The Changing Memory: How Internet Search Engines Inhibit the Creation of New Ideas

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ABSTRACT

Internet search engines allow people to access new information in seconds. Although the Internet provides easy access to a mass of information, over-reliance on it changes how human memory works, which may have an adverse effect on critical thinking. Individuals with a dependence on search engines tend to remember *where* they found the information rather than the material *itself*. Human memory systems work by connecting new information to old in the brain, which requires people to actively think about the material they are taking in. When people bypass critical thinking due to Internet search habits, they cannot form the neural connections needed to create new ideas. As people continue to rely on Internet searches when confronted with a question to which they do not know the answer, abilities to think critically and creatively and to recall information suffer as memory systems change, hindering the ability to generate new ideas.

Background

To explore the topic of generating ideas, it is important to understand how human memory works. In her TED-Ed lecture, neuroscientist Catharine Young explains, "When you experience something, […] the experience is converted into a pulse of electrical energy that zips along a network of neurons. Information first lands in short term memory […] then [it is] transferred to long-term memory" (Young, 2015, 0:27). The transferring of information from short-term memory to long-term is also referred to as memory consolidation. To ensure people can retrieve the information they have committed to memory, Dr. Barbara Oakley, in her book A Mind for Numbers, says: "You need to revisit it a few times to increase the chances you'll be able to find it when you need it" (Oakley, 2014, 43). Recall is essential for the effective utilization of memory pathways because neural connections that represent the information strengthen, making it easier to access and use information when needed. Furthermore, American writer Nicholas Carr, in a speech about how the Internet changes the way people think, explains that "it's only during memory consolidation that you connect that piece of information to everything else you've learned and thought and experienced in your life" (Carr, 2015, 10:37). Besides recalling the knowledge that people input into their brain, individuals must put in effort to understand the information they are taking in to avoid forgetting it due to a lack of a strong neural connection. Critical thinking supports the formation of strong connections between neurons because neural pathways strengthen when new information is connected to old (Young, 2015, 1:02). It is by using both critical thinking and active recall that people can come up with new ideas by engaging with information in their long-term memory.

As people rely more on Internet searches to find information, researchers have found that human memory systems are changing as a result. In a study regarding Internet searching and its effects on memory, psychology professors Guangheng Dong and Marc Potenza found that "people may be becoming better at remembering where information is located than at recalling information; this has been termed the 'Google Effect'" (Dong and Potenza, 2015, 1). Reliance on Internet searches discourages the use of memory consolidation and instead promotes the use of an Internet search as a secondary storage system. People are no longer cultivating the right environment for the creation of new ideas as memory systems change and critical thinking and recall falter. With the Internet creating potential changes to human memory, it is important to explore the implications of the Google Effect on the creation of ideas.

The Internet as a Secondary Storage System

As human memory systems change to remember where information is by using the Internet as a secondary storage system, people will be unable to retrieve searched information from their memory, hindering the development of ideas with newfound information. Researchers ran a study that had participants read 40 memorable trivia questions that they were to answer using a search engine and then type the found answers into a computer. Half of the participants were told that the computer would save what was typed and the other half were told that the computer did not save it. After they finished, participants were asked to write down as many of the statements as they could remember. The researchers found that "participants recalled the places where statements were kept better than they recalled the statements themselves" (Sparrow et al., 2011, 776-778). People who rely on the Internet to access information for them again, as needed, will experience decreased ability to store the information in their brains successfully. When individuals do not critically think about new material after a search, they are unable to create the connections needed to utilize the knowledge at a different time or connect it to future information. Since these connections are being used to remember where knowledge is stored and not what the information is, they are not being used efficiently and cannot be used in the creation of new ideas as the information cannot be retrieved from memory. For a person to form a new idea, the information must be transferred to long-term memory and then revisited again, which people who tend to rely on the Internet do not do because they know they can access the material at any time via the Internet. When people know they will have easy access to information on the Internet, they will remember where the information is stored rather than the information itself, failing to store new information in their minds and create unique thought.

