

Human-Computer *Visual* Interaction

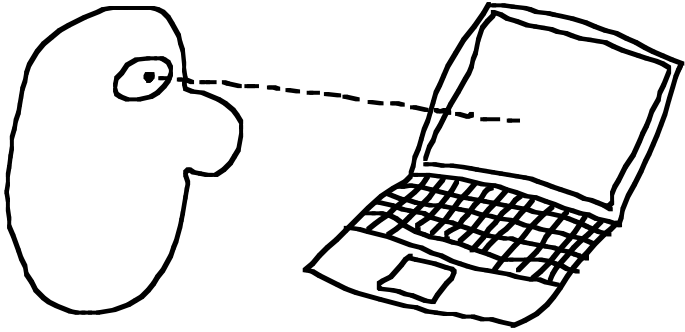
Anthony Hornof, Assistant Professor
Computer and Information Science
University of Oregon



Current Collaborators: Moira Burke, Anna
Cavender, Nik Gorman, Tim Halverson, Rob
Hoselton, Ishwinder Kaur, David Kieras, Erik
Nilsen, Troy Rogers, Jeffrey Stolet

Funded by ONR and NSF

Human-Computer *Visual* Interaction

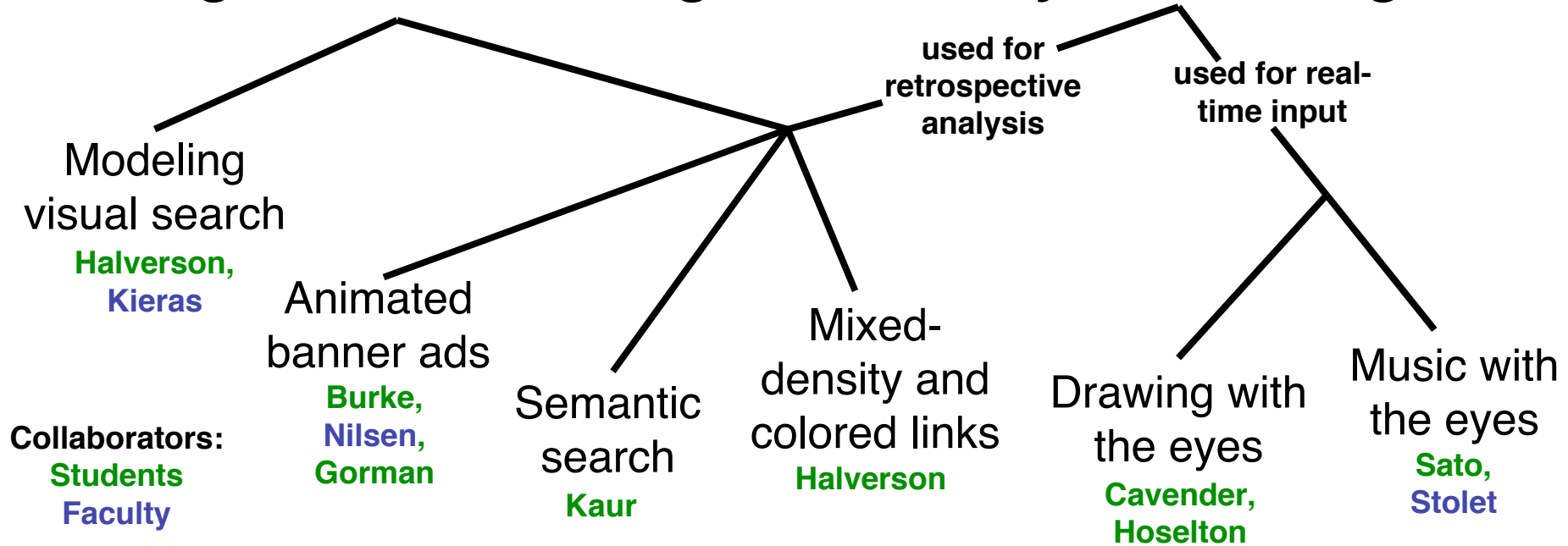


*Improving the throughput using the
visual and oculomotor channels*

Research areas and projects of
Anthony Hornof, University of Oregon

Cognitive Modeling

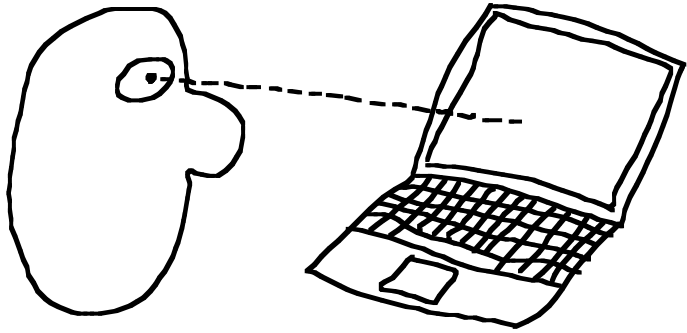
Eye Tracking



Sponsorship: ONR, NSF

(Jan., 2004)

Human-Computer *Visual* Interaction

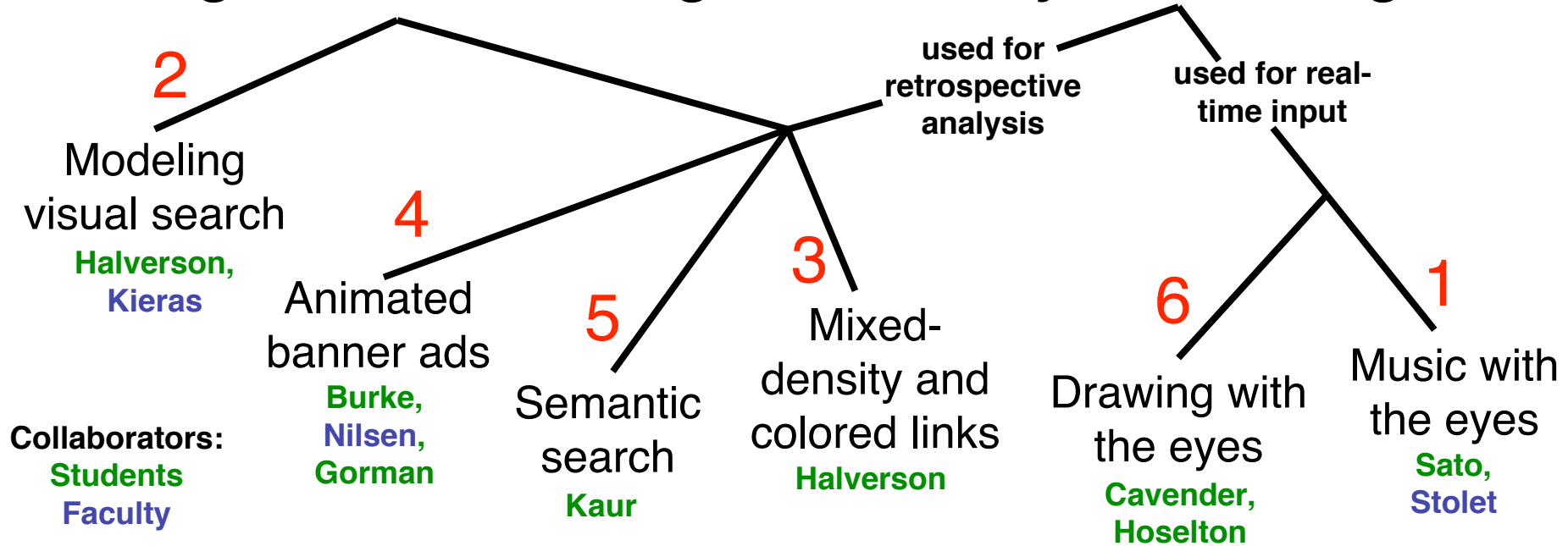


Improving the throughput using the visual and oculomotor channels

Research areas and projects of Anthony Hornof, University of Oregon

Cognitive Modeling

Eye Tracking



Sponsorship: ONR, NSF

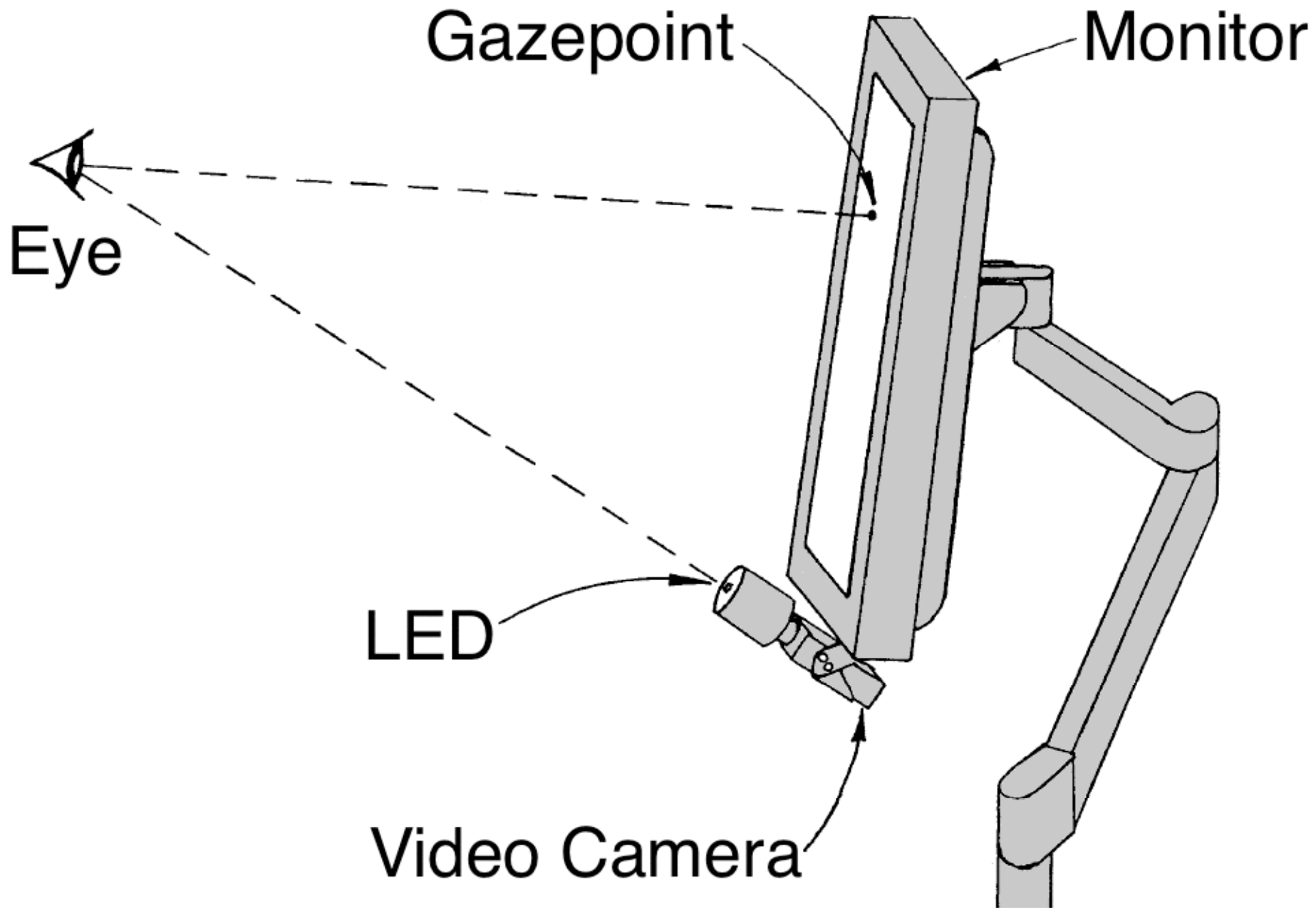
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How the Eyes Move

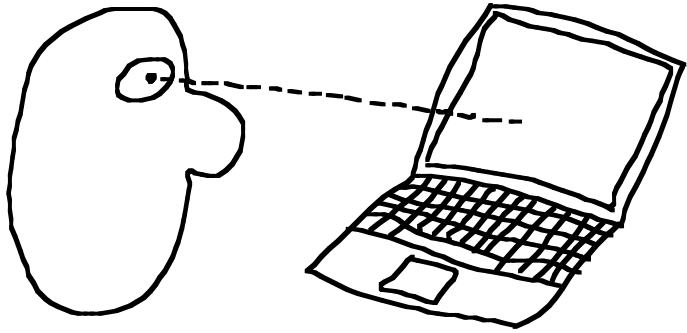
The eyes move with **saccades**, or quick ballistic jumps (~30 ms).

Between saccades, the gaze is stationary (with a slight tremor) for **fixations** that last 100 to 400 ms.

An eye tracker reports the position.



