Explaining Query Modifications

An alternative interpretation of term addition and removal

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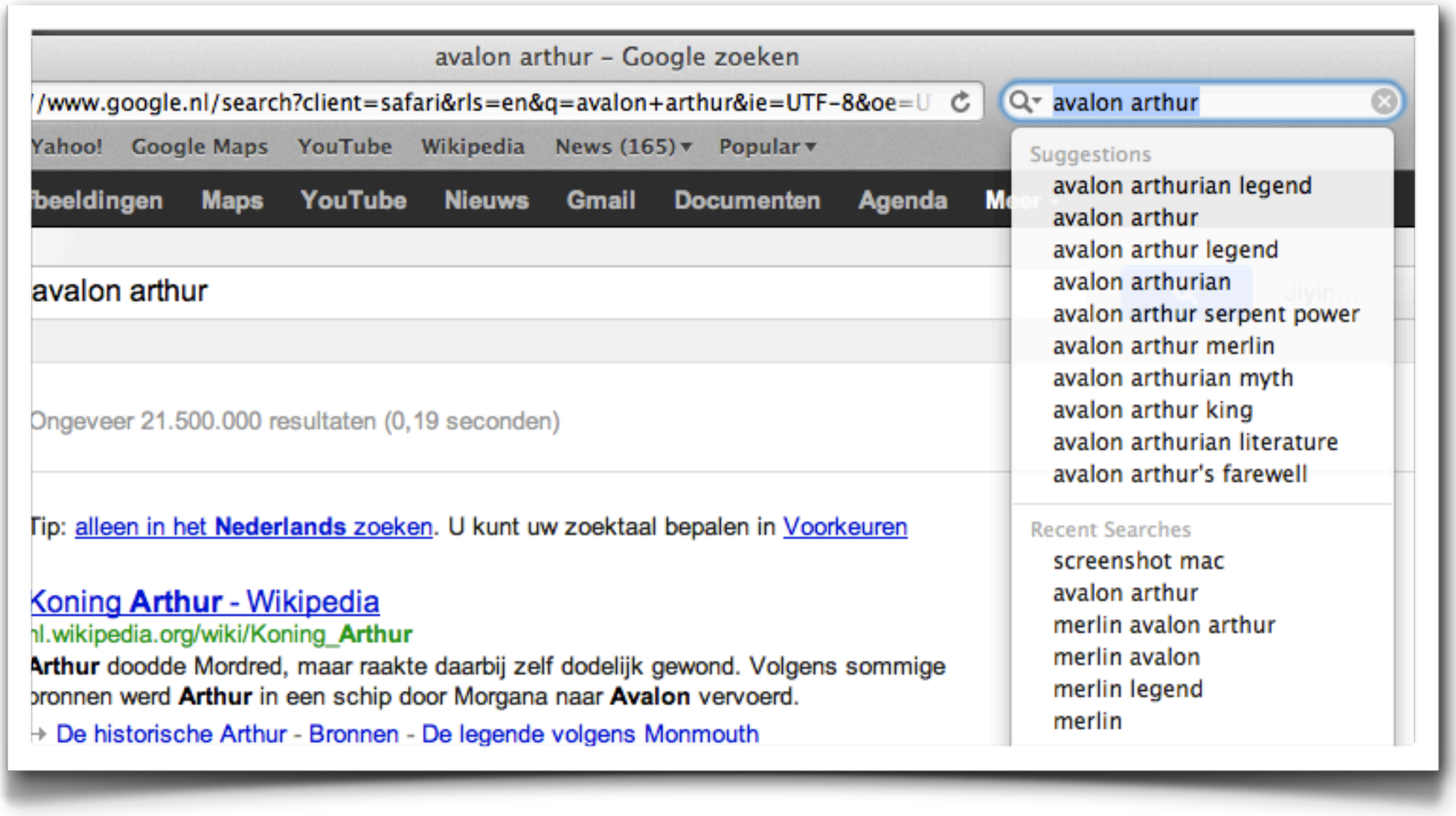
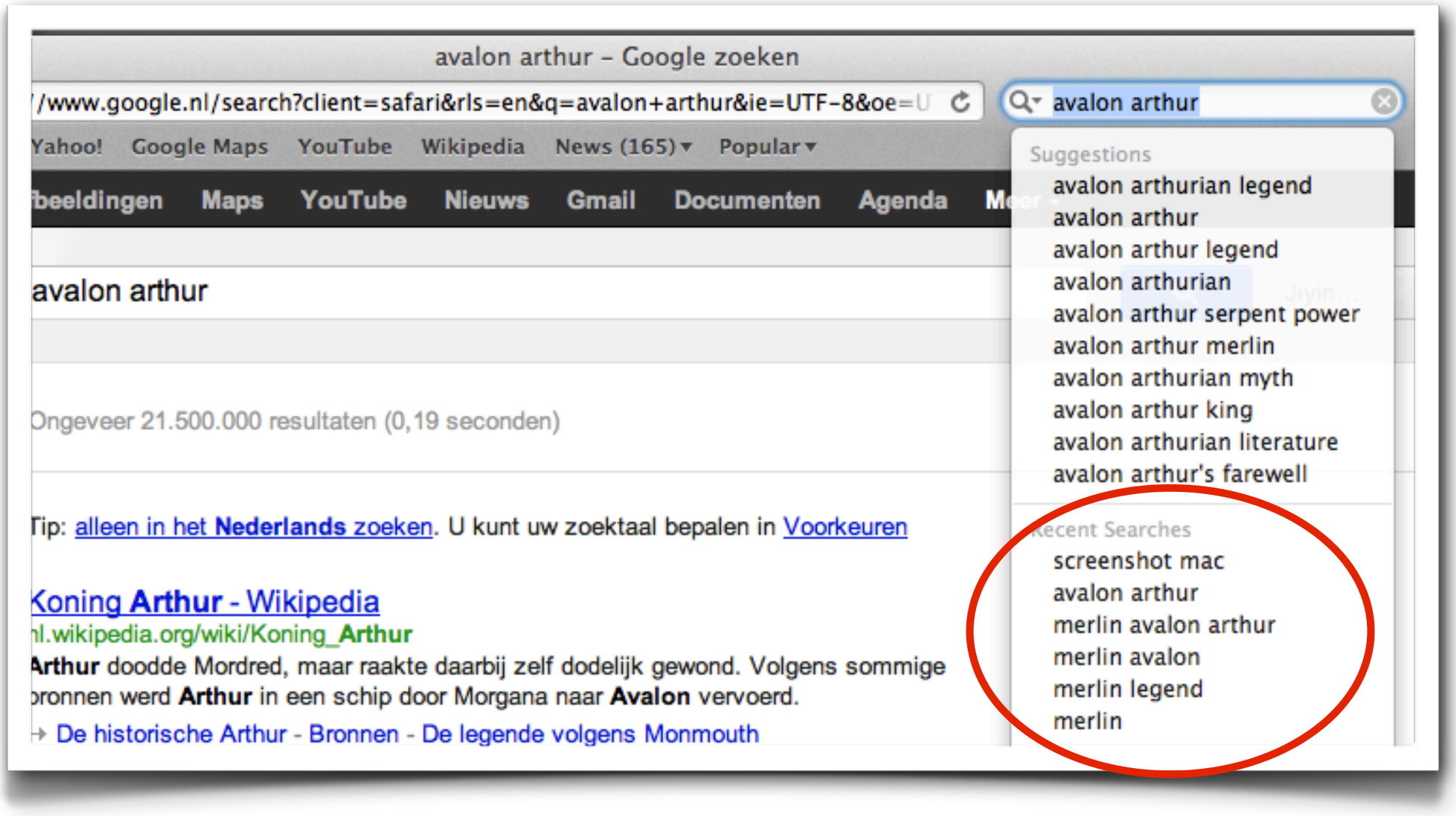
Query modifications



