

## Introduction

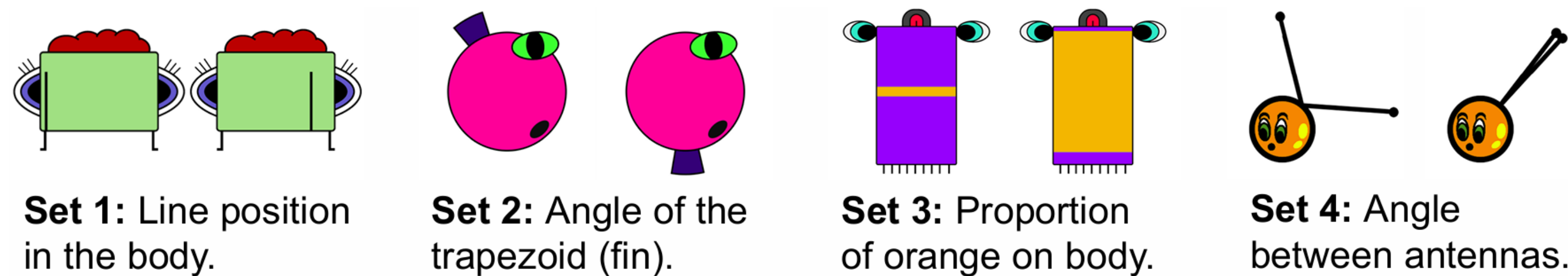
- Category systems do not form all at once.
- Prior work tends to focus on the emergence of **flat category systems** through cultural evolution (e.g., Carr et al., 2017) or the emergence of different levels of abstraction during development (e.g., basic level; Mervis & Crisafi, 1982).
- We explore how hierarchical category systems adapt to environments encountered over time.**
- Experiments examining sequence effects suggest order of item presentation affects where category boundaries are drawn (Medin & Bettger, 1994; Egré et al., 2013; Carvalho & Goldstone, 2017).

## Experiment

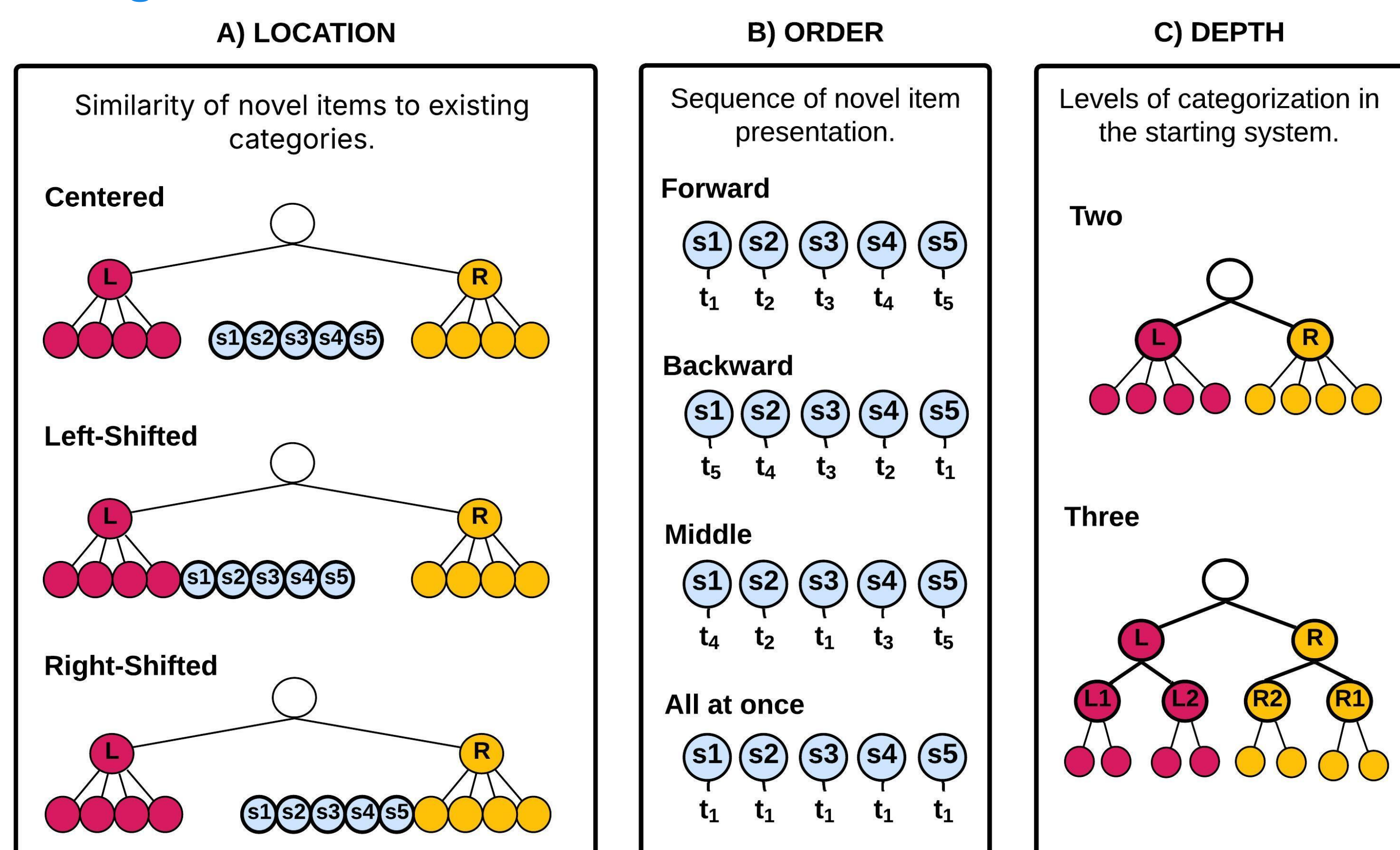
**Goal:** study the effects of item presentation order, item similarity, and system complexity on the evolution of a category system.

