Increased Semantic Similarity Reduces the Forward Asymmetry in Free Recall

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Introduction

Temporal organization has been cited as a marker of a healthy memory system. In free-recall studies, participants tend to recall items from successive list positions. This temporal contiguity effect is also marked by a tendency to make recall transitions in the forward direction. These aspects of temporal organization are robust to a number of experimental manipulations and provide important constraints for models of memory search, but there have been few experimental manipulations that successfully modulate these phenomena.

Retrieved-context theories of memory search, such as the Context Maintenance and Retrieval model (CMR; Polyn et al., 2009), propose that temporal contiguity is due to the associations formed between items and the context in which they are studied. They further propose that the forward-going nature of contiguity is due to the influence of pre-existing item associations on the state of context.

This leads these models to predict that the forward asymmetry effect should be modulated by a manipulation of these pre-existing associations. We examined this prediction by manipulating the semantic similarity of items on the study list.

Experiment 1
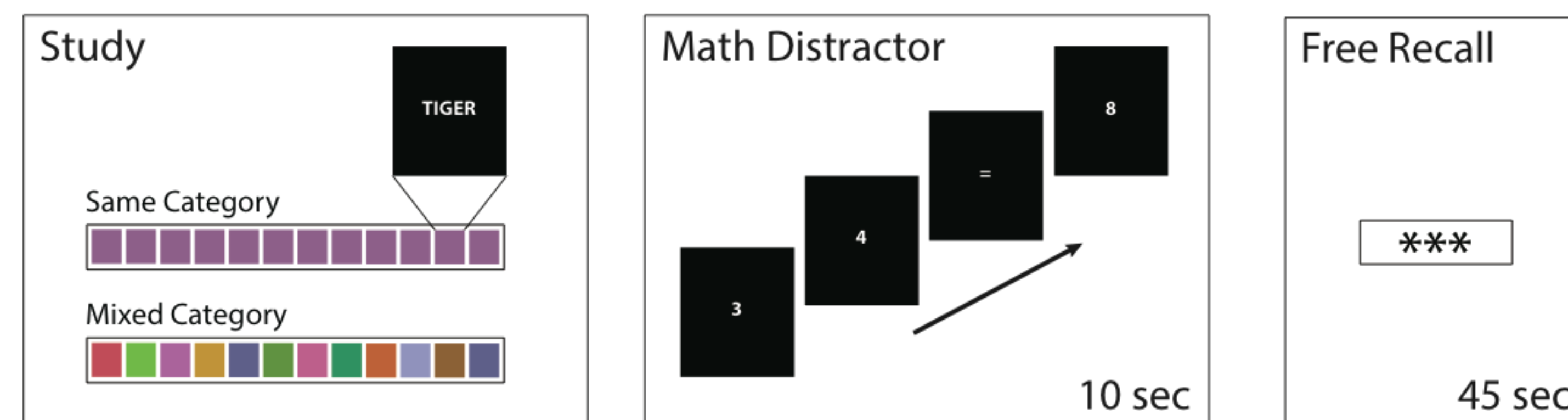
34 participants each studied and recalled a total of 24 lists.

Presented items were drawn from 24 distinct taxonomic categories based on normed word pools developed by Battig & Montague (1969) and Van Overschelde et al. (2003). Each list contained 12 items, either all from a single category (same) or one item from each of 12 different categories (mixed).

A 10 second math distractor followed each list, followed by a 45 second free recall period.

Experiment 2

41 participants each studied and recalled a total of 24 lists.