Human-Computer *Visual* Interaction

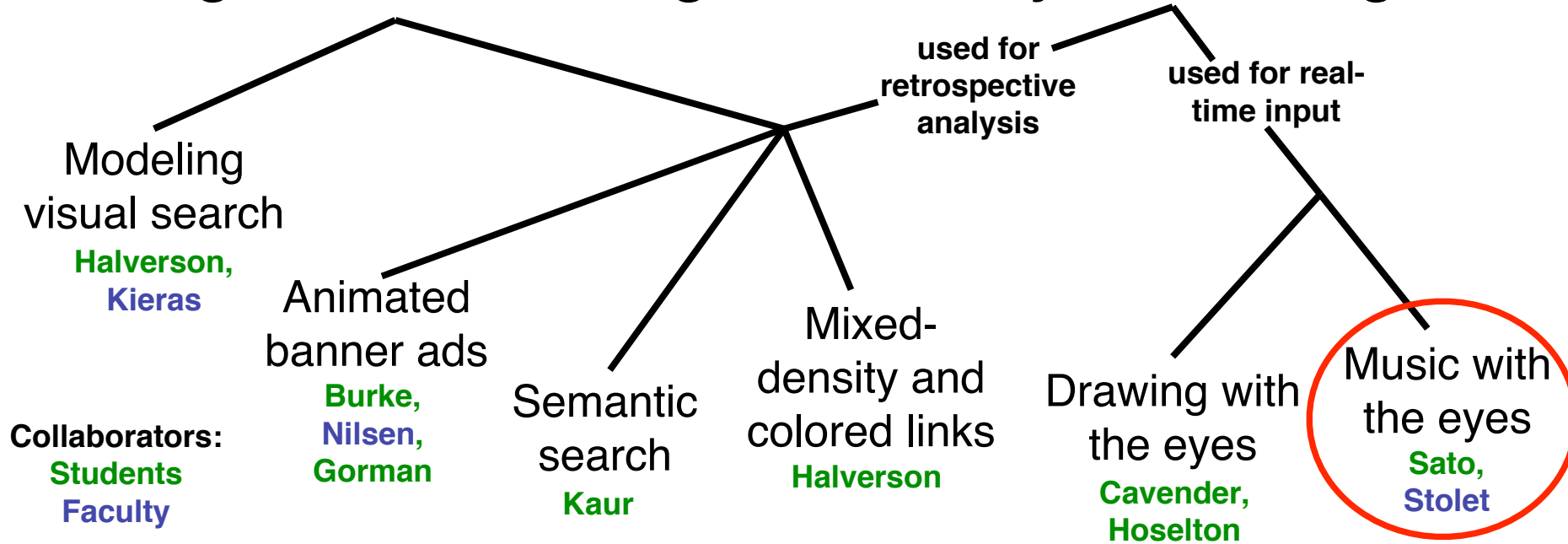


Improving the throughput using the visual and oculomotor channels

Research areas and projects of
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Cognitive Modeling

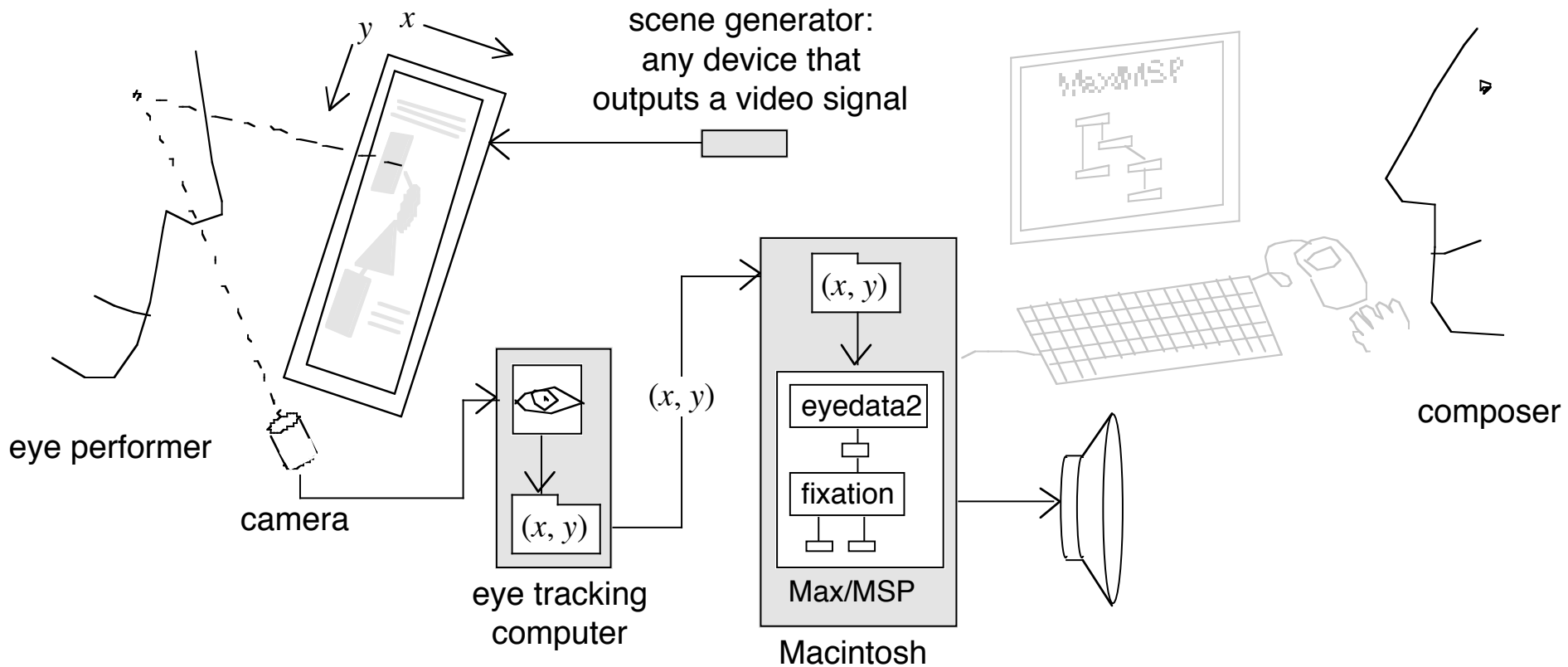
Eye Tracking



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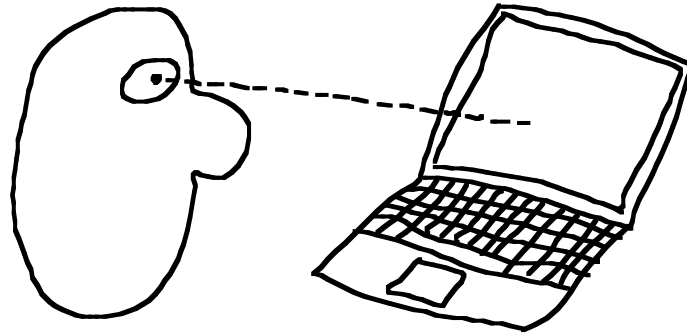
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EyeMusic



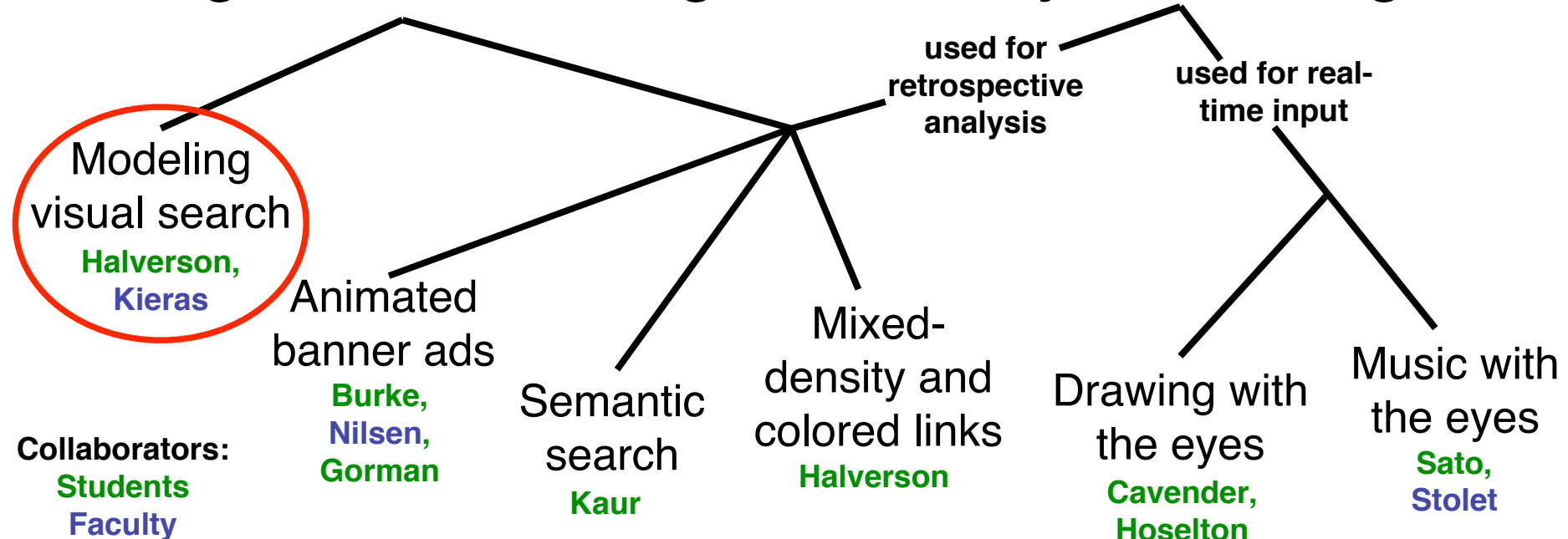


Human-Computer *Visual* Interaction



Cognitive Modeling

Eye Tracking



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Human-Computer Interaction (HCI) needs better predictive theories

From the 2004 NSF Solicitation for the HCI program:

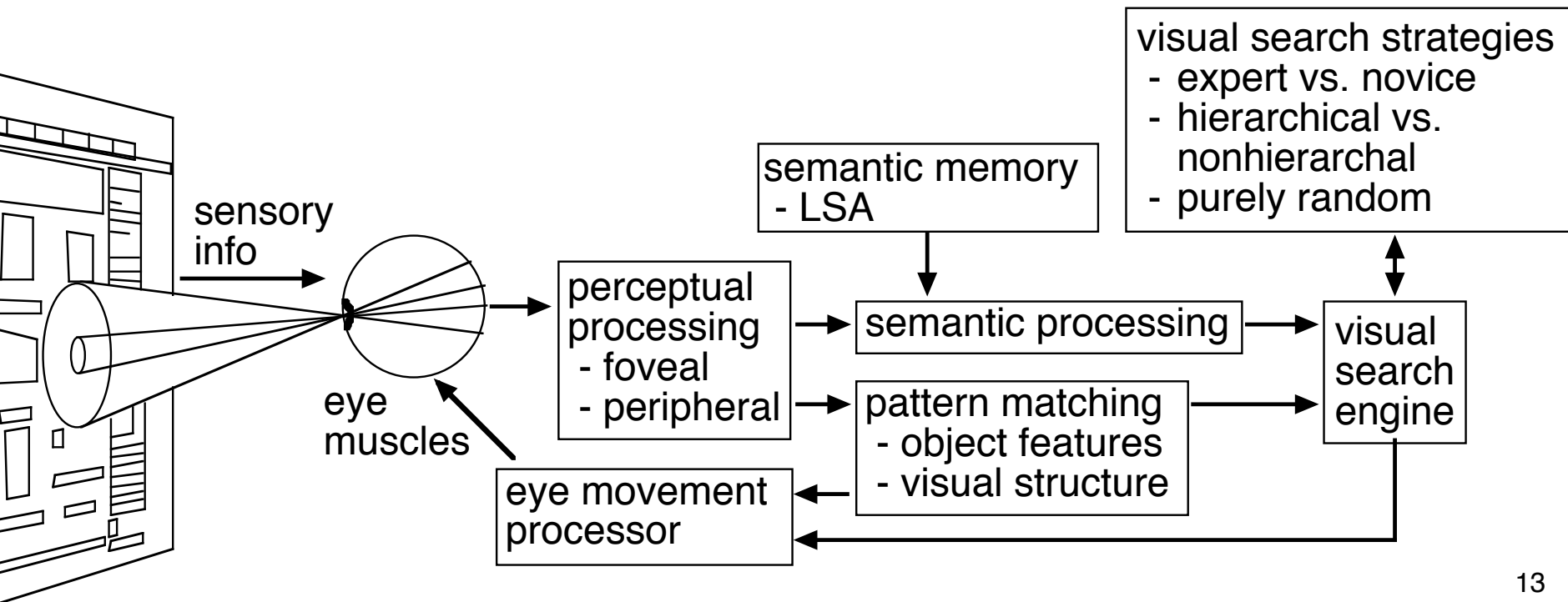
“Perhaps the most often-cited deficiency of HCI to date has been a lack of effective models and theories, which could predict *a priori* how well a proposed system will work before it is actually implemented and, more generally, inform future research efforts.”

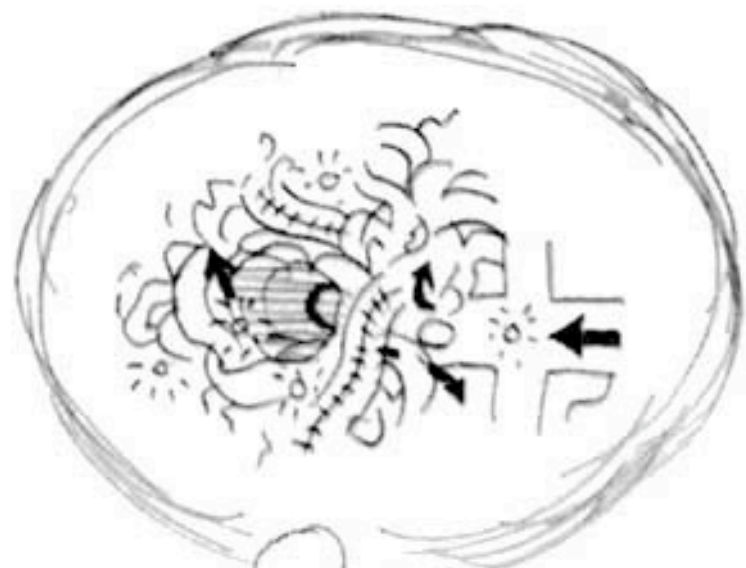
How will people find the rates?



Cognitive modeling of visual search

- Two main goals:
 1. Explain user behavior (*post hoc*).
 2. Predict user behavior (*a priori*).
- Simulate perceptual-motor processes and cognitive strategies.
- A generic cognitive architecture for visual search:





Stegerson

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Searching Unlabeled versus Labeled Groups

X5X	ZEJ	←Precue A
X3X	HAN	
	NUJ	
	BEG	
	PIJ	
	SAR	

X6X	ZIP	C
	ZIL	
	RAM	
	FOZ	
	SEN	

X1X	MAX	E
	DUD	
	FOV	
	FUT	
	REX	

X4X	WOM	B
	VIN	
	KIM	
	HOW	
	KEZ	

X2X	ZIS	D
	DOB	
	ZEY	
	SAH	
	NIR	

1° of
visual
angle

X5X	HIJ	F
	SOK	
	ZOS	
	ZEJ	
	RED	

Search strategies are encoded as production rules.

Rules for Unlabeled Search

...

5. Find the target.

FIRST-SACCADE-TO-NAMED-OBJECT-LOCATION
REMOVE-FIRST-SACCADE-LOCATIONS-FROM-WM
CREATE-COLLECTION-OF-POSSIBLE-NEXT-SWEEP-
ITEMS-FIRST-FIXATION-LOCATION
CREATE-COLLECTION-OF-POSSIBLE-
NEXT-SWEEP-ITEMS
SACCADE-TO-RANDOMLY-CHOSEN-NEXT-
SWEEP-OBJECT
REMOVE-ALL-NEXT-SWEEP-ITEMS-FROM-WM

6. Click on the target.

TARGET-IS-LOCATED-SO-STOP-SCANNING-AND-
MOVE-GAZE-AND-CURSOR-TO-TARGET
PREPARE-TO-PUNCH-MOUSE-BUTTON-ON-TARGET
PUNCH-MOUSE-BUTTON-ON-TARGET

...

Rules for Labeled Search

...