Furthermore, using the Internet as a means of keeping information will reduce a person's ability to recall material found through Internet search engines, resulting in an unproductive relationship between a machine and user. The concept that people tend to use the Internet as a secondary storage system evolved from the theory of transactive memory proposed by Dr. Daniel Wegner, which states that "transactive memory is a system of group cognition and memory in which one remembers who knows pertinent information instead of remembering the information itself" (Friede, 2013, 6). In the case of Wegner's theory, the Internet would be the system of group cognition, replacing the idea that transactive memory use is limited to a network of humans. The problem occurs when researchers examine how transactive memory works within groups of people versus machines. Transactive memory differs in machines, as researchers explain, "The Internet does not place any responsibility on the user to retain unique information for others to draw upon" (Firth et al., 2019, 122). Transactive memory within groups involves people sharing information amongst each other, utilizing human memory pathways. For a person using the Internet, transactive memory serves as a storage system between machine and user, limiting the need for the user to remember and later recall the information. Firth et al. continue, "[T]he Internet acts as a single entity that is responsible for holding and retrieving virtually all factual information, and thus does not require individuals to remember what exact information is externally stored, or even where it is located (Firth et al., 2019, 122). In a group situation, transactive memory systems are useful because members will ask each other for information and they must recall that knowledge, making it easier to access again for future use. The Internet bypasses retrieve and recall as people use it as a secondary storage system. Thus, the stored information cannot be used in creating ideas because it will not be readily available in their minds. A user's relationship with the Internet as a method of storing information consequently limits a person's ability to recall newfound information.

Dependence on Internet Search Engines

People form a dependence on Internet searches because it is an easier method of finding an answer, resulting in a decrease of a people's capabilities for creative thoughts as they avoid consulting their own memory first. Having a mass of information at hand can be helpful in some cases but can be detrimental when an individual forms a habit of immediately using a search engine. Researchers found that "people are easily dependent on the Internet search

engines" in a study that examined how Internet searches made people dependent on technology when confronted with a question to which they did not know the answer (Wang et al., 2017, 1). As users perform Internet searches more often to find answers, they will develop a habit of going to the Internet for any question they may have. If people do not first consult their mind for any possible information that may aid them in finding an answer to a question, the neural pathways used to come to a distinct thought on the subject may not be triggered. The study led by Wang et al. followed 14 women and 17 men in a three-step process: a pre-test, six days of Internet search engine training, and a post-test. The pre-test and post-test tasked participants with a search-remember-recall and recognition task and recorded their brains with fMRI. The training had participants finish six search tasks consisting of 80 fill-in-the-blank questions, which they answered using a search engine. The study found that "subjects reported stronger impulses to search the Internet in post-test compar[ed] to pre-test" (Wang et al., 2017, 2-4). After undergoing Internet search training, people in the study had a greater urge to search the Internet when they did not know an answer during the post-test compared to before they completed Internet search training in the pre-test. It can be understood that Internet searches take away the desire for people to consult their memory first, which reduces their need to use the information they find and instead develops an impulse to consult the Internet for answers. Human memory systems work best if users try to relate a question to something they already know. When this process is circumvented due to the ease of Internet access, the ability to form ideas falters because old information is not revisited. As the Internet becomes a sole source for confronting questions, a person's ability to form ideas will decline as Internet searching habits stop them from considering any prior knowledge they may have on a subject.

Moreover, when people encounter questions to which they do not know the answer, they are primed to think searching the Internet, promoting a dependence on search engines. Priming occurs when exposure to one stimulus influences how a person responds to a following event. Malcolm Gladwell, in his book Blink: The Power of Thinking Without Thinking, presents an experiment by psychologist John Bargh who had participants unscramble sentences. The sentences contained words that could be attributed to old people, and the experimenters observed that participants walked out of the room more slowly than when they walked in after performing the task. Gladwell explains, "I […] was making the big computer in your brain — your adaptive unconscious — think about the state of being old […and] it took all this talk of old age so seriously that by the time you finished the test and walked down the corridor, you acted old" (Gladwell, 2007, 53). People's minds will use previous experiences to prepare them to respond to a situation. When people are primed to think about searching the Internet, they will avoid thinking about the question and instead search online to find an immediate answer. Similar to how thinking about old age could make participants walk like an older person, the quick and easy access to information that Internet search engines provide encourages users to search the Internet when they have a question because it has helped them in the past. This is disadvantageous to human memory systems because a person will not take the time to critically think about the question as they go straight to the Internet to find an answer. When people experience the benefits of Internet searching, they become more influenced to use search engines when they must find a solution.

