

# Modeling User Behavior and Interactions

## Lecture 1: Modeling Searcher Behavior

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# Overview of the Course

- **Lecture 1:** Modeling searcher behavior
- **Lecture 2:** Interpreting behavior → relevance
- **Lecture 3:** Using behavior data → ranking
- **Lecture 4:** Personalizing search with behavior
- **Lecture 5:** Search user interfaces



# Lecture 1: Models of Search Behavior

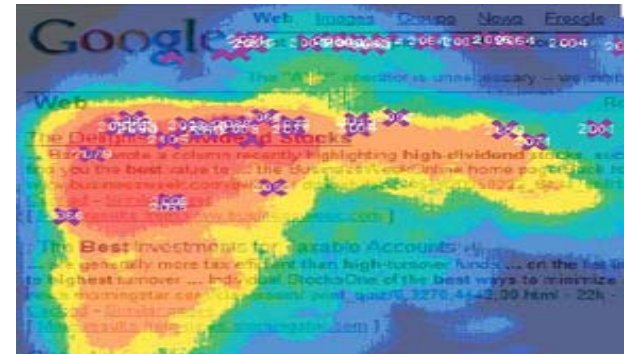
- Understanding user behavior at micro-, meso-, and macro- levels
- Theoretical models of information seeking
- Web search behavior:
  - Levels of detail
  - Search Intent
  - Variations in web searcher behavior
  - Click models



# Levels of Understanding User Behavior

[Daniel M. Russell, 2007]

- Micro (eye tracking):  
lowest level of detail, milliseconds
- Meso (field studies):  
mid-level, minutes to days
- Macro (session analysis):  
millions of observations,  
days to months

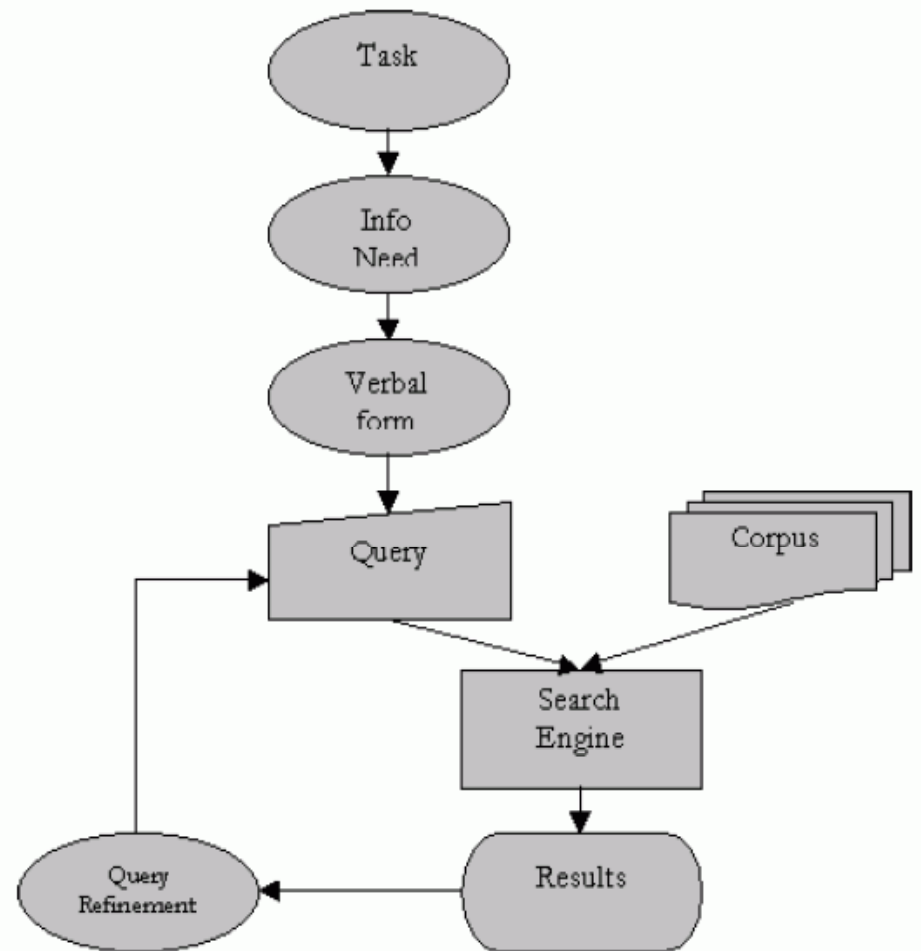


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URL
http://www.google.com/ig?hl=en
http://127.0.0.1:4664/search?q=wardrobe+in+NBC&num=2&
http://www.google.com/search?hl=en&q=wardrobe+in+NBC
http://ad.doubleclick.net/adi/N339_cbshealthwatch/B1809262
http://adopt.specificclick.net/adopt.sm?i=1013290775&sz=po
http://www.cbsnews.com/stories/2004/07/01/entertainment/m
http://127.0.0.1:4664/search?q=wardrobe+in+NBC&num=2&
http://www.google.com/search?hl=en&q=wardrobe+in+NBC
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http://www.google.com/search?hl=en&lr=&safe=off&q=will+ar
http://www.nbc.com/nbc/footer/FAQ.shtml
http://nbc.resultspage.com/display.php?w=wardrobe
http://www.nbc.com/nbc/Will_&_Grace/wardrobe/frames/sear
http://www.nbc.com/nbc/Will_&_Grace/wardrobe/frames/s
```



# Models of Information Seeking

- “Information-seeking ... includes recognizing ... the information problem, establishing a plan of search, conducting the search, evaluating the results, and ... iterating through the process.” - Marchionini, 1989
  - Query formulation
  - Action (query)
  - Review results
  - Refine query



Adapted from: M. Hearst, SUI, 2009



# Key Concept: Relevance

- Intuitively well understood
  - same perception globally – “y’know”
  - a “to” and context always present
- Relevance:
  - a relation between objects **P** & **Q** along property **R**
  - may also include a measure **S** of the strength of connection
- **Example: topical relevance** (document on the correct topic)



# Relevance clues

- What makes information or information objects relevant? What do people look for in order to infer relevance?
  - Topicality (subject relevance)
  - Extrinsic (task-, goal- specific)
- Information Science “clues research”:
  - uncover and classify attributes or criteria used for making relevance inferences



# IR Relevance Models

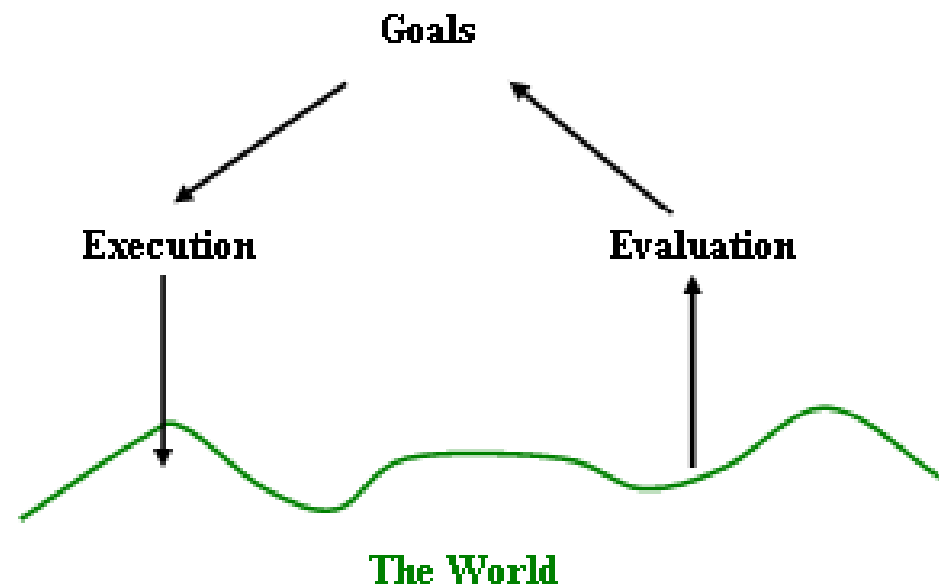
- All IR and information seeking models have relevance at their base
- **Traditional IR model** has most simplified (topic) version of relevance (**topical**)
  - Enough to make progress
- Variety of integrative models have been proposed
  - more complex models = increased challenge to evaluation and implementation in practice





# Cognitive Model of Information Seeking

- Static Info Need
  - Goal
  - Execution
  - Evaluation



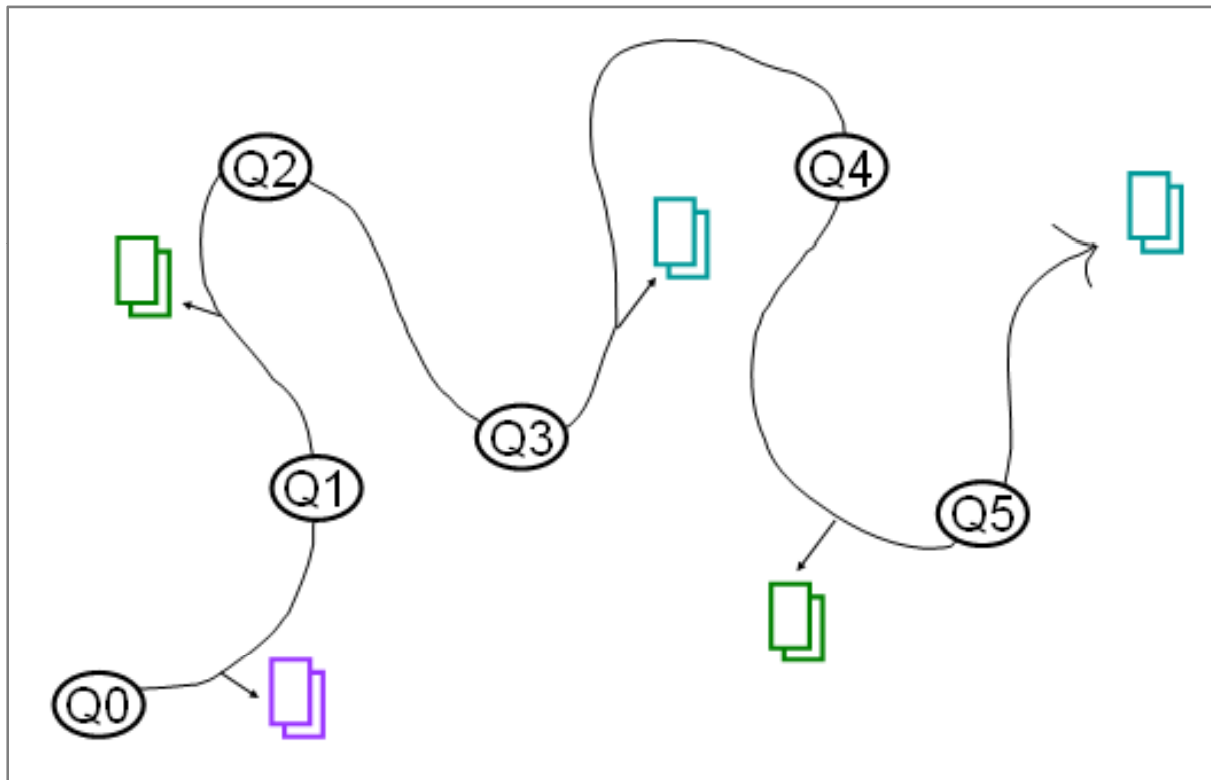
# Relevance dynamics

- Do relevance inferences and criteria change over time for the same user and task, and if so, how?
- As user progresses through stages of a task:
  - the user's cognitive state changes
  - the task changes as well



# Dynamic “Berry Picking” Model

- Information needs change during interactions



[Bates, 1989] M.J. Bates. The design of browsing and berrypicking techniques for the on-line search interface. *Online Review*, 13(5):407–431, 1989.



