# Exploring Information Seeking and Searching Intentions: An Overview of Recent Research at Rutgers University

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# Information Seeking and Searching Situation

- A person, facing a *problematic situation*, with respect to some *task or goal*, decides that *interacting with information* could help to achieve the goal or accomplish the task.
- That person makes a decision about how to best carry out that interaction. This is the *Seeking* decision (Wilson, 1999)
- When the decision is made to interact with information through the means of some system, *Searching* commences

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# The Goal(s) of Information Retrieval

- To support the person(s) in achieving the the goal or task which motivated them to engage in information seeking and searching
- To do this through helping the person(s) to resolve their problematic situation
- To do this by supporting effective interaction with the IR system and the information objects within that system
- To do this by responding appropriately to the information searching intentions of the person(s) during the course of an information searching session

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# Moving from System-Centered to Person-Centered Information Retrieval

- Recognize that information retrieval is inherently *interactive*
- Recognize that the information retrieval situation is inherently *dynamic*
- Recognize that people engage in information seeking and searching *sessions*
- Make the person in the IR system the central actor
- Make interaction with information objects the central process

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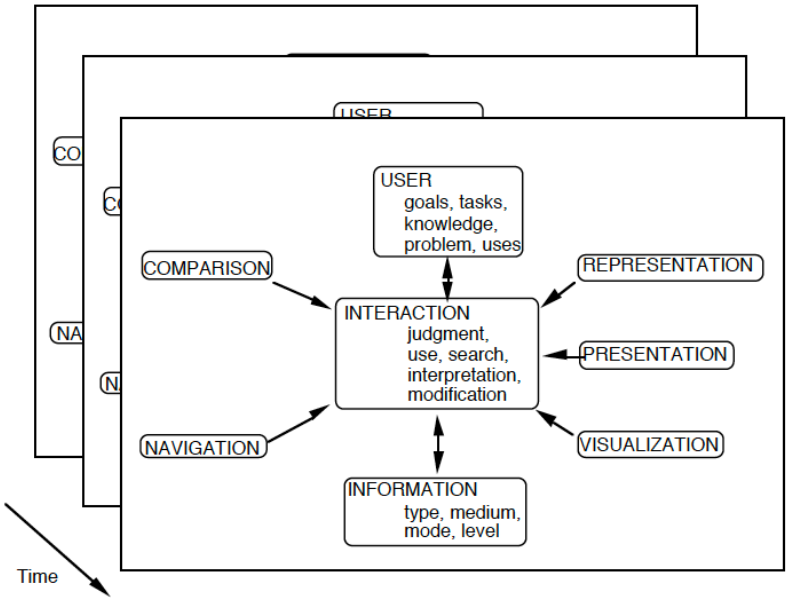
# A Model of Interaction with Information (Belkin, 1996)



# Taking Account of the Interactive Nature of IR

- A research program at Rutgers University Department of Library and Information Science
- Personalization of the Digital Library Experience (POoDLE) _IMLS
- Automatic Identification of Information Searcher Intentions During an Information Seeking Session – Google
- Characterizing and Evaluating Whole Session Interactive Information Retrieval (CHEWS-IIR) – NSF (in progress, described today).

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# General Pattern of our Studies

- Construct work tasks of different types, with associated information searching tasks
- Have participants conduct search for one work task
  - Log behaviors
  - Record search session
- Play back information search session for participant annotation
- Iterate for next work task, to final work task
- Exit interview

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# Work Tasks and Information Search Tasks

- Journalism Domain
  - Any topic
  - Several well-defined types of work tasks, e.g.
    - Advance obituary; Copy editing; Prepare for interview; Story pitch; Prepare story
- Constructed work and search tasks differ on values of specific *facets*
  - Faceted classification of task (Li & Belkin, 2008)

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# Li & Belkin (2008) Facet Analysis of Task (modified)

- Source of Task
  - Self, Group, Assigned
- Task Doer
  - Individual, Group
- Time
  - Frequency
  - Length
  - Stage
- Product
  - Physical, Intellectual, Decision, Factual
- Process
  - One-time, Multiple
- Items
  - Named or Not
  - Whole or Part
- Goal
  - Quality
    - Specific, Amorphous, Mixed
  - Quantity
    - Single or multiple goals
- Common attributes of task, e.g.
  - Objective/Subjective task complexity, Urgency, Salience, Difficulty, …

# Example Task and Classification

**Assignment 1. Copy Editing (CPE)**
**Your Assignment**: You are a copy editor at a newspaper and you have only 20 minutes to check the accuracy of six italicized statements in the excerpt of a piece of news story below.
**Your Task**: Please find and save an authoritative page that either confirms or disconfirms each statement.