Query modifications



Query modifications

merlin	
merlin legend	term addition
merlin avalon	term substitution
merlin avalon arthur	term addition
avalon arthur	term removal
screenshot mac	different

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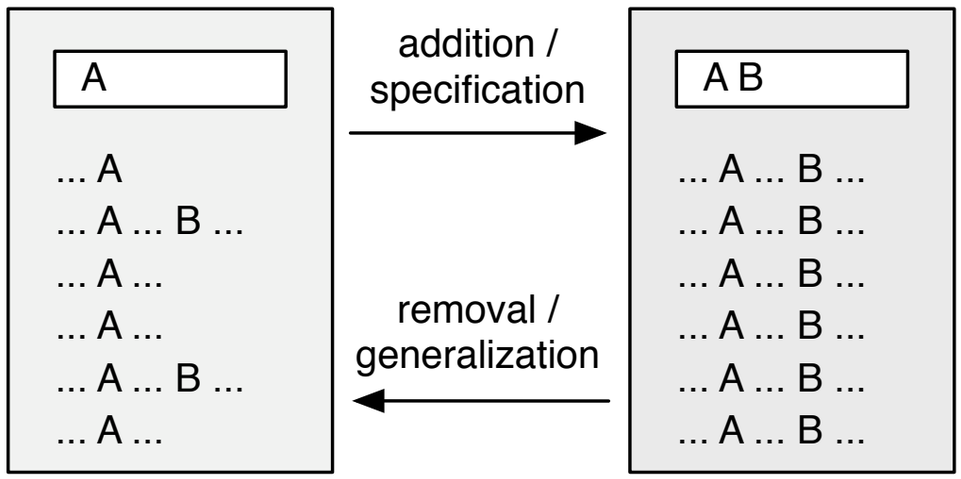
We study: term additions and removals between consecutive query pairs

