Training)

800 ms

300 ms

800 ms

Same Species   Different Species
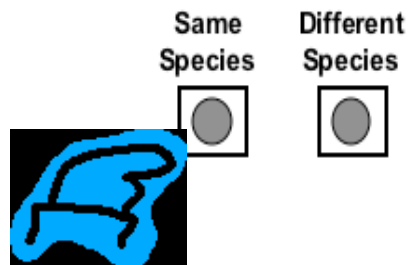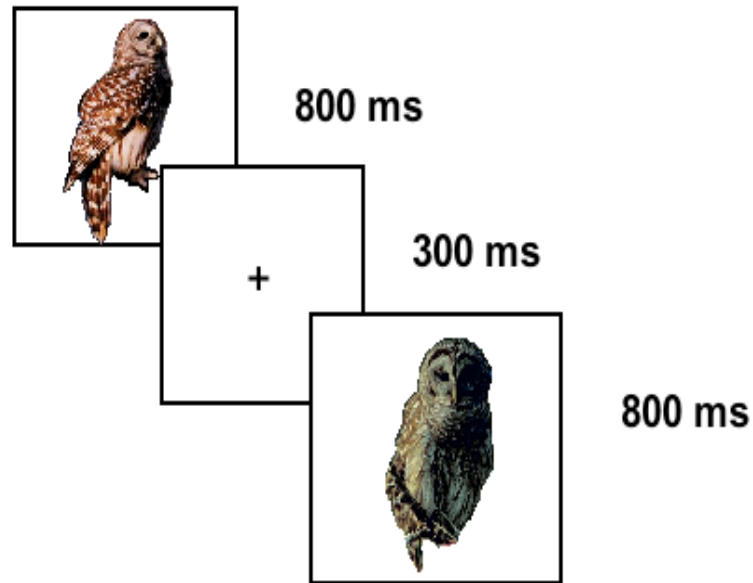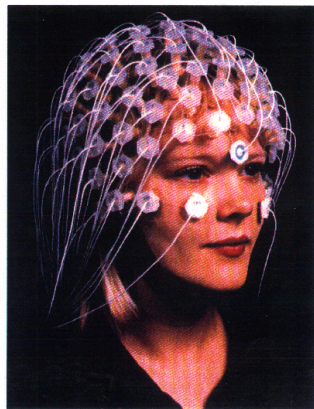
Are birds from same **species**?
(not exemplar identity matching)

Car Training Experiment

Sport-Utility Vehicles (SUVs)   **Antiques**   **Sedans**
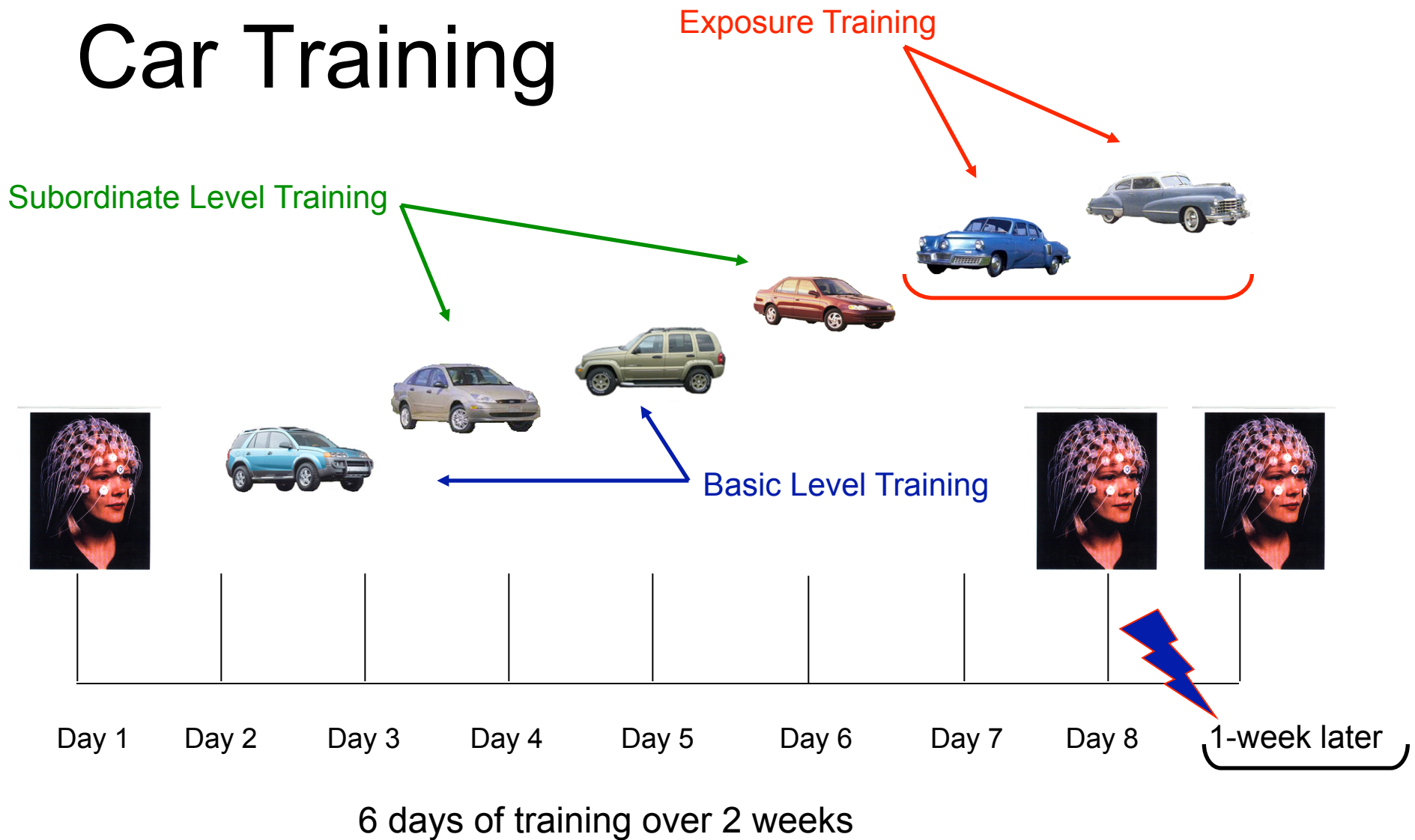
(Scott, Tanaka, Sheinberg, & Curran, 2008)

Car Training

Exposure Training

Subordinate Level Training

Basic Level Training

Day 1 Day 2 Day 3 Day 4 Day 5 Day 6 Day 7 Day 8 1-week later

6 days of training over 2 weeks

11

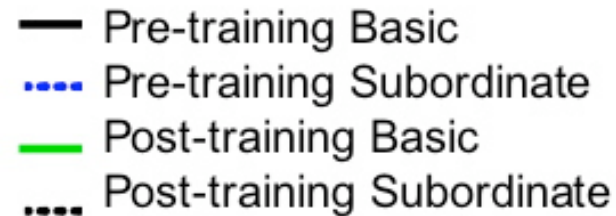(Scott, Tanaka, Sheinberg, & Curran, 2008)

Training Effects

- **Similar results for Birds and Cars**

- **Accuracy (d')**
  - Only enhanced by subordinate training.

- **N170**
  - Enhanced equally by subordinate, basic, and exposure training.

- **N250**
  - Only enhanced by subordinate training.

— Pre-training Basic

···· Pre-training Subordinate

— Post-training Basic

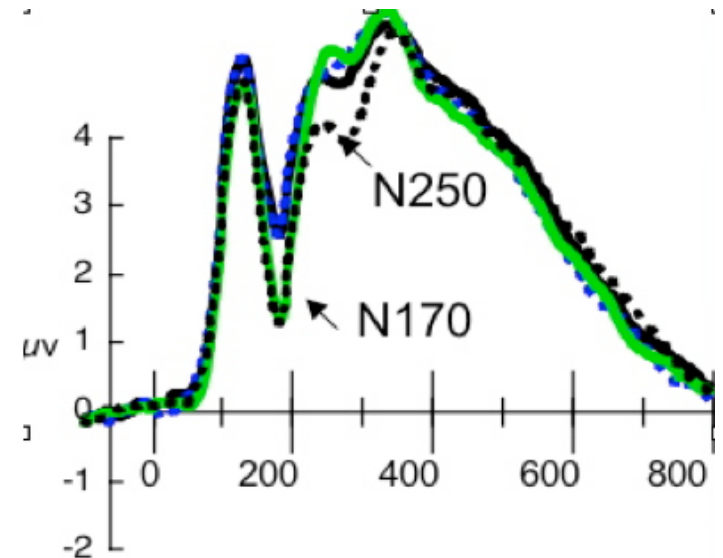···· Post-training Subordinate

Training Effects

- Similar results for Birds and Cars
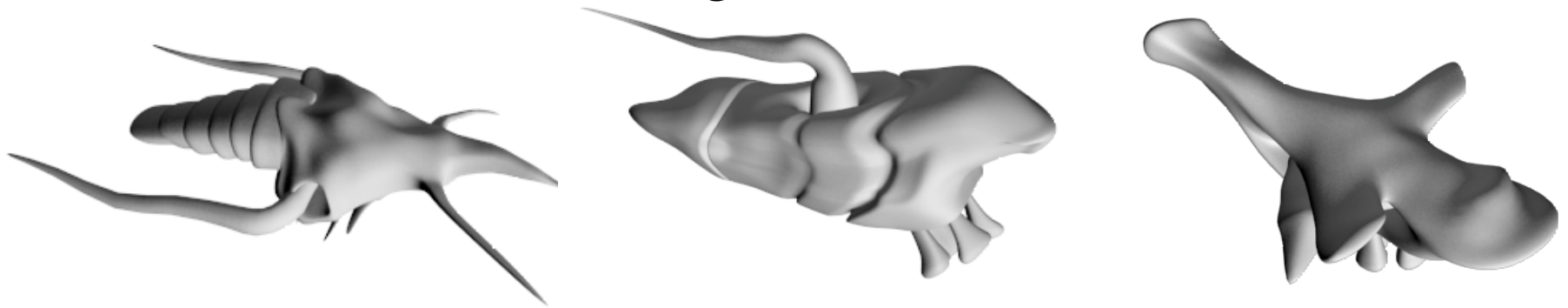
- Accuracy (d')
  - Only enhanced by <u>subordinate</u> training.
- N170
  - Enhanced equally by subordinate, basic, and exposure training.
- N250
  - Only enhanced by <u>subordinate</u> training.
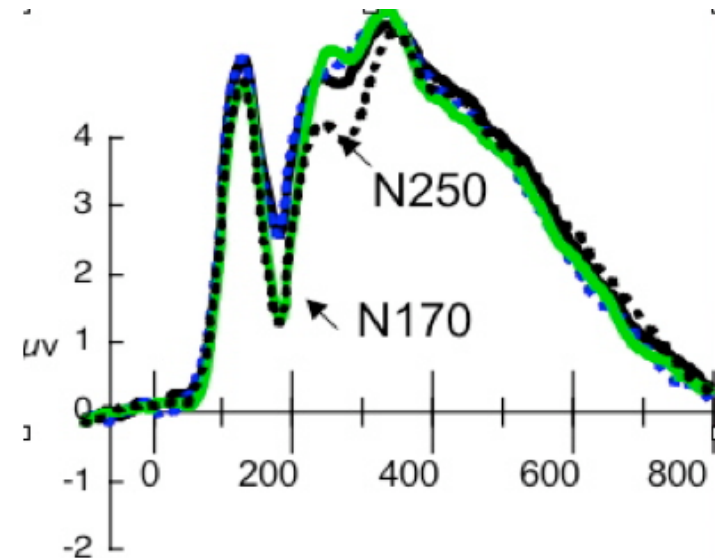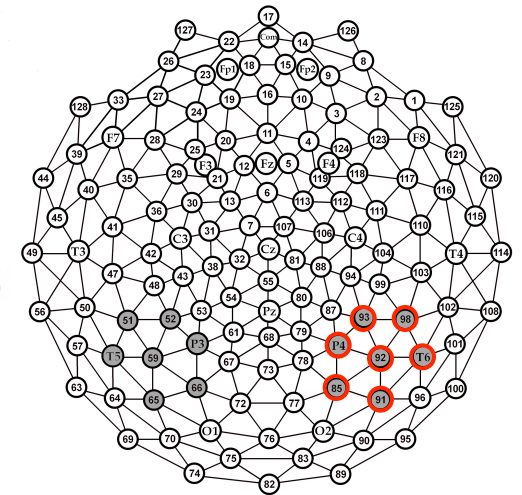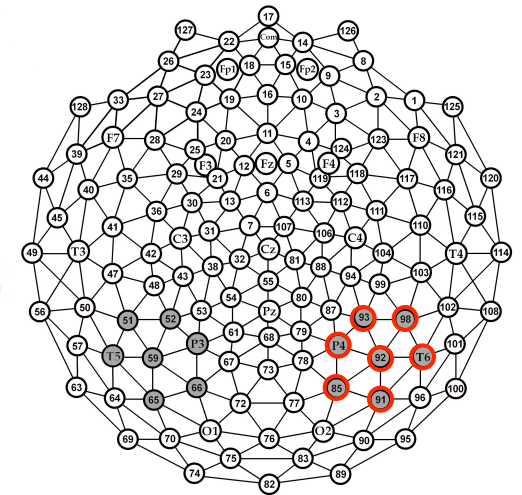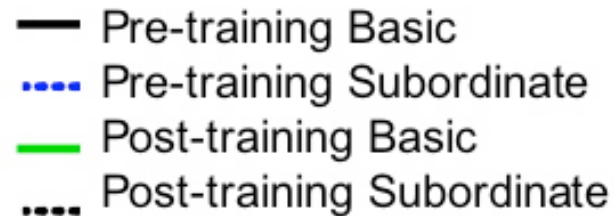
Pre-training Basic
Pre-training Subordinate
Post-training Basic
Post-training Subordinate

New Questions

- Can similar training effects be observed with novel stimulus categories?

