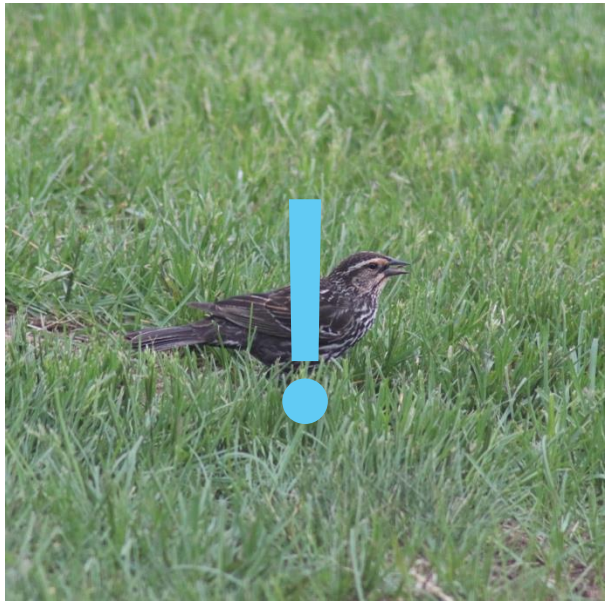
# How surprising information shifts our attention and influences learning

Em Heffernan

**Category learning:** grouping items by attending to shared features

Category learning is an imperfect process. Because they look similar, we might assume that the center bird is related to the bird on the left, but it's actually a blackbird!

