Visuospatial Biases as a Window Into Embodied Cognition

Andriy Myachykov
(andriy.myachykov@northumbria.ac.uk)

1. SIMULATED COGNITION

2. VISUOSPATIAL BIASES IN KNOWLEDGE REPRESENTATIONS

3. INTERACTIONS BETWEEN CO-ACTIVATED REPRESENTATIONS

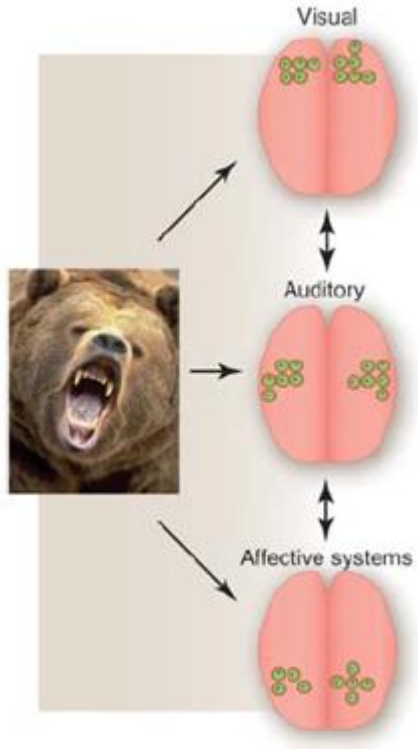
1. **SIMULATED COGNITION**
2. VISUOSPATIAL BIASES IN KNOWLEDGE REPRESENTATIONS
3. INTERACTIONS BETWEEN CO-ACTIVATED REPRESENTATIONS

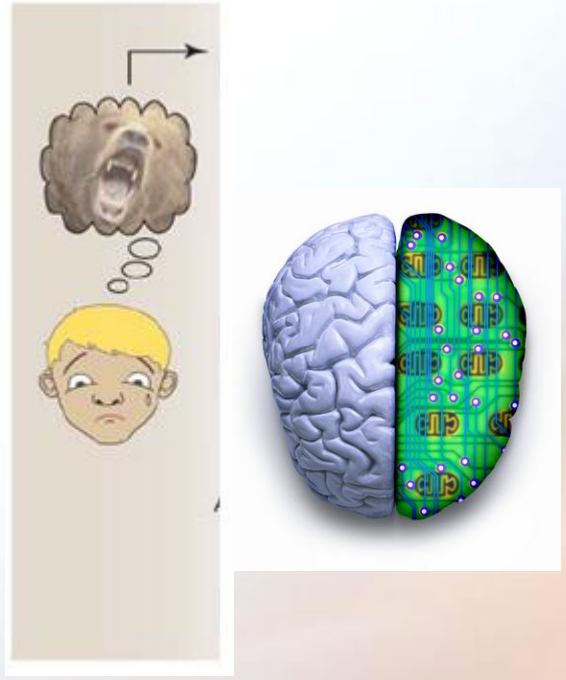
- ✓ How is knowledge acquired, stored, and retrieved?
- ✓ How are the processes of acquisition, maintenance, and retrieval related to the mind's embodied experience?

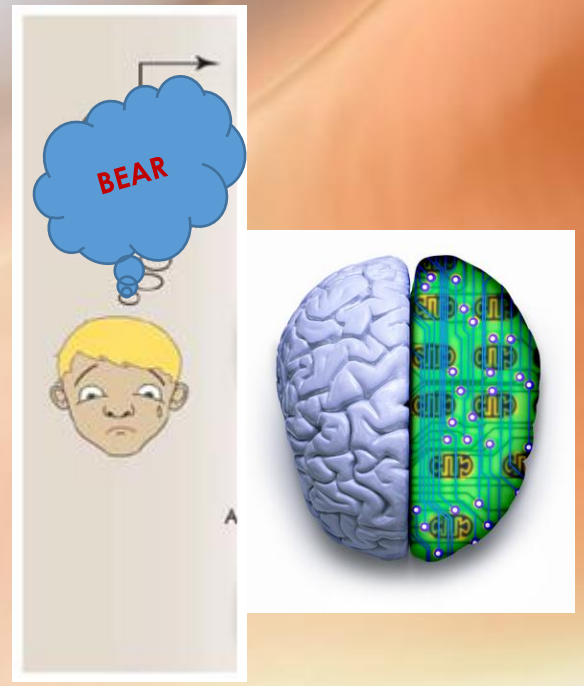
Cognition and Experience

- **Perceptual state (auditory, visual, etc)**
- **Motor state (action)**
- **Affective state (emotion)**

Propositional Meaning in the Brain

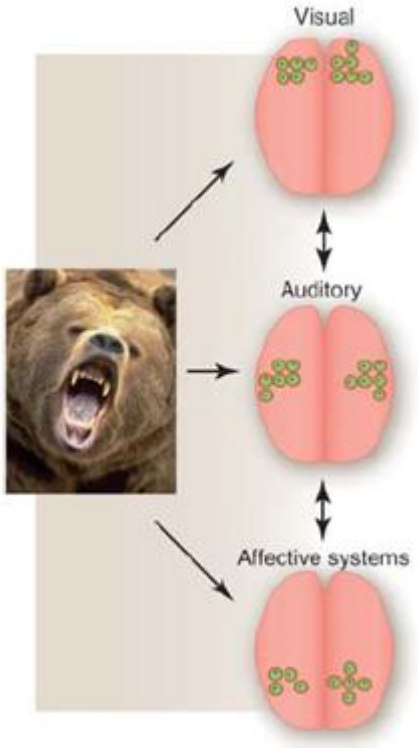


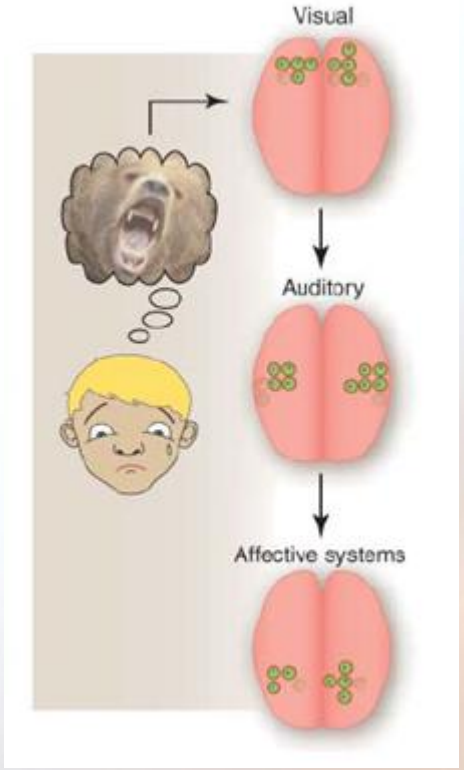


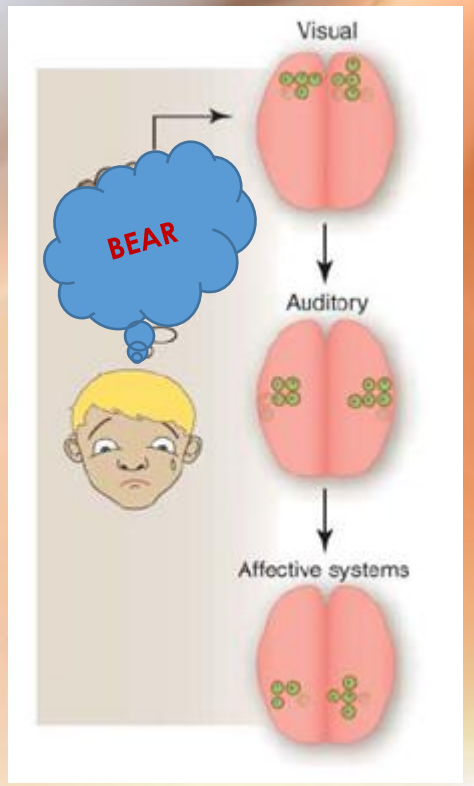


(e.g. Decartes 1664; Fodor & Pylyshyn 1981; Pylyshyn 2009).

Simulated Meaning in the Brain







From: Niedenthal, et al. (2007). Embodying Emotion, *Science, 316,* 1002 – 1005.

"Simulation is the re-enactment of perceptual, motor, and introspective states acquired during experience with the world, body, and mind"
(Barsalou 2008)

Simulation Sources

(Myachykov, et al., 2013, *TOPICS*)

- ✓Tropism (in Botanics, *Tropism* refers to the changes in an organism in response to an external stimulus)
  - Tropic effects include the representational features that reflect the organization and nature of the physical world we live in (source of light, gravity, etc.)
- ✓Embodiment
  - Embodied effects include the representational features that reflect the organization and nature of our physical bodies (upward posture, frontal binocular vision, upper limbs for manipulation, etc.)
  - Embodied effects can be general and individually specific.
- ✓Situated context
  - Situated effects include the representational features that emerge from variable contexts – social, cultural, perceptual, educational, etc.

Simulation Modalities

- ✓Sensory
  - Sensory effects include the representational features that reflect the perceptual history of the concept (more = up, louder; right = positive, etc.)
  - Sensory effects correspond to sensory modalities: visuospatial, auditory, haptic, olfactory, gustatory, proprioceptive.
- ✓Motor
  - Motor effects include the representational features that reflect the motor history of the concept (affordances, other effects associated with specific effectors)
- ✓Physiological
  - Physiological effects include the representational features that reflect the history of physiological state(s) associated with the concept – heart beat, temperature, arousal, etc.
- ✓Introspective
  - Complex states including mindfulness, meditation, etc.

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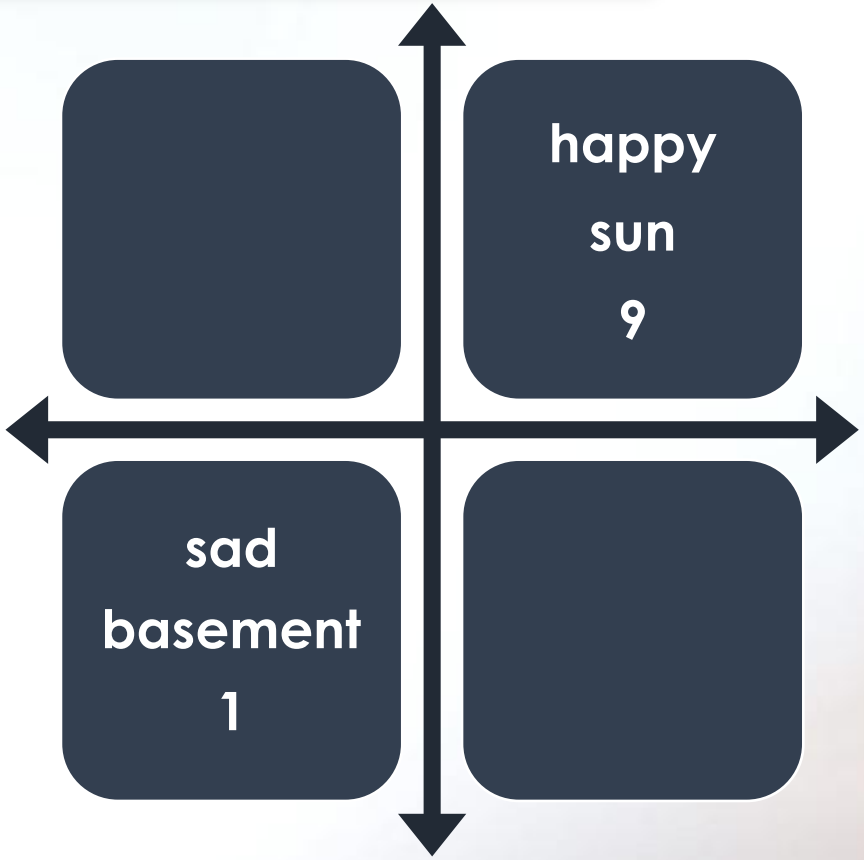
Visuospatial Biases in Knowledge Representations



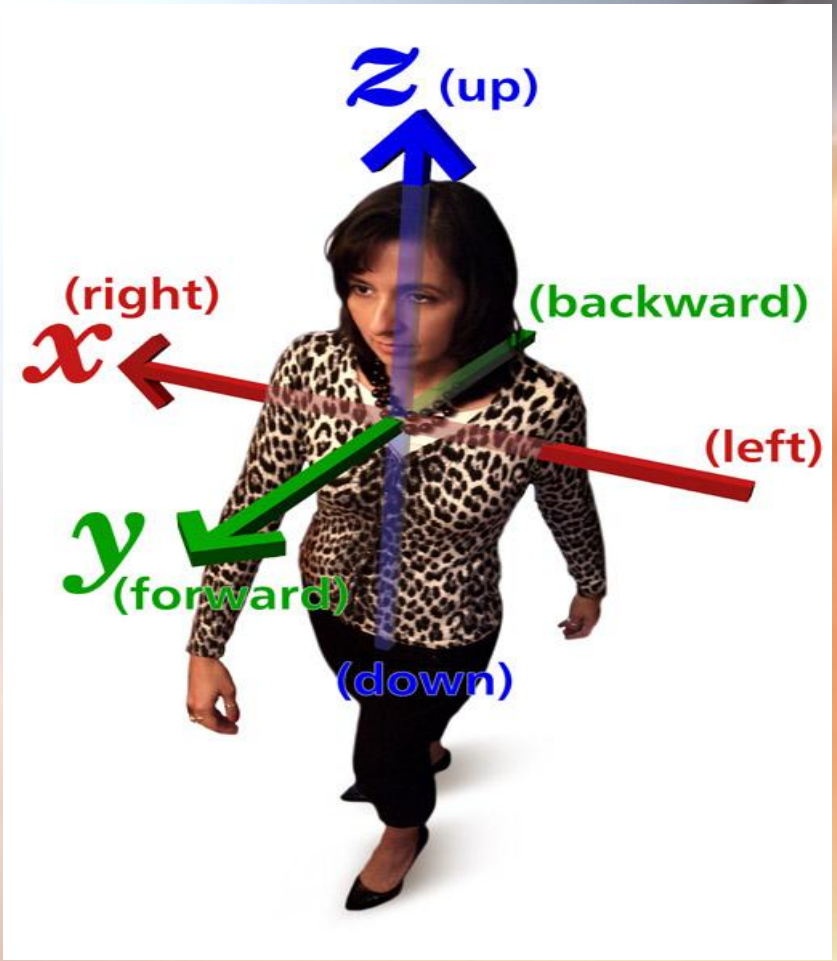
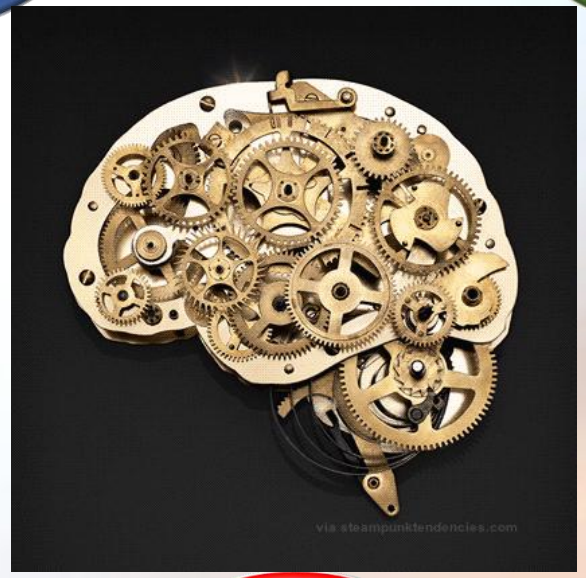


Image: http://en.wikipedia.org/wiki/Relative_direction

Affordances

Numbers



Valence

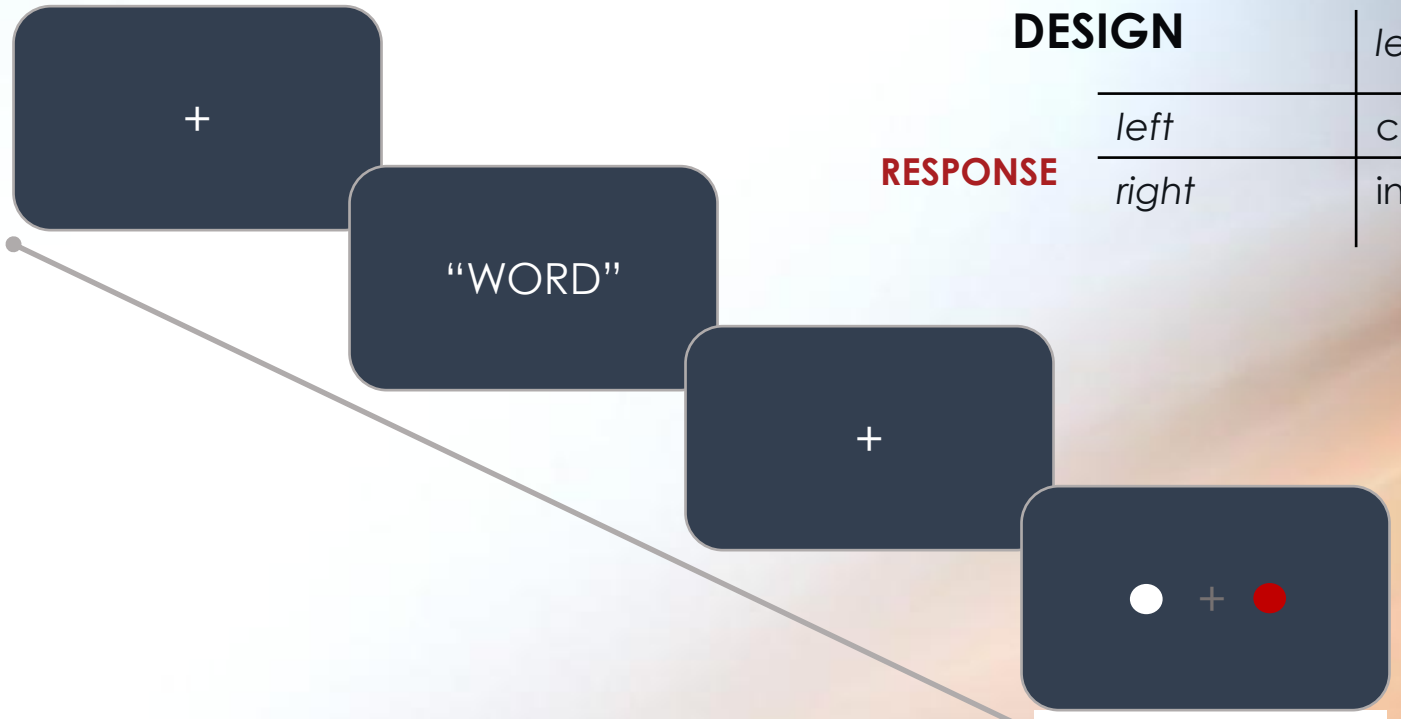
Time

Space

Horizontal Space in Spatial Semantics

Horizontal Biases in Spatial Semantics

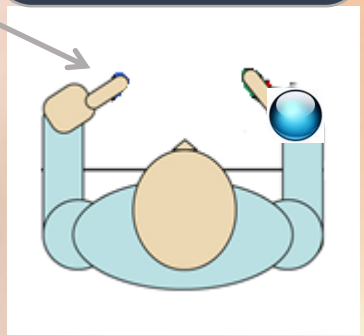
(Chapman & Myachykov *in prep*)



