Why the eyes rotate in their sockets

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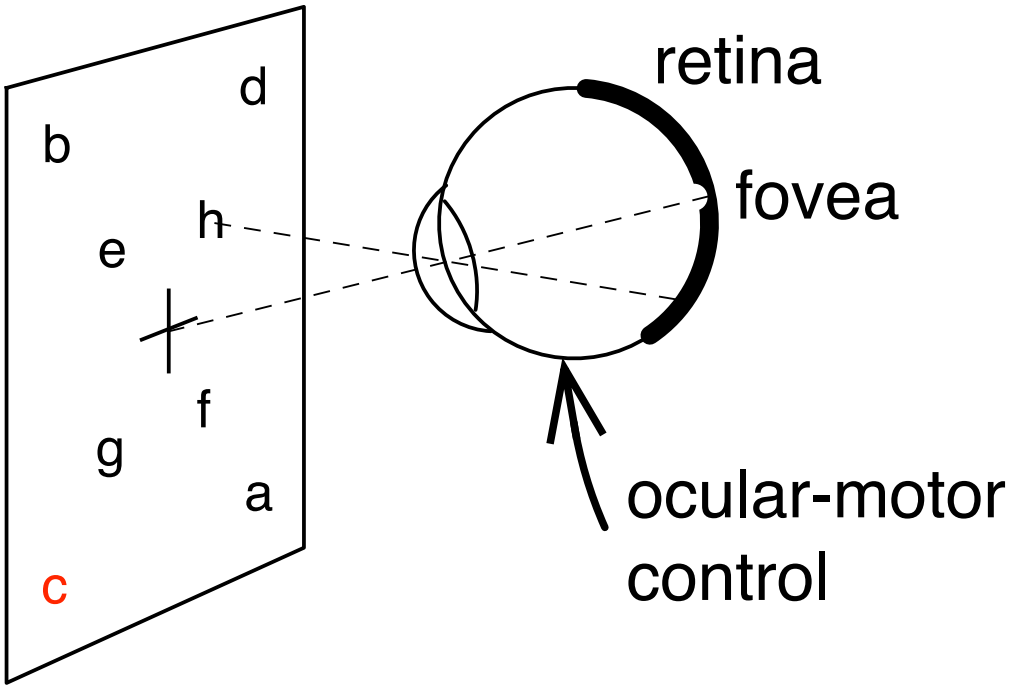
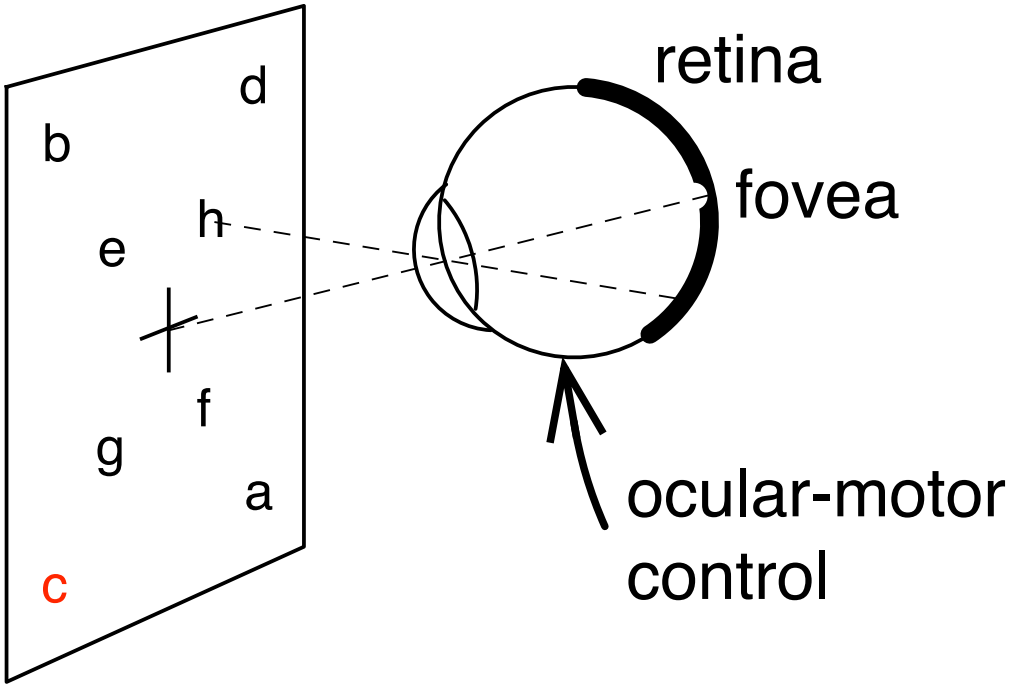
The eyes rotate in their sockets to orient high-resolution vision towards items of interest.



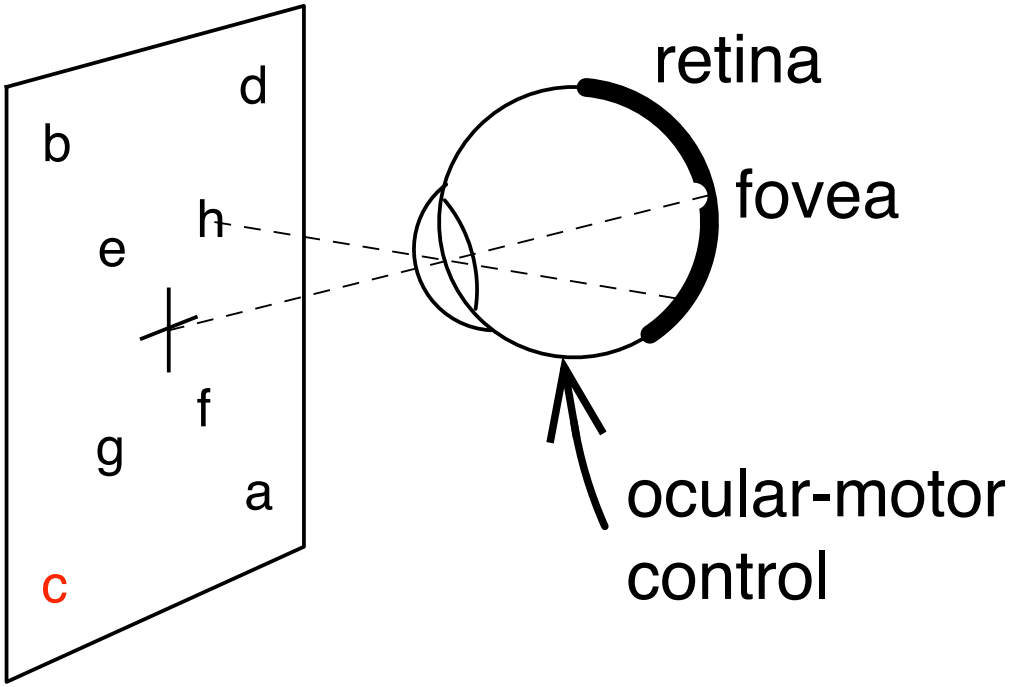
- The eyes are oriented with quick saccades (≈25-50 ms), and visual information is perceived during fixations (≈200-400 ms).
- Eye movements are generally motivated by strategic decisions to acquire perceptual information needed for a task.

The eyes rotate in their sockets to orient high-resolution vision towards items of interest.