**savannah sparrow**

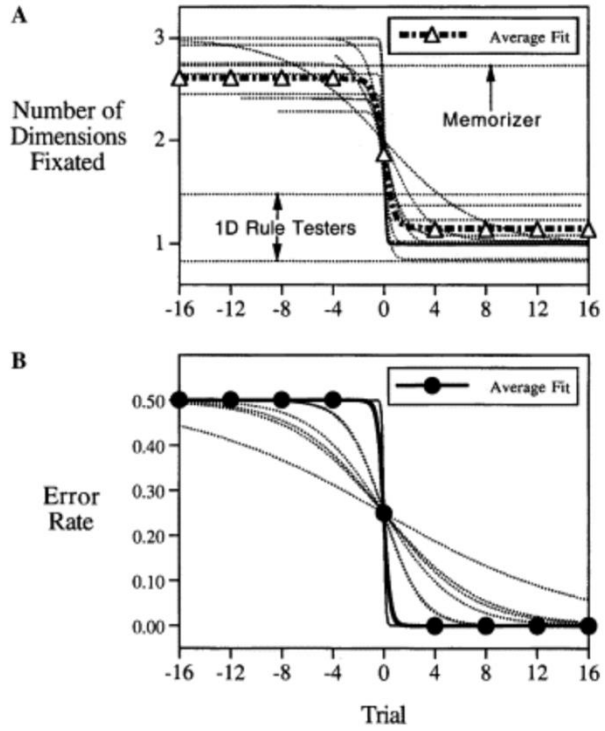


**~~another sparrow??~~**

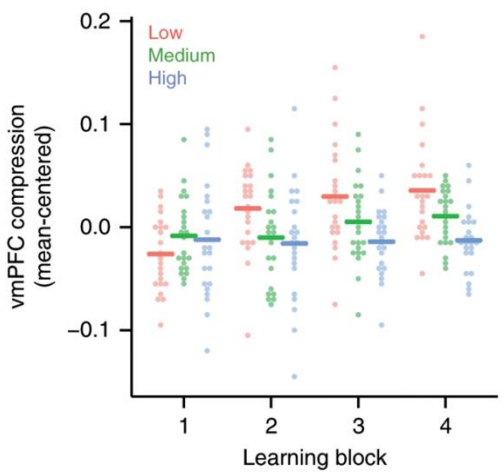
**female red-winged black bird**

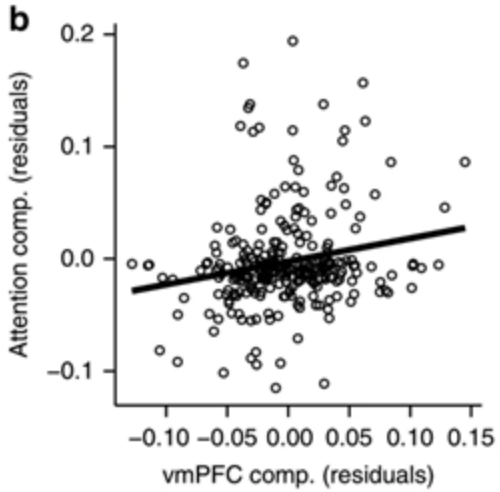
**red-winged black bird**

# Attentional tuning in category learning




(Rehder & Hoffman, 2005)



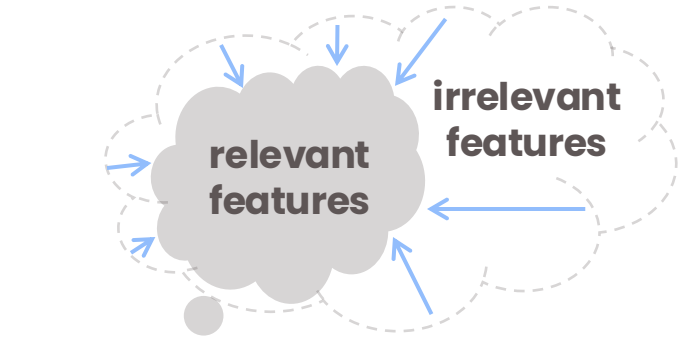



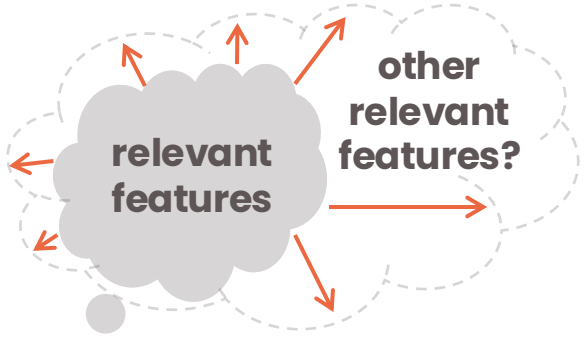

We can measure attention during learning via eye or mouse-tracking

(Rehder & Hoffman, 2005; Blair et al., 2009; Zaki & Salmi, 2009; *Chen et al., 2013…)

We can also measure attentional compression in the brain

(Mack, Preston, & Love, 2020)