- Does perceptual expertise training benefit from spaced learning?
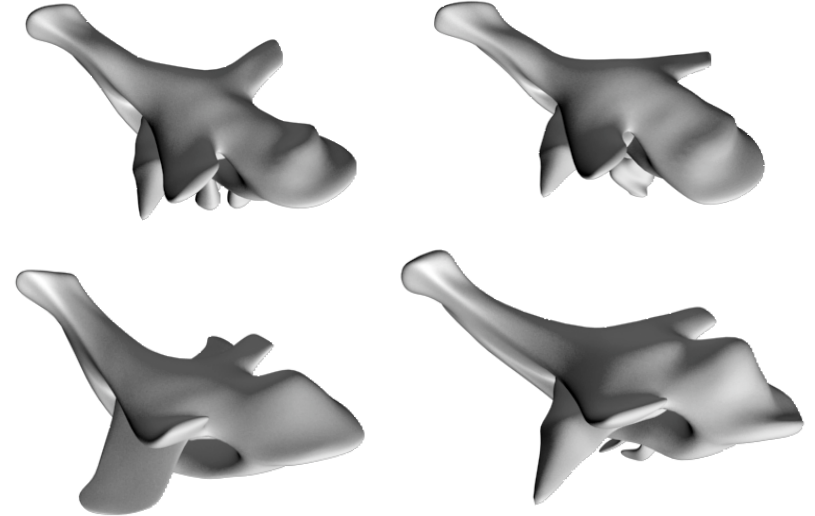
Creature Families
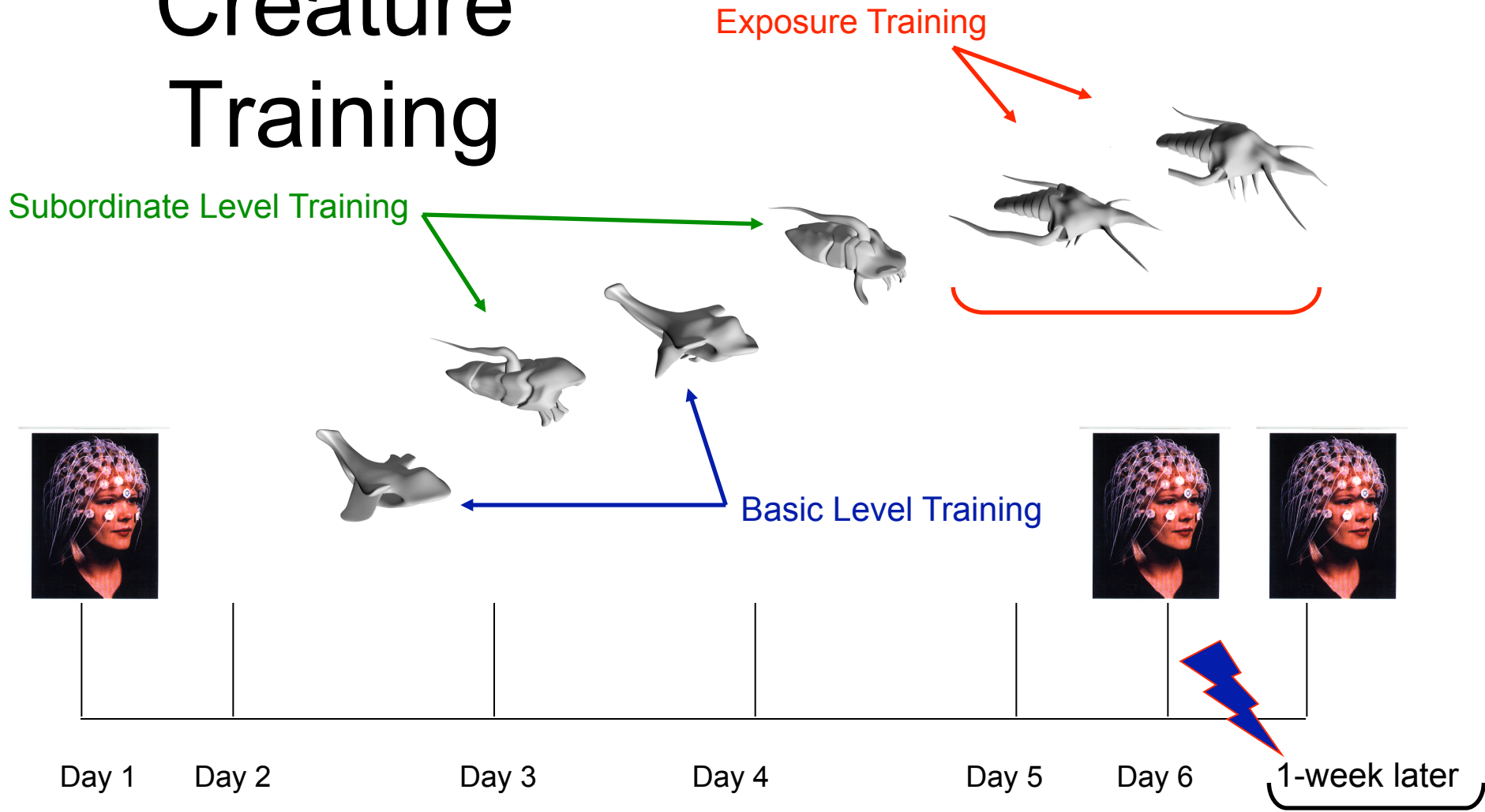
Family 1

Species A

Species B

Family 2

Species A

Species B

3 Families
16 species/family
16 exemplars/species

15

Creature Training

Exposure Training

Subordinate Level Training

Basic Level Training

| Day 1 | Day 2 | Day 3 | Day 4 | Day 5 | Day 6 | 1-week later |

4 days of training with spacing manipulated

16

(D'Lauro, Scott, Tanaka, Sheinberg, & Curran, in preparation)

Long Spacing: 2 days between training sessions
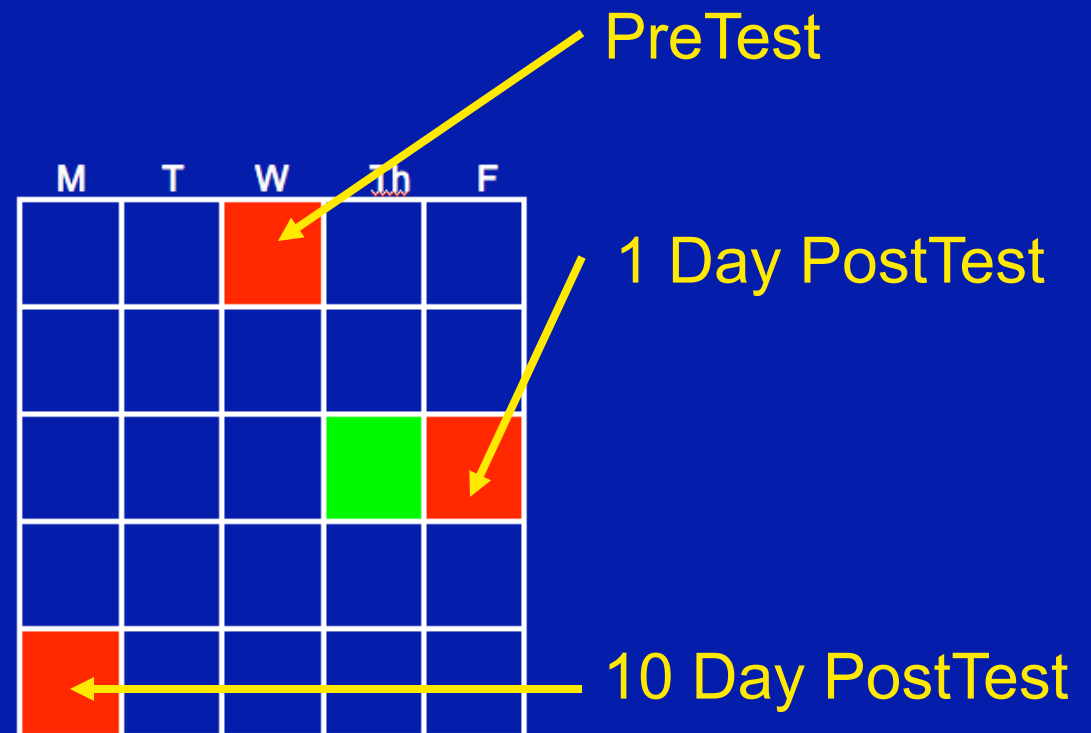
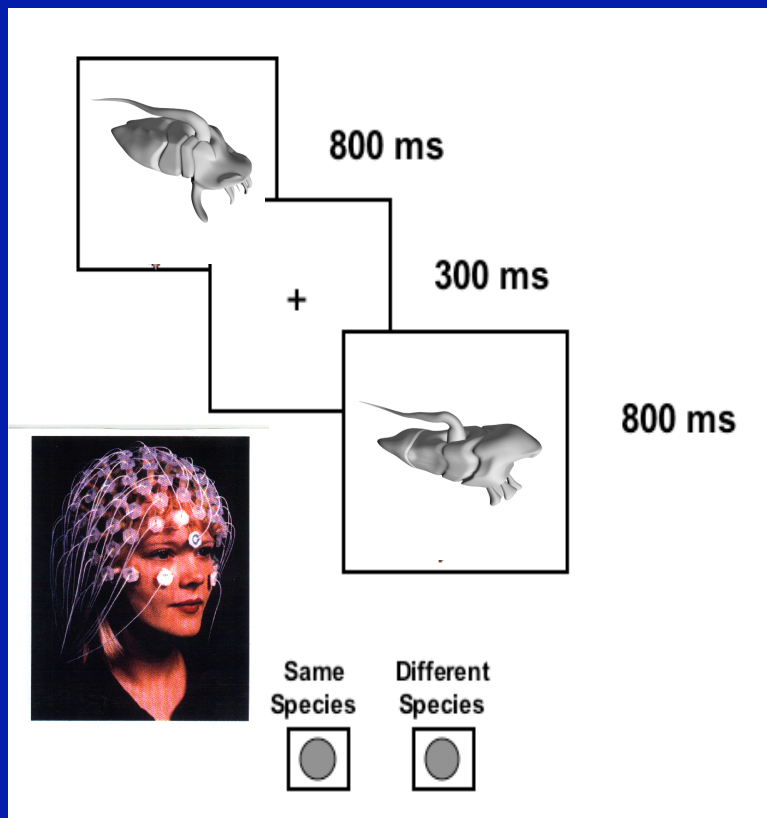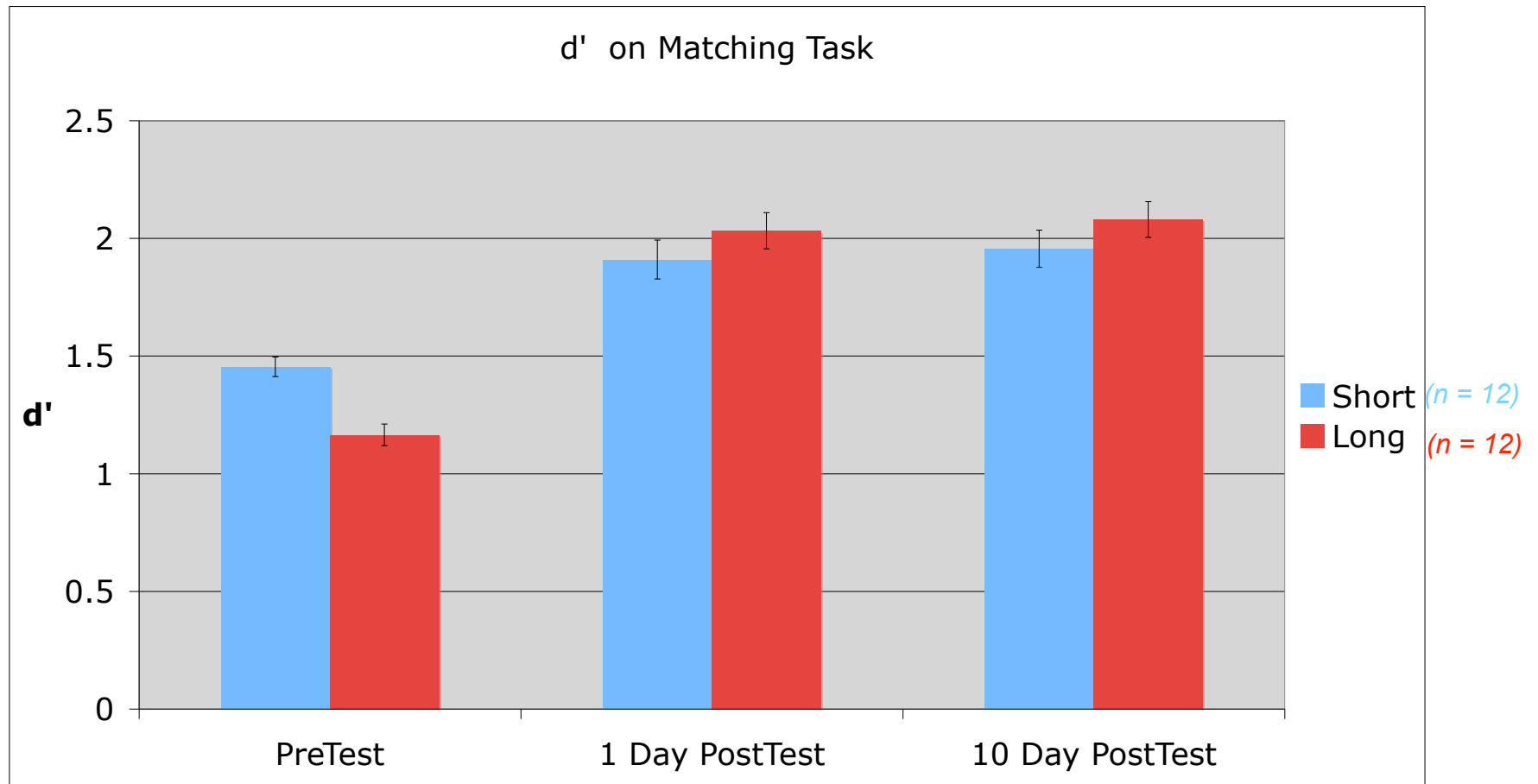Short Spacing: 0 days between training sessions
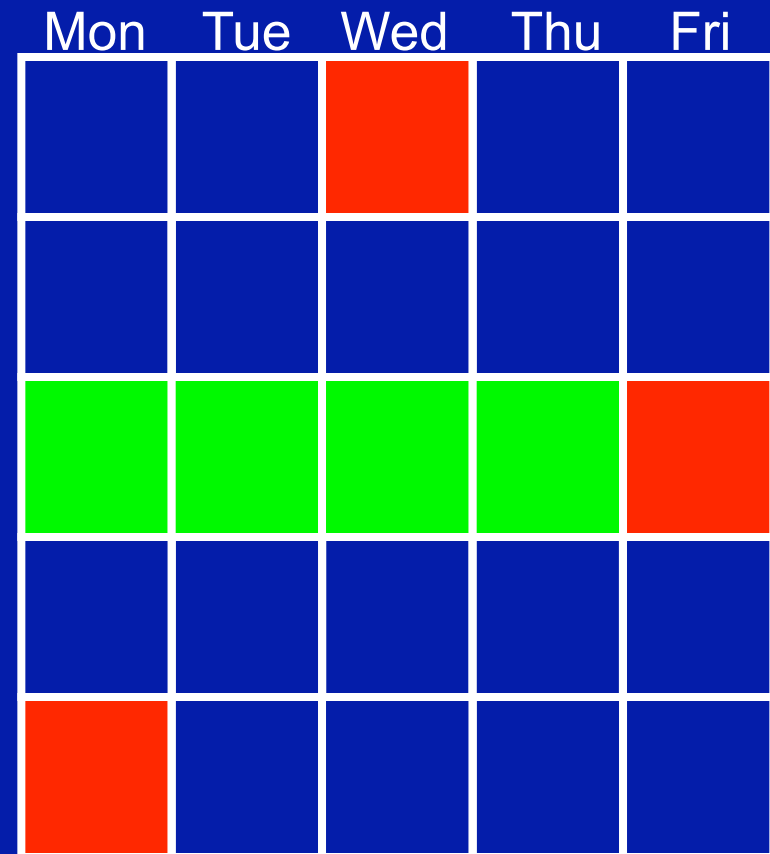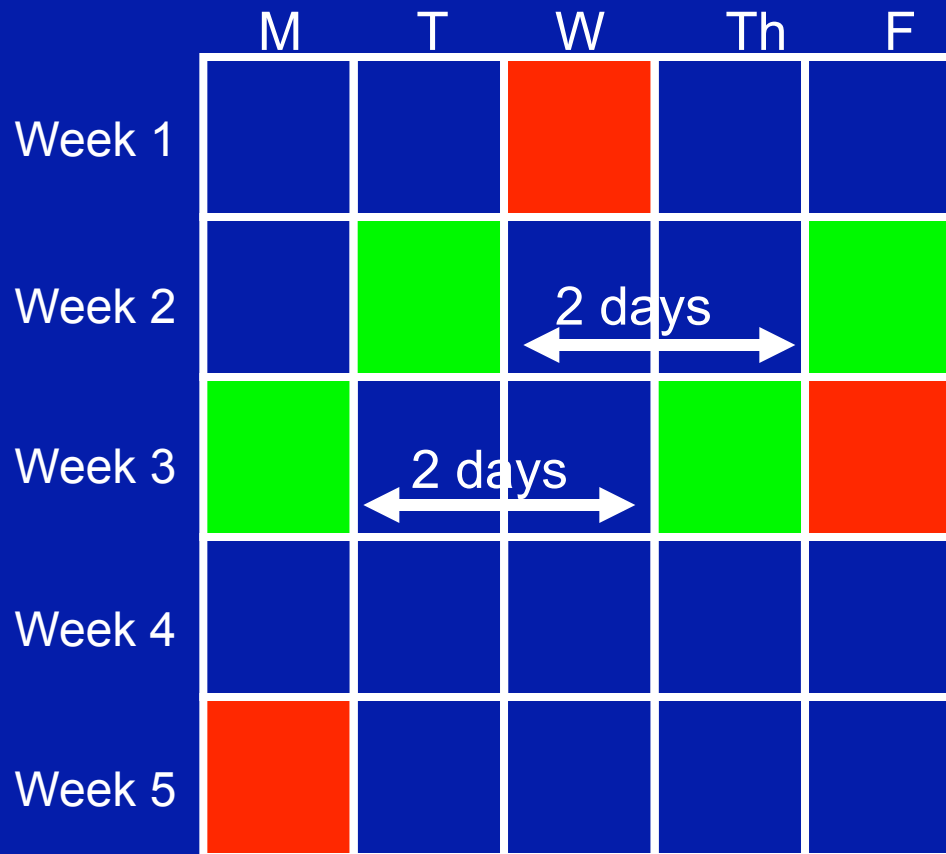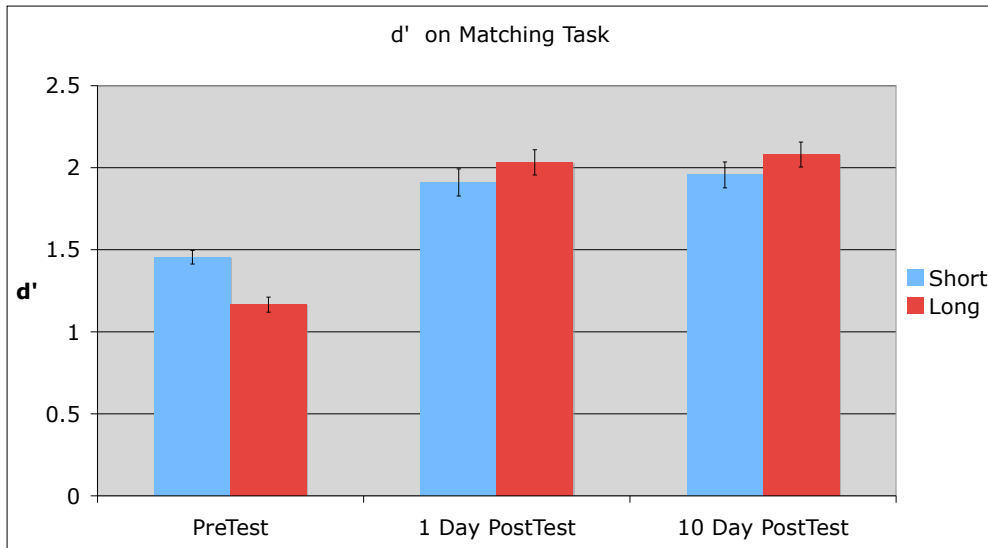
ERP Test Session   Training Session