A commonly accepted interpretation

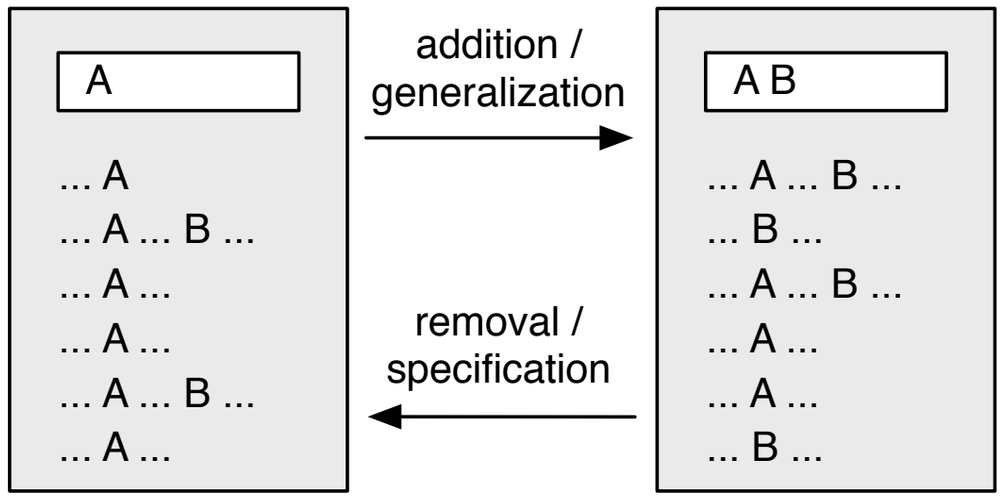
- An intersection-based interpretation



- It is valid if the retrieval system employs strict boolean operations, e.g., returned documents always contain *all* query terms
- Implicitly used in many studies (e.g., Boldi et al., 2010, Bruza and Dennis, 1997, Costa and Seco, 2008, He et al., 2002, Jansen et al., 2009)

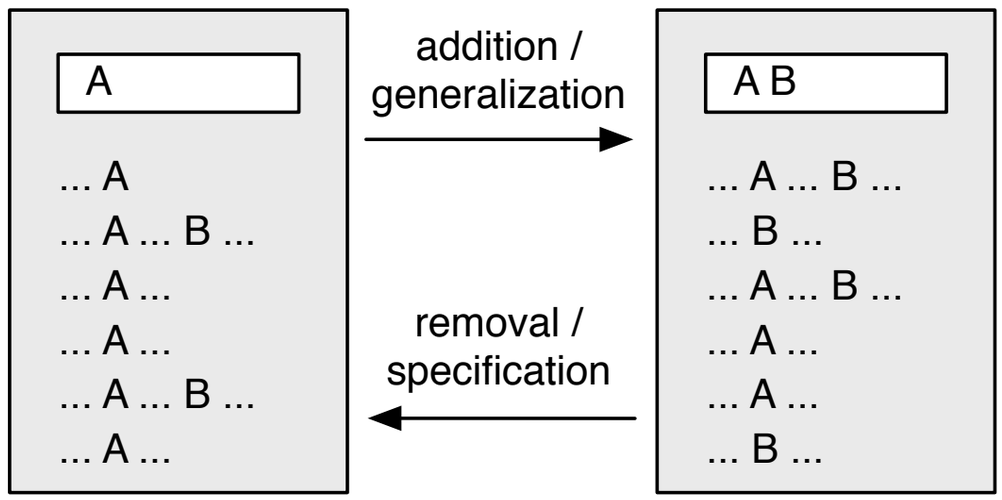
An alternative interpretation

- Modern search engines often return documents contain *some* of the query terms, i.e., non-boolean operations



An alternative interpretation

- An union-based interpretation
  - Removal may be used to get rid of non-relevant documents that contain all query terms
  - Addition may be used to include documents about the added term



Union-based interpretation: an example

shoulder pain and numbness in index finger

About 220,000 results (0.20 seconds)

Neck/**shoulder**/arm **pain**. Thumb, **index** and middle **finger**
www.medhelp.org/posts/...**shoulder**...**pain**...**index**...**finger**.../11901
5 Dec 2006 – is a lil crooket and the C shape in the back of my neck is
so he feels he can correct the problem. It doesn't seem to be working ...