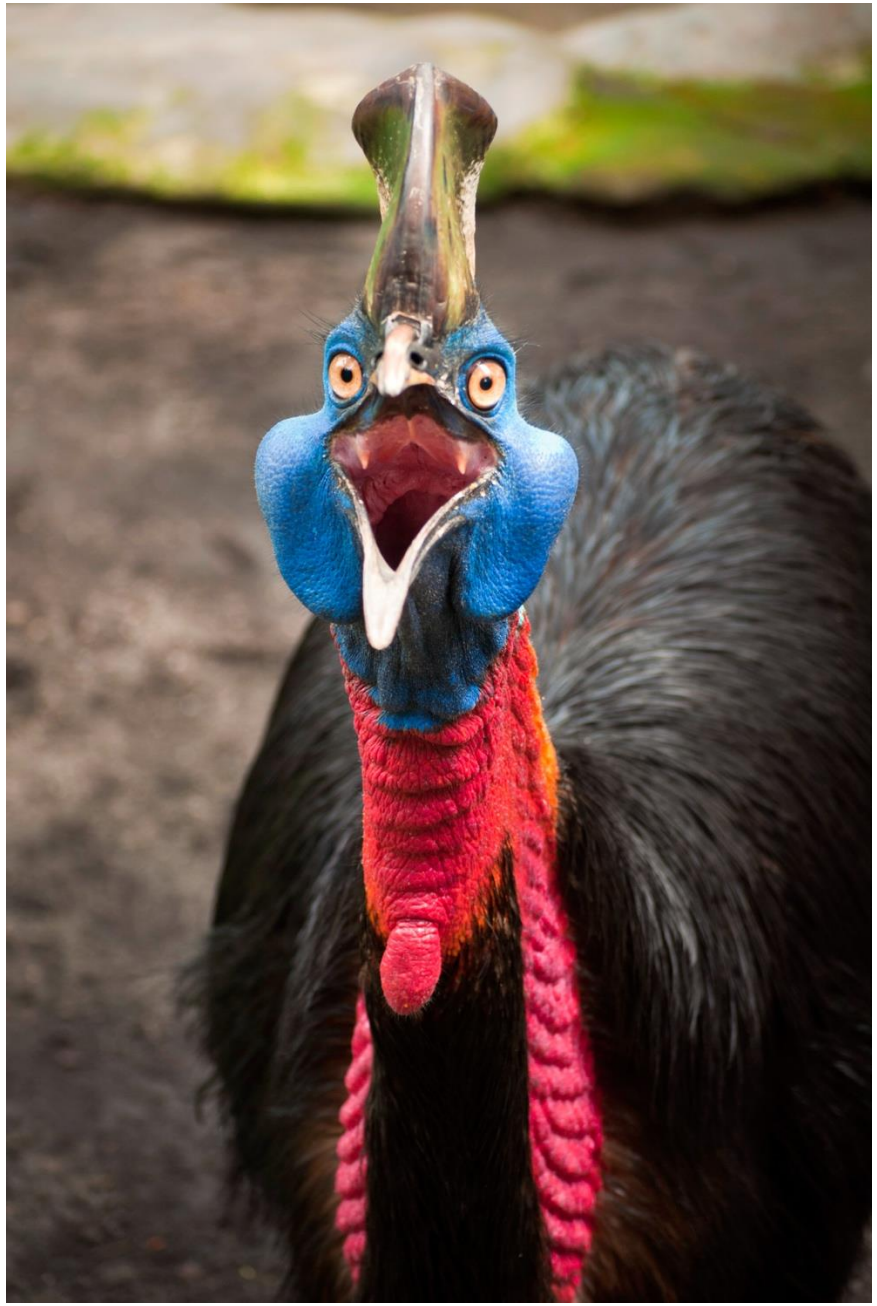

**Rule Learning**

**Exception Elicits Prediction Error**

**Attention Expansion**

The ability to rapidly reallocate attention should be associated with better learning outcomes. However….

# Not all exceptions are created equal!



Cassowary (Ghetty Images)

## Crossover exceptions

- Similar to **existing knowledge**, confusable
- Elicit prediction error, cause uncertainty
- Must be distinguished from rule-followers

## Oddball exceptions

- Unique features, distinct from **existing knowledge**
- Novelty without prediction error
- Stored in isolation

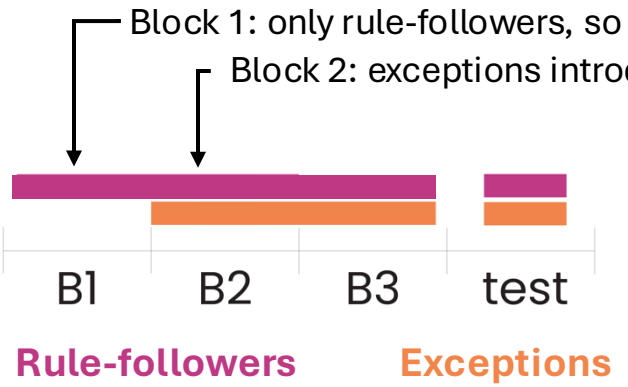
The ability to rapidly reallocate attention should be associated with better learning outcomes <u>when exceptions overlap with existing knowledge</u>

