Google has revolutionized how people seek information, making its all-white first page an iconic tool of the Information Age. However, Google does not serve an important category of information need. When we do not know what information we need, we engage in browsing or exploratory search. We explore information when we wish to formulate an idea or a thesis or identify a problem or, indeed, solve a problem. Google does not serve this type of information need effectively. Because searchers do not know what information they need when they commence the search, it is difficult to formulate queries to search engines, and because there are no criteria for judging relevance, it is difficult for searchers to identify needed information if and when they see it in the results list.

Most of us get by utilizing Google as it is, relying on alternative information channels – colleagues, experts, enlightened parents and teachers – to get us started in exploratory search. However, there are many informationally disadvantaged people in our society who have no such informational networks, who cannot get over the information barriers that block them from finding the information they need to construct a better life.

In this short article, I condense a theory of information need and information search presented in my book [1]. In my theory, the searcher’s information need actualizes over a period of time as the searcher connects via frequent interactions with new information to her own knowledge-belief system. Therefore, the theory of information need connects a searcher’s actualization of her information need to the searcher’s formation of new knowledge or new beliefs or the modification of old knowledge or old beliefs.

The formation or modification of the human knowledge-belief system is more difficult than it seems. In the next section, I describe how the human knowledge-belief system is almost a closed system. I then describe a solution...
that forces us to open up the closed system, from evolutionary psychology. In the last section of the article, I model the exploratory search situation of a searcher in Figure 1 and outline an exploratory search engine in Figure 2.

**Exploratory Search Is Difficult: An Almost Closed System**

We start from the premise that idea formation during exploratory information search is difficult. This is because the state of mind of the searcher conducting an exploratory search is almost a closed system. Information, according to our perspective, is not additive or thing-like. Instead, we define information as a process that, when it manages to enter the human perceptual-cognitive system, ends up modifying the searcher’s knowledge structure. This definition corresponds to Brookes’ fundamental equation of information science. The term knowledge structure has also been referred to as a schema or frame.

According to the frame theory of Minsky, humans have frames for every human interaction with their environment, which predict all future similar interactions. There is a specific frame for going to a birthday party that predicts the experience of going to a future party based on past experiences with birthday parties. We have a template or exemplar stored in human memory for all such events that make up our human experience. This method of experiencing the world, based on past experience, creates a somewhat closed perceptual-cognitive system.

The Meno’s paradox of Plato comments on this closed system: “If we can only see what we already know, how can we know what we do not know?” The paradox continues to perplex philosophers and psychologists to this day. However, from the point of view of our survival in a constantly changing physical and social environment, it is essential that new information find its way into our knowledge system. We must come to know about changes in the environment – these include signs of an approaching fire to macro problems like global warming – if we are to adapt our behavior and survive as a species.

**Evolution’s Solution: Opening the Closed System**

A solution to the Meno paradox is proposed by evolutionary psychology, which places at the center of human existence the necessity of humans being able to ascertain and process new, unfamiliar environmental information into new and adaptive behavior strategies. I will briefly describe two evolutionary psychology theories, one by Donald dealing with human cognitive development in the Paleolithic period, the other with the Neolithic period.

Donald compares the evolution of human representational strategies to that of the Neanderthals. While humans survived, the Neanderthals, who shared both a temporal and physical space with humans 35,000 years ago in southern Spain and were in many ways more physically fit than humans, did not. The Neanderthal brain evolved in two stages: episodic and mimetic representational structures. Donald conjectures that the human cognitive processing system developed two further representational structures, called the mythic and symbolic representational strategies. According to Donald (p. 3): “The key word here is representation. Humans did not simply evolve a larger brain, an expanded memory, a lexicon, or a special speech apparatus; we evolved new systems for representing reality.”

