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Cognitive offloading an emerging concept: A review study

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Abstract

Cognitive offloading refers to the act of reducing the requirement of mental processing of a task through the use of external environment. For instance, write down the crucial information on piece of paper, set reminders for upcoming appointments and make a shopping list. Offloading play a significant role in enhance the performance during the task with high level of cognitive requirement such as multiple pieces of information in task must be simultaneously maintained. The offloading relies on metacognition- is becoming aware of one's cognition, thinking and is high order thinking skills. The people opt to use cognitive offloading depends on metacognitive evaluation of their mental abilities. Through the depiction of metacognitive evaluation, people find high memory load that leads to greater professed difficulty of remembering, then people decide to use external storage to reduce the internal demands. The frequency of use of cognitive offloading strategies increases as the increase of cognitive demand or memory load. The cognitive offloading improves the performance on the short term and perspective memory.

Keywords: Cognitive offloading, metacognition, memory load, short term memory, perspective memory

Introduction

Cognition is derived from Latin word Cognoscere, which means to know or to come to know. The cognition is the mental process of acquiring knowledge and understands the things through thought, experience and the senses. It consists of many aspects of intellectual functions such as attention, formation of knowledge, reasoning, computation, problem solving, decision making, and comprehension. Offloading refers to acknowledge the person to store the information without relying on the mental efforts. It permits the person to use the extra cognitive resources for problem solving, drawing inferences and decision making. Offloading is an extensive and fundamental strategy for remembering. Cognitive offloading is the use of external environment to modify the requirement for the information processing to complete a particular task. It lessens the cognitive demand on memory in order to reduce the demands on internal storage space. The cognitive offloading is the strategy, when we write the relevant information like phone numbers, se reminders in smart phones for the later attempt (Risko and Gilbert, 2016) ^[17].

In current scenario, people depend on technology constantly. People use the smart phone for the multiple purposes such as for mathematical calculations, pick up important information, schedule and attend events in order to attend to all the appointments at their designated time. People remember all these things by using the external technology aid without rely on internal memory. Through using all these tools, people are reducing their mental efforts as well as increase the cognitive capacity and this phenomenon is known as cognitive offloading. There are some examples of cognitive offloading, storing important contacts on a phone, using navigation app to finding directions, archiving E-mails for later use, writing down information in diaries or piece of paper, set remainders using a smart phone, make a shopping list, storing data in computer or laptops, programmed an appointment into our online calendar, use calculator and write notes on smart phones or computers.

Sub-Division of Cognitive Offloading

The Cognitive Offloading is sub-divided into two parts: thinking with the body and putting cognition into the-world on the basis of action that offload the cognitive demand. In thinking with the body, we actively use our bodies to reduce the cognitive demand. A clear-cut example

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of this kind of cognitive offloading is external normalization and internal normalization. In external normalization, individuals often physically tilt their head to normalize the orientation to encounter a rotated stimulus (for instance, tilted book). Internal normalization which is an internal transformation that aligns a representation of a stimulus with a representation stored in memory (Dunn and Risko, 2015) [5]. Risko *et al.*, 2014 [19] portrait on the account of the external normalization in the rotated words and rotated frame display that could be argued to more closely look like the types of rotated stimuli individuals would have experienced in their day-to-day lives (Example, a rotated page of text). Arango-Munoz, 2013 [1] suggested regarding the external normalization or cognitive offloading as the metacognition that involves both metacognition monitoring and control in which individual assess their cognitive processing and take action to regulate the cognition. Dunn and Risko (2015) [18] revealed regarding the external normalization that individual's prior experience influences the metacognitive judgment. The individual use the external strategies not only for actual performance benefits in the present but for performance benefits in the past. The person gets benefit from the prior experiences from external normalization that contribute to raises to choose the offloading. The persons are influenced through their experiences by using the strategy for cognitive offloading (Walsh and Gluck, 2014) [22].