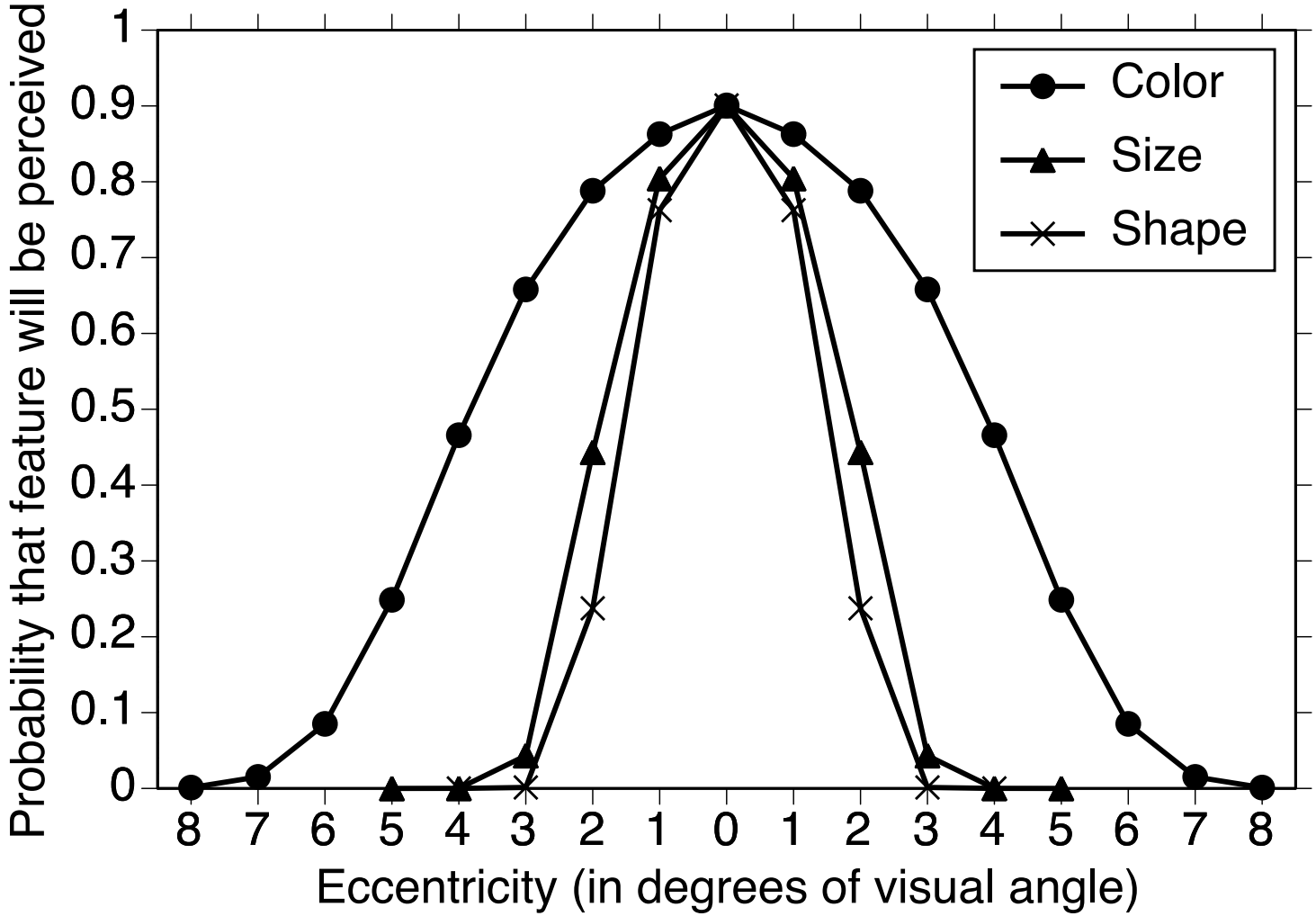
- For example, if you ask someone to fixate the crosshairs, he or she will execute a strategy to issue the saccades needed until it is perceived that the center of the crosshairs are being viewed in as much detail as possible.
- If you ask someone to look at the *h*, they will make strategic eye movements until *h* is in high resolution vision.

The eyes rotate in their sockets to orient high-resolution vision towards items of interest.



- Eye movements are determined by (a) predictions of how the world is organized and (b) availability functions that determine the probability that an object's feature can be perceived.
- Availability functions are influenced by:
  (a) the distance to the object,
  (b) the feature in question,
  (c) the size of the object, and
  (d) the density of other nearby objects.

Visual-perceptual availability functions



The probability that a feature can be perceived as a function of its eccentricity from the current point of gaze. Color is more available than size or shape. These values were estimated to model a particular icon search task (Kieras & Hornof, *CHI 2014*).

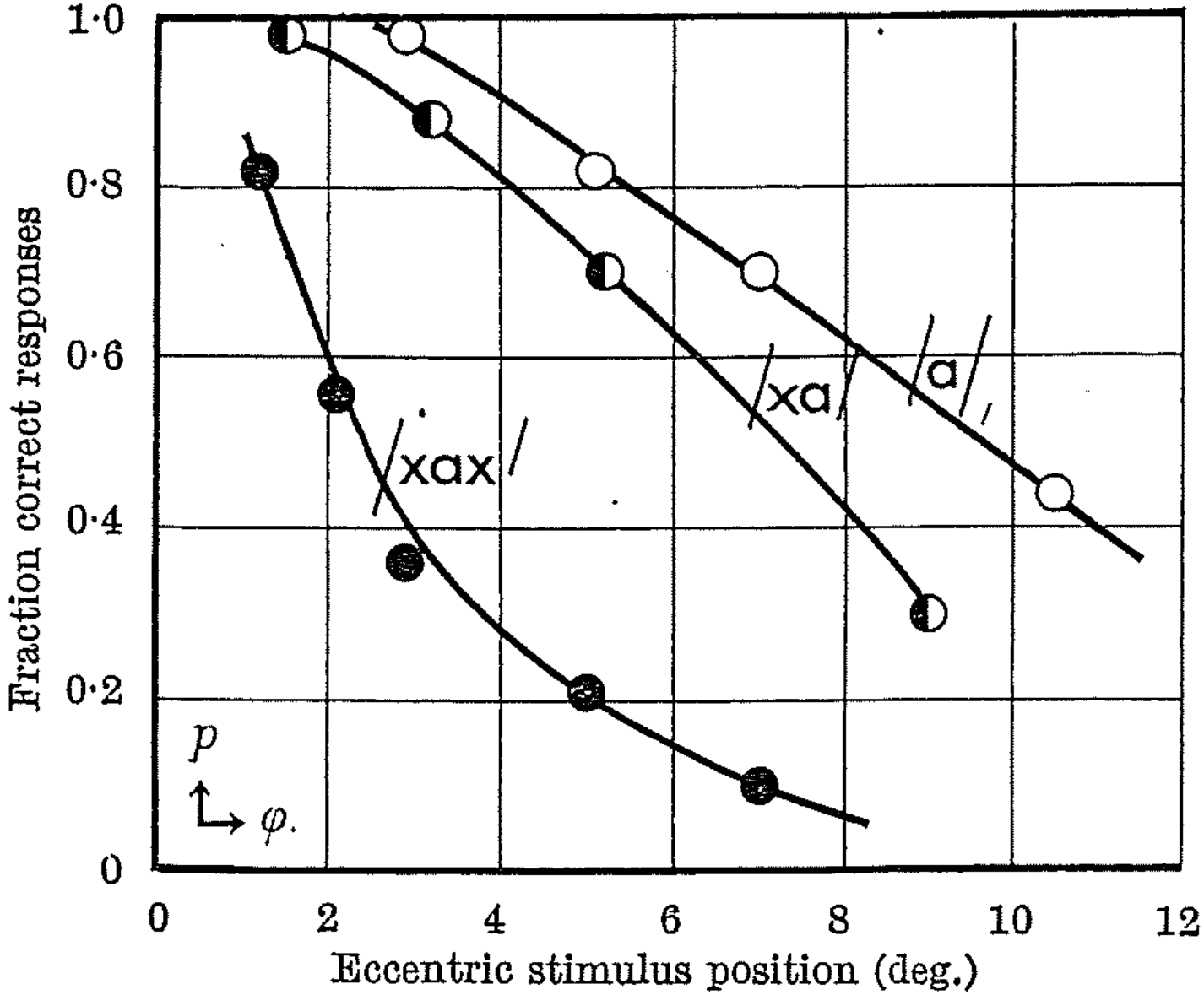


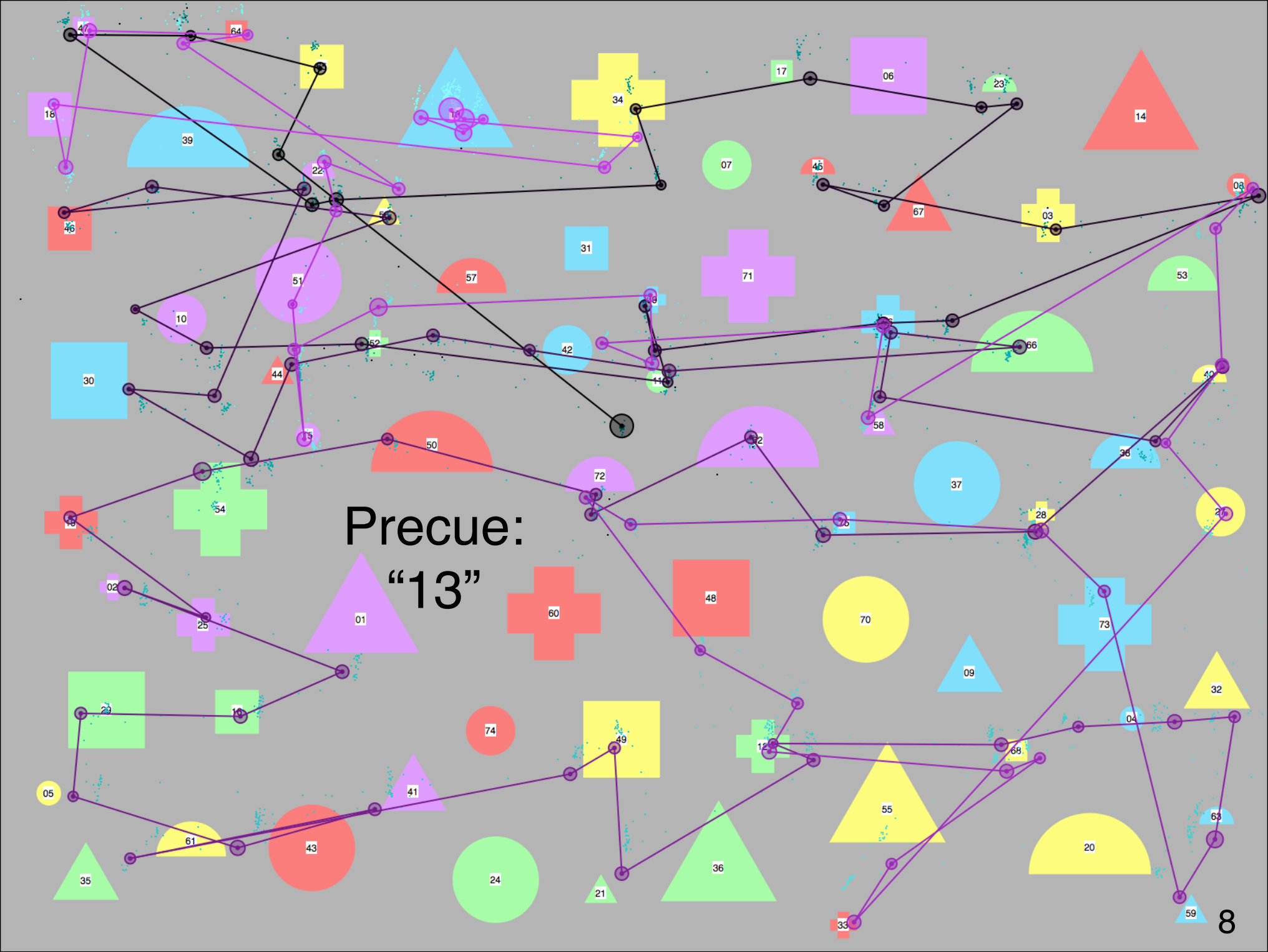
Fig. 1. Fraction of correct letter responses as a function of retinal eccentricity of the stimulus. Scores decrease substantially when the stimulus is flanked at normal spacing on one side (the foveal side) (*/xa/*) or at both sides (*/xax/*). Observer, H. B.