5a. Search the group labels for the target group.

FIRST-SACCADE-TO-GROUP-LABEL-LOCATION
IDENTIFY-THE-FIRST-CURRENT-GAZE-ITEM
SACCADE-TO-THE-NEXT-GROUP-LABEL-IN-ORDER
TARGET-GROUP-IS-FOUND

5b. Find the target with a systematic search in the group.

START-SYSTEMATIC-SEARCH-IN-TARGET-GROUP
SACCADE-TO-NEXT-SWEEP-ITEM-DOWN-IN-
TARGET-GROUP
TARGET-IS-LOCATED-SO-STOP-SCANNING

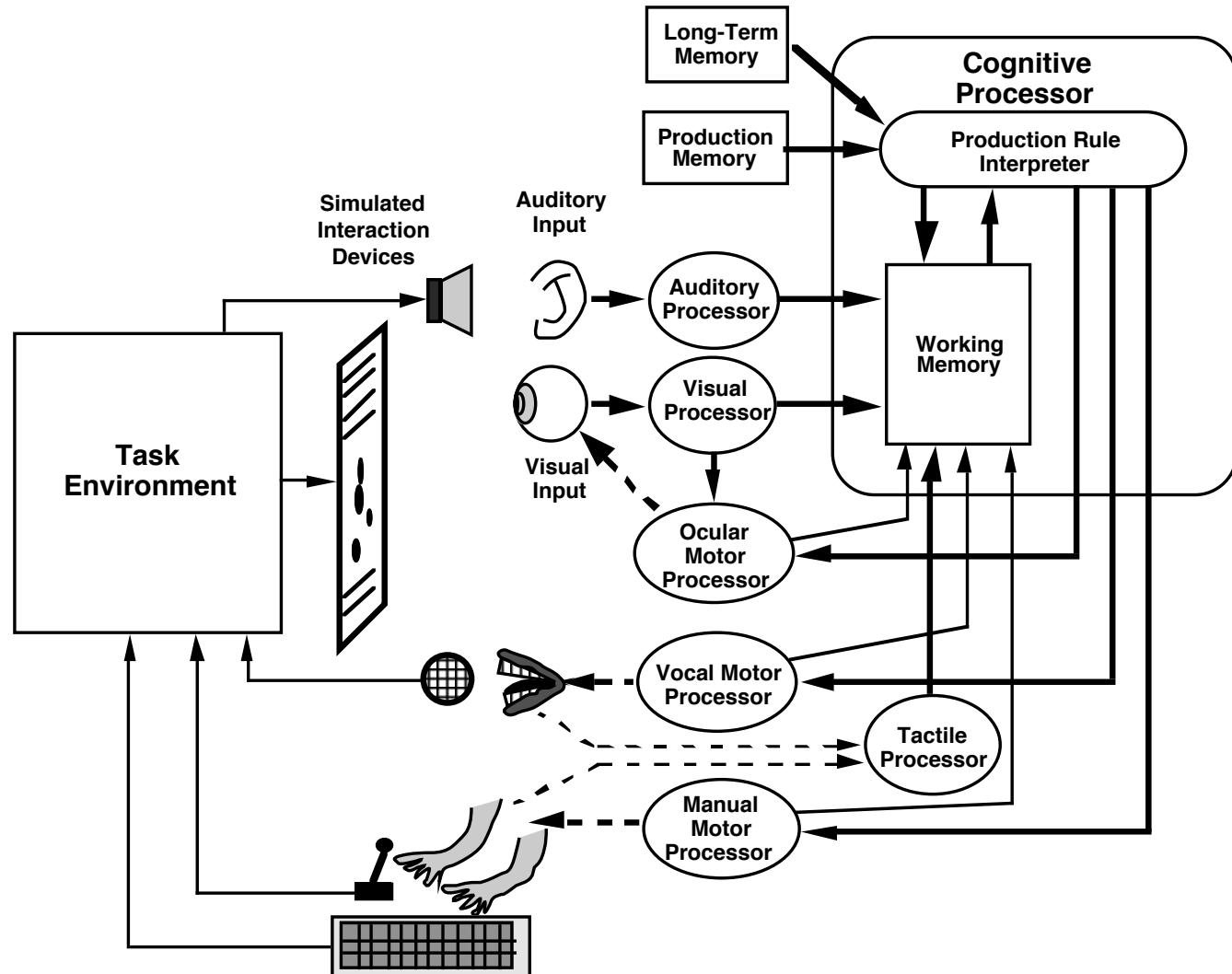
6. Click on the target.

SCANNING-IS-STOPPED-MOVE-GAZE-AND-CURSOR-
TO-TARGET
PREPARE-TO-PUNCH-MOUSE-BUTTON-ON-TARGET
PUNCH-MOUSE-BUTTON-ON-TARGET

...

The EPIC Cognitive Architecture

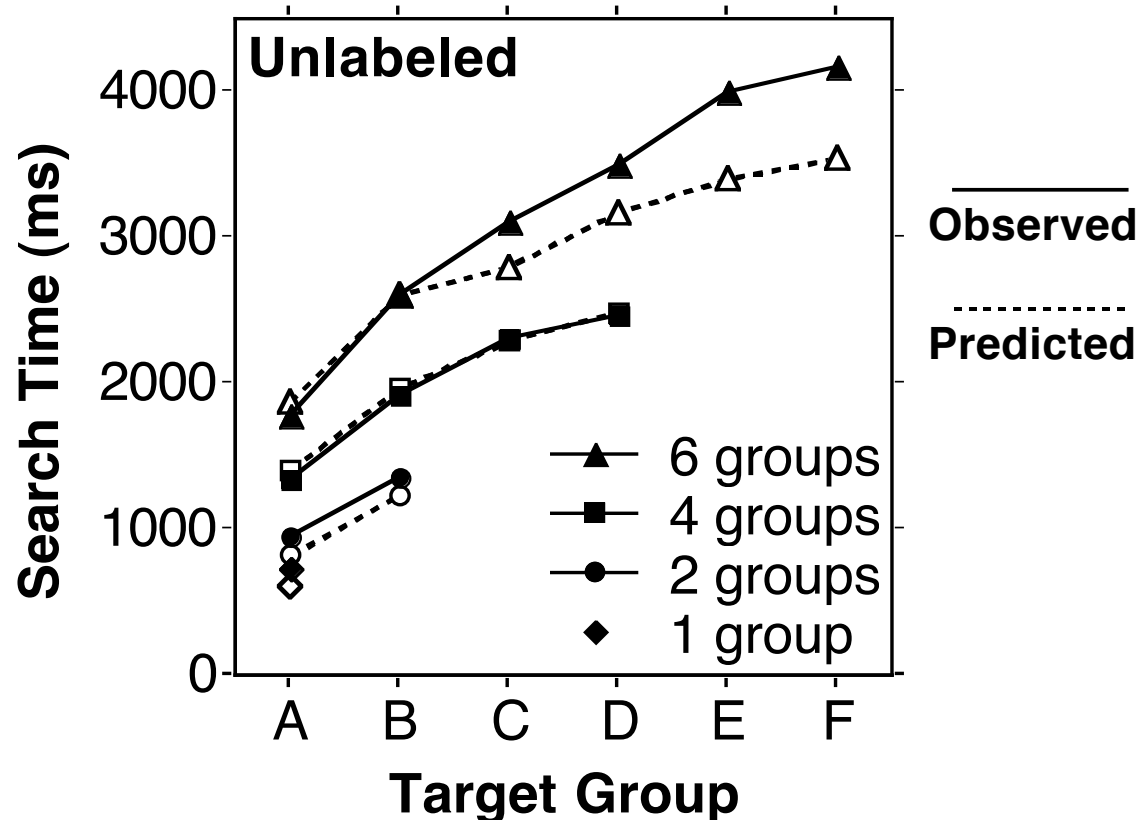
- Kieras and Meyer (1995).
- Executive Process-Interactive Control.
- A framework for building computational models.



Reaction Time Data Explained *Post Hoc*

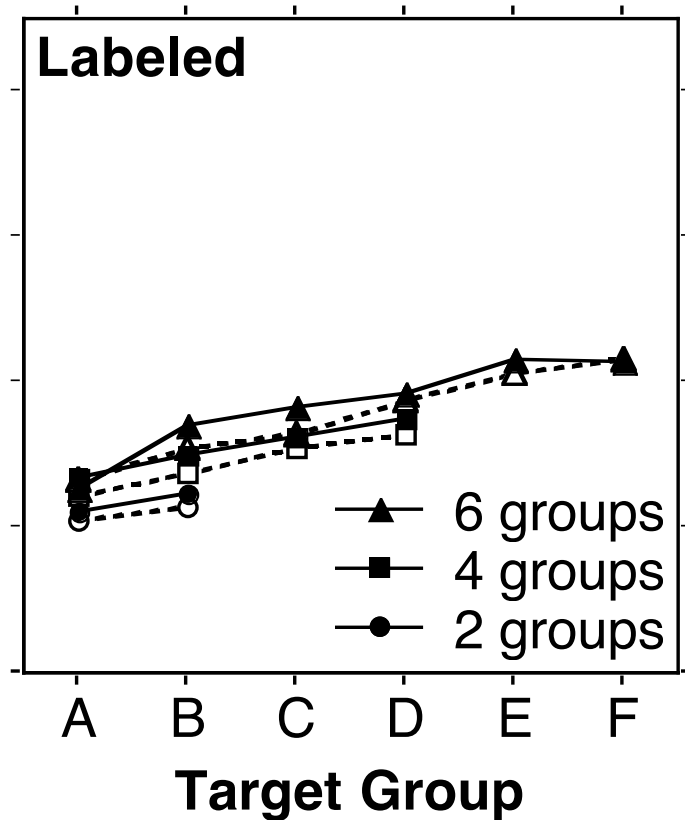
Unlabeled Groups

Noisy-systematic search strategy

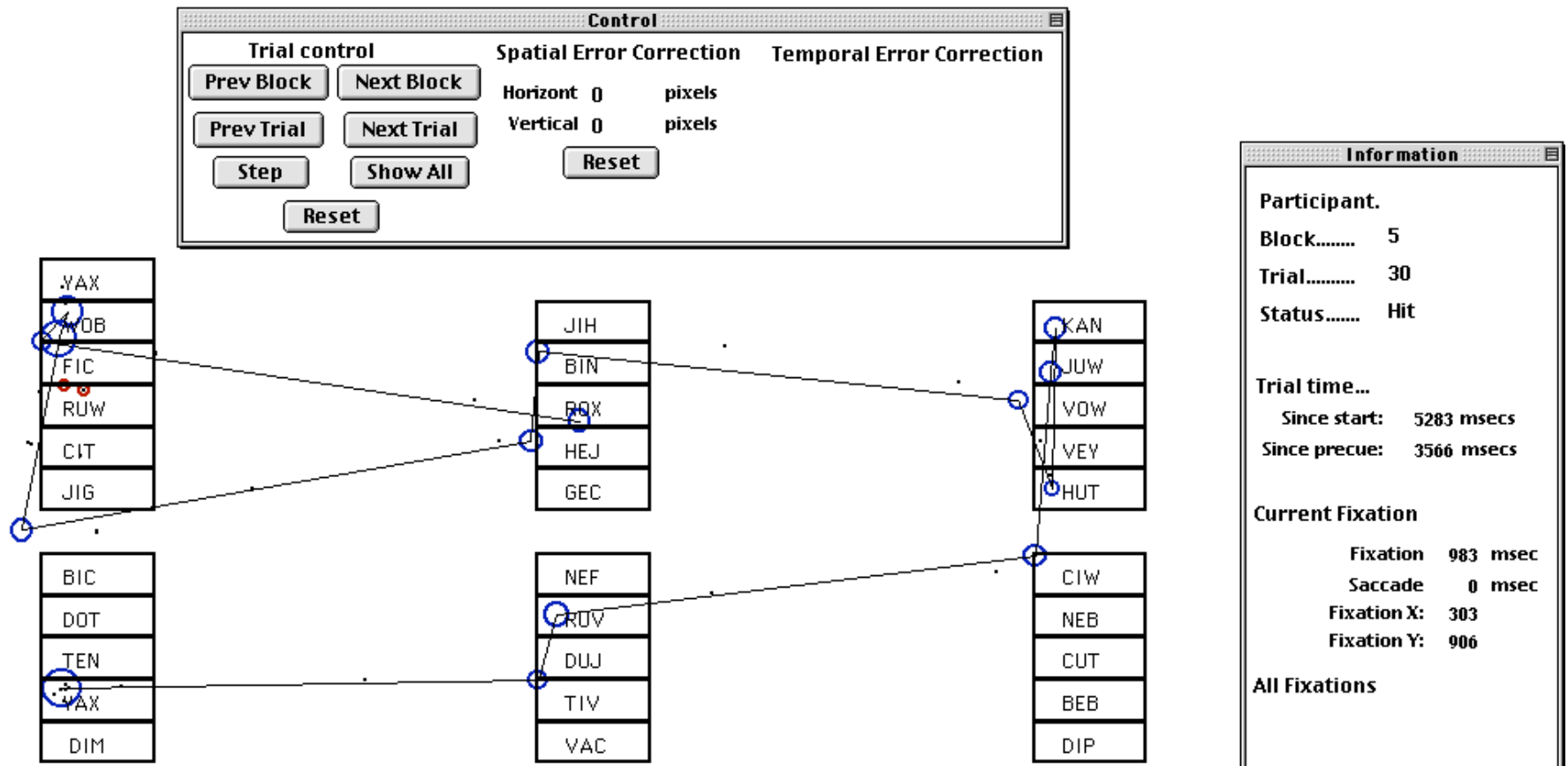


Labeled Groups

Two-tiered search strategy



We developed VizFix—a tool for visualizing and analyzing eye movement patterns



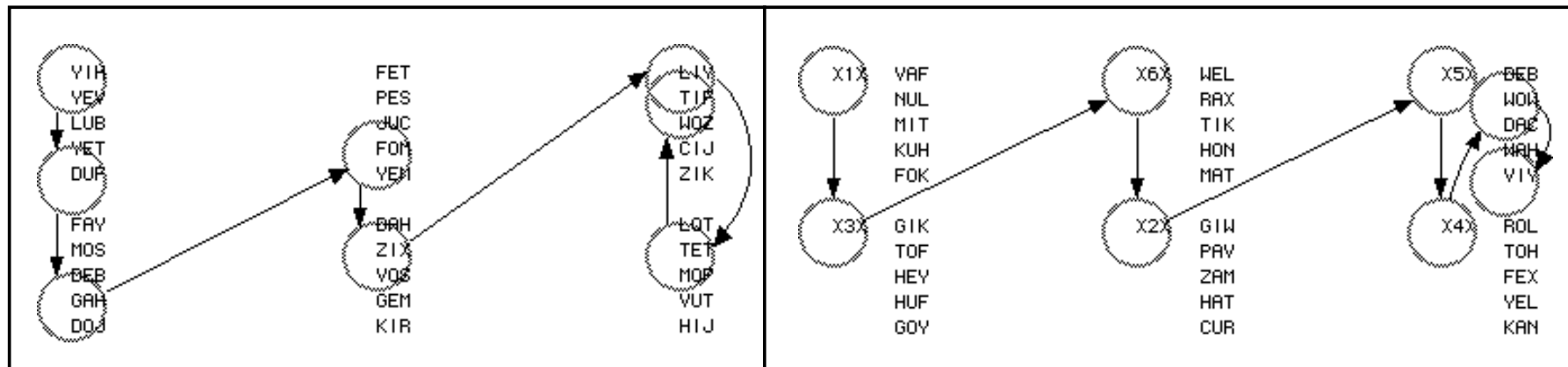
Analyzed thousands of trials of eye movement data. (Time consuming; tedious.)