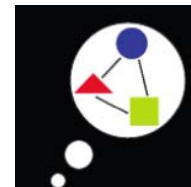
# Information Foraging Theory

**Goal:** maximize rate of information gain.

Patches of information → websites

**Basic Problem:** should I continue in the current patch or look for another patch?

**Expected gain** from continuing in current patch, **how long** to continue searching in that patch



CLICK TO COMPARE

SORT BY Hotel Name

SORT BY Star Rating

SORT BY hotels.com Picks

SORT BY Price

<input type="checkbox"/>	1		<b>Sofitel Paris La Defense Centre</b> ★★★★★ Paris La Defense / La Defense Hotel Info: 800-246-8357 <a href="#">Show Amenities &amp; Rates</a>	from \$113.00 LOWEST AVG. NIGHTLY RATE LOW PRICE GUARANTEE <a href="#">SELECT</a>
<input type="checkbox"/>	2		<b>Hotel Lutetia</b> ★★★★★ Left Bank, St-Germain-Des-Prés / Paris Hotel Info: 800-246-8357 <a href="#">Show Amenities &amp; Rates</a>	from \$225.00 LOWEST AVG. NIGHTLY RATE LOW PRICE GUARANTEE <a href="#">SELECT</a>
<input type="checkbox"/>	3		<b>Hyatt Regency Paris Madeleine</b> ★★★★★ / Paris Hotel Info: 800-246-8357 <a href="#">Show Amenities &amp; Rates</a>	from \$427.00 LOWEST AVG. NIGHTLY RATE LOW PRICE GUARANTEE <a href="#">SELECT</a>
<input type="checkbox"/>	4		<b>Hotel De Vendome</b> ★★★★★ Concorde/Madeleine / Paris Hotel Info: 800-246-8357 <a href="#">Show Amenities &amp; Rates</a>	from \$438.00 LOWEST AVG. NIGHTLY RATE LOW PRICE GUARANTEE <a href="#">SELECT</a>
<input type="checkbox"/>	5		<b>Le Meurice</b> ★★★★★ City Center / Paris Hotel Info: 800-246-8357 <a href="#">Show Amenities &amp; Rates</a>	from \$623.00 LOWEST AVG. NIGHTLY RATE LOW PRICE GUARANTEE <a href="#">SELECT</a>
<input type="checkbox"/>	6		<b>Hotel Royal Monceau</b> ★★★★★ / Paris Hotel Info: 800-246-8357 <a href="#">Show Amenities &amp; Rates</a>	from \$400.00 LOWEST AVG. NIGHTLY RATE LOW PRICE GUARANTEE <a href="#">SELECT</a>
<input type="checkbox"/>	7		<b>L' Hotel De Sers</b> ★★★★★ Next To The Champs Elysees / Paris Hotel Info: 800-246-8357 <a href="#">Show Amenities &amp; Rates</a>	from \$368.00 LOWEST AVG. NIGHTLY RATE LOW PRICE GUARANTEE <a href="#">SELECT</a>
<input type="checkbox"/>	8		<b>Jolly Hotel Lotti</b> ★★★★★ On A Right Bank Street / Paris Hotel Info: 800-246-8357 <a href="#">Show Amenities &amp; Rates</a>	from \$229.00 LOWEST AVG. NIGHTLY RATE LOW PRICE GUARANTEE <a href="#">SELECT</a>
<input type="checkbox"/>	9		<b>Hotel De Crillon</b> ★★★★★ Tulleries Gardens / Paris Hotel Info: 800-246-8357 <a href="#">Show Amenities &amp; Rates</a>	from \$690.00 LOWEST AVG. NIGHTLY RATE LOW PRICE GUARANTEE <a href="#">SELECT</a>

# Hotel Search

Goal: Find  
cheapest 4-star  
hotel in Paris.

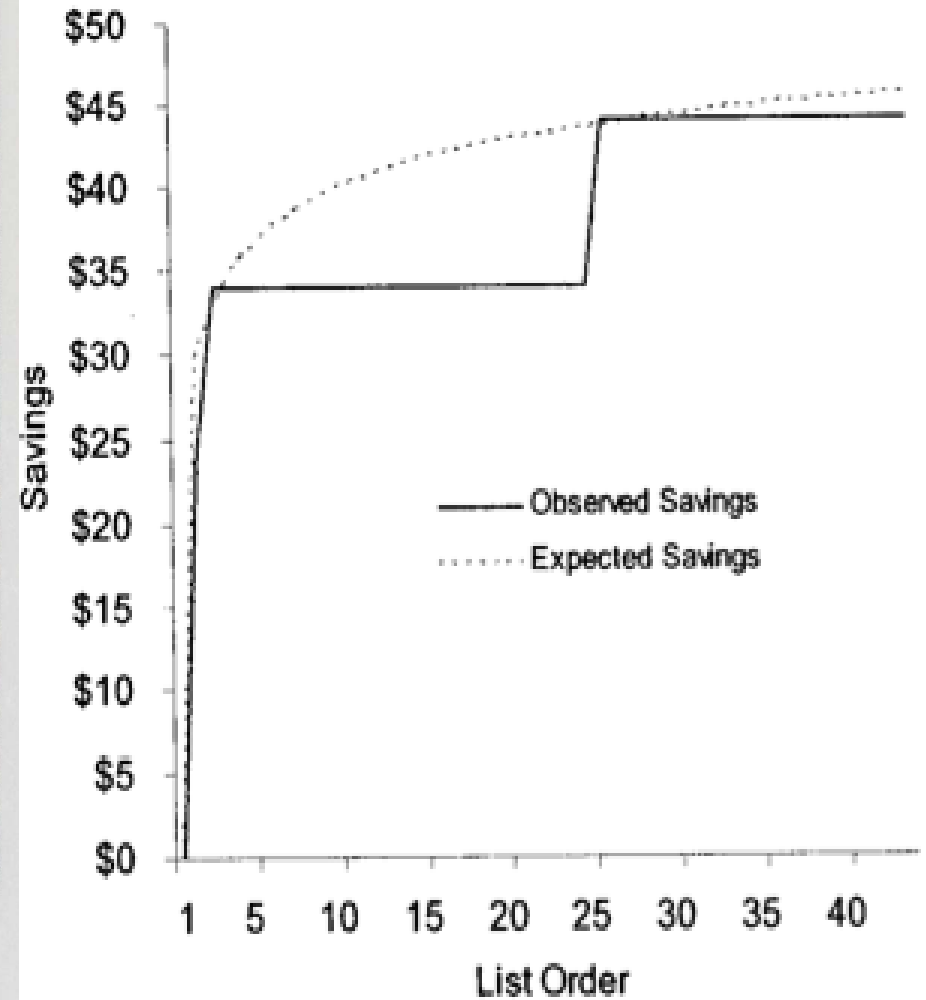
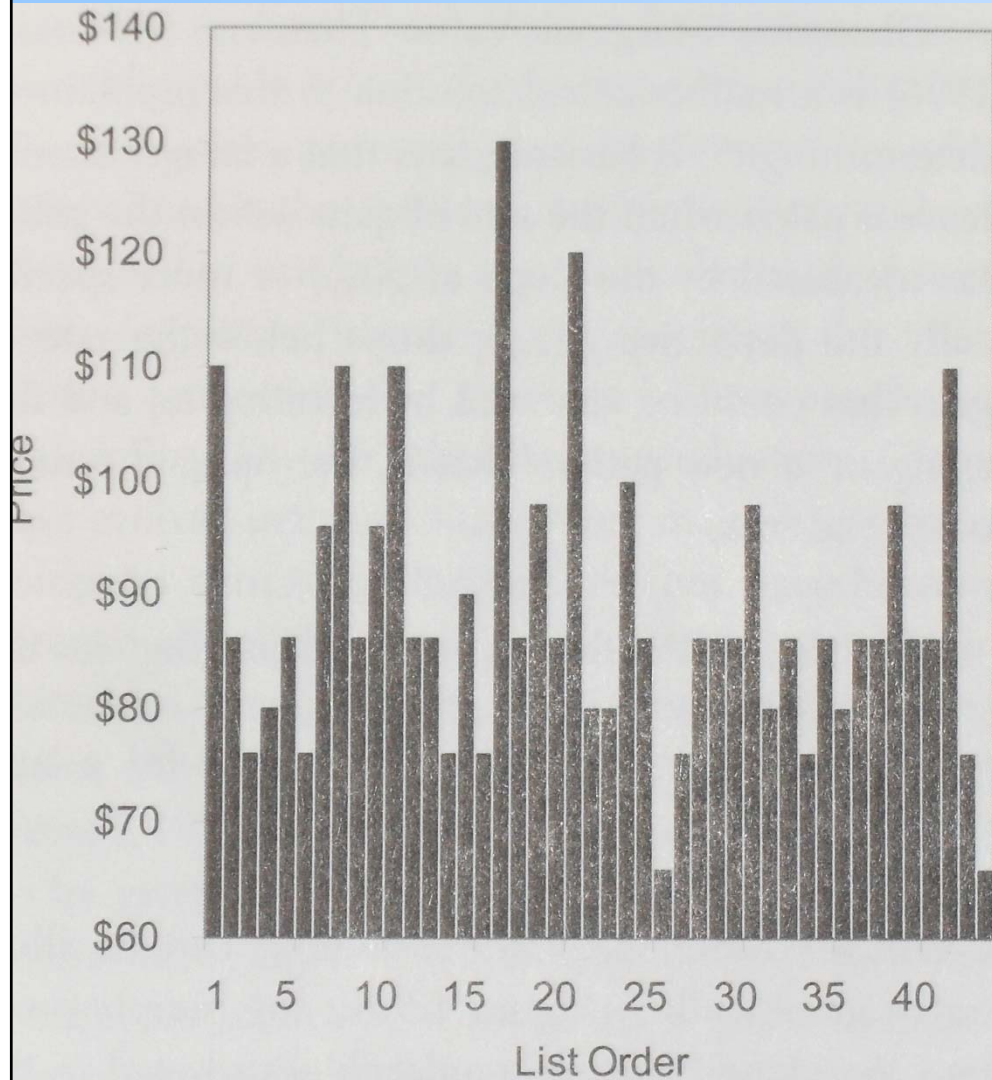
Step 1: pick hotel  
search site

Step 2: scan list

Step 3: goto 1

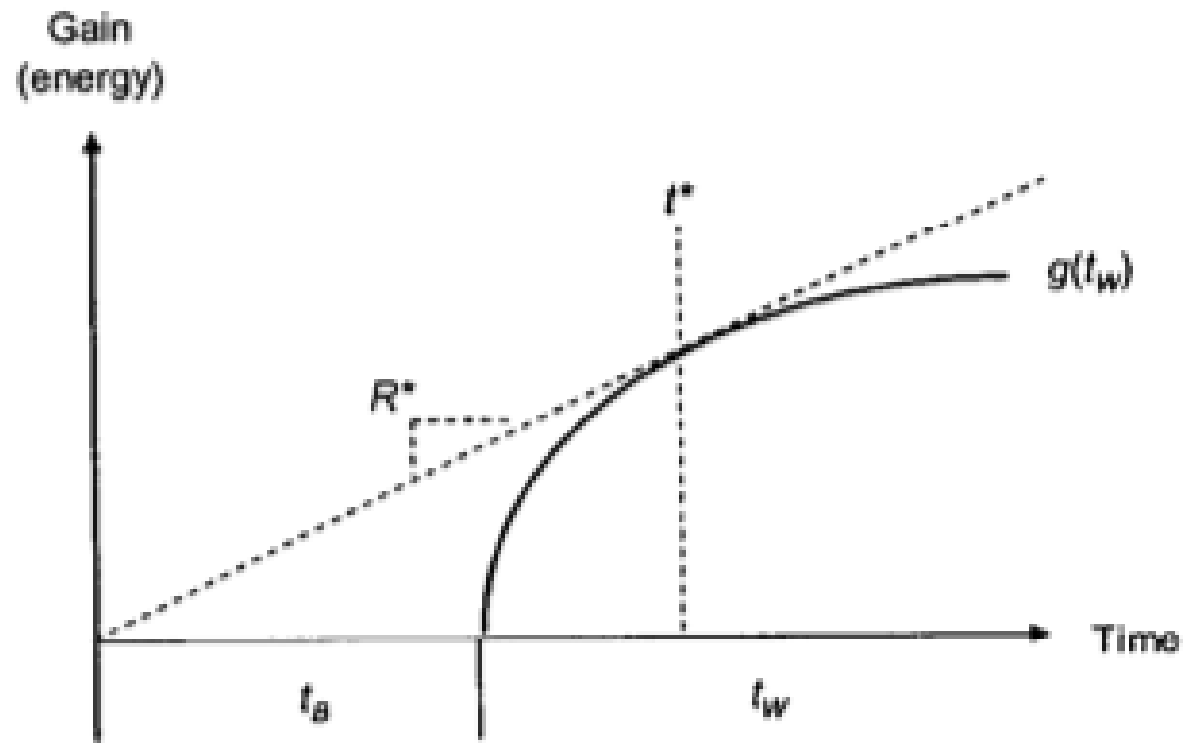


# Example: Hotel Search (cont'd)



# -Charnov's Marginal Value Theorem

Diminishing Returns Curve; 80% of users don't scan past the 3<sup>rd</sup> page of search results



$R^*$  = steepest slope from origin = tangent from origin

If  $t_b$  is low, then people tend to switch more easily. (web snacking)



# Browsing vs. Search

- Recognition over recall (I know it when I see it)
- Browsing hierarchies/facets more effective than querying





# Orienteering

- Searcher issues a quick, imprecise to get to approximately the right information space region
- Searchers follow known paths that require small steps that move them closer to their goal
- Expert searchers starting to issue longer queries



# Information Scent for Navigation

- Examine clues where to find useful information

The screenshot shows the Bureau of Labor Statistics (BLS) website. The main navigation menu includes: [Data](#), [Economy at a Glance](#), [Surveys & Programs](#), [Publications & Research Papers](#), [About BLS](#), [Other Statistical Sites](#), and [Contact Information](#). The website header features the BLS logo and the text "U.S. Department of Labor Bureau of Labor Statistics" with the URL [www.bls.gov](http://www.bls.gov). A secondary navigation bar contains: [About BLS](#), [Jobs in BLS](#), [Get Detailed Statistics](#), [Economic News Releases](#), [Glossary](#), [What's New](#), [Contact Us](#), and [Find It! In DOL](#).