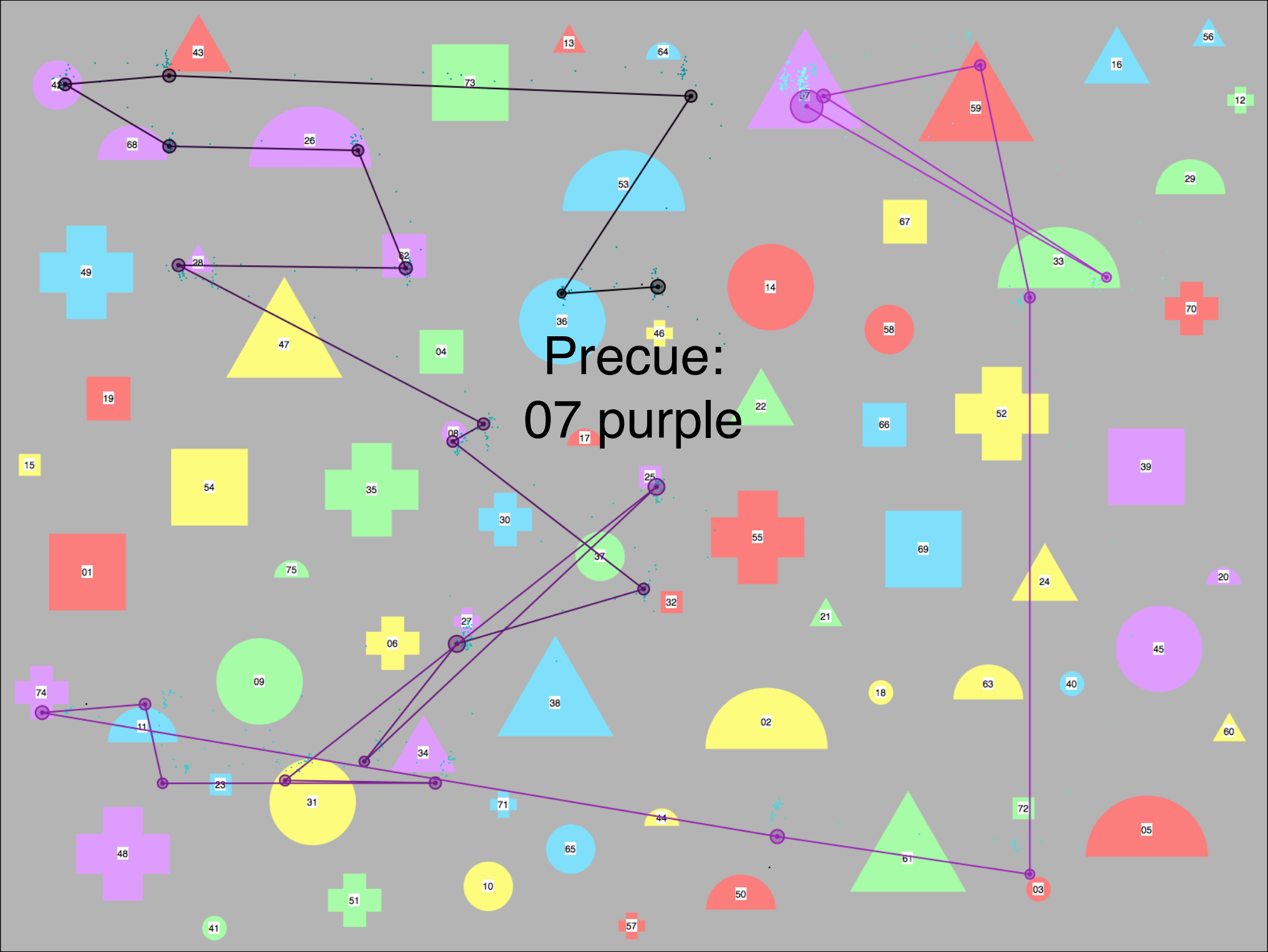
200 ms presentation (Bouma, 1970)

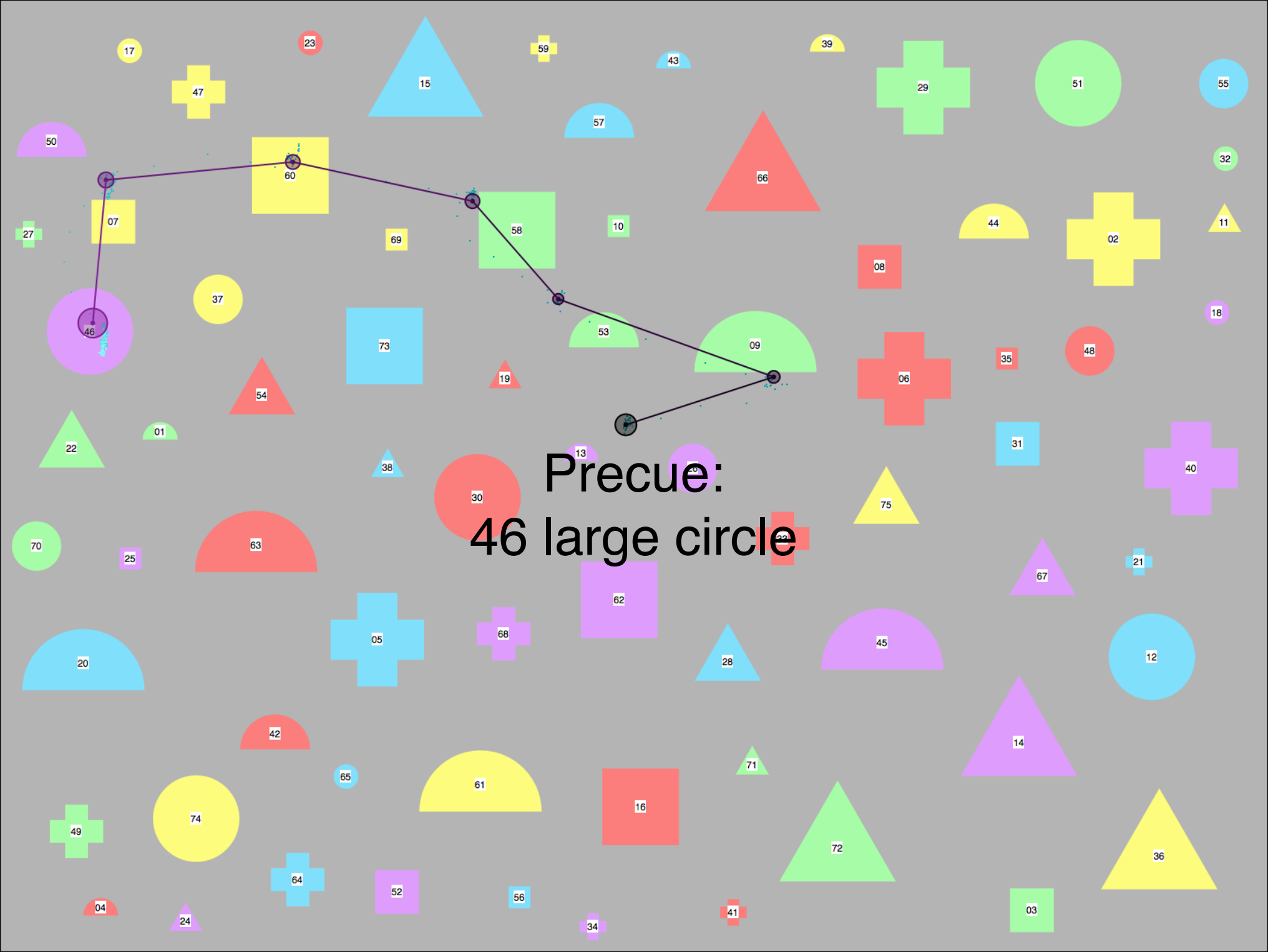
What this means for visual search in an unstructured unfamiliar visual field

In general, people can find things the fastest if they know the color of the “target”. But knowing the size and shape help, too. If people have to study the fine detail of objects, search tends to be slow.