**Product**: Fact; **Items**: Named/Part; **Goal**: Specific

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# Example Task and Classification

**Assignment 2. Story Pitch (STP**)
**Your Assignment**: You are planning to pitch a science story to your editor and need to identify interesting facts about the coelacanth ("see-la-kanth"), a fish that dates from the time of dinosaurs and was thought to be extinct.
**Your Task**: Find and save web pages that contain the six most interesting facts about coelacanths and/or research about their preservation.

**Product**: Fact; **Items**: Not Named/Part; **Goal**: Specific

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# Example Task and Classification

**Assignment 3. Relationships (REL)**
**Your Assignment**: You are writing an article about coelacanths and conservation efforts. You have found an interesting article about coelacanths but in order to develop your article you need to be able to explain the relationship between key facts you have learned.
**Your Task:** In the following there are five italicized passages, find an authoritative web page that explains the relationship between two of the italicized facts.

**Product**: Intellectual; **Items**: Named/Part; **Goal**: Mixed (Specific + Amorphous)

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# Example Task and Classification

**Assignment 4. Interview Preparation (INT)**
**Your Assignment**: You are writing an article that profiles a scientist and their research work. You are preparing to interview Mark Erdmann, a marine biologist, about coelacanths and conservation programs.
**Your Task**: Identify and save authoritative web pages for the following: Identify two (living) people who likely can provide some personal stories about Dr. Erdmann and his work. Find the three most interesting facts about Dr. Erdmann's research. Find an interesting potential impact of Dr. Erdmann's work.

**Product**: Intellectual; **Items**: Not-Named/Whole; **Goal**: Amorphous

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# Participants and Procedure

- Journalism undergraduate university students
- Entry questionnaire – demographics
- Searches for two (of four) tasks conducted in lab with eyetracker (20 minutes each)
- Pre-search questionnaire (when presented with task description)
  - Familiarity with task, topic
  - Expected difficulty
- Search conducted on Web , any search system, through Coagmento
- Post-search questionnaire
  - Experienced difficulty
  - Confidence in task success
- Playback search for annotation, by Query Segment
  - QS is query n, all that happens up to and including query n+1 (or end)
- Exit interview
  - Comparison of two tasks and two search sessions

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# Annotation

- Play back QS n
- What were you intending to accomplish during this period
  - Choice of intentions, can be multiple
- For each intention: Was this intention satisfied? If no, why not
  - [text entry]
- What were you hoping to accomplish with [query n+1]
  - [text entry]
- Play back QS n+1

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# Xie's (2002) Interactive [Search] Intentions

- Identify search information (Something to start; Something more to search)
- Learn (Domain knowledge; Database content)
- Find (Known item; Specific information; Sharing named characteristic; Without predefined criteria)
- Keep record
- Access item or set of items
- Evaluate (Correctness; Usefulness; Best; Specificity; Duplication)
- Obtain (Specific information; Part of item; Whole item)

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# Data Analyses (So Far)

- Querying behavior and search intentions
  - Relationships between query reformulation “types” and search intentions
  - Effect of intention satisfaction on query reformulation type
  - Classification of reasons for query reformulation
- Intentions and search behaviors
  - Are the Xie search intentions necessary and sufficient
  - Sequences of search intentions
  - Prediction of search intention based on search behavior

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# Query Reformulation Types (Liu et al. 2010, modified)

| Type | Definition | Examples |
|---|---|---|
| **Generalization** | At least one term in common in two queries; second query contains fewer terms than first query | world economic impact on global warming on Arctic region → global warming on Arctic region |
| **Specialization** | At least one term in common in two queries; second query contains more terms than first query | impact Dr. Erdmann → impact Dr.Mark Erdmann |
| **Word Substitution** | At least one term in common in two queries; second query has the same length as first query, but contains some terms not in the first query | Igor Semiletov research → igor semiletov methane |
| **Repeat** | Exactly the same term(s) repeated from any previous queries within the session | Coelacanths (1st query)→ Coelacanths (5th query) |
| **New** | No common terms in two queries | where is madagascar → coelacanths live young |
| **Spelling Correction** | The second query corrects misspelling of the previous query | methane clarites artic economic immpact → methane clarites arctic economic impact |
| **Stem Identical** | Two queries with the same morphological root | methane km → methane kilometers |

# Query Analyses

- Data for 24 participants, 48 search sessions
- 434 queries
- 383 query reformulations, therefore 383 instances of reasons for query reformulation
- 1824 search intentions
  - median per QS 4, range 1-16
  - 1575 satisfied, 249 unsatisfied

