# Modelling immediate serial spatial recall in a macaque (*Macaca mulatta*)

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# Comparative Cognition of Serial Order



- In the field of comparative cognition, much research has contrasted the capacity of human and nonhuman primates to remember sequences
- In humans, memory for serial order is crucial for vocabulary acquisition (e.g., Baddeley et al., 1998) and the learning of action sequences (e.g., Agam et al., 2005)
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# Sequence Processing In Primates



- Studies of several primate species—chimpanzees, capuchin, and rhesus monkeys—have revealed that they are capable of remembering and recalling fixed sequences of:
  - motor actions (Custance et al., 1999; Whitten, 1998)
  - visual images (Schwartz et al., 1991; 2000)
  - spatial locations (Hikosaka et al., 1999)
- Like humans, they appear to represent sequences by learning each items' ordinal position (Chen et al., 1997; D'Amato & Colombo, 1988, 1989; Orlov et al., 2000)
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- In humans, memory for serial order is examined using the *Immediate Serial Recall (ISR)* task
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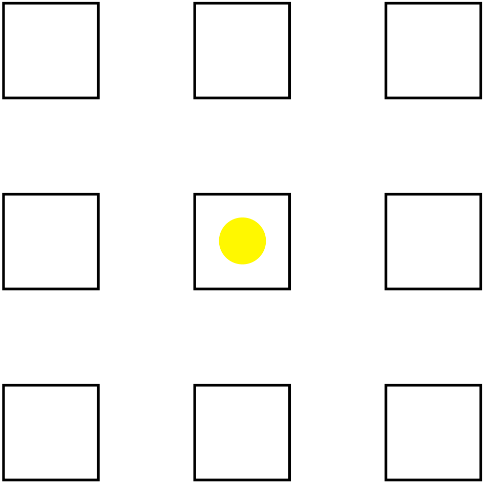

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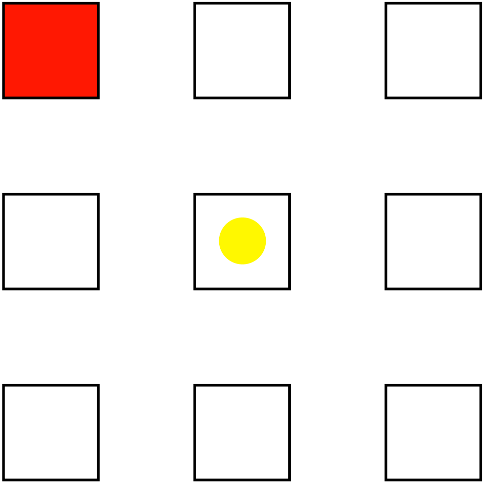

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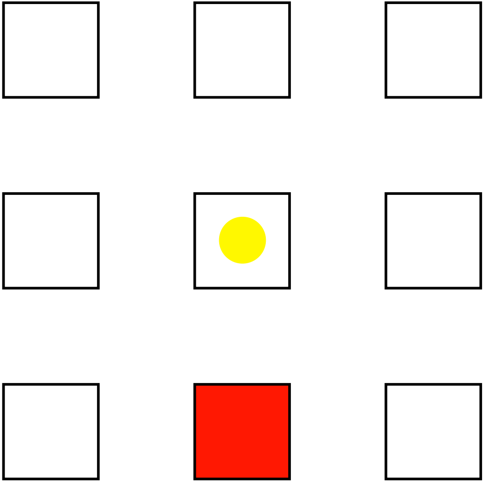

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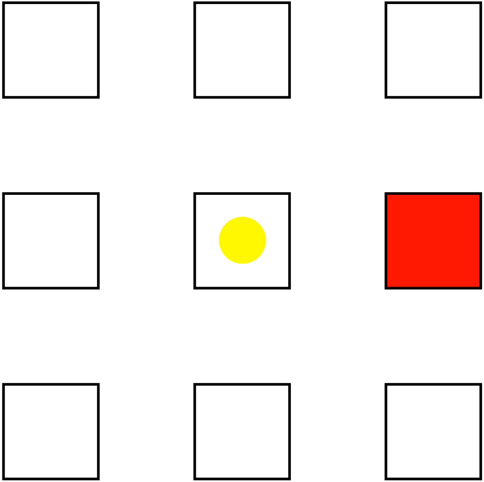

