The underlying reasons for making reminders: An investigation on memory offloading from the perspective of cognitive psychology

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Abstract. Setting reminders has become a part of people's daily life. Apart from the convenience brought by the digital era, why people like setting reminders is still not very clear yet. The field of cognitive psychology gives several explanations. One of the most common explanations would be that people may not trust their memory as they usually forget the task they need to do. This essay purposes to analyse this viewpoint by reviewing the most recent findings in this area. Three main topics would be involved in this essay. The role of memory would be introduced first. Then, the influence of metacognitive confidence will be discussed. Other factors also contributing to the reason such as avoidance to cognitive effort and personality traits will be finally discussed. After analysis the previous studies, it could be concluded that the purpose of reminder setting was to serve the limited memory capacity. However, this purpose is not the only factor affecting reminder setting. Metacognitive confidence and avoidance to cognitive effort were found as another two important factors contributing to reminder setting so far. Individual differences such as personal traits were suggested as a potential factor affecting this behaviour, but no solid evidence was found to support this.

Keywords: Cognitive offloading; Reminder setting; Working memory; Metacognition.

1. Introduction

It is not over-exaggerated that one of the greatest talents of being a human is being able to use tools to help people store information. To record numbers and events, the ancestors used rope and knots or engraving with stones. Later, people were allowed to write information down on as notes for short-term reminders or as a book for long-term storage. Nowadays, with the popularized internet and smartphones and electronic devices, the capacity of information storage for individuals has become limitless. Such a process of changing information processing by using physical actions in order to reduce cognitive demand is known as cognitive offloading [1]. The research on cognitive offloading was not paid particular attention until recently [2]. However, the importance of studying cognitive offloading arises from its prevalence in daily life (e.g., setting reminders and searching for information on the internet). The present study reviews the up-to-date studies in the field of cognitive offloading. This essay will firstly review the findings in mechanisms of cognitive offloading in order to reveal the mechanism behind reminder setting.

The role of memory capacity in cognitive offloading: main purpose but not the main reason.

One of the main purposes of cognitive offloading is to mitigate the cognitive and memory effort and to overcome the limits of cognitive capacity [1]. For example, working memory storage limits are 3 to 5 and short-term memory limits which is 5-9 items [1, 3]. Before discussing the main findings about the relationship between memory capacity and cognitive offloading, it is critical to illustrate the difference between working memory and short-term memory. The difference between working memory and short-term memory was based on the cognitive effort involved. Working memory involves information managing (e.g., delayed intention) and updating, but short-term memory only refers to the passive storage of information [4]. Thus, short-term memory is usually considered a sub-category of working memory [4].

From the working memory perspective, previous studies mainly used a paradigm involving delayed intention, as people with lower working memory were found to have difficulty fulfilling the

delayed intention [5]. The relationship between working memory and cogitative offloading was widely investigated with the paradigm created by Gilbert et al. [6]. In the paradigm, participants were required to continuously move the circles with numbers or alphabet out the different borders of a square in ascending order [6]. Every time when participants moved the number out of the square, a new number would appear with colour fading within seconds [6]. The colour of the number correspondingly matches the colour of the border. Participants needed to remember the colour so that they could match the number to the right border when the ordered number appeared [6]. The time gap between the time that the number appeared and the time that the number needed to be moved created the delayed intention. Participants were usually instructed that they could, could not or were free to use offloading strategy by moving the number to the position that was close to the border. Previous studies demonstrated the relationship between working memory and offloading behaviour. The study by Gilbert demonstrated that memory capacity predicted externalizing behaviour and performance. People with lower memory capacity were found more likely to offload [7]. When the task requires high memory demands, participants were more likely to show offloading behaviour. The same result was also found in the study by Ball et al [2]. In addition, Gilbert's study also demonstrated the benefit of cognitive offloading. The performance of participants with lower memory ability showed significant improvement when they were allowed to use offloading strategies, and there was no significant difference between participants with low memory capacity and high memory capacity.

Similar results were also found in the study of short-term memory. Previous studies present a set of letters aurally and ask the participant to recall them [8]. The size of the letter sets was 2, 4, 6, 8 and 10. Similar to the findings in the working memory, the propensity that participants chose to offload behaviour increased as the size of letter sets increased. Participants' accuracy of recalling the letter set significantly improved in the conditions allowing to use of offloading strategies.

However, in conflict with previous findings, the study of Morrison and Richmond did not find that people with poorer memory capacity benefit more from the offloading behaviour, as there was no significant improvement in performance when they used offloading strategies [9]. This could result from the fact that the study applied a short-term memory measuring paradigm which could be more easily used than the working memory measure as the study tried to replicate the finding of Risko and Dunn [1]. Therefore, based on the findings of the relationship between working memory capacity and the cognitive offloading strategy used, it could be suggested that the more working memory capacity a task demands, the more likely people would use cognitive offloading strategies.