17

ERPs during creature species matching task

PreTest

1 Day PostTest

10 Day PostTest

Learning Benefits from Spacing

d' on Matching Task

Short (n = 12)
Long (n = 12)

PreTest   1 Day PostTest   10 Day PostTest

d' to Δd'
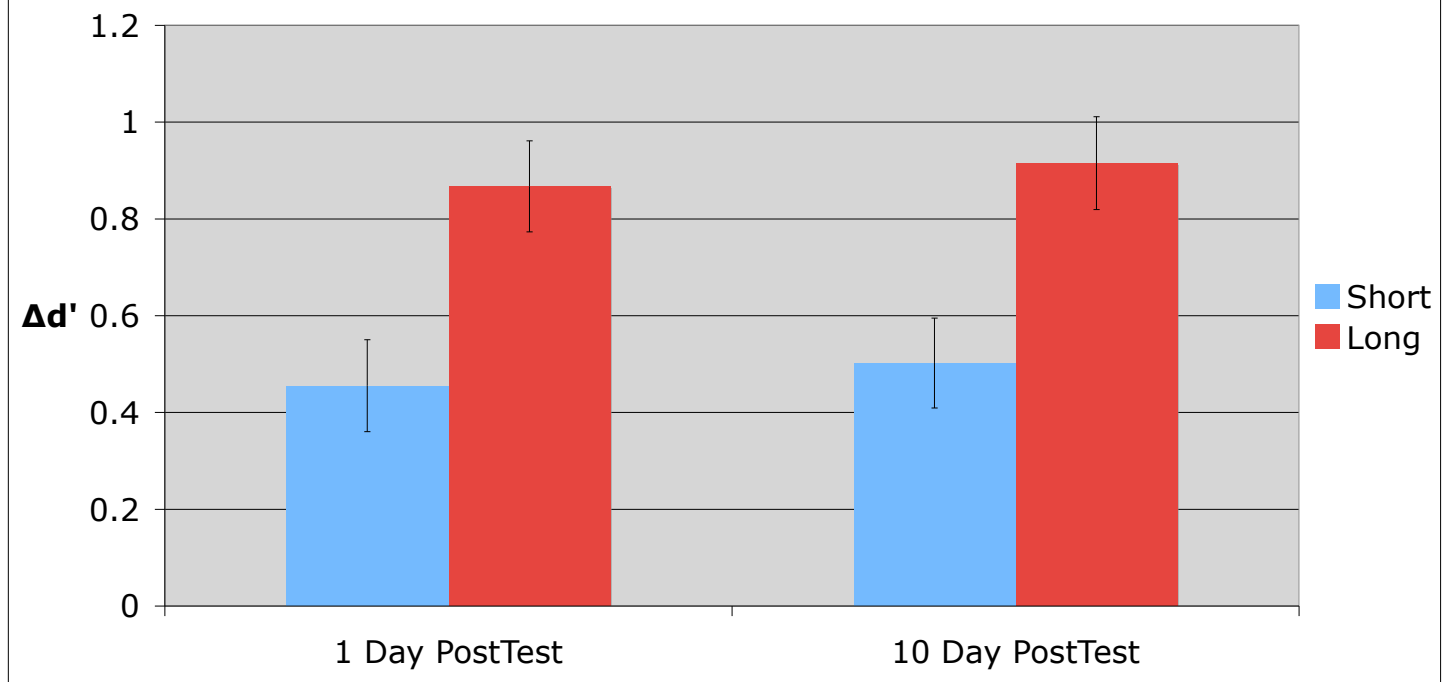
PostTest-PreTest

The Relationship Between RI and Optimal ISI

Cepeda et al. metaanalysis

$$ISI = 0.068 * RI^{0.757}$$

Optimal Spacing Delay
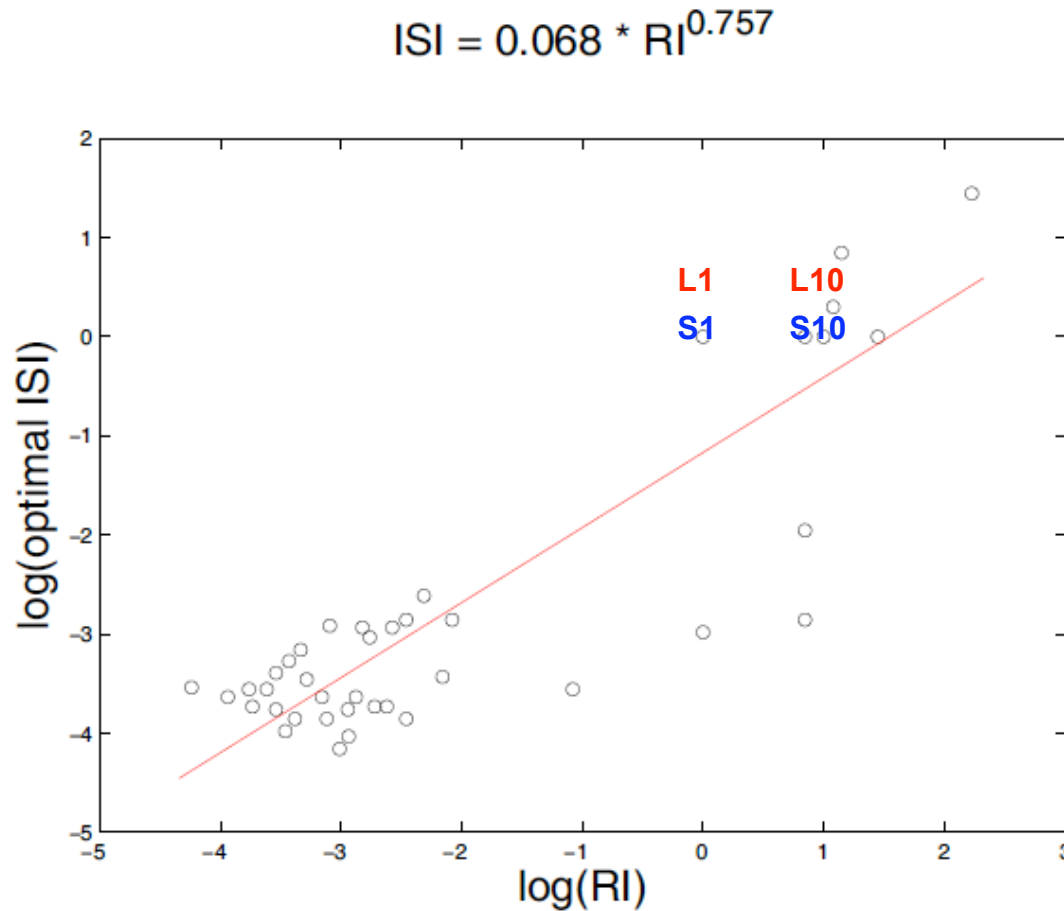
Retention Interval