Shoulder Blade **pain and numb index finger** - Neurology
www.medhelp.org/posts/.../**Shoulder**...**pain**-and...**index-finger**/.../123...
30 Apr 2010 – Went back to clinic for second round of **pain** meds. This
give me naflex, naproxen and steroids. Also Vicadin pills so I can sleep

nerve **pain shoulder numbness finger**
www.arthritis-treatment-and-relief.com/nerve-**pain-shoulder-numbne**...
nerve **pain shoulder numbness** finger. ... Enter your First Name (optio
Weakness will be felt in the biceps, with **numbness** along the thumb an

shoulder pain numbness in pointer **finger**
www.arthritis-treatment-and-relief.com/**shoulder-pain-numbness**-in-p...
Pain, **numbness**, or tingling in the hand, wrist, palm, thumb, or **first** thr
May complain of diffuse **numbness** in the forearm, upper arm, and **sho**

Numbness in index finger-under nail - Carpal Tunnel Syn
www.healthboards.com/.../547916-**numbness-index-finger**-under-nai...
28 Oct 2007 – **Shoulder** and Arm **Pain** with left pointer finger **numbnes**

numbness in index finger

About 299,000 results (0.11 seconds)

Paresthesia (**Finger Numbness**): Check Your Symptoms
www.medicinenet.com › home › arthritis center › arthritis az list
15+ items – **Numbness Fingers** Forum.
Arthritis — Arthritis is infla
Carpal Tunnel Syndrome And Tarsal Tunnel Syndrome — Carpal tunnel ..

Numbness Tingling
www.handhealthresources.com/.../**numbness**_tingling.htm
If you experience **numbness** and tingling in the thumb, **index finger**, n
and/or part of the ring finger, you may have a compression or irritation

Index Finger Numbness
www.buzzle.com/articles/**index-finger-numbness**.html
12 Oct 2011 – **Index finger numbness** can lead to tingling and pain in
fingers. Let's read more about symptoms, causes and treatment of this

Numbness in index finger left hand, please help ? - Yaho
answers.yahoo.com › ... › Pain & Pain Management
4 Feb 2012 – This happen out of no where. Its the same color it...

- Why is my right **index finger** numb? - 14 Feb 2011
- The tip of my middle **finger** is numb.? - 11 Jan 2010
- **Numbness** in my right middle **finger**? - 7 Jul 2007
- What causes **numbness** on my right **fingers** , thumb, pointer and ...

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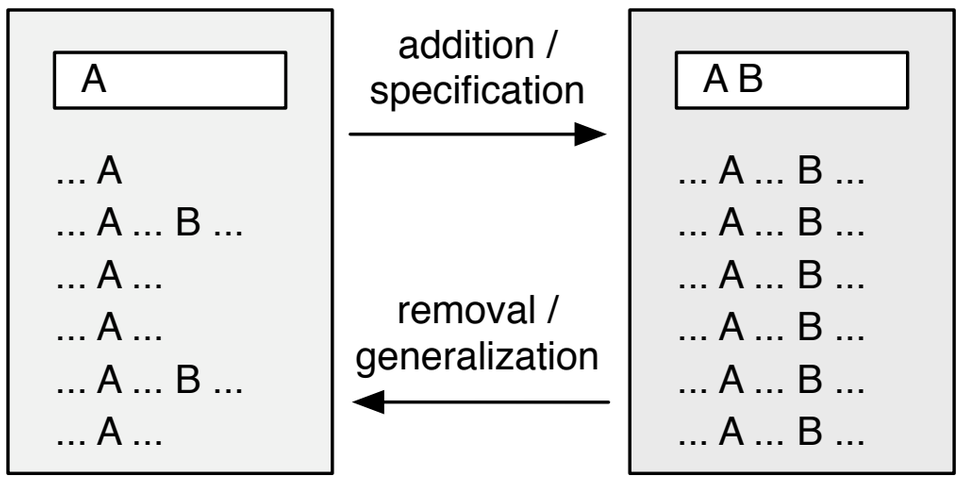
A research question

- How well can each of the two interpretations of term additions and removals explain the query modification behaviors of the searchers?