Cognition offloading through putting cognition into the world as a repository of representational information for offloads the cognitive process that eliminates the requirement of internal representation. For instance, individual records the information that needs to be remembered in external environment such as write the information on paper, type into computer (Storm and Stone, 2015) [21].

The cognitive offloading is supported by the theory of distributed cognition was given by Hutchins. The theory describes how mental processes might be spread among individuals and objects as they interact in an environment. Hutchins believed that the cognition is not exclusively within the mind but the external world. During the task performance, the relevant information might be stored in multiple external forms. These types of forms may be present physical in the environment such as a piece of paper, a computer file.

Role of Metacognition in Cognitive Offloading

The term metacognition was coined by John Flavell. It refers to higher order thinking which involves active awareness and control over the cognitive processes engaged in learning. There are two elements of metacognition: metacognitive regulation and metacognitive knowledge. The metacognitive regulation may be defined as individuals make adjustments with their processes that helps in learning such as planning, information management strategies, comprehension monitoring, de-bugging strategies and evaluation of progress and goals. The metacognitive knowledge refers to acquired knowledge that might be used to control cognitive processes.

Metacognitive Model of Cognitive Offloading

This model proposed the selection between cognitive offloading and internal processes is the result of metacognitive evaluations of mental capacities and world (arrow A). For example, decide through evaluating the unaided the spatial memory and GPS system to go to friend's house. In addition, engage in either internal or external strategies through metacognitive evaluation (arrow B). Offloading might be directly influence the lower level

cognitive processes (arrow C).

On the basis of metacognitive model, the people go for offload to be remembered things rely on metacognitive evaluation. According to the metacognitive belief and experiences regarding the internal and external memory storage people the cognitive offloading to remember the items. The metacognitive model suggests that the whether people opt for offload to be remembered information should rely on memory load. If the people perceive high memory load during the task and have difficulty in remembering the items then the person use the external resources to overcome the internal demands to complete the particular task. The experience of cognitive offloading can alter the thinking about the internal capacities or metacognition of an individual. For instance, the offloading information retrieval onto the internet can enhance the estimates of knowledge (Fisher *et al.*, 2015) [6]. Storm and Stone (2015) [21] revealed that cognitive offloading leads to both costs and benefits in terms of cognitive processes. For example, the offloading may have both positive and negative impacts with respect to retrieval from internal memory storage. The metacognition involves knowledge about cognition and develop metastrategic knowledge with regard to task performance such as awareness of task difficulty, task performance and appropriate strategies that improve the performance of the task. The metacognition beliefs that engaged in cognitive offloading are valuable factor that reduce the cognitive demand and build up the confidence on the task. The metacognitive evaluation of mental abilities influences the cognitive offloading. The improvement in the accuracy of metacognitive evaluation can helpful in optimize the offloading behavior. Metacognition able to alter the offloading behaviour (Boldt and Gilbert, 2019) [3]. The metacognition forecast the offloading. The people who are less confident more likely to set reminders than the more confident person, so that the cognitive offloading might be guided by metacognition belief. The people decide to use offloading then the people evaluate their memory for individual items or their metacognition as well as how much offloaded items would improve their memory performance (Hu, X. *et al.* 2019) [12].