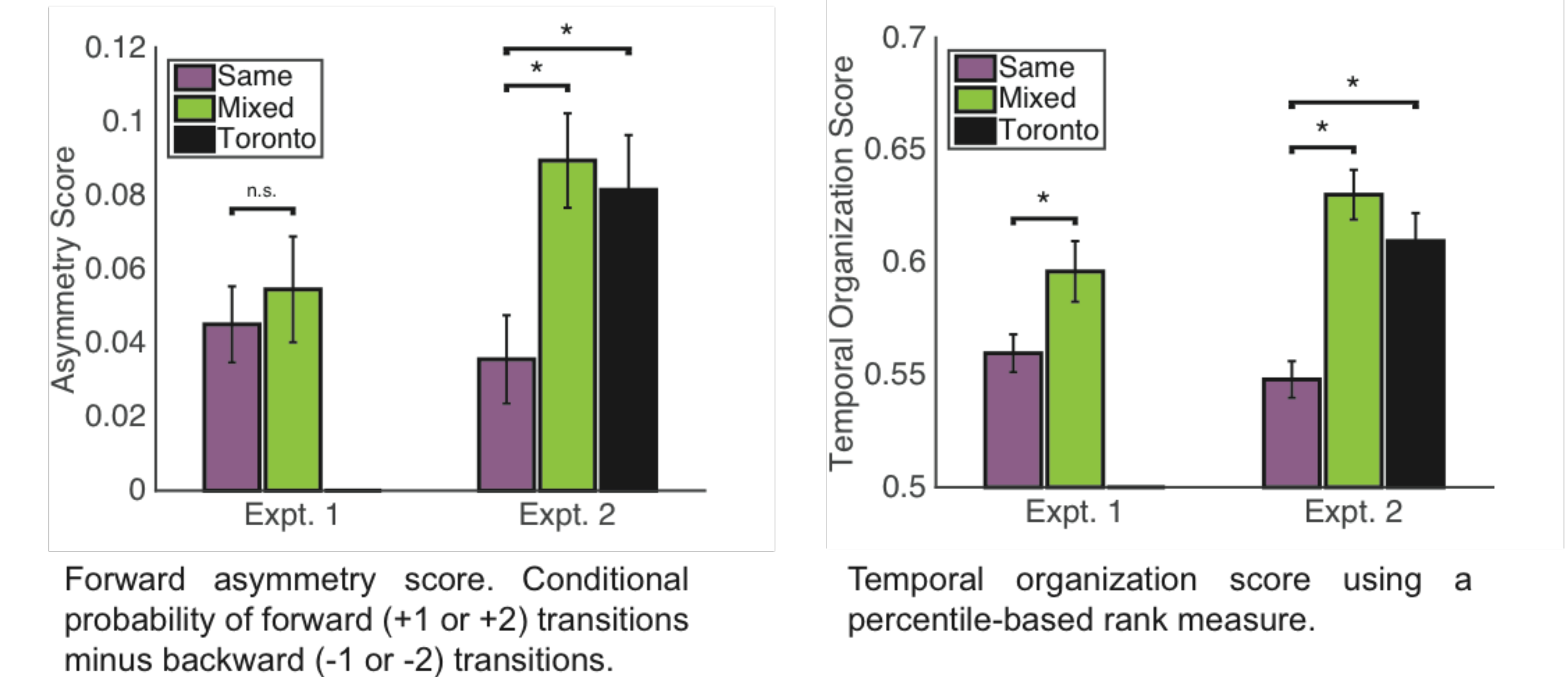Presented items were drawn from 32 distinct taxonomic categories, across same- and mixed-category lists.

Toronto Noun Pool

Participants were also presented lists of random items drawn from the Toronto Noun Pool (Friendly et al., 1982).