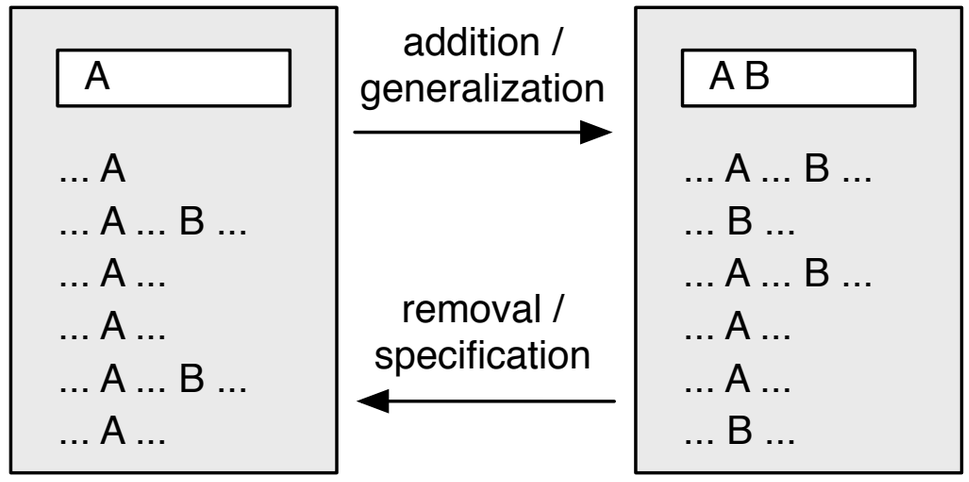
Method

- Assumptions

Intersection-based



Union-based



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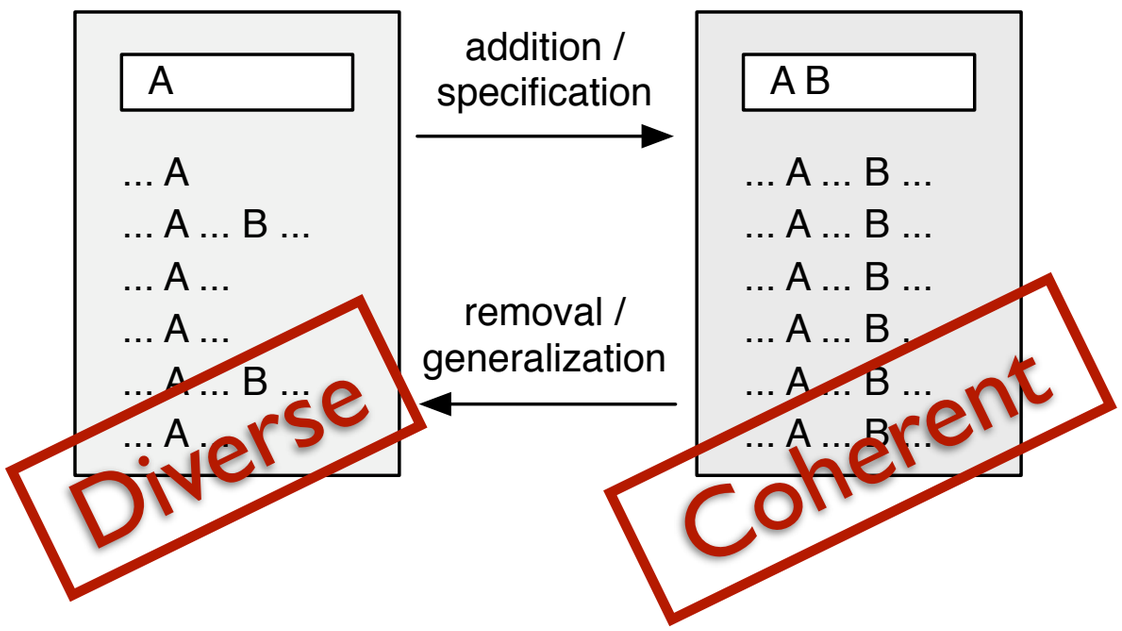
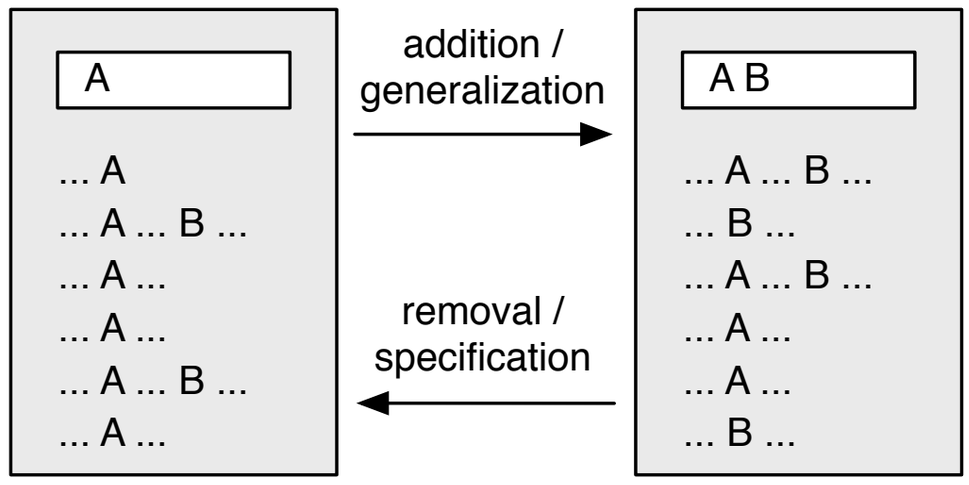