Eye Movement Data Explained *A Priori*

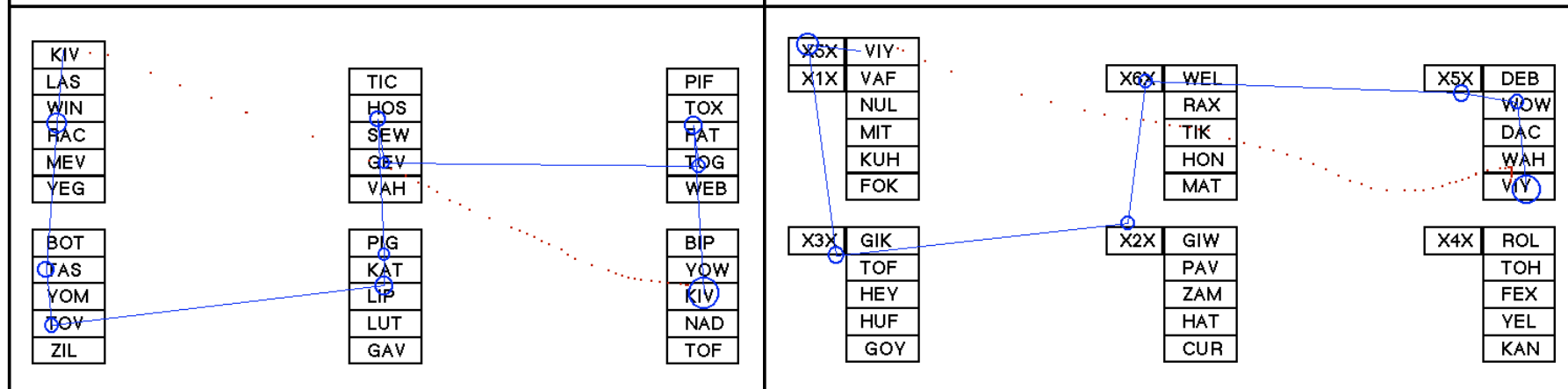
Unlabeled Groups

Labeled Groups

Models



Humans



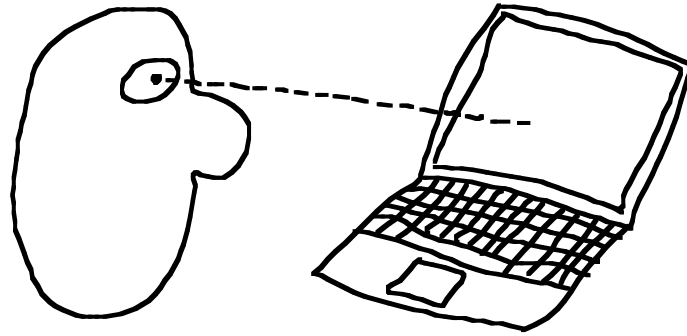
Cognitive models built based on the reaction time data predict eye movement patterns observed in humans. We are moving closer to accurate *a priori* predictions of real-world human search behavior.

Cognitive Modeling and Eye Tracking of Human-Computer Visual Interaction Tasks

Research goals include:

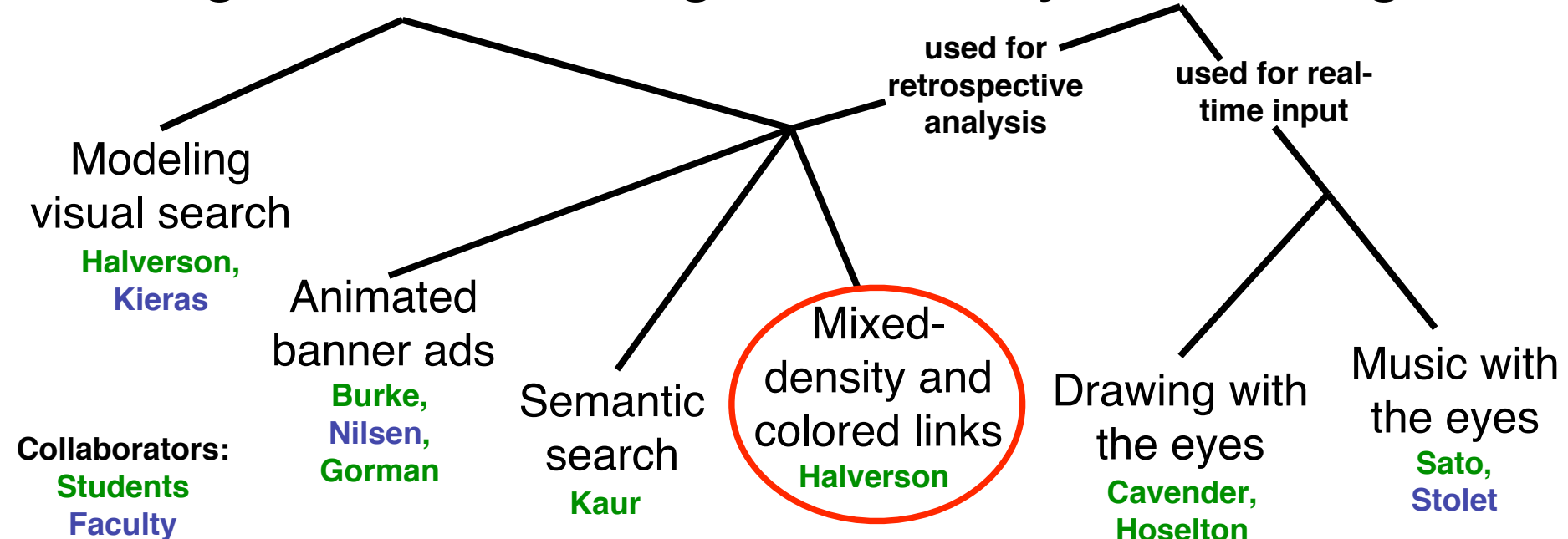
- Run experiments that are 50% cognitive psychology, and 50% real-world tasks.
- Build a library of strategies for different tasks and user profiles.
- Validate each strategy with eye tracking.
- Combine them all into a predictive theory at the core of a designer's tool.
- Validate the tool.

Human-Computer *Visual* Interaction



Cognitive Modeling

Eye Tracking



Real-world mixed density and color search

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The Effects of Local Density: Experimental Task

lean
waist
bra
slope
doll

bird
butter
juice
bat
flash
scare
button
dad
nose
smack

deer
tube
miner
town
lighter
sleep
rug
ash
guest
fire

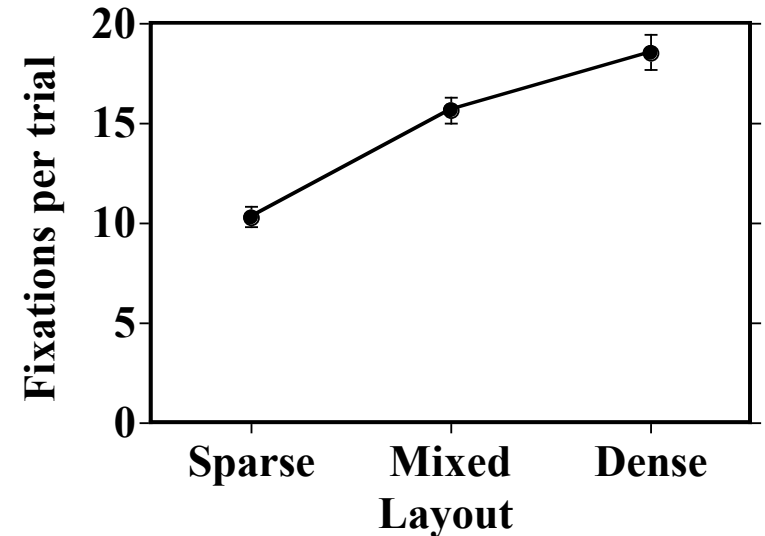
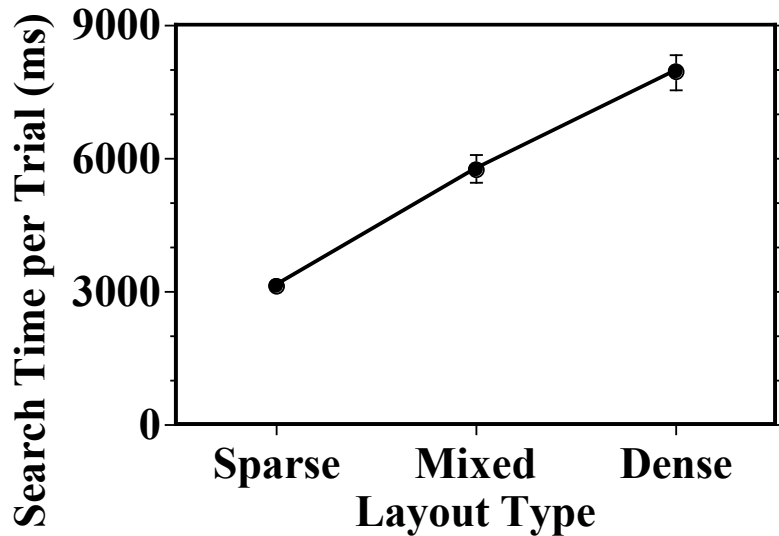
lump
ink
moose
cousin
groan
mother
bush
flag
state
mud

fall
pearl
copper
wine
prayer

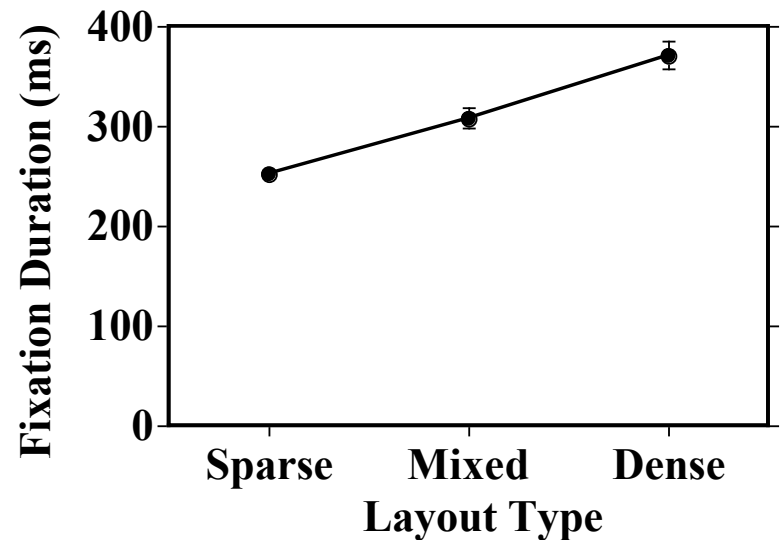
land
purse
shout
palm
lung

- Two types of groups: dense and sparse
- Layouts: 6 sparse groups, 6 dense groups, mixed groups
- Each item equally likely to be the target

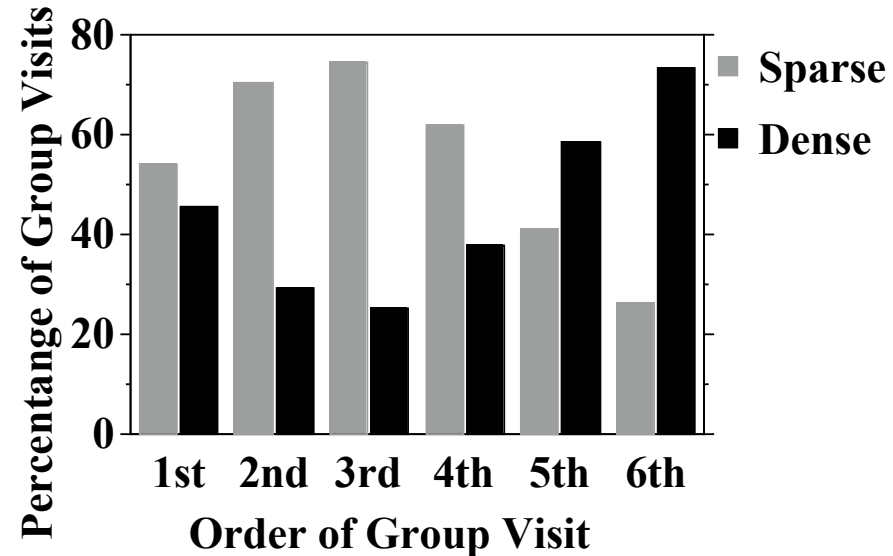
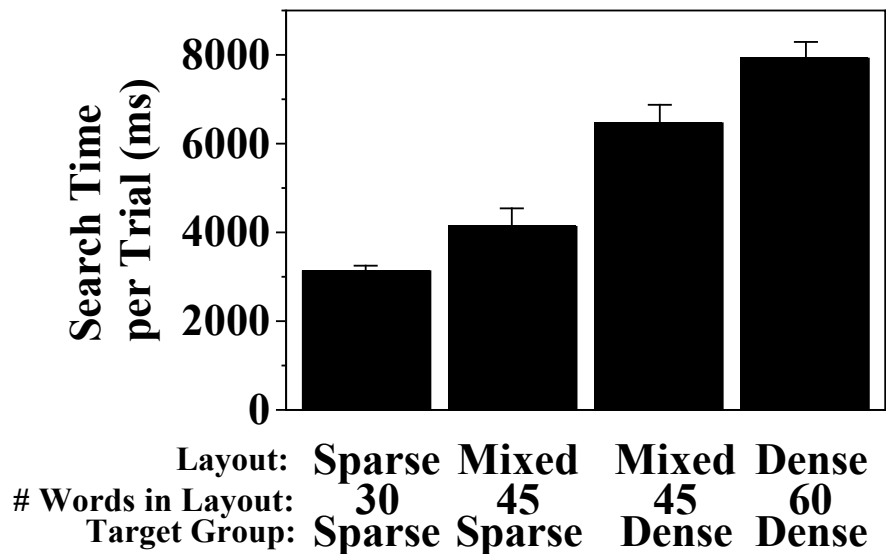
Results per Trial



- Search time and fixations per trial correlate with number of items.
- Mean fixation duration goes up with density.