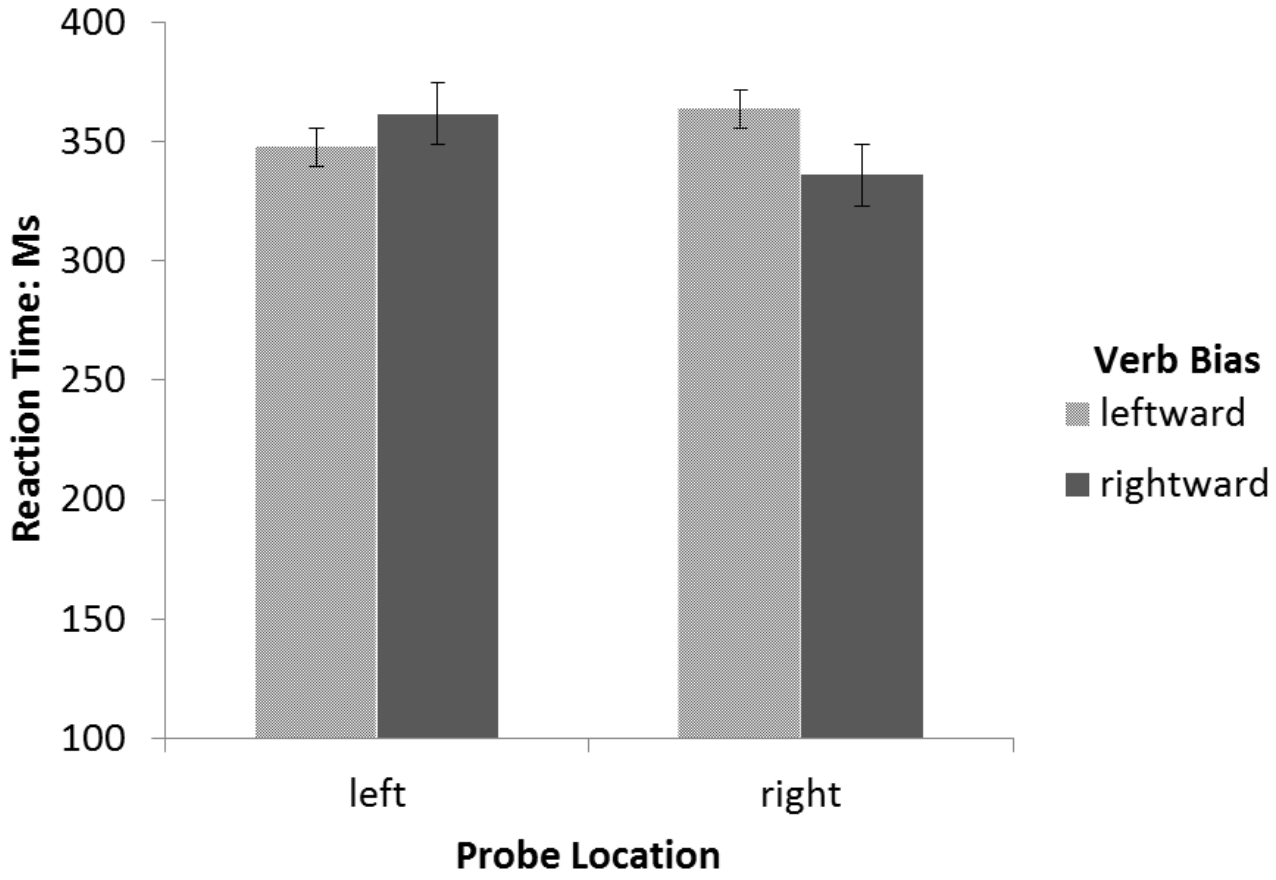
DESIGN	SPATIAL BIAS: *left*	SPATIAL BIAS: *right*
RESPONSE: *left*	congruent	incongruent
RESPONSE: *right*	incongruent	congruent

MATERIALS

left	right
retreat	*advance*



Verb Bias x Probe Location



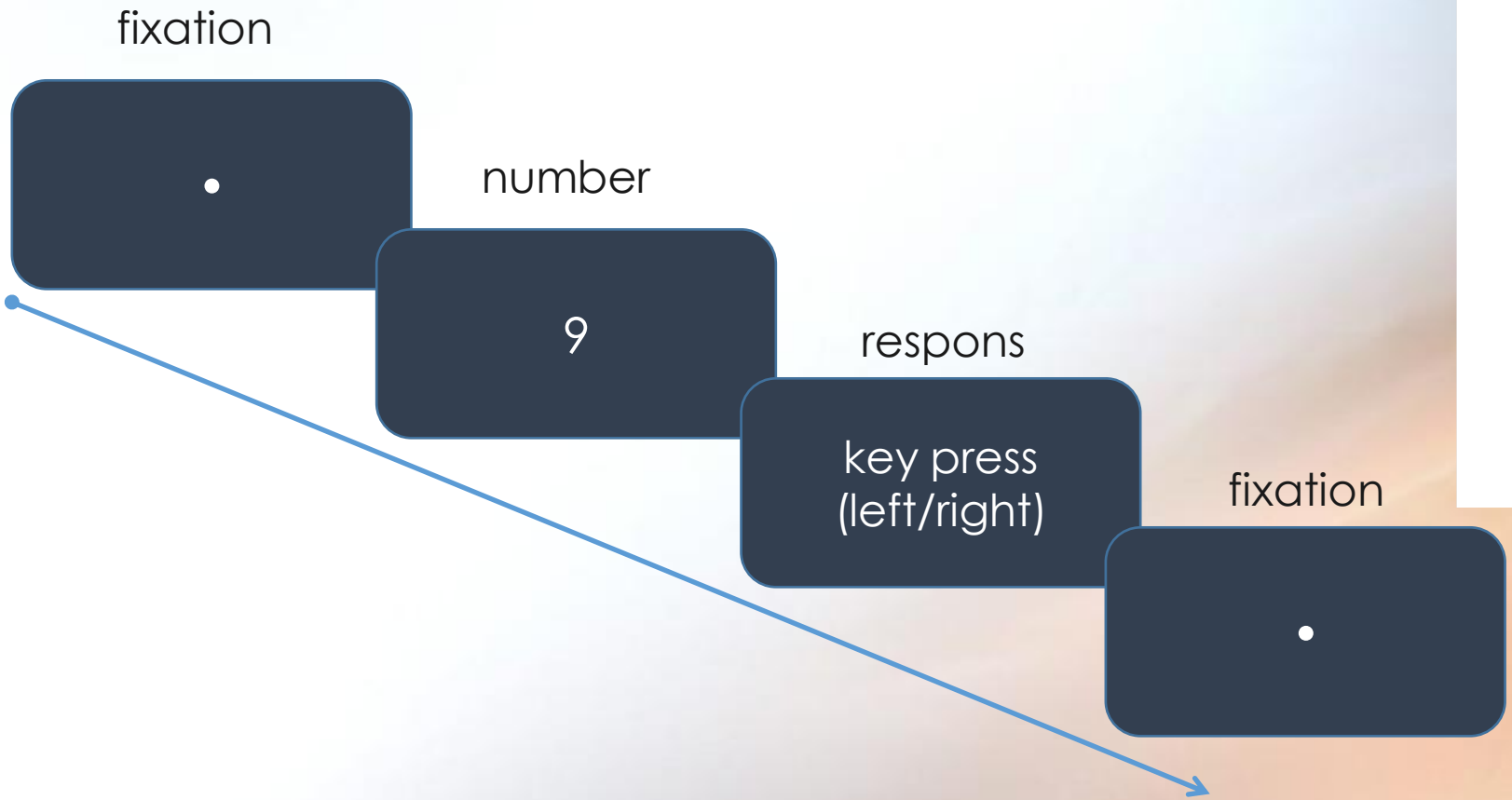
$F(1,23)=6.189$, $p=.023$

✓ Understanding verbs of spatial semantics orients attention

Horizontal Space in Numbers

SNARC
(Spatial-Numerical Association of Response Codes)

(Dehaene et al 1993)



Odd or Even?

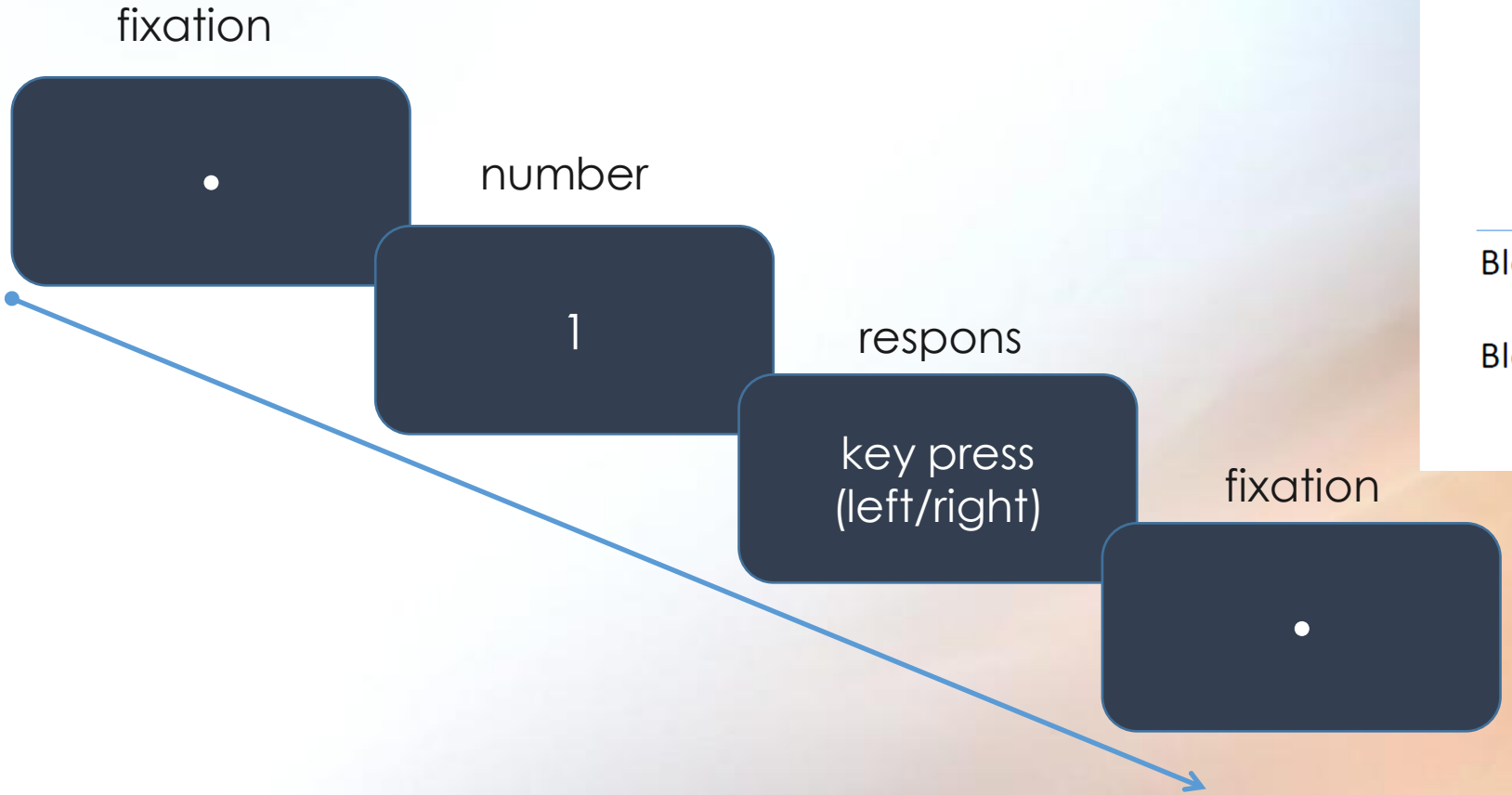
8

	Left Hand	Right Hand
Block 1	Even	Odd
Block 2	Odd	Even

- **Parity task:** *Press right for "odd", left for "even".*

SNARC

(Dehaene et al 1993)



Odd or Even?

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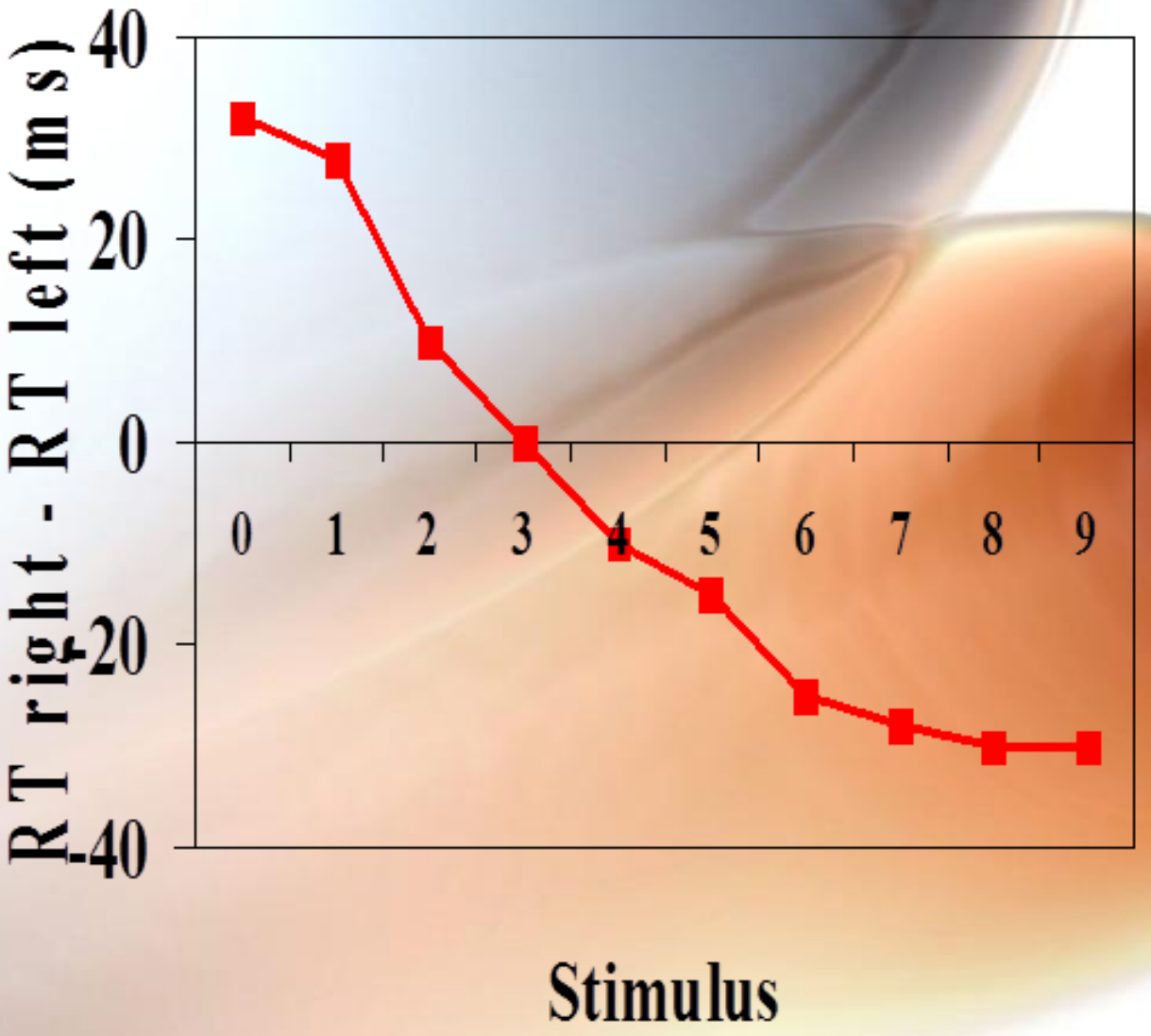
	Left Hand	Right Hand
Block 1	Even	Odd
Block 2	Odd	Even

- **Parity task:** *Press right for "odd", left for "even".*

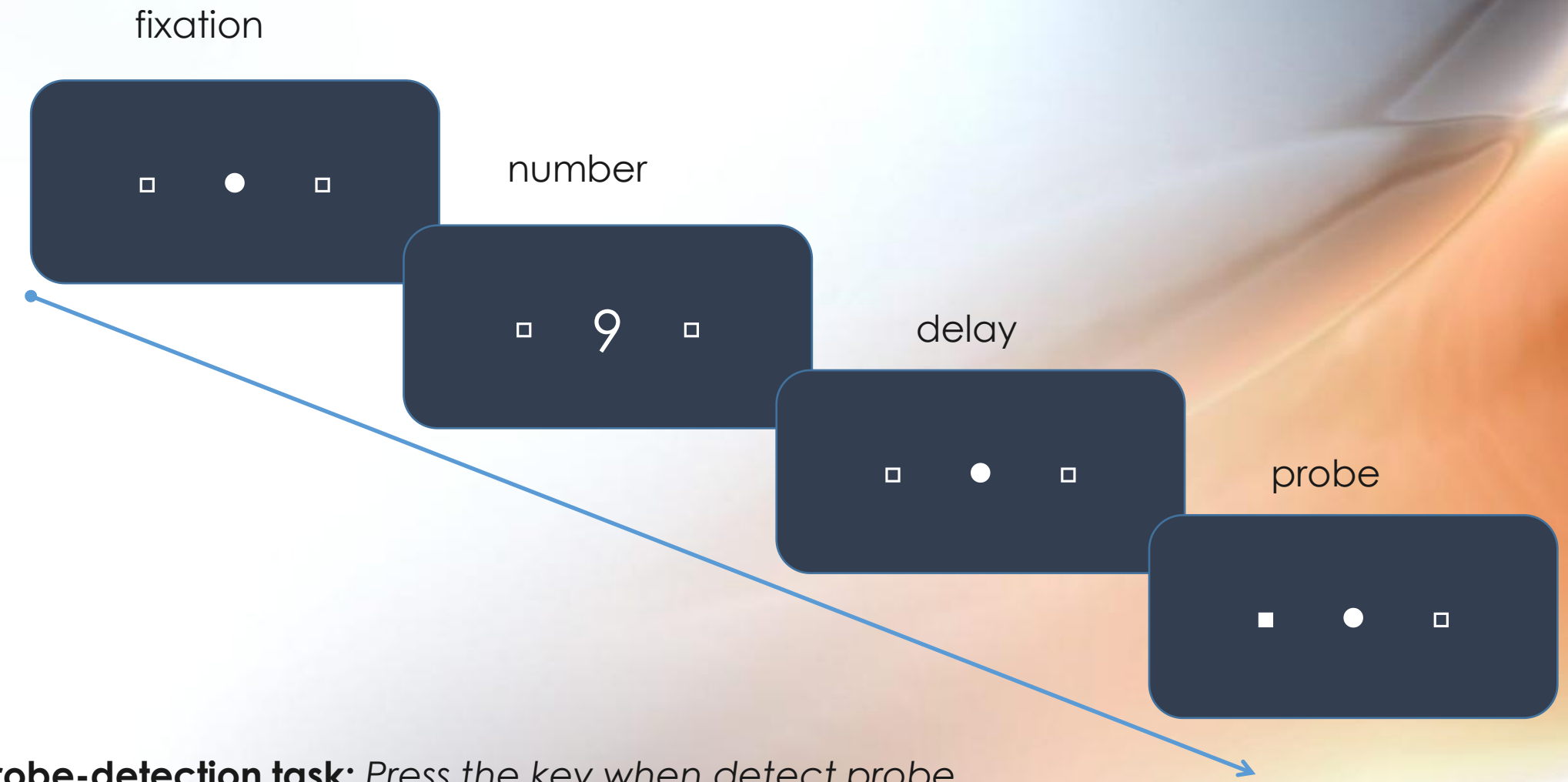
SNARC

- ✓ People are faster to signal parity of the large numbers with the right-hand, and the small numbers – with the left-hand, responses. Suggests that numbers are perceived as arranged along the MNL.