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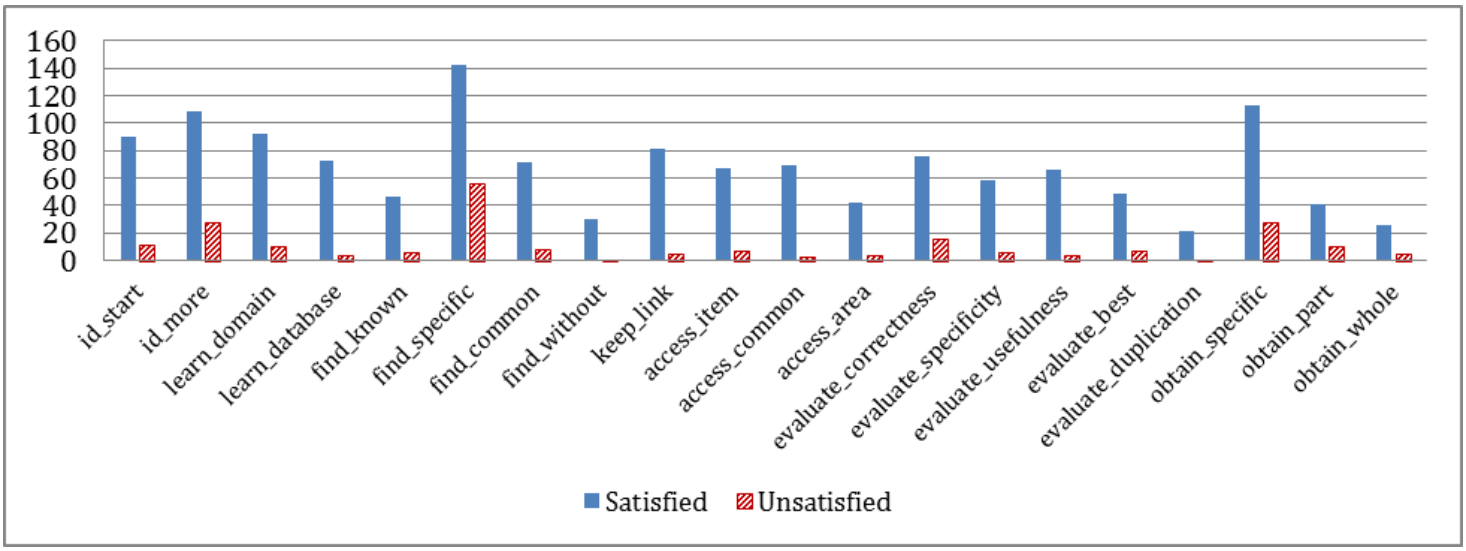
# Total counts for each intention



# Query Reformulations and Search Intentions

- RQ1: *What types of reformulations are used following any search intention*
- RQ2: *What types of reformulations are used when an intention is either satisfied or not satisfied*?
- RQ3: *What are the subsequent intentions of reformulations*

Rha, E.Y., Belkin, N.J., Mitsui, M. & Shah, C. (2016) Exploring the relationships between search intentions and query reformulations. In: *Proceedings of the 79th Annual Meeting of the Association for Information Science and Technology,* (9 pp.). Silver Spring, MD: Association for Information Science and Technology

