

# CAIS Paper: Dynamic Query Suggestion in Web Search Engines: A Comparative Examination

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**Abstract:** The purpose of this study is to examine the performance of dynamic query suggestion in three popular web search engines, namely Google, Yahoo! and Bing. Using the TREC Web Track topics, this study conducts a comparative examination of the number, type and variations in the query term suggestions provided by the Web search engines.

Résumé:

## Introduction

Web search engines are constantly revising and changing their indexing and search algorithms based on massive user interaction data in the hope of maintaining a large and loyal audience base. Over the past 15 years, information science research has made significant contributions to the advancement of search systems through extensive research into information search behaviour, web search engine performance and users' query formulation behaviours and patterns. A quick glance at the list of research expertise sought and publications by researchers working for major web search engines demonstrate a strong emphasis on information science research and on such key concepts as query, users, relevance, and search behaviour. This trend suggests strong and truly global evidence for the significance of information science research and the ways in which it contributes to knowledge economy and to the advancement of search as a daily activity of billions of users.

Over the past few years, Google, Bing and Yahoo! have consistently been reported as the three major web search engines. Together, they share around 96% of the search market, namely Google (66.9%) Bing (18.1%) and Yahoo! (11.1%) (comScore, December 12, 2013). Over the past few years, these three search engines have introduced dynamic term/query suggestions functionalities to support users in query formulation, reformulation or query expansion. The purpose of this study is to examine the performance of dynamic query suggestions in these three popular web search engines. Specifically, it will comparatively examine the number, type and variations in the query term suggestions provided by these Web search engines to explore if there are differences in the suggested terms across the search engines. This study contributes to the better and comparative understanding of dynamic term suggestions with implications for information interaction and information retrieval research as well as online and web search education.

## Prior research

There have been several studies of web search engine user studies reported in the literature. Since our study focuses on query and query term suggestions, the literature review will specifically address this aspect of the search process. Query formulation has been investigated in many different information retrieval contexts, including online catalogues, experimental

information retrieval systems, digital libraries and web search engines. One specific area associated with query formulation has received particular attention is query and term suggestion within the query formulation process. This attention is due to the complex, cognitive, affective and behavioural aspects of the search process and challenges associated with the development of well-formulated queries by users. Early studies on query term suggestion can be traced back to the extensive research into automatic and interactive query formulation strategies and relevance feedback (Efthimiadis, 1996).

Dynamic query term suggestions can be provided as the user types in a term before they view the results or it can be presented following the result display stage. Hearst (2009) notes that “dynamic query term suggestions (sometimes referred to as *auto-suggest*, *autosuggest*, or *search-as-you-type*) are a promising intermediate solution between requiring the user to think of terms of interest (and how to spell them) and navigating a long list of term suggestions”. These suggestions may be based, for example, on popular queries, queries that have previously been successful, and/or characteristics of potentially relevant documents (Wacholder, 2011), or on terminological sources such as thesauri and other types of controlled vocabularies (Shiri & Revie, 2006).

One of the early studies of the use of term suggestions by the Altavista search engine users reported that users who took advantage of term suggestions, did so to increase their search precision, preferring phrases that modified terms in the original query (Anick, 2003). Smith and Watcholder (2010) examined the semantic and linguistic reasons for which users fail to use suggested terms and noted that this may be due to the searcher’s ability to recognize a semantic relationship between the words used in a query and the words in a suggestion. Kelly et al. (2009) compared a query suggestion system to a term suggestion system and found that participants saved more documents with query suggestions than with queries created using suggested terms and that participants preferred the query suggestion system to the term suggestion system. Term suggestion systems usually provide single terms to be added to a query, whereas query suggestion systems provide more sophisticated search statements to user to choose. In another study, Kelly and her colleagues (2010) studied the impact of query popularity and query quality on the usage of query suggestions and found that the users were able to distinguish between high quality and low quality query suggestions and that the users were not influenced by usage information. Other researchers have examined topic and query complexity measures based on the number of terms in queries (Shiri et al., 2003) and the number of facets in queries (Niu and Kelly, 2014).

A study of the effect of Google instant dynamic query suggestions and query result display based on a single search task found that dynamic term suggestion may not change users search behaviour in terms of the search process, number of queries and query length, but it led to shorter users time spent on Google homepage and in reformulating queries. The study concluded that Google dynamic term suggestion feature did not result in saving time or constructing queries with more concepts, but the results could be different for simple search task (e.g., known-item retrieval), or unfamiliar task/topic, where the users have difficulty formulating search requests (Shah et al., 2012). This could be the subject for further exploration. Niu and Kelly (2014) investigated how and when people integrate query suggestions into their searches and the outcome of this usage. They found that participants with lower search experience used more

suggestions and that participants used more suggestions towards the end of their searches and when searching for more difficult topics.