d' on Matching Task

d' to Δd'
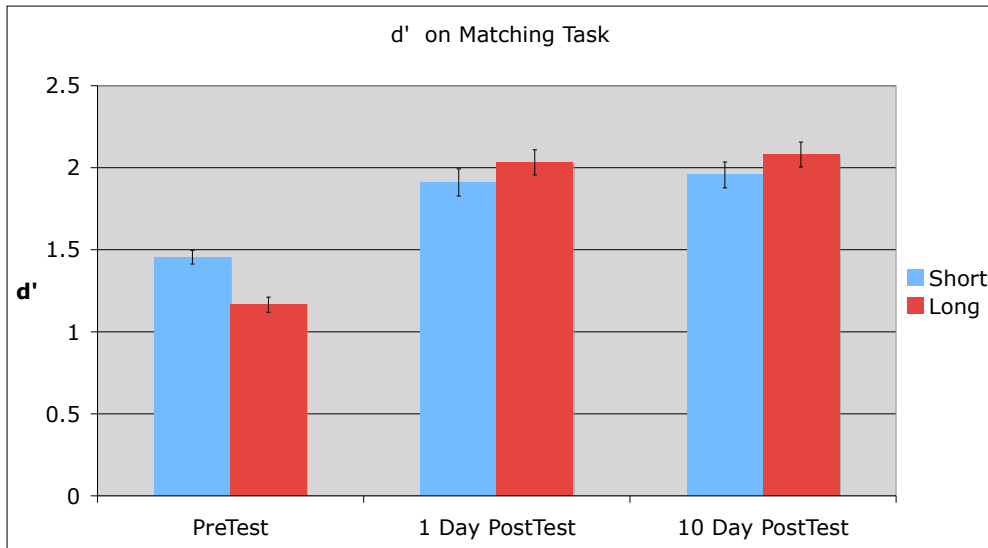
PostTest-PreTest

Δd' on matching task
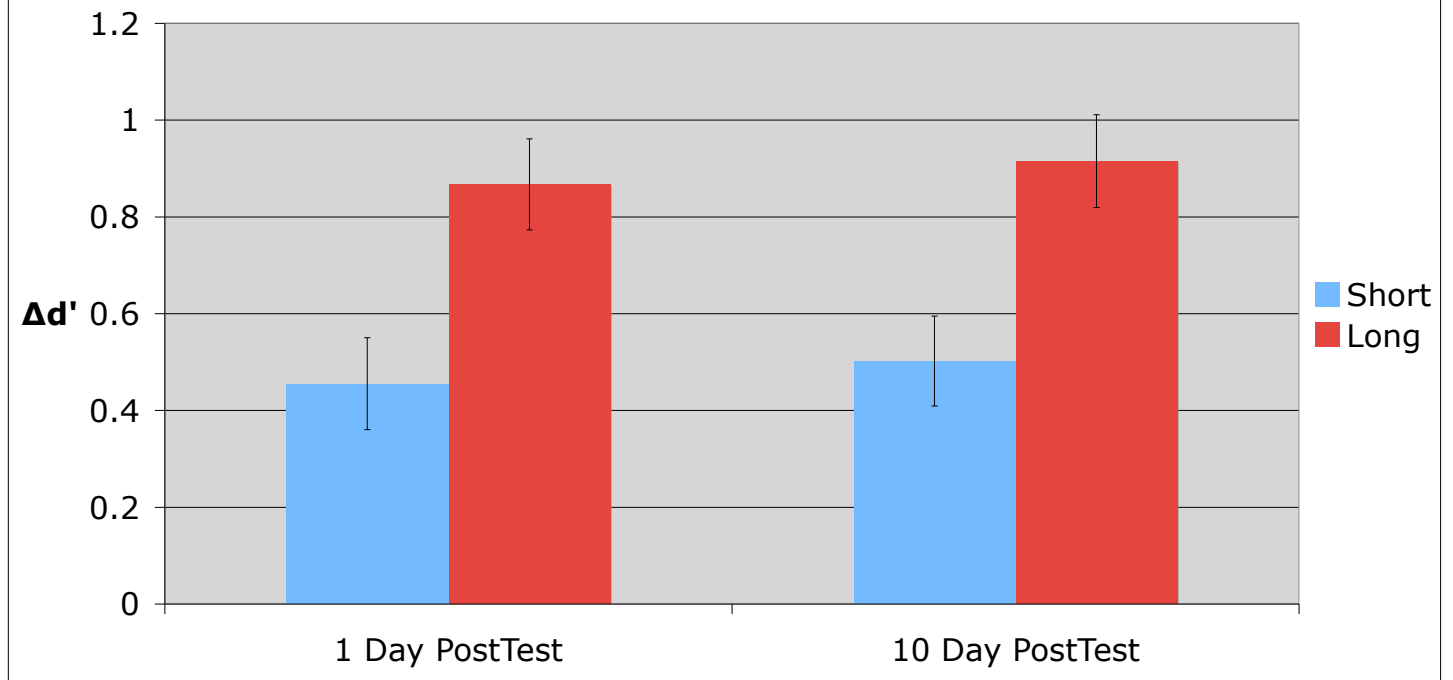
Exposure and Basic-Level training only improved performance after Long Spacing.

Δd' - 1 Day PostTest

Post-Pre ERP differences are increased by Spacing

Exposure
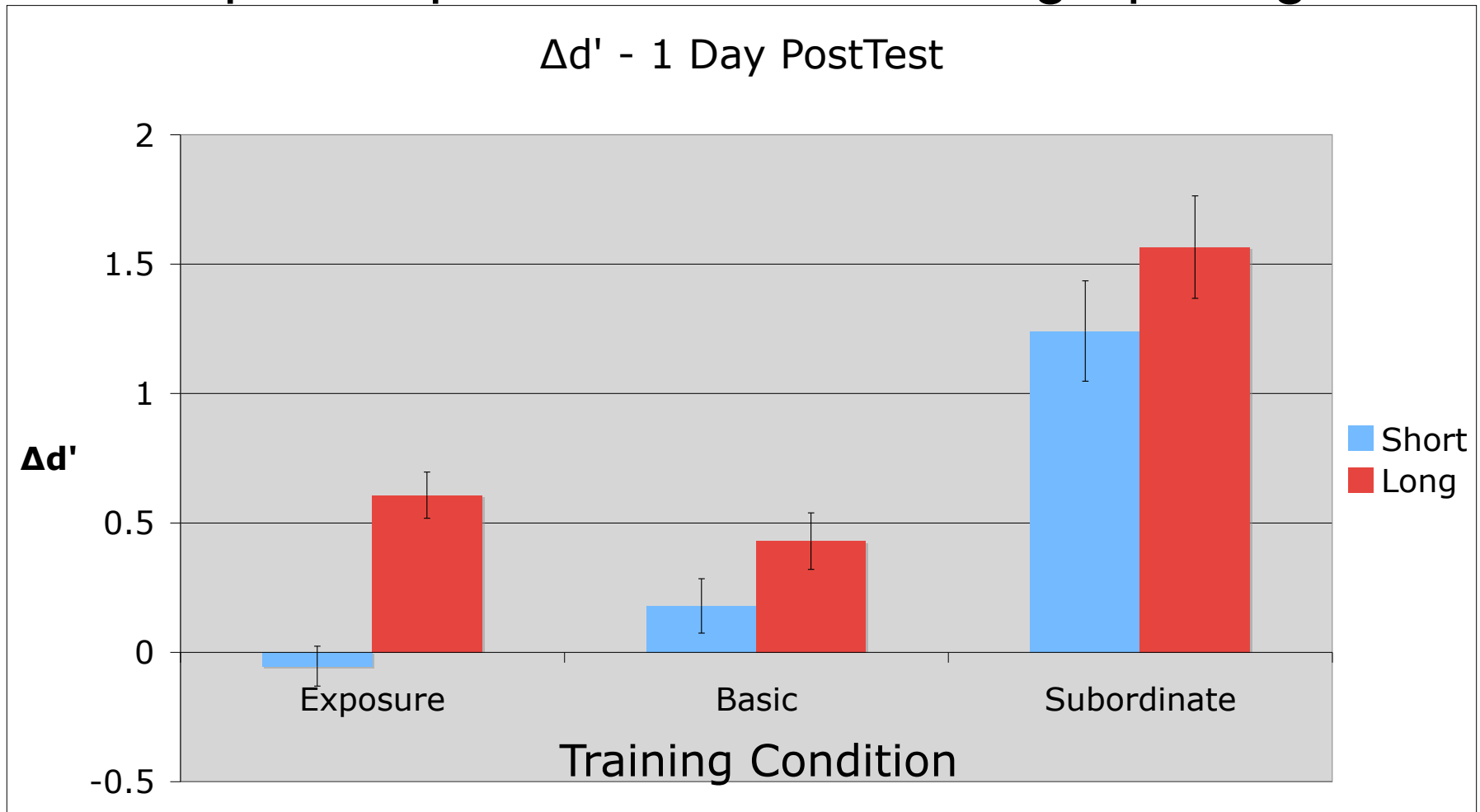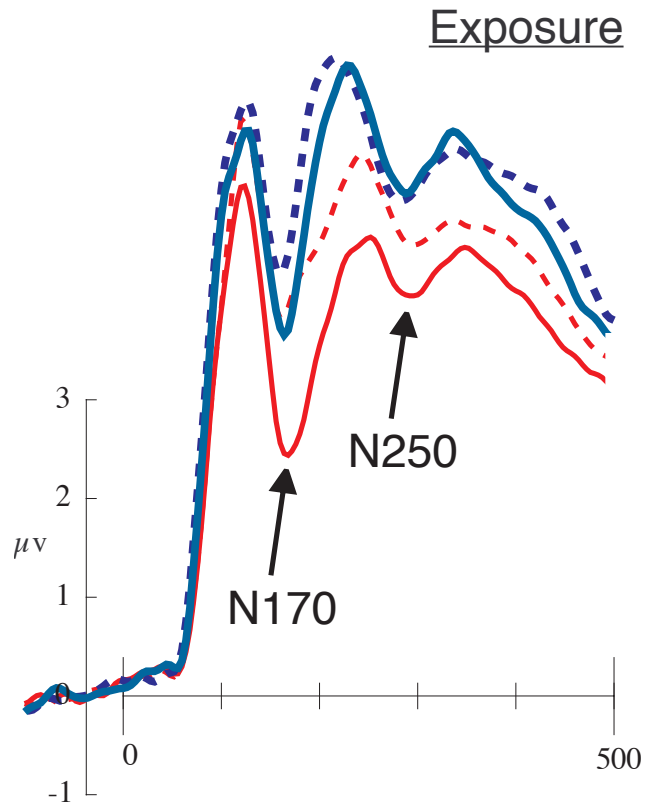
- – – – – Long-PreTest
- ▬▬▬▬ Long-PostTest
- ▪▪▪▪▪ Short-PreTest
- ▬▬▬▬ Short-PostTest

24

Post-Pre ERP differences are increased by Spacing

Exposure   Basic   Subordinate

N170   N250

μv   3   2   1   0   -1   0   500

- - - - Long-PreTest   - - - - Short-PreTest
——— Long-PostTest   ——— Short-PostTest