However, this essay argues that previous studies mainly reported the desirable results corresponding to such suggestions. To be specific, in the study of Gilbert, the externalization proportion was higher in the hard trials (experiment b) than in the easy trials (experiment a) [7]. There were still 37% of participants who did not apply cognitive offloading strategies. Similarly, in the study of Risko and Dunn, even when the letter sets in size of 10, which is not within the short-term memory capacity of the human (i.e., 5 to 9 items), there were still more than 10% of participants did not show offloading behaviour [1]. By contrast, 42% of participants showed offloading behaviour in the condition with a set size of 2, even though the offloading behaviour brought no benefit (i.e., there was no difference in the recall rate between the group with writing notes and the group without notes).

Thus, such evidence disassociated the purpose and the driving factors of cognitive offloading. Although the purpose of cognitive offloading is to reduce cognitive effort, reducing cognitive effort was not the only factor affecting cognitive offloading behaviour since there were still a large proportion of participants not affected by the demand of reducing cognitive effort. In addition, previous studies lack effective measures to control the working memory load of participants. It would be hard to measure how much did the offloading behaviour benefit the performance. This essay suggests that future studies could apply the method used in the study of Hesselmann by asking participants to remember a set of numbers in size of 6 and testing their performance at the end of the experiment. The cognitive load could, therefore, be created [6]. Under such conditions, whether cognitive offloading could really benefit the participants could be revealed.

2. Metacognition: the role of confidence in offloading behaviour

Since the limit of memory capacity was not the only reason behind the offloading behaviour, this raises another question regarding what else drives the cognitive offloading behaviour. The answer could be found from the decision-making perspective as it was shown that people with lower memory capacity are more likely to choose offloading behaviour [7]. Thus, people may evaluate their own memory capacity before making a decision on whether to use reminders in the task. This evaluating process involves the factors of metacognition (i.e., the ability to reason about the mental processes and the ability of oneself) [8]. This was firstly empirically studied in the study of Gilbert [6]. The study demonstrates the influence of metacognition on offloading behaviour by using the intentional offloading paradigm. The study showed that low meta-cognition is the predictor for offloading behaviour. In addition, the study found no correlation was found between the metacognition confidence and objective ability shown in the task, which means that the two factors have their influence independently and people's meta-accuracy for the memory capacity is low [6]. This implied the disassociation between memory capacity and metacognition. However, the study also found that participants tend to be underconfident, especially when the task was hard (i.e., when the task had three targets and interruptions), which was similar to the finding of a study investigating the relationship between metacognition and prospect memory [1]. The disassociation between memory capacity and meta-cognition raised another question towards whether metacognition and memory capacity have the same effect.

3. The comparison between metacognition and memory capacity

The comparison between the effect of memory capacity and metacognition was indirectly investigated in the previous studies. This was supported by the findings in the reminder bias. In the study of Gilbert et al, an updated version of the intentional offloading paradigm was used, and participants were given choices to make the optimal decision [5]. Participants were asked to make choices between using their own memory with a high reward and using reminders with a low reward [5]. This task needs participants to evaluate the cost (the time to make a reminder) and benefit (recalling the words). It was found that people showed a consistent preference for the use of reminders in both conditions. This effect was still found even when the reward involved financial incentives. The consistent preference for using reminders is called reminder bias [6]. Furthermore, the reminder bias was predicted by participants' metacognition. The lower metacognitive confidence was strongly associated with the increasing use of reminders. Since the systematic bias was affected by metacognition, it may be suggested the superiority of the metacognitive influence. Even though an individual may have better memory capacity, cognitive offloading would still be preferred if the metacognitive confidence of the individual is low.

However, not only could the reminder bias be predicted by the metacognition, but it could also be manipulated by the metacognition. In Gilbert et al.'s study, both confidence level and task difficulty level were manipulated [5]. The confidence level was manipulated with feedback. Participants in the high confidence condition were only given positive feedback such as "Excellent work! you responded correctly to most of the special circles. "despite the real accuracy. Similarly, those in the low confidence condition were only given negative feedback such as "Space to improve" [5]. Results from four conditions were compared (difficult task- positive feedback, difficult task-negative feedback, easy task-positive feedback and difficult -negative feedback). The results found the effect of both memory demand and metacognition. The reminder bias scores were higher in the difficult condition than in the easy condition when the feedback conditions stayed are same. Similarly, the reminder bias scores were higher in the negative feedback condition compared to the positive feedback condition when the difficult conditions were the same [6]. Surprisingly, no significant difference was found between the reminder bias score between the positive feedback-difficulty task condition and the negative feedback-easy task condition. Therefore, it would not be possible to tell which factor plays a more important role in the reminder bias.