Further exploring this point, Sparrow et al. performed an experiment that investigated whether people are primed to use the Internet as an external memory drive by the need to find information, limiting their ability to apply critical thinking to questions. For example, if the question was about "whether there are any countries with only one color in their flag […] do we think about flags or immediately think to go online to find out?" (Sparrow et al., 2011, 776). The experiment compared two groups who answered either easy or hard trivia questions with a "yes" or "no" answer in two sections. After each section, participants did a color-naming task with words colored blue or red to test reaction times between computer and general terms after the questions. The researchers expected participants to have computer terms in mind after hard questions as they hypothesized participants had a desire to access information that would allow them to answer. The researchers concluded that people tended to be "primed to turn to the computer to rectify the situation" when faced with a difficult question (Sparrow et. al, 2011, 776). Whenever people come across a tough question, their minds know that the Internet can give them an answer quickly and with little effort as scientists in the study had expected. Consequently, instead of consulting their memory for possible connections of this new information to past knowledge, people will use Internet searches as a storage method rather than transferring the

material to their long-term memory. Additionally, when people do not make connections with their past knowledge in an act of critical thinking, it will be harder for them to retrieve and recall the information at any given time to use in the creation of new ideas. People are primed to use a computer when confronted with difficult questions because of its ability to give answers quickly; this instant solution reduces a person's ability to think critically.

Unhealthy relationships with Internet searches are involved in the inability to retain knowledge as information is acquired in a passive way. To use material gathered through Internet searches in the creation of new thought, additional work is required by the user. A study on the effects of Internet searching by psychology professors Dong and Potenza found that "if people are using Internet search engines as external memory drives as suggested […] they may show a diminished ability to remember knowledge learned through Internet-based searches" (Dong and Potenza, 2015, 1). When people build a reliance on Internet search engines for information, their ability to remember what they found decreases as they do not have the need to recall information. Recall is essential to the retention of information because "if two neurons communicate repeatedly […] the efficiency of communication between them increases" (Young, 2015, 1:02). When an individual recalls material, the neural pathways related to that information become more efficient and easier to access. This active way of thinking will make it easier for a person to retrieve information rather than acquiring it passively. For people to generate unique ideas, prior knowledge along with new information stored in the long-term memory are needed, furthering the case for an active method of information gathering. Dependence on the Internet for search and storage reduces recall rates in humans, which without additional efforts, will result in the inability to come up with new ideas.

Creative Thinking Generates Ideas

Creative thinking is humanity's advantage over computers as it allows people to come up with ideas. However, Internet searches inhibit our use of creative thinking. Dr. Henning Beck, a neuroscientist and author, explains in his TED Talk: "Computers are intelligent, but intelligence is nothing special […] And it's the mistake in our thinking, not the perfection, that separates us from the noncreative machines […] It means that we can come up with a new thought—a new activity pattern—without knowing before whether this is correct or not" (Beck, 2016, 7:35). Humans do not have to check with an algorithm to produce a thought, unlike computers. Instead, human memory pathways provide the ability to synthesize various pieces of information to form ideas. Furthermore, people do not have to be correct in their thinking to create an idea whereas machines must follow programmed orders to form a product. Woolley et. al, in a research paper on imagination and creativity, describe that "most creative endeavors will result in multiple experiences of creative inconclusiveness prior to a single instance of creative achievement" (Woolley et al., 2020, 182). Their discussion on creativity agrees with Beck's sentiment on human thinking because mistakes in a person's cognition, such as ideas that fail to have an outcome, are a part of the process of creating ideas. As mentioned earlier, people tend to use the Internet as an external memory storage. When people rely on the Internet for information gathering and storing, they are unable to undergo processes of trial and error that occur during idea creation. The process of using the creative mind to form ideas involves actively using and processing searched information to work through multiple versions of ideas. To do so, a person must not rely on the Internet for storing and retrieving information. Internet searches allows a person to access an immense amount of information; however, it is only with effort from the creative human mind that ideas can be made from that knowledge.