The main content area is divided into several sections:
 

- Inflation & Consumer Spending**: [Consumer Price Index](#), [Inflation Calculator](#), [Contract Escalation](#), [Producer Price Indexes](#), [Import/Export Price Indexes](#), [Consumer Expenditures](#), [Price Index Research](#)
- Wages, Earnings, & Benefits**: [Wages by Area and Occupation](#), [Earnings by Industry](#), [Employee Benefits](#), [Employment Costs](#), [State and County Wages](#), [National Compensation Data](#), [Collective Bargaining](#), [Wage Calculator](#), [Compensation Research](#)
- Productivity**: [Productivity and Costs](#), [Multifactor Productivity](#), [International Comparisons](#)
- Safety & Health**: [Injuries and Illnesses](#), [Fatalities](#), [Incidence Rate Calculator](#), [Profiles](#)
- International**: [Import/Export Price Indexes](#), [Foreign Labor Statistics](#), [International Technical Cooperation](#)
- Occupations**: [Occupational Outlook Handbook](#), [Occupational Outlook Quarterly](#), [Employment](#), [Wages by Area and Occupation](#), [Injuries, Illnesses, and Fatalities](#), [Employment Projections](#), [Standard Occupational Classification \(SOC\)](#)
- Employment & Unemployment**: [National Employment](#), [National Unemployment Rate](#), [State and Local Employment](#), [State and Local Unemployment Rates](#), [Mass Layoffs](#), [Employment Projections](#), [Job Openings and Labor Turnover](#), [Employment by Occupation](#), [Longitudinal Studies](#), [State and County Employment](#), [Time Use](#), [Business Employment Dynamics](#), [Employment Research](#)
- At a Glance Tables**: [U.S. Economy at a Glance](#), [Regions, States, and Areas at a Glance](#), [Industries at a Glance](#)
- Publications**: [Occupational Outlook Handbook](#), [Monthly Labor Review Online](#), [Compensation and Working Conditions Online](#), [Occupational Outlook Quarterly](#), [The Editor's Desk](#), [Career Guide to Industries](#), [Economic News Releases](#), [More »](#)
- Research**: [Research Papers](#), [Compensation](#), [Employment](#), [Price Index](#), [Survey Methods Research](#)
- Industries**: [Industries at a Glance](#), [Employment, Hours, and Earnings](#), [Occupations](#), [Injuries, Illnesses, and Fatalities](#), [Producer Price Indexes](#), [Employment Costs](#), [Productivity](#)

The "Latest Numbers" section displays the following data:
 

- CPI**: +0.7% in May 2007
- Unemployment Rate**: 4.5% in Jun 2007
- Payroll Employment**: +132,000(p) in Jun 2007
- Average Hourly Earnings**: +\$0.06(p) in Jun 2007
- PPI**: +0.9%(p) in May 2007
- ECI**: +0.8% in 1st Qtr of 2007
- Productivity**: +1.0% in 1st Qtr of 2007
- U.S. Import Price Index**: +1.0% in Jun 2007

 A note at the bottom indicates "» p- preliminary".

At the bottom of the page, there is a navigation bar with the text: "The Bureau of Labor Statistics is an agency within the U.S. Department of Labor".

Search results listings must provide the user with clues about which results to click



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# Summary of Models

- Many cognitive models proposed
- Classical IR Systems research mainly uses the simplest form of relevance (**topicality**)
- Open questions:
  - How people recognize other kinds of relevance
  - How to incorporating other forms of relevance (e.g., user goals/needs/tasks) into IR systems



# Lecture 1: Models of Search Behavior

- Understanding user behavior at micro-, meso-, and macro- levels
- ✓ Theoretical models of information seeking
- **Web search behavior:**
  - Levels of detail
  - Search Intent
  - Variations in web searcher behavior
  - Click models



# Web Searcher Behavior

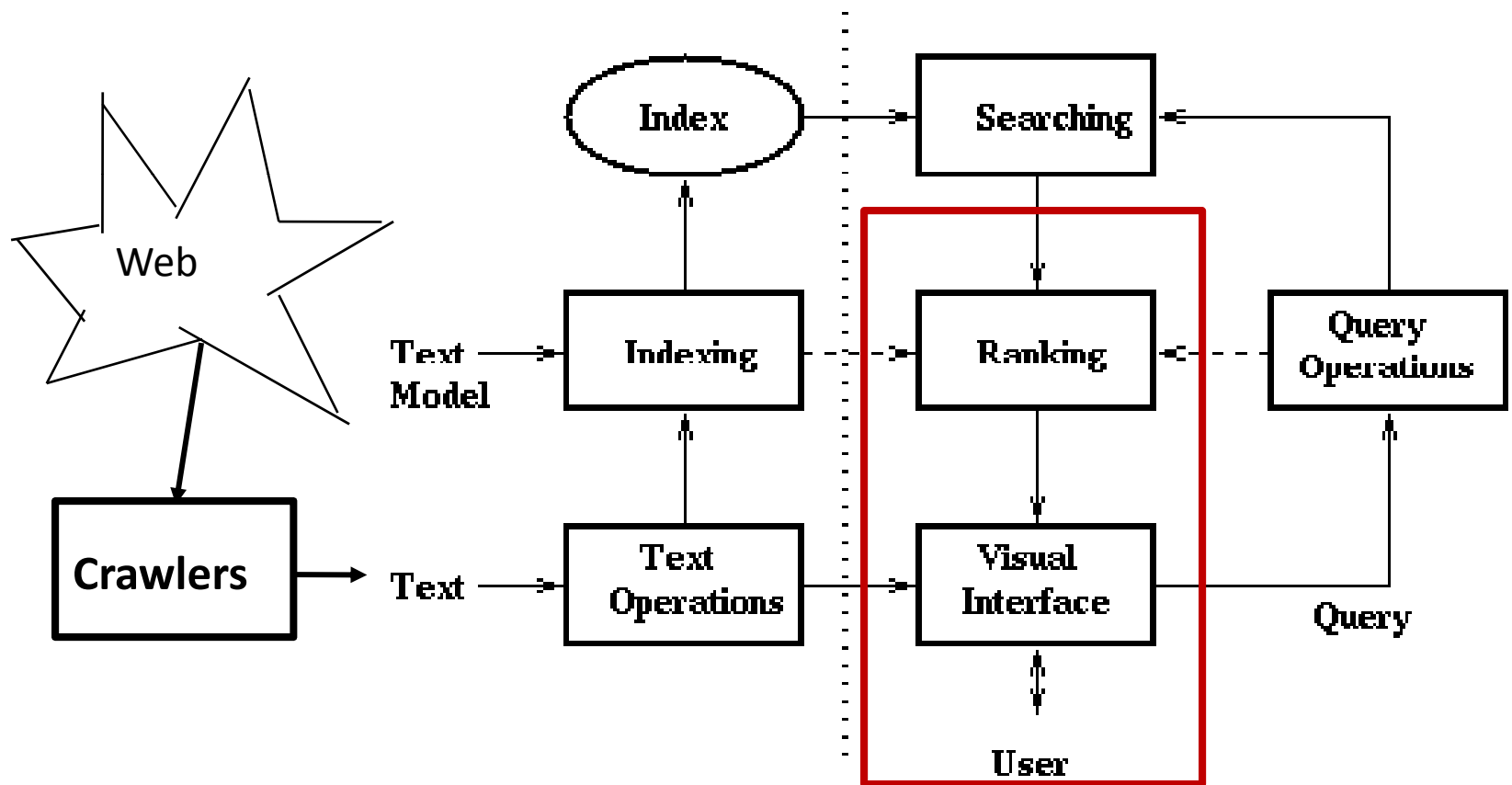
- **Meso-level:** query, intent, and session characteristics
- **Micro-level:** how searchers interact with result pages
- **Macro-level:** patterns, trends, and interests



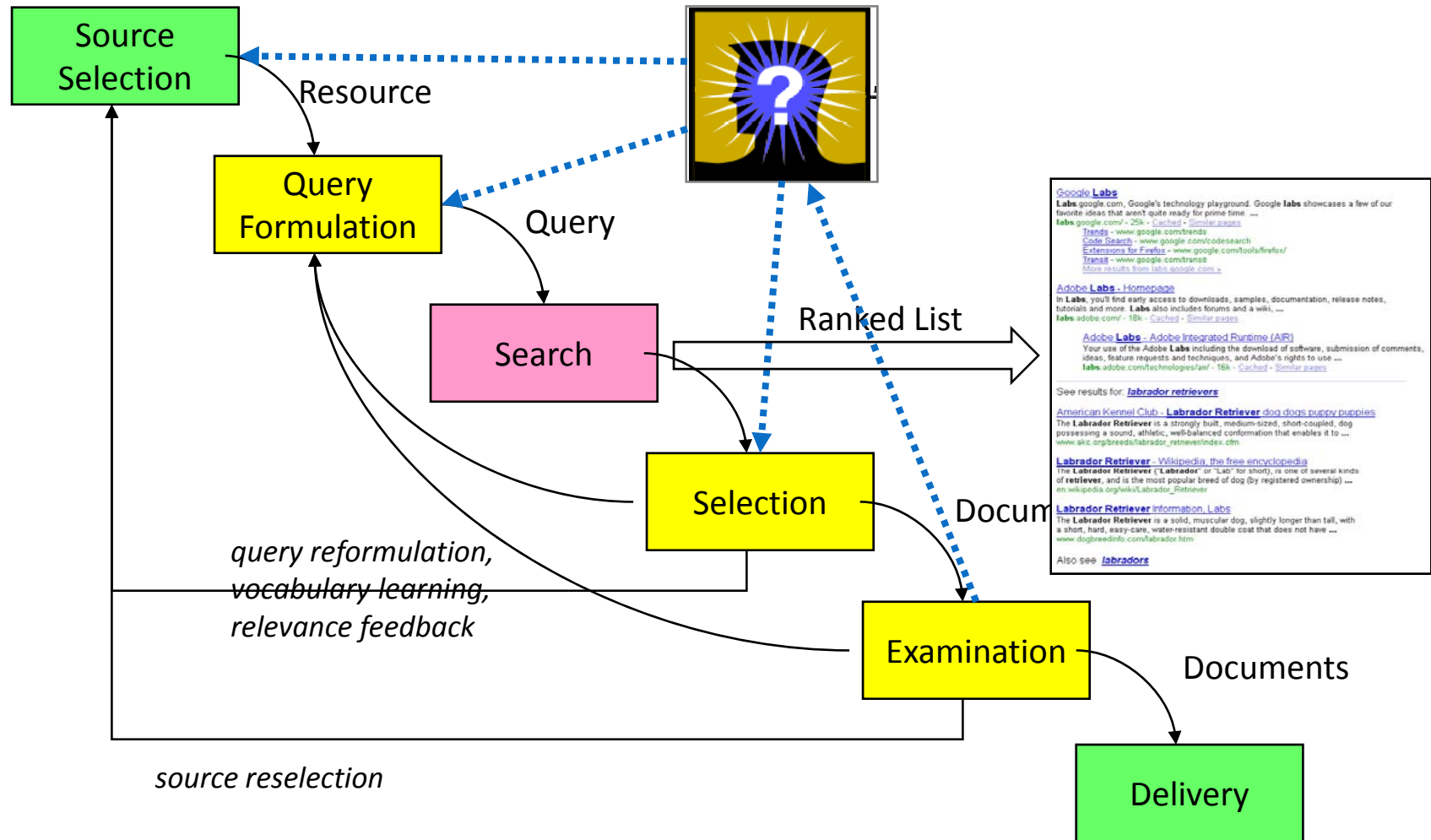
# Web Search Architecture

[from Baeza-Yates and Jones, WWW 2008 tutorial]


## Example centralized parallel architecture



# Information Retrieval Process (User view)



# Some Key Challenges for Web Search

- Query interpretation (infer intent)
  - Ranking (high dimensionality)
  - Evaluation (system improvement)
  - Result presentation (information visualization)
- 





# Intent Classes (top level only)

[from SIGIR 2008 Tutorial, Baeza-Yates and Jones]

## User intent taxonomy (Broder 2002)

- **Informational** – want to learn about something (~40% / 65%)
  - History nonya food
- **Navigational** – want to go to that page (~25% / 15%)
  - Singapore Airlines
- **Transactional** – want to do something (web-mediated) (~35% / 20%)
  - Access a serviceDownloads
    - Jakarta weather
  - Shop
    - Kalimantan satellite images
    - Nikon Finepix
- Gray areas
  - Find a good hub
    - Car rental Kuala Lumpur
  - Exploratory search “see what’s there”



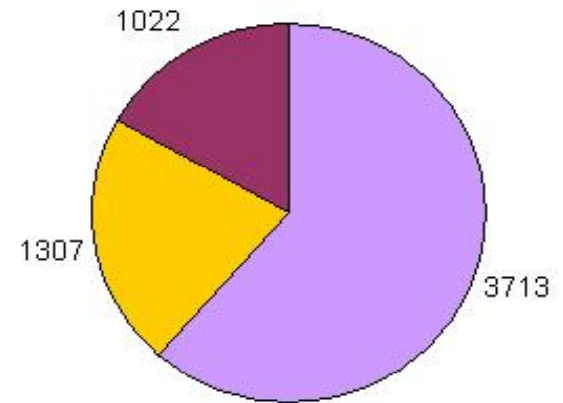
# Web Search Queries

- Cultural and educational diversity
- Short queries and impatient interaction
  - Few queries posed and few answers seen (first page)
  - Reformulation common
- Smaller and different vocabulary
  - Not “expert” searchers!
