Query Suggestion and Reformulation

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Joseph Hackman

OHSU CSLU

Intel Corporation

Analyzing and Evaluating Query Reformulation Strategies in Web Search Logs

Jeff Huang

University of Washington
Information School

cikm09@jeffhuang.com

Efthimis N. Efthimiadis

University of Washington
Information School

efthimis@u.washington.edu

Study Goals

- Formulate a theoretical foundation for user-refined queries.
- Define a taxonomy for query refinement strategies
- Compare effectiveness of query refinement strategies

Computer-Generated Reformulations

- What we covered in class/book chapters

Query Session Boundary Detection

- Answers the question: “Is a query a new query or a reformulation?”
- Can simply be approximated from difference in query content and time
- This work solves the problem backwards: a session is a string of reformulated queries.

Click Data Analysis

- One Question: “If a result is clicked, does that make it relevant?”
- Another: “If a result was clicked, was the query well-formed?”

Taxonomy

Present Study	*Anick [3]*	*Teevan [34]*	*Jansen [16], He [15], Lau [24]*	*Whittle [36]*	*Bruza [7]*	*Guo [13]*
word reorder	syntactic variant	word order				
whitespace and punctuation		non-alphanumerics, word merge			SPL, PUN	word splitting, word merging
remove words		remove words / duplicates	generalization	D(k)	DEL	
add words	head, modifier	add words, add stopwords	specialization	C(k)	ADD	
url stripping		domain				
stemming	morphological variant	stemming and pluralization		M(k)	DER	word stemming
acronym[1]	acronym	abbreviations			ABR	expansion
substring[2]						
abbreviation						
word substitution	alternative, hyponym, change	word swaps, synonyms	reformulation	W(k), w(k)	SUB	
spelling correction	spelling	misspellings		M(k)	SPE	spelling correction
* not detected	elaboration, location	reformulation		S(k), s(k)		
* not in data		capitalization, extra whitespace		J(k)	CAS	

Definitions

- **Word Reorder:** All or Part of Query is two words reversed.
- **Whitespace and Punctuation:** Only whitespace/punctuation changed.
- **Remove Words:** Words are removed, also can be reordered.
- **Add Words:** Words are added, also can be reordered.
- **URL Stripping:** Remove '.com' 'www.' 'http'
- **Stemming:** Stemmed form of both queries same.
- **Form Acronym:** First characters of query form new query. (must be whole query)
- **Expand Acronym:** First query is (*not* contains)acronym that is expanded.
- **Substring:** Second prefix or suffix of first.
- **Superstring:** First prefix or suffix of second.
- **Abbreviation:** One or more words are prefixed or suffixed.
- **Word Substitution:** Entire Query is related or every word is related to corresponding word. (according to WordNet)
- **Spelling Correction:** Levenshtein Edit Distance <= 2

Undetected Reformulations

- **Semantic Rephrasing:** Same meaning from semantically unrelated terms.
- **Multi-Reformulations:** e.g. Add & Spelling Correct, URL-Strip & Whitespace

Limitations

- Low Edit Distance
- WordNet
- URL Stripping too explicit
- Abbreviations require strict substrings

Table 2: Missed reformulations in sample evaluation data

Undetected Reformulation	*Occurrences*
1. Semantic Rephrasing	108
2. Multi-Reformulations	60
▪ 2-reformulations	46
▪ 3-reformulations	14
3. Classifier Rule Limitations	32
▪ spelling correction	15
▪ word substitution	11
▪ url stripping	3
▪ acronym	2
▪ abbreviation	1
Total	200

Experiment

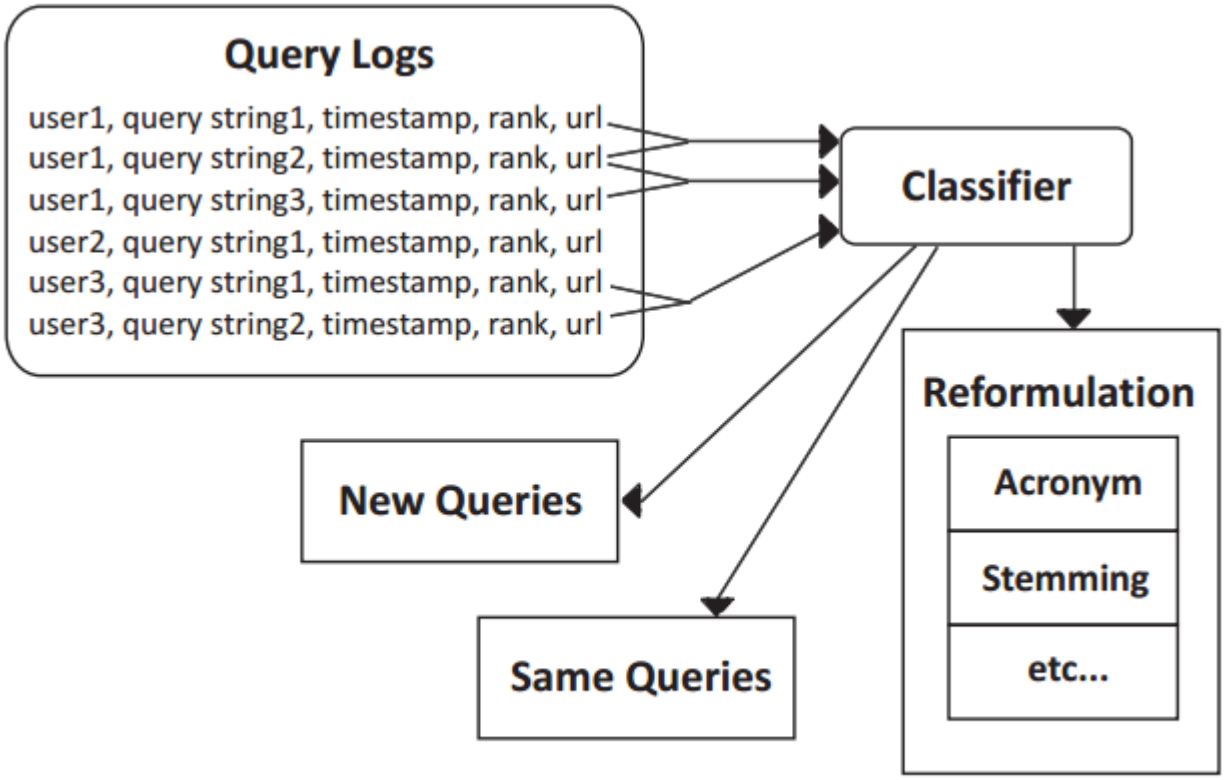


Figure 1: Diagram of the queries and classifier

Experiment

- Optimizing for Precision
- 100 AOL Users' queries manually classified: 9,091 query pairs. (All exact duplicates removed)
- 2,483 reformulations and 6,608 new queries (72% accuracy baseline)