SNARC and Attention (motor response)

(Fischer et al 2003)

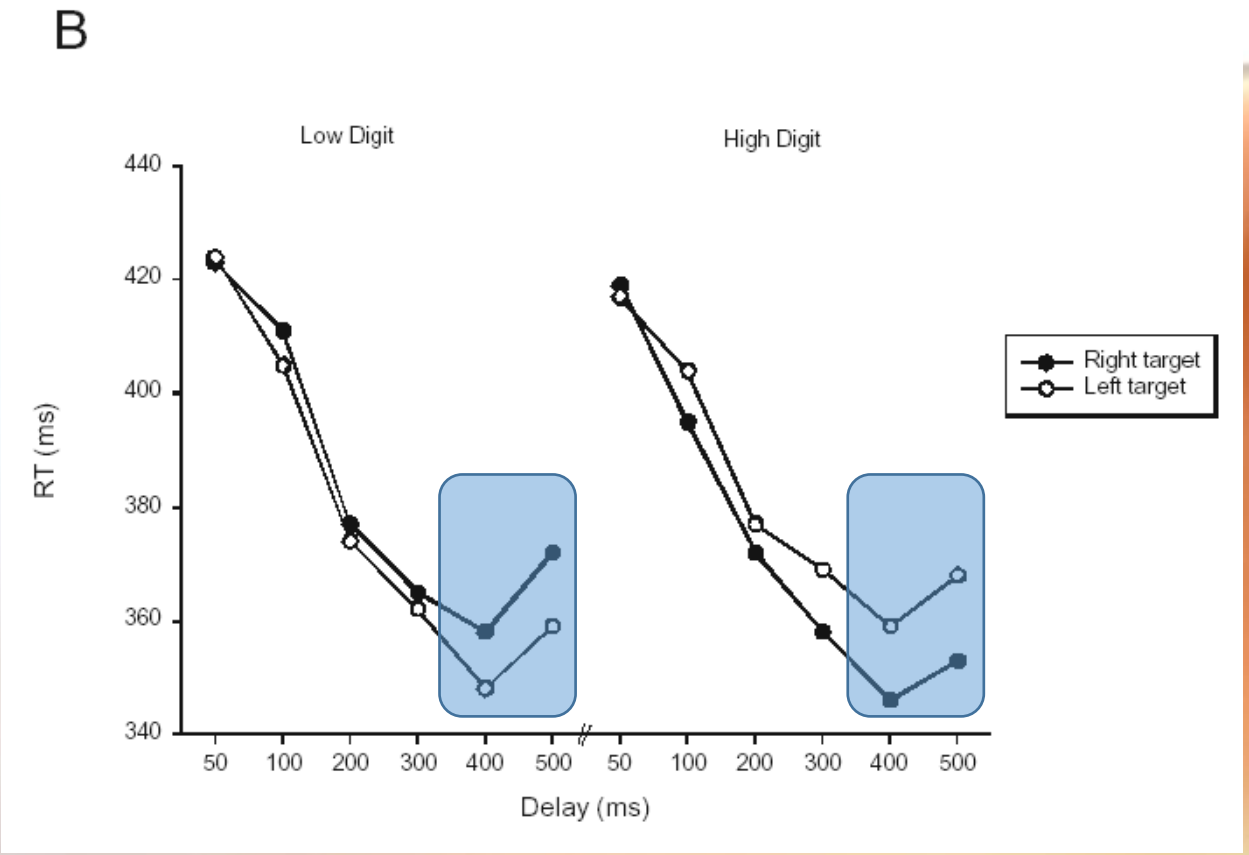


- **Probe-detection task:** *Press the key when detect probe*

SNARC and Attention (motor response)

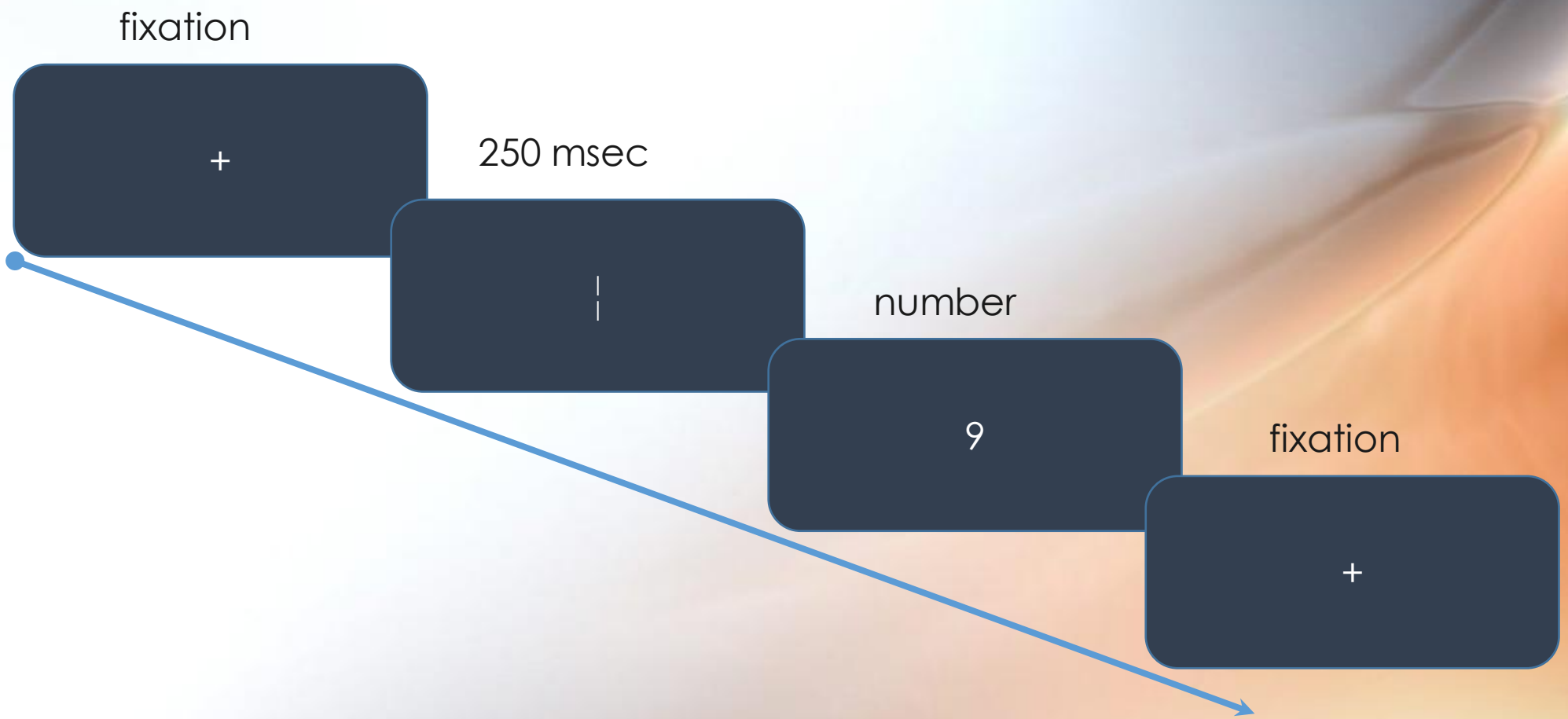
(Fischer et al 2003)

- ✓ People are faster to detect left probe after small and right probe after large, numbers.



SNARC and Attention (eye movements)

(Fischer et al 2004)

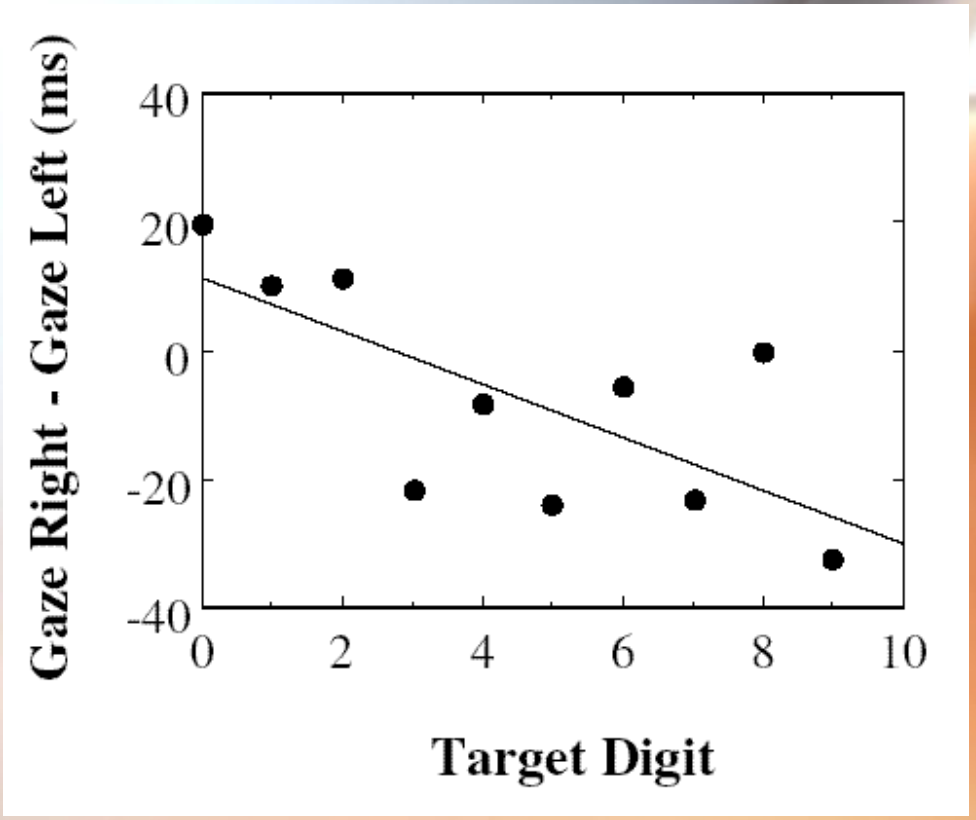


- **Saccade task:** *Look left for even, right for odd number*

SNARC and Attention (eye movements)

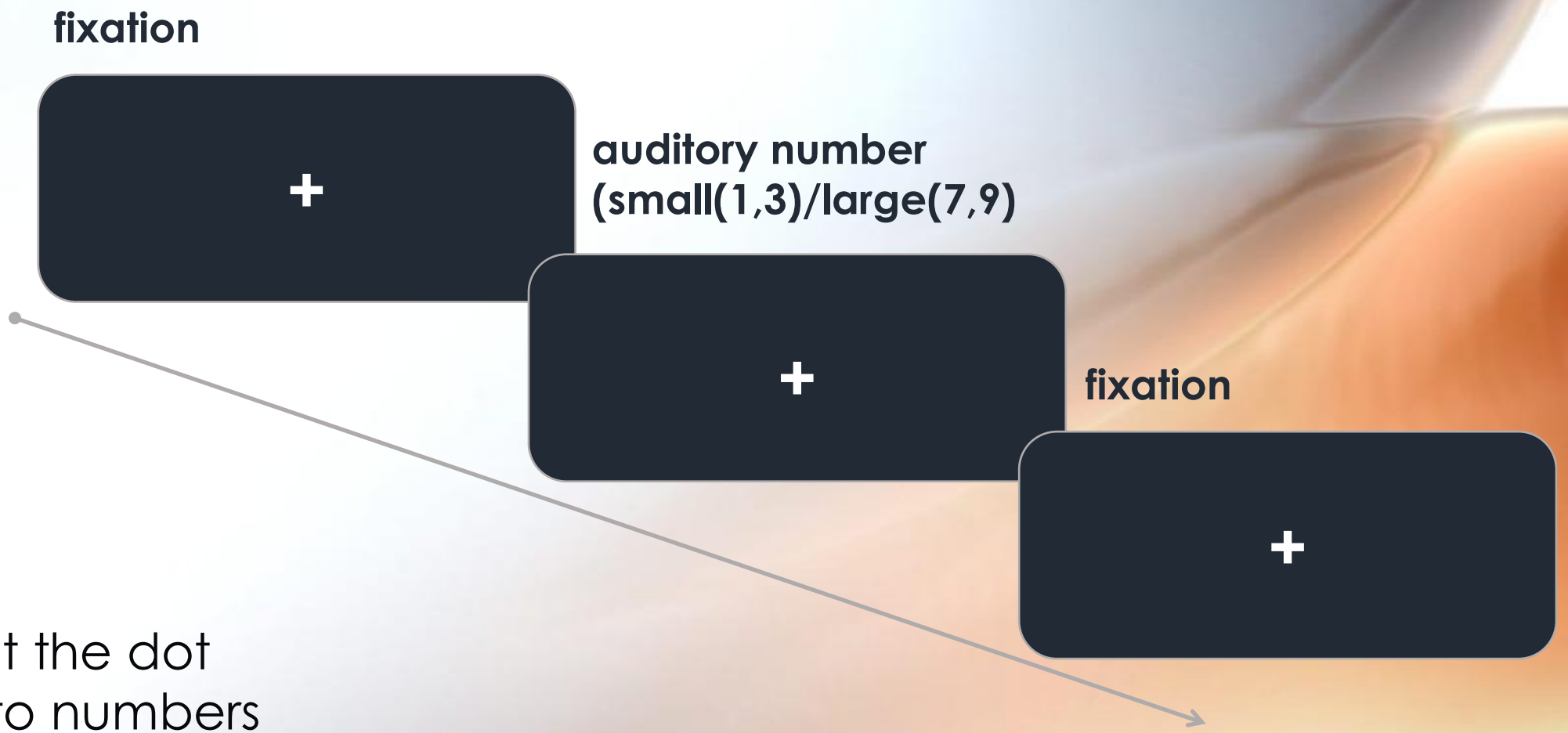
(Fischer et al 2004)

- People are faster to *look* left after small numbers and right – after large numbers



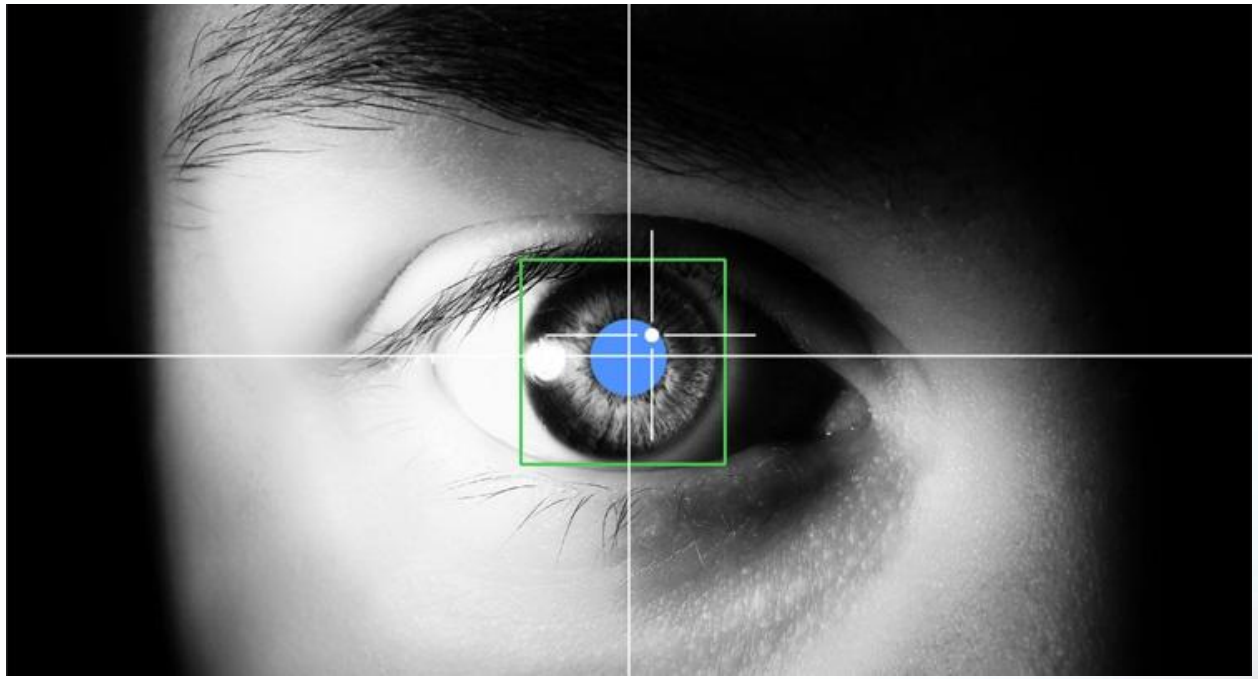
SNARC and Attention (eye movements)

(Myachykov et al 2015 *Acta*; 2016 *PsyRes*)

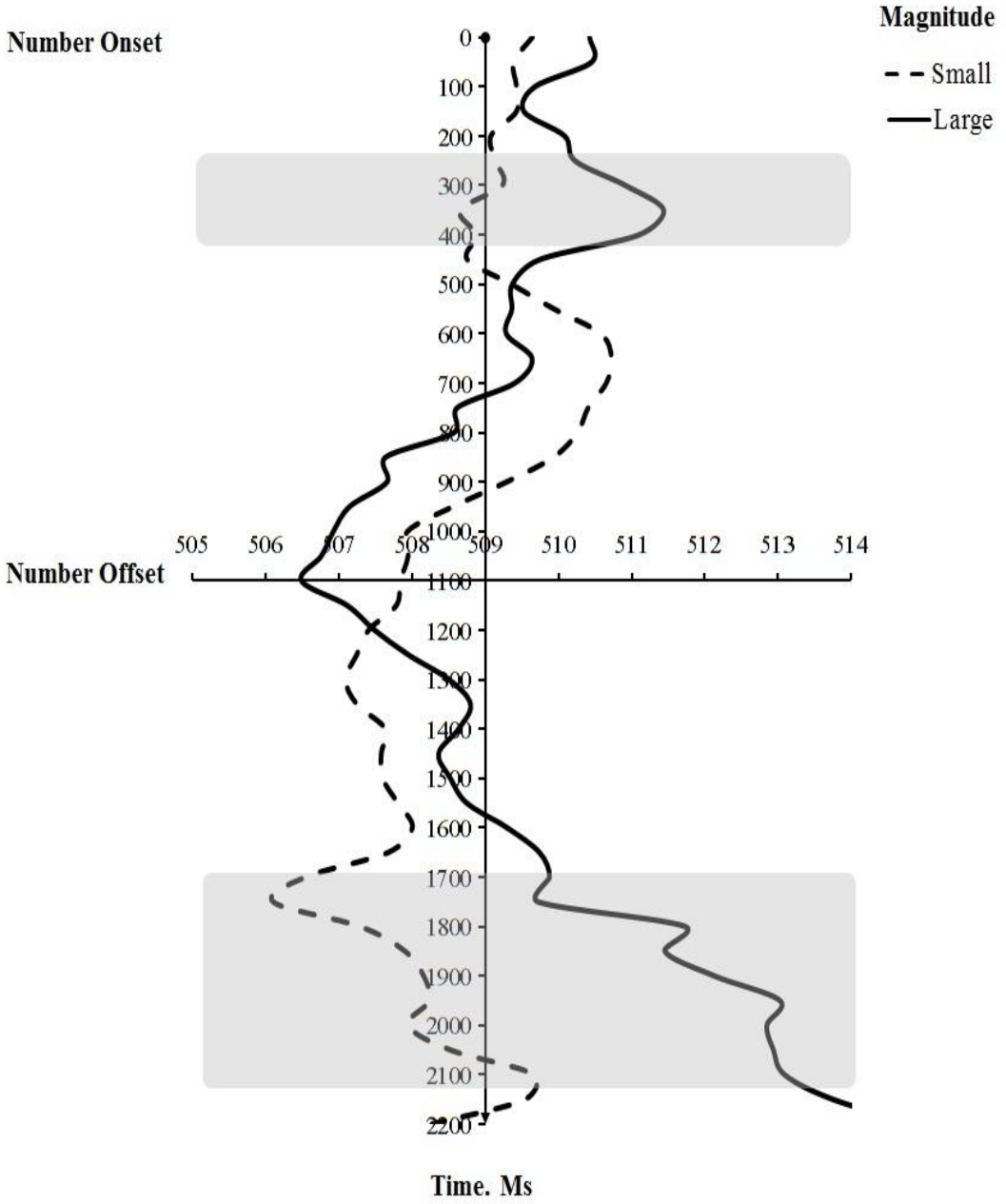


Task:

- Look at the dot
- Listen to numbers
- Press button when you hear “5”

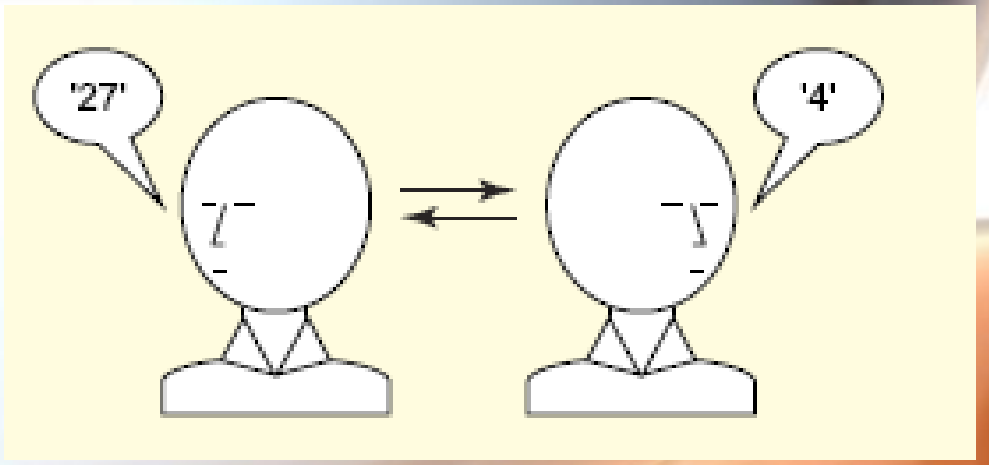


- ✓ Understanding numerical magnitude automatically orients attention

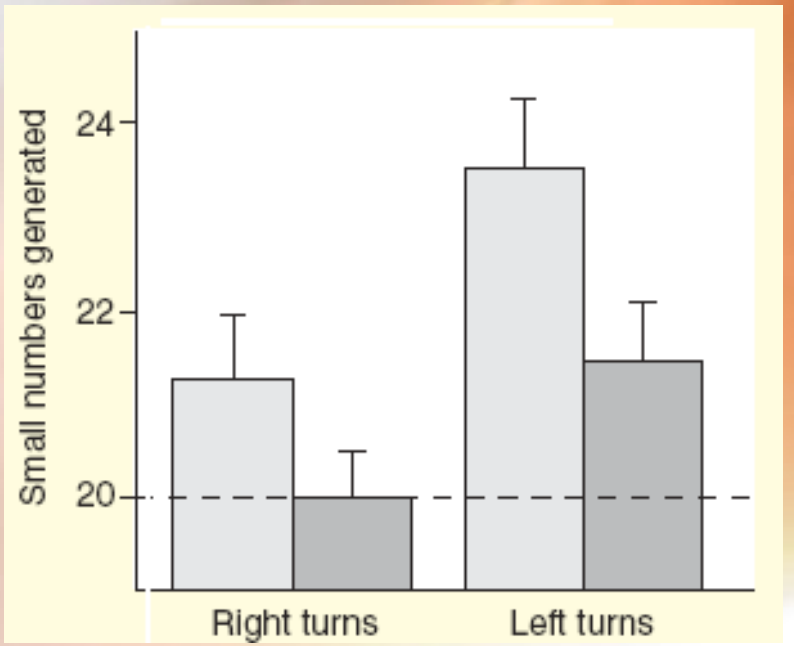


Random Numbers In Your Head

(Loetscher et al 2008)



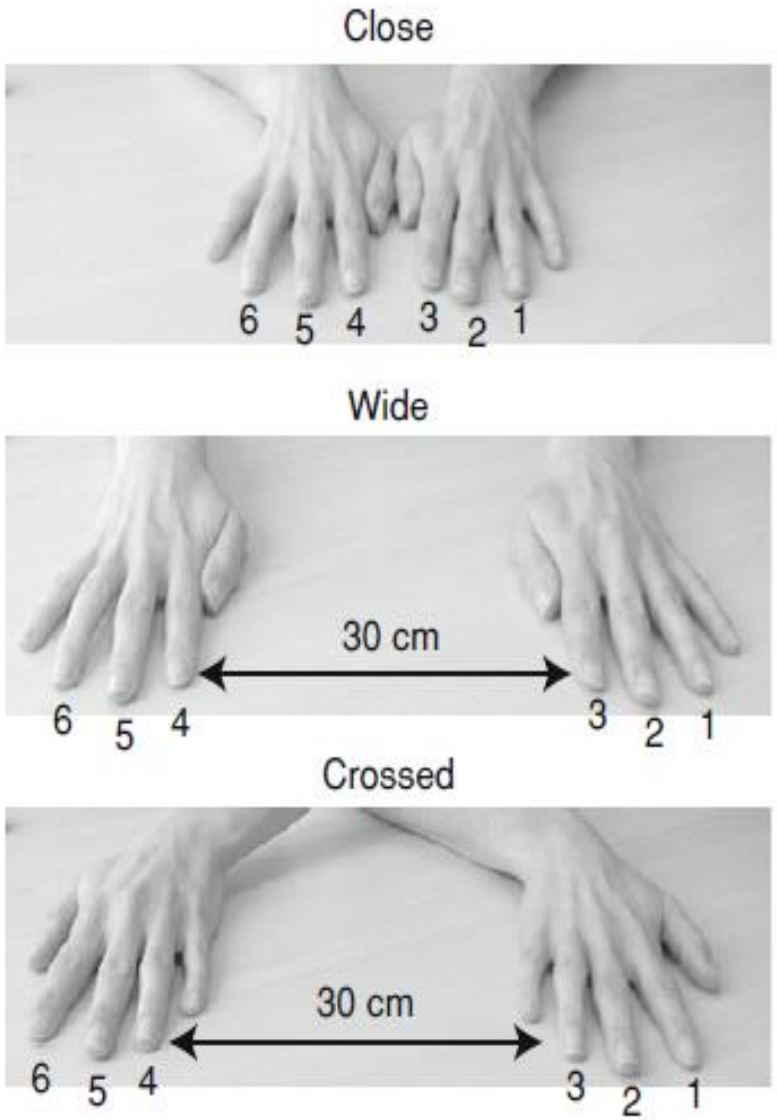
- ✓ People produce larger numbers on right turns, smaller numbers on left turns

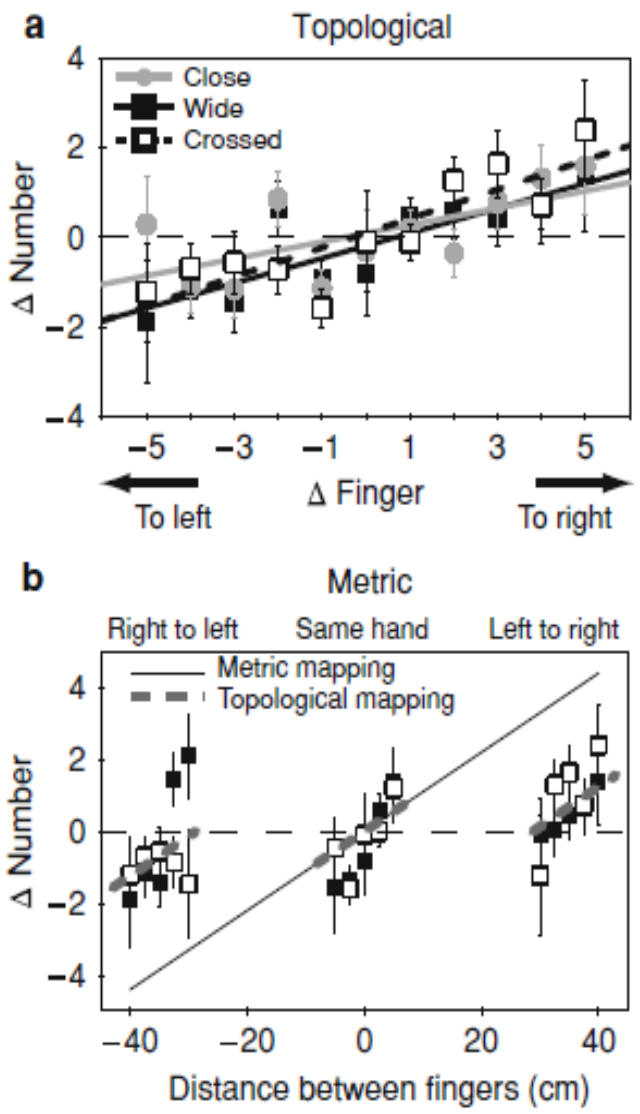


Random Numbers In Your Fingers

(Plaisier & Smets 2011)

- ✓ Naming a smaller number than the previous one was associated with tapping a finger to the left of the previously tapped finger.





Random Numbers In Your Fingers

(Vicario 2012)

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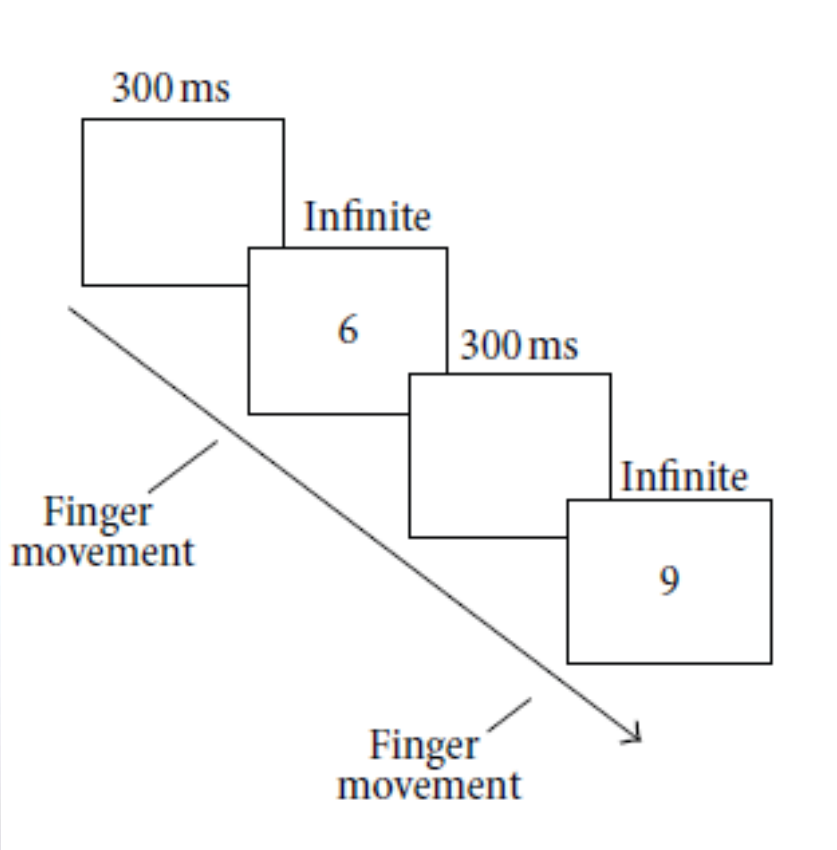
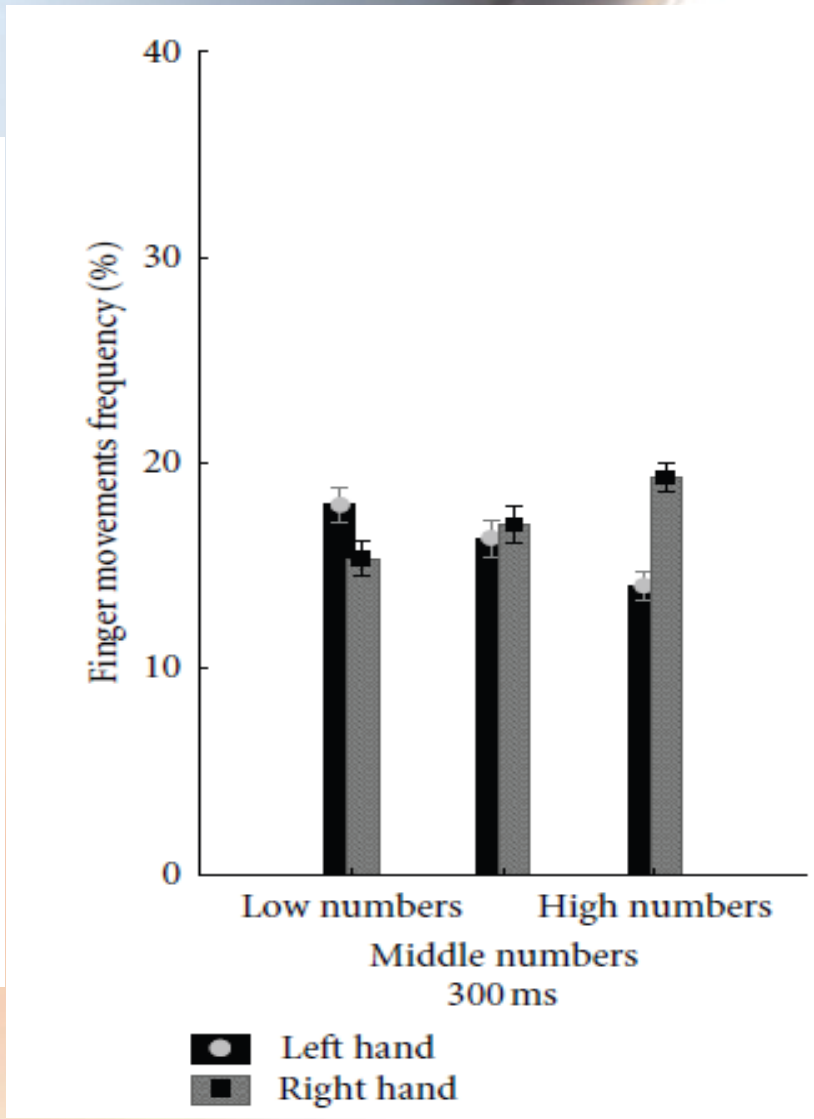


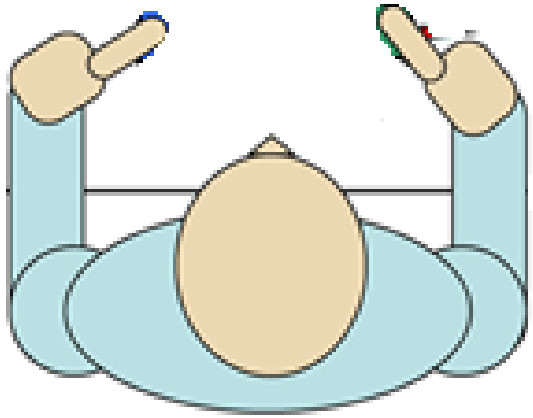


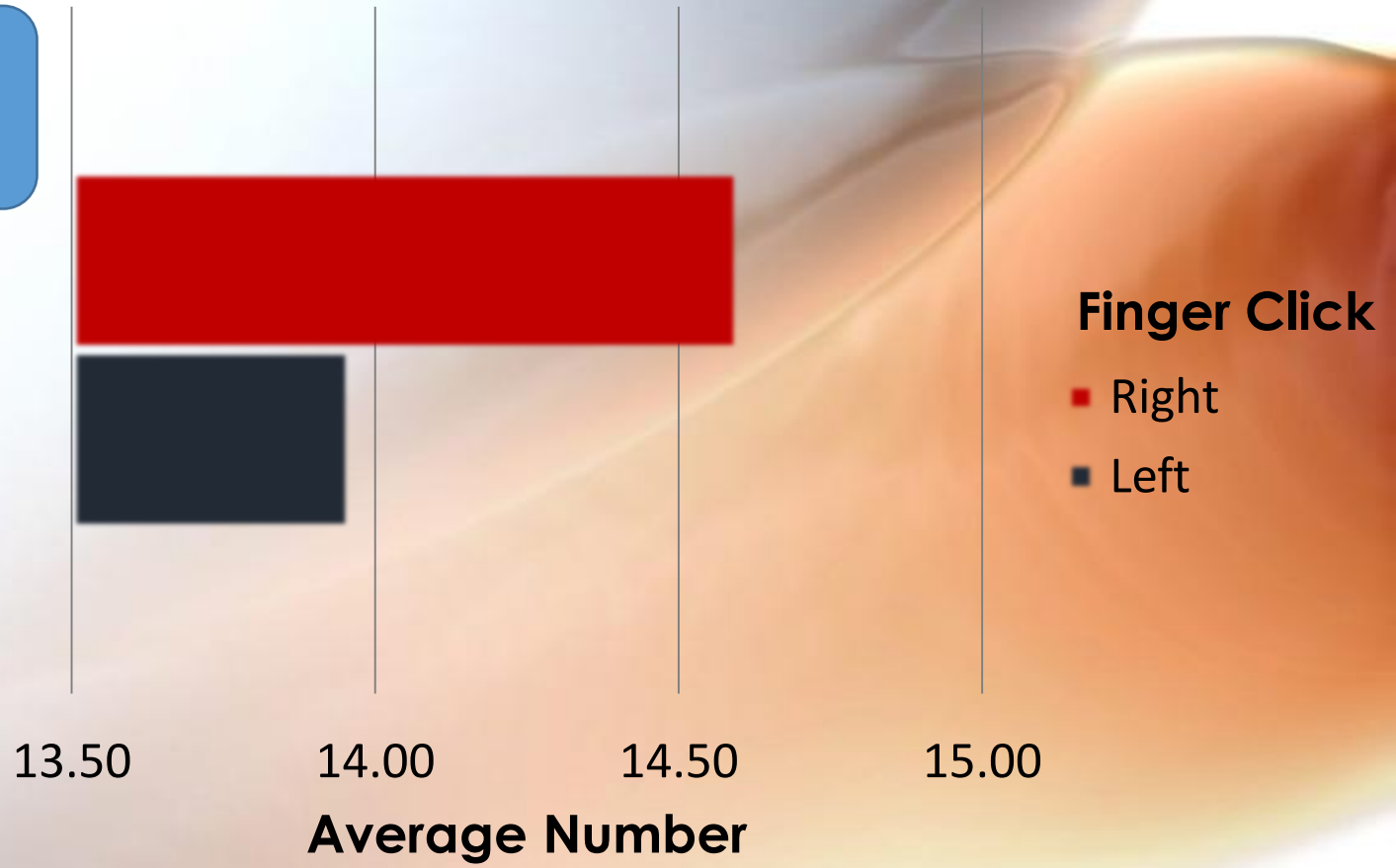
Random Numbers In Your Fingers

(Myachykov, *in prep*)