Nevertheless, even though metacognition could predict and influence reminder bias, the accurate meta-cognition would not eliminate the reminder bias. The study by Engeler and Gilbert tried to build accurate meta-cognition by using cognitive training by asking participants were asked to make a prediction of their performance and then receive feedback after the intentional offloading test [5]. The training did show the effect of eliminating metacognitive bias and retaining metacognitive accuracy, as the bias score in the training group was close to 0. Surprisingly, participants without the metacognitive bias still showed reminder bias in the following offloading task. Eliminating metacognitive bias did not have an effect on reminder bias [5]. Therefore, the effect of memory capacity demand and metacognition are independent, as there was no interaction found. However, there was no evidence to conclude the amount of influence for each factor since the reminder bias could not be eliminated by simply reducing the negative metacognitive bias. This also suggested that cognitive offloading is affected by other factors other than memory demand and metacognition.

4. Other factors contributing to offloading behaviour

4.1 Avoidance to cognitive effort

One of the critiques of previous studies is that previous studies over-focused on the outside factors affecting offloading behaviour. In other words, cognitive offloading was considered to be only passively affected by memory capacity and metacognitive confidence. Therefore, it should be questioned if cognitive offloading could be decided by people's own desires. One explanation for this perspective is that people have the tendency to avoid cognitive effort. Previous studies mainly suggested that people tend to avoid extra cognitive effort when doing cognitively demanding tasks such as decision-making [1, 9]. The study by Sachdeva and Gilbert tested effort avoidance in cognitive offloading [9]. The study tried to use monetary incentives to reduce effort avoidance. Participants in the study were asked to choose whether they would like to choose the small reward with using reminders or the large reward without using reminders. The rationale behind the design was that financial reward could raise a strong desire for people to overcome their effort avoidance tendency so that people would set fewer reminders. This is based on the finding of a previous study that providing a financial incentive is a more efficient way to make people use their cognitive effort [10]. If people's offloading behaviour is only decided by the memory capacity limitation and metacognitive confidence, no difference would be found between the condition with financial incentives and the condition without the financial incentives when the memory capacity limitation and metacognitive confidence are controlled. As expected, Sachdeva and Gilbert indeed found that when people were informed that they would be given financial rewards. Therefore, this suggested that the tendency to avoid cognitive effort is another factor influencing offloading behaviour. Memory capacity limitation and metacognitive confidence are not the only two factors affecting cognitive offloading behaviour.

However, even though it was argued that this cost-averse tendency could represent people's own intention in offloading the memory loading. However, this avoidance of cognitive effort could still be because of the limitation of the working memory capacity [4]. Because of the limited working memory capacity, there will be an extra opportunity cost (i.e., the cost incurred during switching attention) apart from the memory cost already put in the task when people try to maintain the old intention and a new intention. In other words, if the working memory is limitless, the cost of switching tasks would be too small to be counted. Therefore, although this viewpoint may suggest that people use offloading strategy because of their internal desire, in essence, it still arises from the conflict between the great cognitive demand and limited working memory capacity.

4.2 Individual differences

Different from memory capacity, metacognition is more flexible and could be affected by many factors, such as cognitive ability and personality traits [11, 12, 13]. Recently studies started to pay more attention to the relationship between individual differences and metacognition and tried to build

a bridge between personal traits and offloading behaviour through metacognition. For example, Kirk et al. tried to bridge the cognitive offloading behaviour and anxiety through metacognition as it was found that higher anxiety level was related to low metacognitive confidence [14]. However, no direct correlation was found between the two factors. However, this failed attempt does not mean that personal traits cannot contribute to cognitive offloading. The recent study of Benwell et al. successfully bridges personal traits and second-order decision making (i.e., the decision-making involving the consideration of consequence) through metacognitive confidence [15, 16]. This means it would be still possible to find that personal traits as a contributor to cognitive offloading as cognitive offloading, similar to second-order decision making, also involve the consideration of consequence. To be specific that people would consider that setting reminders would have a higher chance for them to remember the later tasks than just using their own memory.

5. Conclusion

To sum up, empirical studies showed that people use reminders could because they do not trust our own memory. This essay reviewed findings of memory capacity and metacognition which are the two main factors found to have an effect on cognitive offloading by far. Saving memory capacity and relieving cognitive demand were indeed the main purpose of cognitive offloading. However, it is not the main factor affecting offloading behaviour, as metacognitive confidence also plays an important role in offloading behaviour. The comparison between the influence of the two factors did not suggest which one is more influential. However, from the metacognitive training study, it could be confirmed that the factors affecting offloading behaviour were more than just two. As it was shown, the tendency of avoiding cognitive effort is another factor affecting the offloading behaviour. In short, people use reminders because of a lack of trust in their own memory. They are usually not confident with their own memory ability. Nevertheless, the reasons are not only limited to this. People's tendency to avoid cognitive effort and their own memory capacity should also be concerned. The new study direction should be moving forward to investigate the relationship between the factors affecting metacognition, such as personal traits and offloading behaviour, as there is little understanding of the topic, and the previous study has bridged the personal traits and decision-making through metacognition.

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