### Stimuli

- Four sets that vary uniformly along a continuous feature dimension.



### Design



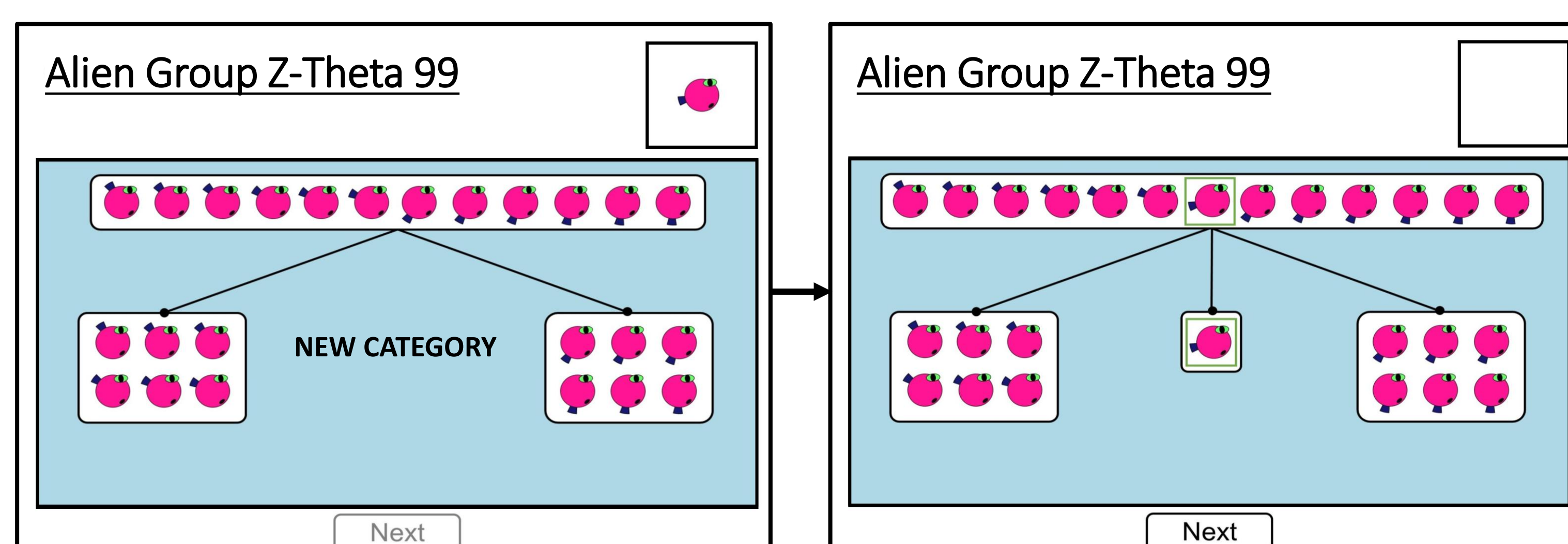
### Procedure

- Participants first completed practice tasks where they were asked to categorize images of animals into a taxonomy.