  - “Which box do I type in?”

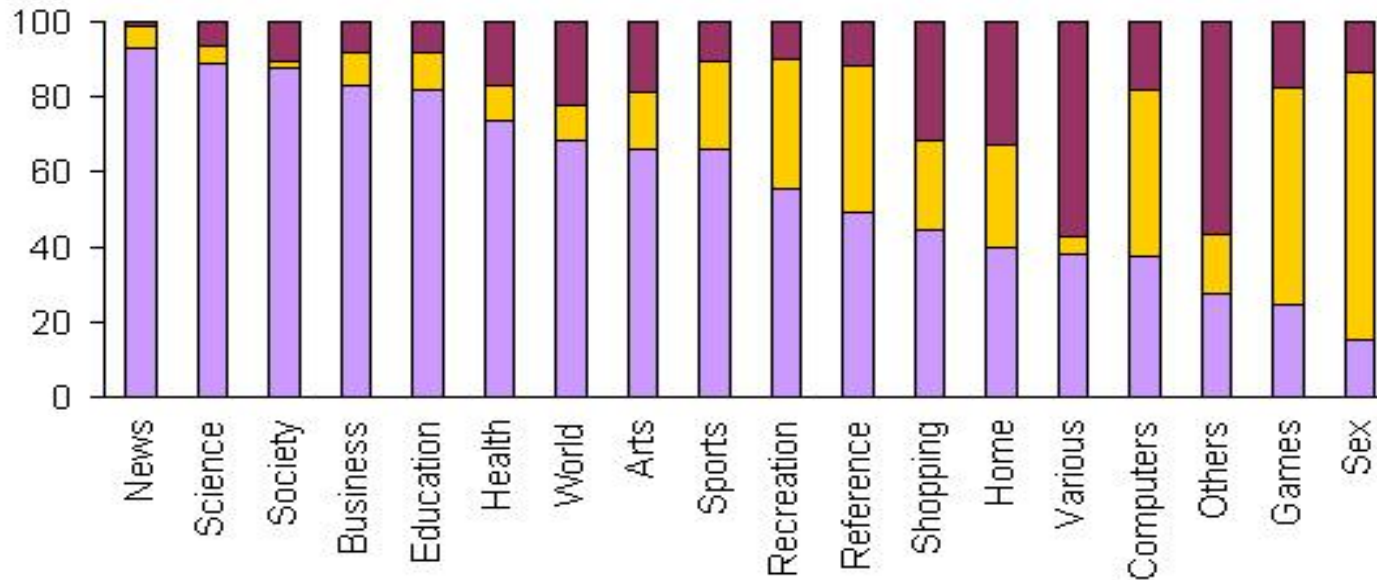


# Classified Queries

[from SIGIR 2008 Tutorial, Baeza-Yates and Jones]



Informational Not Informational Ambiguous

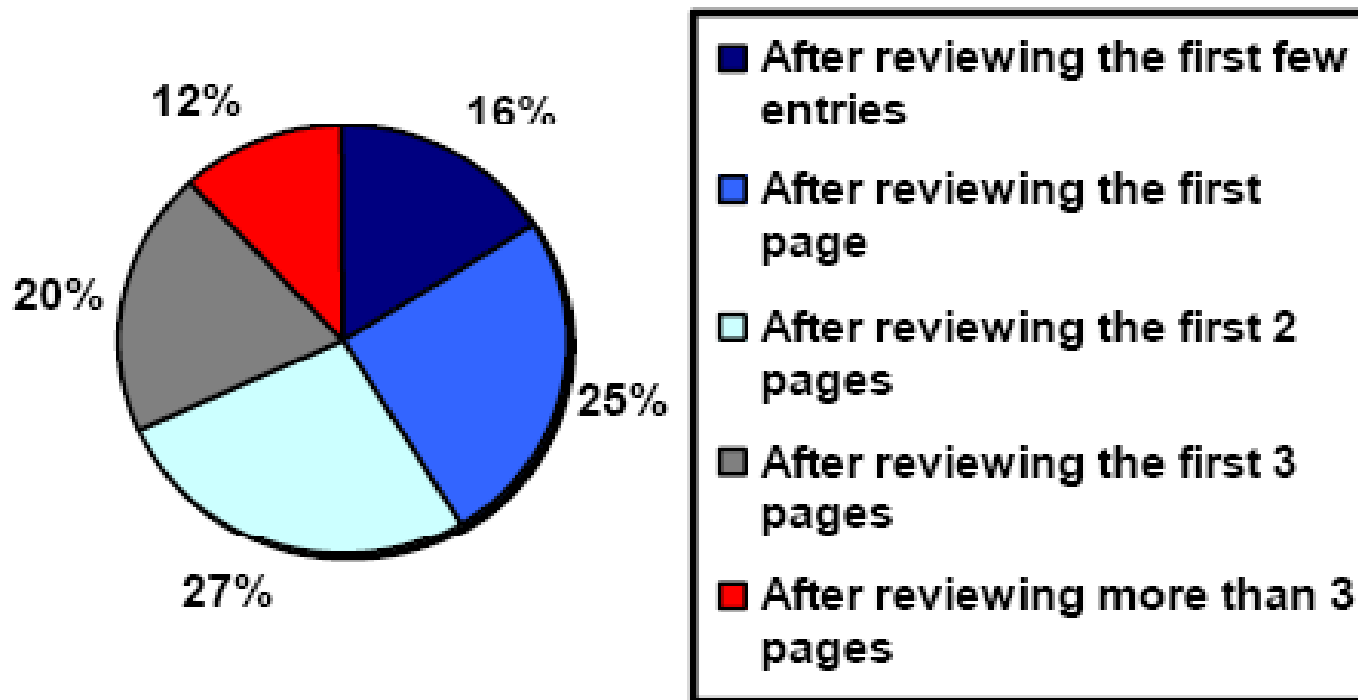


Informational Not Informational Ambiguous



# People Look at Only a Few Results

“When you perform a search on a search engine and don't find what you are looking for, at what point do you typically either revise your search, or move on to another search engine? (Select one)”

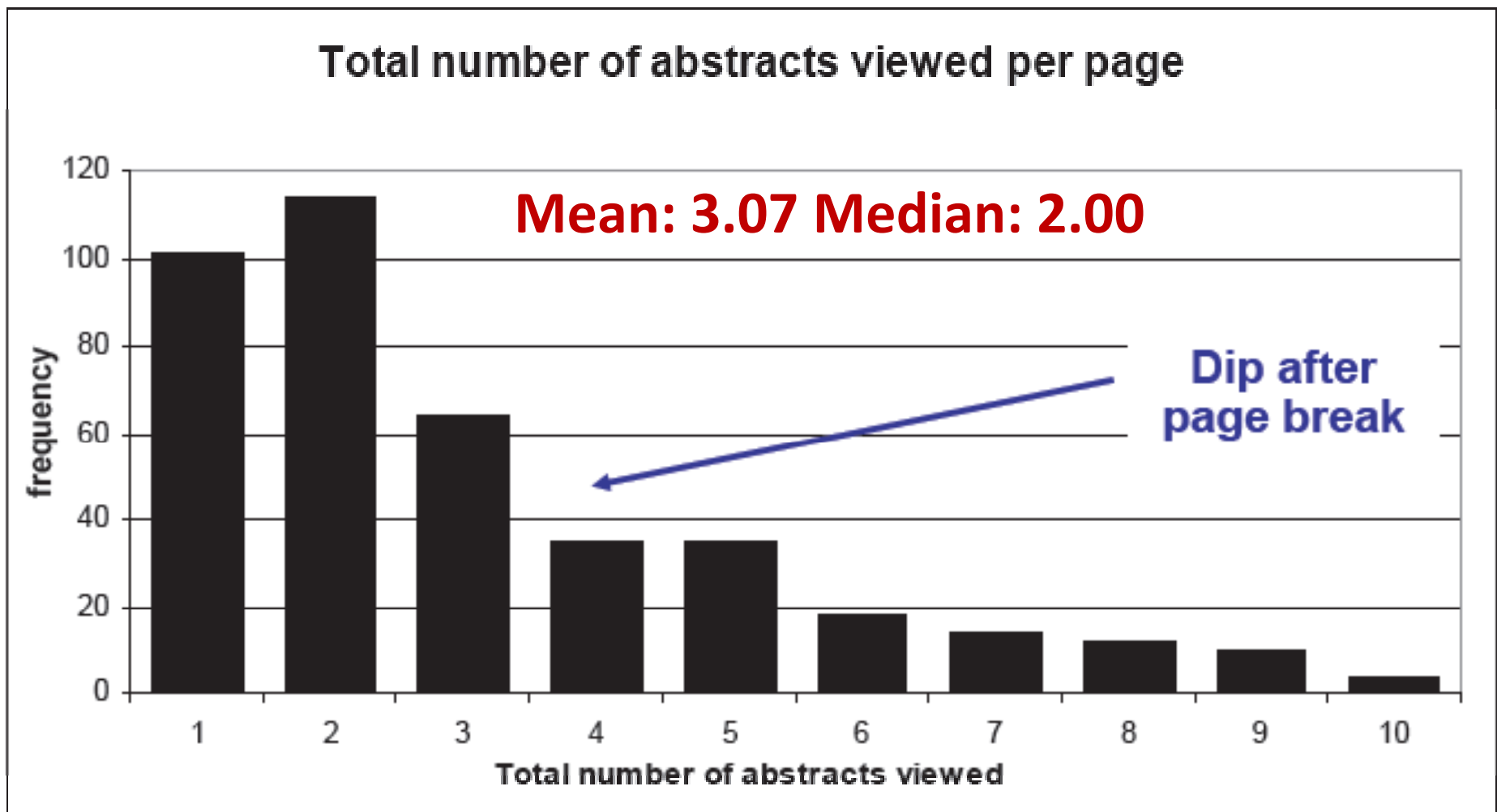


(Source: [iprospect.com](http://iprospect.com) WhitePaper\_2006\_SearchEngineUserBehavior.pdf)



# Snippet Views Depend on Rank

[Daniel M. Russell, 2007]



# Snippet Views and Clicks Depend on Rank

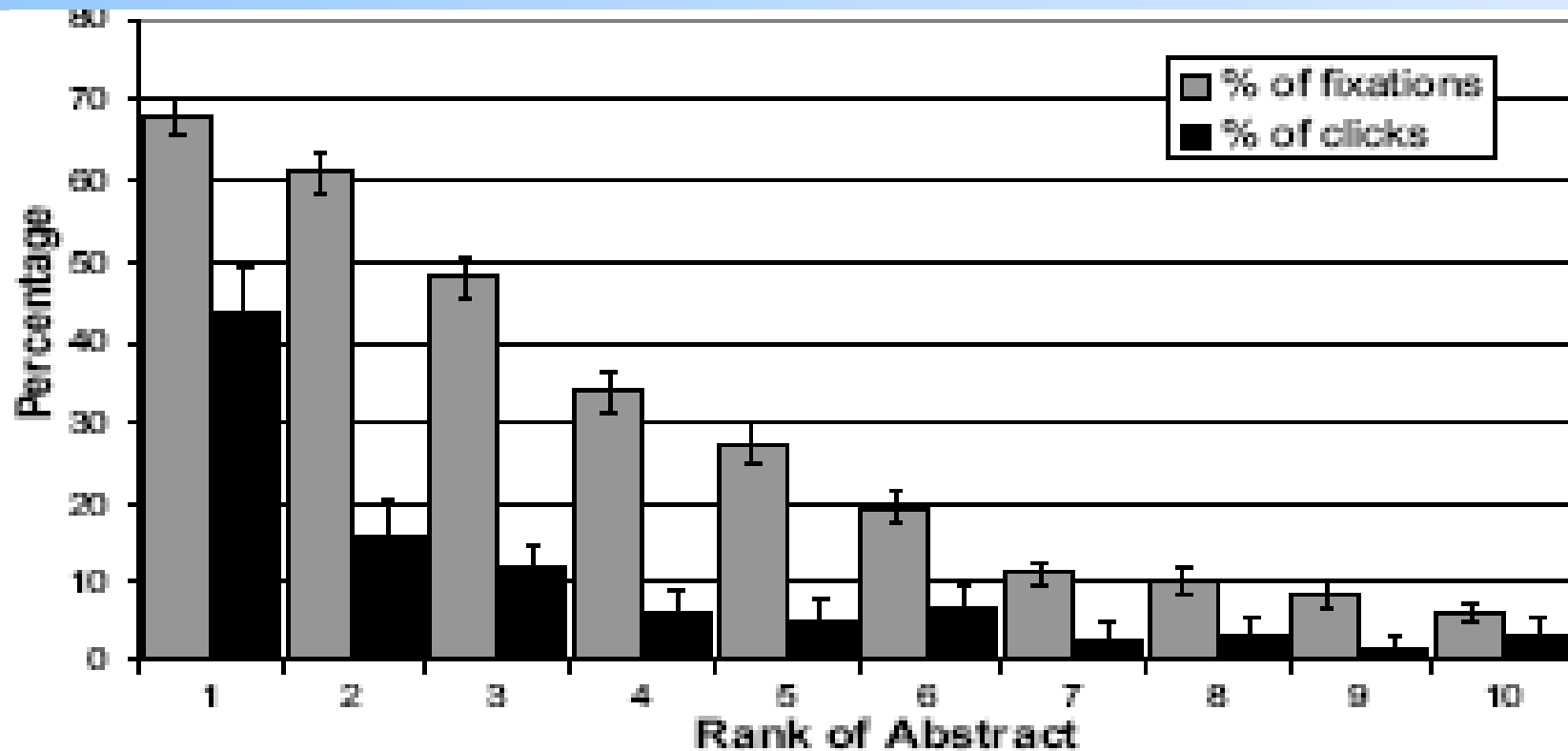


Figure 1: Percentage of times an abstract was viewed/clicked depending on the rank of the result.