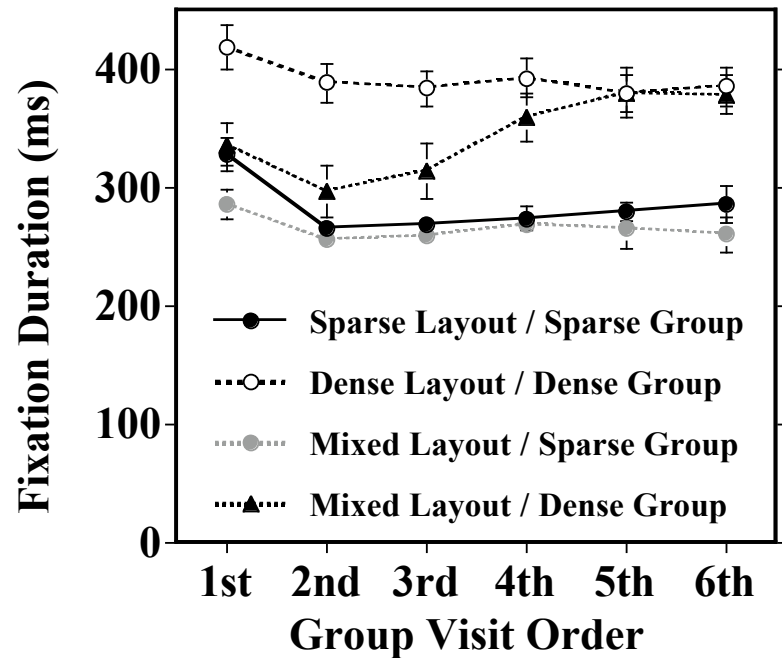
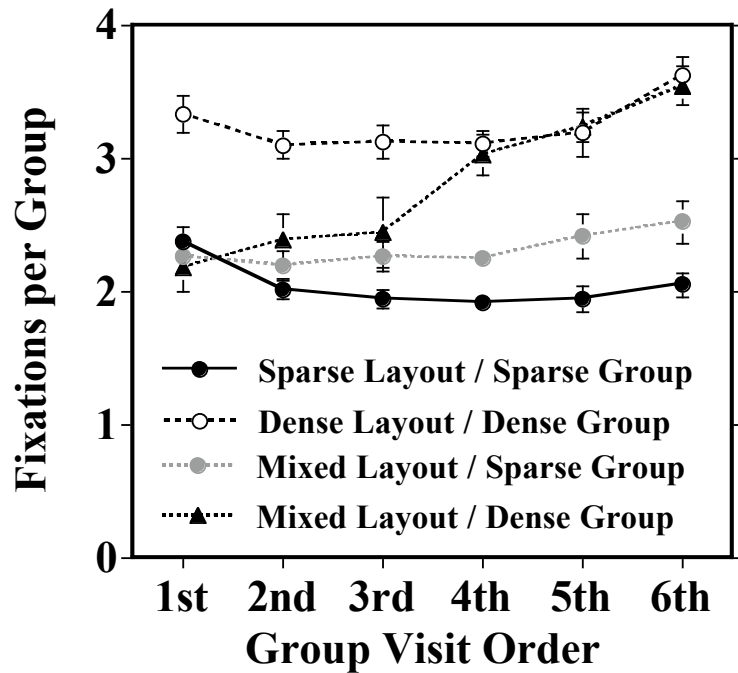
Sparse Groups Visited First



Participants searched sparse groups first:

- Search time by layout type and target type.
- Order of groups visited in mixed-density layouts.

Mid-Trial Strategy Shift

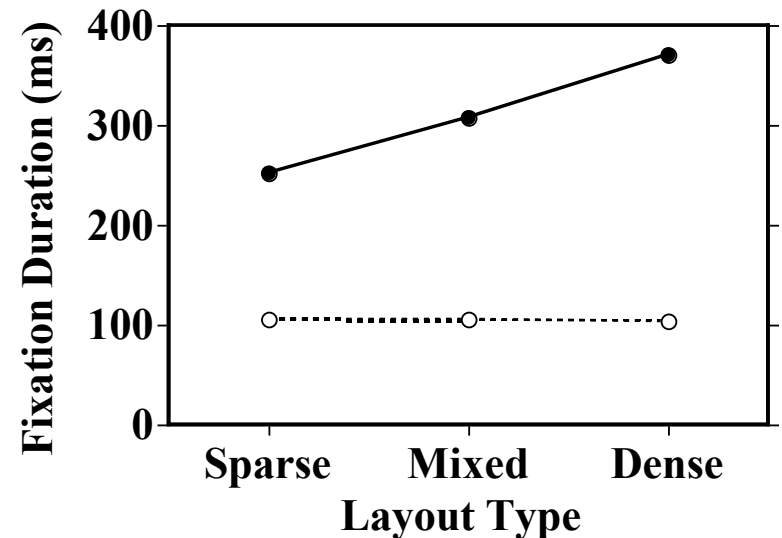
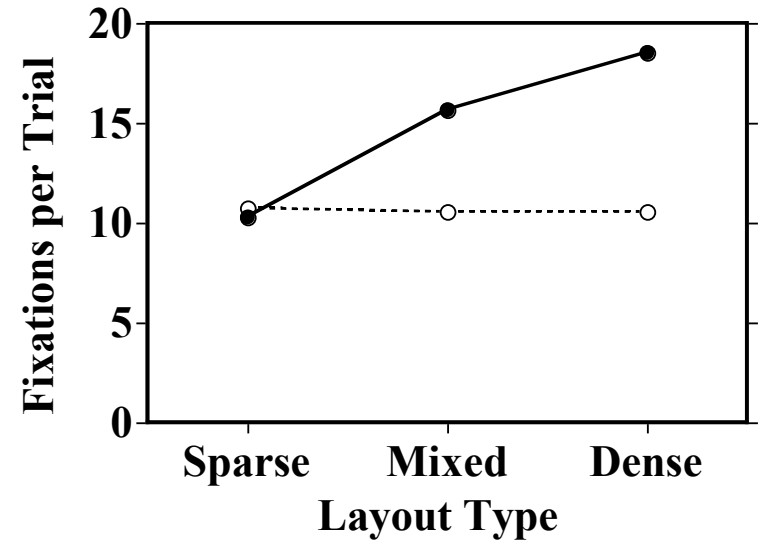
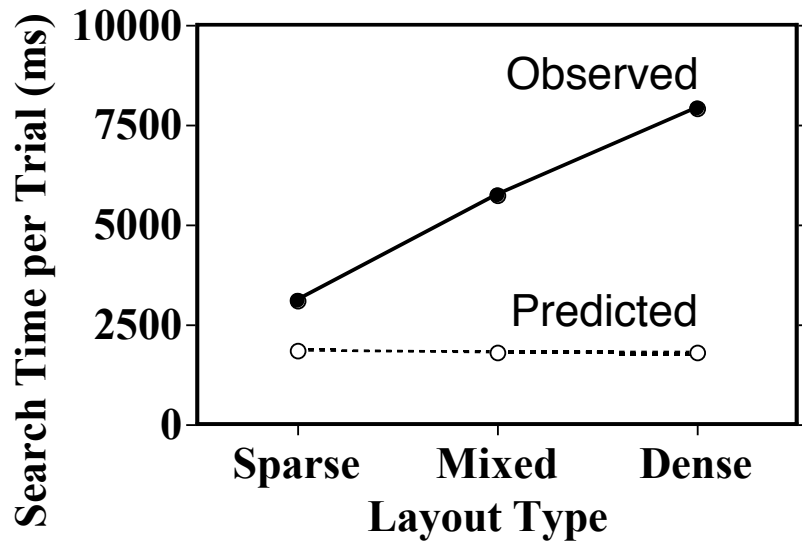


In mixed density layouts, the strategy shifted around the third group visited.

Modeling the general patterns of behavior in mixed-density search

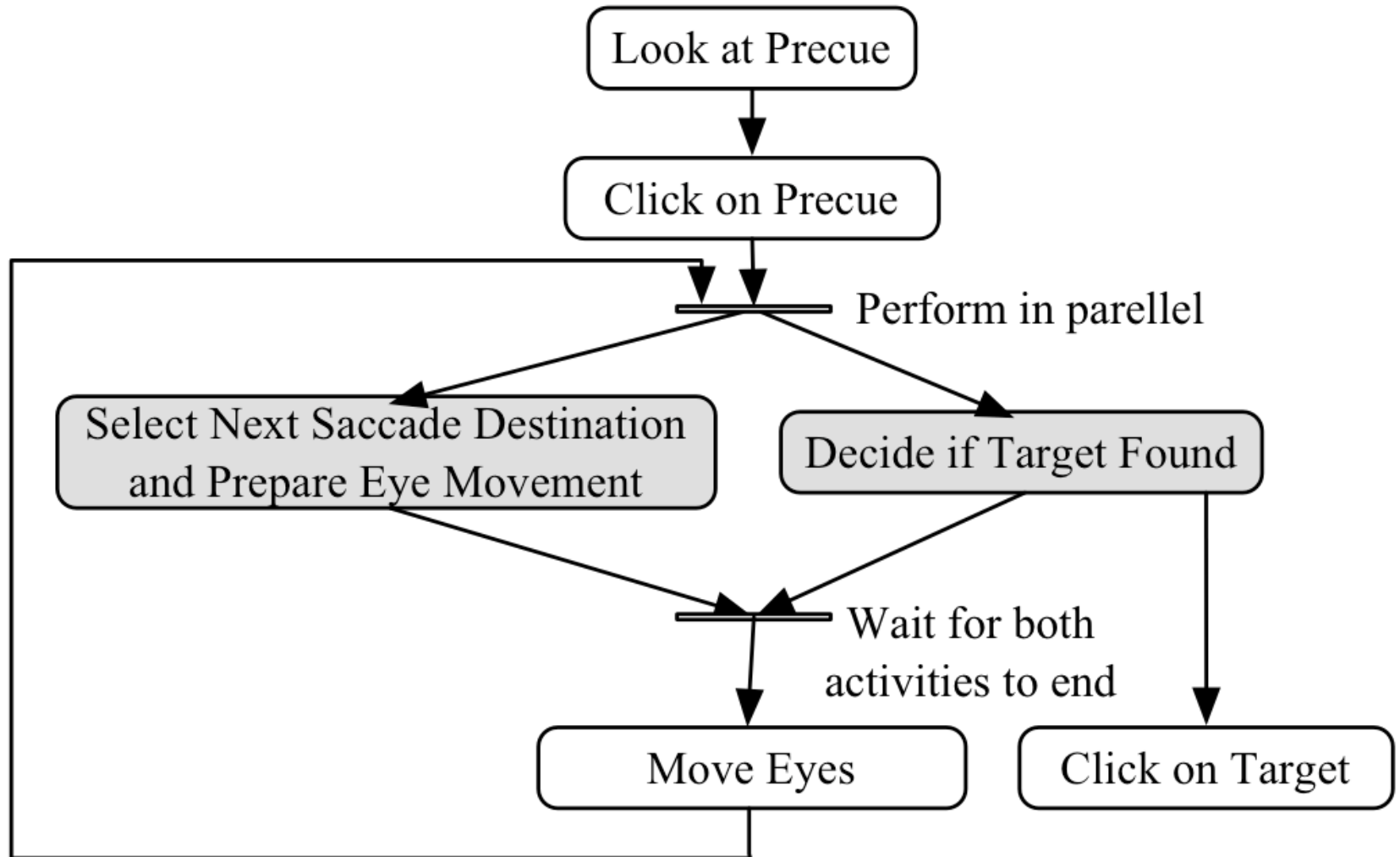
- Account for the fundamental search behavior first, strategy shifts later.
- Previous work showed that a random search strategy with 2 to 3 items per fixation is a good first approximation for predicting mean layout search time.
- Such a strategy benefits for *a priori* engineering models, such as each object need be encoded with only one directly-extractable feature—its location.

Base Model: Random Search

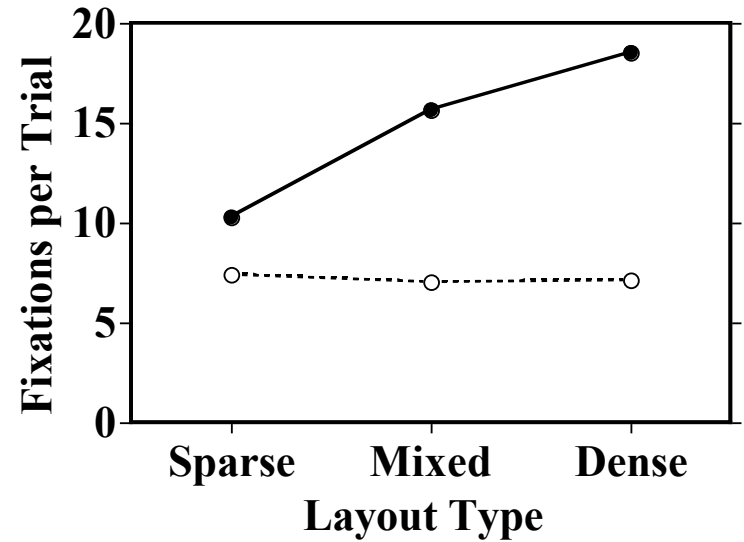
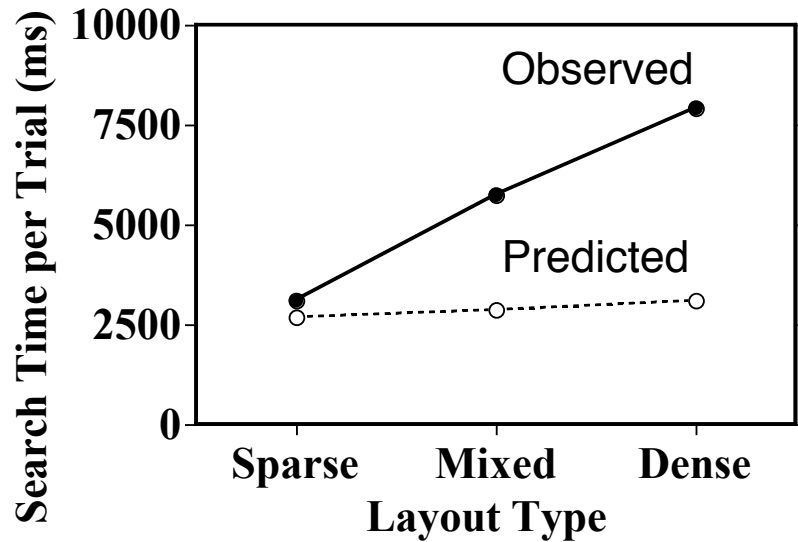


- Purely random search
- Keep moving the eyes
- All perceptual properties set to EPIC's defaults
- Only explains Sparse.