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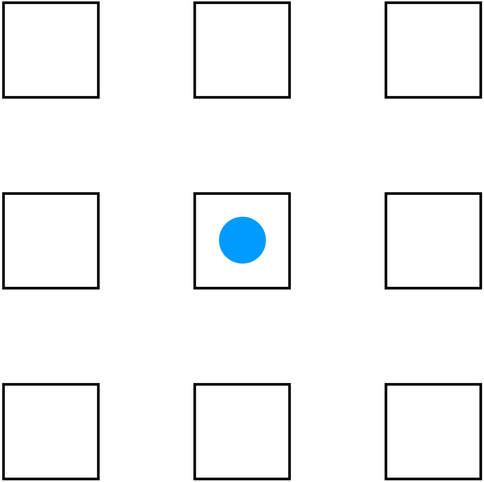

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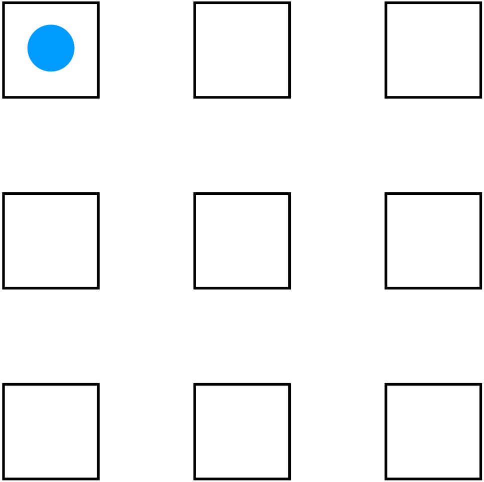

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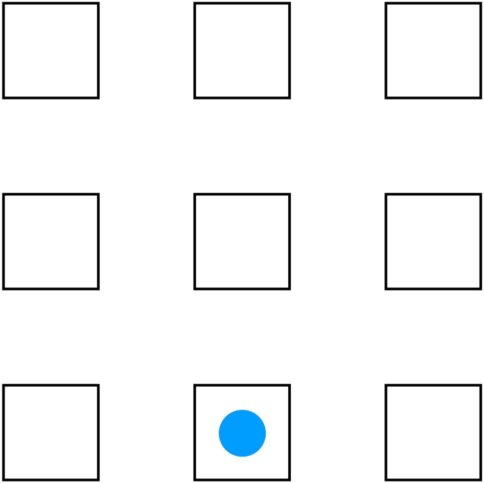

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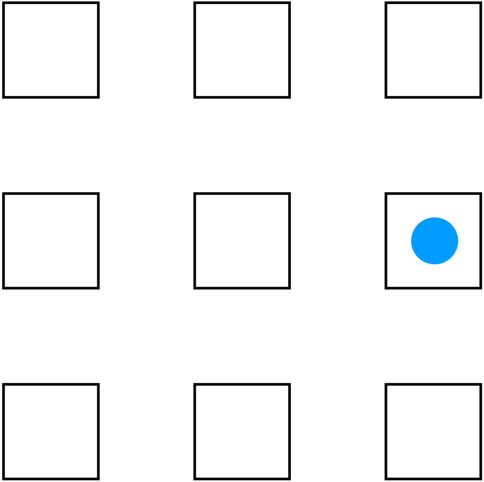

# Seven Benchmark Effects of Human ISR Shown By Jelly



- List Length Effect
- Primacy Effect
- Repetition Errors
- Transposition Gradients
- Item Confusion Errors
- Fill-in
- Protrusions

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# List-Length, Primacy, and Repetition Errors



- List-Length Effect
  - Human verbal and spatial ISR performance decreases with increasing sequence length (Cranell & Parrish, 1957; Jones et al., 1995; Smyth & Scholey, 1996)
- Primacy Effect
  - Human verbal and spatial ISR performance decreases as a function of the ordinal position of items
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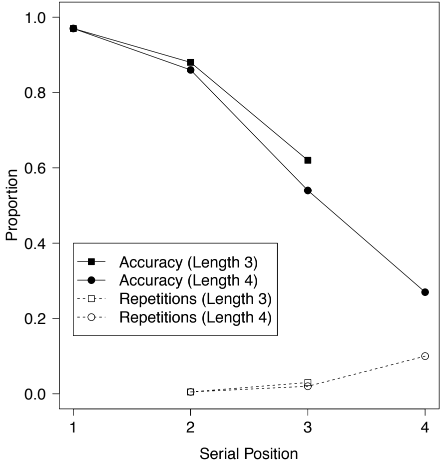

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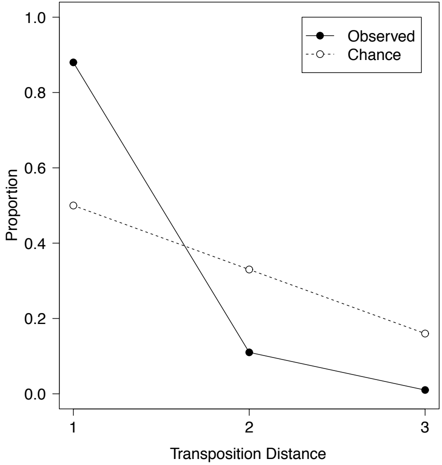