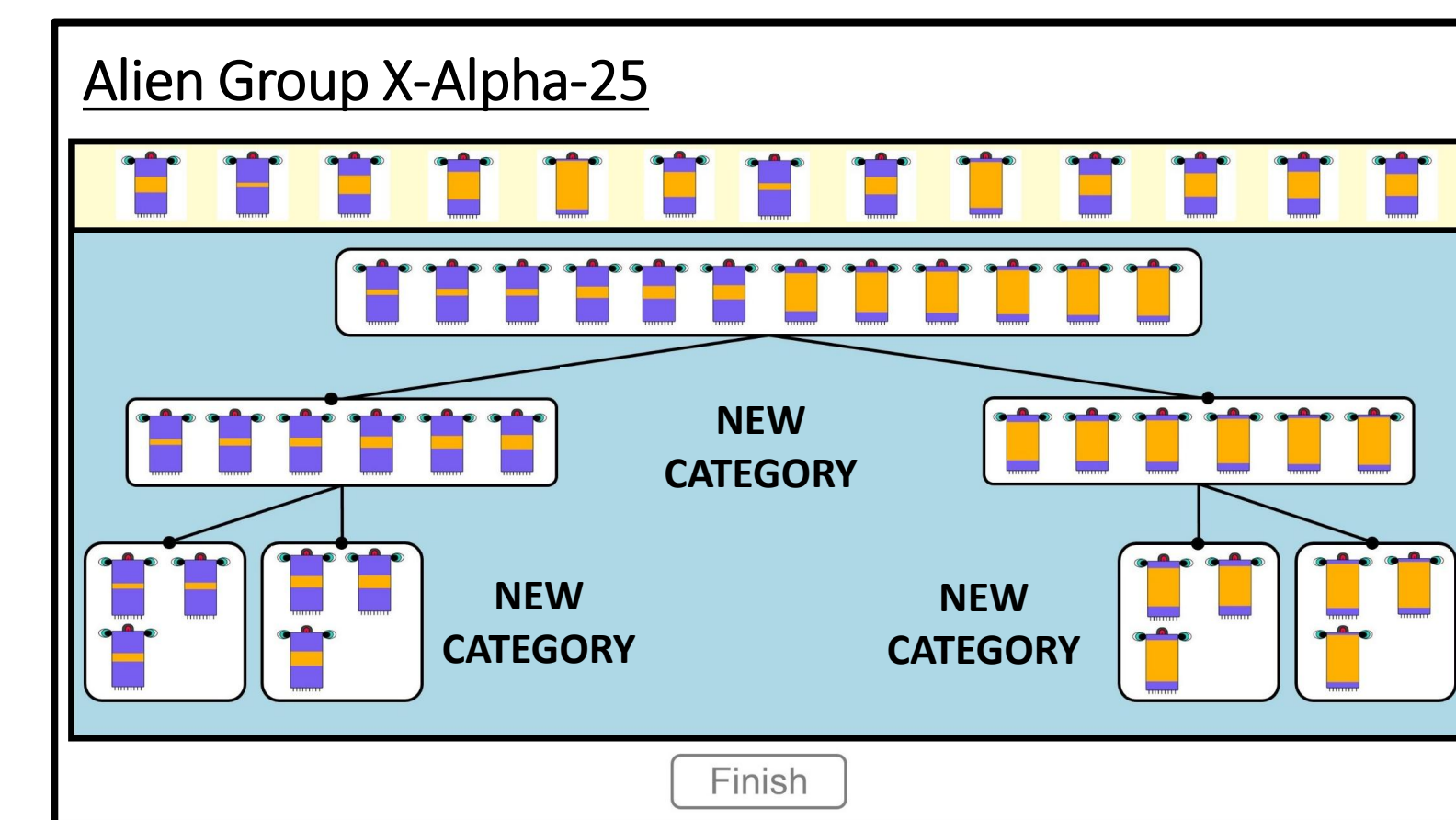
#### For each trial:

- Participants familiarize themselves with a starting category system in the two-level or three-level condition.
- Participants then extend a category system by incorporating items into **new** categories or **existing** bottom-level categories.
  - New category options: 1 in the two-level condition, 3 in the three-level.
- Participants categorized 9 novel items and 4 distractors either in-sequence or all at once.

