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Does delayed corrective feedback enhance acquisition of correct information?

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ABSTRACT

Many studies concerned with misinformation correction during learning report that delayed corrective feedback is superior to immediate feedback. However, the mechanism for this effect has not been confirmed. The interference-perseveration theory predicts that immediate feedback following participants' wrong responses elicits proactive interference that deteriorates acquisition of feedback information. In contrast, delayed feedback following errors leads to participants' forgetting these errors during the delay period; consequently, in the latter, interference should decline leading to superior acquisition of corrective information. However, results of these studies have been inconsistent. The present study manipulated whether initial errors were visually cued before feedback (no error-cueing, error-cueing) along with the timing of the feedback (immediate, delayed). The interference-perseveration theory predicts that when errors are not cued, delayed feedback should result in superior acquisition of correct information compared to immediate feedback. When errors are cued, proactive interference should effect a deterioration in acquisition of corrective feedback. Results confirmed neither of these predictions, thus challenging the interference-perseveration hypothesis. Moreover, additional analysis suggested that memory for errors has the ability to enhance the retention of correct answers and it does not hinder recall.

1. Introduction

Many studies have reported that corrective feedback (CF) has the ability to remedy misinformation (e.g., Butler, Karpicke, & Roediger, 2007, 2008; Butler & Roediger, 2008; Kulhavy, 1977; Kulhavy & Anderson, 1972; Metcalfe & Kornell, 2007; Metcalfe, Kornell, & Finn, 2009; Mullet, Butler, Verdin, von Borries, & Marsh, 2014; Pashler, Cepeda, Wixted, & Rohrer, 2005). However, debates surround the optimum time to provide CF (e.g., Kulik & Kulik, 1988; Mullet et al., 2014).

Behaviorism theory contends that CF should be regarded as a type of reinforcement (Skinner, 1958). Therefore, CF should be given immediately following a student's response when learning (for a review, see Renner, 1964). Some researchers recommend immediate CF as an important tool in learning (e.g., Epstein, Epstein, & Brosvic, 2001). However, laboratory experiments have repeatedly demonstrated that learning of correct information can be enhanced by delayed CF following a student's response rather than CF that is immediately provided (the delay-retention effect: DRE. e.g., Brackbill, Wagner, & Wilson, 1964; Butler et al., 2007; Butler & Roediger, 2008; English & Kinzer, 1966; Kulhavy & Anderson, 1972; More, 1969; Phye & Andre, 1989; Sassenrath & Yonge, 1968; Smith & Kimball, 2010; Sturges, 1969, 1972). Although some reviews have claimed that immediate CF is more effective than delayed CF for promotion of learning in educational settings (e.g., Hattie & Timperley, 2007; Kulik & Kulik, 1988), a recent practical study that utilized homework given to college students reported that delayed CF elevated their results on a later examination (Mullet et al., 2014).

Regarding correct responses on an initial test, the beneficial effect of delayed CF can be conceptualized in the following manner. Initially correct responses could be consolidated through spaced practice where CF given later is identical to those correct responses (Butler et al., 2007). When CF is delayed, practice on the material is spread over a period of time, whereas practice is only given once in mass when CF is provided immediately after a response (see Cepeda, Pashler, Vul, Wixted, & Rohrer, 2006). This spacing account has been supported by Smith and Kimball (2010). However, this support does not hold for initially wrong responses (e.g., Butler et al., 2007).

The interference-perseveration theory (Kulhavy, 1977; Kulhavy & Anderson, 1972) can account for the beneficial effect of

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delayed CF for correcting initially wrong responses. Kulhavy and Anderson (1972) noted that since errors committed early in learning tend to reappear later (e.g., Elley, 1966), errors made on an initial test are likely to be repeated in later trials for the same item. Additionally, they pointed out the similarity between the DRE paradigm and the proactive interference paradigm, which leads them to propose that proactive interference should also occur in the DRE paradigm. For example, in the DRE paradigm, if a participant recalls an erroneous response (B) from a cue (A), then A would become paired with B. This connection was thought to proactively interfere with the to-be-learned pair of A and C (target). Kulhavy and Anderson (1972) argued that this sequence resembles the procedural sequence in proactive interference experiments wherein a participant first learns an A-B list, then learns the A-C list later. Thus, when participants receive CF immediately after generating an error, it is likely that this error will proactively interfere with acquisition of the correct information. In contrast, the delayed CF could benefit learning because it allows learners to forget such errors during the delay interval, and this, in turn, would reduce interference. For example, in a paired-associate learning task using an A-B/A-C paradigm, a three-day separation for learning the A-B list and the A-C list markedly reduced proactive interference (Underwood & Freund, 1968). In fact, in a study with a multiple-choice test, the proportion of initial errors correctly identified at the time of CF was higher for immediate CF than for delayed CF (Kulhavy & Anderson, 1972; see also Phye & Andre, 1989). Moreover, a body of research exists in which the proportion of initial errors that were corrected on the final test was greater for the delayed CF condition than for the immediate CF condition, a result supporting the interference-perseveration account (Kulhavy, 1977; Kulhavy & Anderson, 1972; Phye & Andre, 1989; Sassenrath, 1975; Surber & Anderson, 1975).