Union-based



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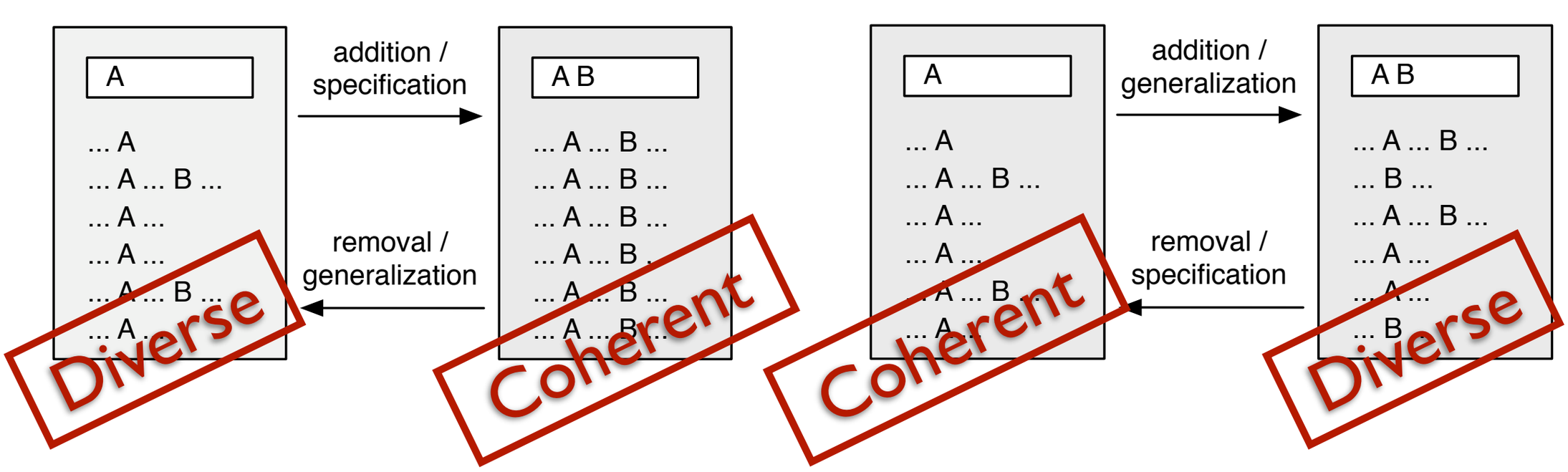

Method

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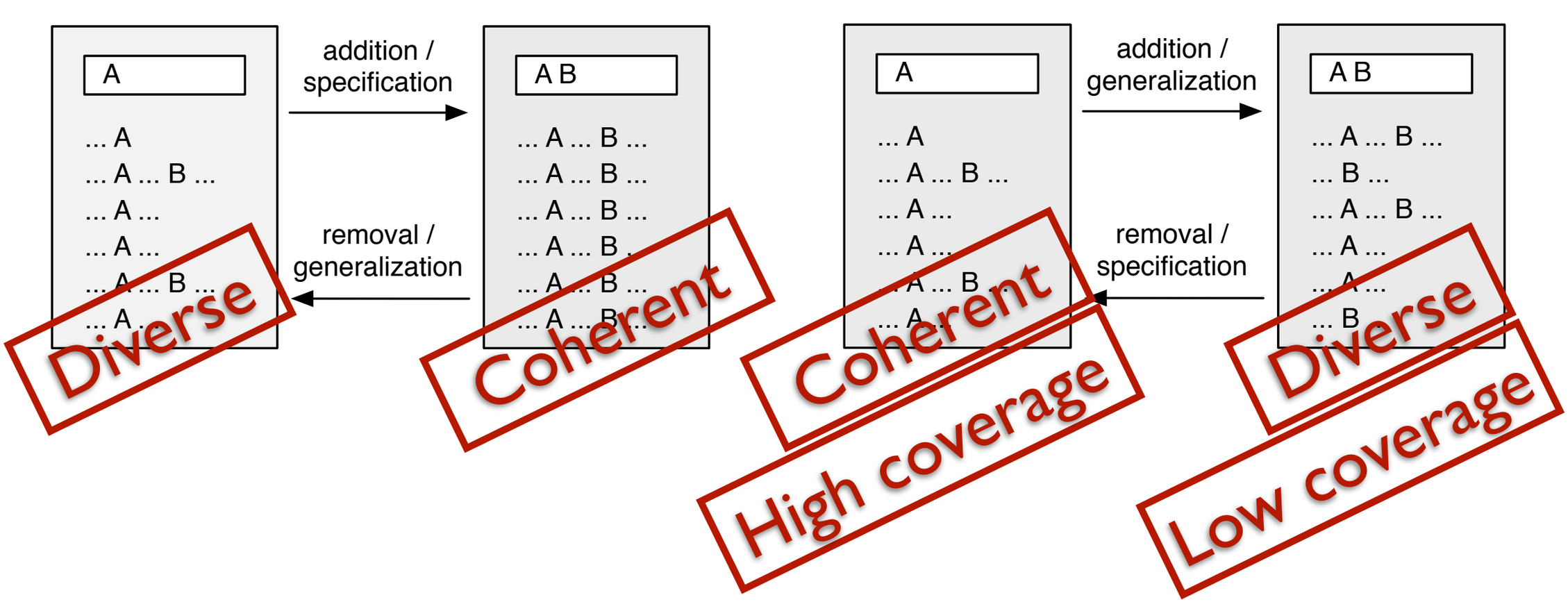

Method

- Empirical validate:
  - Do more coherent or less coherent result sets more often lead to term removals and term additions?
  - Do term removals and term additions increase or decrease the coherence of the result sets?
  - Do term removals often occur when many of the original result sets do not contain all query terms and term additions occur when all results do contain all terms?

