The varied influence of prior knowledge on perception, retention, and new learning

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Introduction

Prior knowledge and expertise influence a range of cognitive processes, including memory and high-level perception.

This influence can stem from:
(1) Item-specific semantic knowledge (e.g. memory advantage for word vs. non-words)
(2) Generalized domain semantic knowledge even in the absence of item-specific knowledge (e.g. memory advantage for legal nonwords vs. illegal nonwords).

To disentangle these factors, we examined how expert birdwatchers processed personally-familiar and unfamiliar birds in comparison to a control group.

Specific and generalized expertise modulated 1) ability to remember encoded information (item memory) 2) translation between illustration-photo formats (matching) and 3) the learning of new unfamiliar birds (one-week training game between baseline and final session)

Design

Stimuli

Three Lists:
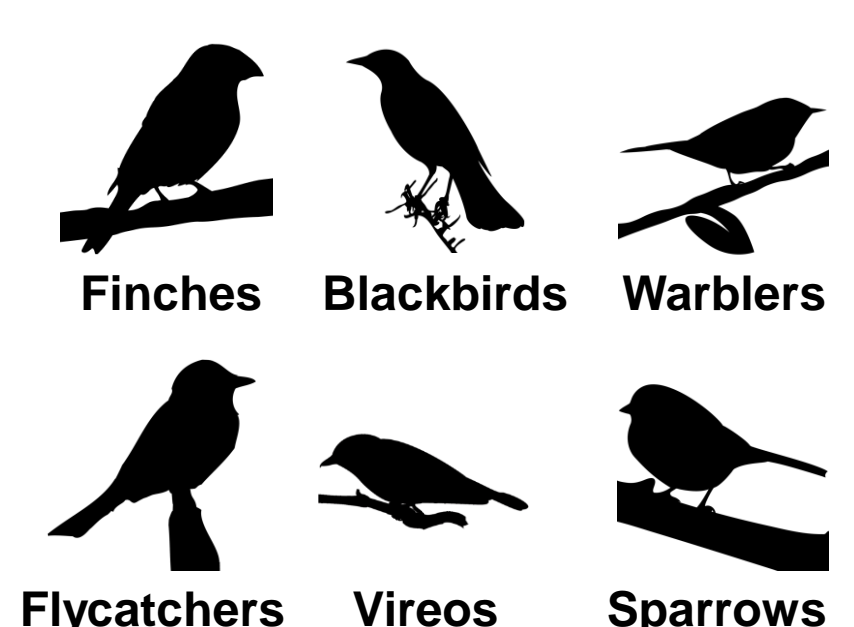**LOCAL** (familiar)
TRAINING (unfamiliar)
TRANSFER (unfamiliar)

36 species/list

LOCAL	TRAINING	TRANSFER
Toronto area	Non-local	Non-local

Each list contains birds from the same 6 **families** (with 6 species per family)

Finches, Blackbirds, Warblers, Flycatchers, Vireos, Sparrows

For each species
--1 x field guide illustration
-- 8 x exemplar photos

Exemplar photos normed for match to illustration in separate online study

Procedure Overview

Session 1 - Baseline
Tasks include
• old/new memory
• matching
• subjective similarity

Conditions: LOCAL, TRAINING

Online training – 1 week

Session 2 – Post training
Tasks with repeated exemplars and new exemplars, plus name test

Conditions: LOCAL, TRAINING, TRANSFER

Old/new memory task

Do test block pictures show a repeated bird species or a previously-unseen species?

* for repeated species, test phase includes all new exemplar photos

Study … Test …
OLD NEW OLD NEW

Matching task

Are the illustration and the photo same species or different?