Temporal Organization

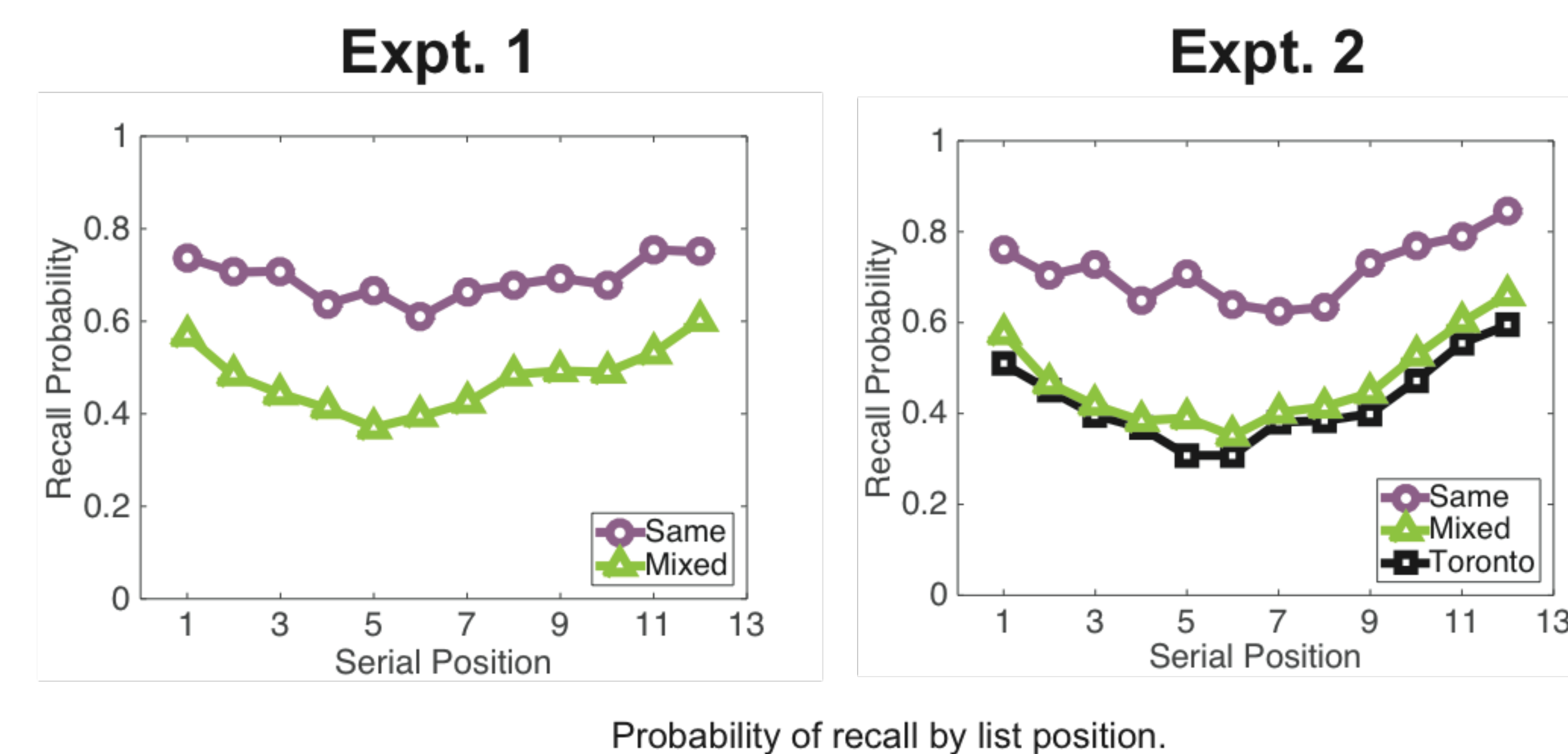Expt. 1   Expt. 2

Lag-Conditional Response Probabilities.
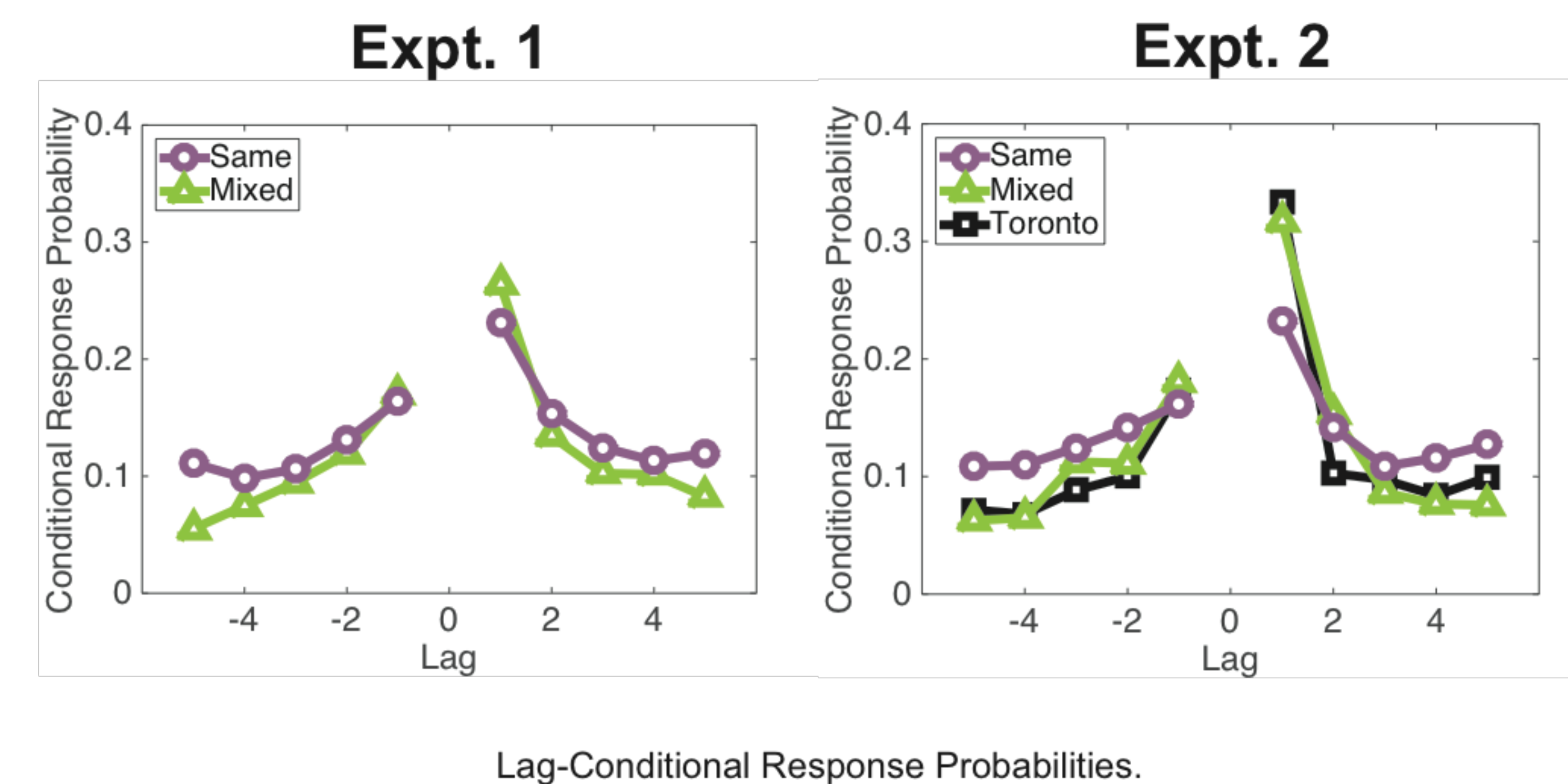
We observed **decreased forward asymmetry** for same-category lists in Expt. 2. However, we observed **decreased temporal organization** for same-category lists in general across both studies.

This reduction in overall temporal organization is exhibited in a flatter lag-CRP function, where shorter transitions are less likely and larger transitions are more likely.


Forward asymmetry score. Conditional probability of forward (+1 or +2) transitions minus backward (-1 or -2) transitions.

Temporal organization score using a percentile-based rank measure.