1

9

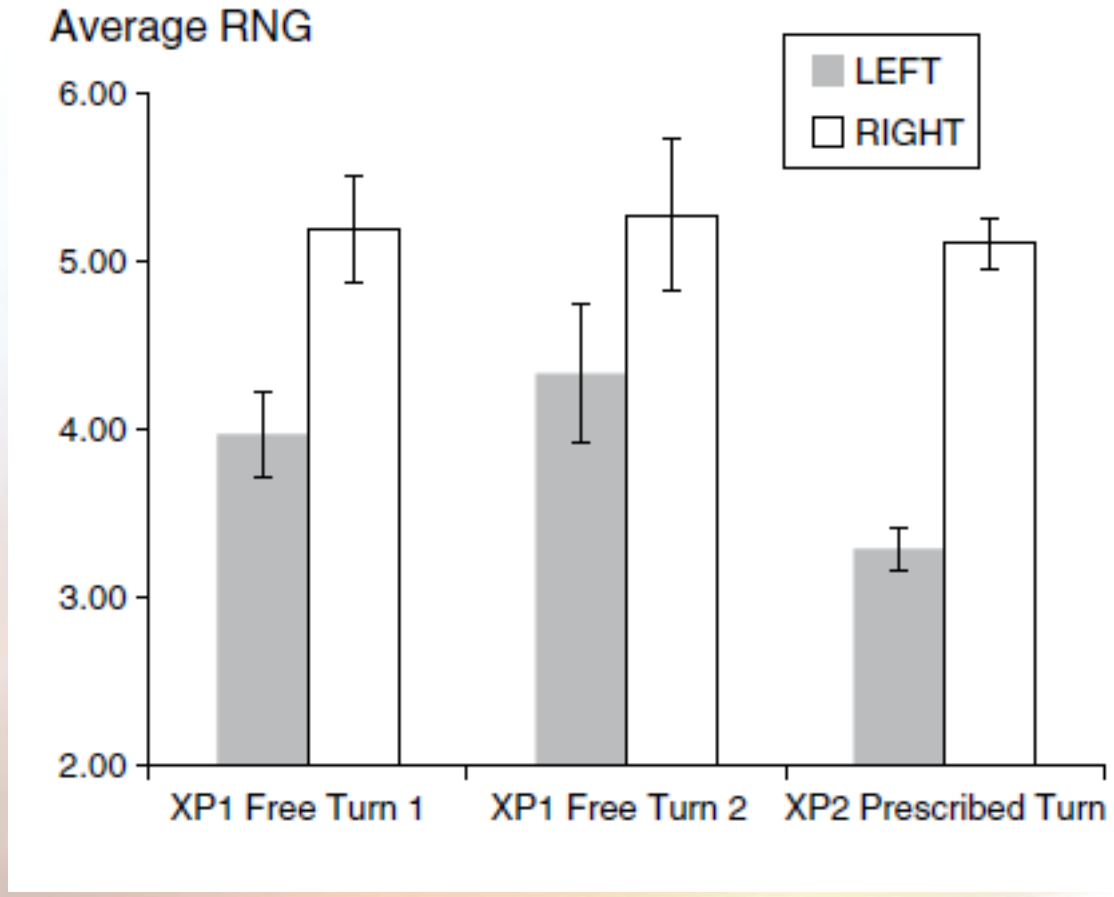




Random Numbers In Your Walk

(Shaki & Fischer 2014)

- ✓ People produce larger numbers on rightward walks, smaller numbers on leftward walks.



ATOM: A Theory of Magnitude

(Walsh 2008; 2015)

1. Time, space, number and weight magnitudes are all part of a generalised magnitude system.

2. Concepts other than numbers should show similar spatial biases.

3. Different concepts relying on magnitude should interact.

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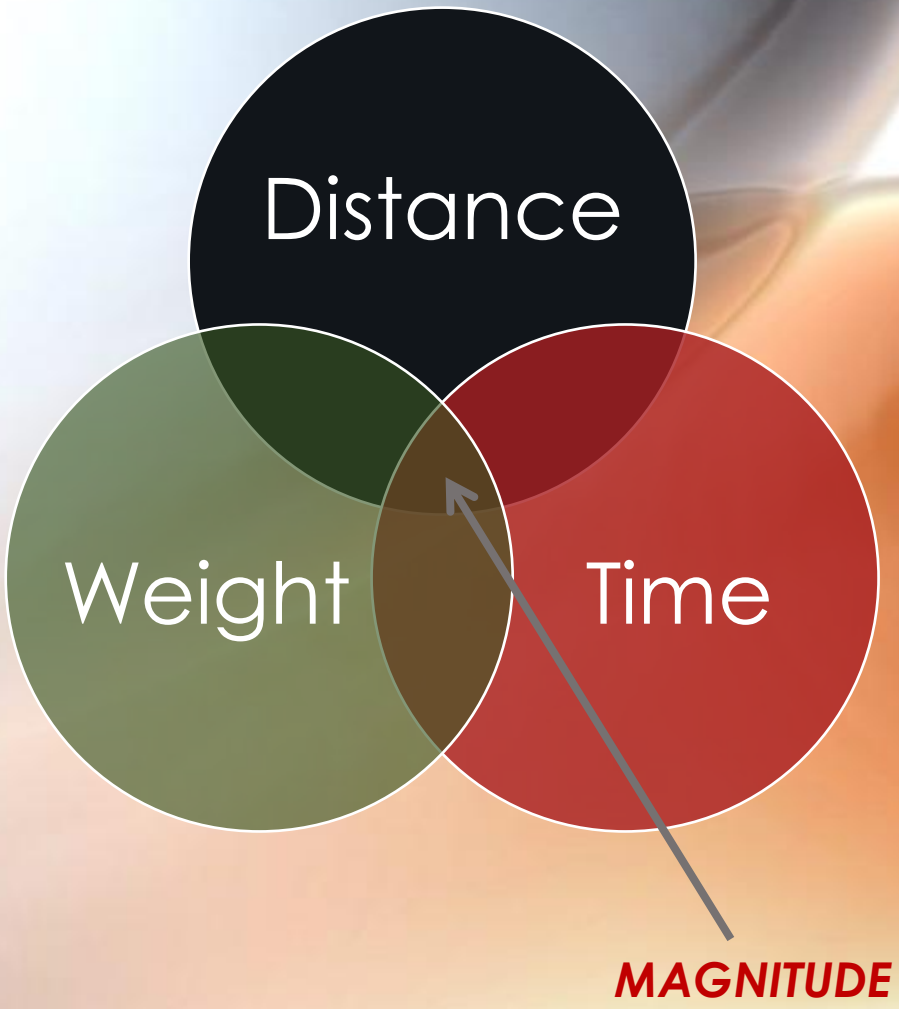
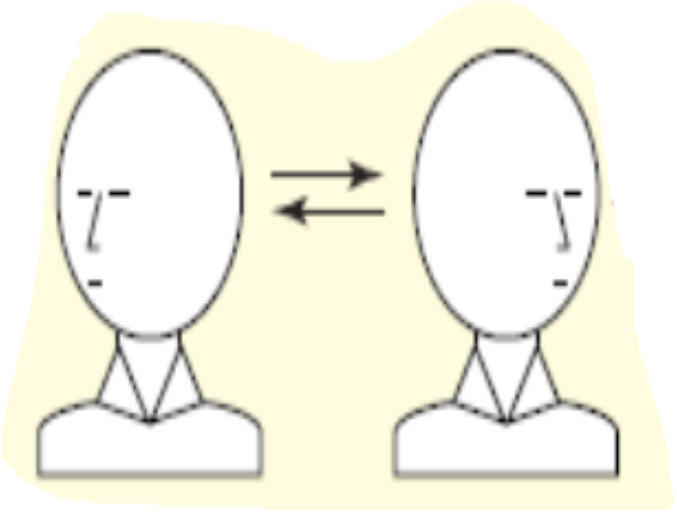


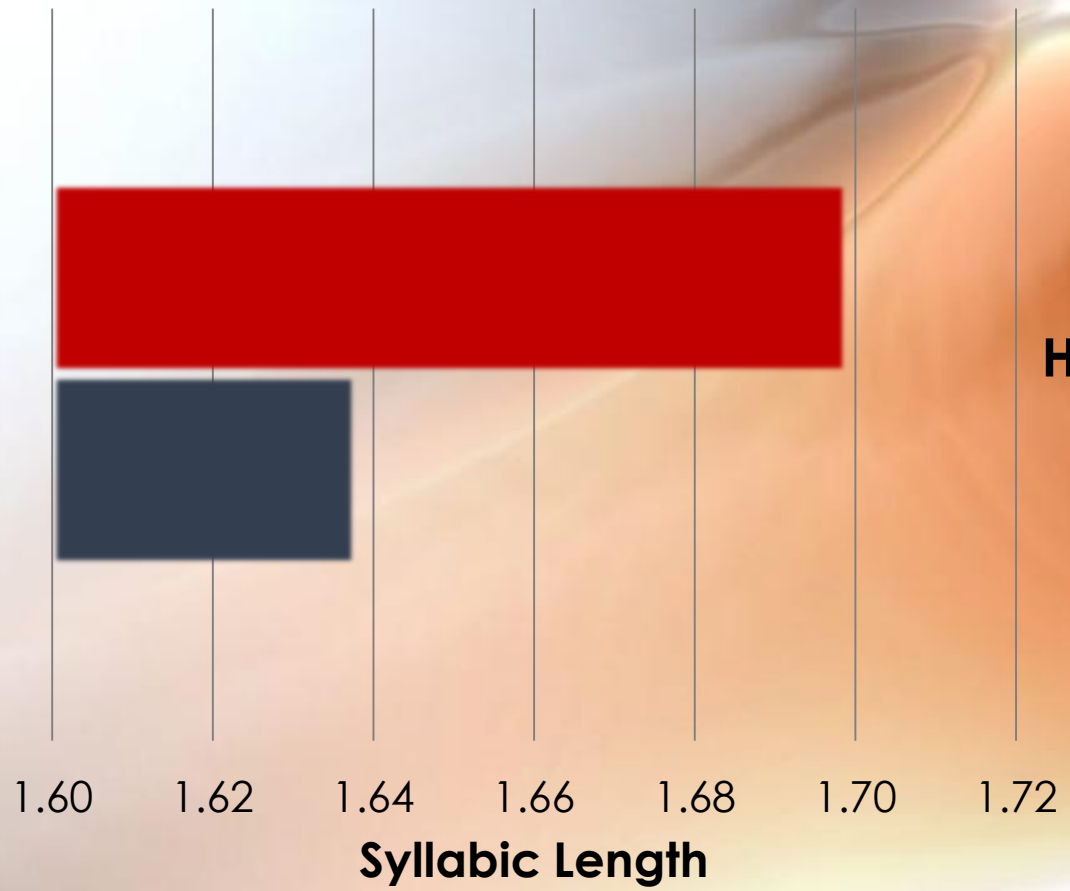
Random Words In Your Head

(Myachykov, Chapman, & Scheepers, *in prep*)

homeostasis

idiosyncrasy





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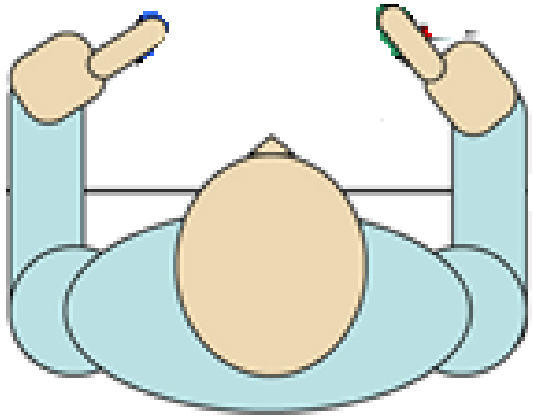

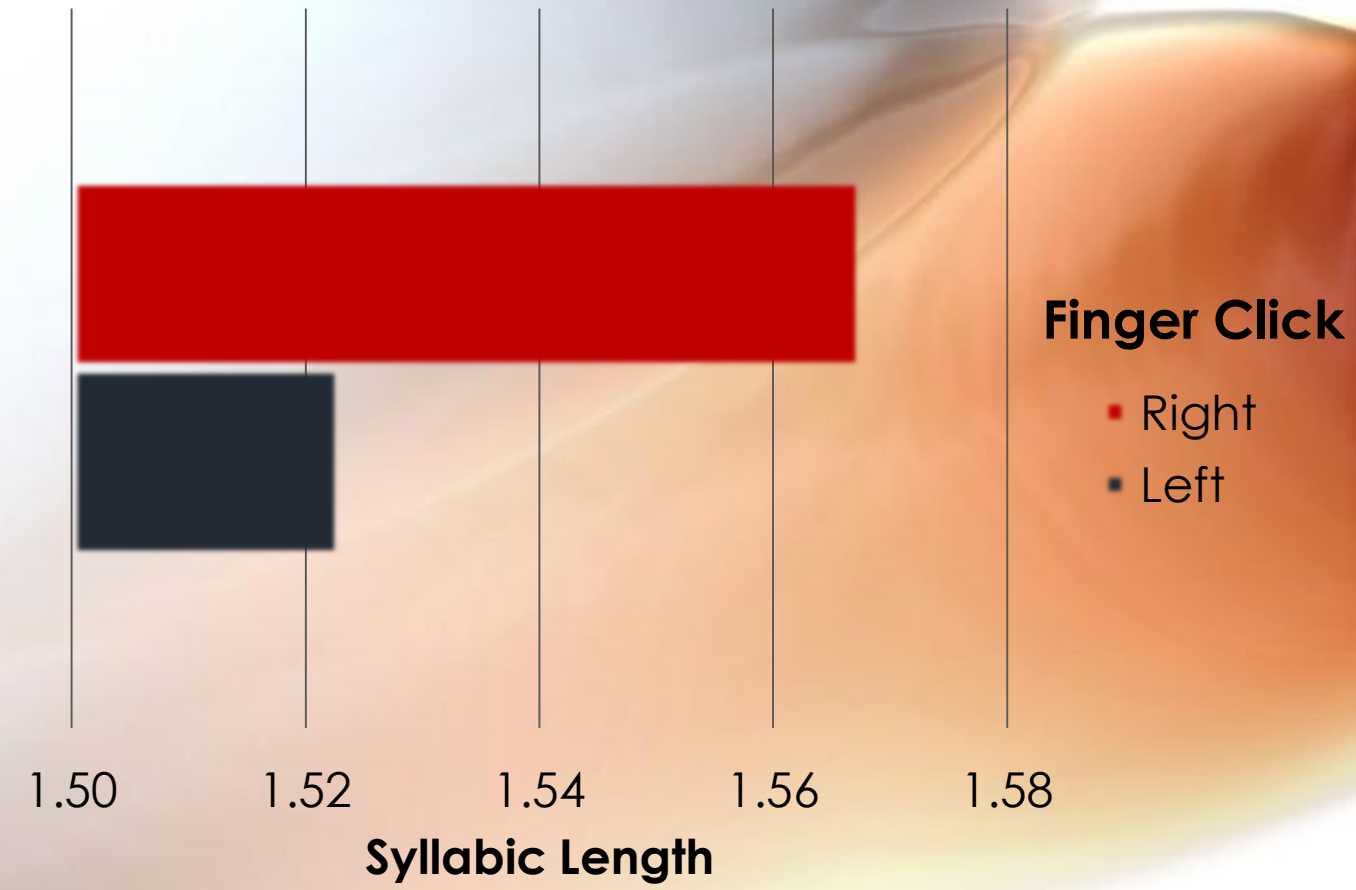

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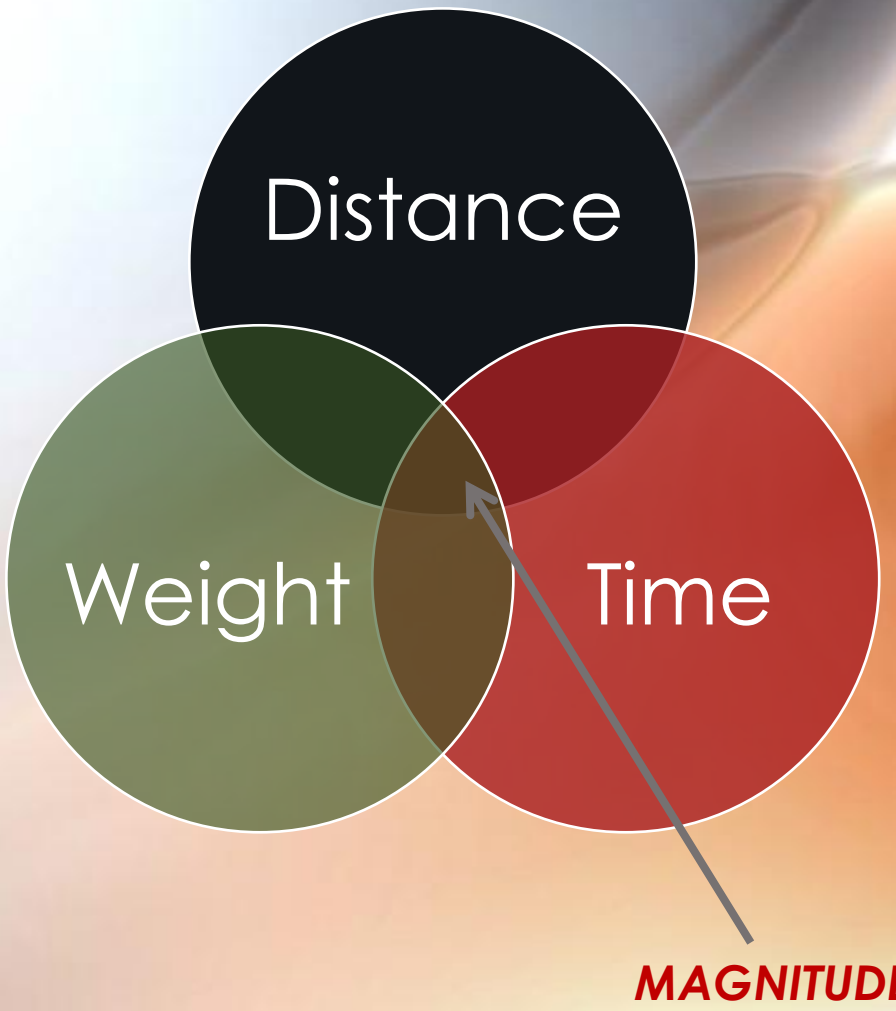