There is currently little research on how different popular search engines provide dynamic query suggestions for various query types. The study reported here is a step towards bridging this gap. This study adopts a comparative approach in examining dynamic query suggestion features in three major web search engines. It examines and compares the number, nature, type and variations of query terms suggested by the search engines using Text Retrieval Conference (TREC) web track Topics. The key research questions that are addressed in this study include:

- How do these search engines provide term/query suggestions for TREC topics?
- What is the average and mean number of terms suggested by the search engines?
- How do the web search engines treat single word and multiple word topics (complex)?
- How do the Web search engines perform on simple and complex topics in terms of suggestion relevance?
- Are there variations in the number of suggested terms by the search engines?
- To what extent are the suggestions aware of the geographic context?

### **Methodology**

In order to provide a baseline for comparing query term suggestion functionalities across the three search engines, 50 topics from the TREC (Text Retrieval Conference) Web Track were used. The rationale for the selection of TREC topics lies in the fact that these topics are designed for the TREC Web Track experiments over web data. The TREC topics are wide-ranging in terms of their subject matter and include single word as well as multi-word topics. Therefore, they are particularly suitable for testing with web search engines where users may search for a broad range of topics. The TREC topics are listed in the Appendix.

The researchers are aware of the fact that contextual factors such as date, time and location have an effect on the performance of the search engines for various types of topics and queries. In this study, searches for all of the TREC topics were completed in Edmonton, Alberta on December 6, 2013 on Google.ca, Yahoo.ca and Bing and using one computer. The main reason for choosing the Google.ca and Yahoo.ca sites was to investigate how the TREC topics would be treated by these geographically focused sites. TREC topics were also selected to avoid as much as possible the bias that may result from Google's use of prior search history and interaction data.

The TREC topics were divided into a) one-word, b) two-word and c) three or more word categories. TREC topics were divided into three separate categories as can be seen in Table 1.

<b>Single word topics</b>	<b>Two-word topics</b>	<b>Three-word or multiple word topics</b>
17	16	17

Table 1. Distribution of TREC topics in terms of the number of words

Searches were conducted on the TREC topics in each of the three search engines and the query term suggestions were recorded in an excel file for analysis and comparison. Screenshots of the search were captured for later analysis. Then the query terms suggested in each search engine were analyzed and categorized based on the above three categories. The suggested queries were

analyzed in terms of the number of suggestions, the content of suggestions, and geographic locations suggested in the suggested queries across the three categories of topics.

### Findings

It is interesting to note that the performance of query term suggestions across the three search engines is varied in terms of the number of suggestions and how they handle single word and multi-word queries. Table 2 provides a comparative overview of the number of suggested query terms for TREC topics.

Search engine	Average # words suggested	Median # words suggested
Google	4	4
Yahoo!	6.46	10
Bing	6.18	8

Table 2. Average and Mean of terms suggested by Google, Yahoo! and Bing

All the three search engines offer spelling error correction features and around 80% of the time they provide 4 or more dynamic query suggestions. As Table 2 shows Yahoo! and Bing provide a larger number of suggested terms as compared with Google. Yahoo! suggests the highest number of terms compared with the other two search engines.

One of the research questions addresses the performance of single word and multi-word queries in the three search engines. One and two word search queries performed better across all three search engines as compared to queries composed of three or more terms. This is perhaps not surprising, as longer queries tend to be much more specific and less open to interpretation by the search algorithm than shorter terms, which may include homonyms and multiple meanings. Table 3 shows examples of single word, two-word and multi-word TREC topics with query suggestions from the three search engines.

Search engine	Dinosaurs Suggestions (single word)	Poker tournament Suggestions (two word)	Obama family tree Suggestions (three or more words)
Google	dinosaurs dinosaurs will die dinosaurs videos dinosaurs tv show	poker tournaments calgary poker tournaments poker tournaments edmonton poker tournaments las vegas	obama family tree obama family tree photo gallery obama family tree chart obama family tree illuminati
Yahoo!	dinosaurs tv show dinosaurs games dinosaurs for kids dinosaurs videos dinosaurs pictures dinosaurs movie dinosaurs alive dinosaurs names dinosaurs coloring pages	poker tournaments in ontario poker tournaments las vegas poker tournaments edmonton poker tournaments calgary poker tournaments in toronto poker tournaments in canada poker tournaments vancouver poker tournaments niagara falls poker tournaments montreal poker tournaments bc	obama family tree

	dinosaurs king		
Bing	dinosaurs dinosaurs in canada dinosaurs games dinosaurs videos dinosaurs tv show dinosaurs for kids dinosaurs pictures dinosaurs movies	poker tournaments in las vegas poker tournaments in ontario poker tournaments in edmonton poker tournaments calgary poker tournaments poker tournaments in canada poker tournaments vancouver poker tournaments canada	obama family tree

Table 3. Examples of TREC topics along with term suggestions from Google, Yahoo! and Bing

Bing and Yahoo provide a larger number of suggestions with more diversity in semantic and even geographical aspects of the queries, whereas Google provides only about 4 on average. However, Google provides query suggestions, even for terms where the other two search engines do not provide suggestions at all. This is particularly interesting as people who may conduct exploratory searches to learn about a topic or increase their knowledge will benefit from a larger number of term suggestions.