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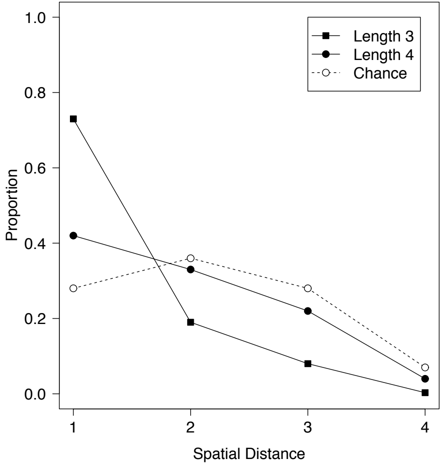

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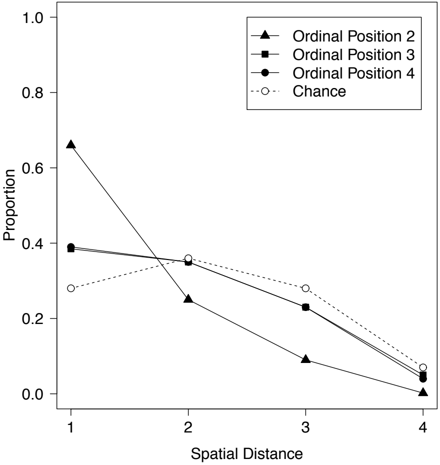

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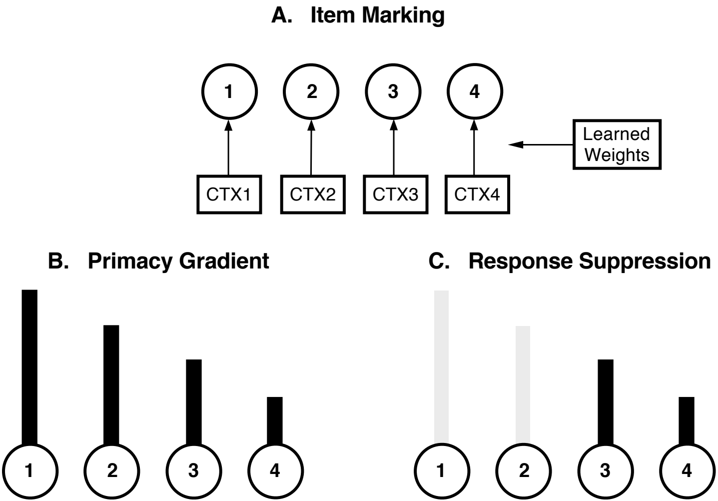
# Inferred Mechanisms Based On Studies of Human ISR



# A Competitive Queuing Approach



- The architecture of the model is based on Competitive Queuing (CQ) models of serial behaviour (e.g., Houghton, 1990)
- Such models possess three core features:
  - fundamentally localist (refractory) representations of items
  - parallel response activation and activation gradient
  - a competitive output mechanism
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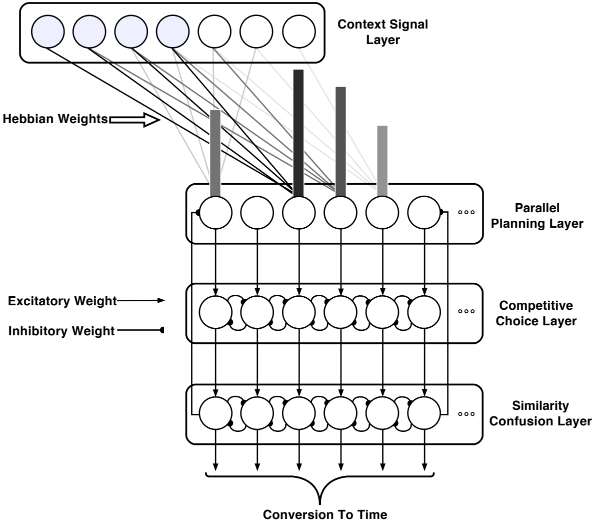
# Competitive Queuing Model: Global Architecture