Results

- Each study used different data
- Precision might have been higher

Table 3: Precision, recall, and accuracy measures for session boundary detection studies

	Precision	*Recall*	*Accuracy*
Present Study	98.2%	61.3%	89.1%
He [15]	60%[4]	98%	
Jones [22]			87.3%
Murray [27]	97.3%[4]	76%	
Radlinski [31]	96.5%[4]		92.3%

Results

- 36,389,567 total queries in logs
- 16,069,421 identified as new queries
- 14,861,326 exact same
- 3,411,706 reformulations

Click Patterns

- Ratio 5:4 of clicks to skips in data

Table 4: Click patterns for queries and their reformulation

	Searcher Actions on Results			
Initial Query	Click		Skip	
Reformulation	Click	Skip	Click	Skip

Click Patterns

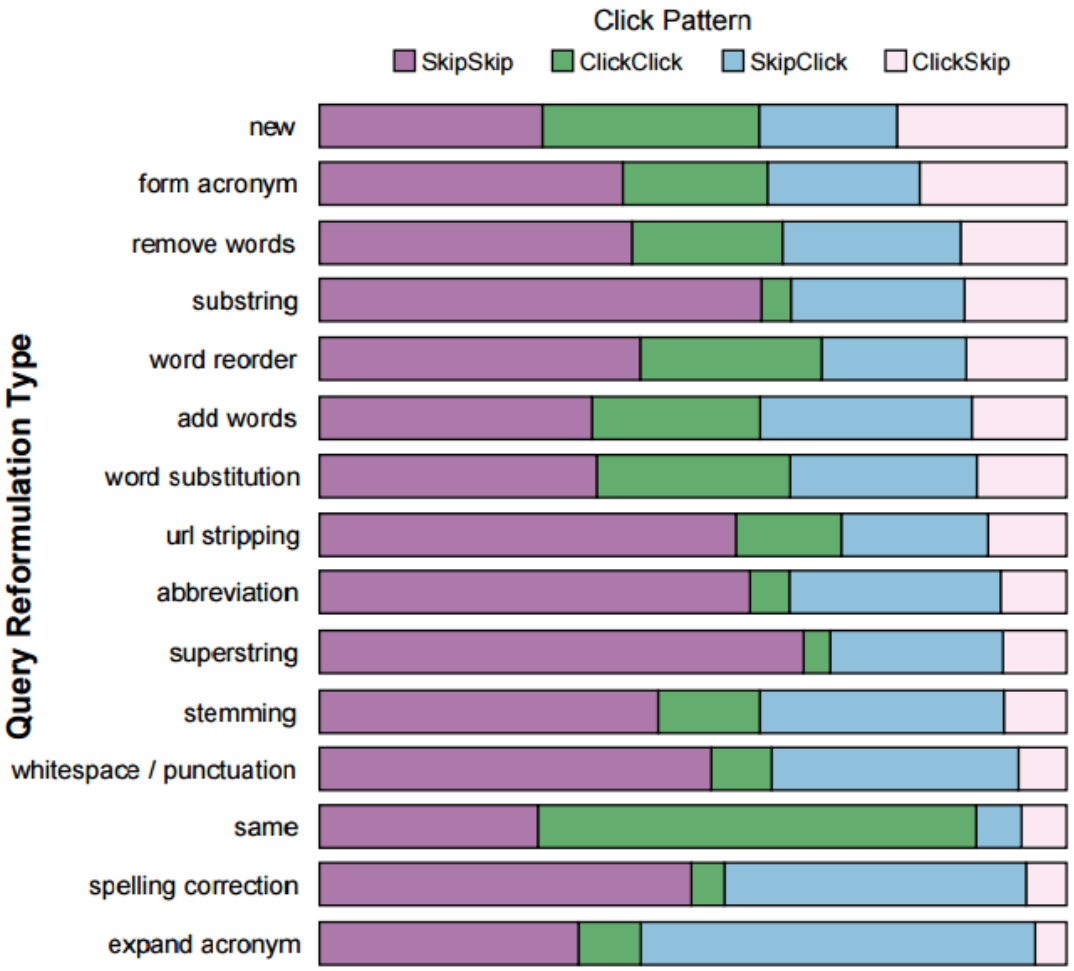


Figure 2: Proportions of Click Patterns used for each Reformulation Type

Click URL

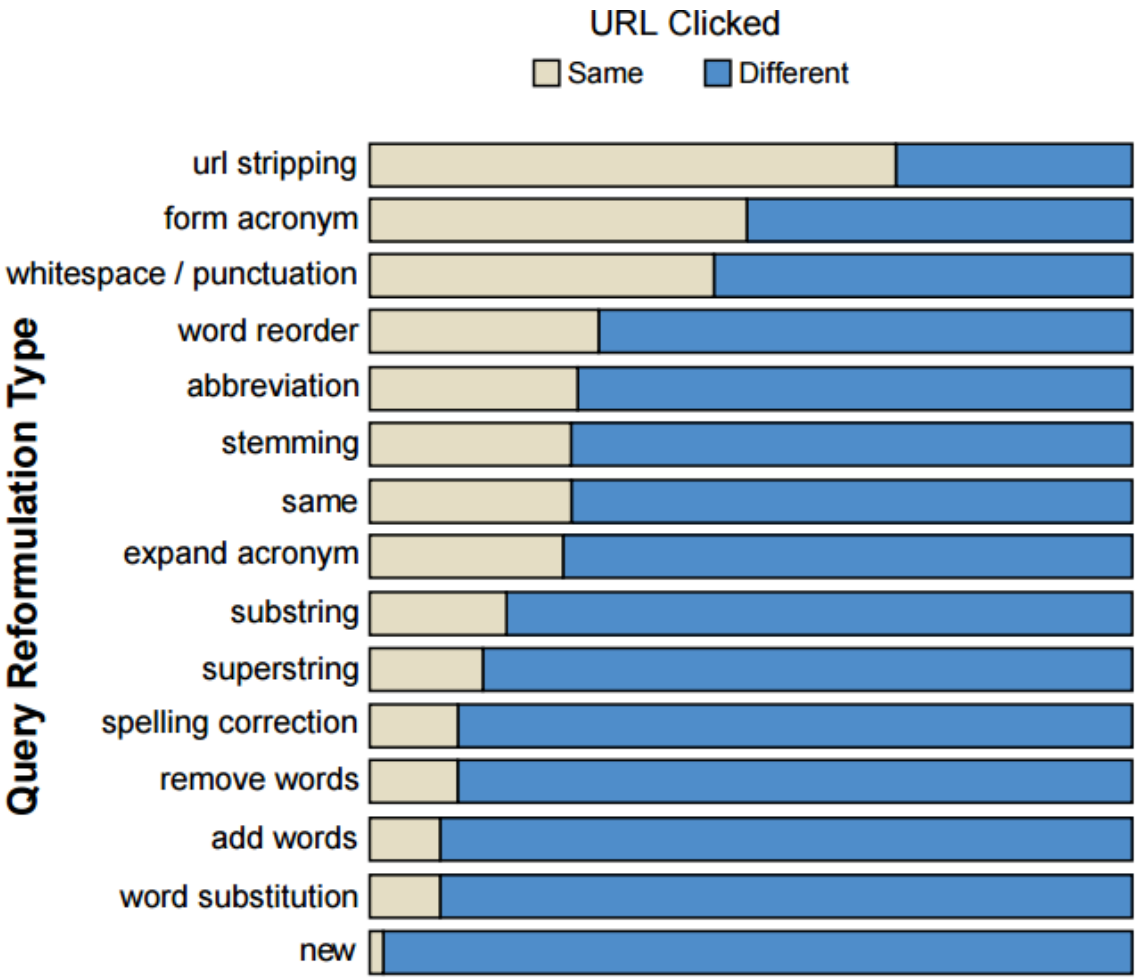


Figure 3: Proportions of URLs Clicked which were the Same vs. Different for each Reformulation Type

Click URL

Table 5: The median time (in seconds) between queries and mean rank change for each reformulation

Reformulation Type	*Median Time (s) between Queries*	*Mean Rank Change*
word substitution	73	+4.04
add words	63	+3.19
substring	33	+3.15
remove words	68	+3.02
word reorder	85	+2.86
expand acronym	42	+2.02
stemming	33	+2.00
new	2,417	+1.91
abbreviation	35	+1.39
superstring	53	+1.10
spelling correction	22	+1.03
form acronym	103	+.64
whitespace & punctuation	27	+.54
url stripping	57	+.29
same	1	-1.83

Limitations

- Lack of Context
- Normalized Query Logs
- Ambiguous Queries
- Search Engine Effects

Applications

- **Search Interface:** Like clicked links turn purple, ignored links can grey out.
- **Session Boundary Detection**