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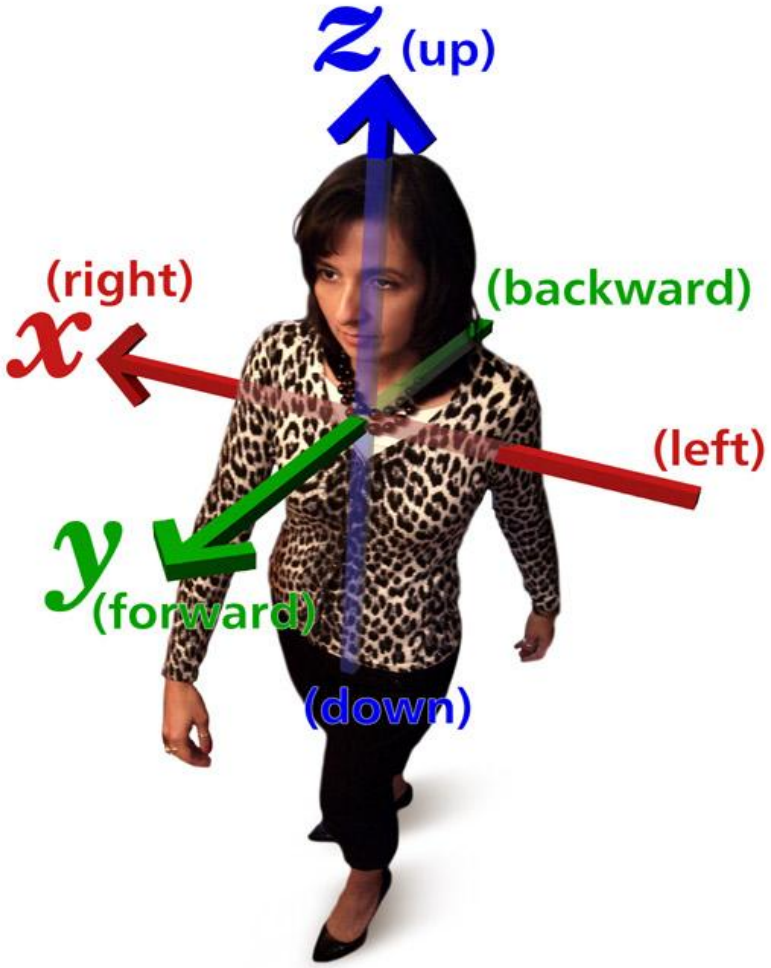
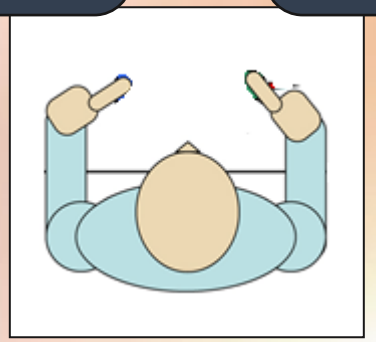
Interplay Between Representations via Shared Visuospatial Biases



- ✓ One
- ✓ Small
- ✓ Yesterday
- ✓ Villain
- ✓ Hate

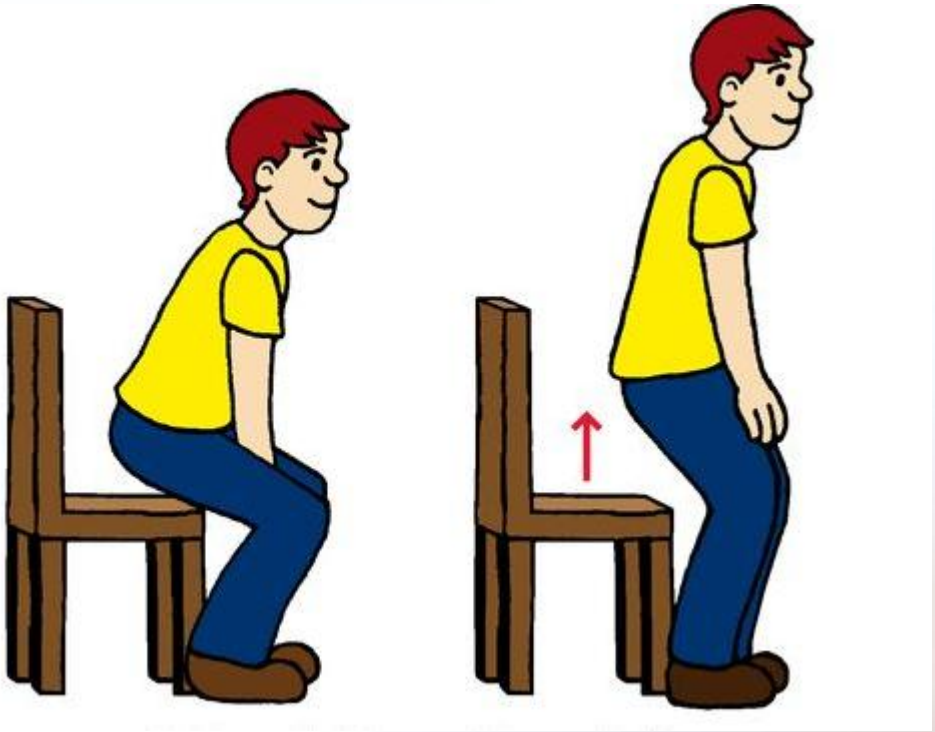
- ✓ Nine
- ✓ Large
- ✓ Tomorrow
- ✓ Hero
- ✓ Love

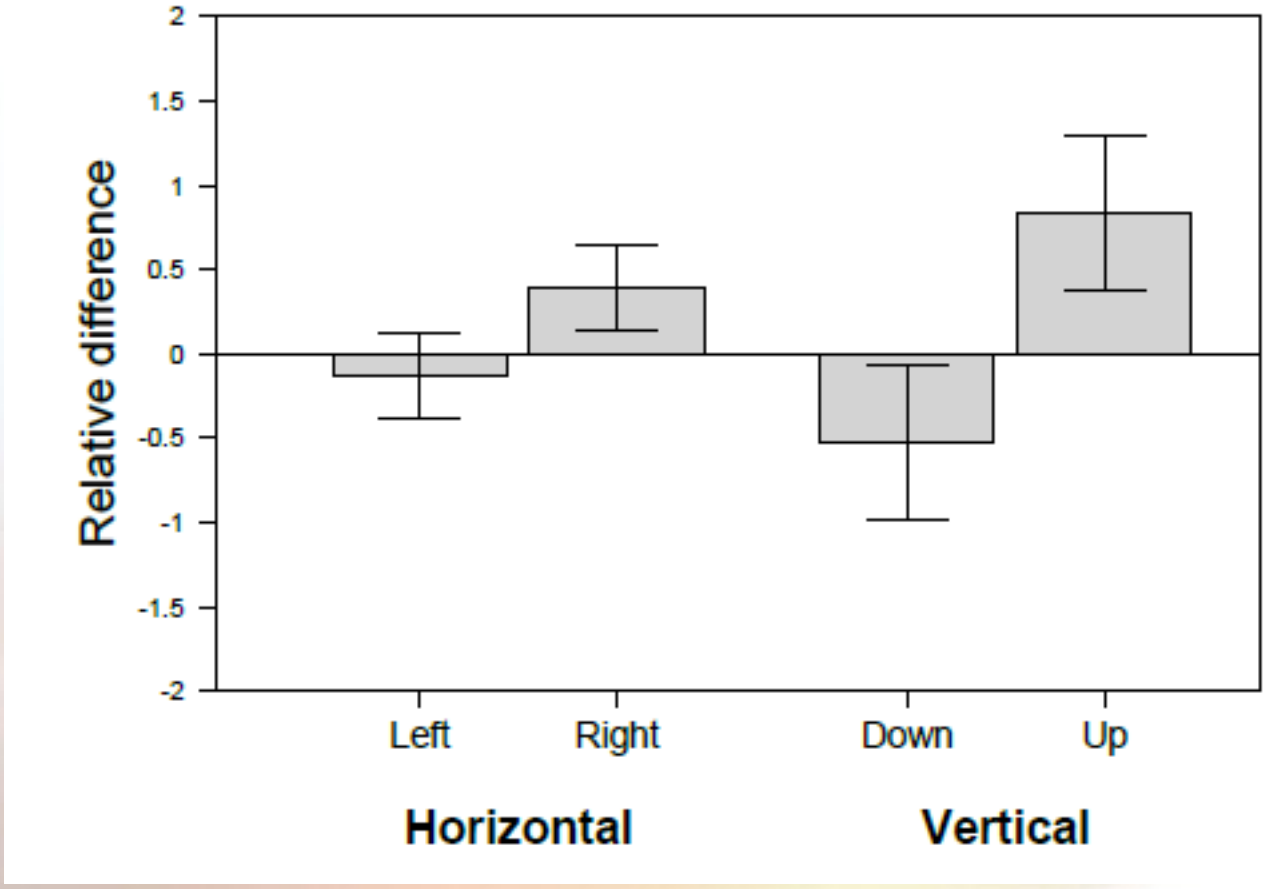


Vertical Space in Emotional Valence and Numbers

Random Numbers In Vertical Space

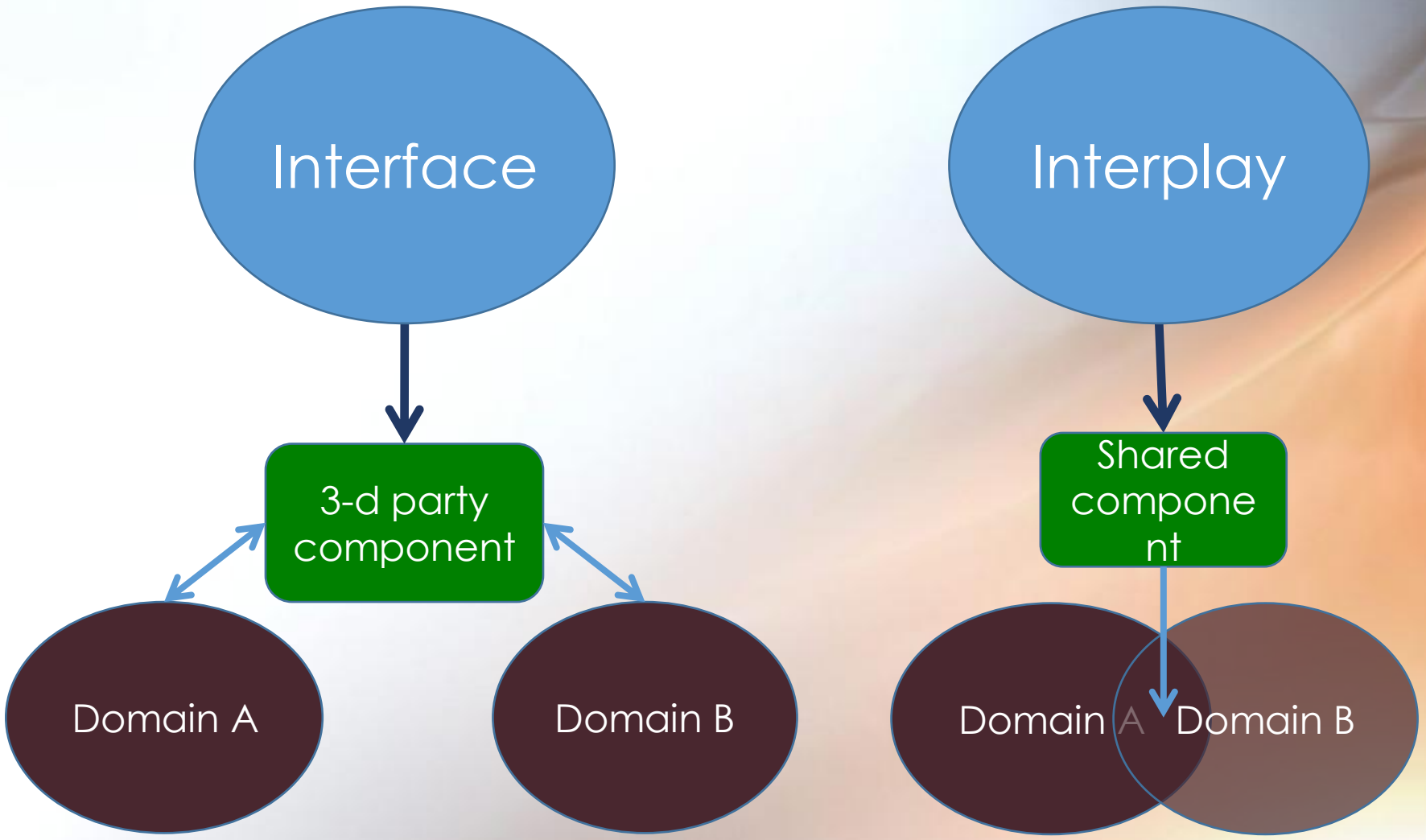
(Winter & Matlock 2013)





Principles for Representational Interactions

(Myachykov, Chapman, & Fischer, *under review*)



Magnitude and Valence

(Myachykov, Chapman, & Trueman, *ongoing*)

DESIGN

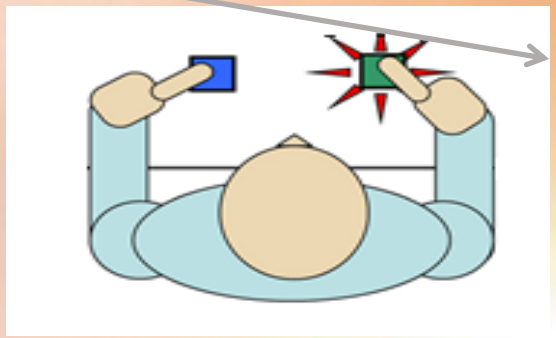
WORD VALENCE

	positive	negative
small	*incongruent*	*congruent*
large	*congruent*	*incongruent*

NUMBER

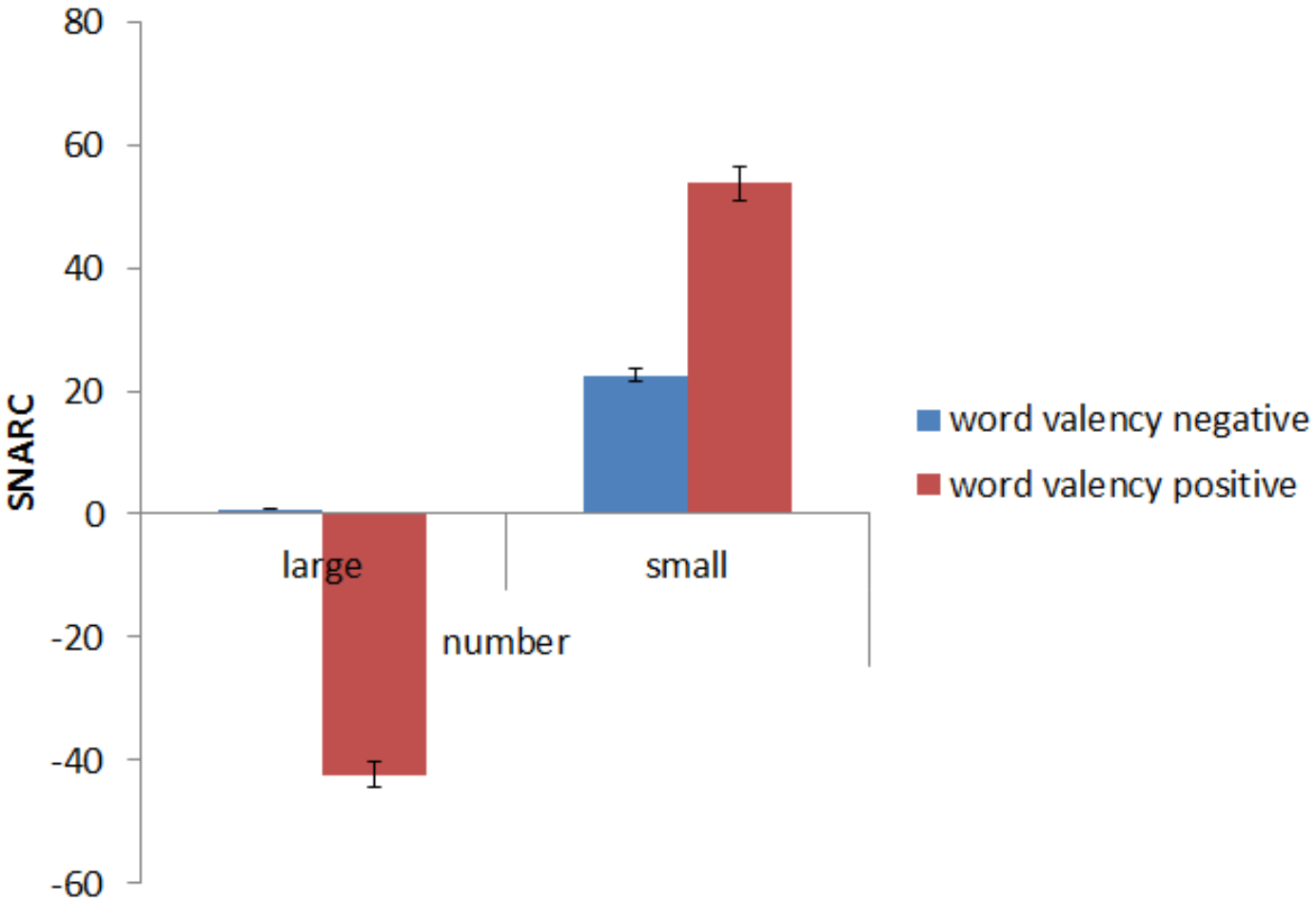
MATERIALS

positive	negative
gift	*victim*



From: Bradley & Lang (1999)