Memorability

Expt. 1   Expt. 2

Probability of recall by list position.

We observed **increased memorability** for items in same-category lists compared to both mixed-category and Toronto lists, regardless of list position (p<0.001 for both comparisons). We also observed **increased memorability** for items in mixed-category lists compared with Toronto lists (p<0.005).

These findings are somewhat contrary to general expectations based on previous work showing a positive correlation between temporal organization score and memorability across a number of studies (Sederberg et al., 2010).
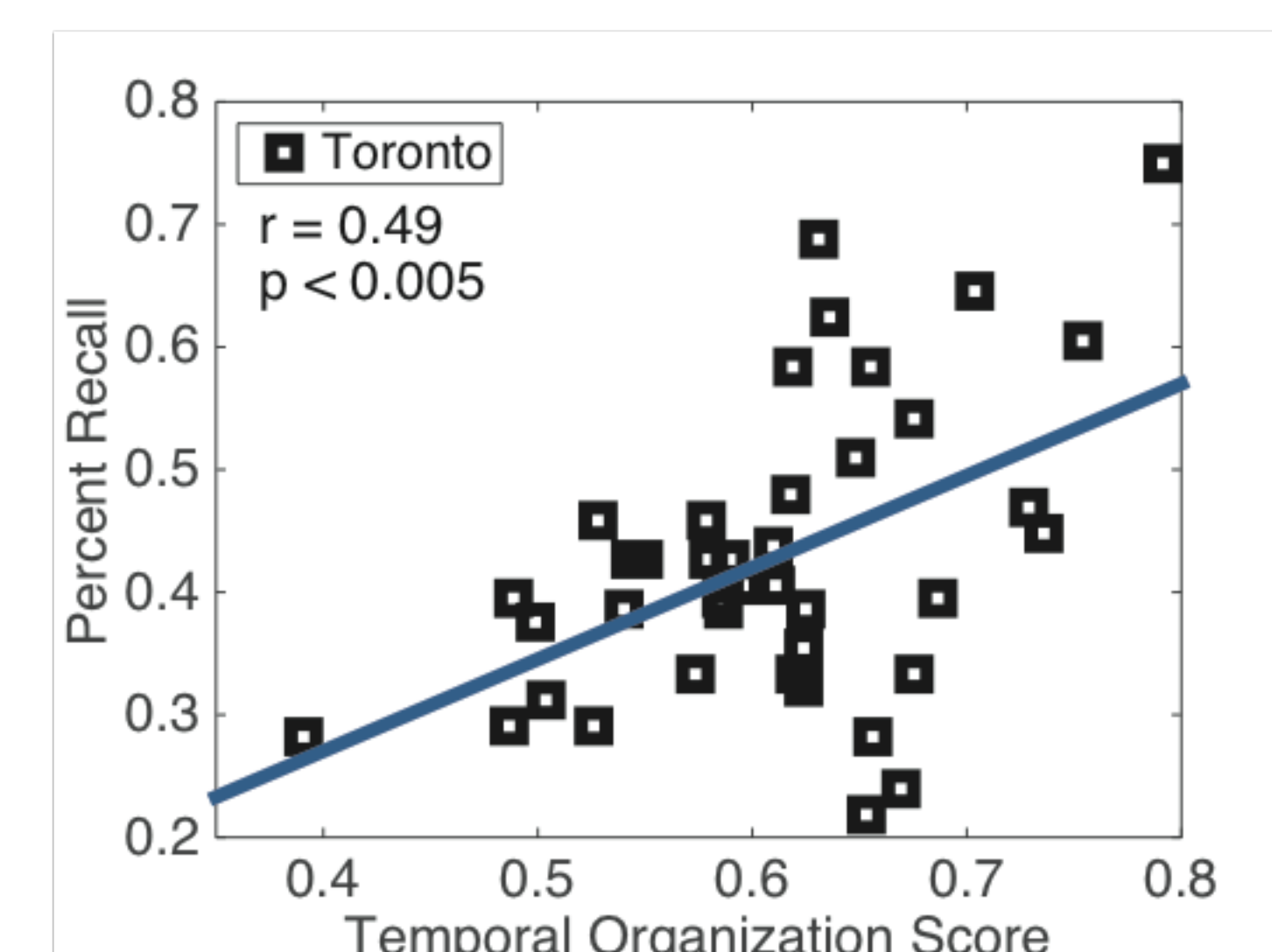
Of the five conditions across both studies, we only observed a significant correlation between temporal organization score and percent recall in the Toronto lists.