- **Better Intelligent Query Assistance**
- **Personalized Search**

Synthesizing High Utility Suggestions for Rare Web Search Queries

Alpa Jain
Yahoo! Labs
alpa@yahoo-inc.com

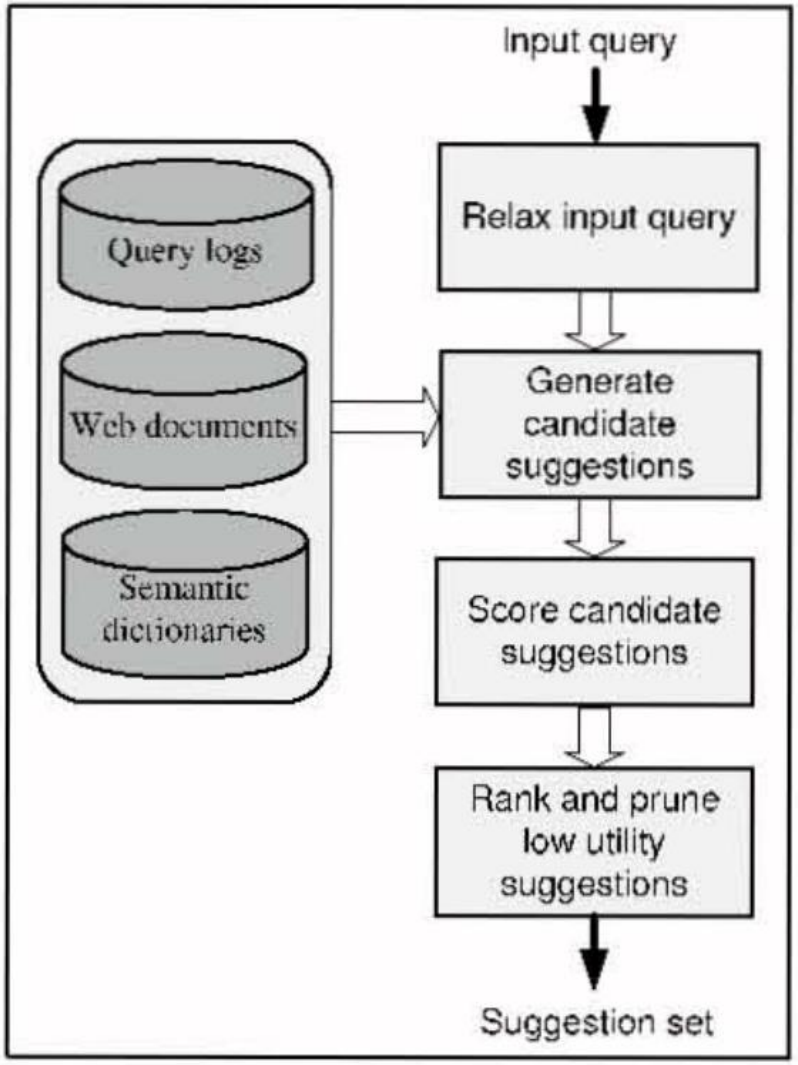
Umut Ozertem
Yahoo! Labs
umut@yahoo-inc.com

Emre Velipasaoglu
Yahoo! Labs
emrev@yahoo-inc.com

Goal

- Generate related suggested queries for a query
  - Framework for synthesizing suggestions
  - Transformations
  - Suggestion ranking technique
  - Evaluation

Synthesizing Queries



mrt singapore

sbs transit singapore
moral recreation therapy
sbs bus guide
mrt map
...

sbs transit singapore
mrt map
sbs bus guide

Relaxing User Queries

- Remove unimportant terms
- Considered as a sequence labelling problem
- Training Data is generated from query sessions (90s) that differ in one term in reformulation, and were skip-click.

description	source
frequency of t_i	query logs
standalone frequency of t_i	query logs
pairwise mutual information for (t_i, t_{i-1})	query logs
is first name	dictionary
is last name	dictionary
is location	dictionary
is stop word	dictionary
is wikipedia entry	wikipedia
has digit	lexical
has punctuations	lexical
position in query	lexical
length	lexical

Generating Suggestion Candidates

Co-occurrence in query sessions

- Suggest query reformulations that have been seen in the logs.
- To account for common queries overall, divide by the frequency of the query to get PMI*
- Account for outliers by moving to LLR:
- $LLR(q_n, q_c) = p(q_n, q_c)pmi(q_n, q_c) + p(q_n, \overline{q_c})pmi(q_n, \overline{q_c}) + p(\overline{q_n}, q_c)pmi(\overline{q_n}, q_c) + p(\overline{q_n}, \overline{q_c})pmi(\overline{q_n}, \overline{q_c})$

*And take the log, but that doesn't affect order.