The extent to which the three search engines provide suggestions that include the geographic context of the searcher is particularly interesting. Yahoo! and Bing offer a larger number of place names for the searched topics. As can be seen in Table 2, the TREC topic ‘Poker tournament’ is treated differently by the three search engines. Yahoo! provides 10 different place names for the topic, Bing provides 6 suggestions and Google provides only 3 suggestions.

However, based on the TREC topics searched, Google was capable of providing suggestions for three-word or multi-word queries better than Yahoo! and Bing did. Table 4 shows the number of query suggestions provided by the three search engines for three-word and multi-word TREC topics.

Search engines	Number of query suggestions for three-word and multi-word topics
Google	16
Bing	11
Yahoo!	9

Table 4. Number of query suggestions for three-word or multi-word topics

Google provided suggestions for all of the 17 TREC topics that have three word or more, whereas Bing provided suggestions for only 11 topics followed by Yahoo! providing only suggestions for 9 topics. This finding suggests that the nature and complexity of search topics should be taken into account while selecting search engines for different types of search topics and tasks.

### Concluding remarks

The findings of this study have theoretical and practical implications for web search, query formulation, online searching and information literacy education. The comparative analysis of

dynamic query suggestion features offered by the three major web search engines suggest that the nature of search topic impacts search success in various ways in the three web search engines. The differences in the number of suggested queries by the three search engines call for a user-centred evaluation of the performance of search engines in terms of satisfaction and usefulness of suggestions across the three search engines. It is hypothesized that the number of query suggestions offered by the three web search engines may have an effect on users' query formulation and expansion behaviour in searching for simple and complex search topics. The number of suggested queries and the way they are presented to the searcher have interface design implications. Research should examine the impact of the presentation of short and long lists of query suggestions on the interaction behaviour of web searchers.

The findings also point to the fact that topic complexity is measured and viewed by the web search engines in different ways. It was found that Yahoo! and Bing provide a greater variety of query term suggestions for single –word and two-word topics, whereas Google performed significantly better in providing query suggestions for more complex queries. While context-aware searching has become an integral part of web search engines, the number of suggestions for location varies across the three search engines. This study found that Yahoo! and Bing offer a larger number of geographic location suggestions for the user to reformulate or refine their queries. These suggestions may be found particularly useful for exploratory searchers who do not have a pre-determined and focused topic and would like to learn and investigate a topic further.

These findings have particularly important implications for online searching and information literacy education. Determining the nature and complexity of a search topic is viewed as a key step in the early stage of the search process. Searcher's prior knowledge of the topic can also function as an important factor in providing targeted online search instruction. Web searchers who conduct searches for simple or complex topics may benefit from using more than one web search engine. For web searchers who are new to a subject area or are investigating a topic for browsing or learning purposes, may find a larger number of suggestions more useful than a short list of suggested queries. The variety of suggested terms allows searchers, with limited familiarity with search topic, to learn and investigate a topic from various perspectives. Topics with a geographic slant may benefit from more than one web search engine.

## References

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# Appendix

## TREC 2009 Web Track Topics

wt09-1:obama family tree  
wt09-2:french lick resort and casino  
wt09-3:getting organized  
wt09-4:toilet  
wt09-5:mitchell college  
wt09-6:kcs  
wt09-7:air travel information  
wt09-8:appraisals  
wt09-9:used car parts  
wt09-10:cheap internet  
wt09-11:gmatt prep classes  
wt09-12:djs  
wt09-13:map  
wt09-14:dinosaurs  
wt09-15:espn sports  
wt09-16:arizona game and fish  
wt09-17:poker tournaments  
wt09-18:wedding budget calculator  
wt09-19:the current  
wt09-20:defender  
wt09-21:volvo  
wt09-22:rick warren  
wt09-23:yahoo  
wt09-24:diversity  
wt09-25:euclid  
wt09-26:lower heart rate  
wt09-27:starbucks  
wt09-28:inuyasha  
wt09-29:ps 2 games  
wt09-30:diabetes education  
wt09-31:atari  
wt09-32:website design hosting  
wt09-33:elliptical trainer  
wt09-34:cell phones  
wt09-35:hoboken  
wt09-36:gps  
wt09-37:pampered chef  
wt09-38:dogs for adoption  
wt09-39:disneyland hotel  
wt09-40:michworks  
wt09-41:orange county convention center  
wt09-42:the music man  
wt09-43:the secret garden  
wt09-44:map of the united states  
wt09-45:solar panels  
wt09-46:alexian brothers hospital  
wt09-47:indexed annuity  
wt09-48:wilson antenna  
wt09-49:flame designs  
wt09-50:dog heat