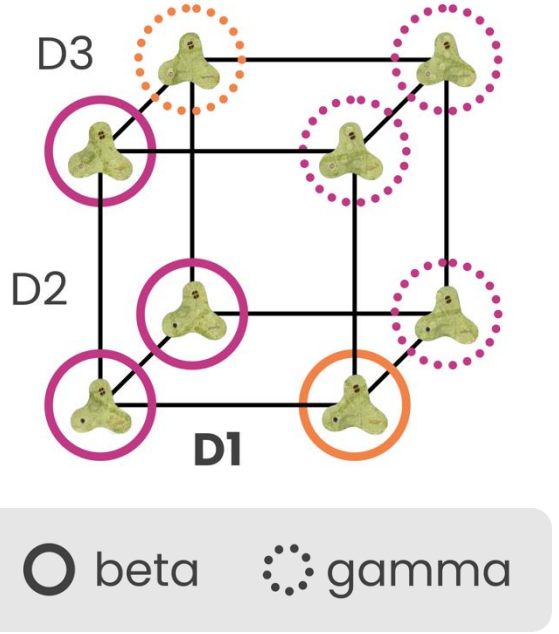
(Palmeri & Nosofsky, 1995; Sakamoto & Love, 2004, 2006; Savic & Sloutsky, 2019; Castro et al., 2021)

# Experiment design

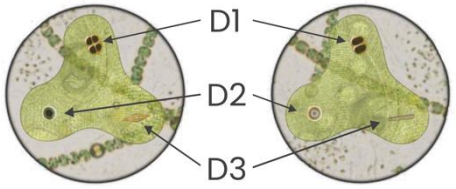
Xuan (Sophia) Zhang

Marian Wang

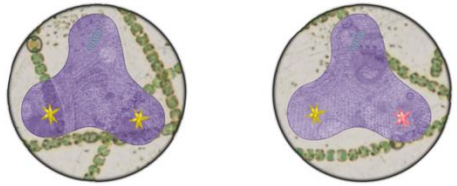



(Shephard, Hovland, & Jenkins, 1961 Type IV)



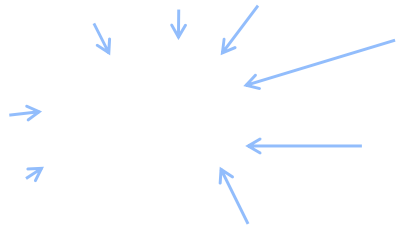

(Blair et al., 2009)

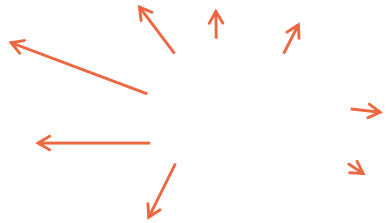


**Crossover exceptions**: Similar to existing knowledge, confusable
Elicit surprise, prediction error, & uncertainty

**Oddball exceptions**: Distinct from existing knowledge
Novelty without prediction error

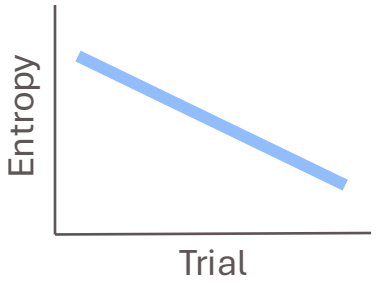
In Information Theory, **entropy (H)** is the amount of information conveyed in an event (Shannon, 1948)

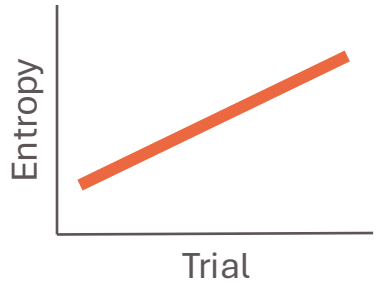




During rule learning, entropy (calculated from mouse-tracking data) should **decrease** as one fixates on fewer features

