

# Conversational Interfaces for Search As Learning

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## Abstract

Searching the web to learn new things or gain knowledge has become a common activity. Recent advances in conversational user interfaces have led to a new research opportunity – that of analyzing the potential of conversational interfaces in improving the effectiveness of search as learning (SAL). Addressing this knowledge gap, in this position paper we present conversational interfaces to support search as learning and novel methods to measure user performance and learning. Our experimental results reveal that conversational interfaces can improve user engagement, augment user long-term memorability, and alleviate user cognitive load. These findings have important implications on designing effective SAL systems.

## Keywords

Conversational interface, search, learning, chatbot

## 1. Introduction

Over 4 billion people around the globe actively use the Internet today; that is over half of the world population. Web search is one of the most common activities on the Internet, particularly for the purpose of gaining new knowledge [1, 2]. Therefore, learning has inevitably become an important part of web search, either actively or passively. Meanwhile, there has been a rise in the use of conversational user interfaces (CUIs) – applications aiming to provide users with seamless means of interaction via virtual assistants, chatbots, or messaging services. This paper lies at the confluence of SAL and CUIs, and explores how learning through web search sessions can be improved by leveraging conversational interfaces.

Prior studies in online learning have revealed that conversational systems can improve learning outcomes in some specific scenarios [3, 4, 5]. However, to what extent CUIs can improve learning environments to better engage learners and alleviate their cognitive load remains unexplored. Furthermore, as the goal of learning is to develop a deep understanding of some information, memorization is an important element [6, 7]. Although conversation can produce unique context linked with information, the effect of conversational systems on human memorability needs further exploration.

In this position paper, we aim to fill this knowledge gap by designing conversational interfaces to improve learning effects during web search sessions. We specif-

ically seek to explore whether CUIs can improve user learning, user experience in terms of user engagement, cognitive load, and long-term memorability of the information consumed. To this end, we make the following contributions.

i) We designed a conversational interface supported by a rule-based conversational agent to assist workers in web-based information retrieval (web search based on desktop browsers). Through experiments in a typical microtask crowdsourcing setup with search tasks, we investigated whether a dialogue-based system can be an alternative to the conventional web search interface. We found that the task execution supported by conversational agents can produce high user satisfaction, while resulting in similar outcomes compared to conventional means [8].

ii) We conducted experiments to assess whether a conversational interface can better engage users. We found that users using CUIs exhibit a higher retention rate, suggesting that conversational interfaces can significantly improve user engagement [9].

iii) To predict user performance and understand how conversational interfaces can alleviate cognitive load, we proposed a coding scheme to estimate users' conversational styles. We found that users' conversational styles are highly correlated to their performances, and CUIs have a strong potential to reduce the cognitive load of users [10].

iv) To study the impact of CUIs on human memorability, an important by product of learning, we conducted an online user study in a classical information retrieval setup. Our results suggest conversational interfaces can serve as a useful means for augmenting long-term human memorability and improving long-term knowledge gain in search as learning [11].

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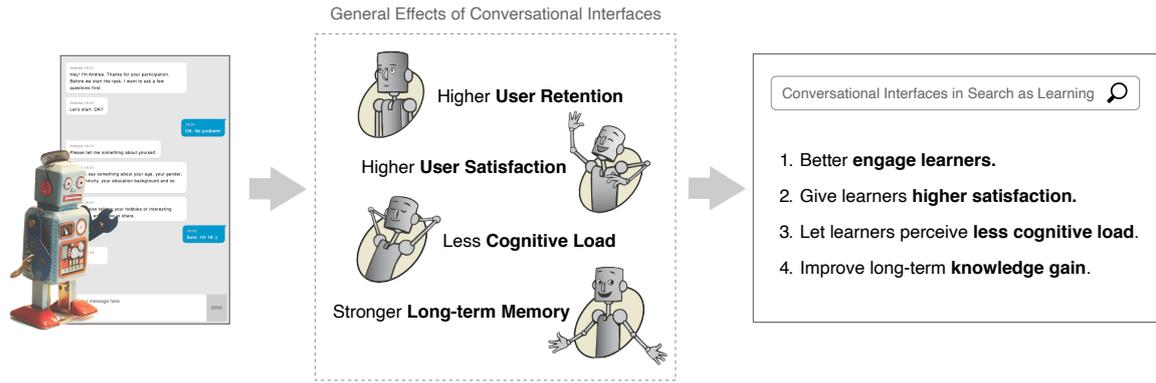
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**Figure 1:** Conversational interfaces in search as learning.

## 2. Conversational Interfaces for SAL

As illustrated in Figure 1, we carried out user studies to explore the potential benefits of using CUIs.

### 2.1. Improving User Satisfaction, Engagement

We investigated the effects of CUIs with regard to user satisfaction and engagement in typical microtask crowdsourcing setups, where users were asked to complete information retrieval related tasks, along with other common types of crowdsourcing microtasks. Furthermore, previous works have shown that monotonous batches of microtasks pose challenges with regards to engaging users, potentially leading to sloppy work due to boredom and fatigue. Therefore, whether conversational interfaces could improve user engagement remains unexplored. We conducted a study involving 800 unique workers and five task types (Information finding, Sentiment analysis, Human OCR, Audio transcription, and Image annotation) across different experimental conditions to address to what extent conversational interfaces can improve the user engagement while completing information searching tasks in typical crowdsourcing setups, and how conversational agents with different conversational styles affect the user engagement while completing tasks.