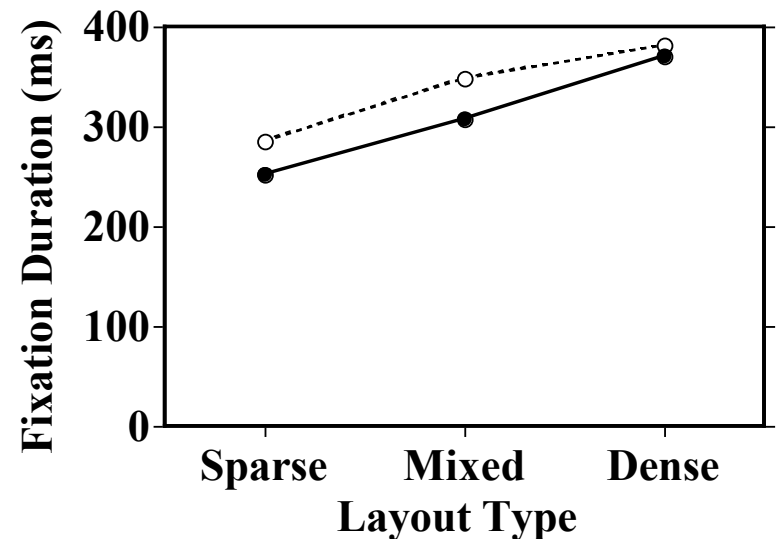
Refined Strategy: “Wait-for-TEXT”



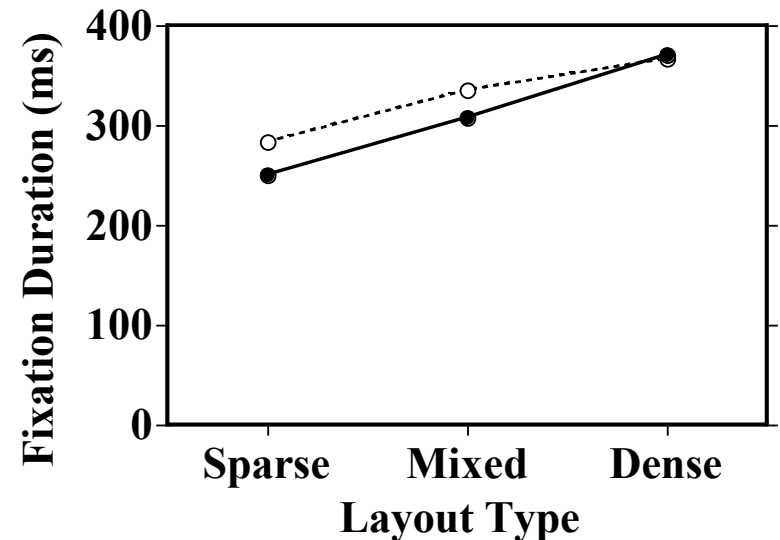
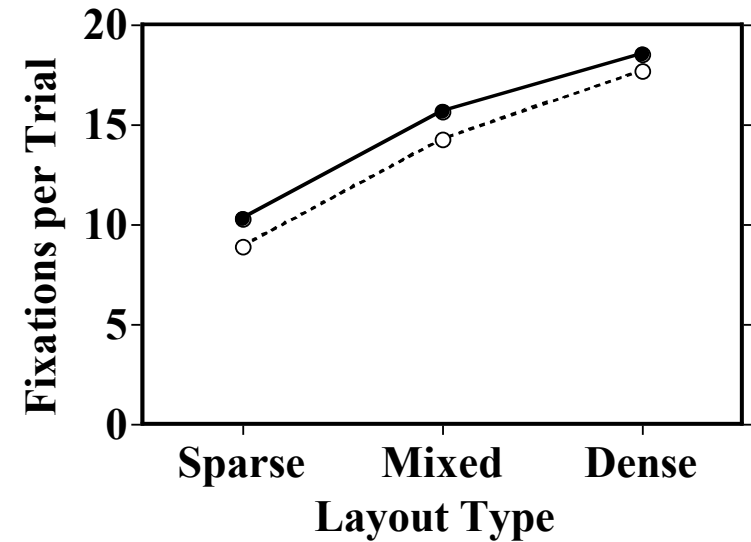
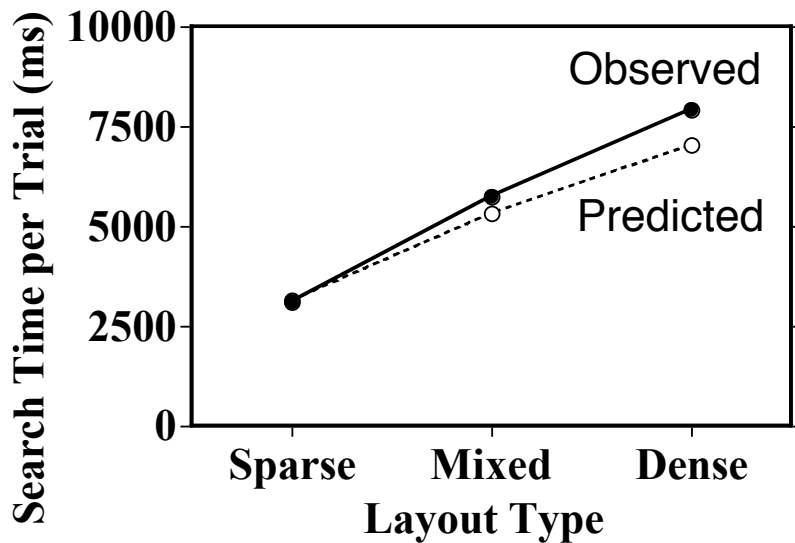
“Wait-for-TEXT” Model



- Perceptual encoding time related to density.
- Explains fixation duration.
- Other measures don't improve overall.



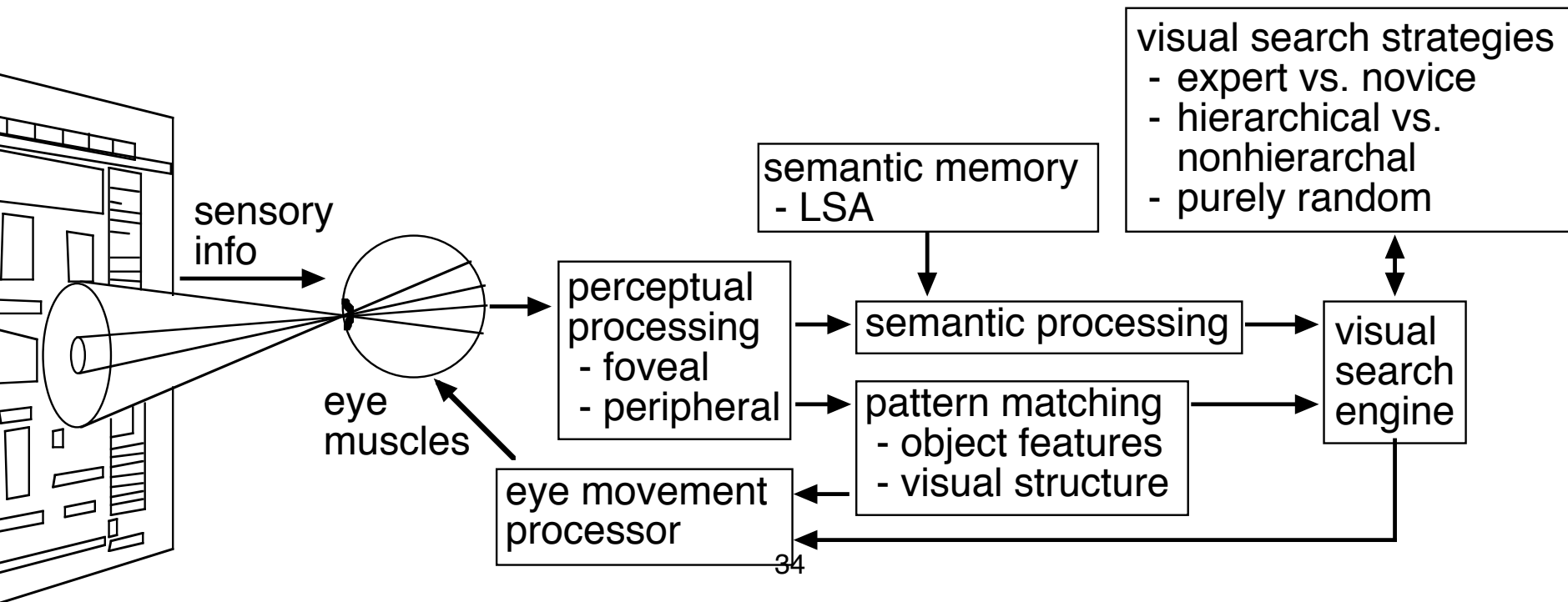
Reduced Text Availability Model



- Sparse: 90% chance of getting TEXT in fovea
- Dense: 50% chance
- Explains all of this data

Lessons Learned for Predictive Modeling

- Evidence that visual a WM limit of 2 to 4 items persists in each fixation in a series of rapid visual fixations during visual search.
- Some measure of density is needed.
- Scan paths are hard to predict, but we can perhaps predict some types of groups will be searched first.



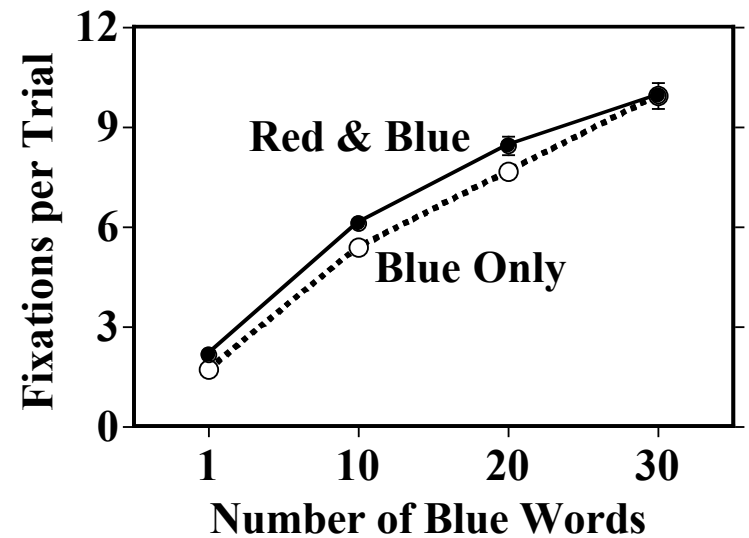
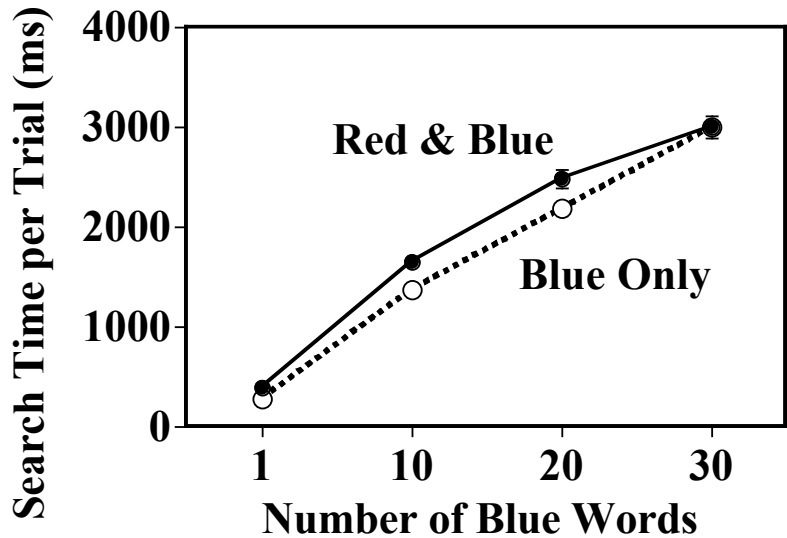
The Effects of Text Color: Experimental Task

- Target is always blue
- Red distractors or blank spaces
- 1, 10, 20, 30 blue words
- Procedure:
 1. Study target.
 2. Click on precue.
 3. Find target.
 4. Click on target.