Although the symbolic representational structure of human cognition developed after the mythic representational structure, Donald makes the assumption that in fact all three previous representational structures (episodic, mimetic and mythic) remain as “fully functional vestige[s]” in the present day human cognitive architecture (p. 269). We focus here on the mythic representational strategy for processing and representing reality to ourselves, which Donald believes was the key evolutionary development in the human brain. In fact, Lewis-Williams and Pearce contend that the mythic representational strategy enabled humans to evolve out of the Paleolithic into the Neolithic period.

According to Lewis-Williams and Pearce, it was not the development of agriculture and sedentary life in villages that caused the shift to the Neolithic period, but rather the mythic representational strategy’s quest for meaning and the development of supportive belief systems that led to village living and agriculture. This transition came about because the mythic leaders, the shamans, required the building of permanent tunnels to the dead so that the dead could be consulted about the afterlife and the meaning of life. This requirement necessitated permanent structures supported by agriculture and the symbolic representational strategies that underlie this new way of living.
We emphasize evolutionary psychology and these two theories because they underline the importance of myth and the human quest for existential meaning as levers to symbolic thinking and learning. In other words, there is an existential aspect to exploratory search that can serve as a portal to opening up the closed system of the human perceptual-cognitive system to new ideas, issues and arguments that make up human symbolic discourse.

Modeling Idea Formation during Exploratory Information Search

The searcher sits down at a search engine such as Google with an information need. The information need is a mental state that the searcher must ascertain, then break down into the concepts or keywords that form the searcher’s query to a search engine. This process is straightforward when the searcher knows her information need: she intends to command the search engine to produce the correct answer (or a citation to a website/page with the correct answer). She intends to affect the search engine’s goal-setting levers so that it will produce the form of answer she knows she is seeking.

For exploratory information search on the other hand, the searcher is questioning the search engine so that the search engine will produce information in the results list that will affect the goal settings, the range of state of readiness of the searcher’s brain [7 p. 101], which, hopefully, will make the searcher’s information need clearer to herself. The searcher intends to open up her own cognitive system to let in the new information. In Figure 1, we label this exploratory search intention “Positive Feedback: Maximize Perturbation.”

In Figure 1, going from left to right, we model the evolution of the mental state of the searcher conducting an exploratory search from the beginning of the existence of the information need to the actualization of her information need after many information searches. The four-pronged symbol represents the evolution of the searcher’s state of mind. The five numbered circles represent the levels of the searcher’s perceptual-cognitive processing system.

The searcher’s information need is initiated by the searcher’s interaction with a new and unfamiliar environmental stimulus, represented by Circle 1. For a 14-year-old, this might be the teacher’s announcement of a history assignment based on a topic of the student’s choice [8]. The new, unfamiliar environmental stimulus “registers” in Circle 2, which is the searcher’s perceptual-conceptual system. We use the word registration to indicate the stimulus evokes questions about it in the searcher’s mind. But because Circle 2 is not consciously aware of them, in Figure 1 we give the questions in the Registration Set probabilities of 2%, 3%, 1% and 3%. Circle 2 identifies the questions arising from the stimulus and begins to answer what the stimulus is by, respectively, categorizing and conceptualizing the stimulus. In exploratory search, based on the Registration Set, the searcher creates a query to the search engine and clicks return. The search engine responds by producing output in its results list.

The searcher we are examining in Figure 1 peruses the results list and clicks on a citation or two; she also scans or reads some of the websites/pages...
cited in the results list. She has a vague sense of interest in the information she finds there. Let us define this vague sense of interest. Where does it come from? In my theory of information need, it comes from Circle 3, where the searcher’s memory “associates” knowledge and beliefs from the searcher’s prior knowledge, stored in memory, with the new information she has just found. She decides to modify or expand her initial query based on her new mental state of her information need.

Her mental representation of her information need has been altered or, in the language we are using here, her information need has been somewhat actualized. When she types in her modified query into the search engine’s search box, she now has a new Expectation Set of possible questions or aspects of questions, indicated in Figure 1 with a 4-item set each with 25% probability of being the final form of her real information need. She feels directionless—that is, because of the equal probability of the alternatives in the set, she can go in any direction. She leaves the search engine.

