10: MEASURING GUIDED SEARCH PARAMETERS IN ECOLOGICAL CONTEXT WITH MOBILE EYE-TRACKING
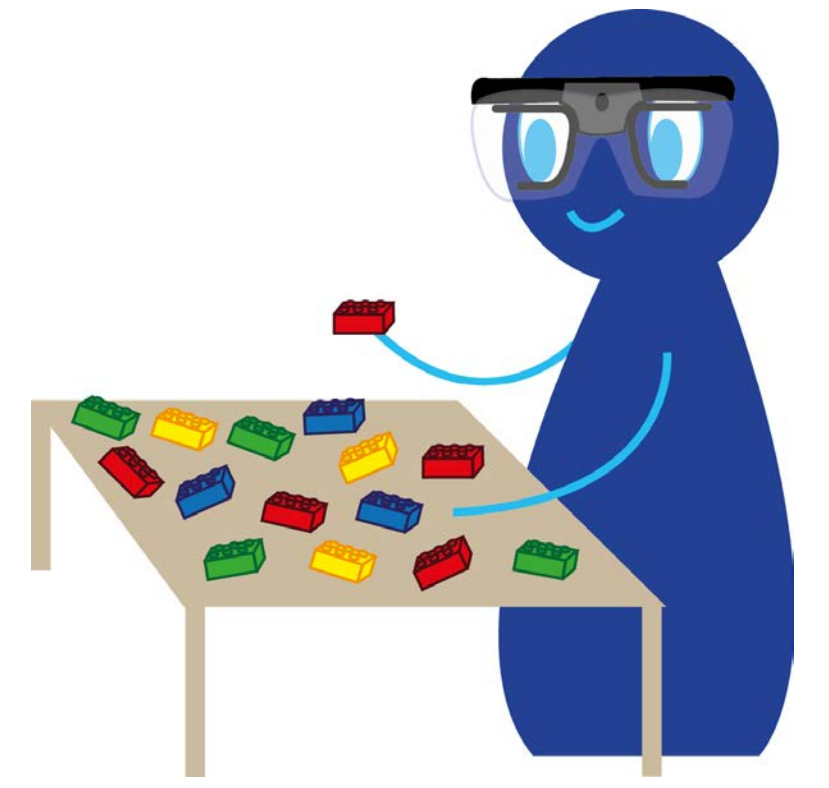
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Guided Search Theory

- Humans routinely look for specific objects among irrelevant objects—a process known as "visual search"
  - Examples: assembling IKEA® furniture, looking for suspicious objects using airport security scanners
- Attentional deployment is "guided" by features of targets together with expectations about likely locations of objects in a scene (Wolfe, 2015)
  - Features and quantities of objects and distractors, expectations, and the number of different targets together define a continuum of visual search efficiencies
  - Efficiency is usually measured as the relation of reaction time (RT) to number of objects (set size)
- **Hybrid search model** (Wolfe, 2012): RT is *linearly* related to the number of distractors (visual set size, VSS) and to logarithm of the number of targets held in memory (memory set size, MSS)
- **Problem**: is it possible to measure visual search parameters in a real-world sensorimotor task and establish the linear relationships predicted by guided search theory?
  - Guided search is usually observed in laboratory settings, where discrete objects are presented on a computer screen
  - Figure 1 illustrates the shape of linear relationships predicted by hybrid search model for different "collection types" (Wolfe et al., 2016)

Method

- 12 participants wearing a Tobii® Pro Glasses 2 mobile eye tracker (60 Hz sampling rate) assembled three LEGO® figures of eight assembly steps in a within-participant setup
- Search patch was presented as a tray with target and distractor blocks, which was shuffled between steps