Magnitude x Valence



$F(1,15)=5.604$, $p=.032$

- ✓ Interaction between valence and magnitude via shared attentional bias

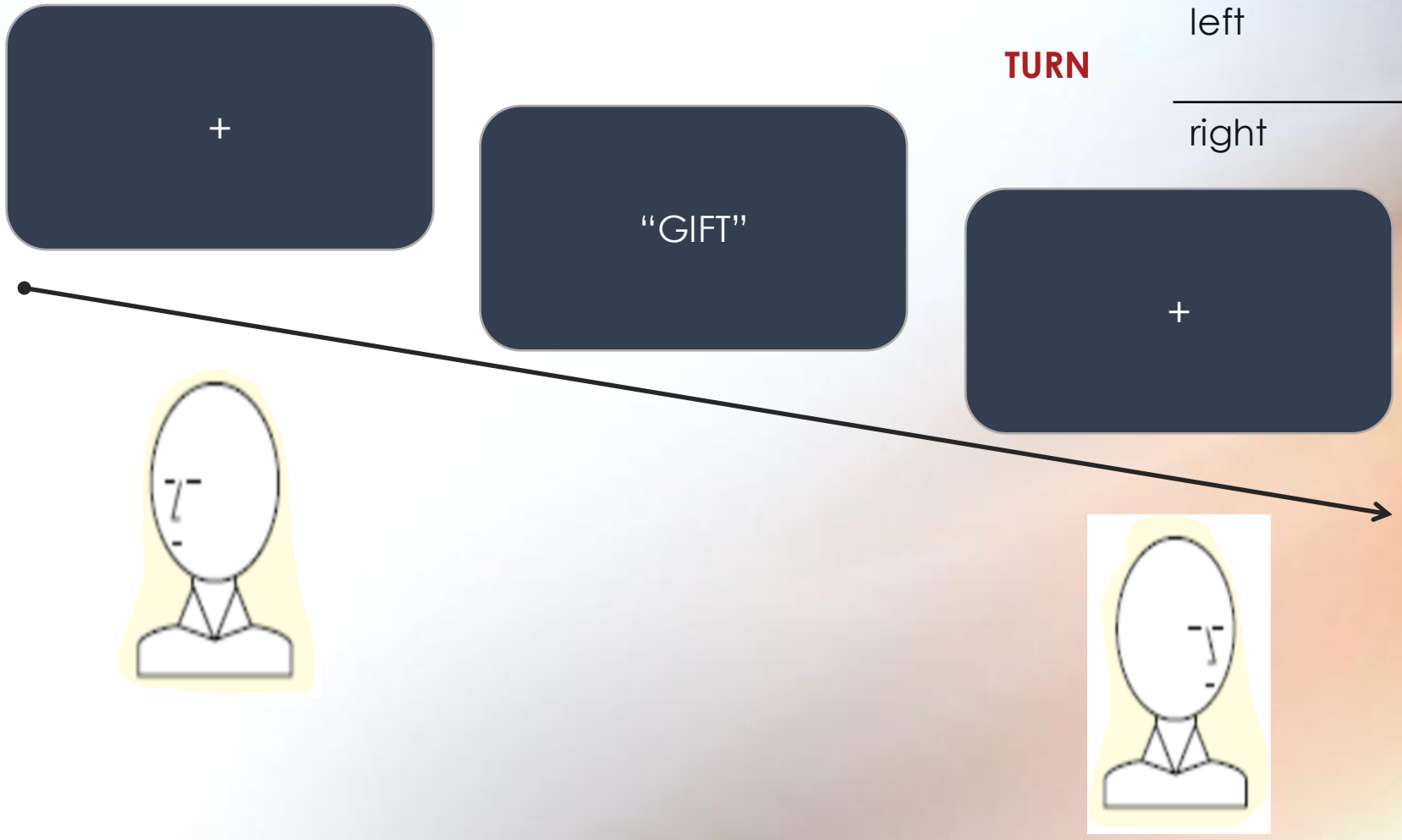
Magnitude and Valence in Your Head

(Myachykov, *ongoing*)

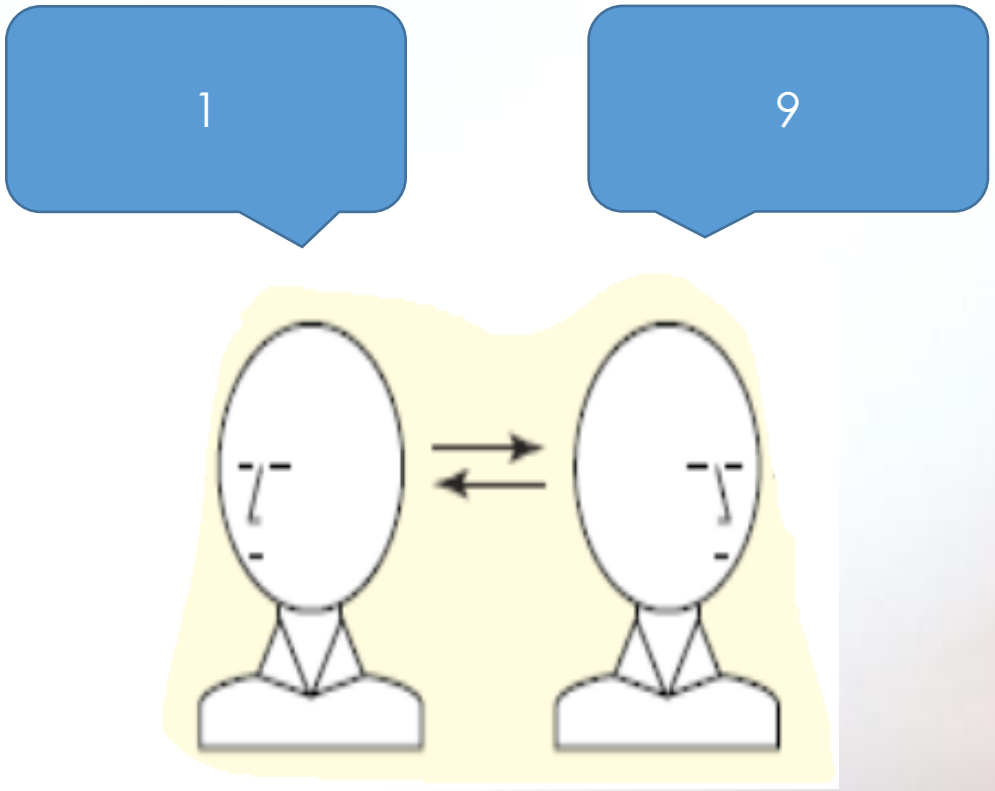
DESIGN

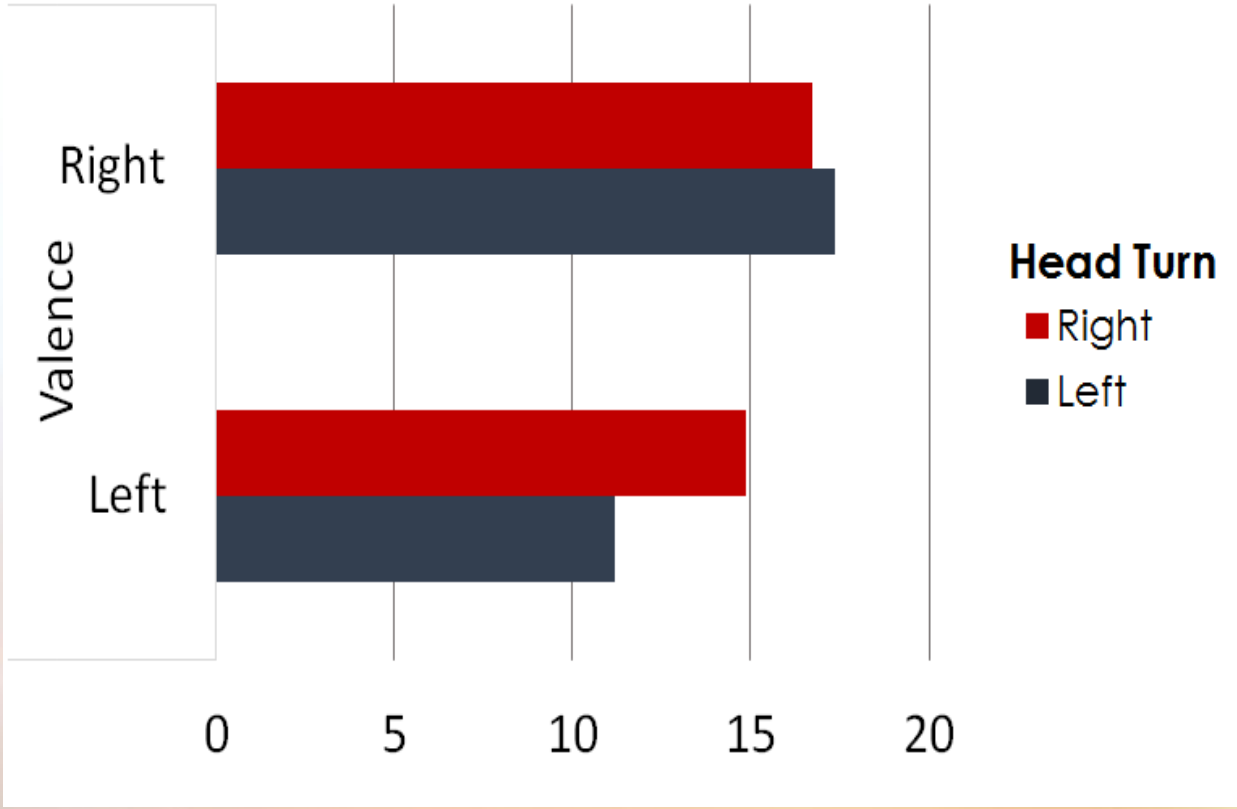
TURN

	WORD VALENCE: positive	WORD VALENCE: negative
left	*incongruent*	*congruent*
right	*congruent*	*incongruent*

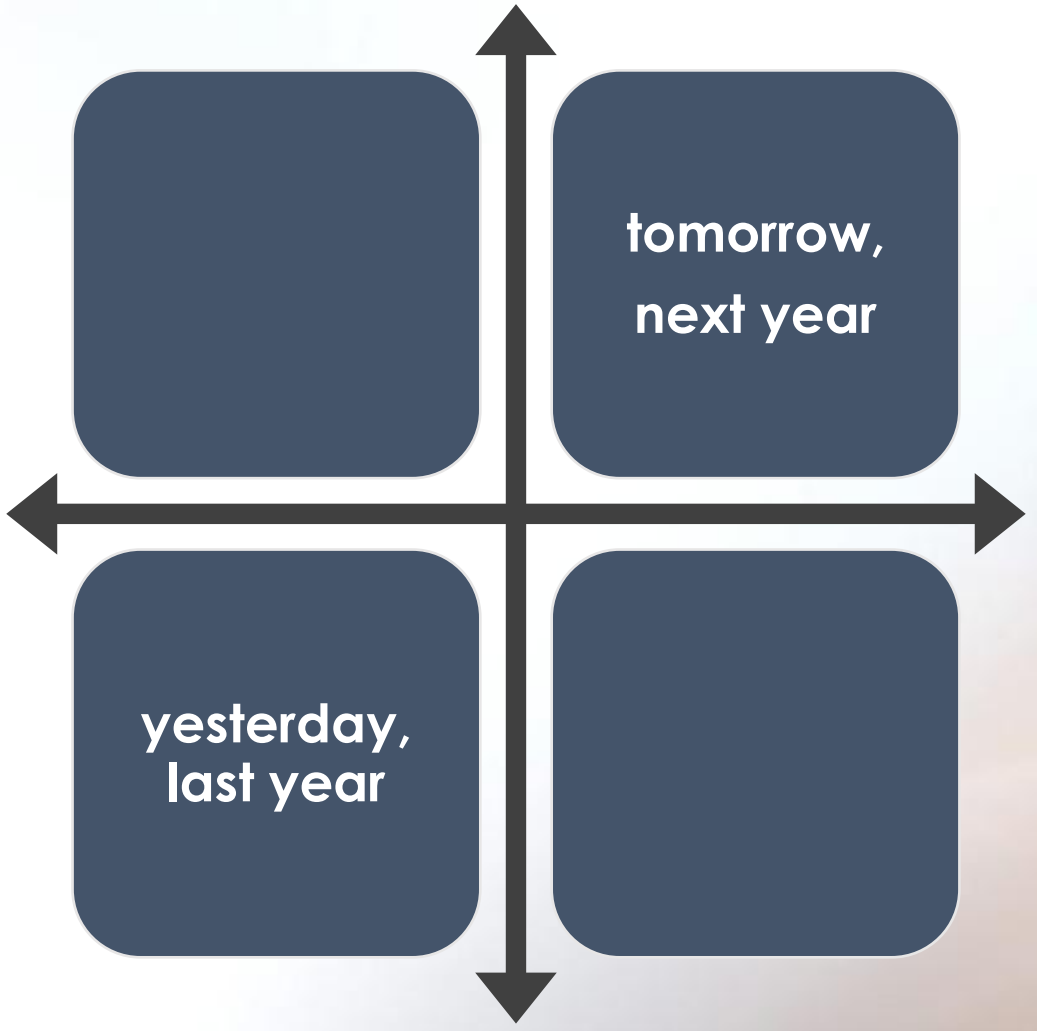


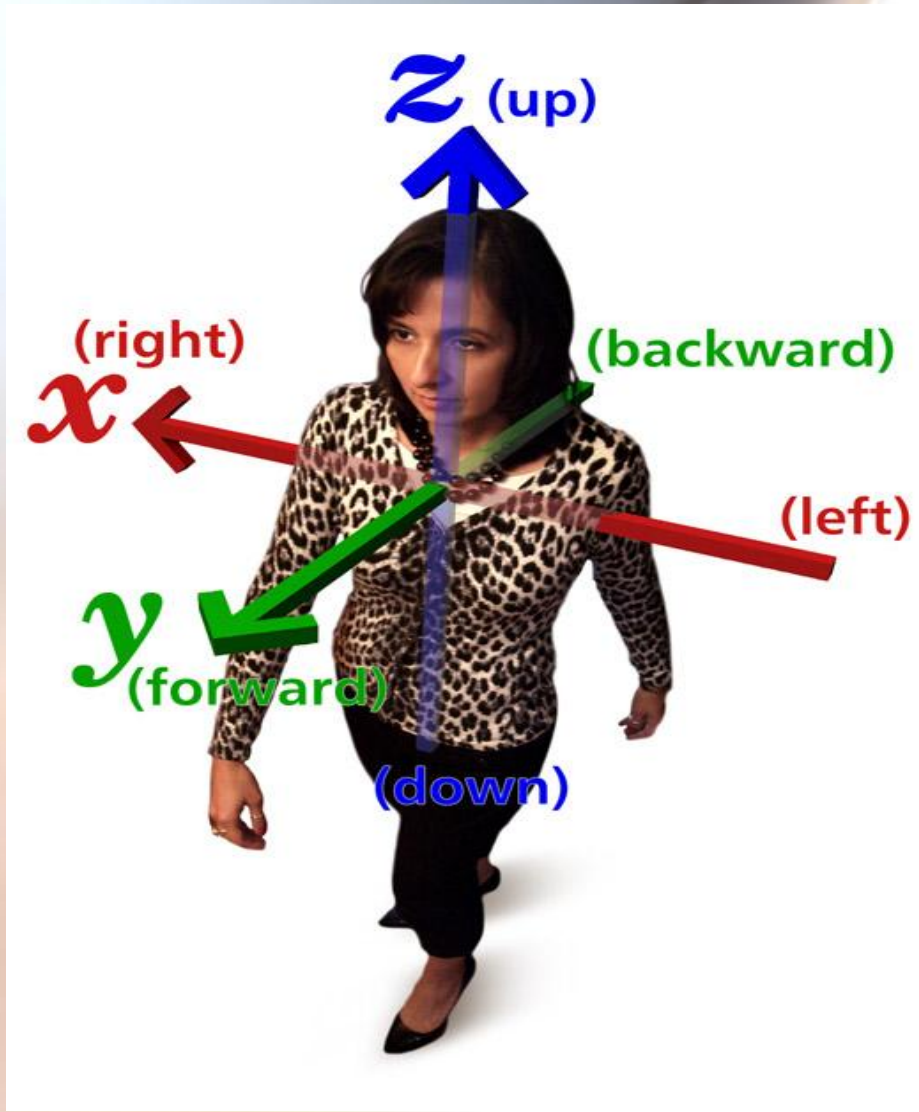
Magnitude and Valence in Your Head





Visuospatial Simulation of Time





Magnitude and Time

(Chapman & Myachykov, *in prep*)

SYNTACTIC TIME

DESIGN

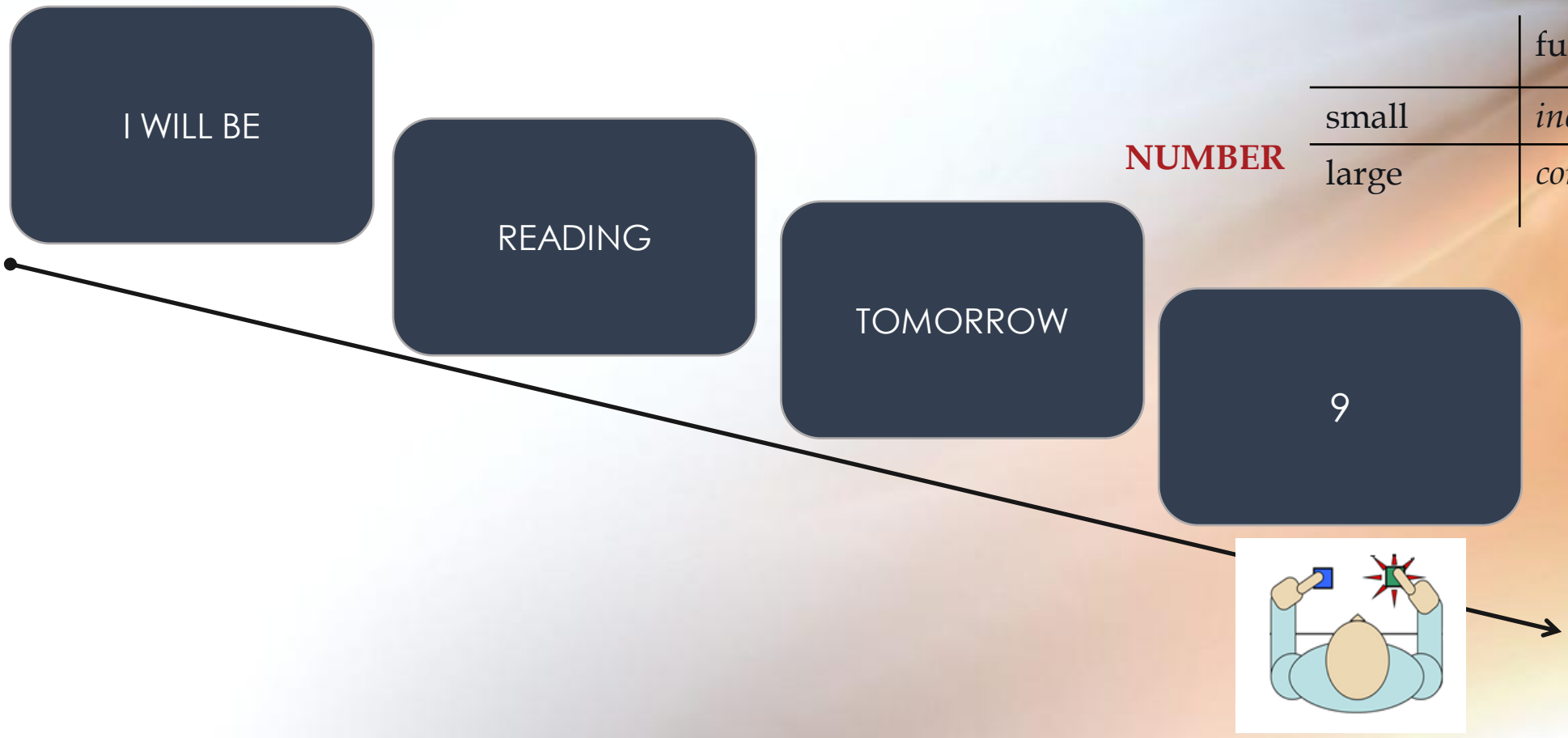
	future	past
small	*incongruent*	*congruent*
large	*congruent*	*incongruent*