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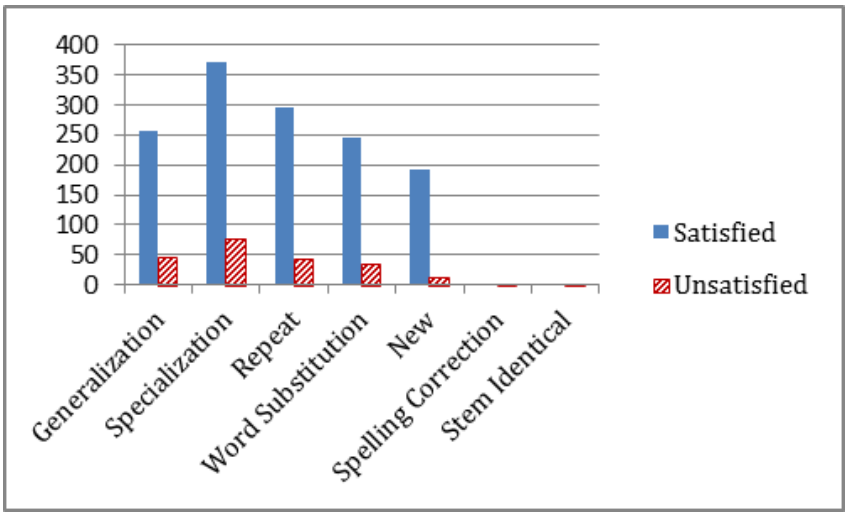
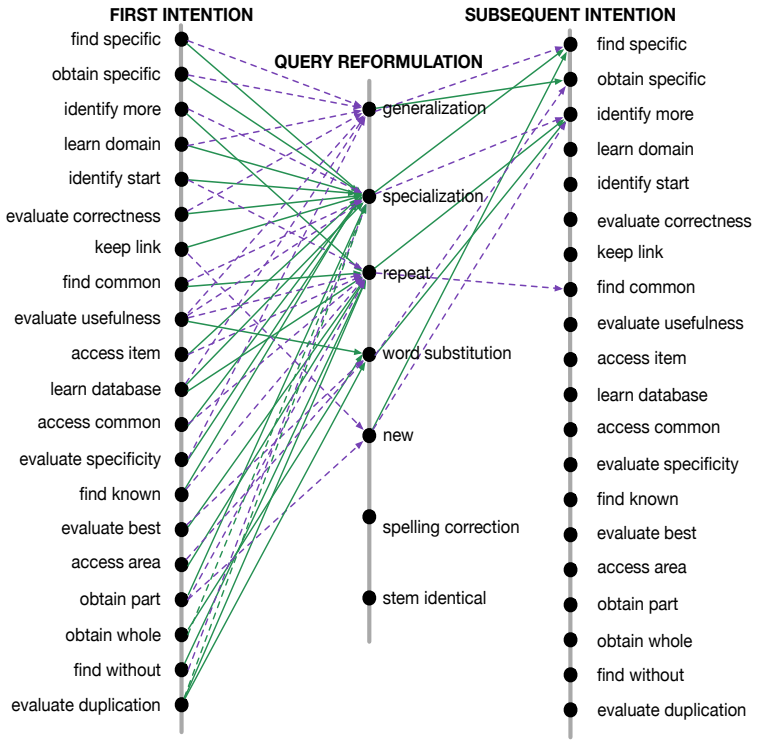
Frequency of satisfied and unsatisfied intentions leading to each reformulation type



# Most frequent intentions, most frequent following reformulations, and most frequent subsequent intentions

| Previous Intention | Satisfaction | Most frequent reformulation | Subsequent intention(s) | Second most frequent reformulation | Subsequent intentions(s) |
|---|---|---|---|---|---|
| Find specific | Y | Specialization | Find specific | Generalization | Find specific |
| | N | Specialization | Find specific | Generalization | Find specific |
| Obtain specific | Y | Specialization | Find specific | Generalization | Obtain specific |
| | N | Specialization | Obtain specific | Generalization | Find specific |
| Identify more | Y | Repeat | Identify more | Specialization | Identify more |
| | N | Specialization | Learn domain | Repeat | Identify more |
| Learn domain | Y | Specialization | Find specific | Generalization | Identify more |
| | N | Specialization | Learn domain | Generalization | Learn domain, Learn database |
| Identify start | Y | Specialization | Find specific | Repeat | Identify more |
| | N | Specialization | Find specific Obtain specific | Generalization | Identify start Find known |


FIRST INTENTION
QUERY REFORMULATION
SUBSEQUENT INTENTION
find specific
obtain specific
identify more
learn domain
identify start
evaluate correctness
keep link
find common
evaluate usefulness
access item
learn database
access common
evaluate specificity
find known
evaluate best
access area
obtain part
obtain whole
find without
evaluate duplication
generalization
specialization
repeat
word substitution
new
spelling correction
stem identical
find specific
obtain specific
identify more
learn domain
identify start
evaluate correctness
keep link
find common
evaluate usefulness
access item
learn database
access common
evaluate specificity
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find without
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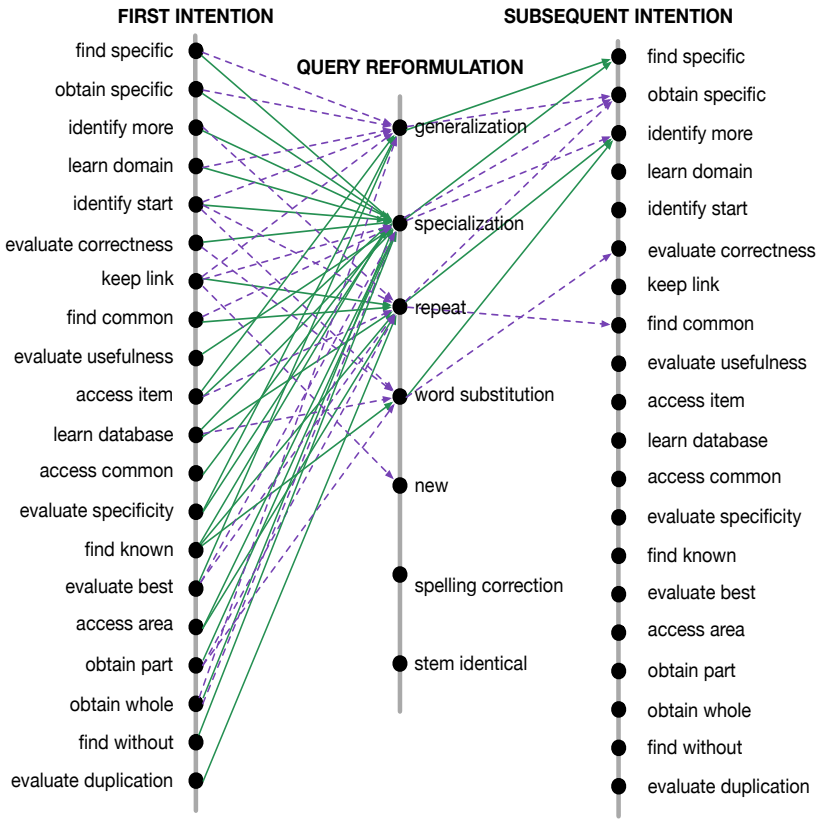
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obtain whole
find without
evaluate duplication
generalization
specialization
repeat
word substitution
new
spelling correction
stem identical
find specific
obtain specific
identify more
learn domain
identify start
evaluate correctness
keep link
find common
evaluate usefulness
access item
learn database
access common
evaluate specificity
find known
evaluate best
access area
obtain part
obtain whole
find without
evaluate duplication