25
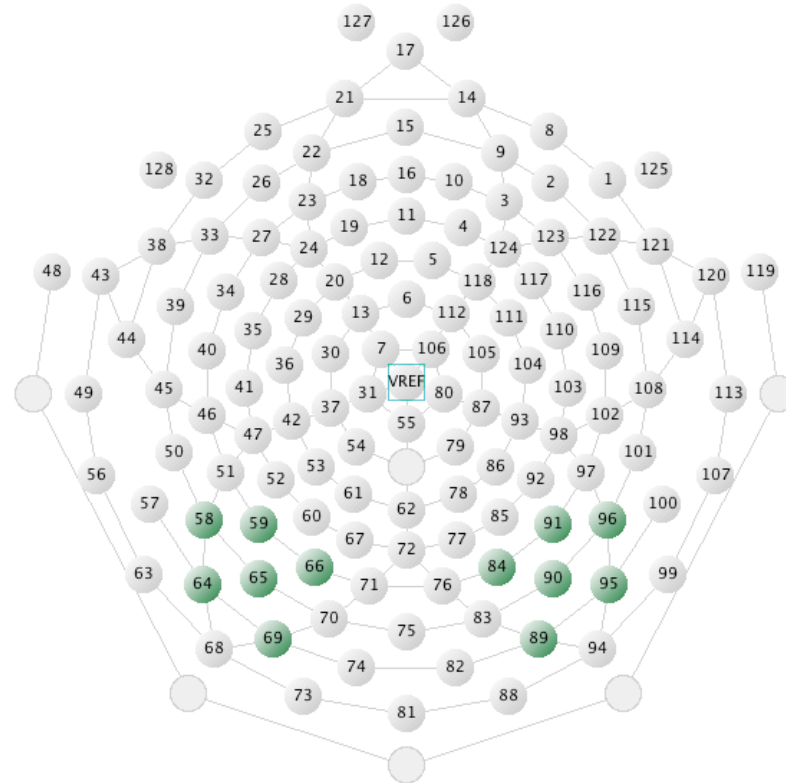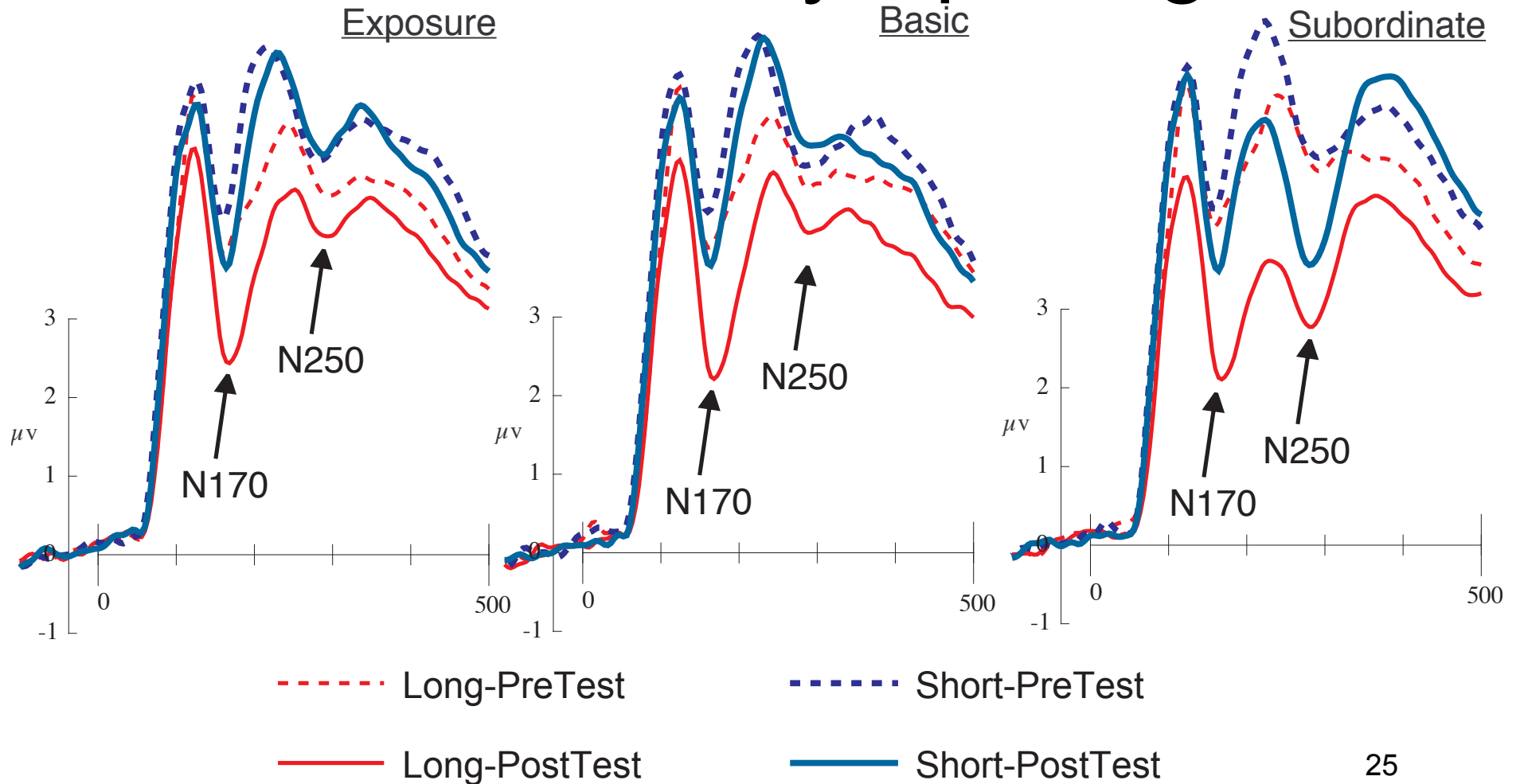
Spacing Enhances Learning-related increases in N170 amplitude

PostTest - PreTest N170 Amplitude (166-190 ms)
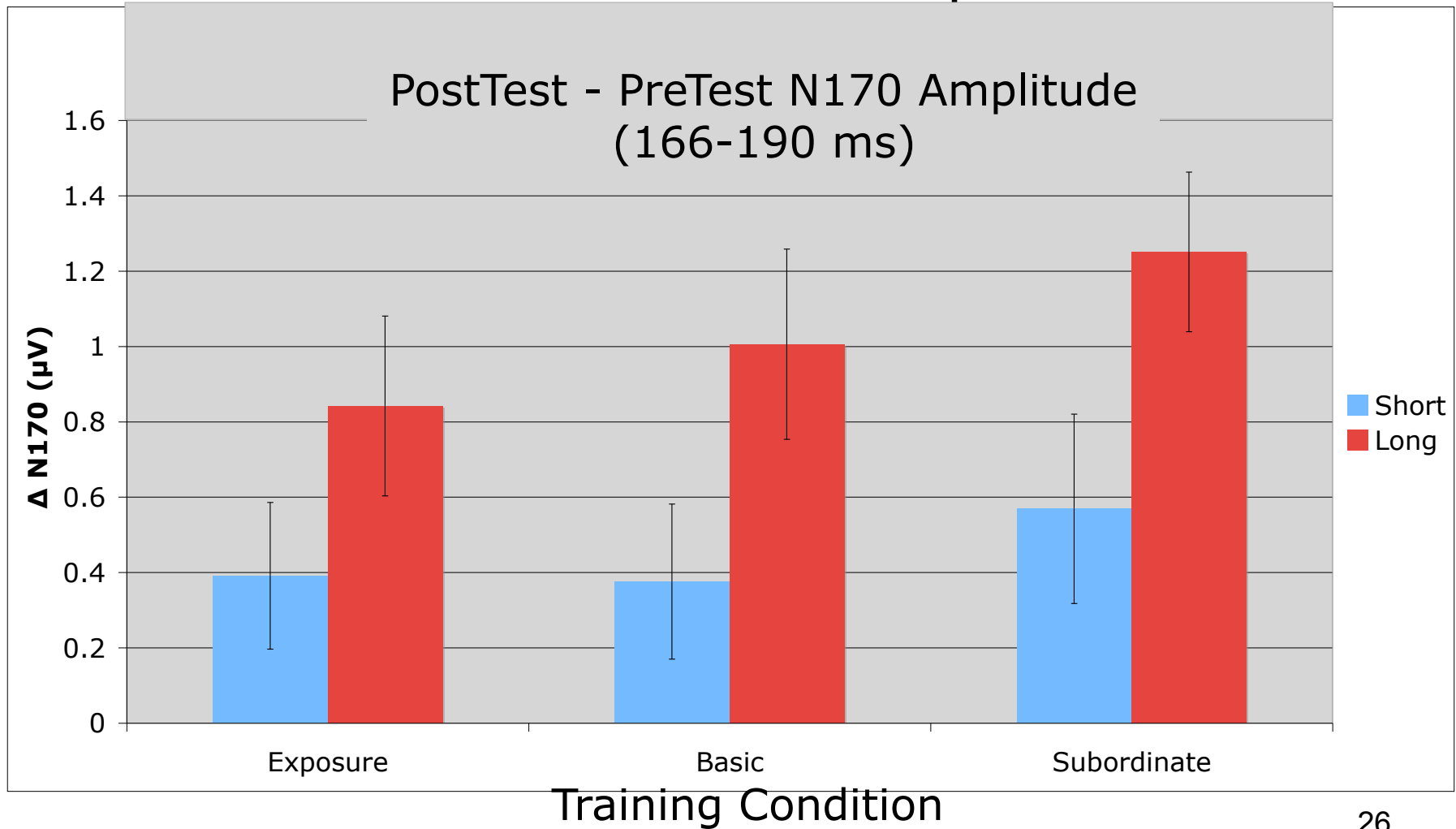
N250 only increased after Subordinate Training, but more so for after Long Spacing.

PostTest - PreTest N250 Amplitude
(230-330 ms)

Y-axis: Δ N250 (µV)

X-axis: Training Condition — Exposure, Basic, Subordinate
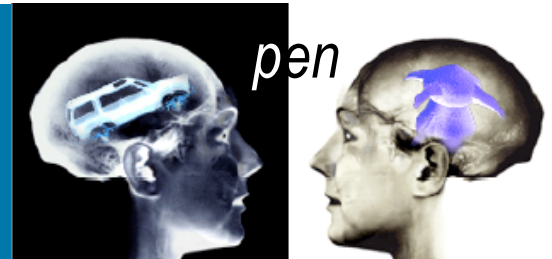
Legend: Short, Long
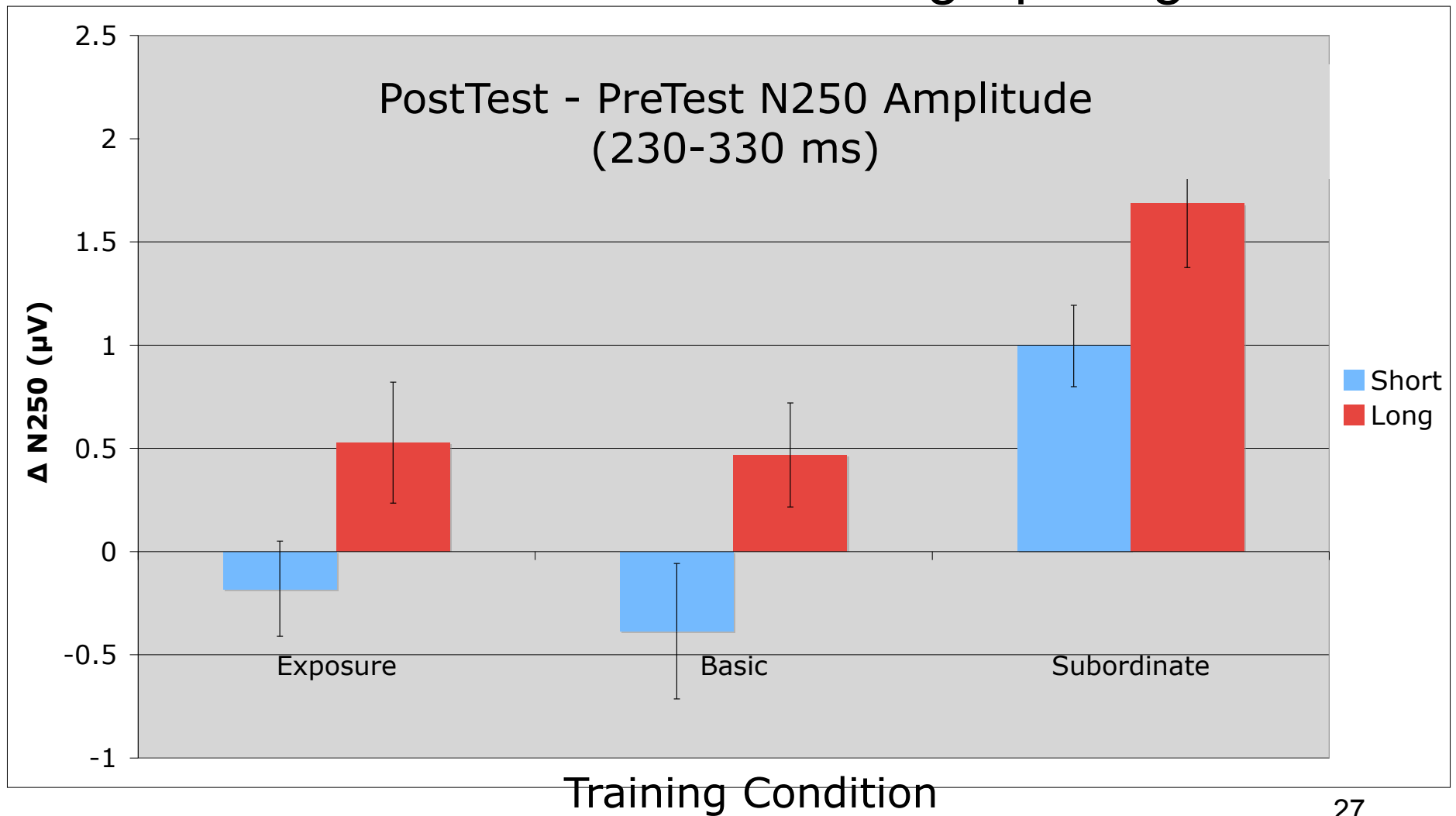
Conclusions

- Perceptual expertise training protocols previously used with birds and cars are also effective for learning novel creatures.

- Spacing enhances learning as well as the ERP correlates of perceptual expertise.
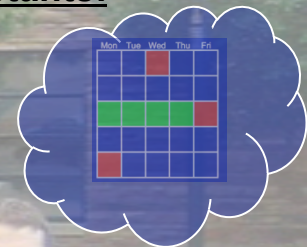
Thanks!

pen
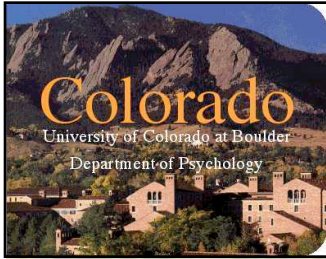
Current Graduate Students:

Katharine Tepe

Chris D'Lauro

Erika Nyhus

Matt Mollison

Professional Research Assistants:

Brent Young

Chris Bird

Visiting Graduate Students:

Vicky Lai

Maria Kharitonova

Brendan Depue

Greg McHaffie

Wolfgang Pauli

Undergrad Research Assistants:

Colin Argys

Liz Eustis

Alex Eichenbaum

Megan Freeman

Emily Kleinfelder

Colorado
University of Colorado at Boulder
Department of Psychology

NIMH
National Institute of Mental Health
NATIONAL INSTITUTES OF HEALTH

Temporal Dynamics of Learning Center
An NSF Science of Learning Center

James S. McDonnell Foundation

Training Sessions

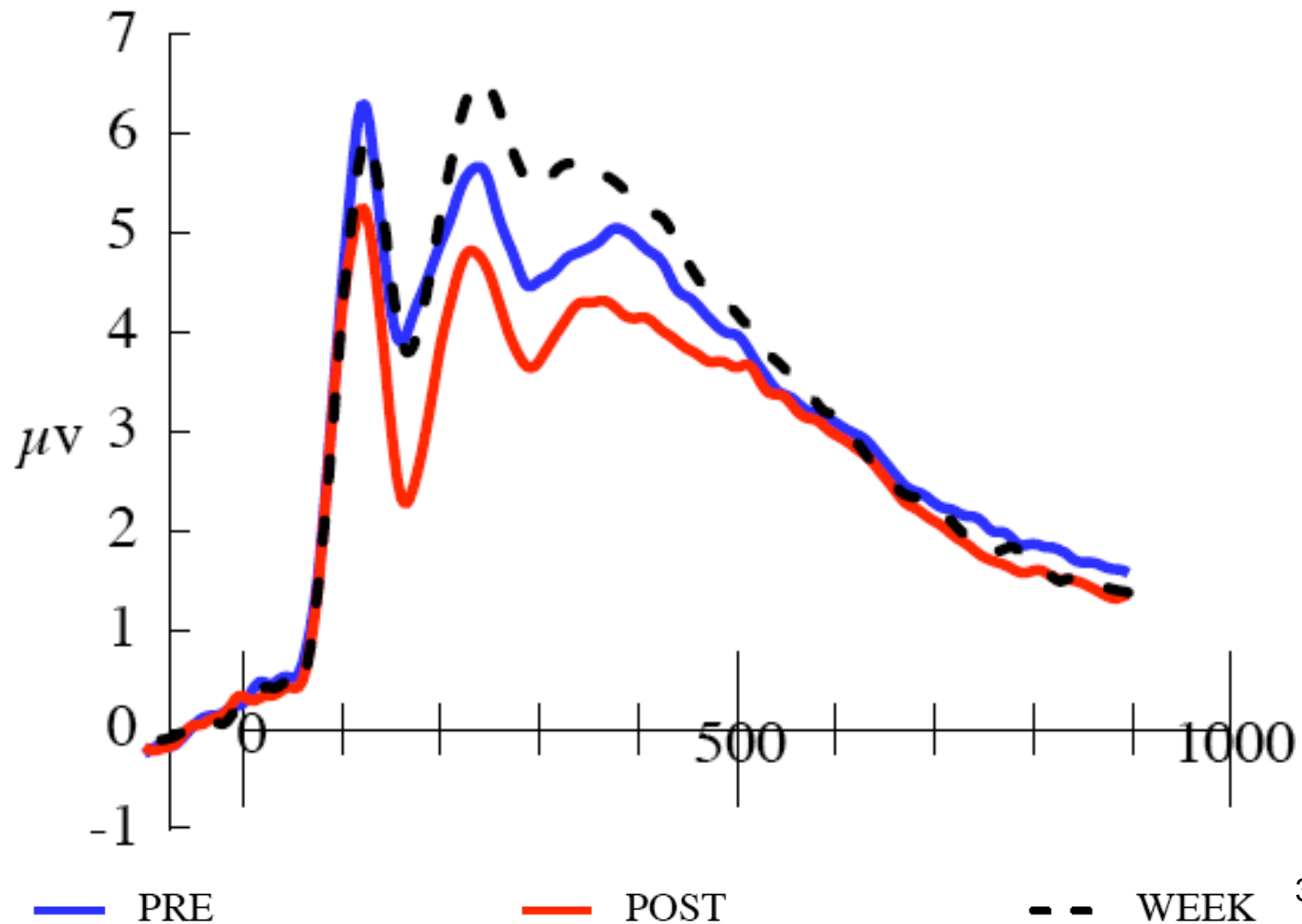Number of Repetitions/Day

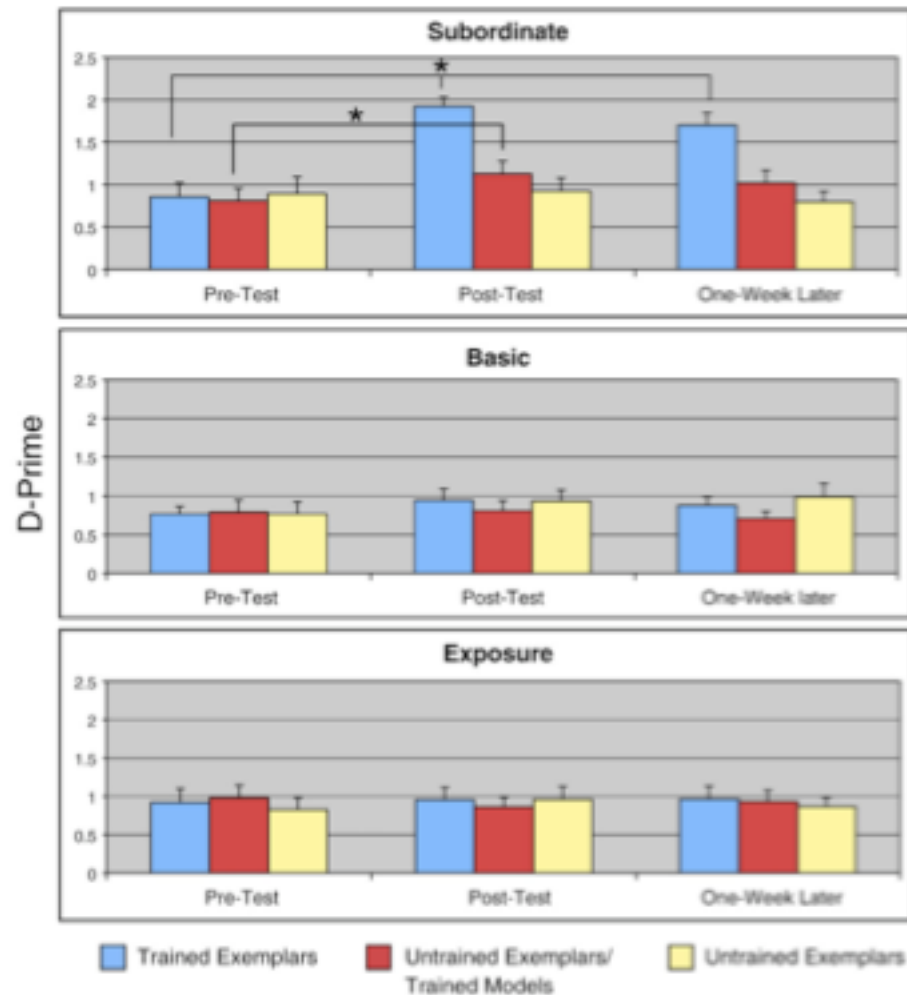# Sub D-Prime : Old-Old>Old-New>New-New
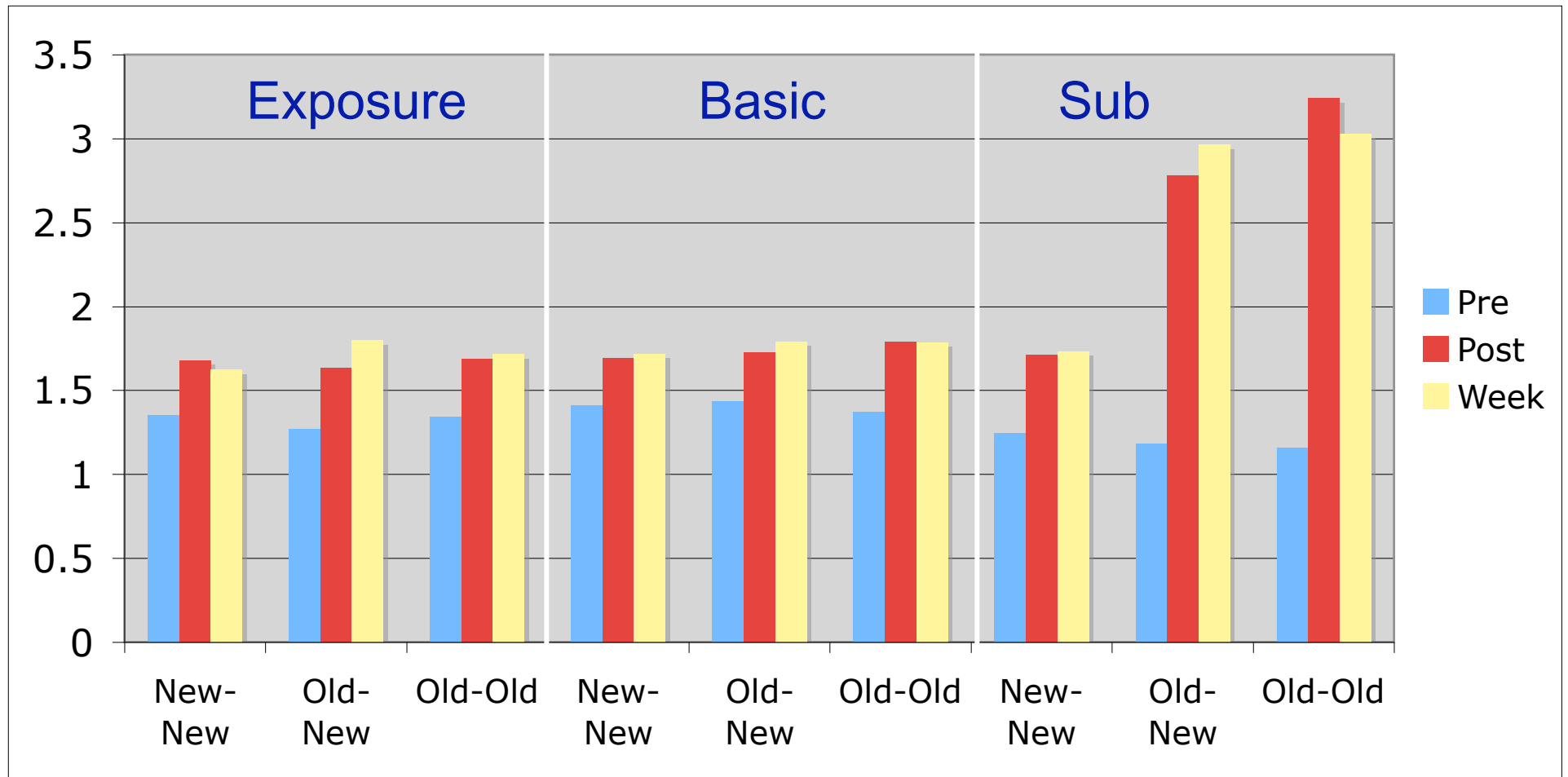
ERP: Post is most negative, week most positive
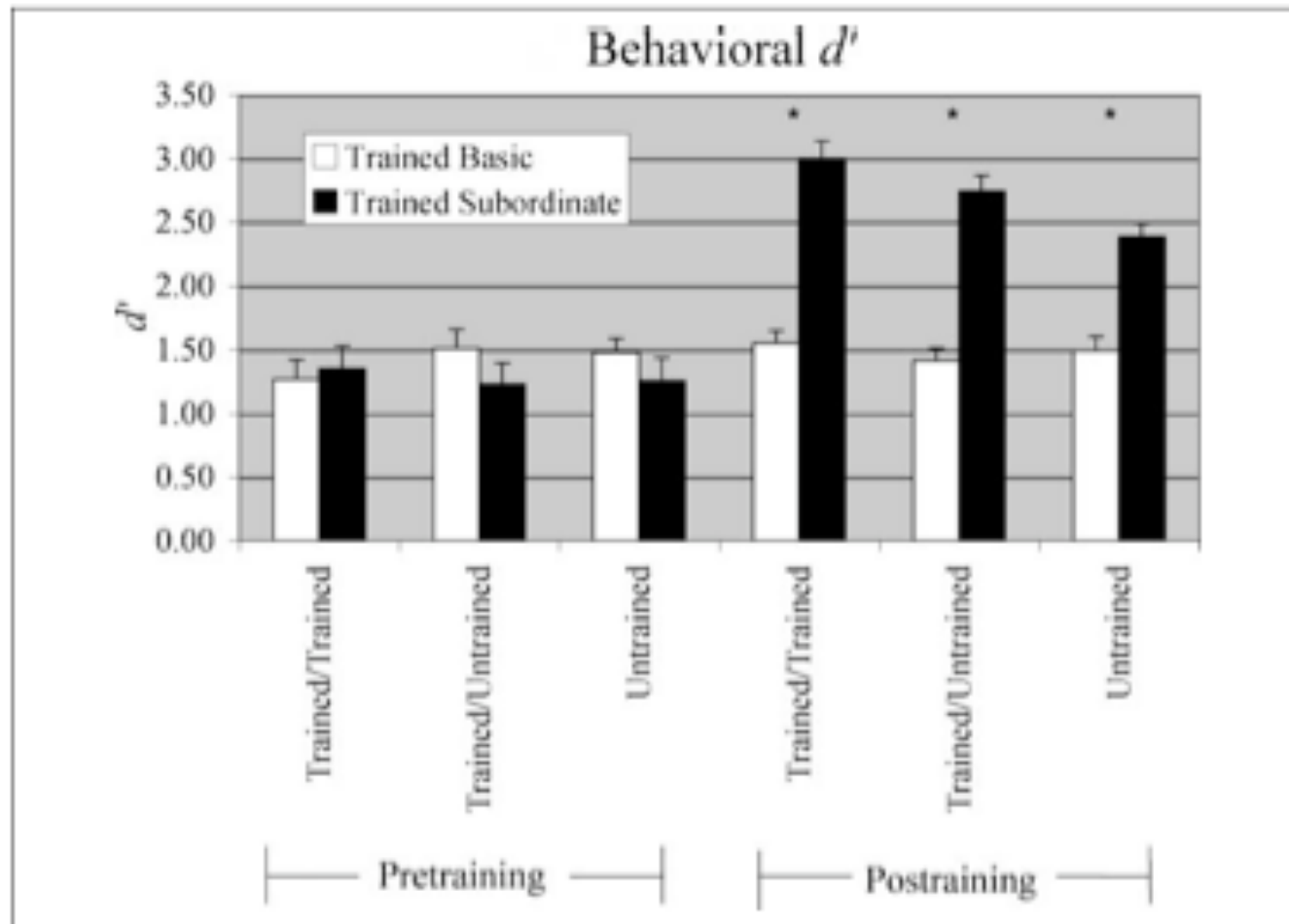
Training Regimen

- Subjects have 4 training sessions.
- Each training session consists of 3 tasks:
  1. Naming (Need 100% to move on)
     - <u>Creatures added pairwise</u>.
  2. Speeded Naming
  3. "Game show" Task

- Creature families are learned at different category levels

Scott et al(2008) - learning by level

Scott et al(2006) - learning by level

Stimulus Training Details

Example: Arns (16 Species)

Shown in Training

Not Shown In Training

A,B,C,D,E,F,G,H   I,J,K,L,M,N,O,P

Shown   **Not Shown**   **Not Shown**

A1-A8   A9-A16

B1-B8   B9-B16

Etc.   Etc.