Semantic relations from web corpus

- Replace phrases with phrase having a similar distribution in a large web corpus

Substitutions from co-clicked URL Queries

- Connect queries that have the same link clicked
- Removing URLs that are exceedingly popular (> 200 queries matched)
- For very unpopular domains, consider all URLs of that domain as the same

Context from original query

- Return the non-critical terms to the queries formed by the above methods
- E.g. (acoustic guitar strings -> classical guitar -> classical guitar strings)

Ranking Suggestions

- Well-formedness (real-world concepts)
- Relevance to original query

Ranking

- Learn ‘good’ vs ‘bad’ using Gradient Boosting Decision Tree
- Prune poor suggestions (<50% chance of ‘good’)
- Rank according to probability

Filtering

- Overly similar queries
- Queries with few important/no important results
- Pick the highest ranked suggestions in-order, ignoring suggestions that fail the above.

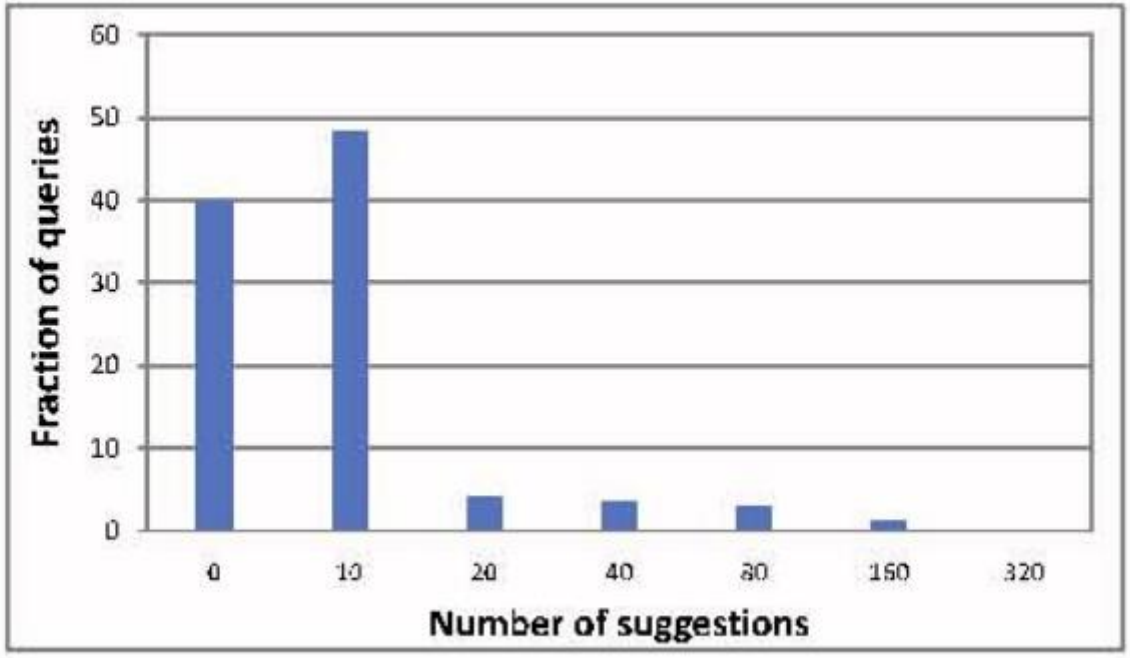
Experiment

- Randomly Sampled 10,000 of 100,000 Yahoo! Queries (without suggestions)
- 10-fold validation
- Query suggestions were human-scored as ‘good’ or ‘bad’

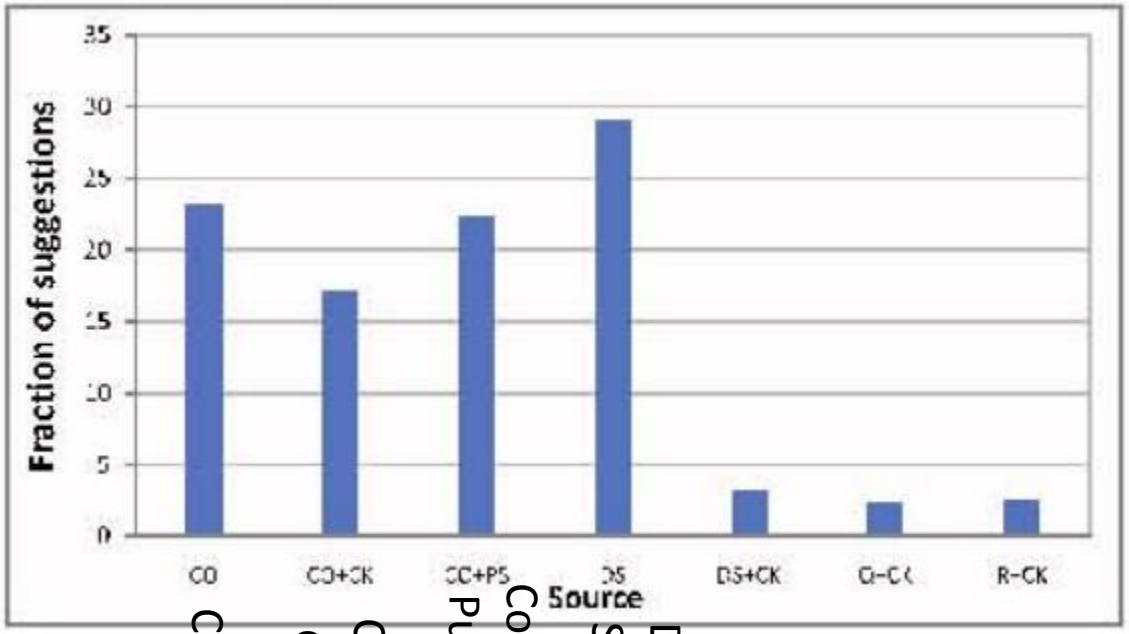
Examples

query	suggestions
free auto parts manual	auto body parts, discount auto parts, auto part stores
minneapolis days inn	minneapolis comfort inn, minneapolis motel 6, minneapolis super 8, minneapolis best western
muscular system diagram	human skeletal system diagram, circulatory system diagram, human muscular system, skeletal anatomy
puppy training 101	dog training basics, puppy housetraining, dog whisperer, puppy training tips
csi crime scene investigation cast	csi miami cast, csi new york cast, csi episode guide, cbs csi miami
honda insight review	ford fusion review, 2010 toyota prius, toyota prius review, honda civic hybrid
obsessive compulsive disorder symptoms	ocd test, ocd symptoms, causes of ocd, ocd treatment, symptoms of ocd