We ran an experiment in which we presented participants with screens of 75 objects, each with a unique number, and a unique combination of color, shape, and size. The objects were randomly re-positioned for every trial. Participants were “precued” with the target object’s number, and sometimes other visual features of the target, and asked to find the target quickly. We recorded their eye movements and studied their visual “scanpaths”.

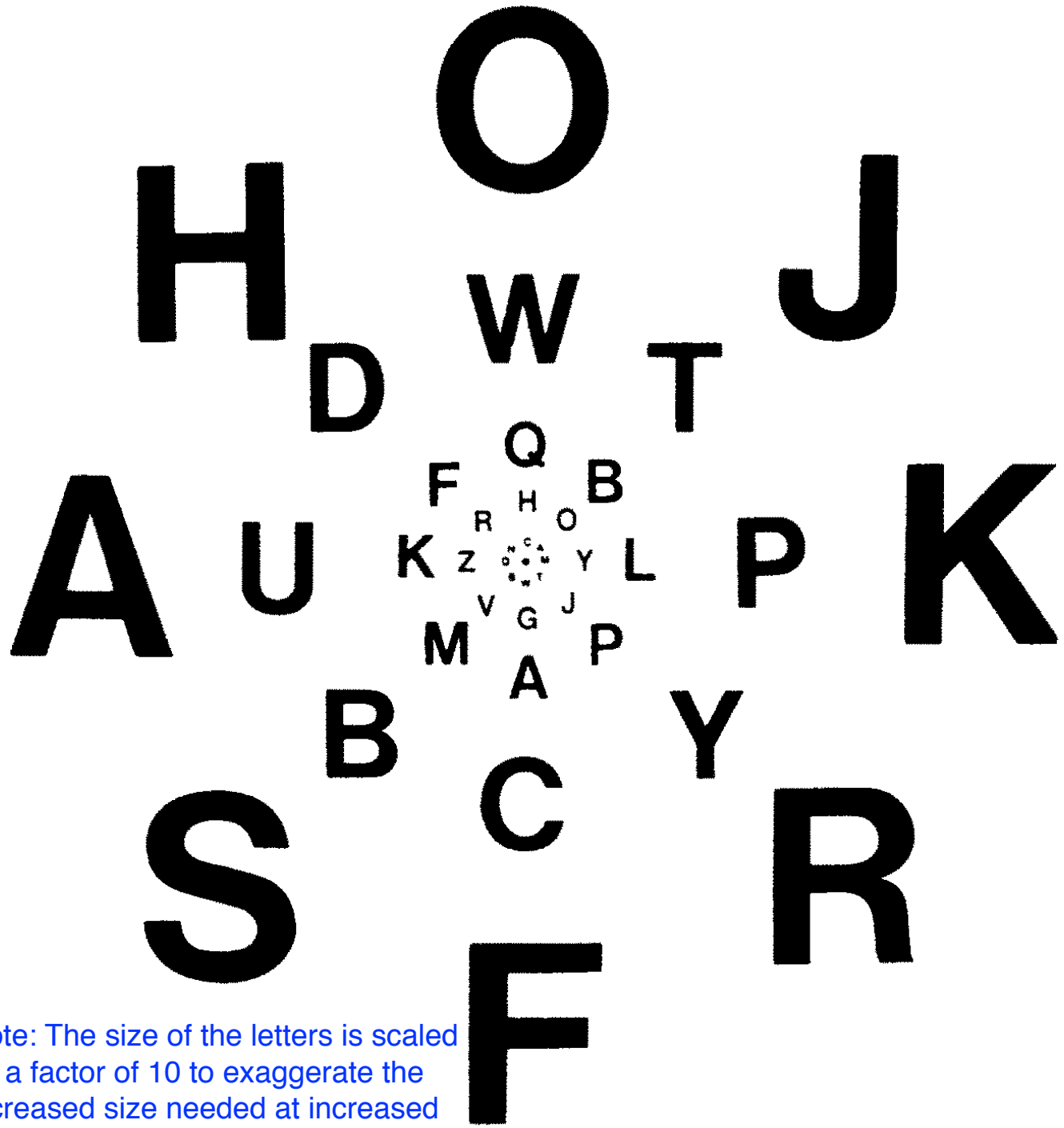

Precue:
“13”


Precue:
07 purple


Precue:
46 large circle

Look at the dot in the center. All letters should be equally available.

An object's size interacts with the availability of other visual features of the object. In other words, object-features (such as color and shape) will remain available as the objects move away from the point of gaze provided that the objects are made large enough.



Note: The size of the letters is scaled by a factor of 10 to exaggerate the increased size needed at increased distances (Rosenholtz, 2016)

Anstis (1974)

Visual availability interacts with **cognitive strategies:**

People interact with the world by executing cognitive strategies.

Cognitive strategies **...**

... are plans that coordinate perceptual, motor and memory processes to accomplish tasks.

... are sometimes conscious, sometimes subconscious.

... usually have a goal state.

... can be complex, such as for dual task performance.

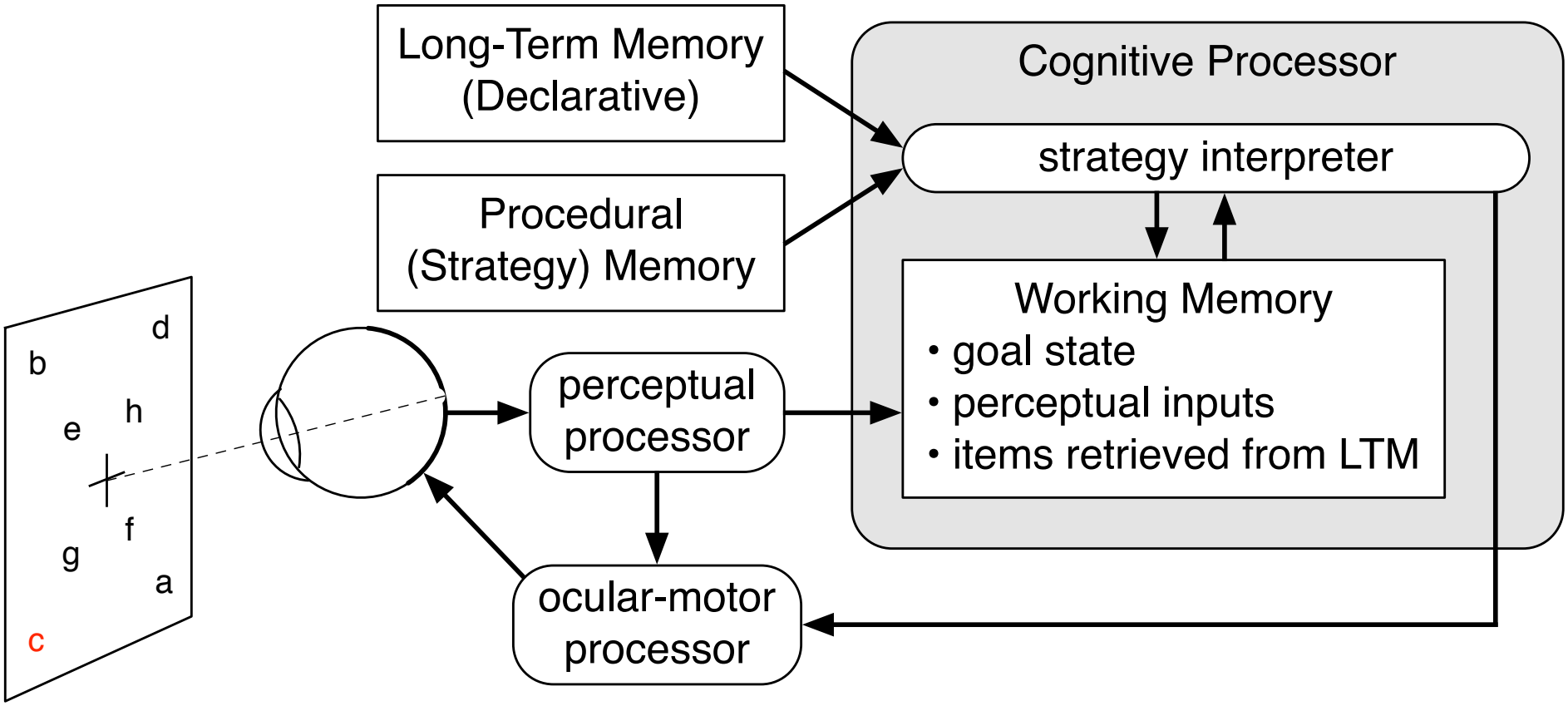
... are compiled; stored in, maintained in, and loaded from memory; parameterized for specific tasks.

They are just like computer programs and functions.

They are well-established but under-appreciated.