# Ad Hoc Assumptions



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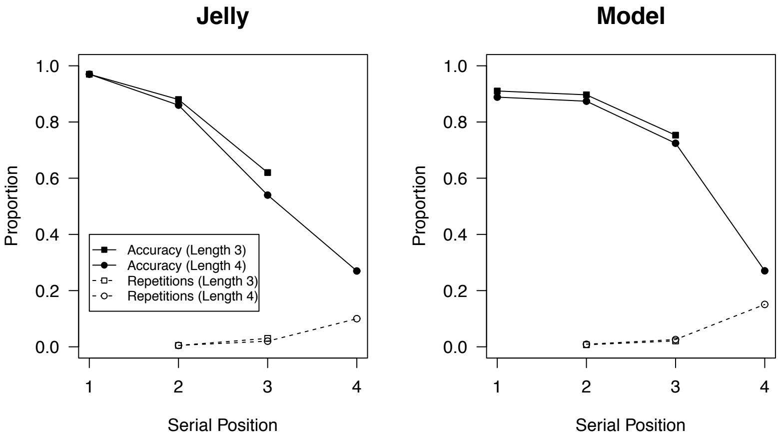
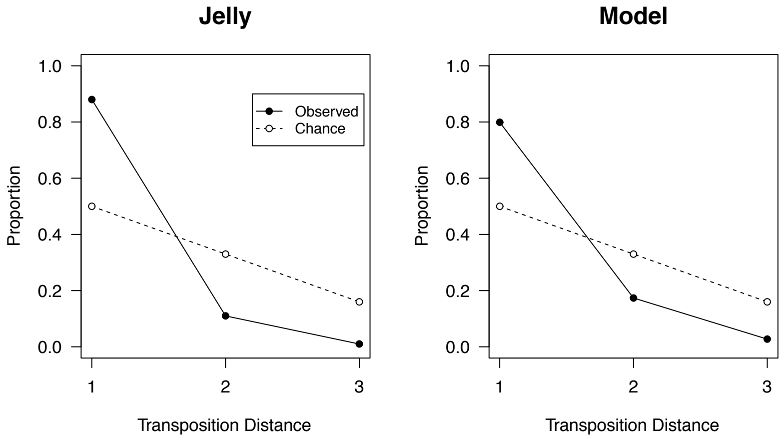


# Aggregate Transposition Error Gradient





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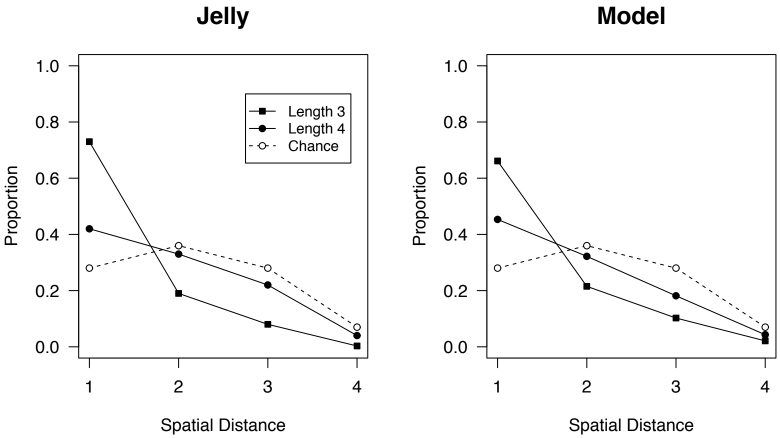
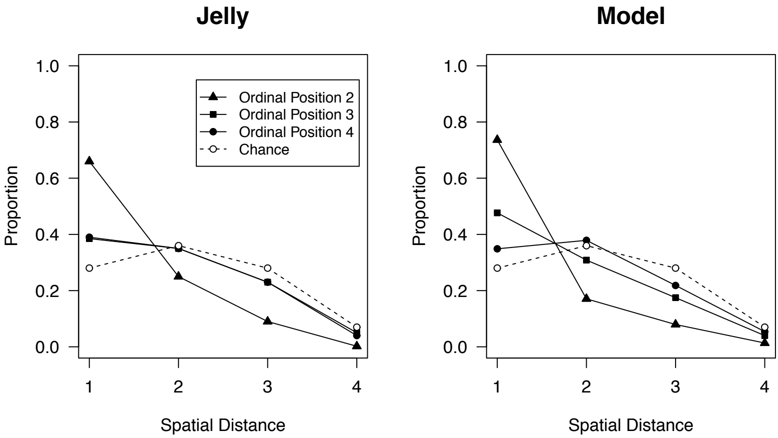


# Item Confusion Errors By Ordinal Position





# Fill-in and Protrusions



- Fill-in
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  - the model predicted a ratio of 10:1
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- In doing so, they suggest that core mechanisms and principles of human ISR may also be appropriate for understanding sequence processing in some nonhuman primate species
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- It will be important to apply the model to other animals of the same species, as well as animals from different species
- Fagot and De Lillo (2012) have recently directly compared the spatial ISR performance of two baboons (*Papio papio*) with humans, and these data are a priority for future modelling efforts

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# Summary and Conclusions



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