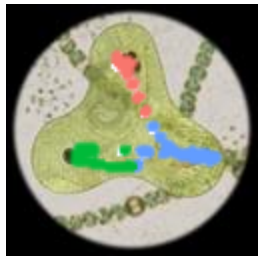
Following (crossover) exception introduction, entropy should **increase** as attention expands



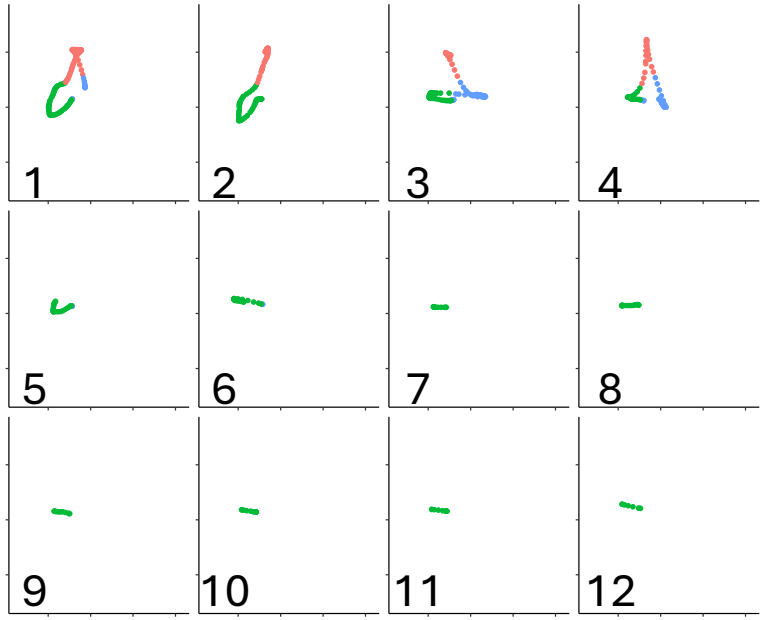




**We can use entropy to track attentional tuning before and after exception introduction**

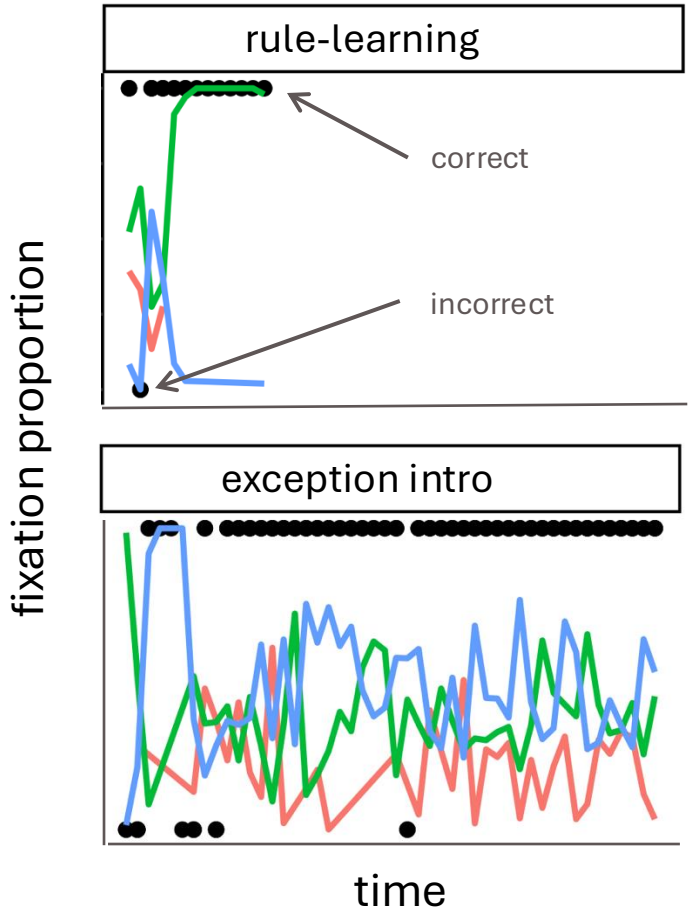
(Entropy in category learning: Davis, Love, & Preston, 2012; Mack, Preston, & Love, 2020)