* in Sess2, both repeated and new exemplar photos

200ms 200ms Match — same species
within family pair — Mismatch
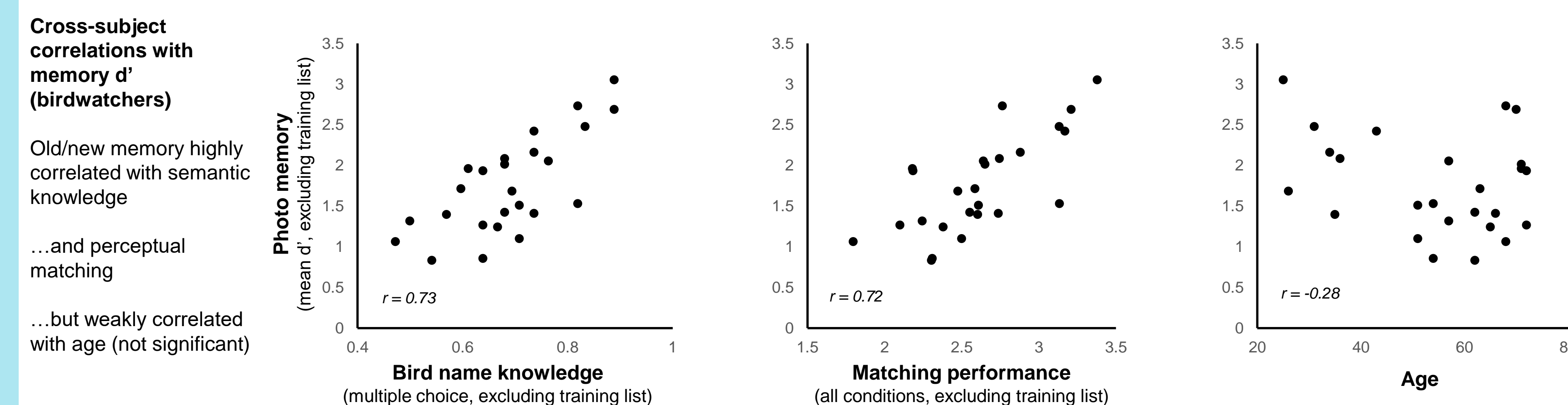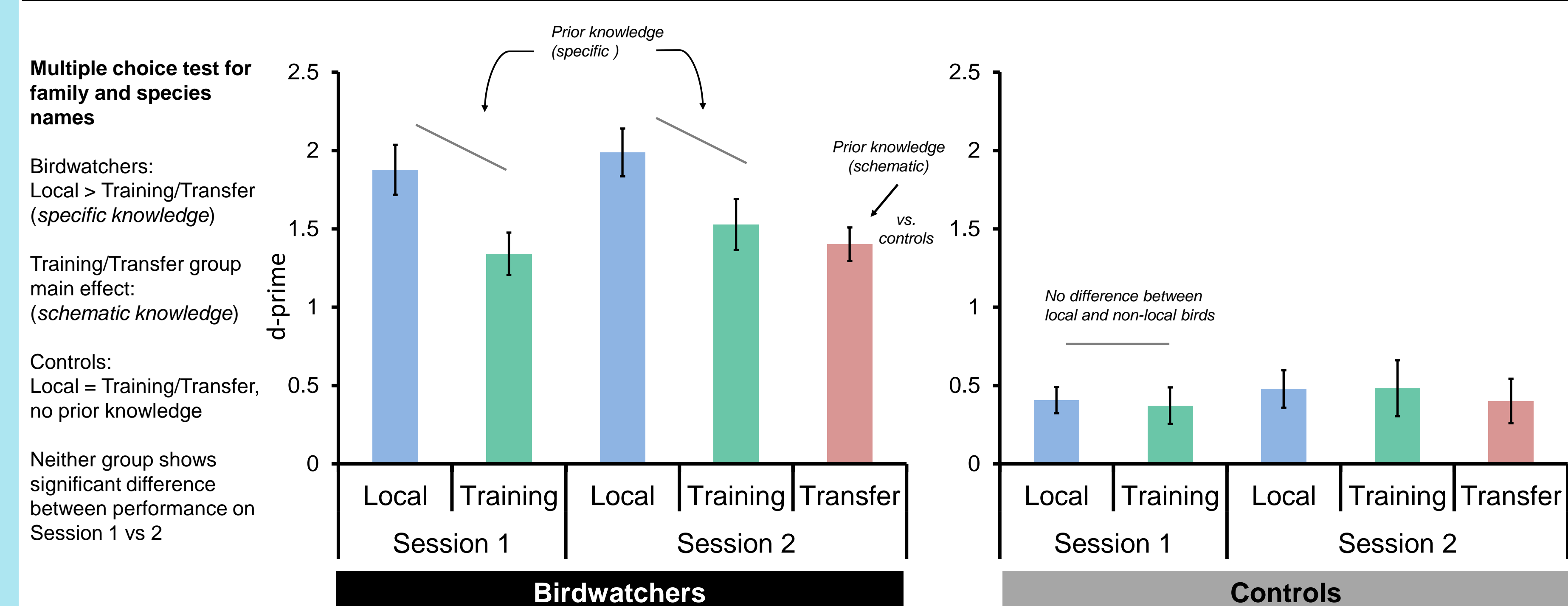