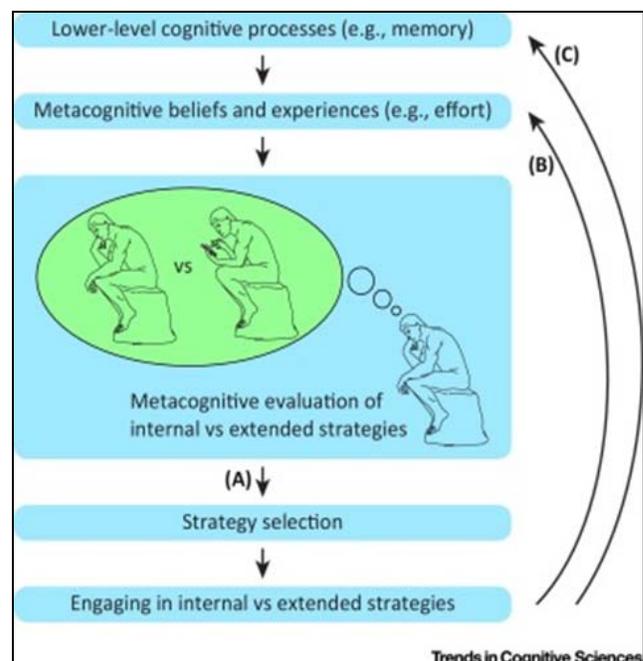


Fig 1A: Metacognitive Model of Cognitive Offloading

Functions of Cognitive Offloading

The cognitive offloading perform many functions such as reduce the cognitive demand, improves performance, is an efficient learning strategy, rely on confidence, reduce the demand on internal storage. Nestojko, J.F. *et al.* (2013) [15] reported that the cognitive offloading reduce the cognitive demand through the qualitative changes in the cognitive processes such as thinking, communicating and learning. Cognitive Offloading is an efficient learning strategy. Redshaw *et al.* (2018) [16] showed that the cognitive offloading is a competent learning strategy. He has been found that the cognitive offloading improve the performance in both adults and children in their short term memory and prospective memory. The people make a decision to rely on offloaded information when they were less confident about retrieve the particular items. The human being more rely on external sources when they were less confident on their own cognitive abilities to remember the items than the more confidence on their own cognitive abilities (Desender *et al.*, (2018) [4]. Boldt and Gilbert (2019) [3] studied regarding the use of cognitive offloading strategies and found that the people used more infrequently cognitive offloading strategies when they were high confident on their memory skills. Gilbert (2015) demonstrated that individuals were more prone to spontaneously set reminders in the offloading task when they found less confident on their memory abilities through metacognitive evaluation of themselves. Hu, X. *et al.* (2019) [12] portrait that the people had more difficulty in remembering when the memory load was high then people opt for external memory storage that reduce the demand of internal storage as well as improve the memory performance. Risko and Gilbert (2016) [17] revealed that cognitive offloading reduces cognitive demand on memory in order to reduce demands on internal storage. The people need only to remember the location of the saved items rather than to encoding the individual items. The cognitive offloading is very helpful strategy to improve the performance of an individual. Risko & Dunn, 2015 [18] conducted Experiment A-Ask-for-help behaviour and memory performance in the memory test of Proportion of ask-for-help trials in the free-choice test was affected by both item difficulty and whether the pair was saved. (B) Memory performance was significantly higher in the free-choice than forced-recall test for saved pairs but not for unsaved pairs. (C) Memory performance in the free-choice test was significantly higher for saved (vs. unsaved) pairs only when participants asked for help. Risko & Dunn, 2015 [18] conducted the experiment on cognitive offloading and in this experiment they asked the participants to learn a series of word pairs whether decide to learn through their own memory or save the word pairs into the computer. In later memory test, the participants had the opportunity to use the offload information on half trial and other half trial this opportunity was not available. This design found that the computer uses as an external environment to save the information that cognitive offloading enhances the long term memory performances. Morrison and Richmond (2020) [14] focused on individual difference factors related to offloading behavior. The study strengthens the idea that the offloading was more benefit in memory performance in high memory load than the lower memory load. (Gilbert, 2015a) [9] showed that offload information significantly improve performance on short-term and prospective memory task and also found that the offloading behavior increases as the number of items to be remember increase. Goupil *et al.* (2016) [10] emphasized on prospective memory task and found that the participants set

more frequent external reminders when there was requirement for three items to be remembered than the one item to be remembered during the task. The decision to offload might also be related to difficulty in items for remember. The people go for offloading more frequently when there was more difficulty to remember and that improves the prospective memory of the people.