(Shiffrin & Atkinson, 1969; Baddeley, 1974; Lachman et al., 1979; Rosenbaum, 1991; Reichle, 2012)

Cognitive Strategies and orienting the eyes

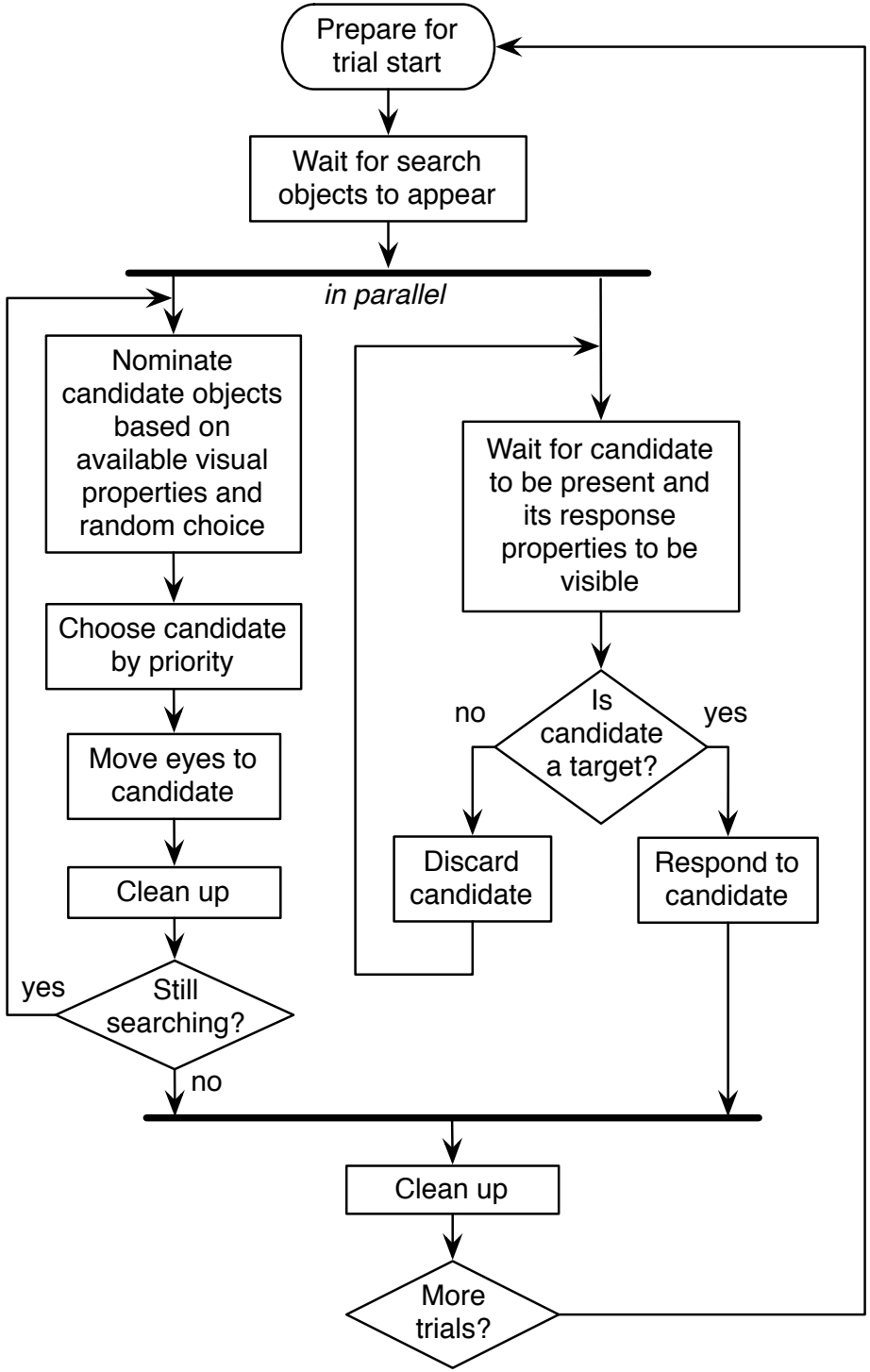


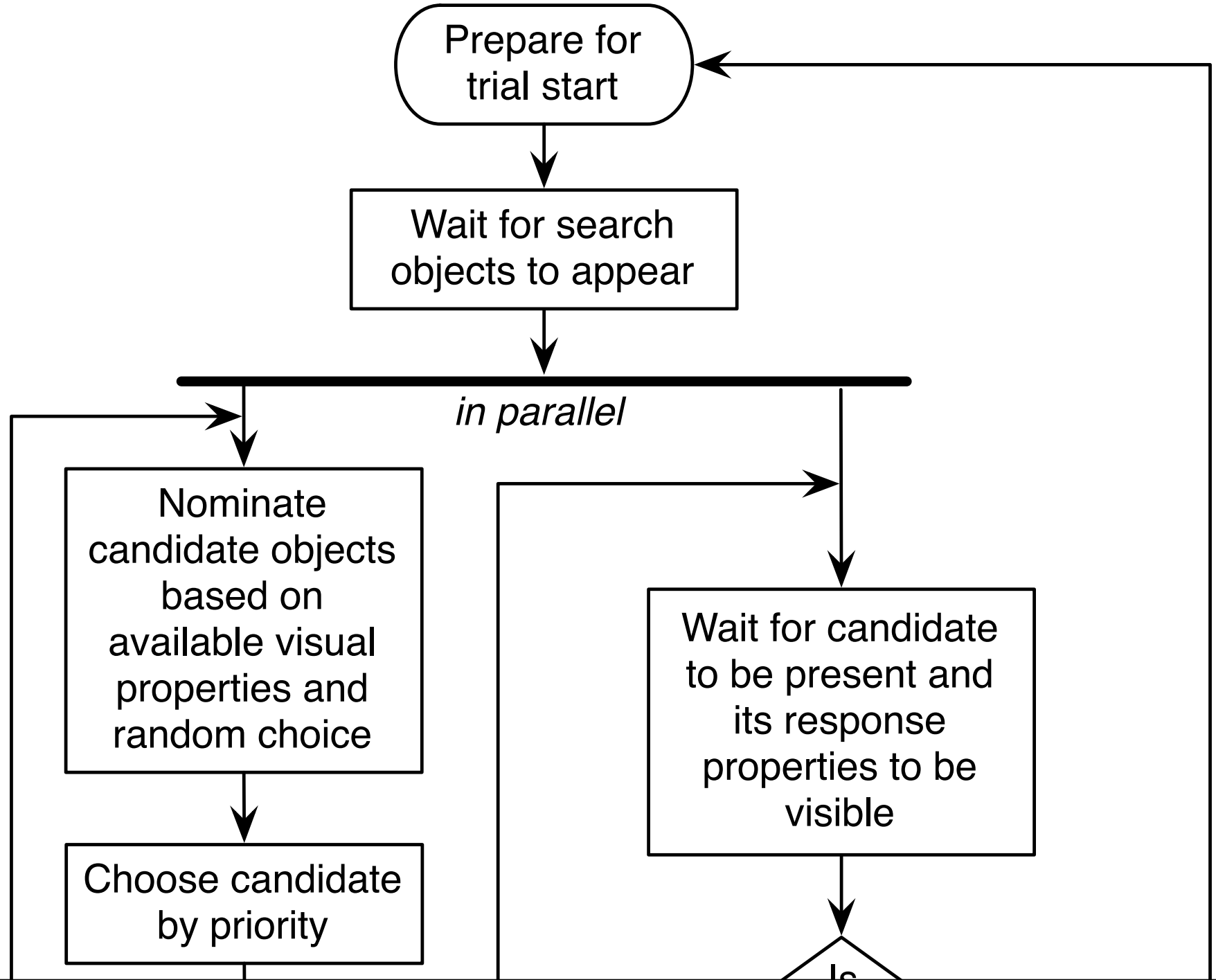
Arrows indicate flow of data and control signals.
Adapted from EPIC (Kieras & Meyer, 1997)