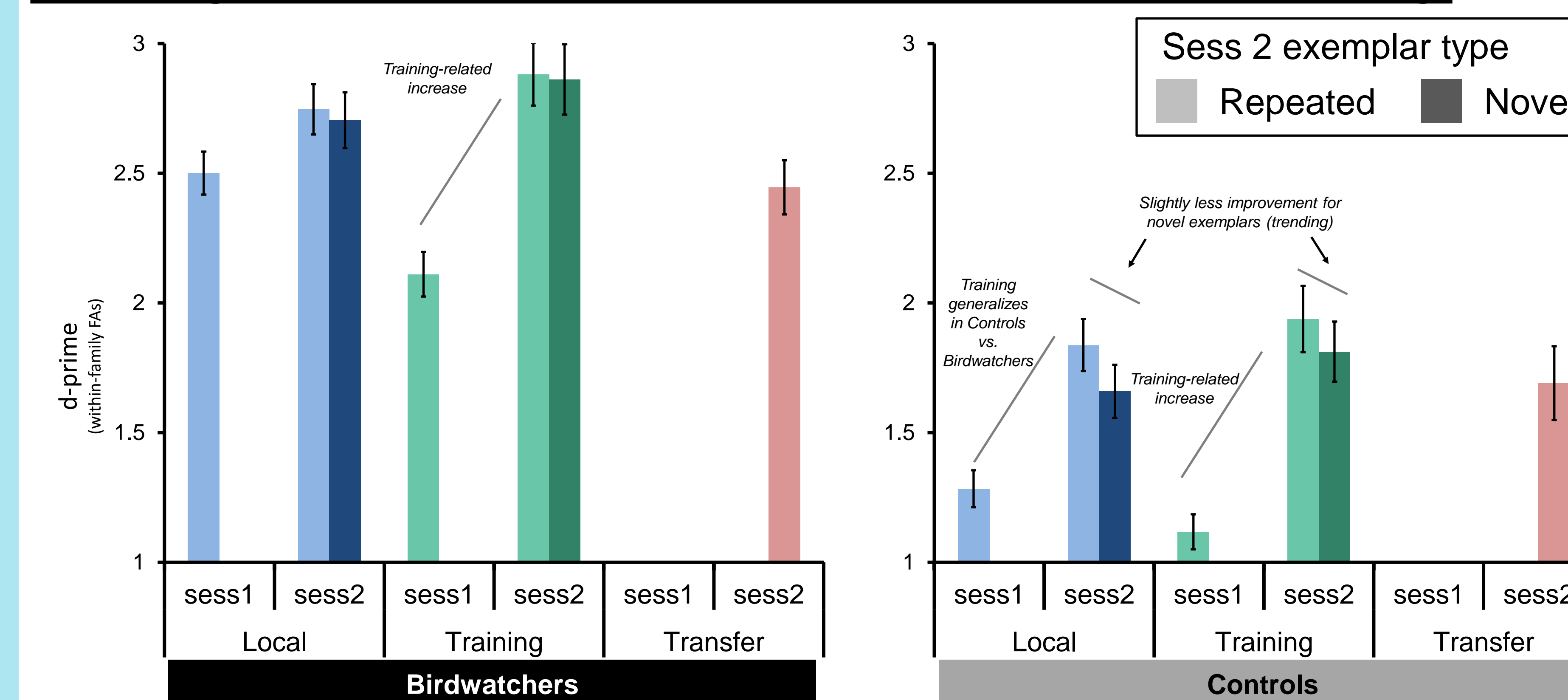between family pair — Mismatch
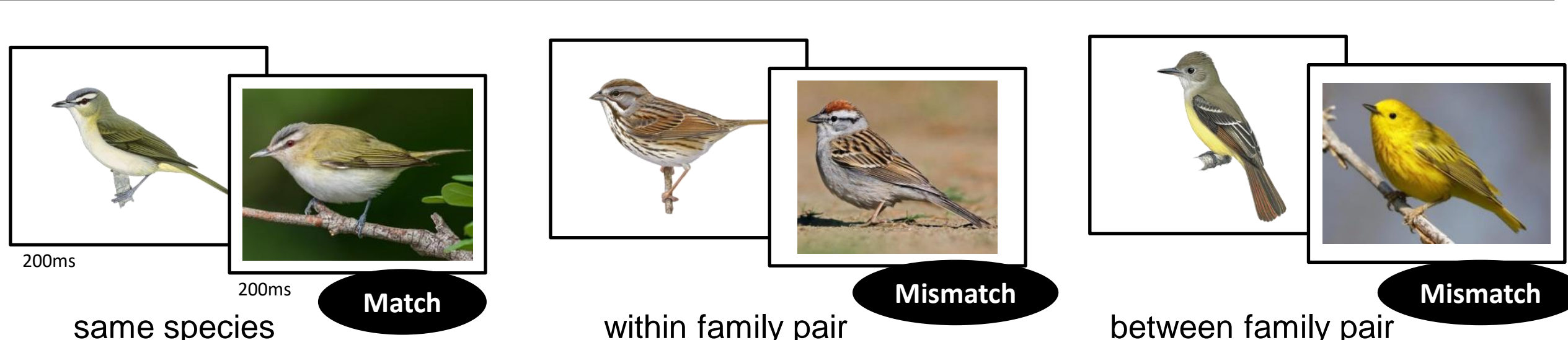
Participants