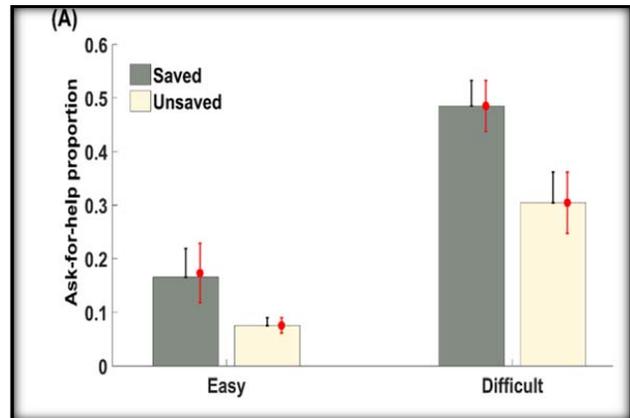


Fig 2A: Memory performance

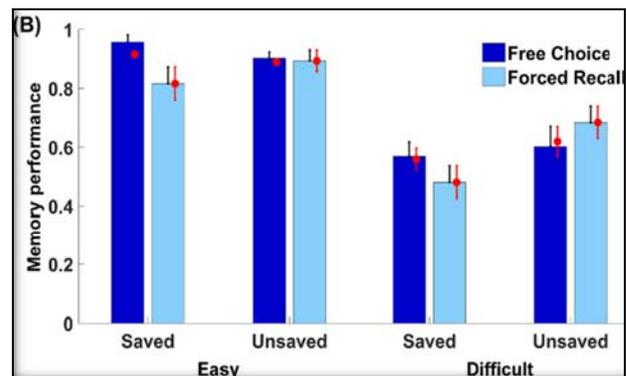


Fig 3B: Memory performance

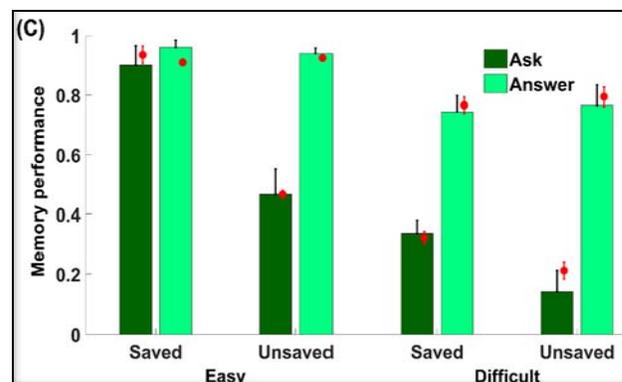


Fig 3C: Memory performance

Cognitive Offloading in Learning

Due to rapid development of technology, the make use of cognitive offloading throughout learning is progressively more ubiquitous. For instance, we often use smart phone, takes notes with laptop when listening to lectures to set reminders. The psychologists, educators can guide the people to understand how and when rely on modern technologies as external tool in learning to maximize their effect on memory performance (X. Hu *et al.* 2019) [12]. Berry *et al.* (2019) [2]

investigated the cognitive offloading approach children with poor working memory. An experiment was conducted in which participants were required to remember and recall sequences of colors through inserting coloured blocks in correct serial order. In one situation cognitive offloading strategy such as grouped by colour was used to arrange the blocks whereas in other situation the blocks of colour were arranged randomly. The results revealed that the ordered situation improved the performance of task for children with poor working memory ability. The structured class environment might provide supplementary ways to enhance learning opportunities for children who have poor working memory.

Cognitive Offloading: Memory and Internet

An experiment was conducted to analyse the likelihood to use a computer or smartphone to give answer of questions. To conduct this experiment the participants were divided into two groups, half of the participants use their memory and other half of the students use Google to give answer of the questions, participants give answer by the method of their choice. The results portrait that the participants were more likely to give answer through internet with less time consults their own memory before reaching for the internet. The results also revealed that the thirty percent of participants were failed to give answer of single simple question from memory who previously consulted the internet. The result showed that the internet and the availability of vast online resources that are ease of access are affecting the thought process for problem solving, recall and learning (Taylor & Francis 2016) [23].