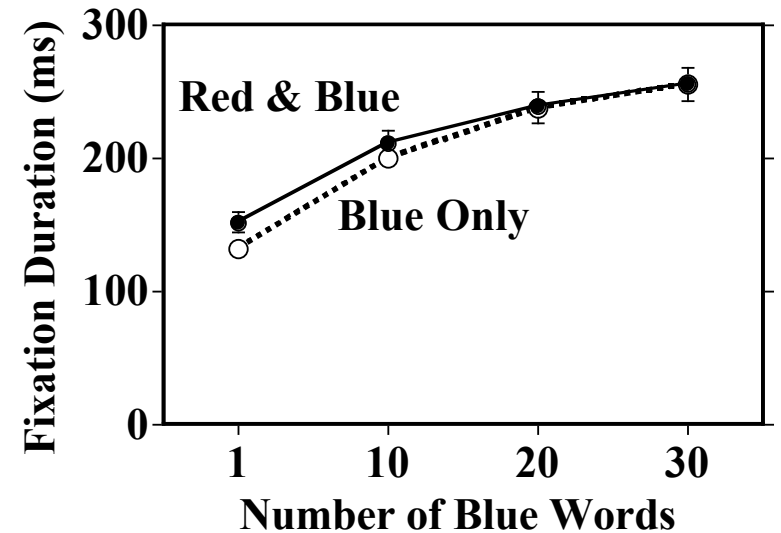
farm	gown	earth
bush	throat	pet
roll	pair	square
smoke	scab	staff
jump	name	author
soft	snail	blade
stout	film	rose
doorway	leap	grave
snow	rain	sheep
dozen	harbor	frown

snow		
leap		doorway
rain		blade
	farm	
pet		
	bush	
jump		scab

Results per Trial

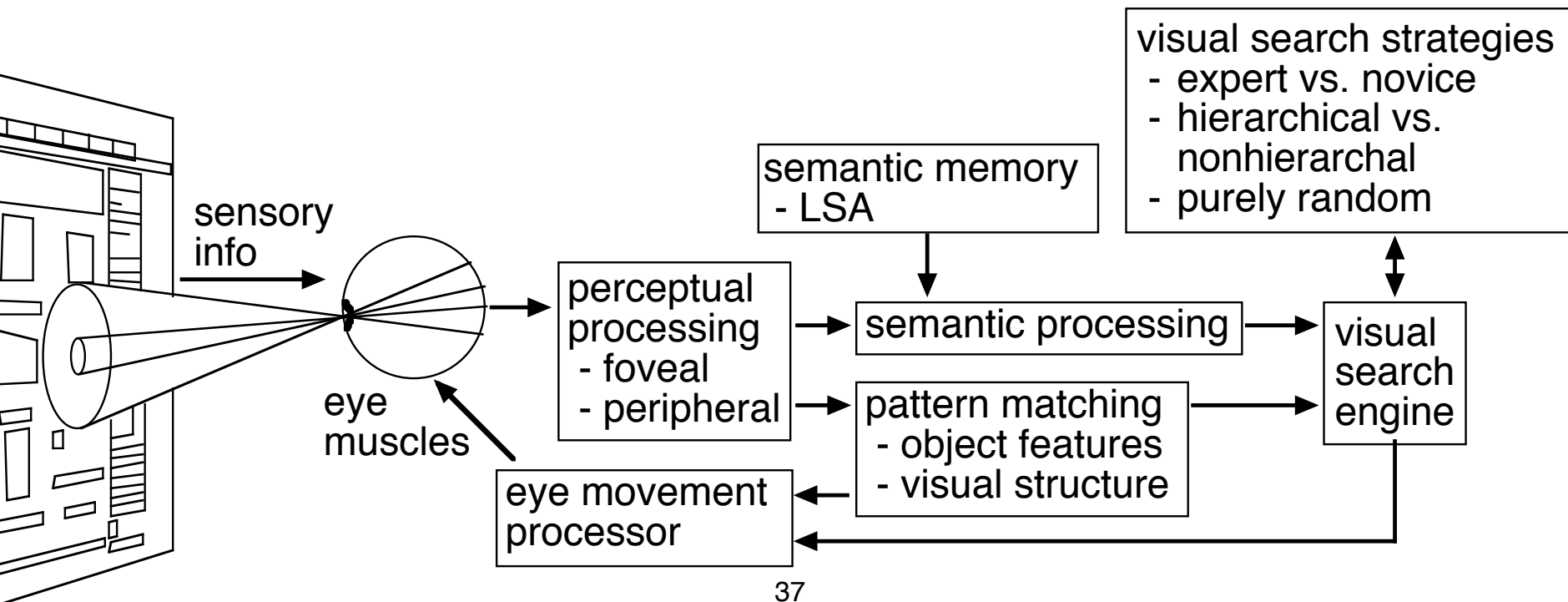


- Faster with fewer blue.
- Faster without red.
- Can almost perfectly confine search to the blue.

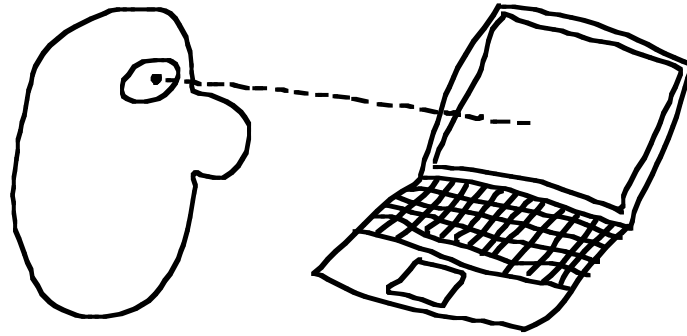


Lessons Learned for Predictive Modeling

- Powerful color effects persist in text search.
- Current work is refining specific parameter sets to use for predictive modeling for searching colored text.

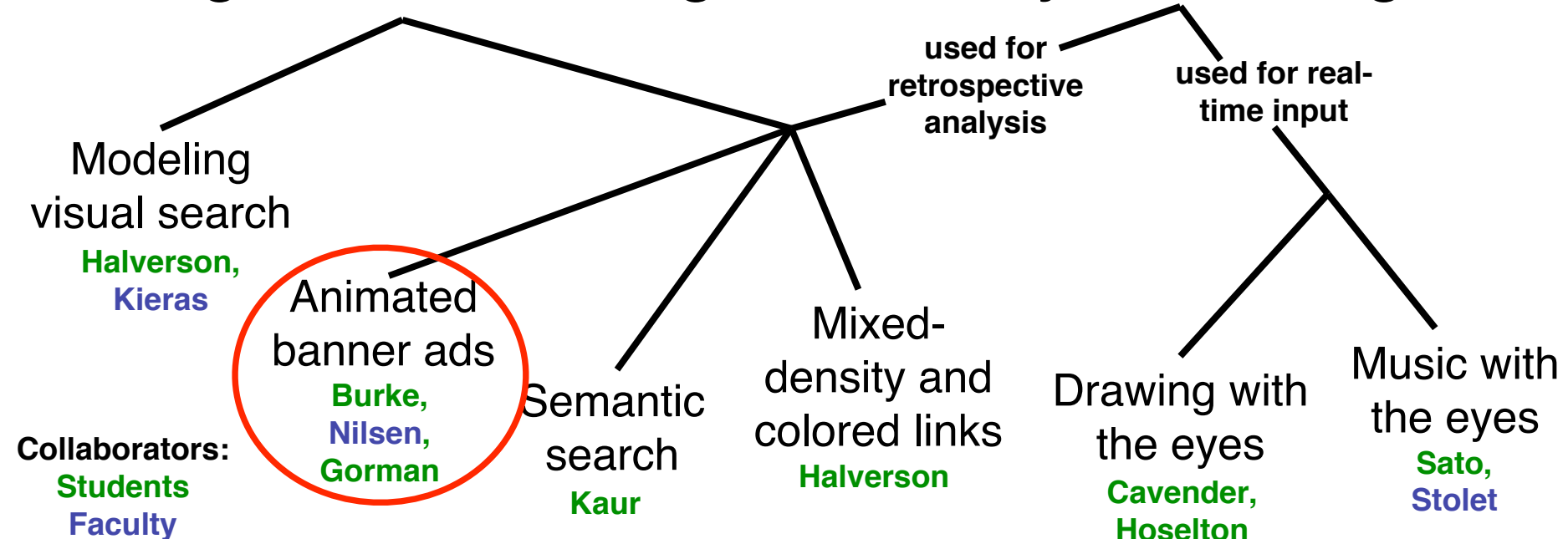


Human-Computer *Visual* Interaction



Cognitive Modeling

Eye Tracking



The Effect of Flashing Banner Ads on Visual Search

- Everyone hates them.
- Some HCI researchers believe people have “banner blindness,” that people basically just ignore banner ads.
- It’s actually worse than that.

Hello Kitty Taxis Now in Tokyo



← click box to reveal
search area

← precue (disappears when
search area appears)



← a banner always
appears here at
the top

[Wrong Color Foot on Amputee](#)

[Bruce Lee's Great Vanishing Act](#)

[At Last: Russians Can Drink and Drive](#)

[Fat Removing Belt Companies Settle Lawsuit](#)

[Who Wants to Be a Licensed Trash Scavenger](#)

[Hello Kitty Taxis Now in Tokyo](#)

[Oil Rush in Trash Cans](#)

[LAPD, FBI Hunt for "Michael Jackson Bandit"](#)



← another banner
appears in a
random row

[Sun-Powered Cars Near Finish Line](#)

[Company Declares War on Staff E-mail](#)

Recognition Memory

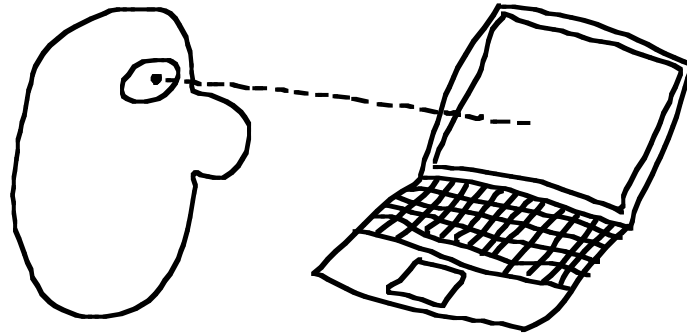
- Participants were asked afterwards (not in instructions earlier) ‘Did you see this ad?’
- People cannot remember what they saw.
- A *hit* rate of only 20% and a *false alarm* rate of 20%. Perfect performance would have been 100% and 0%, respectively.
- Recognition for the static banners was better than for animated banners.
- Yes, people are sort of blind, but...

The ads do slow you down.

Banner Type	Mean Search Time (in msec.)	St. Dev. (in msec.)
Blank	2040	289
Static	2169	300
Animated	2193	297

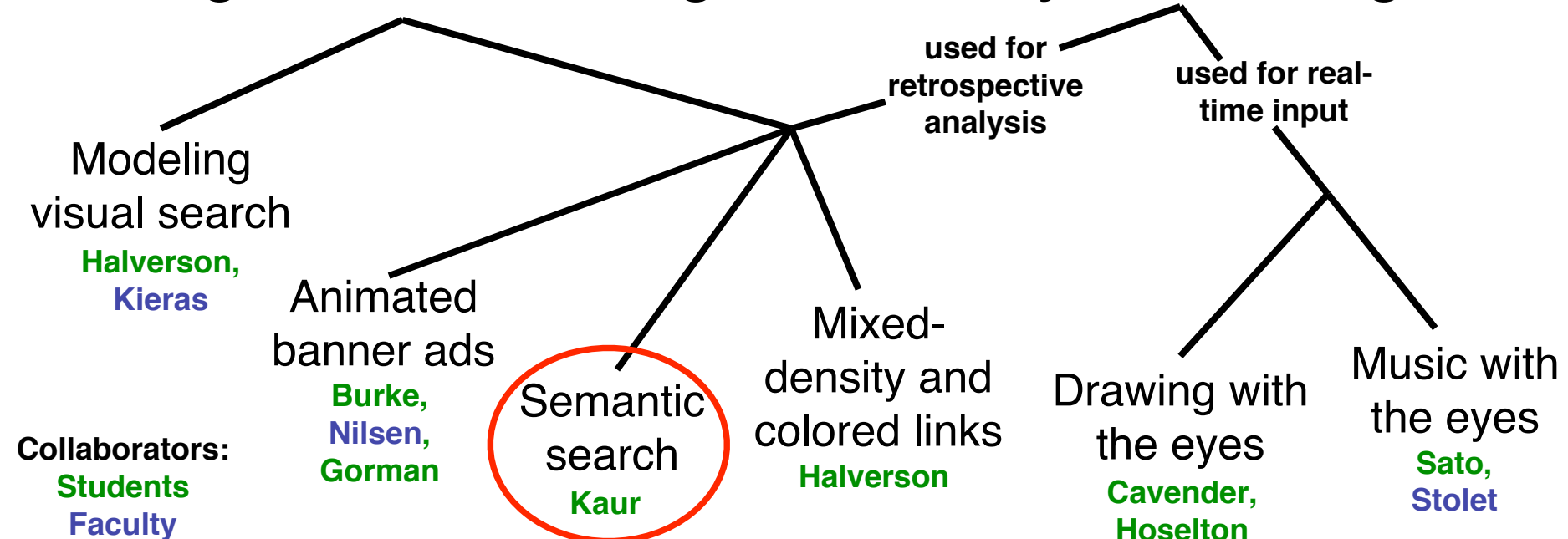
- Yes, people do not remember the ads.
- But people are not blind to the distracting effects. The ads do significantly interfere with a primary visual task.
- Eye movement data will be analyzed to help figure out the best way to model this phenomenon.

Human-Computer *Visual* Interaction



Cognitive Modeling

Eye Tracking



Semantic Search: Where would you click to learn about a major in Biology?

Waynesburg College

Connections That Matter!



Faith · Learning · Serving

Profile

Calendar

Academics

Undergraduate Programs

Graduate & Professional
Programs

Athletics

Campus Life

Technology



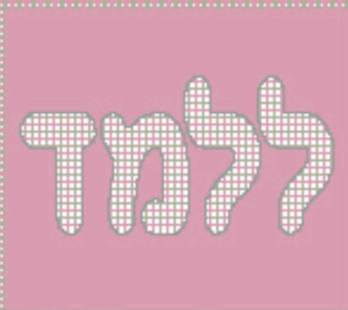
Member
e PAC; Jan 29th 12 Noon Hot Topics A Presentation on Information

Council for Christian
Colleges & Universities

Visitor Information Alumni & Friends Network WC Community

We asked participants where they would click given 45 webpage-goal combinations.

A "high clustering" web page



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January 26, 2004
at 5764

Each student a thread in the tapestry of tradition



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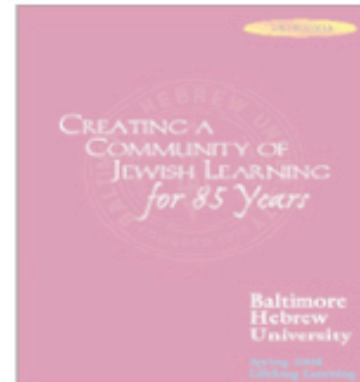


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News for January 26, 2004

Opportunity Rover Lands on Mars

The second Mars rover, *Opportunity*, landed successfully on Mars Saturday night and transmitted images of its surroundings, as reported in Sunday's *New York Times*. Progress was also made on the *Spirit* rover's repairs.

Harry Gray Wins Wolf Prize

Man Professor of Chemistry and founding director of the Beckman Institute, was the Wolf Prize in Chemistry for his "pioneering work in bio-inorganic chemistry, principles of structure and long-range electron transfer in proteins." Gray will receive the prize in May in Jerusalem.