Toronto-area birdwatchers: n=26 (15 F), age=54.3 (mean) / Controls: n=15 (11 F), age = 55.6 (mean)

Results

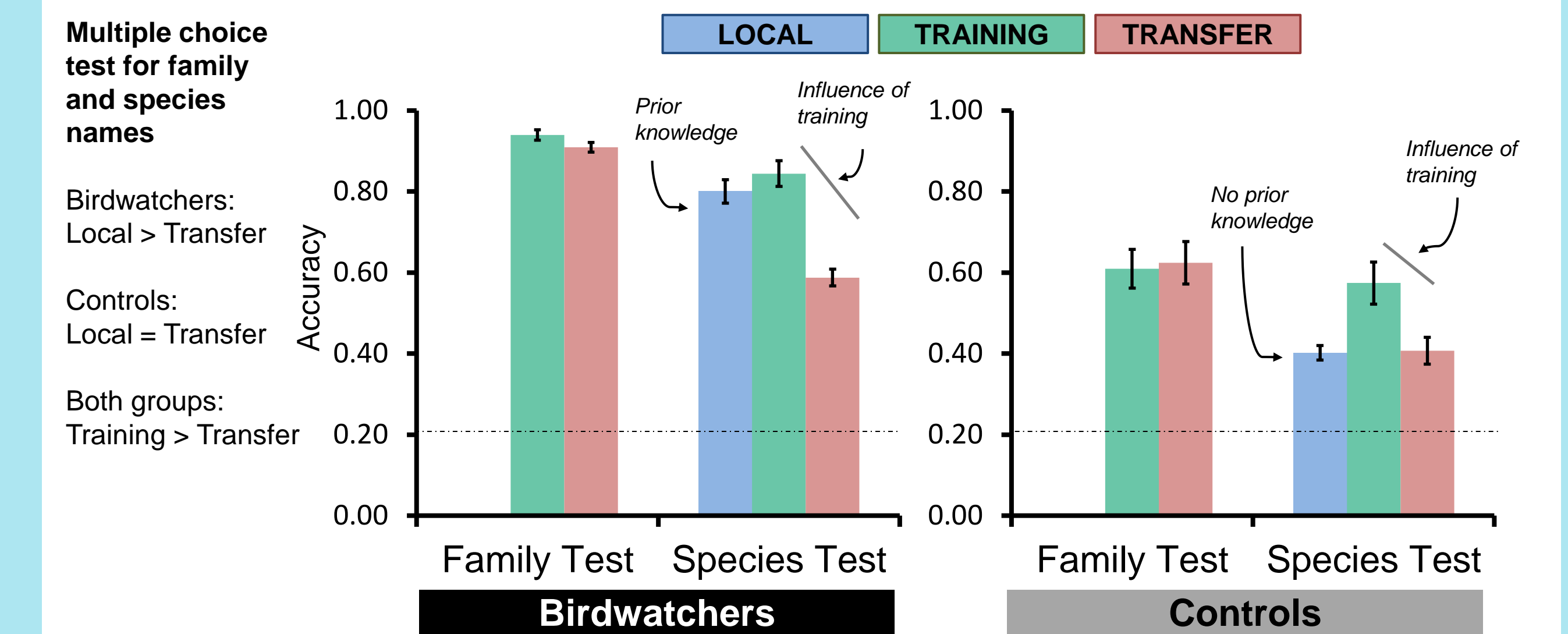### Old/new memory task – Session 1 (baseline) and Session 2 (post training)