In the context of use of novel technology, the reflection of current and future potential for the aspects of offloading for memory the control of memory is very important factor for this consideration. The accuracy of monitoring of memory performance is very important for students. If the students don't focus on it, that leads to student not able to recall the information from their memory during the exam which he did the study from Google for an upcoming exam. Similarly, a student who uses a navigation app to drive home to visit family may be startled when they are able to articulate the directions to a friend (Hamilton and Yoa, 2019). Sparrow *et al.* (2011) [20] demonstrated regarding the Google effect on memory and found that the easily accessible information through internet search engine such as Google creates more tendencies to forget the information. Storm *et al.* (2017) [22] stated that the people were more likely to use the internet to access new information and less likely to depend on their own memory through access the internet for information. The everyday interaction with smart objects fascinating to enhance the human performance with more depends on external processes to satisfy the demand of cognition that may have negative consequences for intellectual and behaviour.

Cognitive Offloading is Helpful and Obstruction

The person use the technology increasingly day by day to do simple tasks such as watching time, date, sunrise, weather in their smartphones, computers or laptops and sync calendars and grocery to do list on all over such devices. The person set reminders for any appointment to reach on time and reduce the internal memory load and use the calculators in smartphones without using their mental math skills to do the simple calculations. All these electronic devices the person use as external storage for cognitive offloading that make the person faster, accurate and efficient and reduce the necessary efforts to perform a mental task. All these external resources

may cause the person to become reliant on them and ultimately affecting how the people remember the information which is valuable for them and these kinds of devices ruining the people cognitively (Tengler 2016) [24].

The many people use the Global Positioning Systems (GPS) for travel. Such offloading ways impair the spatial memory. For example, in one study individual follow a route using turn by turn navigation system and found that individual had poor memory for scenes from route and asked to drive the route a second time without using the navigation system individual performed very poorly (Gardony *et al.* 2015) [7].

Now days, most of the people including students use the camera for multiple tasks. In an examination of impacts of taking picture on memory, individuals visited several objects either took a picture or simply observed the objects. After a day, a test was conducted for the memory of objects and found impaired memory for the photographed objects and to some extent ameliorated this outlay by taking a picture of only one part rather than the whole object. It was argued that individuals offload their memory of the object onto the camera by taking a photograph and there was impairment observed during the memory test that individual did not have availability of picture of the object in their memory (Macias *et al.* 2015) [13].

Conclusion

Cognitive offloading might be predictable to be highly idiosyncratic. Cognitive offloading indicates one of the quintessential examples of how the person uses their body and objects in the external world that help them to think. The metacognitive evaluation and internal demand play a significant role in cognitive offloading. Moreover, cognitive offloading may have impacts on low level cognitive capacities and metacognition. Particularly cognitive offloading is beneficial at high memory demand. Cognitive offloading improves memories such as short term, long term and prospective memory. The reminder strategies of people guide by metacognitive beliefs by which the people carefully weighing between the internal and external recourses to optimize their performance of prospective memory. The control of memory is important factor to use the technologies as cognitive offloading. The accuracy of monitoring of memory abilities, individual can make key decision for their intellectual goals, such as how to recall the valuable information and when to terminate the practice.

Recommendations

The person should have strong confidence judgments about their memory predicted their decision to use saved information, indicating that cognitive offloading is associated with metacognitive evaluation about memory performance. The people should knowledge about when and how use the external recourses to offload the memory that aids their learning by offloading the information. The people should adequately aware about their metacognitive beliefs and experiences about internal and external memory storage, that helps in offload the information which improve the performance on short-term and prospective memory. The people choose to offload to-be-remembered items depend on metacognitive evaluation that they believe will lead to higher memory performance.

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