Dependence on the Internet for information storage can hinder a person's ability to utilize creative thinking and imagination to create new ideas. Humans can imagine new ideas because of their ability to synthesize information and experiences in their mind. In a TED-Ed lecture on the neuroscience of imagination, neuroscientist Andrey Vyshedskiy describes, "[T]o create these new, weird images, your brain takes familiar pieces and assembles them in new ways, like a collage made from fragments of photos" (Vyshedskiy, 2016, 0:41). Creative thinking involves previous knowledge organized in new ways to form a novel thought. To create ideas, the human brain must have new information to synthesize with other knowledge, experiences, and emotions. When a person forms an idea, neurons that encode separate pieces of information link together in a process called neuronal ensemble (Vyshediskiy, 2016, 1:15).

Therefore, it is essential to critically think and retrieve information found on the Internet to create an environment in the brain that supports the linking of pieces of material and the use of imagination. When people's knowledge is replaced by the location of information, their brain cannot make the neural connections needed to create ideas. In his TED Talk, Dr. Beck expands on the importance of using all the information a person assimilates, explaining, "Every efficient procedure will be replaced by algorithms eventually. What cannot be replaced is inefficient thinking—integrating new ideas, giving rise to understanding of stuff" (Beck, 2016, 14:23). While the Internet can give people the material that goes towards the next great idea, it is a person working with the information and fusing it with past knowledge and experiences that results in an original idea. Additionally, to create connections between different pieces of information, people must give their minds an opportunity to work with the knowledge and organize it in different ways during the process of forming ideas. Creative thinking is what allows humans to create new ideas; when people depend on the Internet to store new knowledge, they cannot use that information in the creative thinking process.

The Solution: Building A Positive Relationship with Internet Searching

To avoid dependency on the Internet, people should first consult their own knowledge before undertaking an Internet search for answers to efficiently use their memory systems and attempt to connect new information to existing context. Author Nicholas Carr explains that although computers provide us valuable tools such as Internet searches, relying on those search engines "overrides the mental processes that are really key to the formation of deep thoughts," which is essential to a person's ability to "create the rich set of connections with other information that we've remembered or experiences we've had that gives our thinking richness in distinctiveness" (Carr, 2012, 15:11). When people immediately search for answers, they do not have a chance to form an idea using prior knowledge or experiences with the question at hand. If people make the effort to consult their memory for potential answers before performing an Internet search, they can produce distinct thought that contains their past experiences. Taking the time to retrieve knowledge from long-term memory enables neurons representing one piece of information to interact with neurons that represent a different piece of material to form an idea. People who form a dependence on Internet searching limit their ability to come to an answer with their own experiences, removing the uniqueness of their own thought. Sometimes, it may be necessary to complete an Internet search when an individual cannot come up with an answer after confronting their own mind. In these cases, people should make the effort to connect searched information with their own knowledge to still make use of the mental processes involved in idea generation. Attempting to confront one's own mind for potential answers can help an individual develop a healthier relationship with Internet searching, while still using the critical and creative thinking required to produce unique thought on the subject.

Consistently using and recalling the knowledge a person comes across on the Internet is essential to forming new ideas and avoiding the pitfalls of reliance on Internet searches. When people find answers on the Internet, it is common to move on and not revisit the information again. Instead, people should challenge themselves to recall the information they are taking in rather than rely on the ease of re-accessing that information via Internet searches. To make knowledge more accessible and easier to retrieve in long-term memory, Dr. Barbara Oakley recommends a technique called spaced repetition: "repeating what you are trying to retain […] but spacing this repetition out over a number of days […] research has shown that if you try to glue things into your memory by repeating something twenty times in one evening, for example, it won't stick nearly as well as it will if you practice it the same number of times over several days or weeks" (Oakley, 2014, 43).