Multiple choice test for family and species names

Birdwatchers:
Local > Training/Transfer (*specific knowledge*)

Training/Transfer group main effect: (*schematic knowledge*)

Controls:
Local = Training/Transfer, no prior knowledge

Neither group shows significant difference between performance on Session 1 vs 2

Cross-subject correlations with memory d' (birdwatchers)

Old/new memory highly correlated with semantic knowledge

…and perceptual matching

…but weakly correlated with age (not significant)

r = 0.73 (Bird name knowledge, multiple choice, excluding training list)
r = 0.72 (Matching performance, all conditions, excluding training list)
r = -0.28 (Age)

Matching task – Session 1 (baseline) and Session 2 (post training)
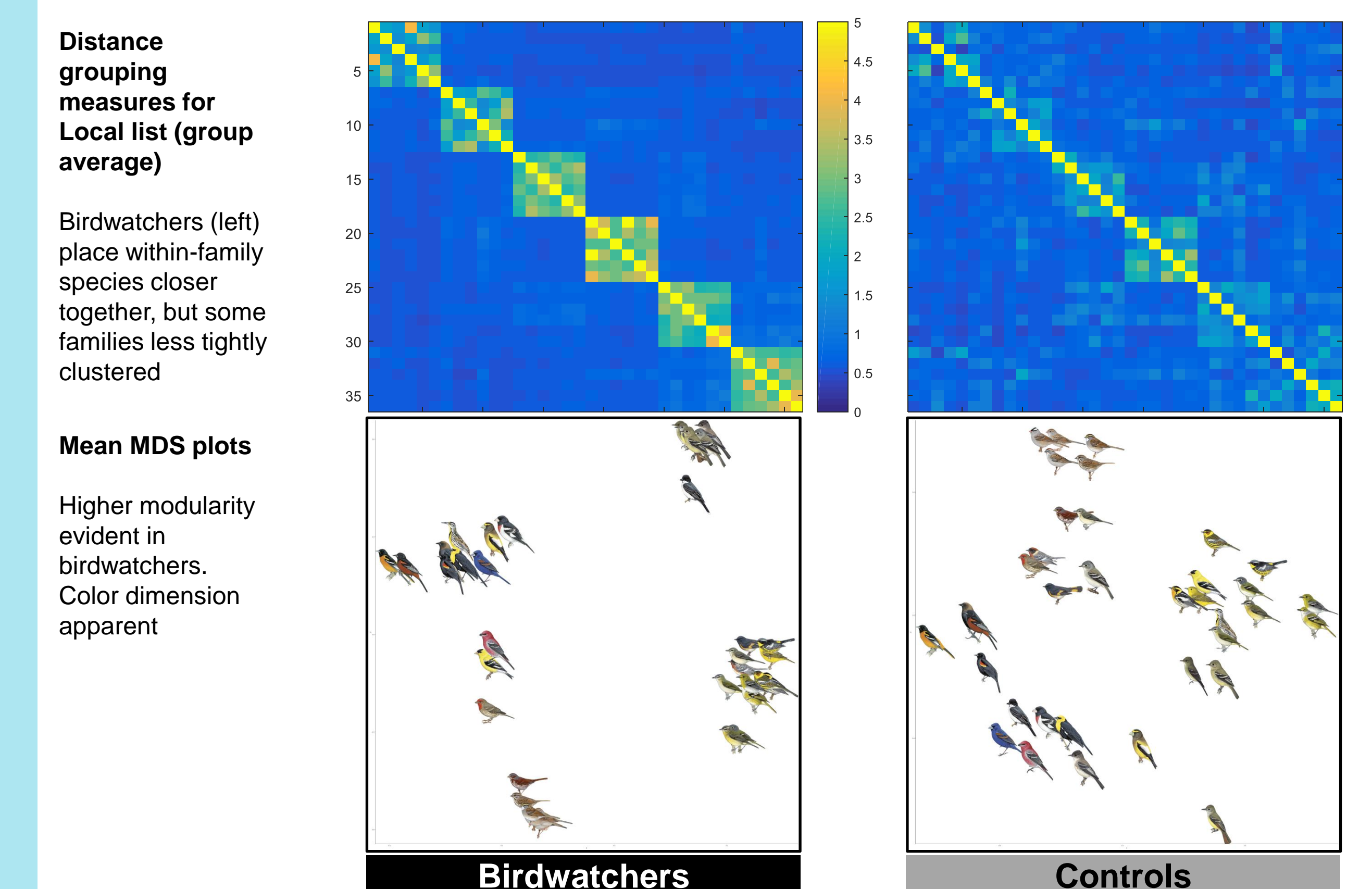