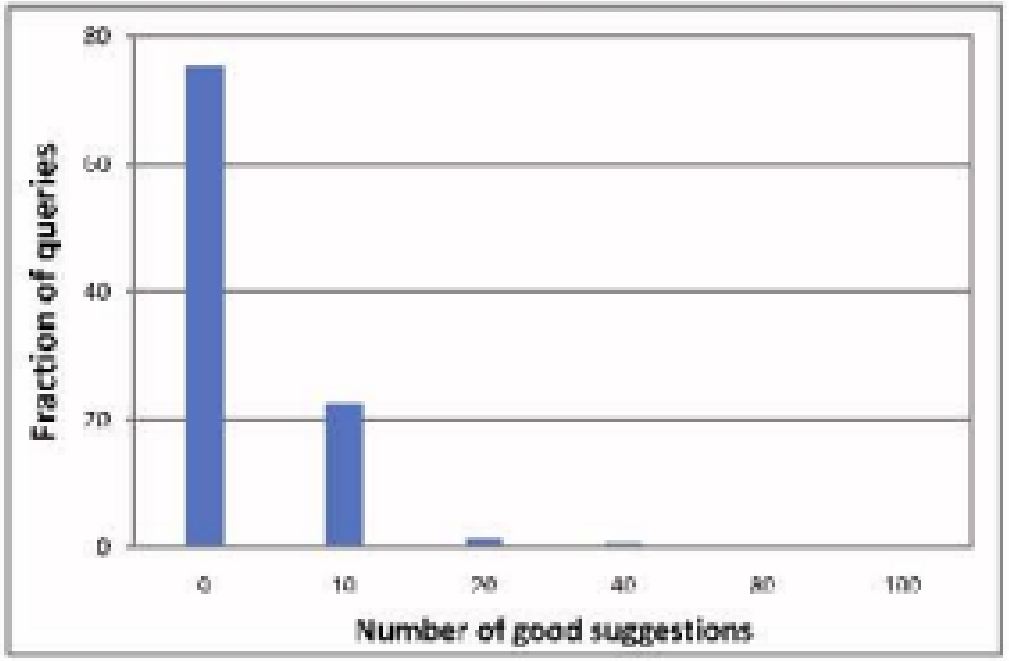
What does this graph mean?



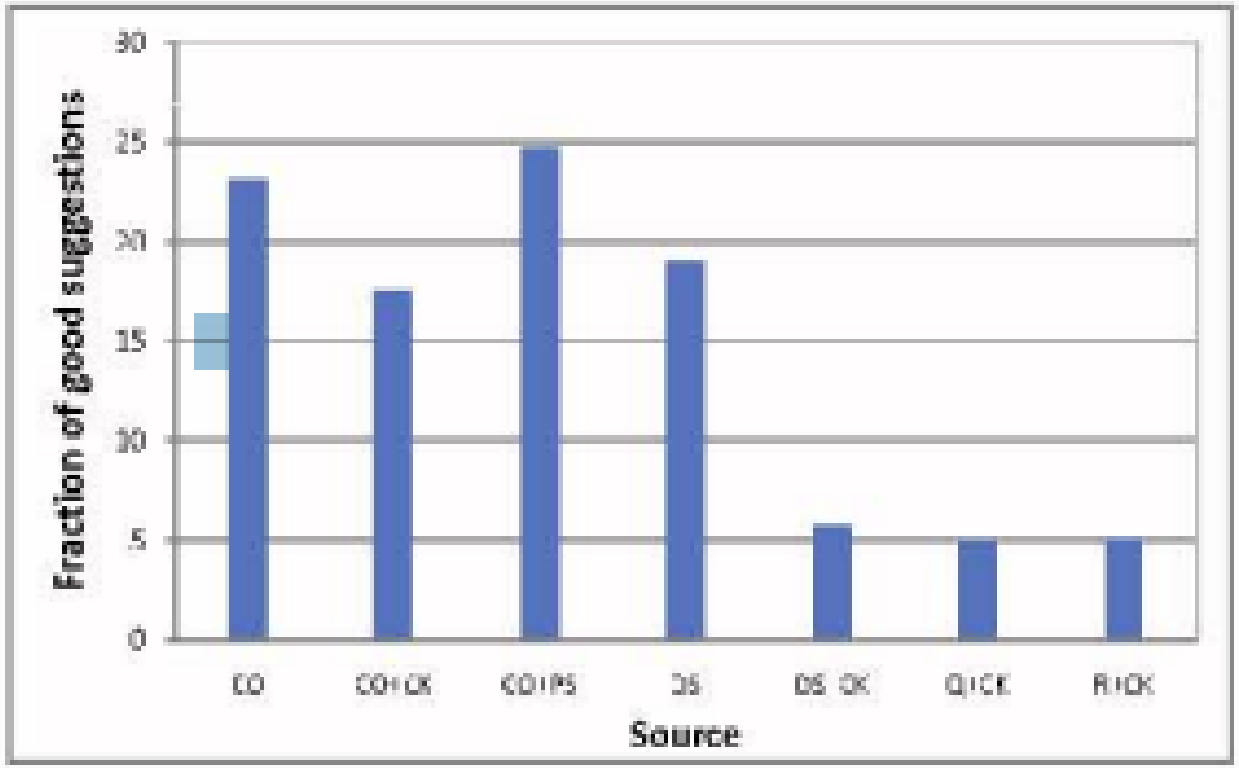
Distribution of candidates



Number of good suggestions per query



Distribution of good suggestions for each candidate generation source



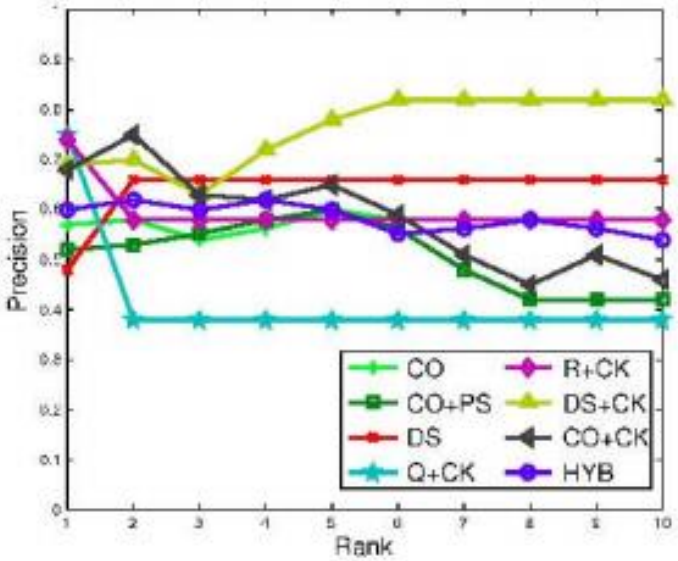


Figure 6: Mean precision at varying ranks.