Method

- Measuring coherence
  - Average similarity scores

$$AvgSim(D_q) = \frac{\sum_{i<j \in \{1,\ldots,N\}} Sim(d_i, d_j)}{\frac{1}{2}N(N-1)}$$

  - Coherence score (He et al. 2008)

$$Coherence(D_q) = \frac{\sum_{i<j \in \{1,\ldots,N\}} \sigma(d_i, d_j)}{\frac{1}{2}N(N-1)} \quad , \text{ where } \quad \sigma(d_i, d_j) = \begin{cases} 1 \text{ if } Sim(d_i, d_j) \geq \theta \\ 0 \text{ otherwise} \end{cases}$$

- Measuring query term coverage

$$Coverage(D_q) = \frac{|\{d | d \in D_q, T_q \subseteq T_d\}|}{|D_q|}$$

Experiments

- Data sets: query pairs (additions/removals) from 3 query logs

Logs	News	iCLEF 08/09	Web
All	556,007	49,174	20, 000
2 terms	282,039	15,713	4,842
>=2 terms	355,660	44,132	17,659

- Retrieval systems : top 16 documents are used as result set
  - News: lemur toolkit
  - iCLEF: FlickLing - a Flickr API
  - Web : Bing API
- A user study verifies that the coherence score agrees with human judgements in determining the coherency of a result set (Cohen's kappa = 0.70)

Validation of the two interpretations

- Do more coherent or less coherent result sets more often lead to term removals and term additions?

		Coherence		Avg Sim		Coverage	
Data		A	R	A	R	A	R
News	all	0.65	>> 0.56	0.56	>> 0.52	0.90	>> 0.29
	2 terms	0.66	>> 0.57	0.56	>> 0.52	0.78	>> 0.40
	>=2 terms	0.66	>> 0.56	0.56	>> 0.52	0.73	>> 0.29
iCLEF	all	0.94	>> 0.71	0.32	>> 0.29	0.80	>> 0.39
	2 terms	0.94	>> 0.73	0.34	>> 0.27	0.81	>> 0.51
	>=2 terms	0.94	>> 0.71	0.35	>> 0.29	0.75	>> 0.39
Web	all	0.68	>> 0.64	0.28	>> 0.27	0.69	>> 0.35
	2 terms	0.70	>> 0.58	0.29	>> 0.25	0.80	>> 0.61
	>=2 terms	0.73	>> 0.64	0.30	>> 0.27	0.64	>> 0.35

≫/≪ indicates significantly larger/smaller with p-value <0.01 using the Wilcoxon rank sum test.

Validation of the two interpretations

- Do term removals and term additions increase or decrease the coherence of the result sets?

		Coherence			Avg Sim			Coverage		
Data		A		R	A		R	A		R
News	all	-0.035	<<	0.072	-0.016	<<	0.034	-0.449	>>	0.554
	2 terms	-0.031	<<	0.078	-0.012	<<	0.034	-0.455	>>	0.601
	>=2 terms	-0.031	<<	0.072	-0.013	<<	0.034	-0.424	<<	0.554
iCLEF	all	-0.138	<<	0.186	-0.012	<<	0.025	-0.282	<<	0.323
	2 terms	-0.151	<<	0.190	-0.029	<<	-0.015	-0.296	<<	0.406
	>=2 terms	-0.148	<<	0.186	-0.033	<<	0.025	-0.278	<<	0.323
Web	all	-0.013	<<	0.039	0.002	<<	0.010	-0.320	<<	0.337
	2 terms	-0.024	>>	-0.08	-0.000	>>	-0.042	-0.384	<<	0.256
	>=2 terms	-0.054	<<	0.039	-0.014	<<	0.010	-0.321	<<	0.338