# Reformulation & Intentions Discussion 1

- RQ1: *What types of reformulations are used following any search intention*
  - *Specialization* is the most common reformulation following 12 of the 20 intentions, then *Repeat*, then *Generalization*
  - Intentions have different patterns of subsequent reformulations
- RQ2: *What types of reformulations are used when an intention is either satisfied or not satisfied*?
  - Inconclusive; too few *unsatisfied*
- RQ3: *What are the subsequent intentions of reformulations*
  - Inconclusive but promising; each subsequent intention has a different pattern of precursor reformulations, despite the domination of *Specialization*

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# Reformulation & Intentions Discussion 2

- Despite the nature of the work and search tasks, participants had no difficulty identifying different intentions associated with different query segments
- Given the different nature of the various intentions, this suggests that search support techniques other than query reformulation could be useful in supporting effective interaction
- The degree of satisfaction of intentions may be due to either low expectations, or inventive use of reformulation

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# Reasons for Query Reformulation

- People reformulate queries, but we don't know what they are trying to accomplish by doing this;
  - RQ1: *What are reasons for query reformulation*
- People reformulate queries, but we don't know how reformulation *types* relate to *reasons* for reformulation;
  - RQ2: *How are types of query reformulation related to users' reasons for query reformulations*
- People attempt to accomplish different search intentions, but we don't know how they go about doing that through query reformulation.
  - RQ3: *How do previous interactive search intentions relate to reasons of following query reformulations*

Rha, E.Y, Wei, S. & Belkin, N.J. (2017) An exploration of reasons for query reformulation. In: *Proceedings of the 80th Annual Meeting of the Association for Information Science and Technology,* (11 pp.). Silver Spring, MD: Association for Information Science and Technology

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# Procedure for Addressing RQs

- Open coding of 383 texts written in response to the question:
  Please explain why you entered this new query, and what you were hoping to accomplish by doing so
- Identification of common structure of reasons, and common elements in that structure
- Development of a faceted classification based on structure and elements
- Analysis of types of reasons in relationship to types of reformulations and types of search intentions

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# Reasons and Coding Examples

| Reason | Open Coding |
|---|---|
| “Trying to find information that is truthful, and more specific to the subject.” | Find truthful information<br>Find specific information |
| “Clarify my original search” | Clarify original search |
| “Looked up for any recent news regarding Arctic oil and gas to see if I could bolster my argument with any recent facts that were perhaps in the news.” | Look for recent news<br>Bolster my argument |
| “I entered this new query because I felt I did not use the right word in my first query referring to people the scientist would have had relations with to provide the answer to the first question of the assignment.” | Use right word |
| “I used a more general phrase to get more background information on the topic and hopefully find authoritative sources that supported the facts.” | Get background information<br>Find authoritative sources |