Mouse-tracking data




Trial-by-trial (rule learning)

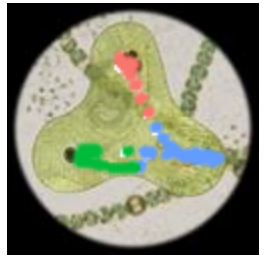



High entropy

Low entropy

# Only confusable exceptions elicit widespread shifts in attention

**Entropy as a measure of attentional distribution**



High entropy  Low entropy

**Crossover introduction**

LB1: Attention contraction

LB2: Widespread attention expansion

LB3: Attention optimization

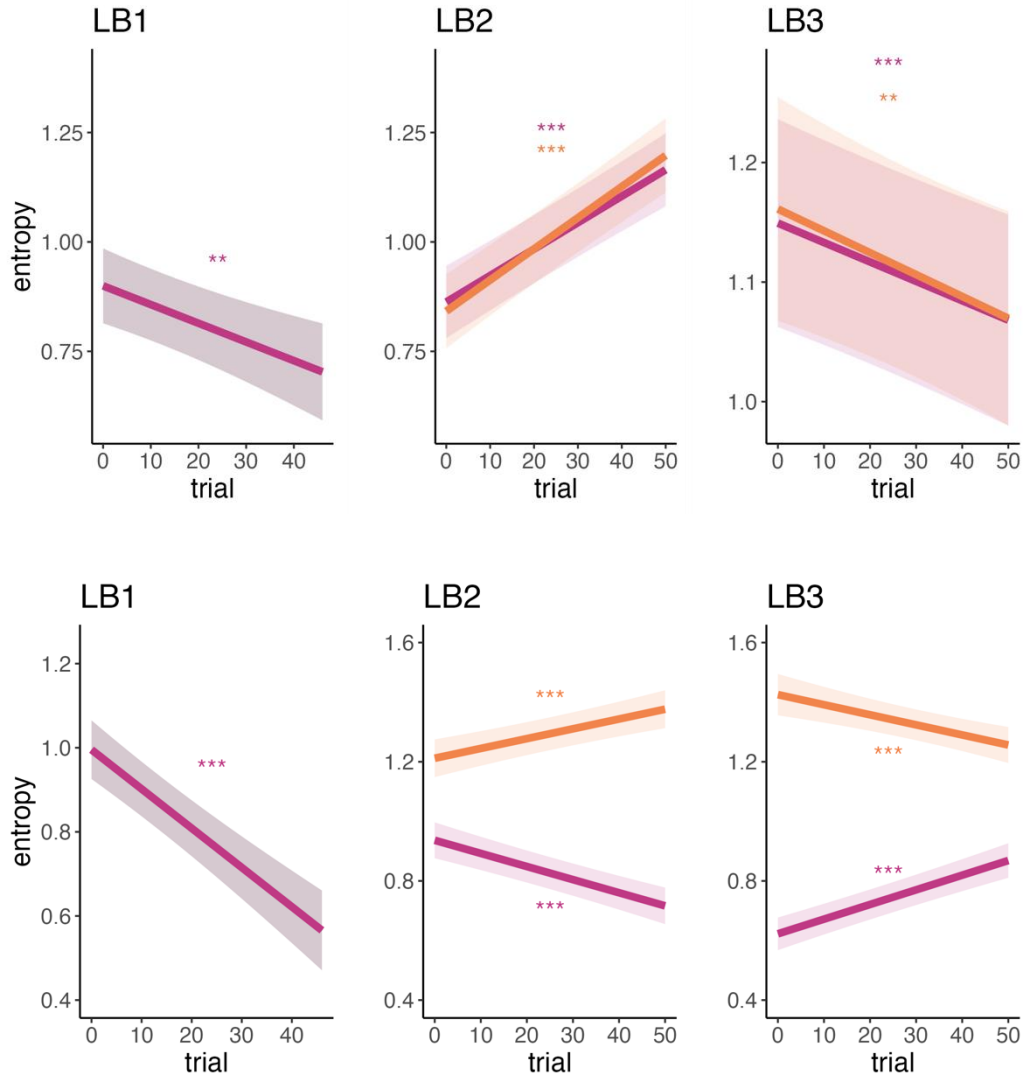