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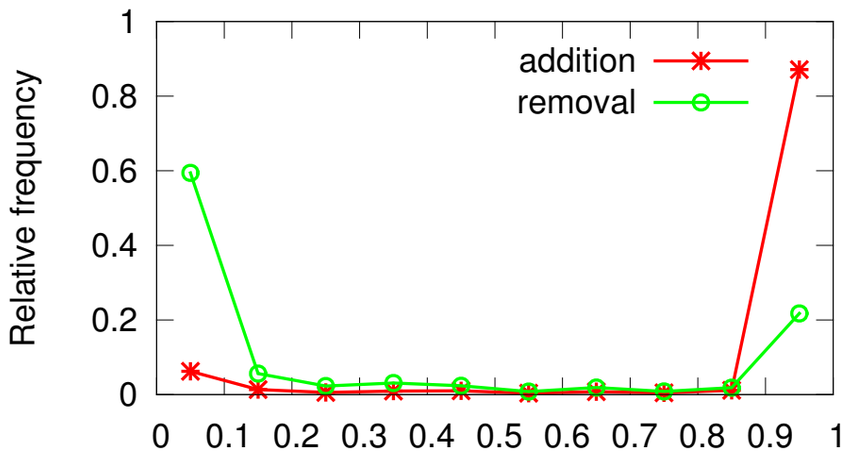
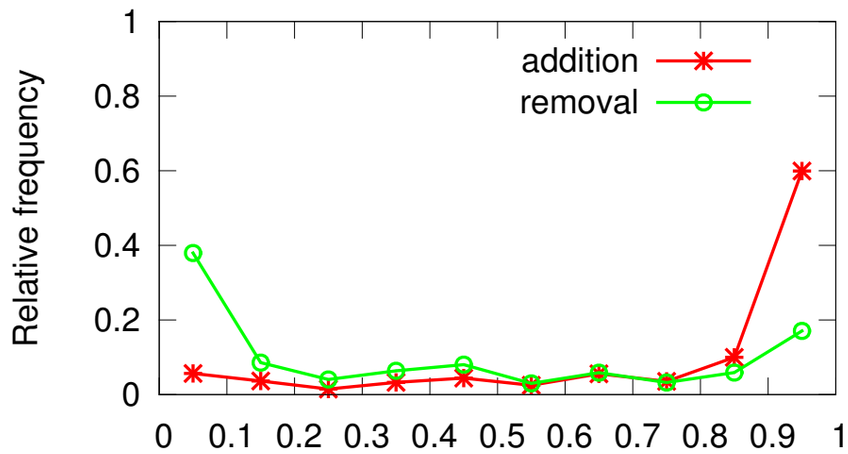
Validation of the two interpretations

- Query term coverage

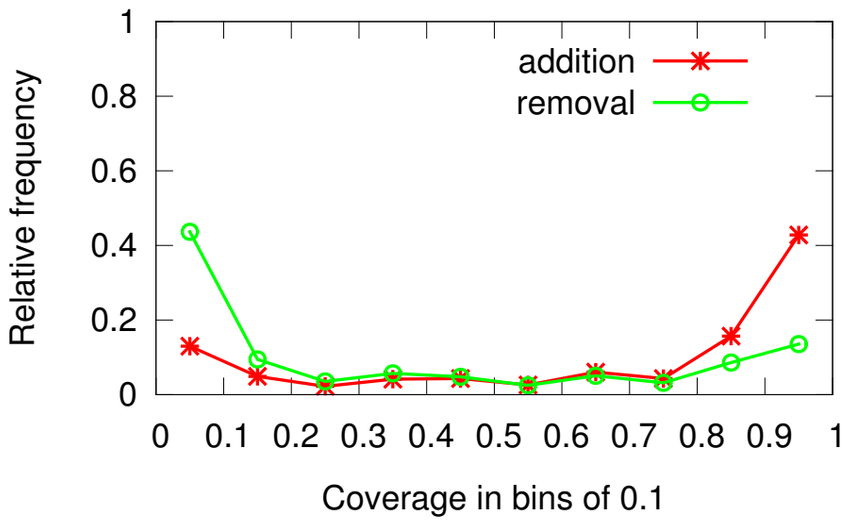
News



iCLEF



Web



Conclusion

- We presented a method to study the relation between query modification and result set coherence
- The widely accepted intersection-based interpretation is not always valid
- An union-based interpretation provides alternative explanation to query modifications
- Implication: log analysis based purely on intersection-based interpretation may lead to biased view on the intentions behind query modifications

References

1. Boldi, P., Bonchi, F., Castillo, C., Vigna, S.: Query reformulation mining: models, patterns, and applications. Information Retrieval 14(3), 257–289 (2010)
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5. Jansen, B.J., Booth, D.L., Spink, A.: Patterns of query reformulation during web searching. JASIST 60(7), 1358–1371 (2009)

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Reliability of the coherence score (skip)

- User study with 3 subjects
- 120 modification pairs
  - for each pair we compute the coherence score of the original and the modified queries and the difference of the two
    - 40 pairs with strong positive difference
    - 40 pairs with strong negative difference
    - 40 paris with roughly equal coherence
- User task
  - Classify the result sets of the 120 pairs into 3 categories:
    - “less specific”, “more specific”, “equally specific”, “incomparable”

Reliability of the coherence score

- Majority vote is used to determine the label of the query pairs
  - 10 cases where majority label is not available
  - 24 cases where majority label is “incomparable”
- Results
  - 80% agreement between coherence score and user judgements (Cohen’s kappa = 0.70)

	Coherence scores		
Majority	Strong negative	Roughly equal	Strong positive
More specific	**23**	3	0
Equal specific	3	**26**	6
Less specific	0	5	**20**