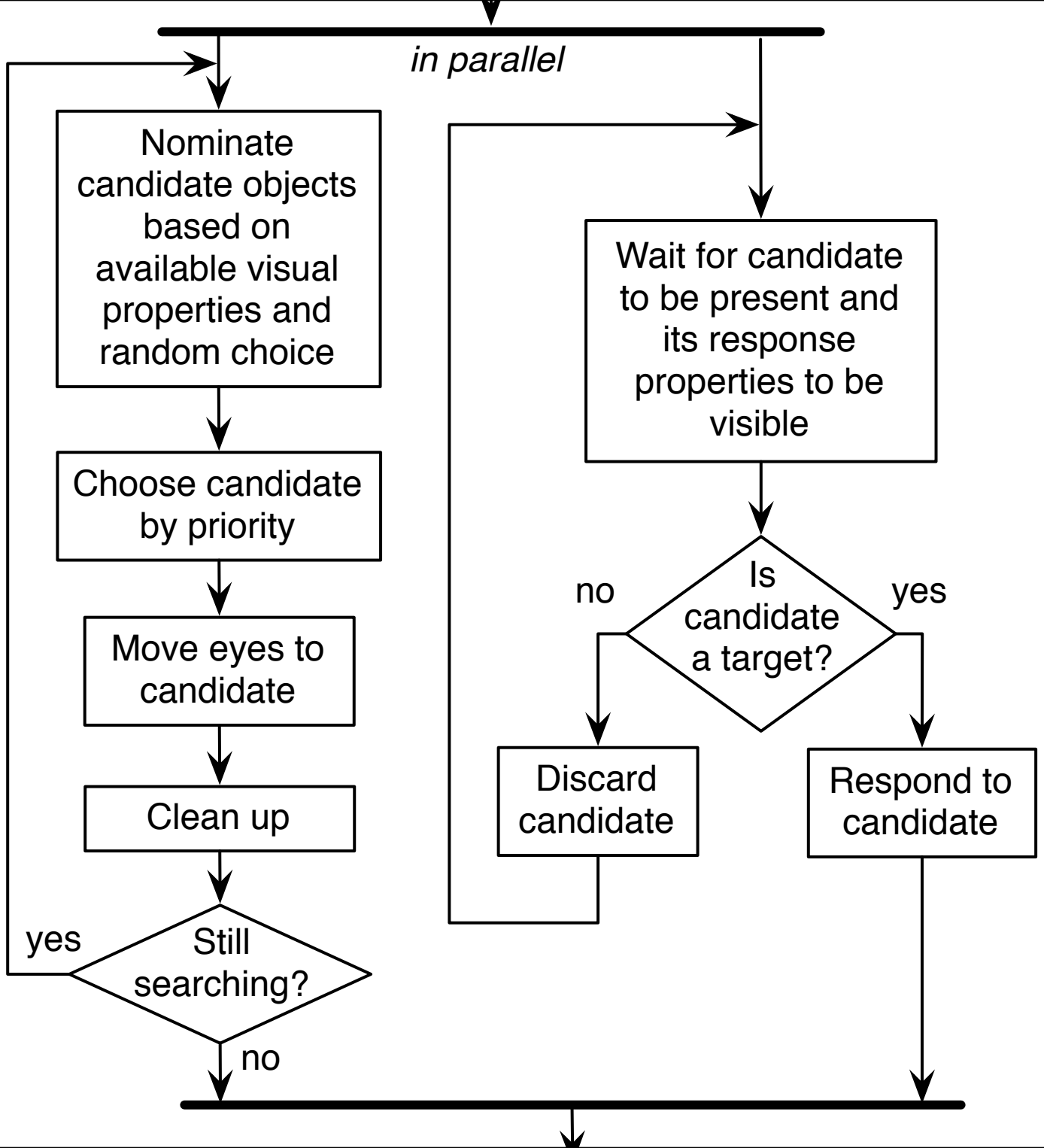
The subset of the human architecture that is used in visual tasks, and used in controlling a computer with eye movements. Missing: additional perceptual and motor processors.

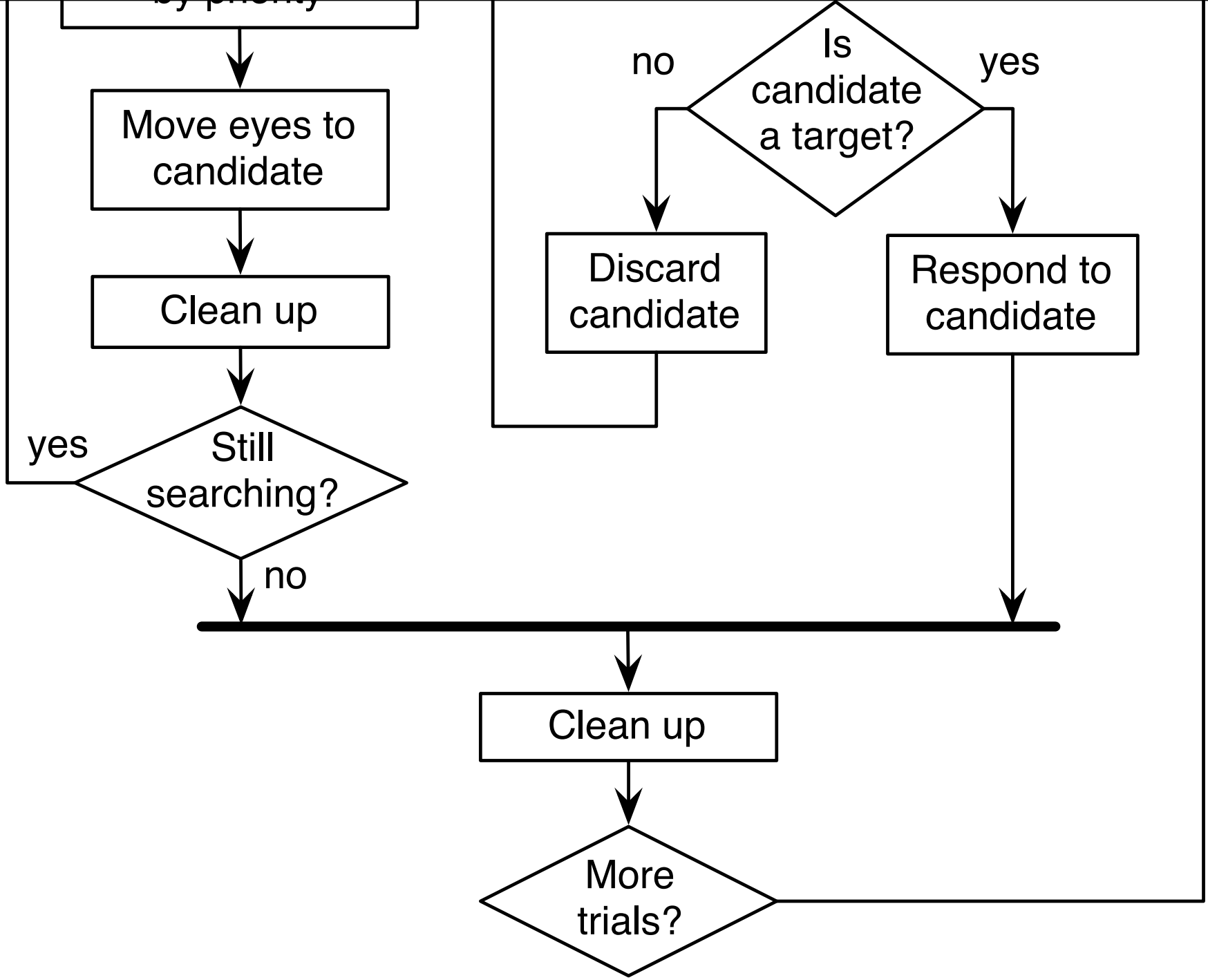
A flowchart summarizing a cognitive strategy for visual search

(Kieras & Hornof, *CHI 2014*)




Prepare for trial start
Wait for search objects to appear
in parallel
Nominate candidate objects based on available visual properties and random choice
Choose candidate by priority
Wait for candidate to be present and its response properties to be visible


in parallel
Nominate candidate objects based on available visual properties and random choice
Choose candidate by priority
Move eyes to candidate
Clean up
Still searching?
yes
no
Wait for candidate to be present and its response properties to be visible
Is candidate a target?
no
yes
Discard candidate
Respond to candidate


Move eyes to candidate
Clean up
Still searching?
yes
no
Is candidate a target?
no
yes
Discard candidate
Respond to candidate
Clean up
More trials?

A lack of a visual hierarchy makes it harder to find things

An example of a layout with no visual hierarchy:

CHI 2003 Conference at a Glance

Introduction
Saturday Tutorials
Sunday Tutorials
Monday Tutorials
Introduction
Workshop Descriptions
Doctoral Consortium
Development Consortium
Special Areas and the CHI Fringe

Technical Program Overview
What's New at CHI 2003
Tuesday Sessions
Wednesday Sessions
Thursday Sessions
Networking Reception
The Commons
Child Care and CHIkids
General Information
Travel Information
Conference Hotels/Map
Conference Committee
Conference Sponsors
About ACM SIGCHI

Following typographic conventions, such as by organizing information using a visual hierarchy, motivates visual strategies