[from Joachims et al, SIGIR 2005]

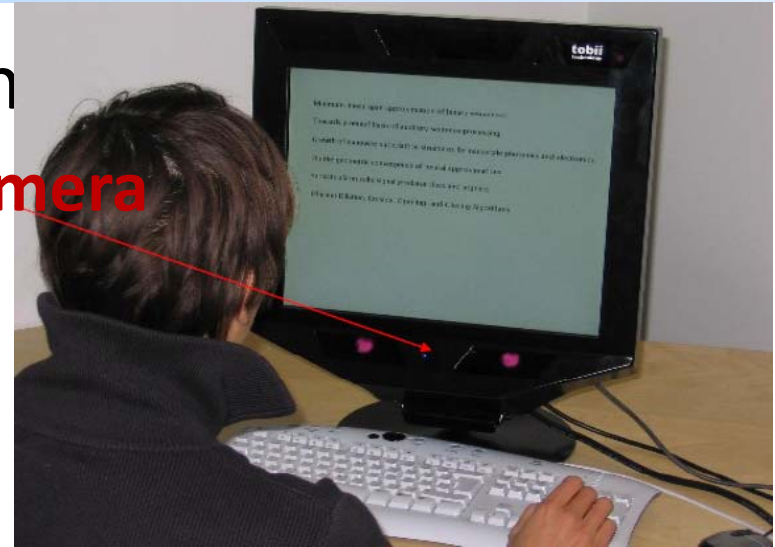


# “Eyes are a Window to the Soul”

- **Eye tracking** gives information about search interests:

- Eye position
- Pupil diameter
- Seekads and fixations

Camera



Reading →

Visual Search →

[Research - Eye Movements](#)  
PINDINGS ON EYE MOVEMENTS DURING SEARCH: The information limits of saccadic targeting: How much guidance is there in eye movements during search? ...  
[www.psych.ucsb.edu/~eckstein/lab/vp\\_EMdet.html](http://www.psych.ucsb.edu/~eckstein/lab/vp_EMdet.html) - 7k - [Väliluistissa](#) - [Samankaltaisia sivuja](#)

[Research - Eye Movements](#)  
What are the processes that guide eye-movements during search? What is the information available to the 1st saccade during search and how does it compare to ...  
[www.psych.ucsb.edu/~eckstein/lab/vp\\_EM.html](http://www.psych.ucsb.edu/~eckstein/lab/vp_EM.html) - 6k - [Väliluistissa](#) - [Samankaltaisia sivuja](#)  
[ [Lisää tuloksia kohteesta www.psych.ucsb.edu](#) ]

[Eye Movements and Visual Search in Dentistry](#)  
Eye Movements and Visual Search in Dentistry. ... Interpretation and the behavior of radiologists; the necessity of using other information for diagnosis ...  
[www.onderwijs.acta.nl/radiologie/web/research/farwest.htm](http://www.onderwijs.acta.nl/radiologie/web/research/farwest.htm) - 12k - [Väliluistissa](#) - [Samankaltaisia sivuja](#)

[Eye movements - uncontrollable](#)  
... Search: Dr. Koop, Web, MEDLINE, ... oculography: An electrical method of measuring eye movements using tiny ... The information provided herein should not be used during ...  
[www.drkoop.com/ency/article/003037.htm](http://www.drkoop.com/ency/article/003037.htm) - 40k - [Väliluistissa](#) - [Samankaltaisia sivuja](#)



# Micro-level: Examining Results

[Daniel M. Russell, 2007]

- Users rapidly scan the search results
- What they see in lower search results is a poor judgment of higher result quality
- Spend most time scrutinizing the top results
  - Trust the ranking

The screenshot shows a Google search for "children's unicycle". The search results are listed under the "Web" tab. Red arrows and numbers (1-6) indicate the order in which a user scanned the results:

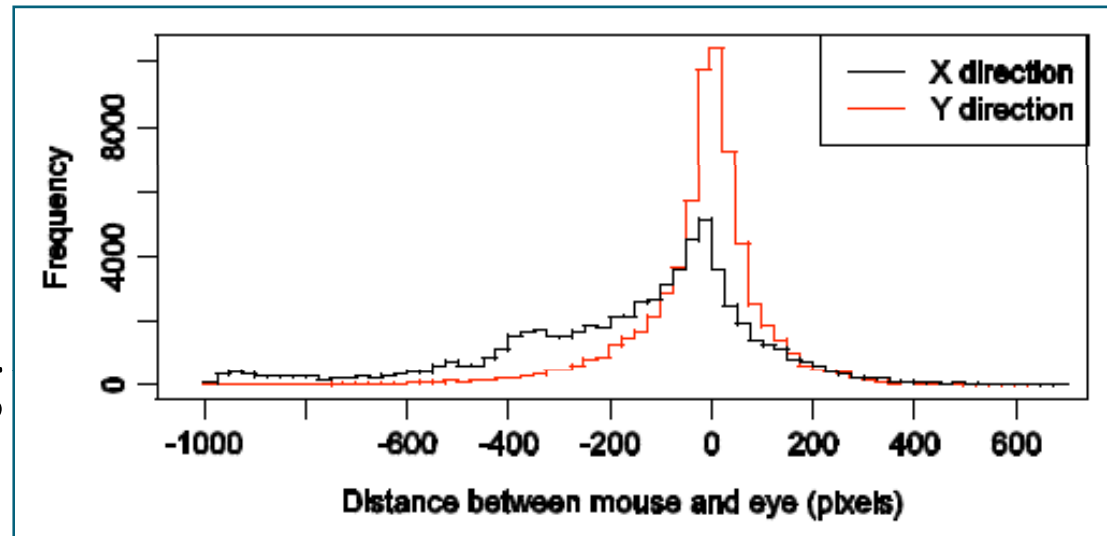
1. [Unicycle.UK.com - F.A.Q. - What size?](#)  
12" wheel unicycle: this is a small children's unicycle size. It's good for children who are too small to ride a 16" unicycle, but it needs smooth ground ...  
[www.unicycle.uk.com/FAQ.asp?Category=53](#) - 23k - Cached - Similar pages
2. [Selecting a unicycle Unicycle.com NZ: buy a unicycle or learn ...](#)  
16" wheel unicycle: this is a children's unicycle, the small wheel makes it only suitable for smooth areas. Best used indoors or on smooth ground; ...  
[www.unicycle.co.nz/View.php?action=Page&Name=Selecting\\_a\\_unicycle](#) - 22k - Cached - Similar pages
3. [100 Miles for Kids - The Goal](#)  
"The Afghan Mobile Mini Circus for Children is an established ... attempt to break the GUINNESS WORLD RECORD for the ONE HOUR UNICYCLE DISTANCE RECORD. ...  
[www.unicycle4kids.org/](#) - 9k - Cached - Similar pages
4. [Unicycles page at Juggling World](#)  
This is a children's unicycle, the small wheel makes it only suitable for very smooth areas. Best used indoors or on smooth ground; not so good outdoors ...  
[www.jugglingworld.biz/shop/products\\_unicycles.html](#) - 100k - Cached - Similar pages
5. [Buy a Unicycle Unicycle.com AU: buy a unicycle or learn unicycling](#)  
Check out a Unicycle Learners Pack for an easy and economical way to take your first steps into the One Wheeled World ... Suitable as a Children's Unicycle. ...  
[www.unicycle.au.com/View.php?action=Page&Name=Unicycles](#) - 10k - Cached - Similar pages
6. [Article - News - A unicycle ride for children](#)  
Adam Brody, 21, of San Juan Capistrano, led a charity event Saturday that benefits the Orangewood Children's Foundation. The Unicycle Club of Southern ...  
[www.ocregister.com/ocregister/news/homepage/article\\_1293785.php](#) - 31k - Cached - Similar pages



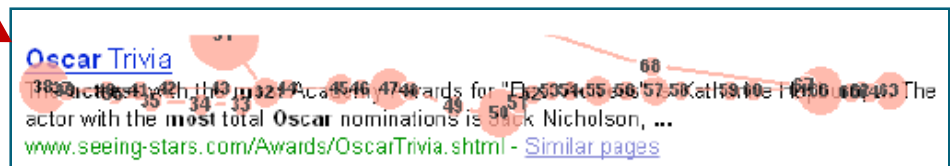


# Result Examination (cont'd)

- Searchers might use the mouse to focus **reading attention**, bookmark promising results, or not at all.



- Behavior varies with task difficulty and user expertise



[K. Rodden, X. Fu, A. Aula, and I. Spiro, *Eye-mouse coordination patterns on web search results pages*, Extended Abstracts of ACM CHI 2008]



# Macro-Level (Session) Analysis

- Can examine theoretical user models in light of empirical data:
  - Orienteering?
  - Foraging?
  - Multi-tasking?
- Search is often a multi-step process:
  - Find or navigate to a good site (“orienteering”)
  - Browse for the answer there: [actor most oscars] vs. [oscars]
- Teleporting
  - “I wouldn’t use Google for this, I would just go to...”