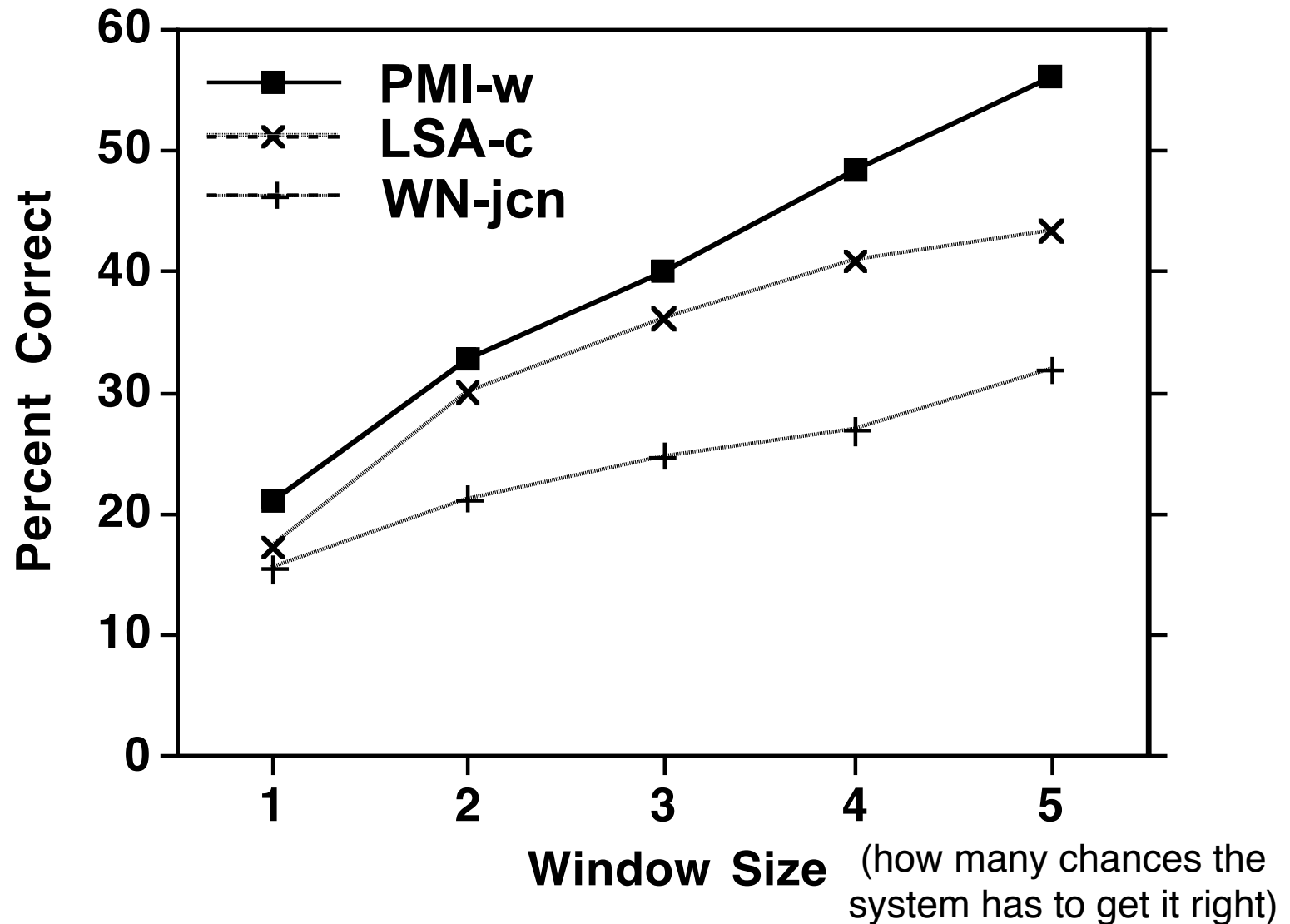
Measure Distance to Storied Star

obtained a highly accurate distance to one of the stars of the Pleiades known since the new results will be useful in the longstanding effort to improve the cosmic distance scale, as well as to research the stellar life-cycle.

JPL

Can semantic systems predict the human responses?

Somewhat. We tried three: PMI-IR, LSA, and WordNet.



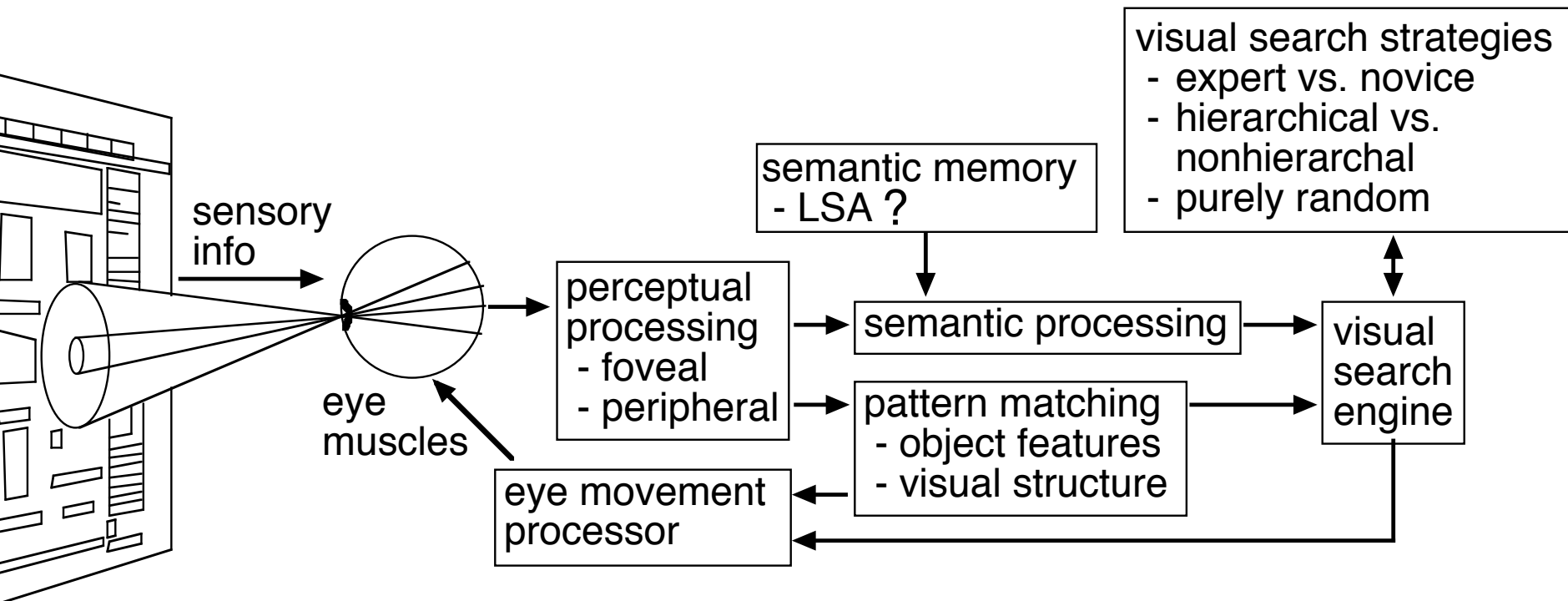
Next question: How does semantic content affect search patterns and strategies?

Are there a disproportionate number of gaze revisits and dwell time on the links with highest semantic similarity?

If so, this would have implications for predictive modeling—the eyes should spend more time on goal-related links.

More Questions: How do we integrate the models?

1. How can theories about how people do a class of tasks (such as visual search) be integrated with each other?
2. How can they be integrated into a comprehensive theory of human information processing?



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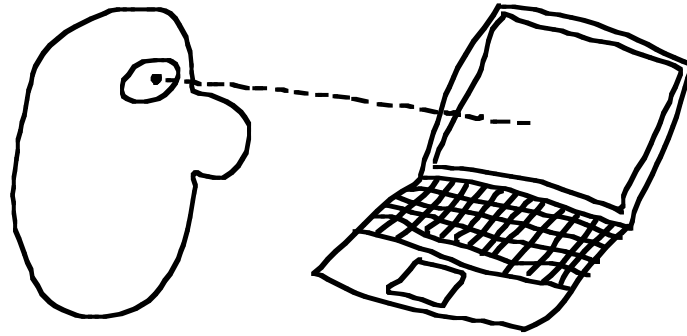
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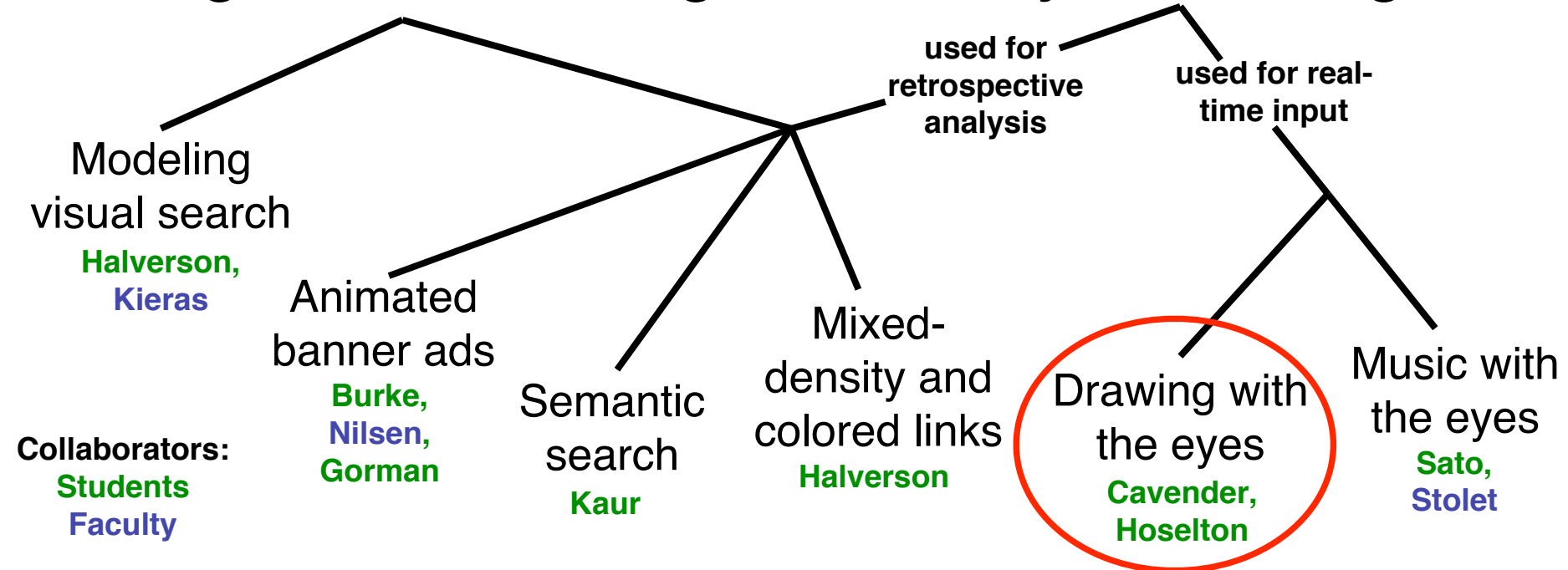
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Human-Computer *Visual* Interaction



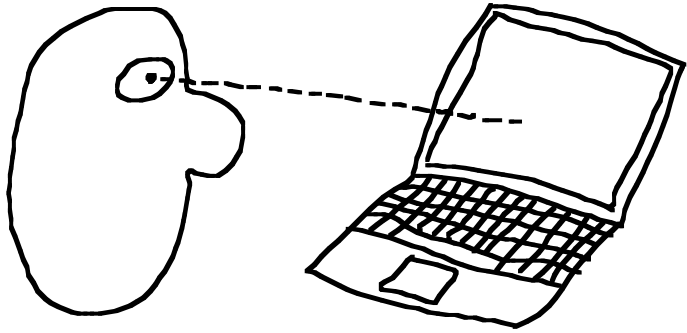
Cognitive Modeling

Eye Tracking



Drawing with the Eyes

Human-Computer *Visual* Interaction

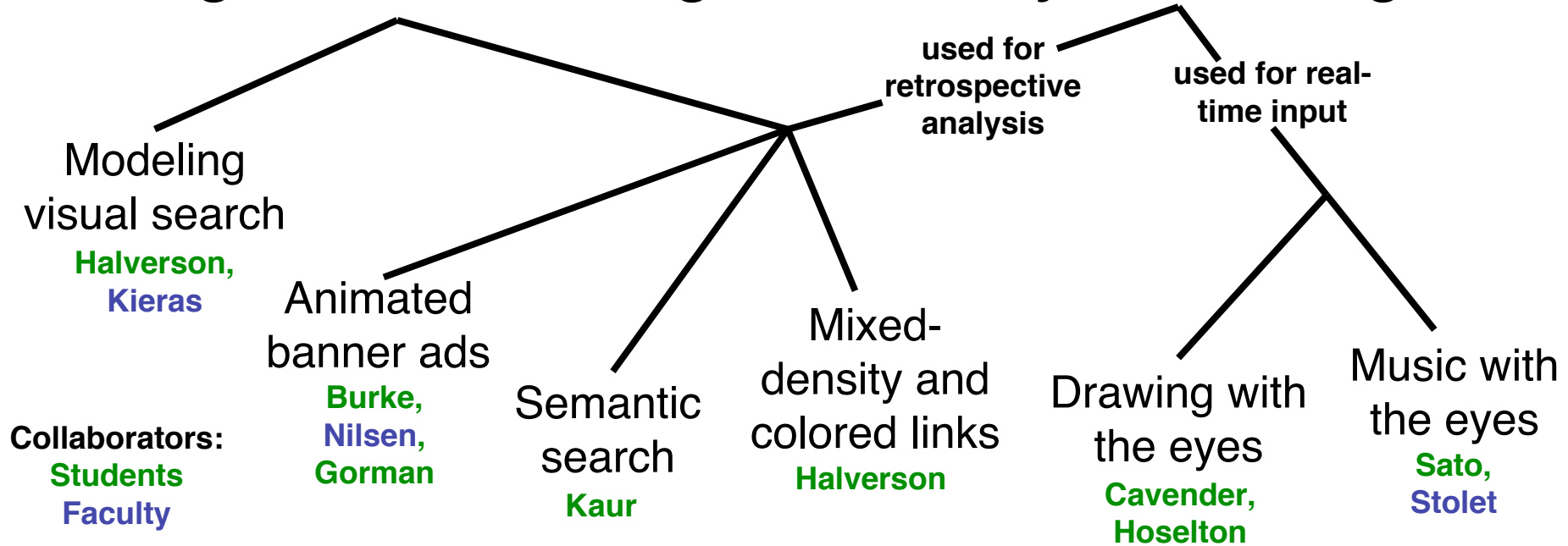


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Cognitive Modeling

Eye Tracking



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(Jan., 2004)