#### Sequence Conditions (x3):



#### All-at-once Baseline (x1):



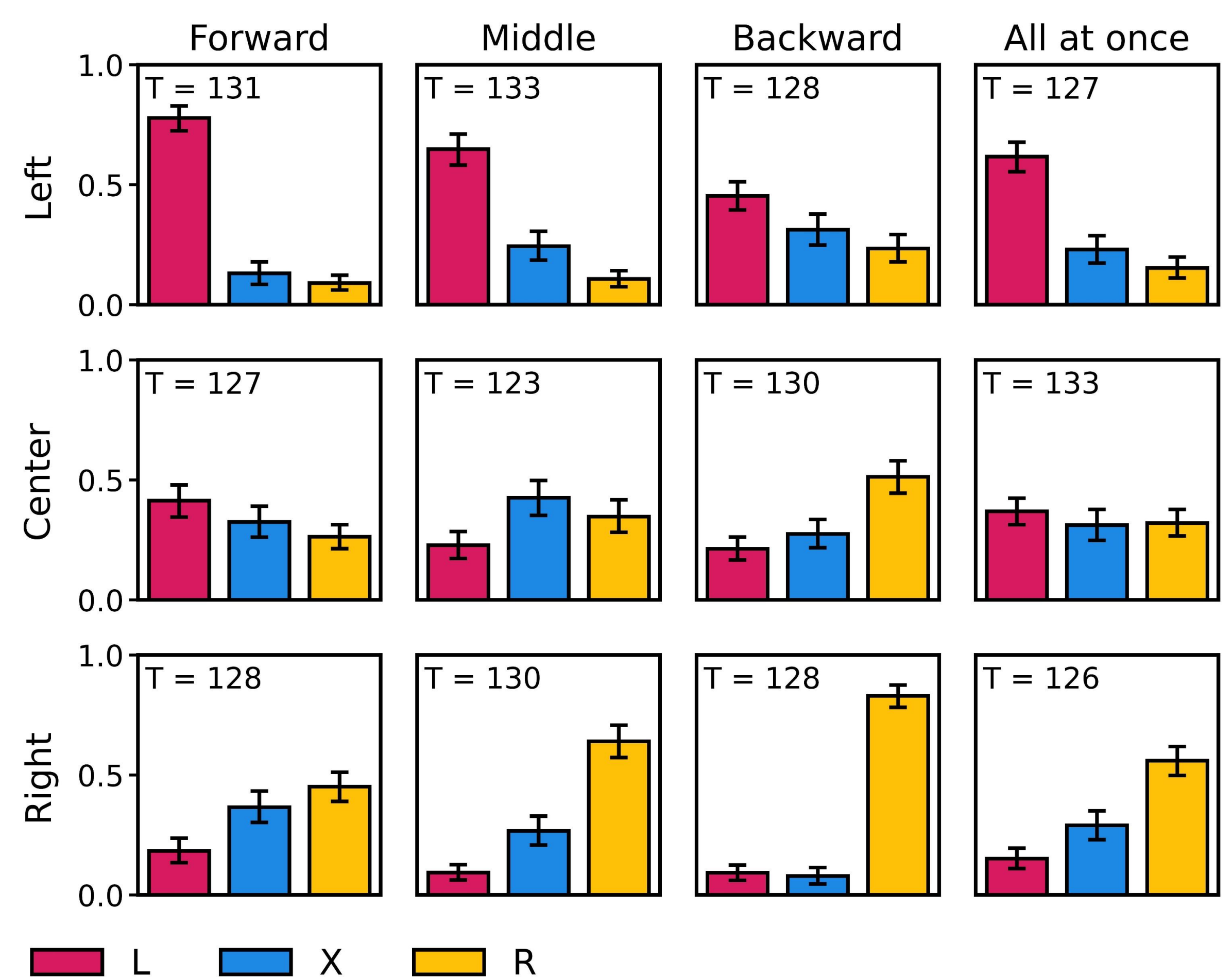
Participants must drag & drop **all** items into categories before continuing.

## Results

386 participants completed 1544 trials (T), categorizing 13,896 novel items and 6176 distractors.