- Triangulation
  - Draw information from multiple sources and interpolate
  - Example: “how long can you last without food?”



# Users (sometimes) Multi-task

[Daniel M. Russell, 2007]

100: Google Search [free roulette] (4s) (DUPE) (p=78)

102: Google Result 7 [www.getlyrical.com/general/free\\_casino\\_games/free\\_online\\_roulette.html](http://www.getlyrical.com/general/free_casino_games/free_online_roulette.html) (3s)

103: Google Result 7 [www.getlyrical.com/general/free\\_casino\\_games/free\\_online\\_roulette.html](http://www.getlyrical.com/general/free_casino_games/free_online_roulette.html) (19s) (DUPE) (p=100)

106: Google Result 8 [www.saliu.com/Roulette.htm](http://www.saliu.com/Roulette.htm) (56s) (p=100)

112: Google Search [shockwave] (4s)

114: Google Result 3 [www.shockwave.com/sw/home/](http://www.shockwave.com/sw/home/) (10s)

117: Google Result 5 [sdc.shockwave.com/shockwave/download/download.cgi](http://sdc.shockwave.com/shockwave/download/download.cgi) (16s) (p=112)

120: Google Search [free roulette] (3s) (DUPE) (p=78)

122: Google Result 1 [www.ildado.com/free\\_roulette.html](http://www.ildado.com/free_roulette.html) (15s) (DUPE)

124: Google Search [free professional roulette] (2s)

126: Google Search (spell correct) [free professional roulette] (10s)

128: Google Result 3 [imagesculptor.com/Roulette/free-roulette-professional-system.php](http://imagesculptor.com/Roulette/free-roulette-professional-system.php) (5s)

129: Google Result 3 [imagesculptor.com/Roulette/free-roulette-professional-system.php](http://imagesculptor.com/Roulette/free-roulette-professional-system.php) (8s) (DUPE) (p=126)

133: Google Result 7 [www.amazon.com/exec/obidos/tg/detail/-/B0007XRSQ4?v=glance](http://www.amazon.com/exec/obidos/tg/detail/-/B0007XRSQ4?v=glance) (2s) (p=126)



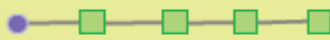
# Kinds of Search+Browsing Behavior

[Daniel M. Russell, 2007]

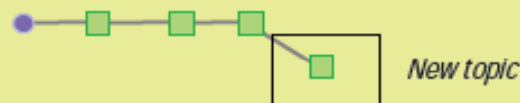
Short / Nav



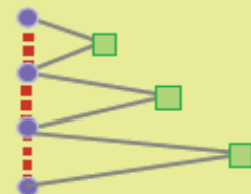
Topic exploration



Topic switch



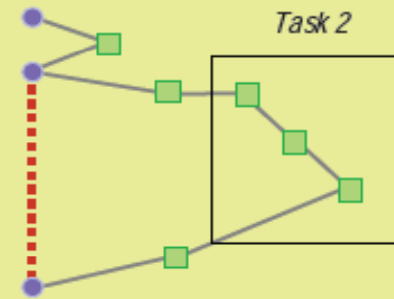
Methodical results exploration



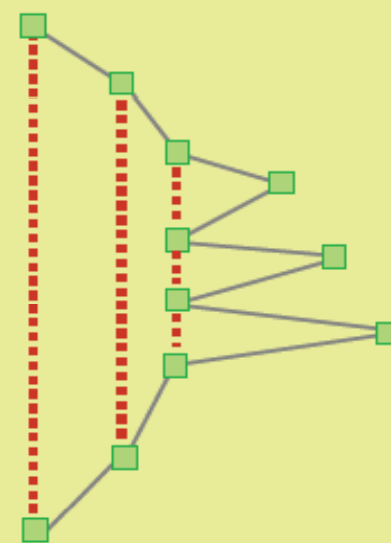
Query reform



Multitasking



Stacking behavior



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# Variance in Behavior between Novice and Expert Searchers

[White & Morris, 2007]

- Some people are more expert at searching than others
  - Search expertise, not domain expertise
- Find characteristics of these “advanced search engine users” in an effort to better understand how these users search
- If we can better understand what advanced searchers are doing maybe we can improve the search experience for everyone



# Characterizing Advanced Searchers

[White & Morris, 2007]

- Four advanced operators used: +, -, "", and "site:"
  - ~1% of submitted queries contained at least one operator
  - 51K users (9%) of users used query operators at least once
- ***padvanced*** used to denote the percentage of a user's queries that contain advanced operators
  - Non-advanced users (*padvanced* = 0%)
  - Advanced users (*padvanced* > 0%)
- Included users who issued > 50 queries
  - ~38K (20%) advanced users
  - ~151K (80%) non-advanced users



# Findings: Query/Result-click

[White & Morris, 2007]

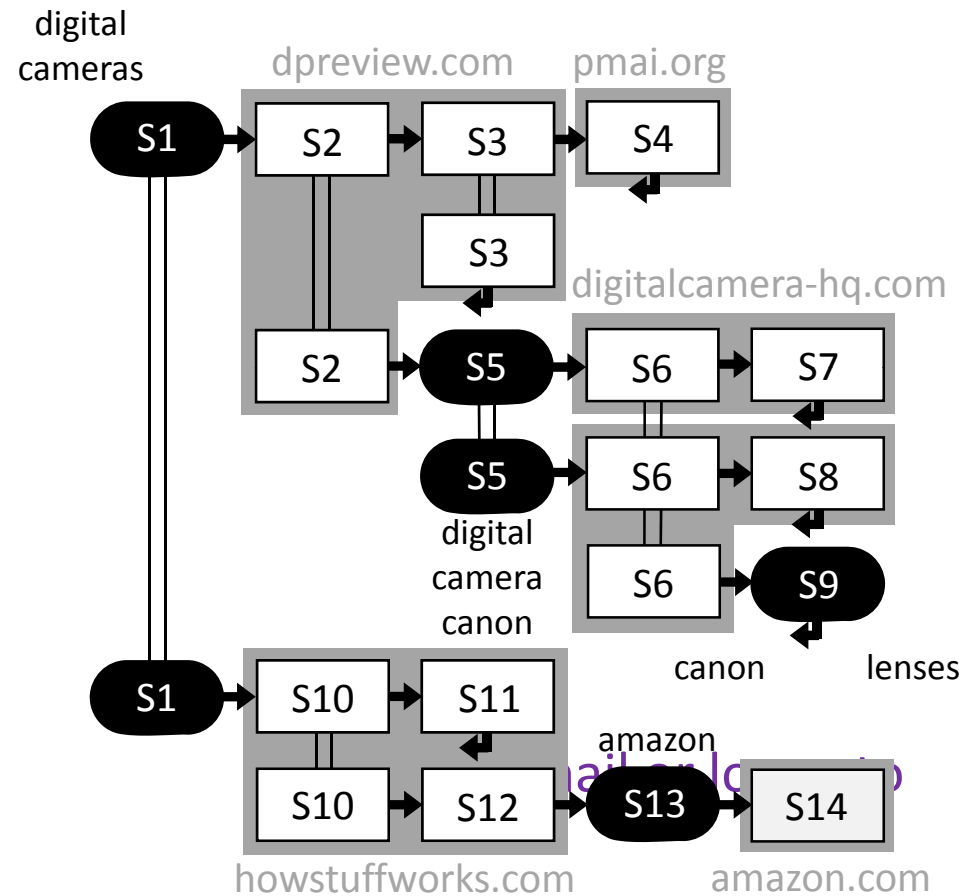
- Factor analysis to study the relationships among the dependent variables
- Factor analysis revealed two factors that could account for ~84% of the variance:
  - Factor A = Querying
    - Query properties associated with position of clicks in result list
  - Factor B = Result-click
    - Querying frequency associated with the likelihood that user will click on a search result and click latency



# Search Sessions

[White & Morris, 2007]

- Session
  - Query → Timeout
- Query trail
  - Query → End trail event
    - Another query
    - Type URL
    - Visit homepage
    - Check Web-based online service
    - Close browser
    - Session timeout





# Findings – Post-query browsing

[White & Morris, 2007]

## Advanced users:

- Traverse trails faster
- Spend less time viewing each Web page
- Follow query trails with fewer steps
- Revisit pages less often
- “Branch” less often

Feature	P <sub>advanced</sub>				
	0%	> 0%	≥ 25%	≥ 50%	≥ 75%
Session Secs	701.10	706.21	792.65	903.01	1114.71
Trail Secs	<b>205.39</b>	<b>159.56</b>	156.45	147.91	136.79
Display Secs	<b>36.95</b>	<b>32.94</b>	34.91	33.11	30.67
Num. Steps	<b>4.88</b>	<b>4.72</b>	4.40	4.40	4.39
Num. Revisits	<b>1.20</b>	<b>1.02</b>	1.03	1.03	1.02
Num. Branches	<b>1.55</b>	<b>1.51</b>	1.50	1.47	1.44
% <sub>Trails</sub>	72.14%	27.86%	.83%	.23%	.05%
% <sub>Users</sub>	79.90%	20.10%	.79%	.18%	.04%

Non-advanced    Advanced    More advanced →



# Findings – Post-query browsing

[White & Morris, 2007]

- Greater the proportion of queries with advanced syntax the more focused their search interactions become
  - Shorter query trails
  - Less “branchy” query trails
- Session time increases but search time drops with increases in padvanced
  - Perhaps more advanced users are multitasking between search and other activities



# Lecture Plan

- Understanding user behavior at micro-, meso-, and macro- levels
- Theoretical models of information seeking
- ✓ Web search behavior:
  - ✓ Levels of detail
  - ✓ Search Intent
  - ✓ Variations in web searcher behavior
  - **Keeping found things found**
  - Click models



# ReFinding Behavior

[From Teevan et al, 2007]

- 40% of the queries led to a same user had clicked on in a past search session.
  - Teevan et al., 2007
- What's the URL for this year's RuSSIR?
  - Does not really matter, it is faster to re-find it

The screenshot shows a Google search for "russir 2009". The search bar contains "russir 2009" and the "Search" button is visible. Below the search bar, there are several search results. The first result is "RuSSIR'2009: 3rd Russian Summer School in Information Retrieval" with a green plus icon. The second result is "RuSSIR 2009: call for participation | PASCAL 2" with a green plus icon. The third result is "3rd Russian Summer School in Information Retrieval (RuSSIR 2009 ..." with a green plus icon. The fourth result is "RuSSIR'2009: 3rd Russian Summer School in Information Retrieval" with a green plus icon. The fifth result is "LINGUIST List 20.171: Applied Ling, Computational Ling, Text ..." with a green plus icon. The sixth result is "3rd Russian Summer School in Information Retrieval (RuSSIR 2009)" with a green plus icon. The seventh result is "ru.ir: RUSSIR 2009 - [ Translate this page ]" with a green plus icon. The eighth result is "SEMICON Russia - Home" with a green plus icon. The ninth result is "SELF-EVALUATION FORMS - CORDIS: FP7: Find a Call" with a green plus icon. The page also shows "Did you mean: russia 2009" and "Results include your SearchWiki notes for russir 2009." The bottom of the page shows "Done".



# What Is Known About Re-Finding

[From Teevan et al, 2007]

- Re-finding recent topic of interest
- Web re-visitation common [Tauscher & Greenberg]
- People follow known paths for re-finding
  - Search engines likely to be used for re-finding
- Query log analysis of re-finding
  - Query sessions [Jones & Fain]
  - Temporal aspects [Sanderson & Dumais]



# Click on previously clicked results?

[From Teevan et al, 2007]

39%

	1 click	> 1 click	Click same and different?	Click on different results?
Same query issued before?	<i>Navigational</i> 3100 (24%)	36 (<1%)	635 (5%)	485 (4%)
New query?	637 (5%)	4 (<1%)	660 (5%)	7503 (57%)

*Re-finding with different query*



# How Queries Change

[From Teevan et al, 2007]

- Many ways queries can change
  - Capitalization (“new york” and “New York”)
  - Word swap (“britney spears” and “spears britney”)
  - Word merge (“walmart” and “wal mart”)
  - Word removal (“orange county venues” and “orange county music venues”)
- 17 types of change identified
  - 2049 combinations explored
  - Log data and supplemental study
  - Most normalizations require only one type of change



# Rank Change Reduces Re-Finding

[From Teevan et al, 2007]

- Results change rank
- Change reduces probability of repeat click
  - No rank change: 88% chance
  - Rank change: 53% chance
- Why?