**Oddball introduction**

LB1: Attention contraction

LB2: Exception-specific expansion

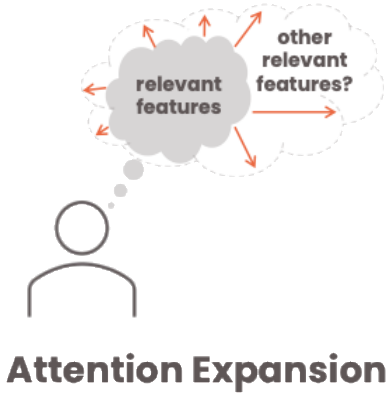
LB3: Potential fatigue?

**rule-followers** **exceptions**




*N = 192 adults, 18–36 years, online*

# Learning confusable exceptions demands attention expansion




## Crossover introduction

LB1: No relation

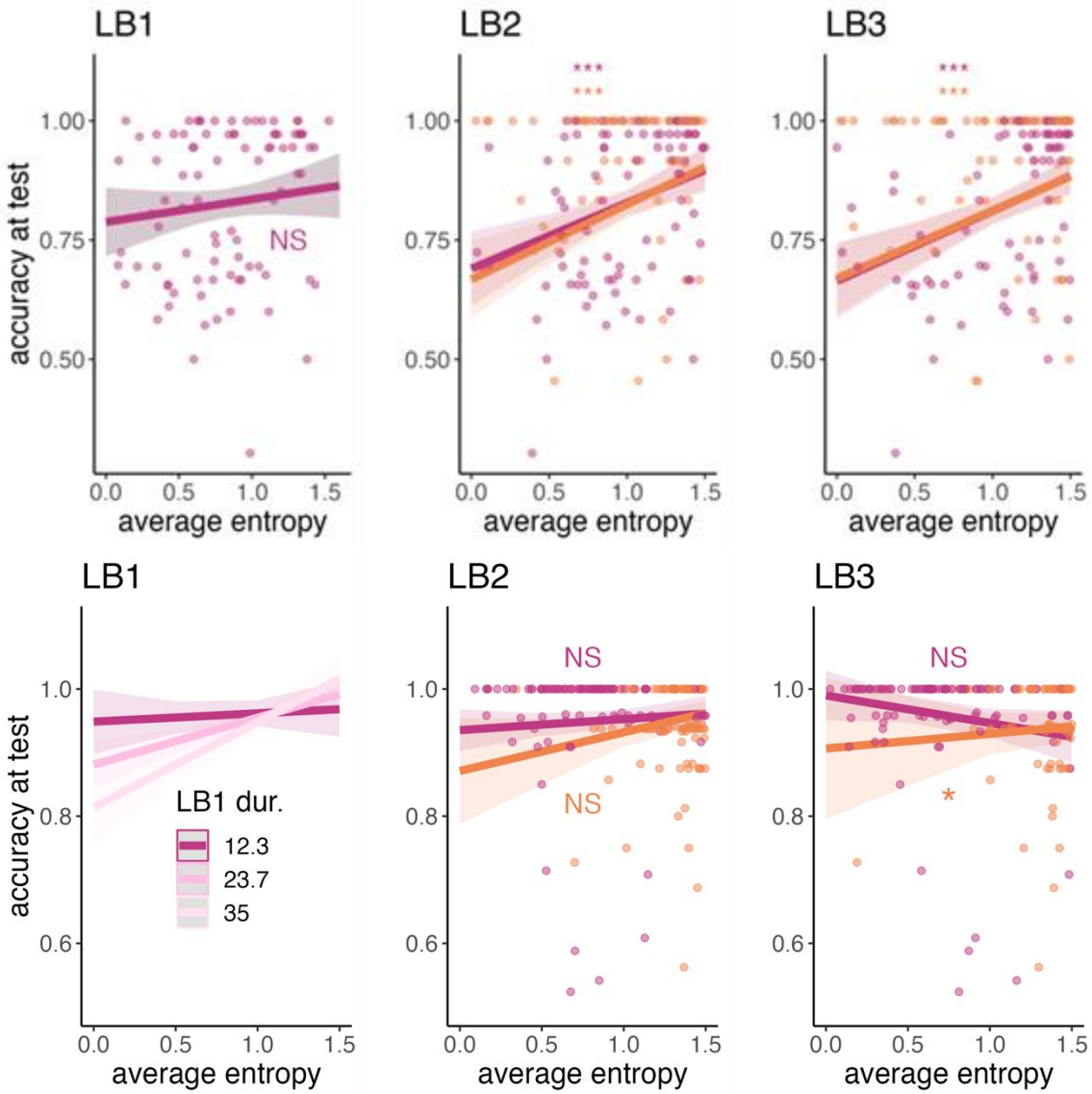
LB2&3: Increased entropy associated with increased accuracy