References
- Wolfe, J. M. (2012). Saved by a log: How do humans perform hybrid visual and memory search? *Psychological Science, 23*(7), 698-703.
- Wolfe, J. M. (2015). Visual search. In J. M. Fawcett, E. F. Risko & A. Kingstone (Eds.), *The handbook of attention* (pp. 27-56). Cambridge, MA: The MIT Press.
- Wolfe, J. M., Aizenman, A. M., Boettcher, S. E. P., & Cain, M. S. (2016). Hybrid foraging search: Searching for multiple instances of multiple types of target. *Vision Research, 119*, 50-59.
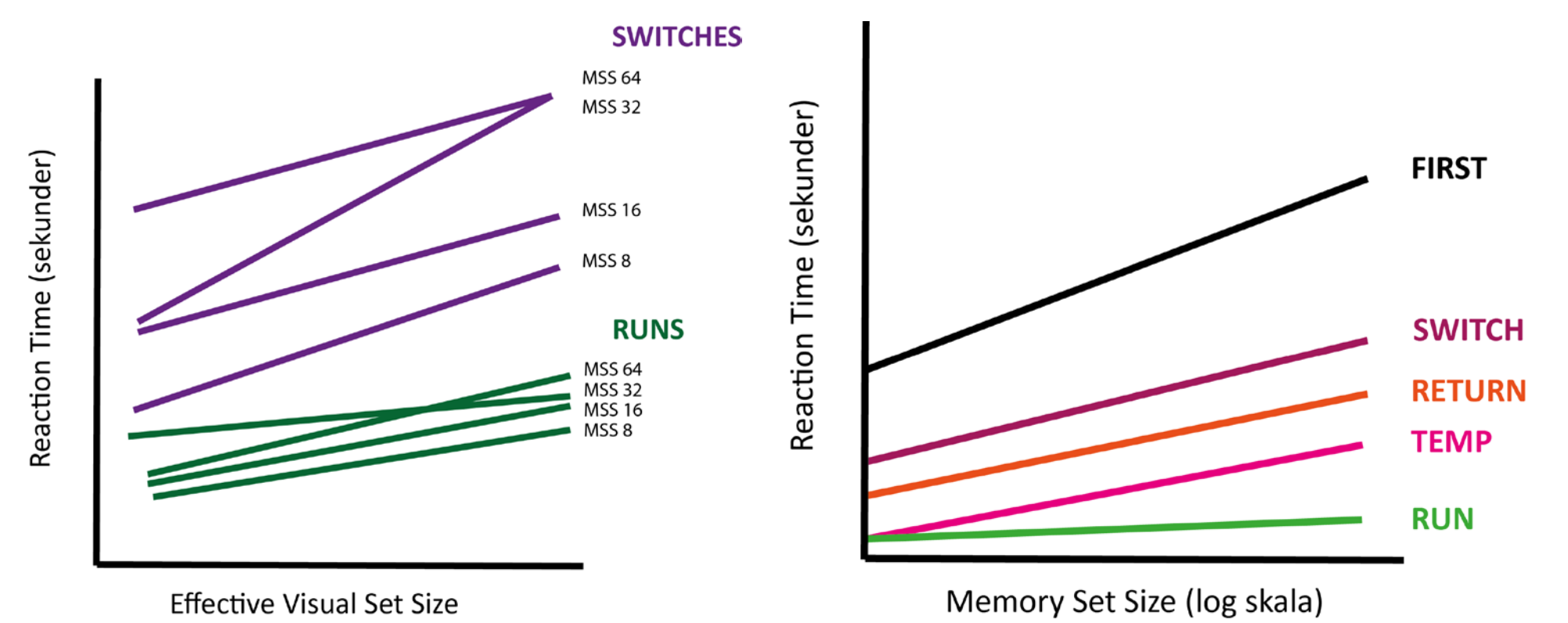
Figure 1: Linear relationships predicted by hybrid search theory

Parameter Measurement

- Straightforward VSS and MSS definitions
  - MSS is defined by the instruction (LEGO® assembly guide); Effective VSS (eVSS) equals number of visible bricks divided by number of possible targets
- Reaction time extracted by manual frame-by-frame analysis of gaze overlay videos (with high interrater agreement)
- <u>How to define RT?</u>
  - Trial begins when cover is removed from the tray; RT is measured from start of first fixation in the tray, or from points related to previously *collected* target
  - **RTF**: From start of first fixation on previous target (p.t.) to start of first fixation on current target (c.t.)
  - **RTS**: From start of last fixation on p.t. to start of last fixation on c.t.
  - **RTT**: From first touch of p.t. to first touch of c.t.
  - **RTFS**: Average of RTF and RTS

	RTF		RTS		RTT		RTFS	
	Estimate	p-value	Estimate	p-value	Estimate	p-value	Estimate	p-value
Intercept	-0.1466	0.5235	0.344	0.0001	0.8227	0.0002	0.3939	0.0827
Effective Visual Set Size	0.0109	$< 2 \times 10^{-16}$ *	0.0127	$< 2 \times 10^{-16}$ *	0.0109	$< 2 \times 10^{-16}$ *	0.0118	$< 2 \times 10^{-16}$ *
Memory Set Size	0.4065	6.36×10^{-5} *	0.3656	0.0006 *	0.3849	8.31×10^{-5} *	0.3861	0.0001 *
Run	0.3688	0.0072 *	-0.5241	0.0003 *	-0.5520	3.19×10^{-5} *	-0.0776	0.5655
Switch	1.9036	$< 2 \times 10^{-16}$ *	0.7978	6.49×10^{-5} *	0.9053	6.57×10^{-7} *	1.3507	8.13×10^{-13} *
Temp	1.9344	0.0111 *	-0.0981	0.9030	0.5629	0.4418	0.9181	0.2213

Table 1: Linear models of RT against eVSS and log(MSS) for different RT measurements

Which RT is Valid?

- The predicted linear relationships are observed (Table 1), coefficient signs are consistent
- Conceptually, RTT is the closest to key press
- RTF, RTS and RTT are less robust, but RTFS is a statistical construction
- None of the methods isolates "cognitive" RT from sensorimotor activity inherent in the task