Bates’s berrypicking model [9] of information search describes the searcher leaving the information system (that is, the library) and picking up information elsewhere—by talking to colleagues or parents, for example—between the first interaction with the information system, the second interaction and so on.

For a student searcher, perhaps her parent has told her to concentrate on something that interests her, for example, music. “What do you think?” the parent asks the student searcher. “Does suffering produce musical genius?” The searcher changes her query to the search engine in consequence. Circle 5, the searcher’s sense of her existential self vis-a-vis her parent’s question, “Does suffering produce musical genius?” opens up Circle 5, the existential top-level of her cognitive processing system. Circle 5 drains into Circle 4, the searcher’s Belief System—things she believes to be true. And this in turn drains into Circle 3 where the cognitive system “associates” beliefs and knowledge stored in the searcher’s memory with information found in the external world. The searcher’s information need has become more actualized. When one of the questions or issues in the Expectation Set reaches, let’s say, a 50% probability that it will be the final form of her real information need, the searcher now knows what information she needs and she can command the search engine to produce the form-of-answer she expects. Our searcher conducts further searches for evidentiary or proof-of-thesis information, signified in Figure 1 by a man with a top hat and magnifying glass. The searcher in Figure 1 is now out of exploratory search and into command search, which is very well served by the Google search engine the way it is now.

An Exploratory Information Search Engine

We visually outline the design of an exploratory search engine in Figure 2. The engine is designed to support idea formation, which requires that the searcher explore information to answer her questions about what it is that she does not know, to actualize her real information need. Such an engine can be designed in many ways. The one we describe here is geared to

![FIGURE 2. Exploratory information search engine: Finding the searcher’s real information need](image)
students researching a school assignment. In its final form, it is an interactive virtual search environment called the Astrolabe, described slide-form in [1]. The exploratory search engine shown in Figure 2 is divided into five steps:

1. The searcher is asked to list four questions she wishes the search engine output to answer. The four-questions method of verticalizing the searcher’s conceptualization of her information need has been shown to be efficacious in research studies of undergraduates researching a history essay (described in [1], pp. 165-169).

2. The searcher is asked to indicate the probability for each of the four questions that it will be the searcher’s final and real information need. Probabilities must total 100%.

3. The searcher is asked to answer the highest probability question based on her prior knowledge.

4. The searcher is asked why she believes this answer to be true, giving three reasons or “because” based on her prior knowledge. These reasons are belief assumptions only and must be justified by seeking evidentiary information in support of these belief assumptions.

5. The searcher is then told by the search engine that these three belief assumptions are her real information need. She must justify her belief in these three belief assumptions by seeking and finding evidentiary information proving/justifying these beliefs. By justifying these beliefs, she therefore proves (to her own satisfaction) that her answer given in step 3 is also true.

The information need of the searcher, when it is fully actualized after using this exploratory search engine, is based on the searcher’s real information need, not a compromised form of the information need [10], which is presently the case with current search engines.

**Conclusion**

The article gives a brief overview of a theory of information need during exploratory information search which connects the formation of the searcher’s real information need to knowledge-belief formation. Exploratory search is not now adequately served by current search engines. The conception of the searcher’s query to the search engine, after she has utilized the exploratory search engine outlined in Figure 2, is an entirely different conception of the searcher’s information need than the model of information need the Google search engine is based on now.

I ask Google to tear down the searcher’s wall to exploratory search. I suggest a small, discrete exploratory search hyperlink under its first page search box. The searcher clicks on this new exploratory search engine hyperlink and arrives in another world of search, where idea formation, problem identification and solution are facilitated. The addition of an exploratory search engine such as the one outlined in Figure 2 will contribute to Google’s status as the essential search tool of our Information Age.

**Resources Mentioned in the Article**