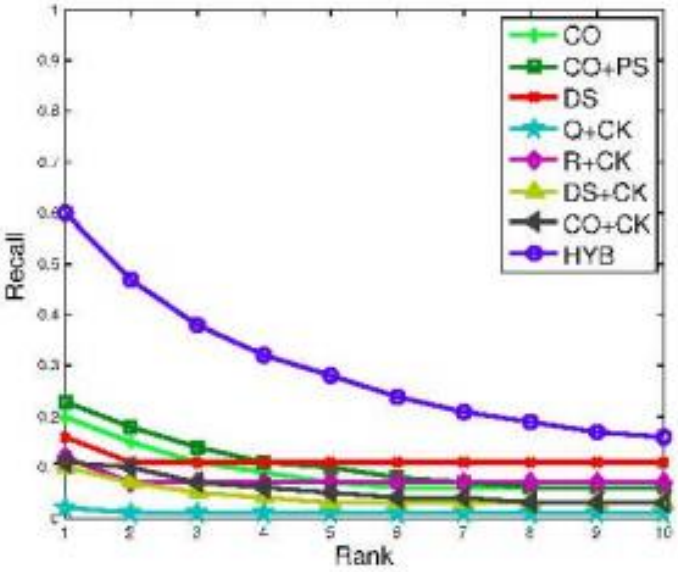


Figure 7: Average recall at varying ranks.

Conclusion (my words, not theirs)

- Applies to queries for which existing systems produce no suggestions.
- Provides not zero numbers of good suggestions.
- Therefore, must be an improvement.
- Individual portions seem only barely significantly improved, value appears to be in combined approach.

Learning to Suggest: A Machine Learning Framework for Ranking Query Suggestions

Umut Ozertem∗
Speech @ Microsoft
Mountain View, CA
umuto@microsoft.com

Pinar Donmez∗
Salesforce
San Francisco, CA
pdonmez@salesforce.com

Olivier Chapelle∗
Criteo
Palo Alto, CA
o.chapelle@criteo.com

Emre Velipasaoglu
Yahoo! Labs
Sunnyvale, CA
emre_velipasaoglu@yahoo.com

Goal

- Learn a query suggestion model that can be applied outside the set of queries in the query logs

Proposed Framework

- **Target Generation:** How useful is the suggestion
- **Features:** Lexical and result set
- **Ranking Model:** Regression / ML
- **Candidates:** Additional candidates are synthesized

Target Generation

- Filter out new queries and un-useful queries.
- Useful reformulations result in a click on a link not returned by the first query or returned later by the first query.
- Correct task boundary errors introduced by common terms (that tend to be searched after many queries)

Task Detection

Table 1: Effect of the implicit session model

$\Pr(q_2 \mid q_1)$		$\Pr(q_2 \mid q_1, c = 1)$	
facebook	0.0286	rei	0.0431
ebay	0.0244	nordstrom	0.0342
amazon	0.0225	dicks	0.0307
rei	0.0214	columbia	0.0281
nordstrom	0.0191	macys	0.0274

q_1 = northface

$\Pr(q_2 \mid q_1)$		$\Pr(q_2 \mid q_1, c = 1)$	
facebook	0.0794	chase	0.0993
chase	0.0415	capital one	0.0558
wells fargo	0.0227	wells fargo	0.0530
capital one	0.0223	american express	0.0404
google	0.0185	bank of america online	0.0281

q_1 = bank of america

Features

Table 2: Lexical features

Feature	Short Description
LEV	Levenshtein distance between q_1 and q_2
LQ1	length of q_1
LQ2	length of q_2
LDIFF	LQ1-LQ2
ABSLDIFF	abs(LDIFF)
ABSLDIFFN	ABSLDIFF/LQ1
NW1	number of tokens in q_1
NW2	number of tokens in q_2
COMMONW	number of tokens in common in q_1 and q_2
COMMONWN	COMMONW/NW1
COMMONWP	tokens in common in the beginning
COMMONWS	tokens in common at the end
COMMONCP	characters in common in the beginning
COMMONCS	characters in common at the end

Features

Table 3: Result set features

Feature	Short Description
LTR11	LTR score of the top result for q_1
LTR21	LTR score of the top result for q_2
LTR15	average LTR score at top 5 for q_1
LTR25	average LTR score at top 5 for q_2
LTR110	average LTR score at top 10 for q_1
LTR210	average LTR score at top 10 for q_2
LTRRATIO1	LTR11/LTR21
LTRDIFF1	LTR11-LTR21
LTRRATIO5	LTR15/LTR25
LTRDIFF5	LTR15-LTR25
LTRRATIO10	LTR110/LTR210
LTRDIFF10	LTR110-LTR210
COURLCOUNT1	boolean, URLs in top result are the same
COURLCOUNT5	number of the same URLs in top 5
COURLCOUNT10	number of the same URLs in top 10
CODOMAINCOUNT1	boolean, domains of the top results are the same
CODOMAINCOUNT5	number of same domains in top 5
CODOMAINCOUNT10	number of same domains in top 10
CODOMAINIQF1	IQF of of the domain at top result, if the same
CODOMAINIQF5	total IQF of the common domains in top 5
CODOMAINIQF10	total IQF of the common domains in top 10
ABOUTNESS	cosine similarity over the aboutness vectors

Aboutness

Table 4: Examples of the aboutness vector

Query	Terms in the aboutness vector (ordered)
iphone 4	iphone, store, 4, camera, phone, apps, inc, facetime, mode, recording, software, 3gs, resolution, battery, shop, network, ios, 3g, broadband, ipod
blackberry storm	blackberry, smartphone, verizon, touchscreen, 3g, storm, rim, blackberry, blackberry curve, iphone, vodafone, blackberry pearl, battery, apps, gps, camera, 2, battery life, gsm, research in motion
toyota prius	hybrid, car, prius, toyota, mpg, photo, price, sales, specs, vehicle, yaris, cars, review, reviews, msrp, specification, milage, model, economy, research
toyota yaris	yaris, hatchback, car, price, hybrid, toyota, models, spec, mpg, liftback, dealer, model, vehicles, review, photo, reviews, city, prius, transmission, vehicle

