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Metacognitive control of the spacing of study repetitions ☆

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Abstract

Rememberers play an active role in learning, not only by committing material more or less faithfully to memory, but also by selecting judicious study strategies (or not). In three experiments, subjects chose whether to mass or space the second presentation of to-be-learned paired-associate terms that were either normatively difficult or easy to remember, under the constraint that subjects needed to space exactly half of the items (and mass the other half). In contrast with recent findings that implemented no such constraint (Son, 2004), subjects chose to space more of the difficult pairs (in Experiments 1 and 2). Reduction in exposure time eliminated but did not reverse this effect (Experiment 3). Subjects who spaced more of the difficult pairs were more likely to exhibit superior memory performance, but, because subjects who made spacing selections that had no effect on the actual scheduling of items also showed this effect (Experiment 2), that enhancement in performance is more likely to reflect subject selection than strategy efficacy. Overall, these results suggest that choice constraints strongly elicit a discrepancy-reduction approach (Dunlosky & Hertzog, 1998) to strategic decision-making, but that reduced study time can eliminate this effect.

Keywords: Memory; Metamemory; Judgments of learning; Spacing effect; Self-regulated study

The question of how people use their metacognitive knowledge to regulate their behaviors has been of much interest in recent years, particularly with regard to the implementation of study strategies. Metacognition plays an integral role in tasks such as self-directed learning (Koriat & Goldsmith, 1996; Nelson & Narens, 1990), and understanding the means by which metacognitions guide learning processes is essential to facilitate and optimize the learning process itself (see Bjork, 1994).

This article pursues that question by examining the strategies that subjects employ in the scheduling of learning events. Recent evidence revealed conditions under which subjects prefer to space easier materials and mass more difficult ones (Son, 2004). That result is fascinating because it either reveals that subjects choose to apply more effective study conditions to easier materials—a result in conflict with the vast majority of findings from study-time allocation experiments—or it reveals a fundamental misappreciation of the greater effectiveness of spacing in promoting learning (e.g., Baddeley & Longman, 1978). However, the present experiments reveal the opposite effect—subjects choose to space difficult and mass easy items. These results thus

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suggest that, under some conditions, subjects do understand the beneficial effects of spacing and also choose to selectively utilize them with difficult materials.

Self-regulation of learning

Theories of self-regulated study claim that active learners use assessments of item difficulty and their own degree of learning in deciding whether to allocate further cognitive resources toward study of that item or to move on to other items (e.g., Dunlosky & Hertzog, 1998; Mazzoni, Cornoldi, & Marchitelli, 1990; Metcalfe, 2002; Nelson & Leonesio, 1988; Nelson & Narens, 1990; Thiede & Dunlosky, 1999). There is some debate, however, with regard to *how* difficulty and resource allocation—specifically, study time allotment—are related.

Discrepancy reduction

One theory emphasizes a discrepancy-reduction mechanism (Dunlosky & Hertzog, 1998). According to this theory, the learner compares their perceived degree of learning of a to-be-learned item to the their desired level of mastery for that item, also known as the norm of study (Le Ny, Denhiere, & Le Taillanter, 1972; see also Nelson & Narens, 1990), and if the degree of learning does not reach that criterion, additional study of that item ensues. Therefore, in reducing the discrepancy between an item's current and desired degree of learning, the model predicts an inverse relationship between the perceived (prior) degree of learning and study time, and hence suggests that people will allot more study time to judged-difficult than judged-easy items (Dunlosky & Hertzog, 1998; see also Thiede & Dunlosky, 1999).

Indeed, a multitude of experiments have shown that people tend to study more difficult items for longer than they study easier items. In a comprehensive review, Son and Metcalfe (2000) reported that, of 46 treatment combinations in 19 published experiments in which subjects controlled the allocation of study time, 35 revealed a strategy of devoting more time to difficult items, and none showed the opposite strategy of devoting more time to easy items. These studies included subjective as well as objective measures of difficulty, and the results were consistently found across age groups and study materials.

Proximal learning

However, Son and Metcalfe (2000) showed that total time constraints caused subjects to apportion more study time to judged-easy items than to judged-difficult items. That is, when the total study time allotted was likely insufficient to master all items, subjects chose to allocate their limited time to items that individually take less time to master, rather than slowly learn fewer difficult items. Similarly, Thiede and Dunlosky (1999) found that if their task was to remember only a small portion of the to-be-learned items, rather than the full set, subjects devoted more study time to easy items.

Metcalfe (2002) surmised that the discrepancy-reduction model adequately accounted for subjects' allocation strategies only under certain conditions, and forwarded a more comprehensive model to incorporate the newer data. She argued that study time should be devoted to those items that are just beyond the current grasp of the individual, in the region of *proximal learning* (Metcalfe, 2002; see also Metcalfe & Kornell, 2003). In the case that those just-unlearned items are the most difficult to-be-learned items, the discrepancy-reduction and region of proximal learning models agree on what the appropriate strategy should be. However, in cases where easy items are still unlearned, the predictions of the two theories are in opposition.

Whereas the discrepancy-reduction model suggests that learners will always devote more time to the difficult items, the proximal learning hypothesis implies that individual differences in expertise within a domain should influence study-time allocation. Metcalfe (2002) demonstrated this effect using English-Spanish vocabulary pairs. To monolingual speakers, even relatively easy items can be difficult to learn, and thus those speakers allocated more study time to those easy pairs accordingly. Experts, on the other hand, spent more time studying the difficult word pairs, and Metcalfe (2002) attributed the group differences in item selection to the difference between the two groups' regions of proximal learning. Novices chose to spend more time studying the easy, yet still unlearned, items before moving on to more difficult items, a result that is not predicted by the discrepancy-reduction model.

Effects of strategy choice

In addition to identifying the strategies used in allocating study time, determining which strategy ultimately leads to superior performance on subsequent recall tests is of importance as well. The actual quality of any study strategy, after all, can only be evaluated by the outcome it produces on the subsequent test. As Son and Metcalfe (2000) pointed out, even though much of the previous literature suggests a tendency for subjects to study the difficult items for longer than the easy items, there are no data showing that subjects who employ such a strategy outperform subjects who spend equal amounts of time on easy and difficult items. While it is intuitive that increased duration of study should lead to higher recall performance for any given item, previous findings have suggested that once study time for an item has been sufficient for initial acquisition, continued immediate study of that item leads to little or no increase in the probabil-