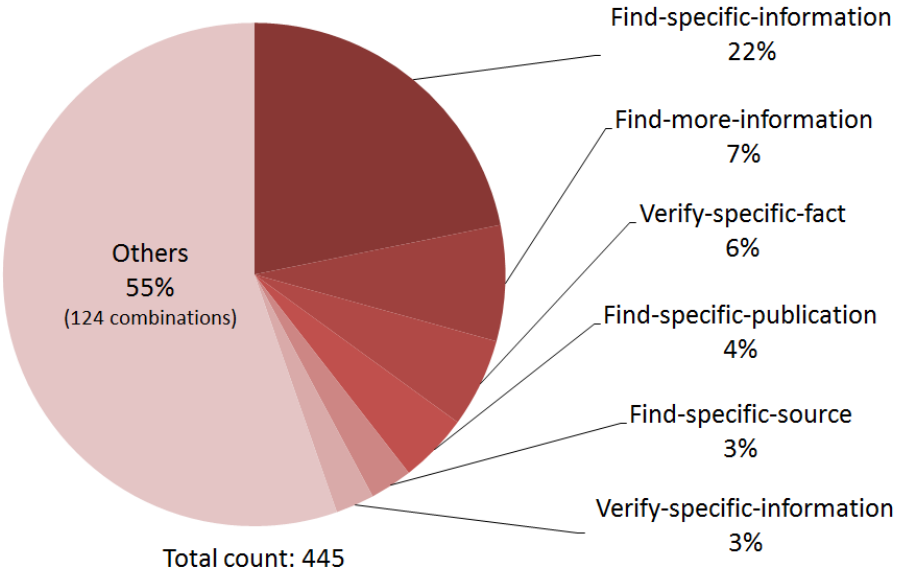
# Examples of Normalization of Open Coding

| Open Coding | Final Combination |
|---|---|
| Find truthful information | Find-accurate-information |
| Clarify original search | Clarify-previous-search |
| Look for recent news<br>Bolster my argument | Find- up-to-date -publication<br>Verify-specific-knowledge |
| Use right word | Correct-previous-query |
| Get background information<br><br>Find authoritative sources | Obtain-background-information<br><br>Find-credible-source |

# Faceted Classification Based on Reason Structure

| Facet | Sub-facets | Values |
|---|---|---|
| Process | Operational | Find; Obtain; Access; Expand; Combine; Correct; Change; Narrow down; Start |
| | Interpretive | Evaluate; Verify; Focus on; Learn; Clarify; Use; Understand |
| Aspect | Depth | General; Specific; Background; Basic; Detailed |
| | Time | New; Previous; Up-To-Date |
| | Quality | Interesting; Accurate; Credible; Better; Useful |
| | Quantity | Multiple; Single |
| | Relationship | Similar; Different; Relevant; More |
| Entity | Content | Knowledge; Information; Topic; Definition; Fact; Domain |
| | Resource | Source; Website; Publication |
| | Search | Search result; Query; Search |

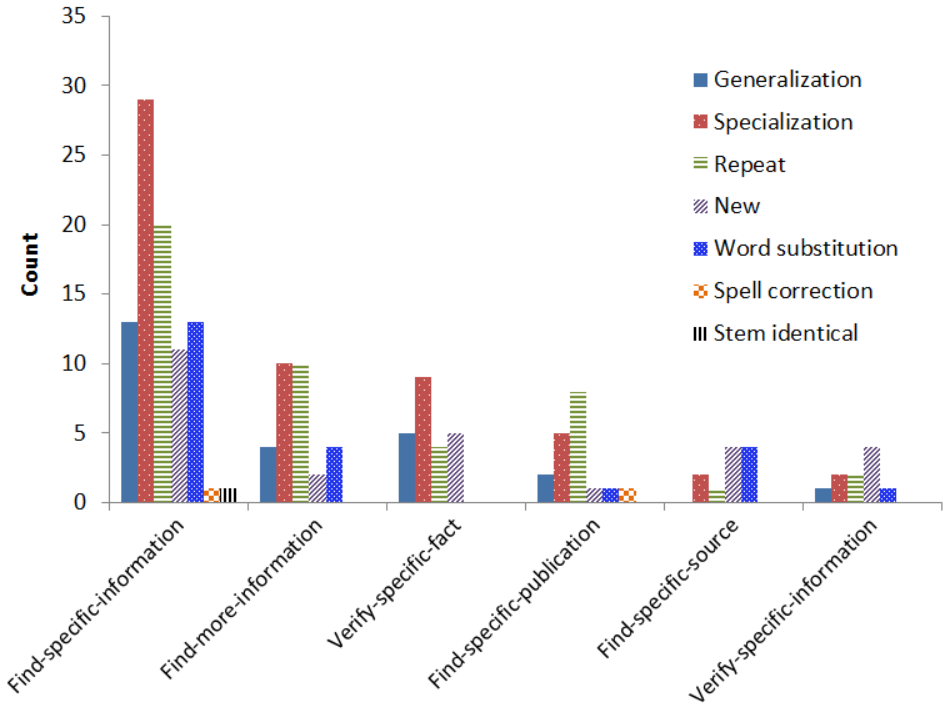
# Distribution of Reasons for Reformulation