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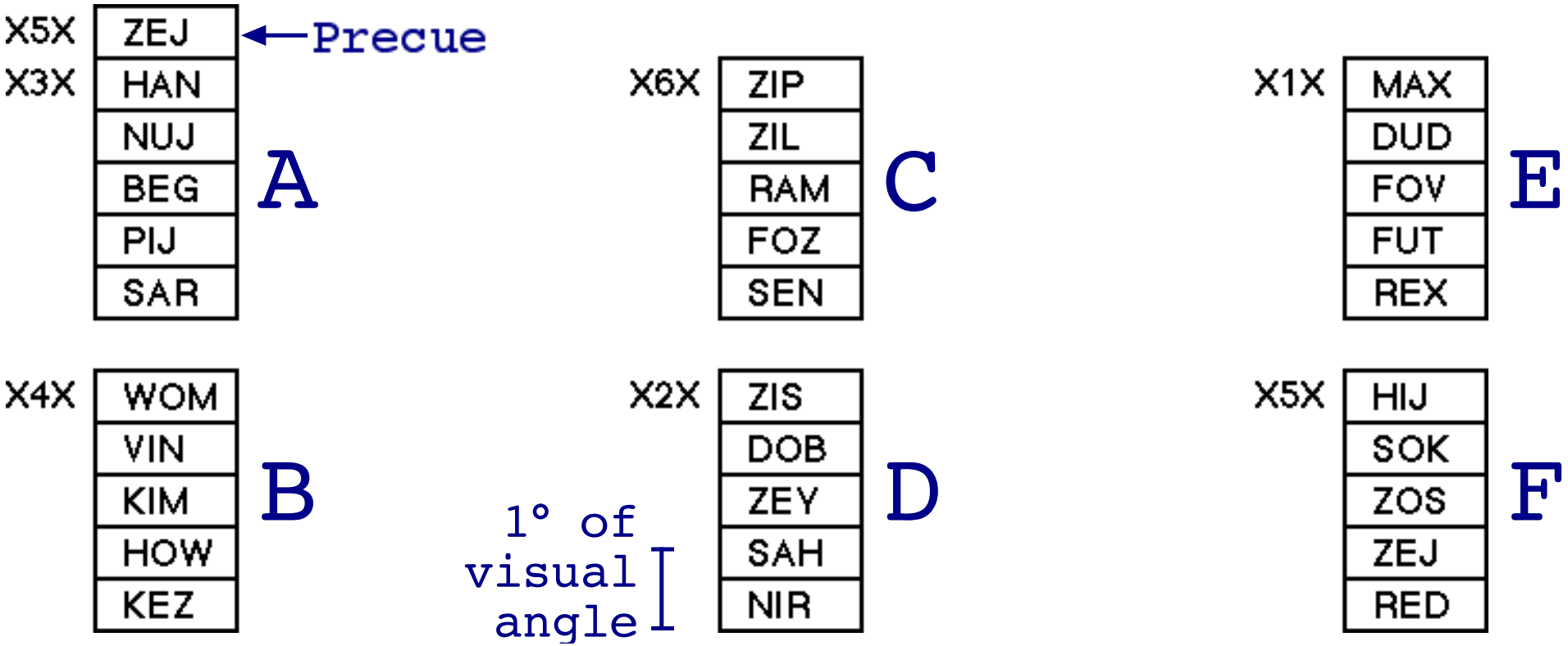
The Experimental Task



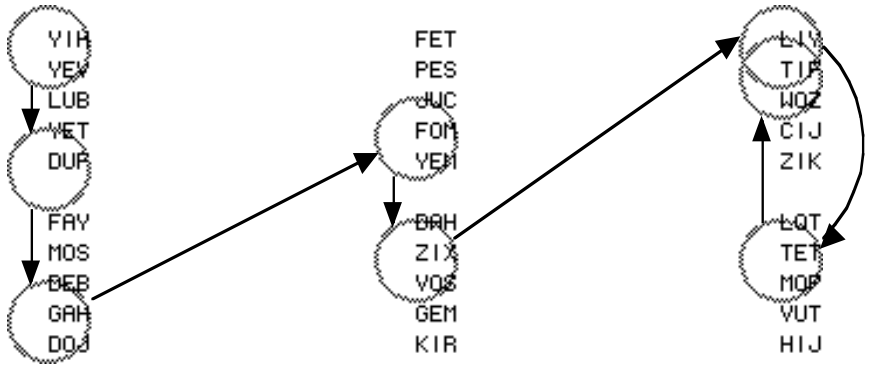
Experimental Design

- 2 x 3 design. Layouts were labeled or unlabeled. Layouts had 2, 4, or 6 groups. Blocked by layout type.
- Procedure: Study precue, click on precue, find target, click on target.
- 16 participants, motivated to search quickly
- Search and selection time recorded separately

Eye movements and search times predicted by a computational model.