## Oddball introduction

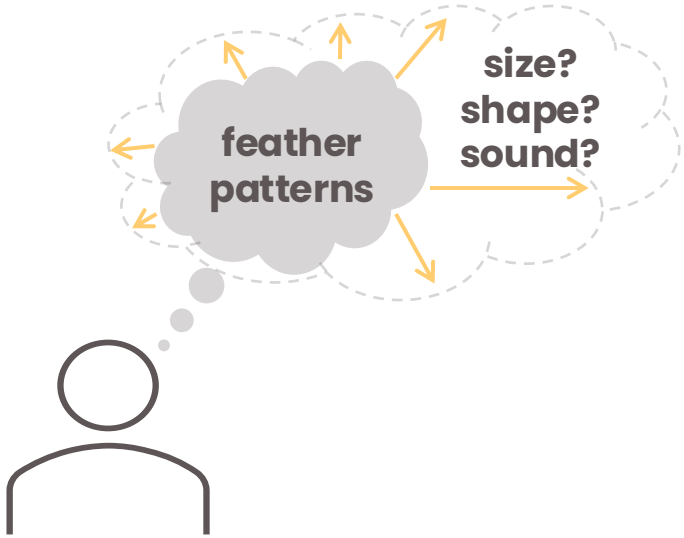
LB1: Duration-dependent relation

LB2: No relation

LB3: Positive relation for exceptions

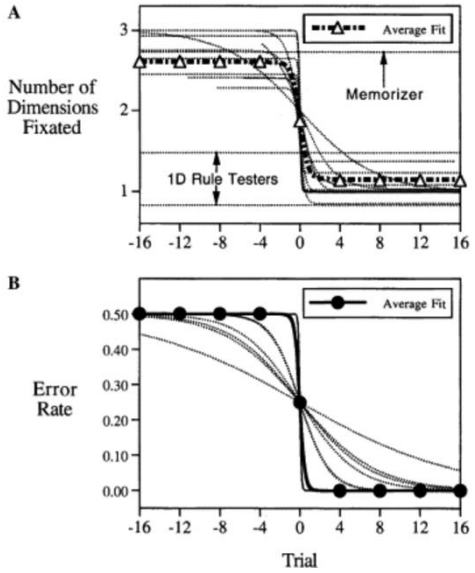


# Some Takeaways




Crossover (but not oddball) exceptions lead to adaptive expansion of attention

How surprising information overlaps with existing knowledge is important for attention and learning




This work corroborates existing findings on how uncertainty mediates selective attention.

# Thank you!

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