  - Gone?
  - Not seen?
  - New results are better?





# Gone? Not Seen? Better?

[From Teevan et al, 2007]

The screenshot shows a search engine interface with the following elements:

- Search Bar:** Contains the text "breast cancer treatments" and a "Search" button.
- Results Header:** "Results for breast cancer treatments (1-10 of 15,400,000)".
- Search Results:**
  - Result 1:** [National Cancer Institute - U](#)  
Provides information about breast various treatment modalities for breast cancer. <http://www.cancer.gov/cancerinfo/>
  - Result 2:** [National Cancer Institute - B](#)  
Expert-reviewed information summary about breast cancer treatment. Last Modified: 06/22/2005. [http://www.cancer.gov/cancerinfo/nci/breast\\_cancer\\_treatment.htm](http://www.cancer.gov/cancerinfo/nci/breast_cancer_treatment.htm)
  - Result 3:** [Breast Cancer Treatments](#)  
Breast cancer alternative treatment modalities. Breast cancer symptoms are naturally addressed. <http://www.newhopehealthclinic.com/breast-cancer-treatments>
  - Result 4:** [Treatments for Breast Cancer](#)  
A look at the treatments for breast cancer with resources for learning more. ... Health > Women and Cancer > Cancer Types A-Z > Breast Cancer > Treatments ... Treatments are always changing ... [http://womenshealth.about.com/library/treatments/bltreatments\\_breastcancer.htm](http://womenshealth.about.com/library/treatments/bltreatments_breastcancer.htm)
  - Result 5:** [Breast Cancer](#)  
... screening and advances in breast cancer treatments have contributed to the decline in breast cancer mortality rates ... you flu shot yet? Breast cancer treatments can leave your immune system weakened. <http://breastcancer.about.com/>
  - Result 6:** [Hormone therapy treatment for breast cancer](#)  
Hormonal therapies include: anti-estrogens, ovarian treatments, aromatase inhibitors (newer drugs that are more effective). Hormone treatment has been proved to reduce the risk of breast cancer coming back. ... <http://www.breasthealth.com.au/treatment/hormonetherapy.html>
  - Result 7:** [Radiation Treatments for Breast Cancer](#)  
Links to resources which cover the different forms of radiation treatment for breast cancer. Information on radiation or radiotherapy treatments for breast cancer can be found in the resources listed below. ... [http://www.healthinsite.gov.au/topics/Radiation\\_Treatments\\_for\\_Breast\\_Cancer](http://www.healthinsite.gov.au/topics/Radiation_Treatments_for_Breast_Cancer)
  - Result 8:** [National Cancer Institute - Breast Cancer Treatment](#)  
Expert-reviewed information summary about the treatment of breast cancer. ... Breast Cancer (PDQ®): Treatment. Last Modified: 06/22/2005. General Information About Breast Cancer. Stages of ... other ... <http://www.cancer.gov/cancerinfo/pdq/treatment/breast/patient>

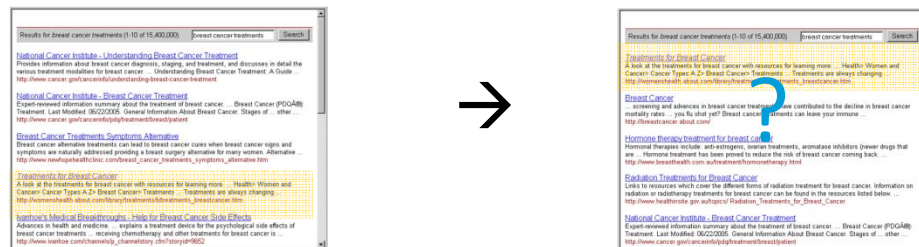
A blue arrow points from the "National Cancer Institute - B" result in the left sidebar to the "Treatments for Breast Cancer" result in the main content area. A yellow oval highlights the "Hormone therapy treatment for breast cancer" result in the main content area.



# Change Slows Re-Finding

[From Teevan et al, 2007]

- Look at time to click as proxy for *Ease*
- Rank change → slower repeat click
  - Compared with initial search to click
  - No rank change: Re-click is faster
  - Rank change: Re-click is slower
- Changes interferes and stability helps



# Helping People Re-Find

- Potential way to take advantage of stability
  - Automatically determine if the task is re-finding
  - Keep results consistent with expectation
  - Simple form of personalization
- Can we automatically predict if a query is intended for re-finding?



# Predicting the Query Target

- For simple navigational queries, predict what URL will be clicked
- For complex repeat queries, two binary classification tasks:
  - Will a new (never visited) result be clicked?
  - Will an old (previously visited) result be clicked?



# Predicting Navigational Queries

- Predict navigational query clicks using
  - Query issued twice before
  - Queries with the same one result clicked
- Very effective prediction
  - 96% accuracy: Predict one of the results clicked
  - 95% accuracy: Predict first result clicked
  - 94% accuracy: Predict only result clicked



# Predicting More Complex Queries

- Trained an SVM to identify
  - If a new result will be clicked
  - If an old result will be clicked
- Effective features:
  - Number of previous searches for the same thing
  - Whether any or the results were clicked >1 time
  - Number of clicks each time the query was issued
- Accuracy around 80% for both prediction tasks



# Re-Finding Summary

- Log analysis supplemented by a user study
- Re-finding is very common
  - Navigational queries are particularly common
  - Categorized potential re-finding behavior
  - Explored ways query strings are modified
- Stability of result rank impacts re-finding tasks
- Can identify re-finding queries with 80-90% accuracy



# Lecture Plan

- Understanding user behavior at micro-, meso-, and macro- levels
- Theoretical models of information seeking
- ✓ Web search behavior:
  - ✓ Levels of detail
  - ✓ Search Intent
  - ✓ Variations in web searcher behavior
  - ✓ Keeping found things found
  - Click models





# Automatic Click models

- Clickthrough and subsequent browsing behavior of individual users influenced by many factors
  - Relevance of a result to a query
  - Visual appearance and layout
  - Result presentation order
  - Context, history, etc.

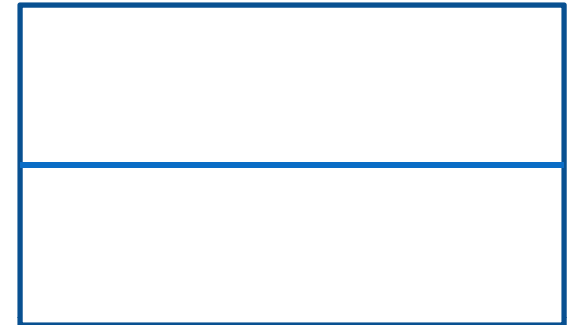


# Hypothesis 1: No Bias

[Craswell et al., 2008]

- Our baseline

$$C_{di} = r_d = C_{dj}$$



- $c_{di}$  is  $P(\text{Click}=\text{True} \mid \text{Document}=d, \text{Position}=i)$
- $r_d$  is  $P(\text{Click}=\text{True} \mid \text{Document}=d)$
- Why this baseline?
  - We know that  $r_d$  is part of the explanation
  - Perhaps, for ranks 9 vs 10, it's the main explanation
  - It is a bad explanation at rank 1 e.g. Eye tracking

Attractiveness of summary  $\sim$  Relevance of result



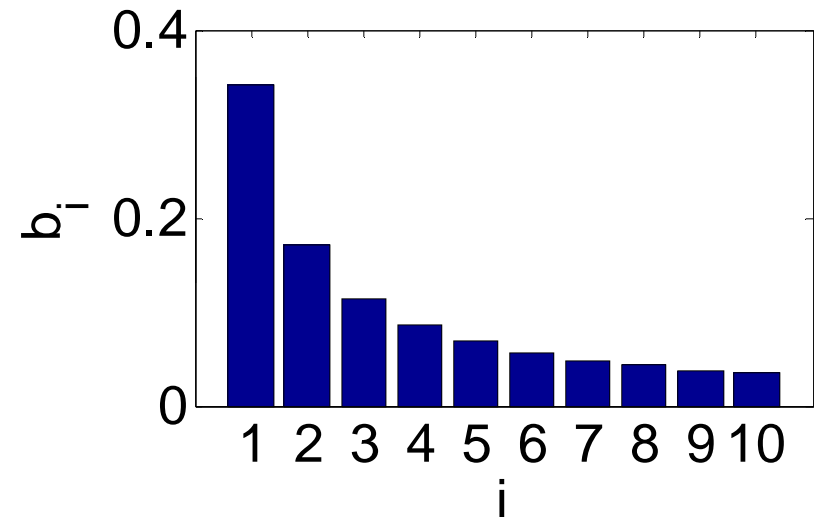
# Hypothesis 2: Blind Clicks

[Craswell et al., 2008]

- There are two types of user/interaction
  - Click based on relevance
  - Click based on rank (blindly)

$$c_{di} = \lambda r_d + (1 - \lambda) b_i$$

- A.k.a. the OR model:
  - Clicks arise from relevance OR position



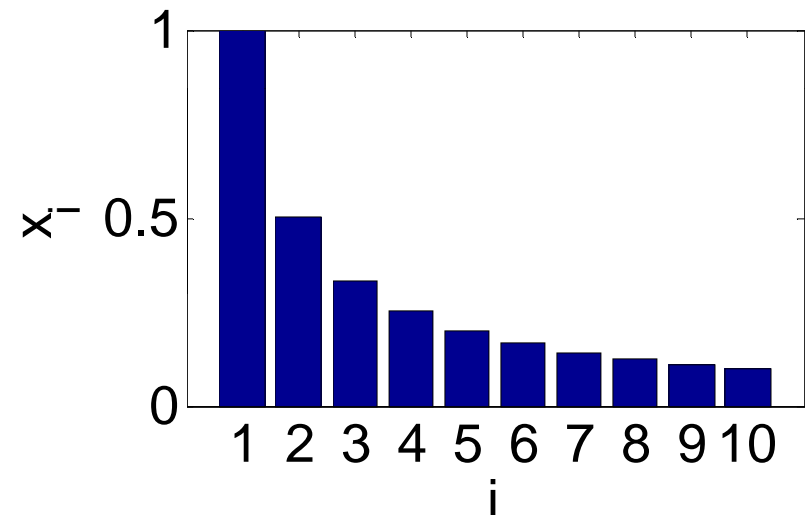
# Hypothesis 3: Examination

[Craswell et al., 2008]