# Mapping Reasons to Search Intentions

| Xie's (2002) Search Intention | Reason Combination |
|---|---|
| Find specific information | Find-specific-information<br>Find-specific-publication<br>Find-specific-source<br>Find-specific-website |
| Identify more to search | Find-more-information |
| Evaluate correctness | Verify-specific-fact<br>Verify-specific-information |
| Obtain specific information | Obtain-specific-information |
| Find items without pre-defined criteria | Find-interesting-fact<br>Find-different-information |
| Learn domain knowledge | Learn-specific-topic |

# Relationship of Reasons to Reformulations



# Reasons and Intentions Discussion 1

- RQ1: *What are reasons for query reformulation*
  - A faceted classification scheme provides ways to characterize reasons at different levels of granularity, but there are many possible combinations
  - Many of the reasons (but not all) map to Xie's (2002) interactive search intentions
- RQ2: *How are types of query reformulation related to users' reasons for query reformulations*
  - Participants used different query reformulation types to accomplish the same reasons, and
  - The same reformulation types were used to accomplish multiple reasons

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# Reasons and Intentions Discussion 2

- RQ 3: *How do previous interactive search intentions relate to reasons of following query reformulations*
  - Inconclusive; dominance of find-specific-information as a reason, and lack of unsuccessful intentions, did not allow meaningful analysis
- Overall conclusion:

People, during the course of an information search session, attempt to do more than just “make a better query”; it seems clear that many of the reasons for query reformulation would be better achieved through other means.

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# Search Intentions and Search Behaviors

Given that people attempt to accomplish different intentions during the course of an information search session, can a system identify what those intentions are, without intervention?

- RQ1: How is a user's Web search behavior associated with his or her information seeking intentions in the same query segment
- RQ2: How is a user's Web search behavior in the current query segment associated with his or her information seeking intentions in the subsequent query segment

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# Procedure, Data and Methods

- Procedure as previously described, but with data for 40 participants
- 80 search sessions, 693 query segments
- Observed search behaviors treated as groups
- Two different analyses, using two slightly different behavior groups
  - Identifying intentions as a binary classification problem – logistic regression
  - Identifying and predicting intentions through significantly different correlations of behaviors when intention is present

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# Observed Behaviors, per Query Segment

- Saved item (binary)
- Number of saved items
- Dwell times on content pages
- Dwell times on SERP viewports
- Query length
- Query reformulation type
- Number of clicks
- Number of sources visited
- Number of pages viewed

- Dwell times are:
  - total dwell time
  - total dwell time until a page is saved
  - total open time
  - total open time until a page is saved
  - first dwell time
  - mean of all dwell times

# Behavioral Groups for Binary Classification
## (Tested singly and in combinations)

- Saving features
  - Saved item (binary)
  - Number of saved items
- Content page features
  - Dwell times
  - Number of content pages, by types: saved, not saved, unsaved, total
- SERP (i.e. viewport on SERP) features
  - Dwell times
- Query features
  - Query length
  - Query reformulation type

# Measuring Performance

- Measures

  TP=True Positive; FP=False Positive; TN=True Negative; FN=False Negative
- Accuracy:

  ACC = TP +TN / TP +TN + FP + FN
- Precision for intention present:

  $P_1$ = TP / TP + FP
- Precision for intention absent:

  $P_0$ = TN / TN + FN
- Baselines
  - Stratified sampling of positive / negative labels proportional to their distribution in training data
  - Assigning the most frequent label in the training data
- Tests for Identification
  - Improvement over the better of the two baselines, Kolmogorov-Smirnoff

# Results for Identification by Classification (1)

| Metric | Range [min, max] | Range Increase [min, max] | Mean | Mean Increase |
|---|---|---|---|---|
| **Accuracy** | [.608, .929] | [0, .129] | .786 | .024 |
| **$P_0$** | [.661, .967] | [0, .545] | .808 | .064 |
| **$P_1$** | [.411, 1.0] | [.044, .91] | .768 | .522 |

**- For all intentions, Accuracy and $P_0$ significantly improved over better baseline (mostly $p < .01$), when using all features together.**

# Results for Identification by Classification (2)

- Accuracy
  - Significant ($p < .01$) but not large improvement in ACC over better baseline for all intentions but one. For most intentions, using all feature groups was best
- Precision present
  - Significant ($p < .01$) and meaningful improvement in $P_{pres}$ for all intentions; For most intentions, one, or a combination of two feature groups performed best, rather than combining all.
- Precision absent
  - Slight improvements, most non-significant, over best baseline. Scores were uniformly fairly high for both baseline

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# Classification Discussion

- Doing better than random with a very simple classifier for two out of three measures
- Doing very well in Positive identification, likely because it's a conservative algorithm
  - Identifying fewer intentions, with more certainty, is probably a win given the problem
- Negative identification may be uninteresting, given the problem
- Interesting start on the problem; next steps are:
  - More and different features
  - Prediction, rather than just identification