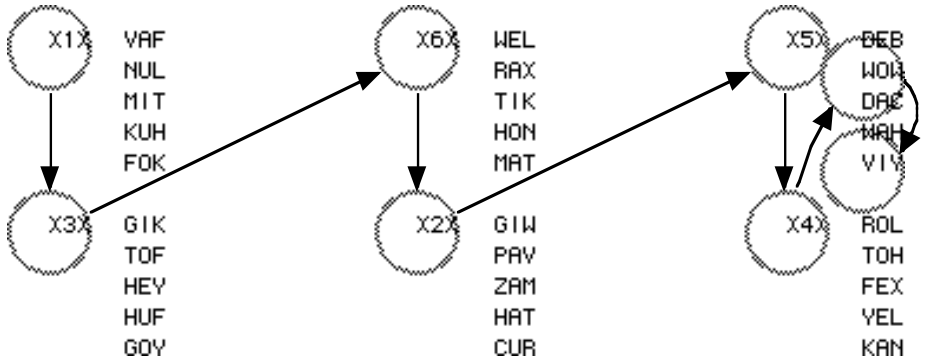
Unlabeled

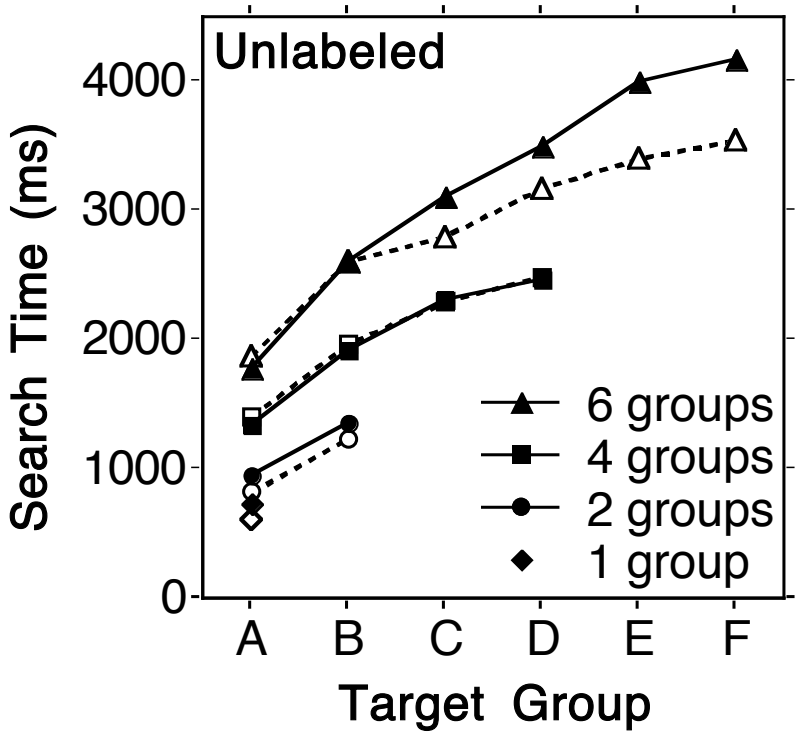
Noisy-systematic search



Labeled

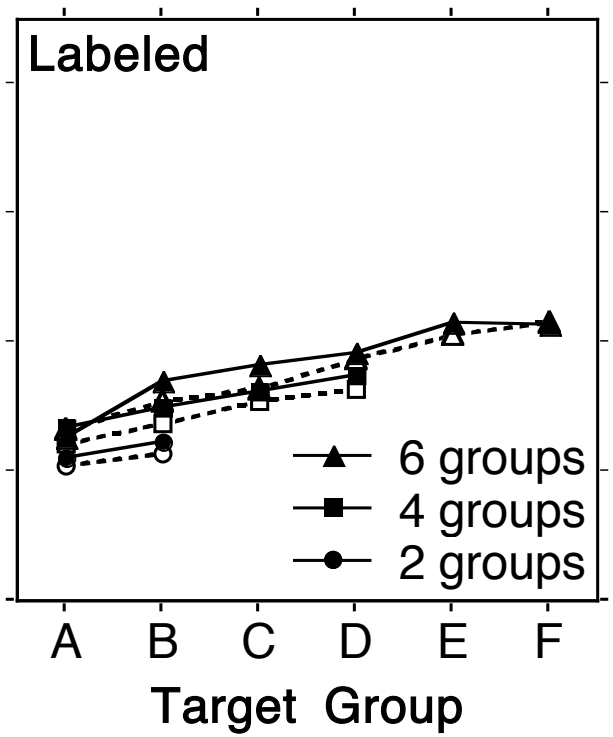
Two-tiered search strategy





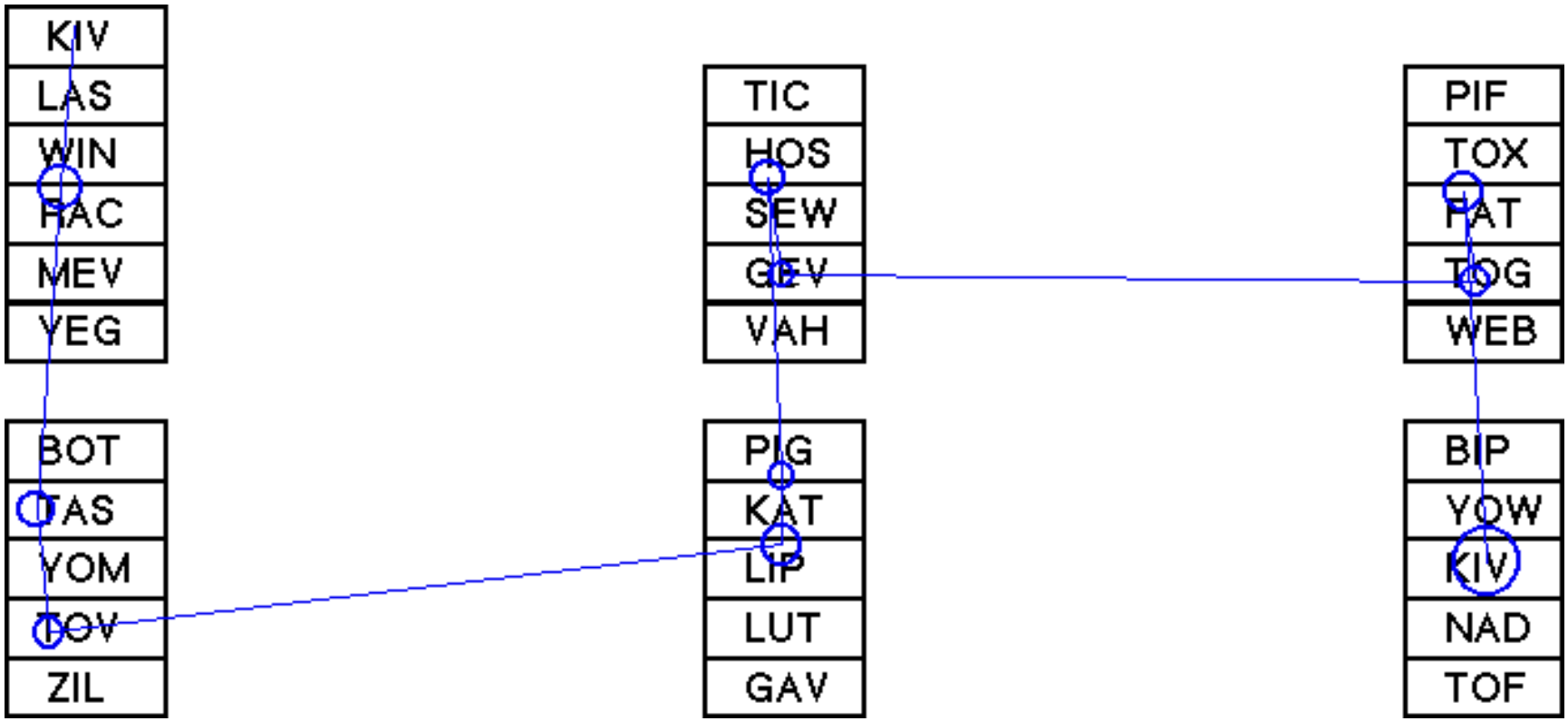
Observed

Predicted



Eye movements from a couple trials

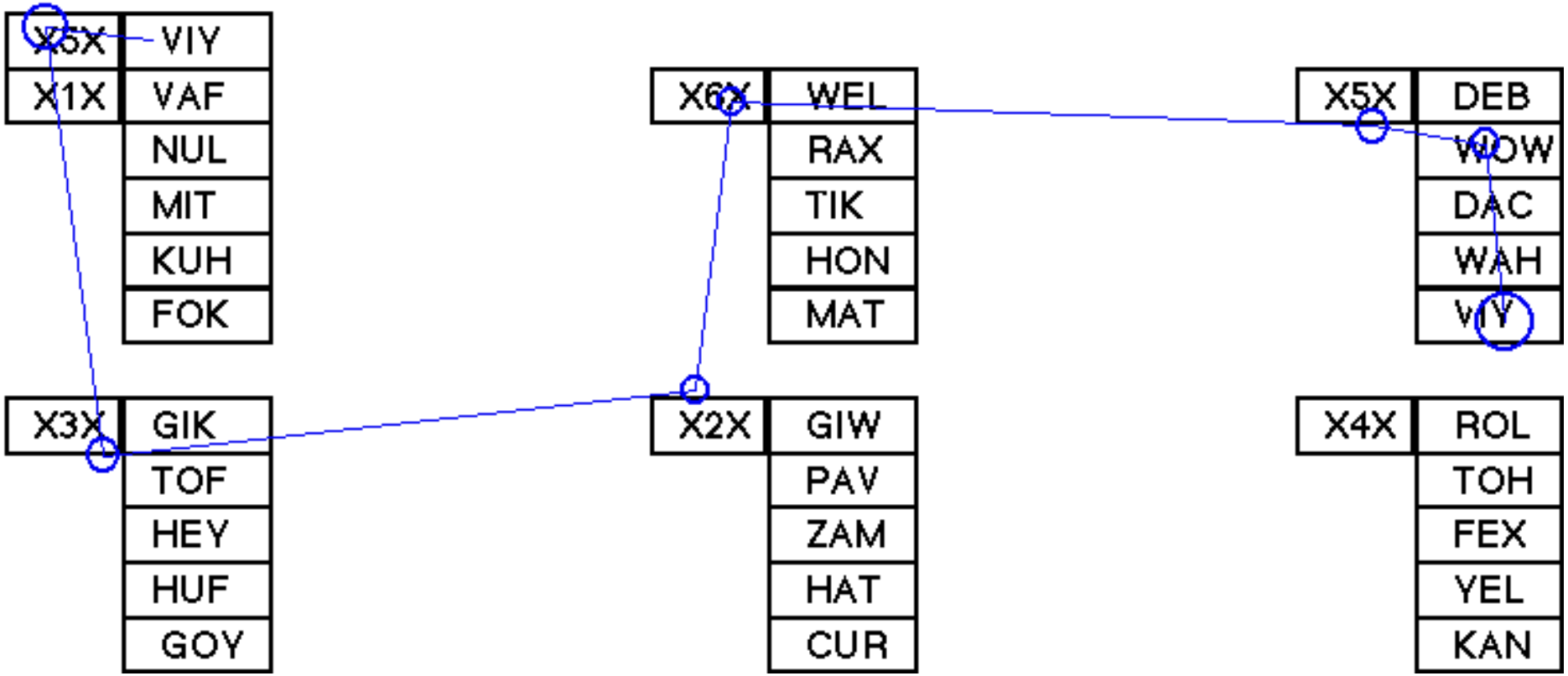
Unlabeled Layout



Visualized with VizFix (Google search on “VizFix”)

Eye movements from a couple trials

Labeled Layout



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Eye movements

Across All Layouts	**Observed**	**Predicted**
Fixations per trial (+)	7.4	7.9
Fixation duration (+)	264 ms	228 ms
Number of scan paths	Many	One
Anticipatory fixations (+)	Yes	Yes
Respond to layout onset (+)	Yes	Yes
Ignore white space (+)	Yes	Yes
Ignore text shape (+)	Yes	Yes
Overshoot the target	Rarely	Yes
Unlabeled Layouts		
Fixations per group	2.1	1.1
Groups revisited per trial	0.69	4.4
Items examined per fixation (+)	2.4	2.6
Labeled Layouts		
Use group labels (+)	Yes	Yes
Groups revisited per trial	0.29	1.2

Further evidence of the role of cognitive strategies in vision.

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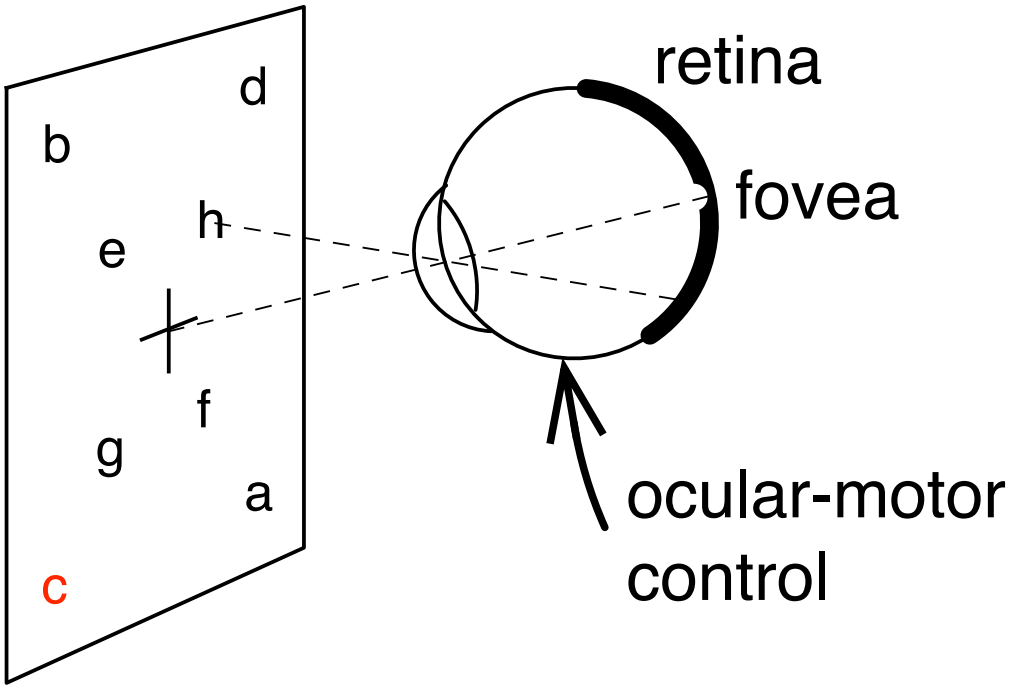

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