We used worker retention (the number of answered optional microtasks) in the batches of tasks and self-reported scores on the short-form user engagement scale [12] to measure user engagement. Our results show that conversational interfaces have positive effects on user engagement in comparison to traditional

web interfaces. We found that a suitable conversational style has the potential to engage workers further (in specific task types). This work reveals the general understanding of conversational interfaces for information searching tasks. The details of the experimental settings and result analysis can be found in [9].

### 2.2. Alleviating Cognitive Load

To study how conversational interfaces could alleviate the cognitive load of users, we classified users into two categories according to their conversational styles and measured their perceived cognitive loads.

We first conducted research to understand user conversational styles. Our previous work about user engagement investigated whether different conversational styles of an agent can increase user engagement. Furthermore, previous works in the field of psychology have shown the important role that *conversational styles* have on inter-human communication [13, 14, 15]. Having been developed in the context of human conversations, the insights and conclusions of these works are not directly applicable to conversational microtasking, since the contrasting goal of workers is to optimally allocate their effort rather than being immersed in conversations. To the best of our knowledge, current conversational agents (particularly for crowdsourcing) have only studied the effects of the conversational style of agents, rather than the conversational style of online users (i.e., workers in the context of microtask crowdsourcing). Therefore, we designed a coding scheme inspired by previous work [15] and corresponding to conversational styles based on the five dimensions of linguistic devices that have been examined. We also designed and implemented a conversational interface that supports our experiments by extracting linguistic

features from the text-based conversation between the user and the agent.

Understanding the role of workers' conversational styles in crowdsourcing can help us better predict user performance, and better assist and guide workers in the training process. To this end, we also delved into the research question: to what extent the conversational style of crowd workers relates to their work outcomes and cognitive task load in information retrieving tasks.

We designed information retrieving tasks with three difficulty levels, where users are asked to find the middle name of famous people. We recruited 180 unique online crowd workers from AMT and conducted experiments to investigate the feasibility of conversational style estimation. We also analyzed the impact of conversational style on output quality and perceived task load (using the NASA-TLX instrument). Our experimental findings revealed that workers with an *Involvement* conversational style have significantly higher output quality, higher user engagement, and less cognitive load while they are completing a high-difficulty task, and have less task execution time in general. The findings have important implications on user performance prediction and cognitive load evaluation in web search session. The details of the experimental settings and result analysis can be found in [10].

### 2.3. Augmenting Long-term Memorability

Since memorization is an essential element of the learning process [6, 7], we aim to fill this knowledge gap by proposing novel approaches to improve human memorability during information retrieval. We specifically focus on web search activities carried out through the desktop browsers. Through rigorous experiments, we seek to address the following research question: how human memorability of information consumed in informational web search sessions can be improved.

Inspired by prior work in psychology and human computer interaction, we propose novel search interfaces that provide a conversational interface. We propose methods to quantify knowledge gain and long-term memorability of information consumed, and investigate the impact of the proposed search interfaces on the memorability of information consumed. We conducted an online user study, with 140 online workers, in a classical information retrieval setup. Results reveal that conversational interfaces have the potential to augment long-term memorability (7.5% lower long-term information loss). Our findings suggest that

conversational interfaces are promising tools for augmenting human memorability in information retrieval.

Furthermore, we also delve into the research question: how the use of text-based conversational interfaces affects the search behavior of users. Through our experiments, we found that users leveraging conversational interfaces input more queries but opened links less frequently compared to users leveraging the traditional Web interfaces. In addition, the users of conversational interfaces tend to type notes themselves, while the Web users input significantly longer notes by copying content directly from the search engine result pages. Our findings have important implications for building information retrieval systems that cater to optimizing the memorability of information consumed and improving long-term learning effects. The details of the experimental settings and result analysis can be found in [11].

## 3. Challenges and Opportunities

We conducted rigorous experiments to understand the role of conversational interfaces in general information retrieval crowdsourcing tasks, which has important implications for the realm of search as learning. We argue that the use of conversational interfaces can provide a number of potential benefits, such as improving user engagement, reducing cognitive load, and augmenting long-term memorability. Our research provides plenty of inspirations for future research directions. Naturally, more research is needed to better understand whether a conversational agent could aid search as learning in general.

Specifically, in terms of the conversational user interface, we only focus on the text-based conversation across all these studies. In general, there are various means to interact with conversational agents (e.g., voice-based agent, video-based agent). The effects of voice- or video-based conversational agents on worker performance and mental conditions still remain unexplored. Furthermore, text-based conversation ignores several paralinguistic features (pitch, voice) and nonlinguistic features (smile, laughter, gestures), which could play important roles in human-computer interaction. Conversational agents and corresponding style estimation methods based on voice or video could be an interesting direction to explore.

Our findings also reveal that users employing conversational interfaces in informational search sessions exhibit a different search behavior compared to traditional web search: they rely primarily on text-based conversation, resulting in a significantly higher fre-

quency of issuing queries but a significantly lower frequency of opening SERP (search engine results page) links. These users appear to consume information by means of viewing titles and snippets rather than opening links and exploring SERPs in detail. We found that users employing conversational interfaces have the potential to better retain information consumed. This is possibly due to the fact that conversational interfaces can generate unique context connected to the information during the search session. Our inspection of users' notes also corroborates that users using conversational interfaces tend to generate information by themselves rather than copying content from sources (Web users' preference). These findings suggest that both note-taking and conversational interfaces can be promising tools towards achieving memorable search as learning in the future.

In the experiments about memorability in web search, we found that only around half of the users returned for our long-term memory test, which is typical of such experiments. Our results show that the users with a relatively higher knowledge gain were more willing to return and participate in our memory test. It should be noted that this participation bias presents a threat to the representativeness of our findings. In our imminent future research on search as learning, we will explore whether a higher user engagement relates to a better user memorability or a better long-term learning effect.

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