Old Species   Old Species   New Species

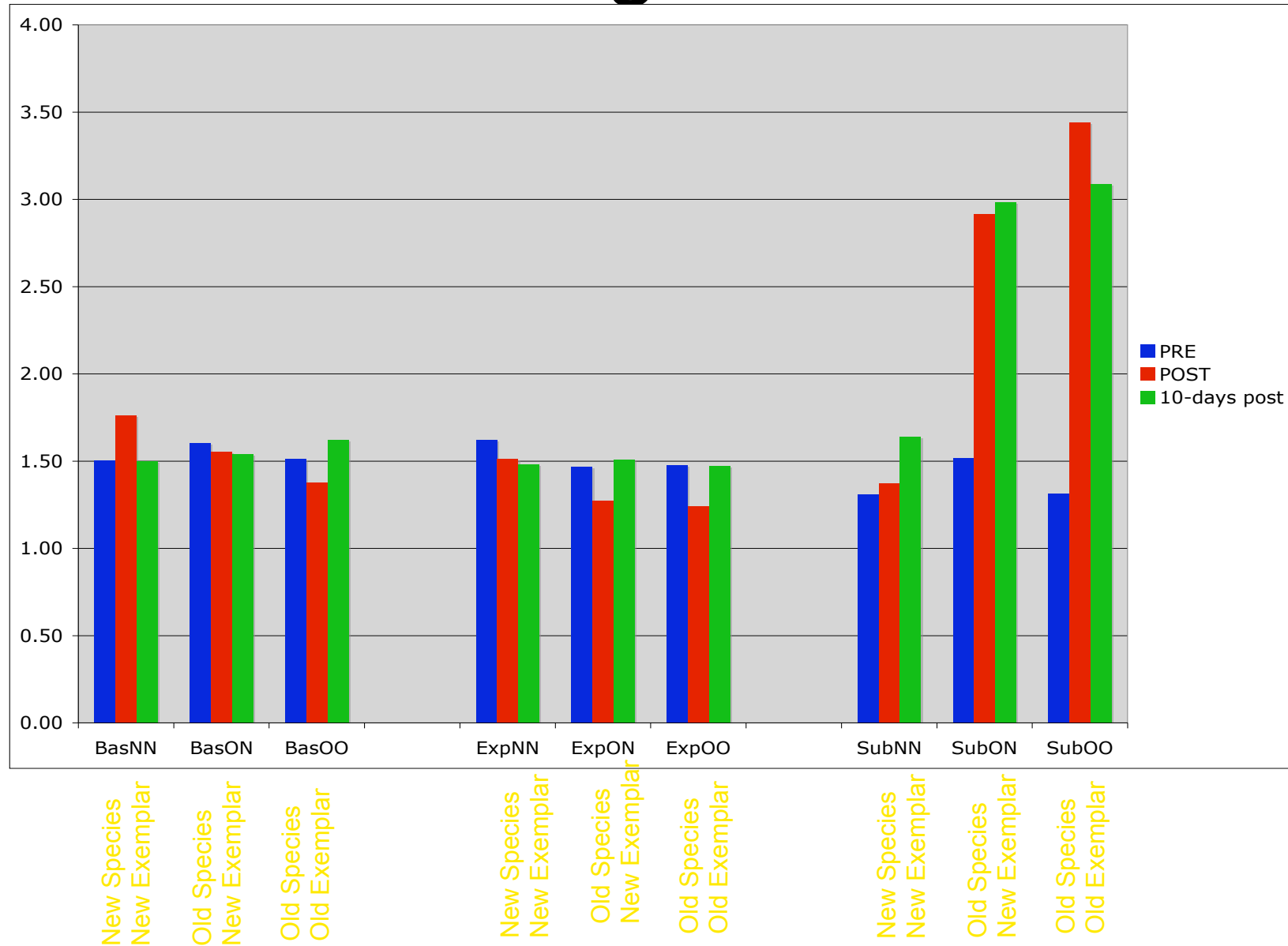Old Exemplars   New Exemplars   New Exemplars
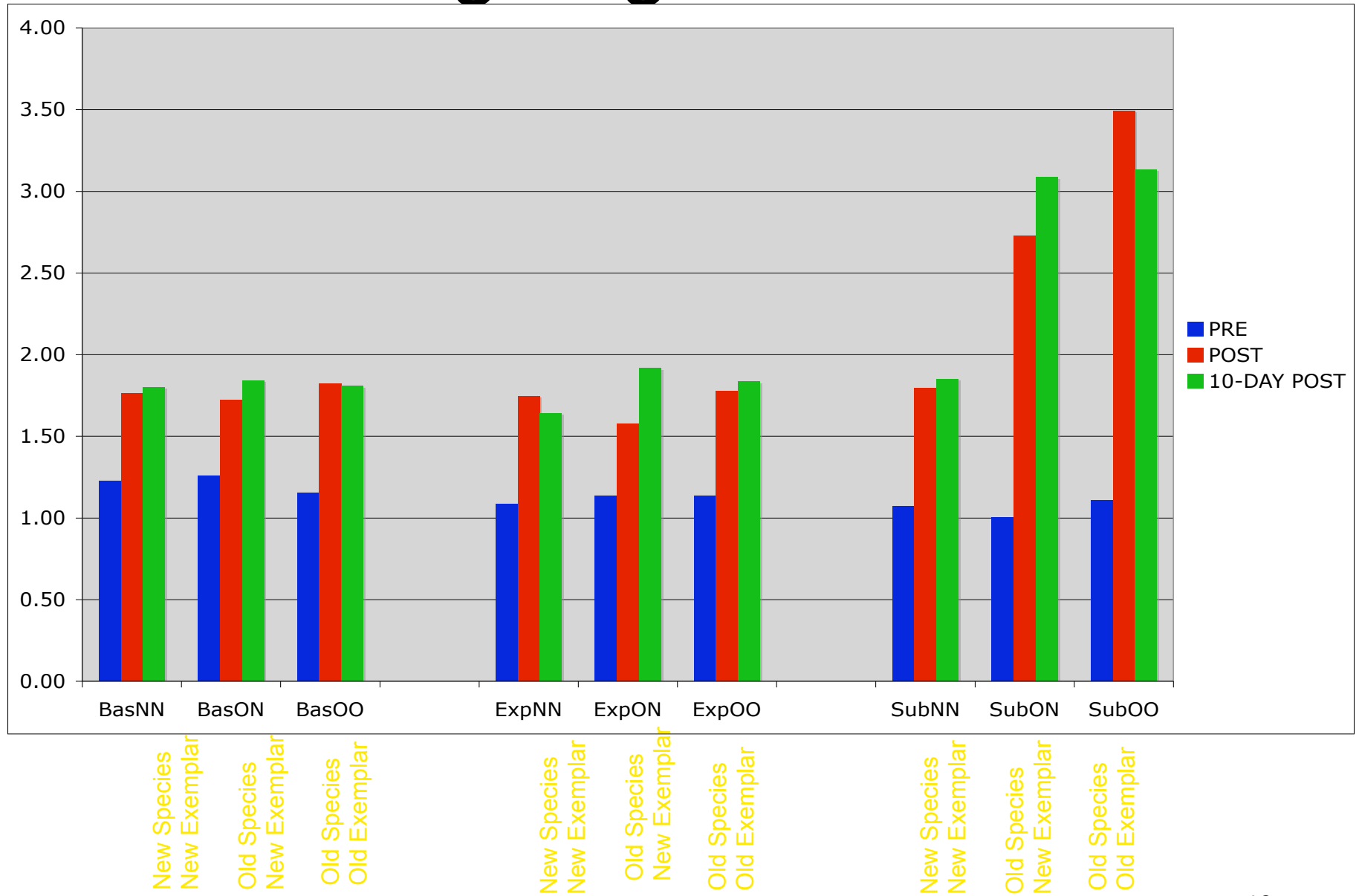
36
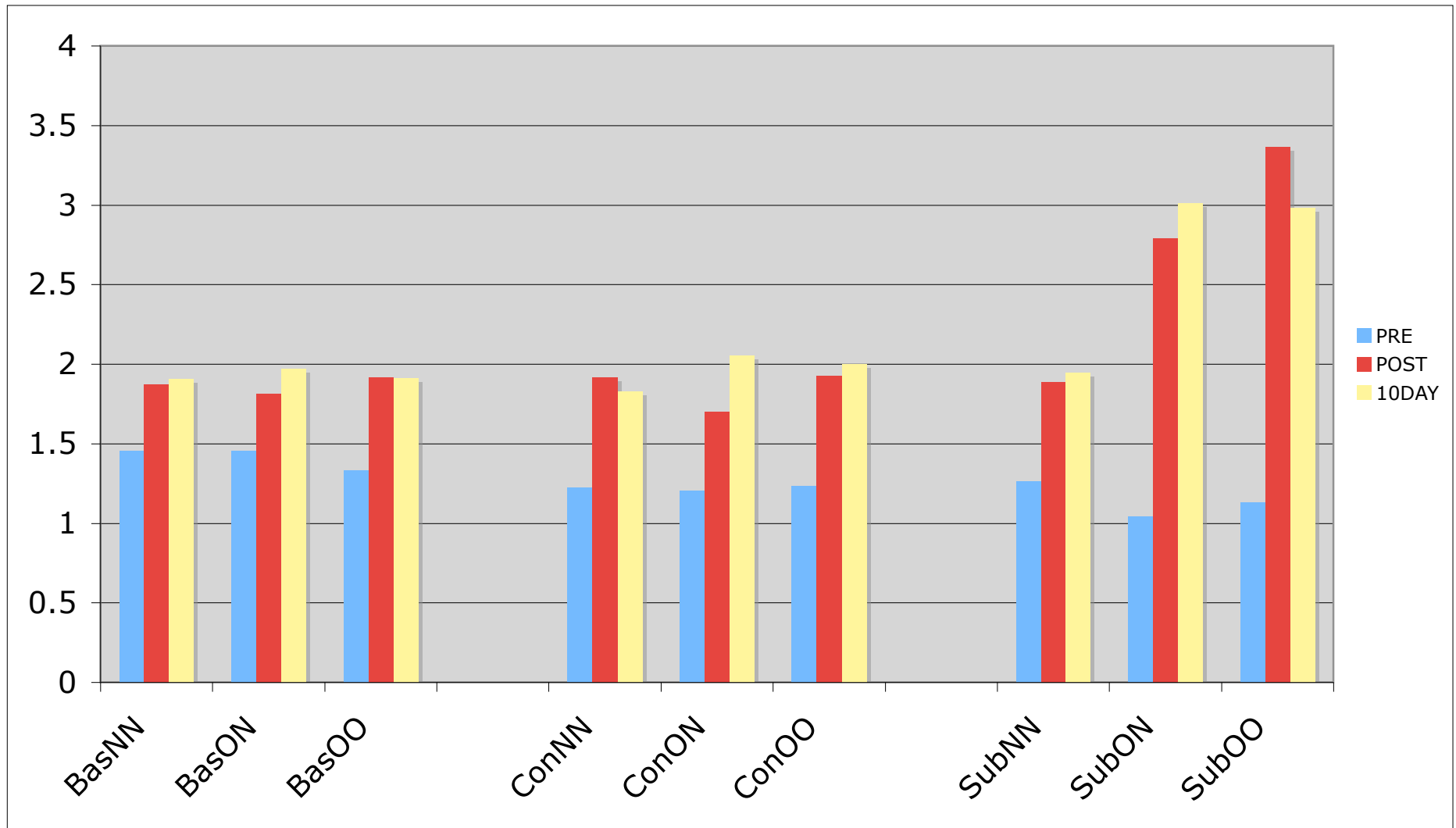
Long D-Prime