Figure 1 illustrates the effects of spaced repetition based on Ebbinghaus' forgetting curve. This forgetting curve reflects human memory retention over time after first acquiring information. Working with newly acquired information at increasing intervals will help the material transfer to long-term memory. The use of spaced repetition improves the ability to use new material in the creation of new ideas as retention of the information increases, making it easier to retrieve when needed. Applications, such as Anki, use an algorithm to help a user follow a spaced repetition schedule, assigning the person what information to study on a given day according to a user's ease of retrieving the information ("Spaced repetition algorithm," n.d.). Ultimately, the Internet's effects on memory systems regarding idea

creation can be negated by an individual promoting an environment that welcomes it. By challenging oneself to process and revisit information, the Internet can be a valuable tool in idea generation.

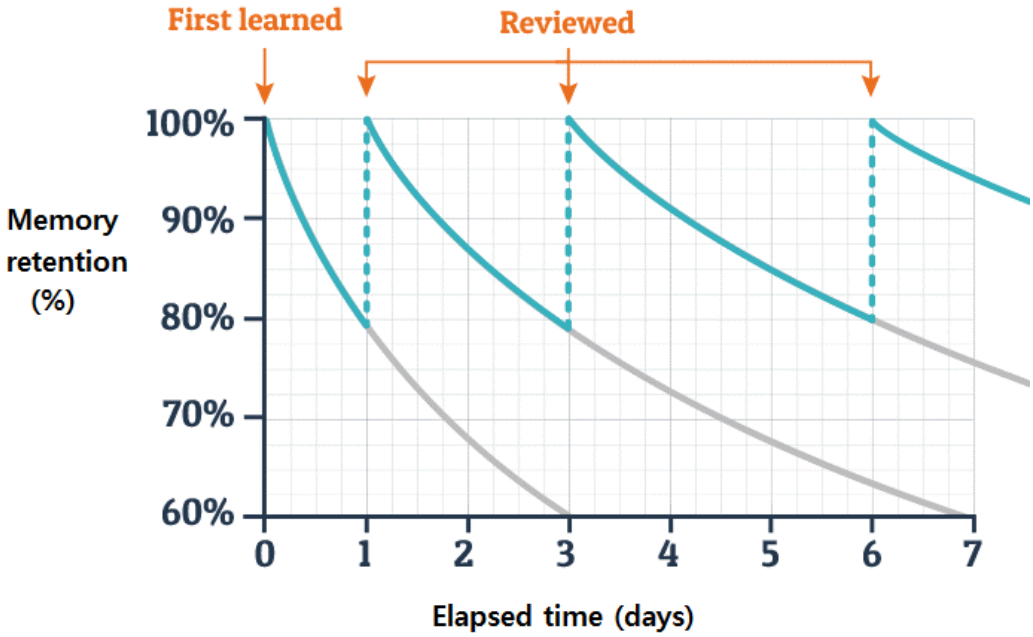

Figure 1. The Effects of Spaced Repetition on Learning (Chun and Heo, 2018, 56).

Conclusion

Dependence on Internet search engines to find answers to problems can cause people to remember where information is rather than the material itself. When people use search engines to find information without taking the time to process it, their abilities to apply critical and creative thinking and retrieve information are inhibited, which obstructs the capacity to create new ideas. Using the brain as a secondary storage system prevents people from transferring information from short-term memory to long-term, making it more difficult to use and retrieve searched information. In addition, when people encounter difficult questions, they are primed to use the Internet immediately, which reduces a person's capacity to think critically because they do not consult their own mind first. Furthermore, a reliance on Internet search engines reduces rates of recall in individuals because they tend to use the Internet as an external memory source, lowering their potential to come up with ideas as they do not connect the new information they have come across with past knowledge and experiences. The Internet can provide a user with instant access to a mass of information, but it is a human trait to utilize memory pathways to form an idea based on different pieces of information and personal experience. It is only when a person utilizes critical thinking and active recall when acquiring new information that they can make it readily available for their mind to use. Creating an environment that encourages idea generation by challenging oneself to process and recall information is essential to building a positive relationship with Internet search engines as well as a strong and nimble mind.

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