On the other hand, there is evidence inconsistent with the interference-perseveration hypothesis. In Smith and Kimball (2010), although initial errors should be more likely to be repeated in a final test for the immediate CF than for the delayed CF, this prediction was not confirmed. Moreover, also observed was a non-significant effect of timing of CF related to the proportion of initial errors that were corrected on a retest one week later. In addition, it has repeatedly been demonstrated that error generation can enhance the learning of corrective feedback information. For example, studies using a paired-associate learning task have demonstrated that when participants estimate a hidden target based on a cue, an erroneous response could enhance the learning of corrective feedback compared to only reading an intact pair (e.g., Grimaldi & Karpicke, 2012; Huelser & Metcalfe, 2012; Izawa, 1970; Kornell, Hays, & Bjork, 2009; Slamecka & Fevreiski, 1983; see also, Metcalfe, 2017; Metcalfe & Xu, in press; Richland, Kornell, & Kao, 2009). Furthermore, Butler, Fazio, and Marsh (2011) reported a phenomenon suggesting that memory for previously generated errors could potentiate the memory for corrective feedback. In the experiment by Butler et al. (2011), participants responded to general knowledge questions, provided a confidence rating for the correctness of each response, and received the correct answers. The results revealed that initial errors were more likely to be corrected when participants were able to recall their errors on the final test than when they were not (but see Metcalfe & Miele, 2014). Butler et al. (2011) suggested the possibility that memory for errors helps error correction. Therefore, it has been unclear whether the interference-perseveration hypothesis, which assumes proactive interference could account for error correction involved in the DRE.

In terms of the retention interval between CF and a final test, various time periods have been investigated (see Kulik & Kulik, 1988). A final test conducted immediately after CF is known as an immediate retention test, whereas a final test implemented some time (e.g., 1 day) after CF is called a delayed retention test. The former is a test for measuring *acquisition* or *encoding* of feedback information, whereas the latter is a test for measuring *retention* of information (e.g., More, 1969; Phye & Andre, 1989; Sturges, 1969). In laboratory experiments, a superior retention effect of delayed CF over immediate CF has been reliably observed (see Kulik & Kulik, 1988). However, our concern is whether the interference-perseveration theory properly predicts the results of an immediate retention test that measures the acquisition of information rather than retention. The interference-perseveration theory posits that the representation of initial errors interferes with the acquisition of CF information (Kulhavy, 1977; Kulhavy & Anderson, 1972). Therefore, the advantage of delayed CF should occur on an immediate retention test as well as on a delayed retention test. However, previous results have been inconsistent; some studies reported beneficial effects of delayed CF (More, 1969; Sturges, 1972), whereas studies have failed to observe such an effect (Sassenrath & Yonge, 1968, 1969; Sturges, 1969). In the latter studies, a ceiling effect may be responsible for the immediate retention test, as Sturges (1969) discussed.

The purpose of our present study is to test the interference-perseveration theory of Kulhavy and Anderson (1972) by using an immediate retention test. Given that participants may forget their initial errors during a delay interval, as this theory assumes, then the recall rate for those errors when CF was given should be lower for delayed CF than for immediate CF. This prediction was observed by Kulhavy and Anderson (1972). However, perseverance of errors was measured as only a dependent variable but has not been directly manipulated as an independent variable. The present study, therefore, manipulated whether the initial errors were visually presented before CF, and participants were asked to recall their errors at the time of the immediate retention test rather than when CF was given.

The present study used a vocabulary learning task that is compulsory in the Japanese school system. The Japanese language has two types of scripts: syllabic *Kana* (either Katakana or Hiragana) and logographic *Kanji*. Kana has virtually no spelling-to-sound irregularities because each Kana character corresponds to a single phonological pronunciation. Japanese words that are composed of Kanji characters (Chinese ideograms), however, can be read in at least two different ways: kun-reading (the native Japanese reading of the character) and on-reading (the reading derived from Chinese). Because most Kanji characters do not correspond to a single pronunciation, Kanji is considered an orthography in which spelling-to-sound correspondences are arbitrary. Moreover, there are a number of cases where Japanese people have learned Kanji words incorrectly, while at the same time others did not always correct those errors unless they interfered with communication. In sum, most Japanese people have learned and used incorrect readings of certain Kanji words. A study with college students reported that the proportion of initial errors corrected by feedback was around 60% on an immediate retention test, indicating no ceiling effect (Iwaki, Matsushima, & Kodaira, 2013).

According to the interference-perseveration hypothesis, in the immediate CF condition, as the representation of an error is kept (i.e. perseverates) in working memory, the representation should proactively interfere with making the connection between a cue and the counterpart (correct answer). Alternatively, in the delayed CF condition the interference should be unlikely to occur due to forgetting the errors. This is a situation where an error representation could not be uploaded into participants' working memory from their long-term memory, consequently not interfering with connecting a cue with its target. The critical factor is whether an error representation connected with a cue is in participants' working memory during learning a correct answer. Therefore, if the interference-perseveration hypothesis is correct, the manipulation of providing participants with their self-generated errors immediately before CF should cause proactive interference to occur for the delayed CF condition as well as for the immediate CF condition. This study then manipulated visual cues of initial errors (i.e., whether these errors were shown to participants) as an independent variable along with the timing of CF. If the visual cueing of errors before CF promotes participants' recall (i.e. upload in working memory) of those errors that have been forgotten during a delay period, then proactive interference should revive and strengthen the errors. This is the case for