Sess 2 exemplar type: Repeated, Novel

Baseline performance
• Birdwatchers show influence of prior knowledge for local birds (vs. non-local Training)
• Schematic knowledge evident in comparison with Controls (non-local Training condition)

Training-related improvements
• Both groups → increased matching performance in training group, in Controls, benefit generalizes to Local and Transfer conditions
• In Birdwatchers, increased knowledge (name test) is associated with greater improvement ($r = 0.38$, $p < 0.05$)

Exemplar type
• In session 2, Controls show modest preference for identically-repeated photos (both Local and Training)
• Improvement in Birdwatchers equal for repeated and novel exemplars

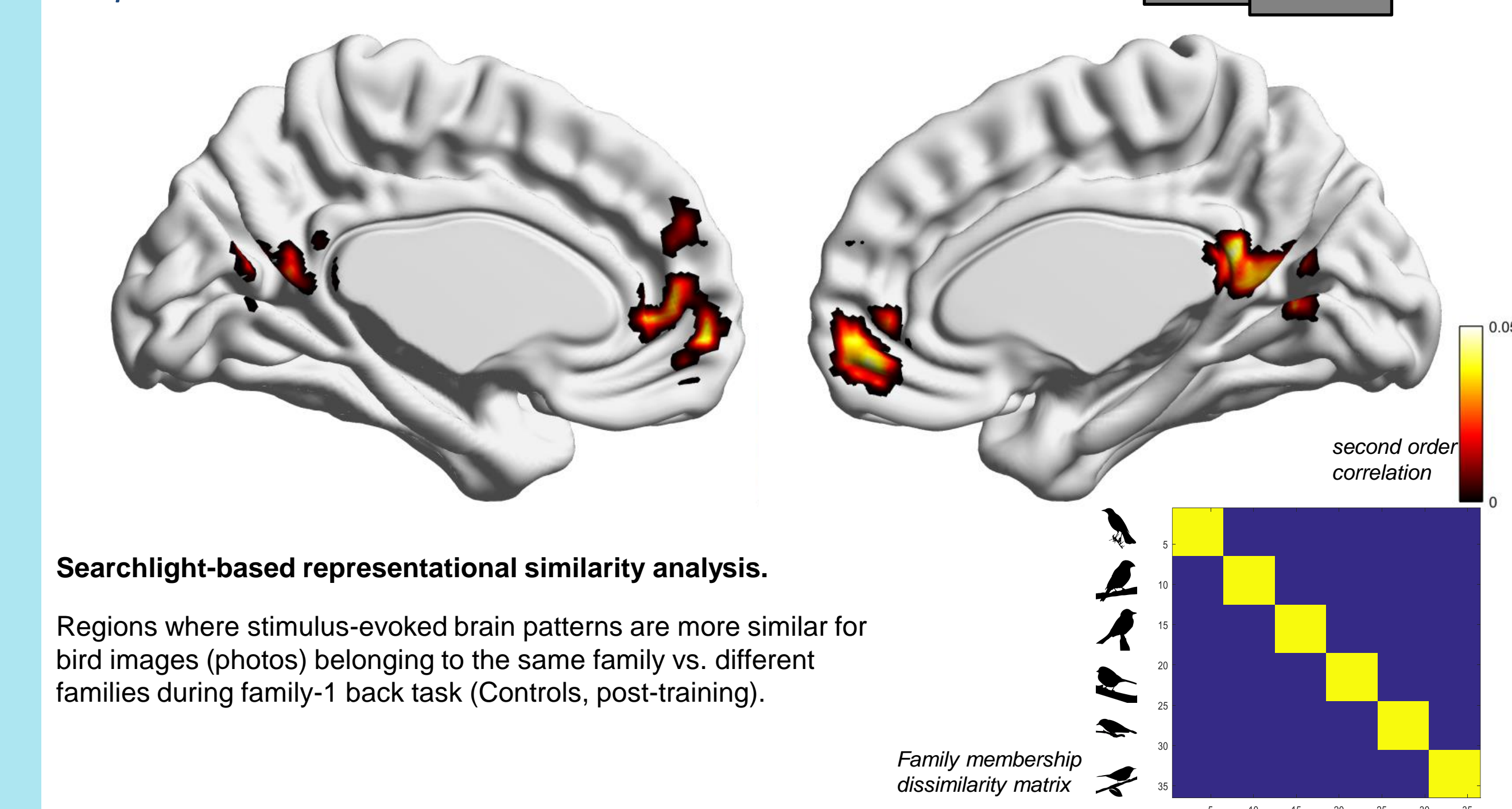### Post-training test for bird family/species names

Multiple choice test for family and species names

Birdwatchers:
Local > Transfer

Controls:
Local = Transfer

Both groups:
Training > Transfer

Family Test | Species Test — Birdwatchers
Family Test | Species Test — Controls

Subjective similarity grouping of birds

Distance grouping measures for Local list (group average)

Birdwatchers (left) place within-family species closer together, but some families less tightly clustered

Mean MDS plots

Higher modularity evident in birdwatchers. Color dimension apparent

Birdwatchers | Controls

Pilot fMRI data

1-back family match task (post-training)

Is current bird from same family as previous bird?

Searchlight-based representational similarity analysis.

Regions where stimulus-evoked brain patterns are more similar for bird images (photos) belonging to the same family vs. different families during family-1 back task (Controls, post-training).

Family membership dissimilarity matrix

Conclusions

Separable influence of both specific and schematic knowledge in birdwatchers revealed (memory and matching task results)
• Item-specific knowledge → highest performance for familiar birds. Within birdwatchers, *degree* of specific knowledge (but not age) also highly correlated with performance
• Domain general knowledge → lower but substantially greater performance for unfamiliar birds

Prior knowledge and new learning – Training to identifying a set of unfamiliar birds increases matching task performance at Session 2 in both groups:
• In Controls, more widespread improvements seen as generalizable aspects of bird identification are learned and broadly applied
• In Birdwatchers, some evidence that degree of prior knowledge (bird name test performance) associated with more efficient learning (greater matching improvement)

Prior knowledge also reshapes organizational structure, revealed in similarity clustering → processing relationships based on more conceptual metrics like family membership may be facilitated by regions involved in schematic processing (e.g. vmPFC, RSC)