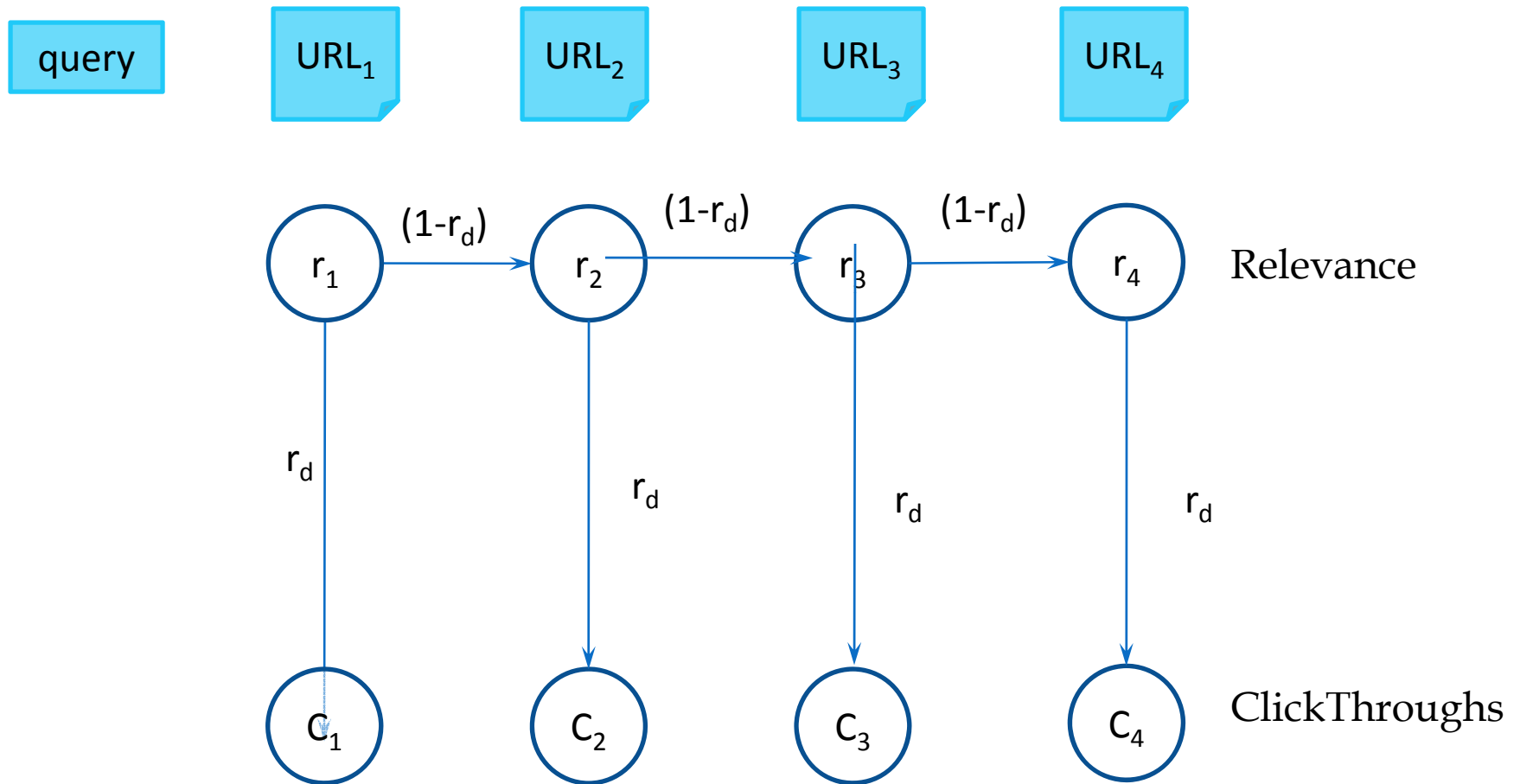
- Users are less likely to look at lower ranks, therefore less likely to click

$$C_{di} = r_d x_i$$

- This is the AND model
  - Clicks arise from relevance AND examination
  - Probability of examination  $x_i$  does not depend on what else is in the list



# Cascade Model Diagram



# Hypothesis 4: Cascade

[Taylor et al., 2008]

- Users examine the results in rank order
- At each document  $d$ 
  - Click with probability  $r_d$
  - Or continue with probability  $(1-r_d)$

$$C_{di} = r_d \prod_{j=1}^{i-1} (1 - r_{docinrank:j})$$



# Cascade Model Example

[Craswell et al., 2008]

- 500 users typed a query
- 0 click on result A in rank 1
- 100 click on result B in rank 2
- 100 click on result C in rank 3

This may seem different from the formulation on the previous slide, but is precisely equivalent

- Cascade (with no smoothing) says:
- 0 of 500 clicked A  $\rightarrow r_A = 0$
- 100 of 500 clicked B  $\rightarrow r_B = 0.2$
- 100 of remaining 400 clicked C  $\rightarrow r_C = 0.25$



# Cascade Model Seems Closest to Reality

[Craswell et al., 2008]

Model	Cross Entropy
Best Possible	0.141 ± 0.0055
Cascade	0.225 ± 0.0052
Logistic	0.236 ± 0.0063
Examination	0.247 ± 0.0072
Baseline	0.250 ± 0.0073

Best possible: Given the true click counts for ordering BA





# Problem: Users click based on result “Snippets”

[Clarke et al., 2007]



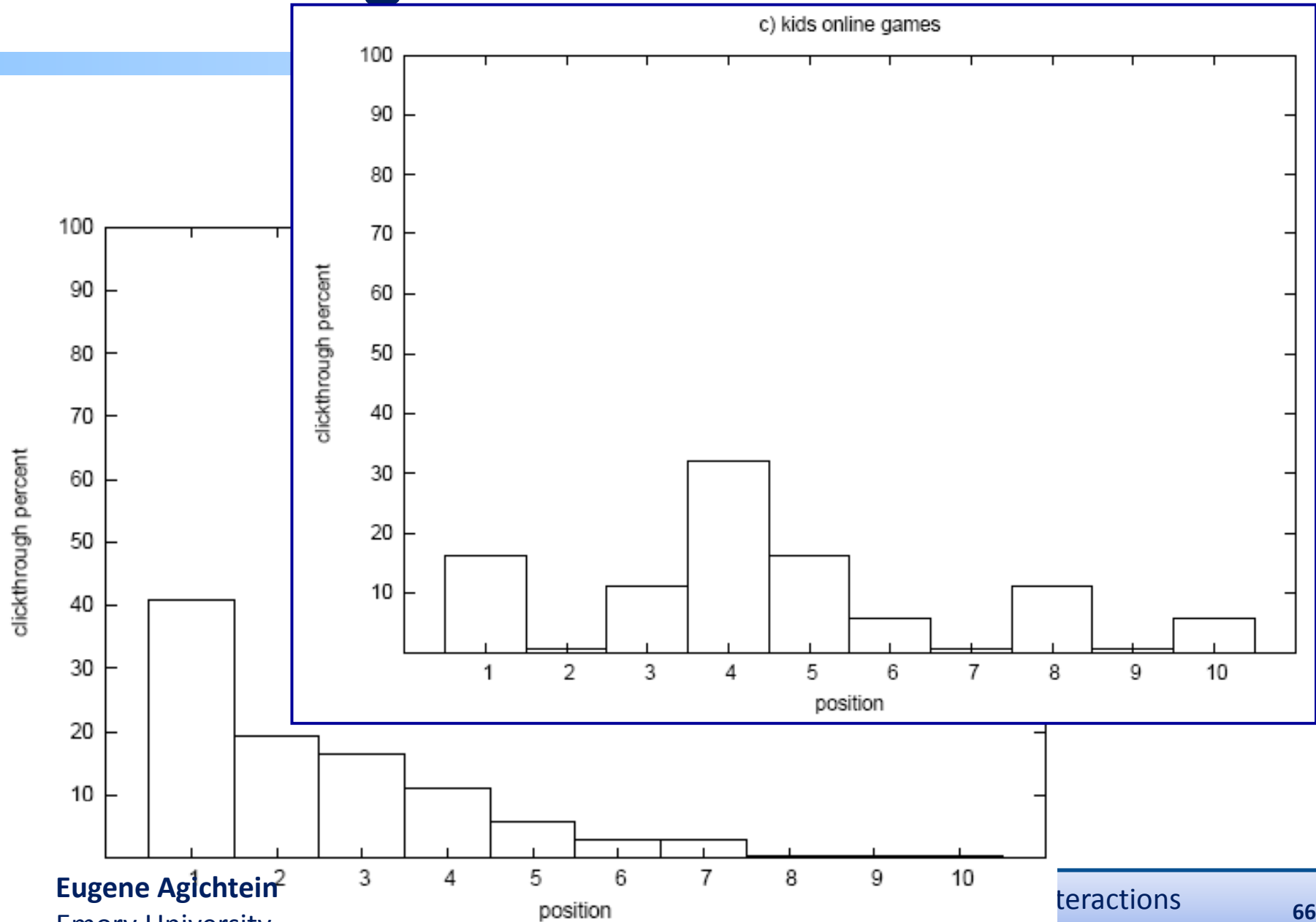
The screenshot shows a search engine interface with a search bar containing the text "kids online games". Below the search bar, there are three search results. Each result consists of a title, a snippet of text, and a URL. Annotations with arrows point to these elements:

- The word "title" is positioned at the top right, with an arrow pointing to the title of the first search result: "Yahoo! Kids: Games, music, movies, videos and fun for kids".
- The word "snippet" is positioned at the bottom right, with an arrow pointing to the text of the third search result: "KIDS' QUEST. Boston Children's Museum gratefully acknowledges The Center for Disease Control's National Center on Birth Defects and Development Disabilities for its ...".
- The word "URL" is positioned at the bottom left, with an arrow pointing to the URL of the third search result: "www.bostonkids.org/kids/online\_games.html".



# Clickthrough Inversions

[Clarke et al., 2007]



# Relevance is Not the Dominant Factor!

[Clarke et al., 2007]

Relationship	Number	Percent
$\text{rel}(A) < \text{rel}(B)$	119	33.5%
$\text{rel}(A) = \text{rel}(B)$	134	37.7%
$\text{rel}(A) > \text{rel}(B)$	102	28.7%

**Figure 3:** *Relevance relationships at clickthrough inversions. Compares relevance between the higher ranking member of a caption pair ( $\text{rel}(A)$ ) to the relevance of the lower ranking member ( $\text{rel}(B)$ ), where caption A received fewer clicks than caption B.*



# Snippet Features Studied

[Clarke et al., 2007]

Feature Tag	Description
MissingSnippet	snippet missing in caption A and present in caption B
SnippetShort	short snippet in caption A (< 25 characters) with long snippet (> 100 characters) in caption B
TermMatchTitle	title of caption A contains matches to fewer query terms than the title of caption B
TermMatchTS	title+snippet of caption A contains matches to fewer query terms than the title+snippet of caption B
TermMatchTSU	title+snippet+URL of caption A contains matches to fewer query terms than caption B
TitleStartQuery	title of caption B (but not A) starts with a phrase match to the query
QueryPhraseMatch	title+snippet+url contains the query as a phrase match
MatchAll	caption B contains one match to each term; caption A contains more matches with missing terms
URLQuery	caption B URL is of the form <i>www.query.com</i> where the query matches exactly with spaces removed
URLSlashes	caption A URL contains more slashes (i.e. a longer path length) than the caption B URL
URLLenDiff	caption A URL is longer than the caption B URL
Official	title or snippet of caption B (but not A) contains the term “official” (with stemming)
Home	title or snippet of caption B (but not A) contains the phrase “home page”
Image	title or snippet of caption B (but not A) contains a term suggesting the presence of an image gallery
Readable	caption B (but not A) passes a simple readability test



# Feature Importance

[Clarke et al., 2007]

Feature Tag	INV+	INV-	%+	CON+	CON-	%+	$\chi^2$	p-value
MissingSnippet	185	121	60.4	144	133	51.9	4.2443	0.0393
SnippetShort	20	6	76.9	12	16	42.8	6.4803	0.0109
TermMatchTitle	800	559	58.8	660	700	48.5	29.2154	<.0001
TermMatchTS	310	213	59.2	269	216	55.4	1.4938	0.2216
TermMatchTSU	236	138	63.1	189	149	55.9	3.8088	0.0509
TitleStartQuery	1058	933	53.1	916	1096	45.5	23.1999	<.0001
QueryPhraseMatch	465	346	57.3	427	422	50.2	8.2741	0.0040
MatchAll	8	2	80.0	1	4	20.0		<i>0.0470</i>
URLQuery	277	188	59.5	159	315	33.5	63.9210	<.0001
URLSlashes	1715	1388	55.2	1380	1758	43.9	79.5819	<.0001
URLLenDiff	2288	2233	50.6	2062	2649	43.7	43.2974	<.0001
Official	215	142	60.2	133	215	38.2	34.1397	<.0001
Home	62	49	55.8	64	82	43.8	3.6458	0.0562
Image	391	270	59.1	315	335	48.4	15.0735	<.0001
Readable	52	43	54.7	31	48	39.2	4.1518	0.0415



# Important Words in Snippet

[Clarke et al., 2007]

Rank	Term	$\chi^2$	influence
1	encyclopedia	114.6891	↓
2	wikipedia	94.0033	↓
3	official	36.5566	↑
4	and	28.3349	↑
5	tourism	25.2003	↑
6	attractions	24.7283	↑
7	free	23.6529	↓
8	sexy	21.9773	↑
9	medlineplus	19.9726	↓
10	information	19.9115	↑

Figure 6: *Words exhibiting the greatest positive (↑) and negative (↓) influence on clickthrough patterns.*



# Click Models Summary

Models proposed to **simulate searcher click process**

- Increasingly sophisticated and theories
- Assume searcher is rational and consistent

But, searchers are **not rational or careful**:

- Attracted/repelled by simple features of summaries

Will incorporate summary and browsing info to extract **relevance information** from clicks (next lecture)



# Lecture 1 Summary. Questions?

- ✓ Understanding user behavior at micro-, meso-, and macro- levels
- ✓ Theoretical models of information seeking
- ✓ Web search behavior:
  - ✓ Levels of detail
  - ✓ Search Intent
  - ✓ Variations in web searcher behavior
  - ✓ Keeping found things found
  - ✓ Click models





# References and Further Reading

- **Marti Hearst**, Search User Interfaces, 2009, Chapter 3 “Models of the Information Seeking Process”: <http://searchuserinterfaces.com/>
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