Short D-Prime
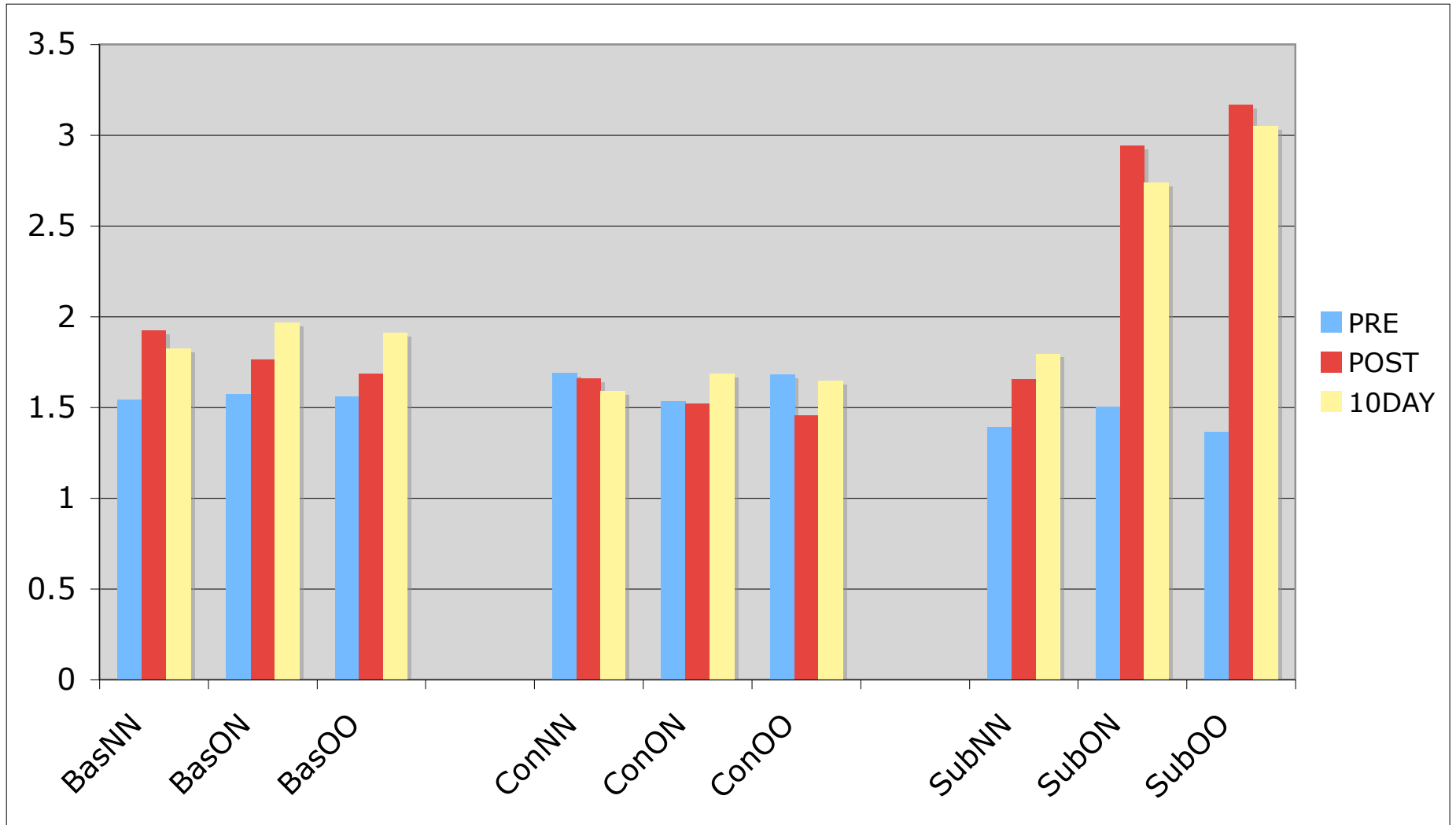
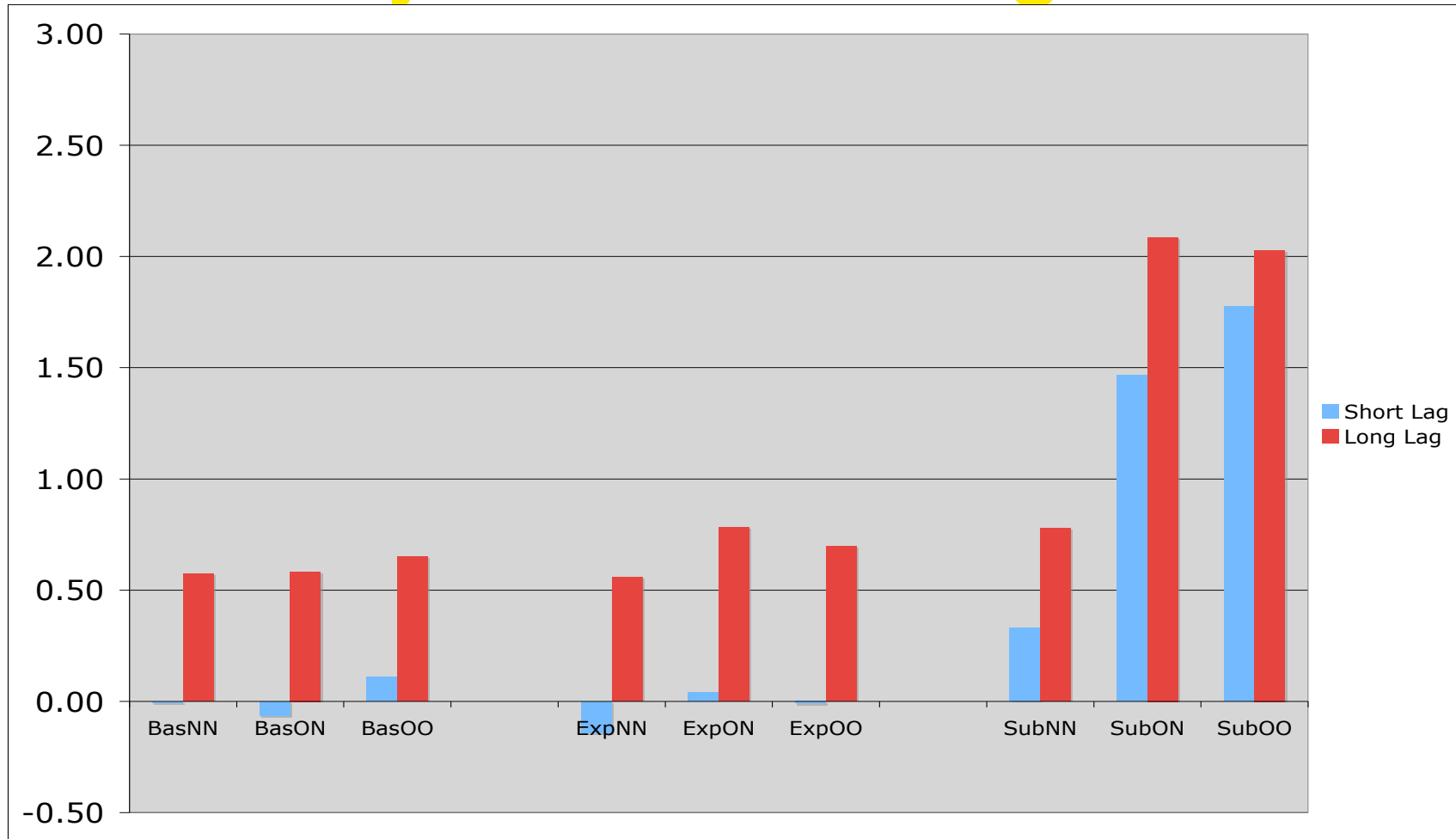# Short Lag D-Primes

Long Lag D-Primes

Post-Training D-Prime Diffs

41
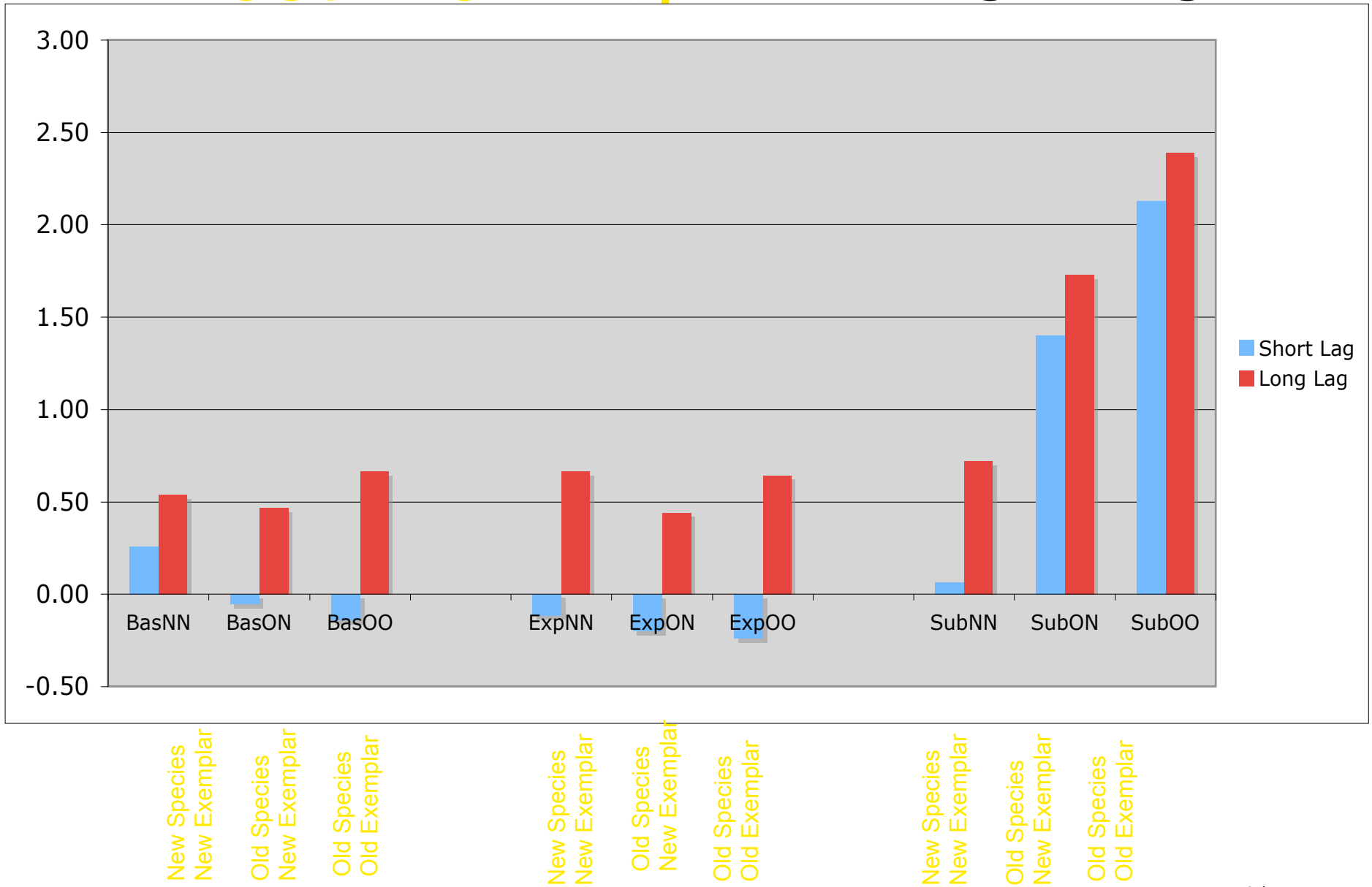
10 Day Post-Training Diffs

42

Subordinate Training D-Prime Diffs
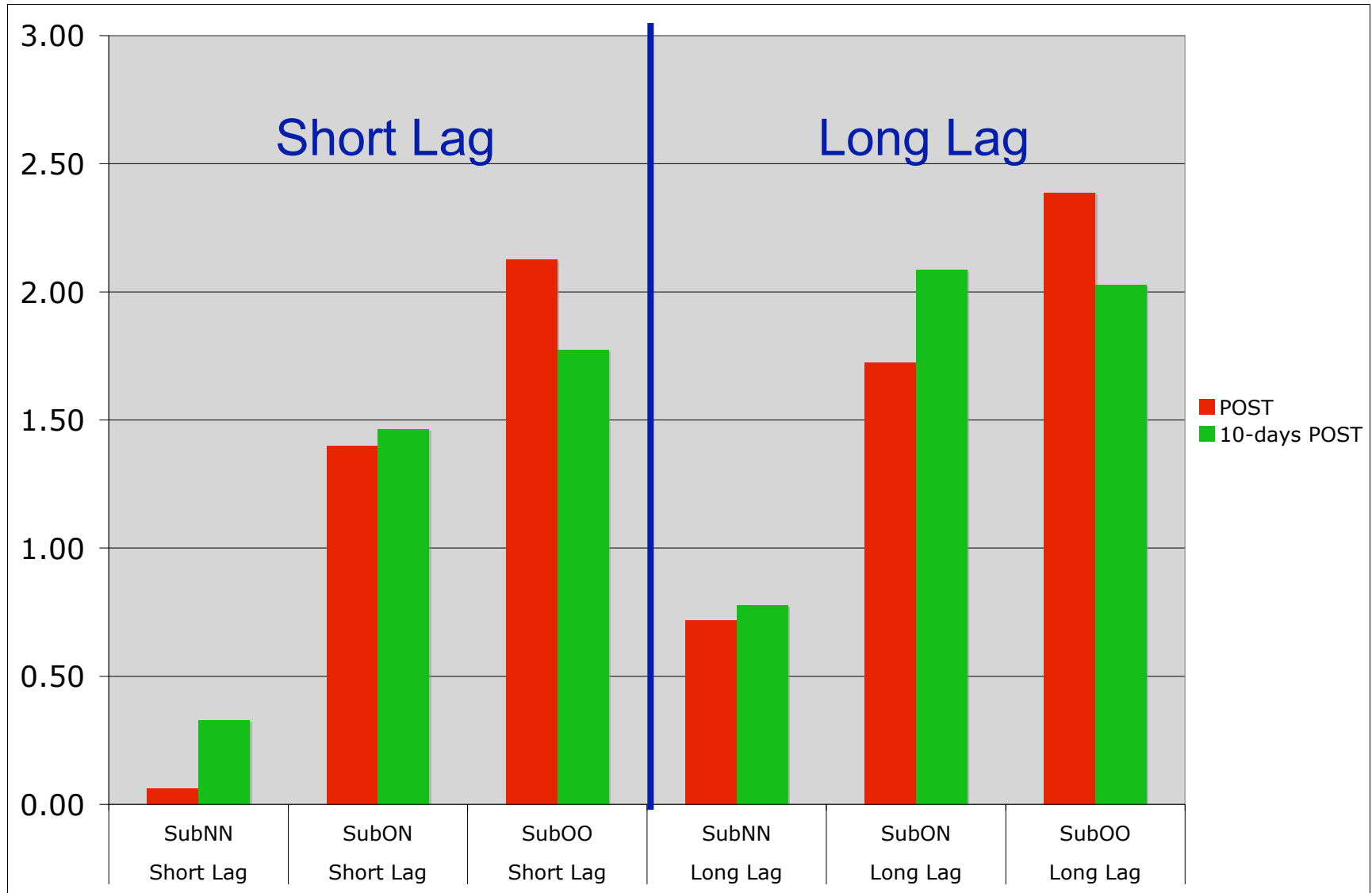
Stimulus Training Details

During Training:

- Species Seen
  - 8 Species of each family will be shown
  - 8 Species of each family will NOT be shown and will be held back for testing

- Exemplars seen:
  - 8 Exemplars from each species will be shown
  - 8 Exemplars from each species will NOT be shown and will be held back for testing