Synthetic Suggestion

- Less important units dropped or replaced
  - Replaced with ‘contextually similar’ terms: terms whose clicks occur on the same documents
- Add most frequent extensions (Machine learning away irrelevant suggestions)

Experimental Setup

- **Query Set:** random 912 anonymized queries
- **Manual Annotation:** 8 professional evaluators
- **Annotation Guidelines:** 4 levels of ratings

Table 5: Coverage, DCG, and Precision improvement compared to the mutual information baseline.

	depth = 1	depth=3	depth=5	depth=7	depth=9	depth=12
Coverage						
10M	-9%	2%	2%	4%	34%	294%
10MC	-9%	0%	0%	2%	33%	282%
10M-ML	-13%	-3%	-1%	2%	32%	289%
10MC-ML	-17%	-7%	-6%	-4%	25%	269%
10M-ML-SY	17%	28%	35%	40%	85%	381%
10MC-ML-SY	17%	28%	34%	40%	84%	365%
DCG on common coverage						
10M	2%	5%	5%	6%	9%	4%
10MC	2%	9%	8%	8%	9%	7%
10M-ML	5%	8%	8%	8%	9%	10%
10MC-ML	5%	7%	8%	9%	10%	9%
10M-ML-SY	7%	9%	8%	9%	10%	10%
10MC-ML-SY	8%	8%	7%	10%	12%	11%
Precision on common coverage						
10M	4%	10%	9%	10%	14%	11%
10MC	8%	13%	11%	12%	15%	11%
10M-ML	7%	10%	10%	11%	12%	12%
10MC-ML	6%	8%	10%	13%	13%	12%
10M-ML-SY	8%	11%	10%	11%	13%	14%
10MC-ML-SY	8%	11%	10%	13%	16%	16%

Table 6: Coverage and CTR improvements of the 10M-ML-SY system in the online test.

	depth = 1	depth=3	depth=5	depth=7	depth=9	depth=12
Coverage	10%	31%	40%	40%	35%	91%
CTR	42%	41%	38%	37%	50%	49%

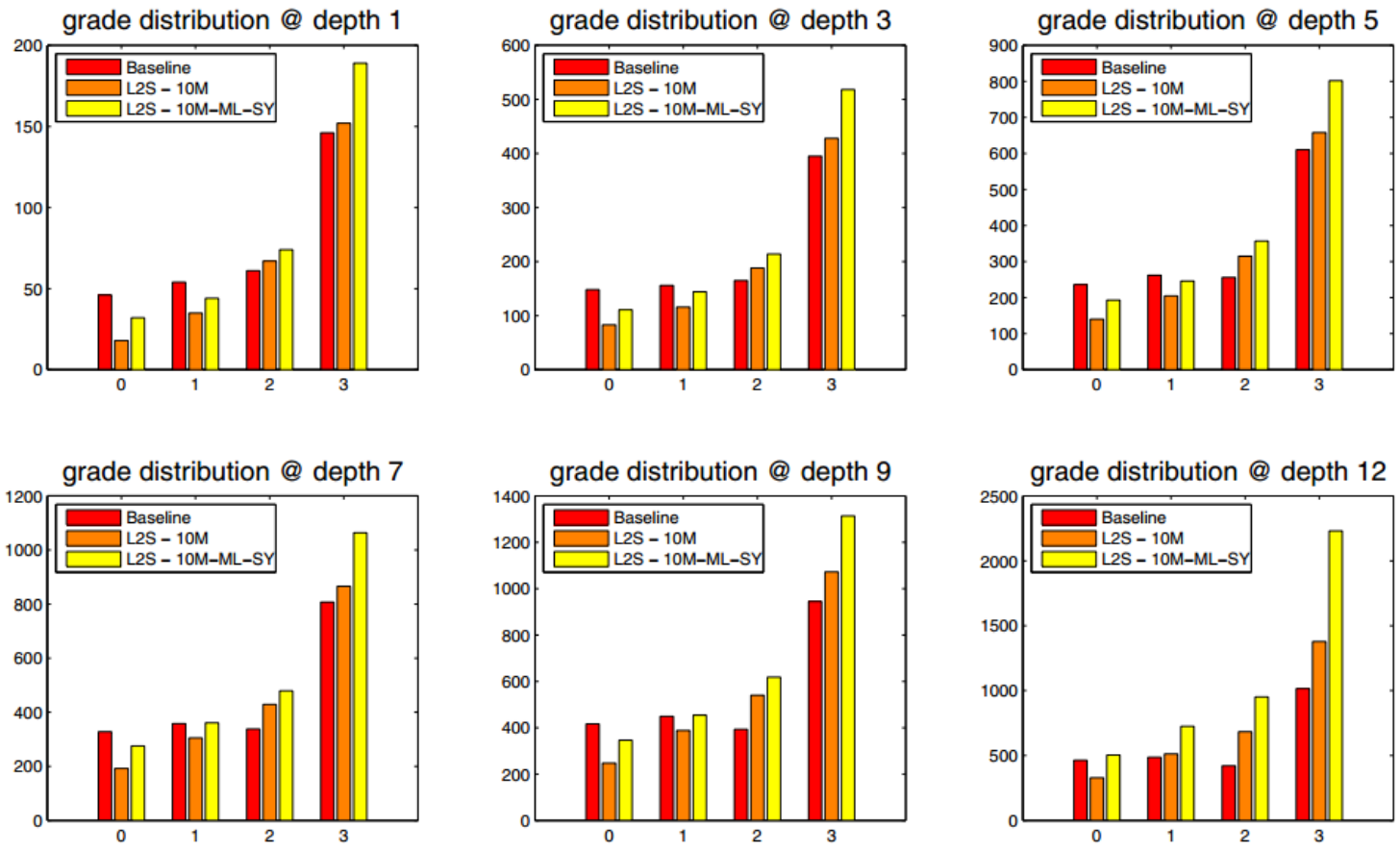


Figure 1: Grade distributions (3=Excellent, 2=Good, 1=Fair, 0=Bad) at different ranks for `10M` and `10M-ML-SY` versus the baseline.