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# Behavioral Groups for Prediction

- Overall search behavior
  - Query length
  - Number of sources visited
  - Number of pages viewed
- Dwell time features
  - Mean dwell time on each SERP viewport
  - Mean dwell time on content pages
- Usefulness judgment
  - Saved item (binary)
  - Number of saved items

# Measuring Strength of Relationship

- RQ 1: How is a user's Web search behavior associated with his or her information seeking intentions in the same query segment
  - Mean value of each search behavior for all query segments
  - Mean value of each search behavior for query segment with given intention
  - Degree of difference between the two indicates strength of relationship
- RQ2: How is a user's Web search behavior in the current query segment associated with his or her information seeking intentions in the subsequent query segment
  - Mean value of each search behavior for all query segments
  - Mean value of each search behavior for query segment preceding query segment with given intention
  - Degree of difference between the two indicates strength of relationship

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# Methods

- Correlation analysis for each behavior-intention pair
- Done for all current, and all subsequent, pairs
- Behaviors distributed non-normally
- Mann-Whitney tests for significant differences

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# Results for Identification and Prediction by Deviation from Mean

- In general, different behaviors, and patterns of behaviors, are associated with different intentions in the current query segment. Many significant such associations
- In general, different behaviors, and patterns of behaviors, in the current query segment are associated with different intentions in the subsequent query segment. Fewer significant such associations than for current intention, but still some for almost all subsequent intentions
- Next two slides show these results for (1) identification and (2) prediction. Black is significantly above the mean; grey is significantly below the mean

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| Current intention | Query | Clicks | Sources | Pages | SERP | Content | if bookmarke | # bookmarks |
|---|---|---|---|---|---|---|---|---|
| **Access** | | | | | | | | |
| website | | | | | | | | |
| common | | | | | | | | |
| item | | | | | | | | |
| **Evaluation** | | | | | | | | |
| best | | | | | | | | |
| correctness | | | | | | | | |
| duplicate | | | | | | | | |
| specific | | | | | | | | |
| usefulness | | | | | | | | |
| **Find** | | | | | | | | |
| common | | | | | | | | |
| known | | | | | | | | |
| specific | | | | | | | | |
| without | | | | | | | | |
| **Identify** | | | | | | | | |
| more | | | | | | | | |
| start | | | | | | | | |
| **Keep** | | | | | | | | |
| link | | | | | | | | |
| **Learn** | | | | | | | | |
| database | | | | | | | | |
| domain | | | | | | | | |
| **Obtain** | | | | | | | | |
| part | | | | | | | | |
| specific | | | | | | | | |
| whole | | | | | | | | |

| Next intention | Query | Clicks | Sources | Pages | SERP | Content | if bookmarked | # bookmarks |
|---|---|---|---|---|---|---|---|---|
| **Access** | | | | | | | | |
| website | | | | | | | | |
| common | | | | | | | | |
| item | | | | | | | | |
| **Evaluation** | | | | | | | | |
| best | | | | | | | | |
| correctness | | | | | | | | |
| duplicate | | | | | | | | |
| specific | | | | | | | | |
| usefulness | | | | | | | | |
| **Find** | | | | | | | | |
| common | | | | | | | | |
| known | | | | | | | | |
| specific | | | | | | | | |
| without | | | | | | | | |
| **Identify** | | | | | | | | |
| more | | | | | | | | |
| start | | | | | | | | |
| **Keep** | | | | | | | | |
| link | | | | | | | | |
| **Learn** | | | | | | | | |
| database | | | | | | | | |
| domain | | | | | | | | |
| **Obtain** | | | | | | | | |
| part | | | | | | | | |
| specific | | | | | | | | |
| whole | | | | | | | | |

# Next Steps

- Add analysis of eye fixation behaviors to the identification and prediction models
- Based on dissertation work by Michael Cole, and related to results reported in Cole, M.J., Hendahewa, C., Belkin, N.J. & Shah, C. (2015) User activity patterns duringinformation search. *ACM Transactions on Information Systems,* 33 (1): Article No. 1 (39 p.)
- Carry out analyses with respect to task types and facet values
  - Substantial evidence that task type influences search behaviors significantly
  - Strong suspicion that task type influences patterns of intentions
- Carry out *in situ* study of search behaviors and search intentions
  - Thirty "professional" participants, searches logged and annotated by intentions, for one week.

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# Thanks for Your Attention


- Acknowledgements due to all of the members of the POoDLE and CHEWS-IIR projects, and to our funders
- Work reported here was supported through the National Science Foundation, grant #IIS-1423239.
- Work reported here was supported by a Google Faculty Research Award to N.J. Belkin & C. Shah
- Some work reported here was supported by IMLS grant LG#06-07-0105-07


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