Computational Modeling

We examined three potential model mechanisms to capture these behavioral phenomena using the Context Maintenance and Retrieval model (Polyn et al., 2009; Kragel et al., 2015). Variants of the model allowed a parameter of interest to vary across list conditions. Model performance was evaluated based on the likelihood of the model to produce recall sequences consistent with the observed behavior, compared with a baseline model in which the parameter did not vary across conditions.

β_{enc} γ α
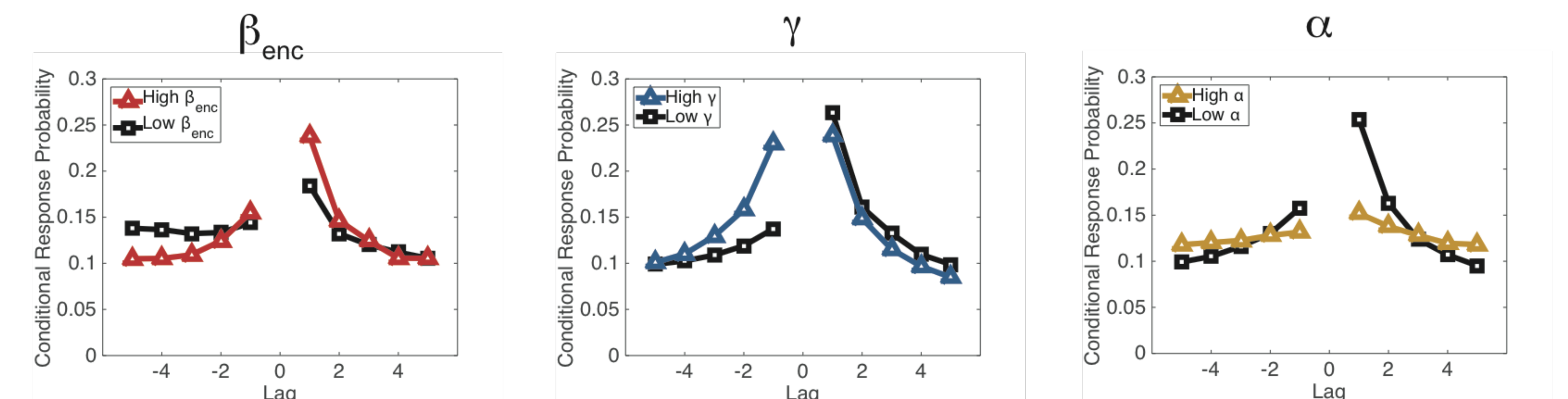
The **contextual integration rate** (β_{enc}) parameter controls how much item information is integrated into the current state of context as an item is studied.

The **association weighting** (γ) parameter controls the relative weight of experimental and pre-experimental associations that allow feature representations to update the current state of context. These associations particularly affect how the contextual state changes when an item is recalled.

The **item-to-item associative strength** (α) parameter determines the uniform strength of associations between context and individual list items. These pre-existing associations are meant to represent a participant's knowledge of relationships between the studied items.

Of these model variants, the **item-to-item associative strength** model provided the best explanation of the behavioral data. Future modeling efforts will examine the role of individual item representations in addition to model mechanisms to examine their influence on the temporal dynamics of memory search.