Example Search on Modern System

- I’m looking for a drug that stops the metabolism of Alcohol and causes a hangover
- I’ve forgotten its name

Web Images Videos Maps News More

59,500,000 RESULTS Any time

Ads related to **alcohol abuse drug**

Alcoholism Abuse | TheWatershed.com
www.TheWatershed.com/Alcoholism · 1,900+ followers on Twitter
Drug & **Alcohol Addiction** Treatment Get Help Now, 24 hrs & Confidential
137 Montague Street #125, Brooklyn · Directions · (561) 860-8049
The Watershed Experience | Insurance Accepted
Testimonials | Award Winning Facility

Drug & **Alcohol Abuse** Help | TheTreatmentHelpline.com
TheTreatmentHelpline.com
Find Top Rated **Drug** & **Alcohol** Rehab & **Addiction** Treatment. Call Now.
For the Addict | For the Family
Services | Faith Based Treatment

Drug Abuse - Rehab Grounded in Neuroscience.
FuturesOfPalmBeach.com/DrugRehab · 12,000+ followers on Twitter
Rehab Grounded in Neuroscience. Real Change is Possible. 877-589-5779
Successful Addiction Treatment - Futures of Palm Beach
Drug Rehab | **Alcohol** Rehab
Addiction Helpline | Treatment in Florida

Drug And **Alcohol Abuse** - Find Local **Alcohol** Rehab Centers.
health.alOt.com/AlcoholRehab
Find Local **Alcohol** Rehab Centers. Search Your Local Listings Now.

Do you mean *alcohol abuse* ***medication***?

Alcohol Abuse and Dependence-Medications - **WebMD**
www.webmd.com › ... › Substance **Abuse** and Addiction Health Center
Mar 12, 2014 · Medicines can be used to help treat **alcohol abuse** and dependence. Some medicines reduce withdrawal symptoms during detoxification. Other medicines

Related searches

Drug and **Alcohol** Addiction
Alcohol Abuse Medication
What is **Drug Abuse**
Alcohol and **Drug Abuse** Information
Alcohol and **Drug Abuse** Programs
Alcohol Drug Abuse Treatment
Alcohol and **Drug Abuse** Help
Drug and **Alcohol Abuse** Articles

Ads related to **alcohol abuse drug**

Drug & **Alcohol** Treatment
SuncoastRehabCenter.com/DrugAl
26,700+ followers on Twitter
When 30 Days is Not Enough to Heal
513-0855

Drug Alcohol Abuse in TX
GreenhouseTreatment.com/TexasR
FREE (331) 725-2510
Premier TX **Alcohol Abuse** Rehab. 9
Now!

See your ad here »

Twitter

Web Images Videos Maps News More

59,500,000 RESULTS Any time

Ads related to **alcohol abuse drug**

Alcoholism Abuse | TheWatershed.com
www.TheWatershed.com/Alcoholism · 1,900+ followers on Twitter
Drug & **Alcohol Addiction** Treatment Get Help Now, 24 hrs & Confidential
137 Montague Street #125, Brooklyn · Directions · (561) 860-8049
The Watershed Experience | Insurance Accepted
Testimonials | Award Winning Facility

Drug & **Alcohol Abuse** Help | TheTreatmentHelpline.com
TheTreatmentHelpline.com
Find Top Rated **Drug** & **Alcohol** Rehab & **Addiction** Treatment. Call Now.
For the Addict | For the Family
Services | Faith Based Treatment

Drug Abuse - Rehab Grounded in Neuroscience.
FuturesOfPalmBeach.com/DrugRehab · 12,000+ followers on Twitter
Rehab Grounded in Neuroscience. Real Change is Possible. 877-589-5779
Successful Addiction Treatment - Futures of Palm Beach
Drug Rehab | **Alcohol** Rehab
Addiction Helpline | Treatment in Florida

Drug And **Alcohol Abuse** - Find Local **Alcohol** Rehab Centers.
health.alOt.com/AlcoholRehab
Find Local **Alcohol** Rehab Centers. Search Your Local Listings Now.

Do you mean *alcohol abuse* ***medication***?

Alcohol Abuse and Dependence-Medications - **WebMD**
www.webmd.com › ... › Substance **Abuse** and Addiction Health Center
Mar 12, 2014 · Medicines can be used to help treat **alcohol abuse** and dependence. Some medicines reduce withdrawal symptoms during detoxification. Other medicines

Related searches

Drug and **Alcohol** Addiction
Alcohol Abuse Medication
What is **Drug Abuse**
Alcohol and **Drug Abuse** Information
Alcohol and **Drug Abuse** Programs
Alcohol Drug Abuse Treatment
Alcohol and **Drug Abuse** Help
Drug and **Alcohol Abuse** Articles

Ads related to **alcohol abuse drug**

Drug & **Alcohol** Treatment
SuncoastRehabCenter.com/DrugAl
26,700+ followers on Twitter
When 30 Days is Not Enough to Heal
513-0855

Drug Alcohol Abuse in TX
GreenhouseTreatment.com/TexasR
FREE (331) 725-2510
Premier TX **Alcohol Abuse** Rehab. 9
Now!

See your ad here »

Twitter

Web Images Videos Maps News More

Also try: Alcohol Abuse Drug · Pills to Stop Drinking · Drugs to Help with Alcoholism

6,600,000 RESULTS Any time

Ads related to **alcohol abuse medication**

NJ Alcoholism Treatment | summithelps.com
www.summithelps.com/Alcohol
Fully Customized, Client-Centered **Addiction** Rehab Program. 888-289-8582
Substance Abuse Addiction Detoxification | Detox Center NJ
256 Columbia Turnpike, Florham Park · Directions · (888) 289-8582

Alcoholism Rehab Center - Affordable & Confidential.
TheWatershed.com/New-York · 1,900+ followers on Twitter
Affordable & Confidential. Supportive Staff w/15 Years of Experience.
137 Montague Street #125, Brooklyn · Directions · (561) 860-8049
The Watershed Experience · Insurance Accepted
Testimonials · Award Winning Facility

Top Alcoholism Treatment - High-End Holistic Addiction Rehab.
TheDunesEastHampton.com/Treatment
High-End Holistic **Addiction** Rehab. 1 on 1 **Treatment**. 888-402-8403
Overcoming Alcohol Addiction - The Dunes East Hampton

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By Buddy T
Alcoholism Expert

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Erik Von Weber/Stone/Getty Images

Updated November 28, 2014.

There are currently only three medications approved by the U.S. Food and Drug Adminstration for the treatment of alcohol abuse and alcohol dependence.

None of these medications are prescribed to people who are still drinking alcohol. They are only prescribed to those who have already stopped drinking and are trying to maintain alcohol abstinence.

There are no medications on the market that are prescribed for people who are still drinking alcohol that will cause them to stop drinking.

Disulfiram

Antabuse, or disulfiram as it is also known, was the first medicine approved for the treatment of alcohol abuse and alcohol dependence. It works by causing a severe adverse