### Sequence Effects

#### H1: Order affects assignment of items to categories.

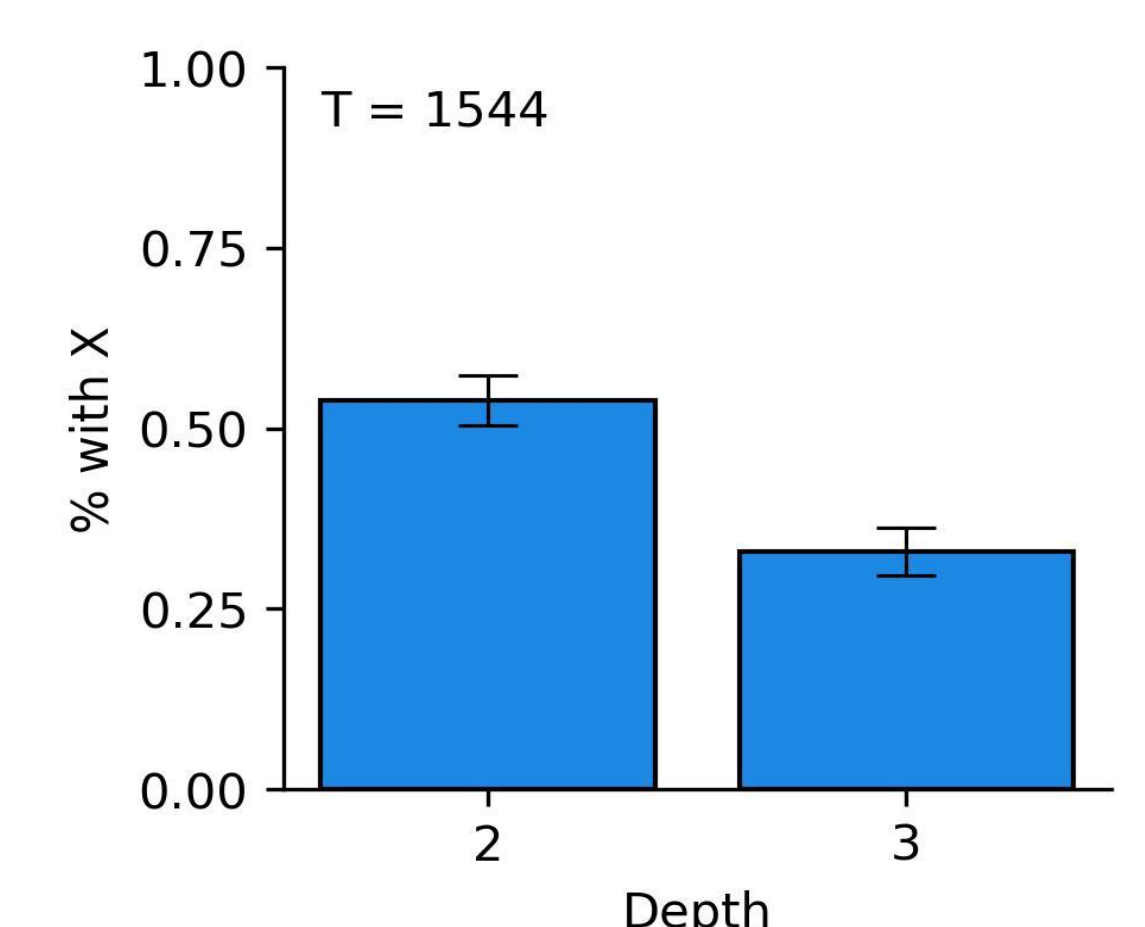


- Order is a significant predictor of second-level category assignment when controlling for location, stimuli, and participant.

### Hierarchy Effects

#### H2: Participants are more likely to create a new second-level category (X) in shallower systems.

Category X is more frequently created in the two-level than the three-level condition,  $\beta = 1.13$ , 95% CI [0.89, 1.38].



### Creating Suboptimal Category Systems

- Assume all-at-once presentation yields the most optimal system.
- Use Jensen-Shannon Divergence to compare sequential category assignments to this baseline.

|       | Forward | Middle | Backward |
|-------|---------|--------|----------|
|       | JSD     | JSD    | JSD      |
| Left  | 0.125   | 0.048  | 0.117    |
| Right | 0.076   | 0.071  | 0.222    |

Orders that **align** with item location are the most divergent.

## Takeaways

- Both the order in which items are encountered and the structure of the existing system shape how a category system evolves.
- Potentially suboptimal systems can be created when items are presented sequentially.
- In more recent work we introduce a hierarchical categorization model to capture these effects.