NUMBER

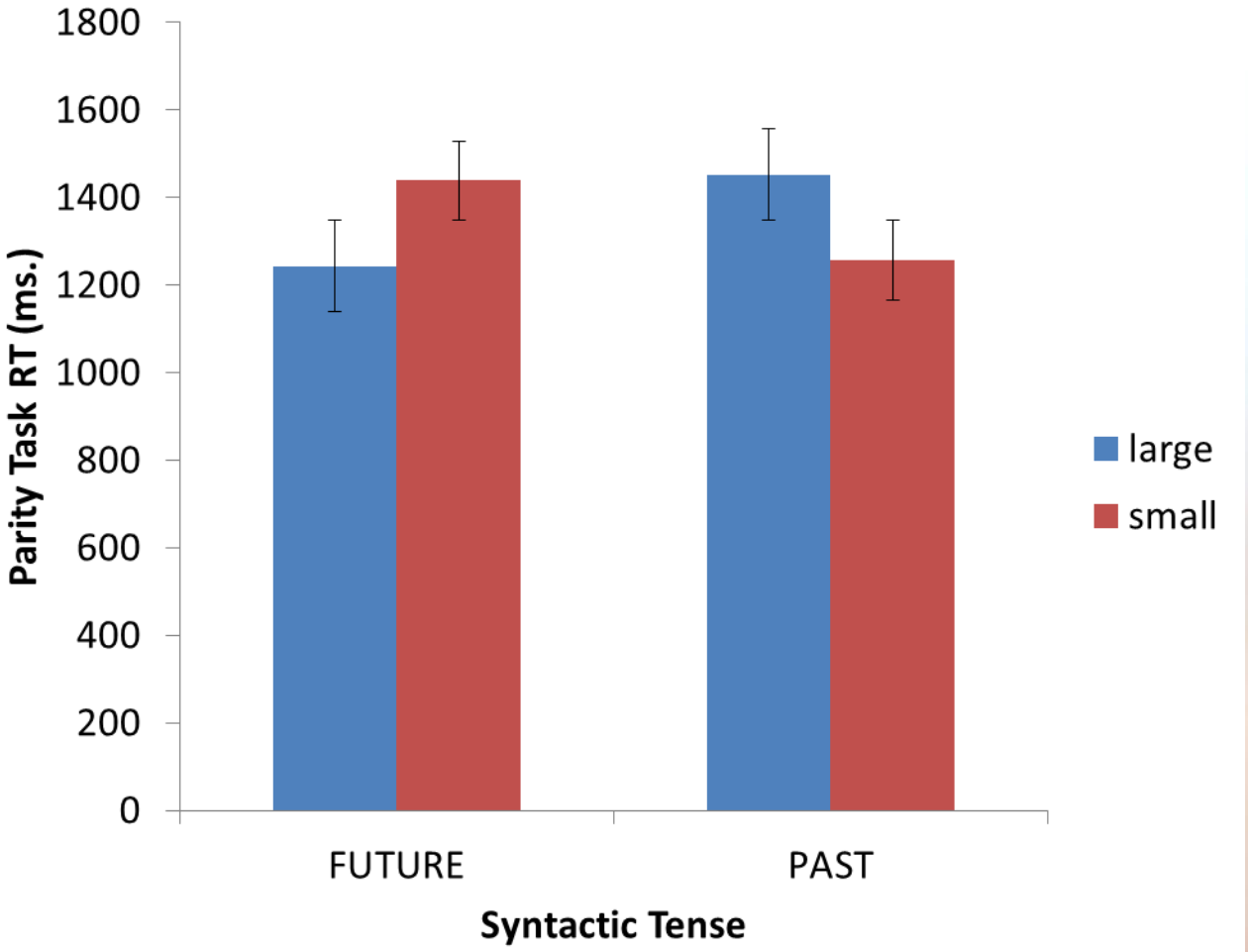
SEMANTIC TIME

NUMBER

	future	past
small	*incongruent*	*congruent*
large	*congruent*	*incongruent*



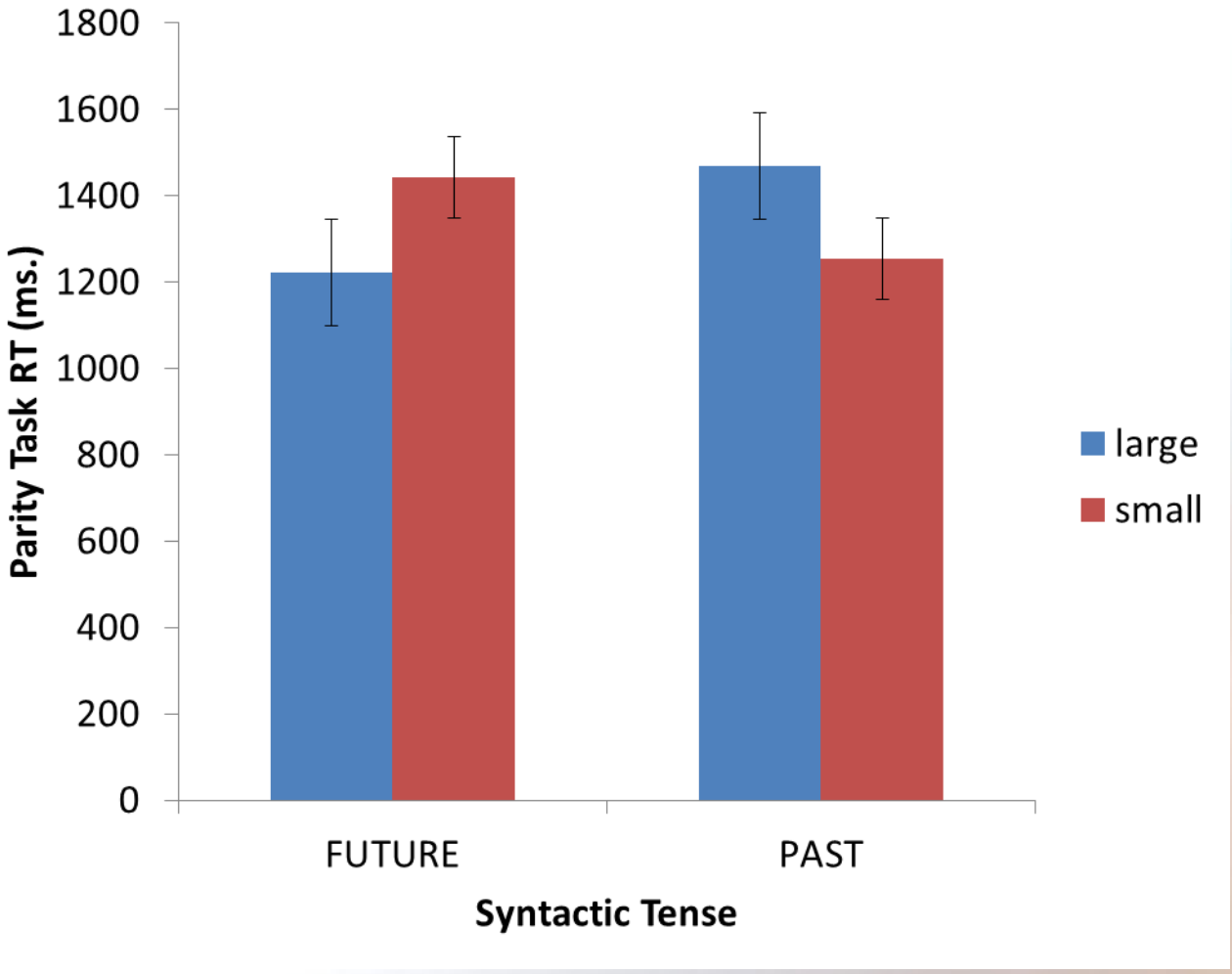
Syntactic Tense x Number Magnitude



$F(1,23)=36.625$, $p<.001$

✓ Understanding syntactic tense orients attention

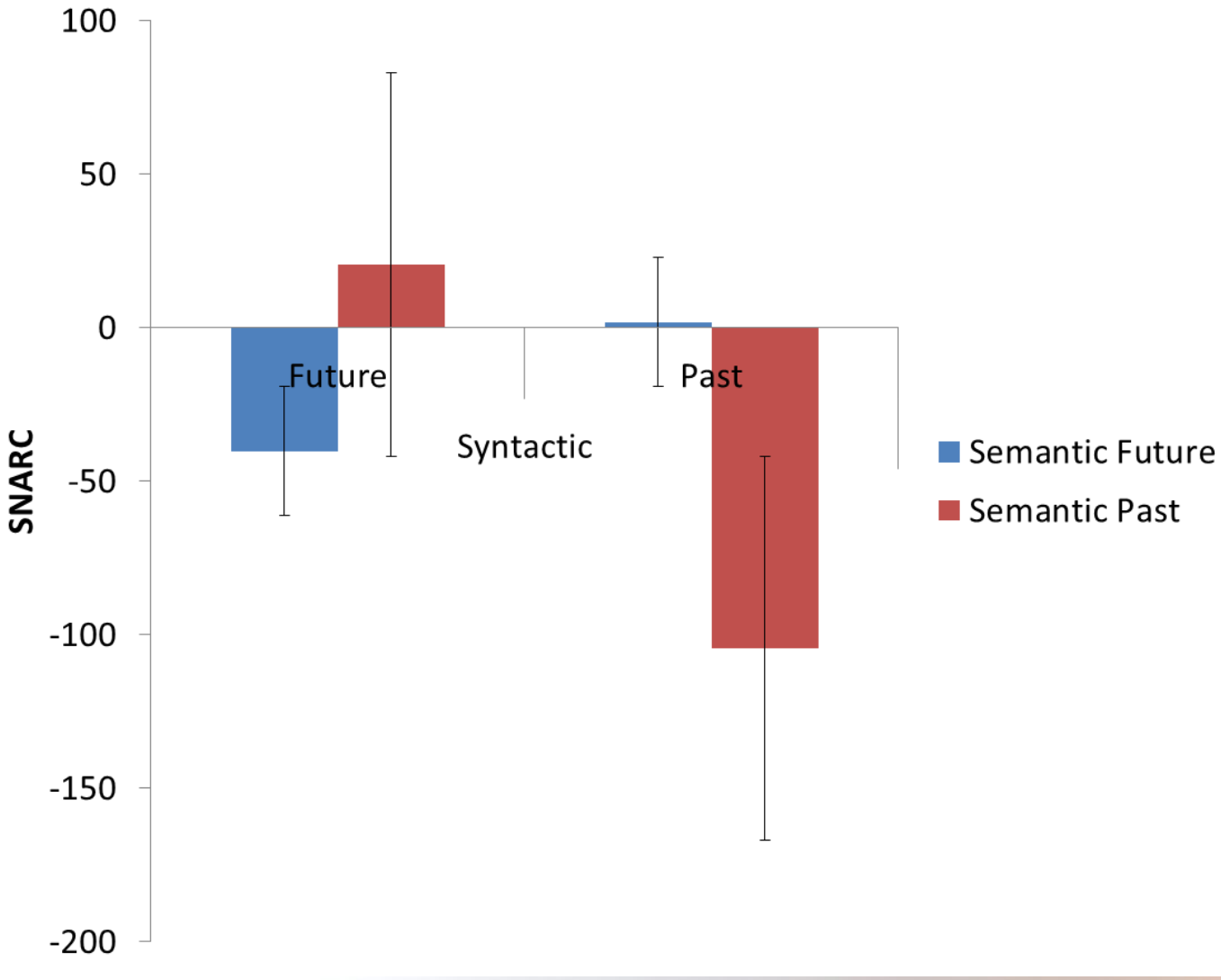
Semantic Time x Number Magnitude



$F(1,23)=30.813$, $p<.001$

- ✓ Understanding temporal semantics orients attention

Syntactic Time x Semantic Time



$F(1,23)=3.649$, $p=.069$

- ✓ Interaction between syntactic tense x temporal semantics orients attention

Magnitude and Time in Your Head

(Myachykov, *in prep*)

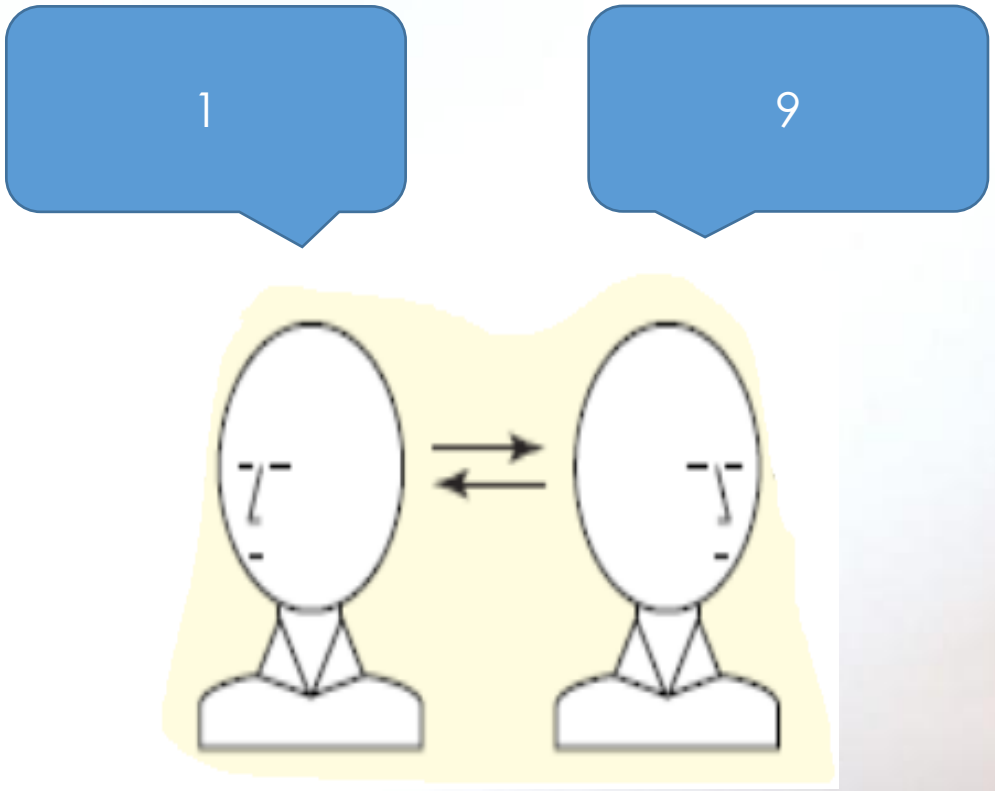
DESIGN

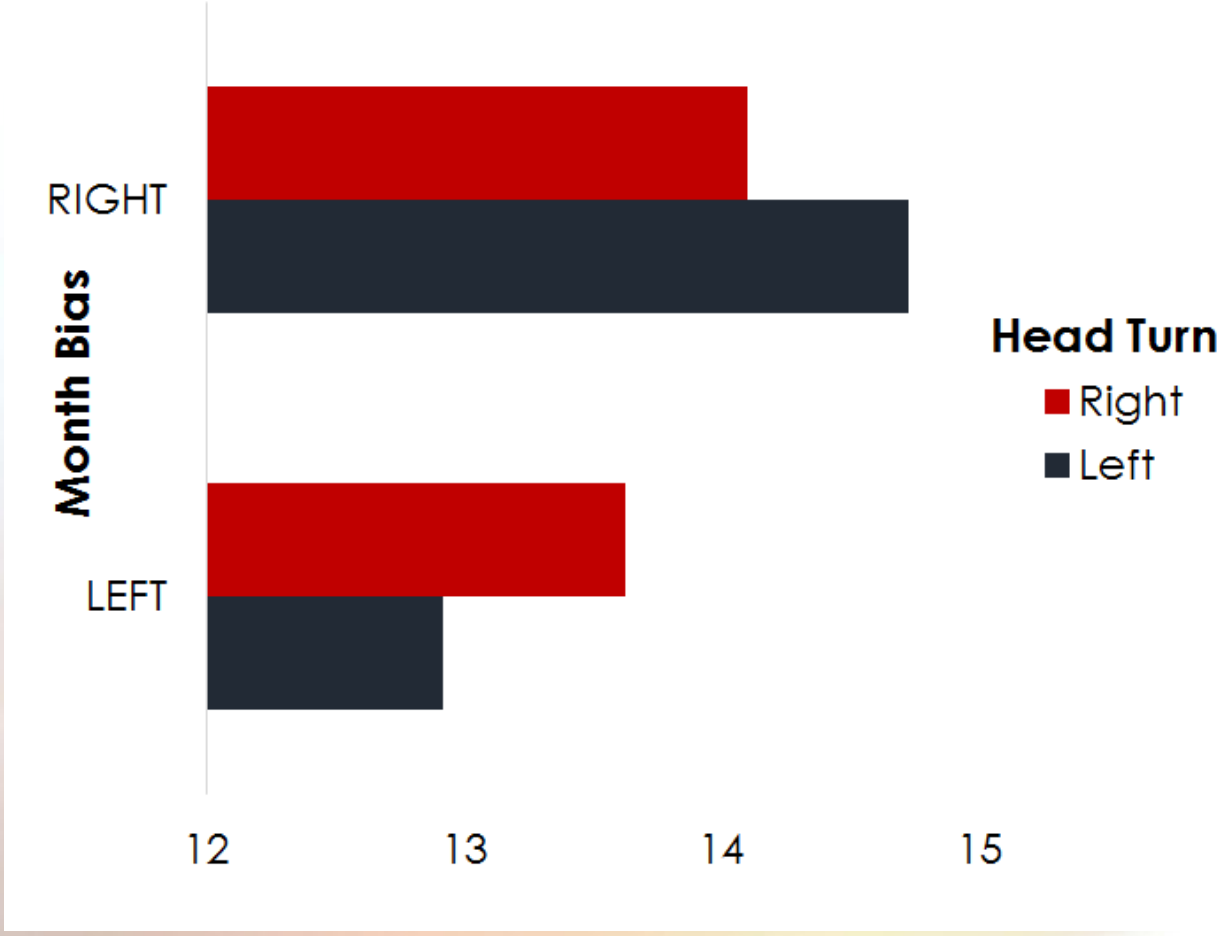
MONTH

	Jan - Jun	Jun - Dec
Left	*congruent*	*incongruent*
Right	*incongruent*	*congruent*

TURN

Magnitude and Time in Your Head

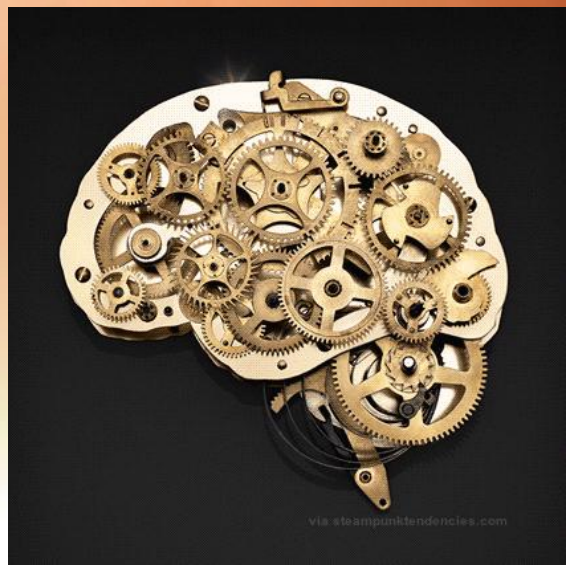




Conclusions

✓**ACCESSING CONCEPTUAL KNOWLEDGE INVOLVES ACTIVATING ASSOCIATED VISUOSPATIAL BIASES**

- Spatial semantics
- Emotional valence
- Numerical magnitude

✓**CO-ACTIVATED REPRESENTATIONS INTERPLAY VIA SHARED VISUOSPATIAL BIASES.**

- Numerical magnitude and emotional valence
- Numerical magnitude and time