1 Introduction

Juxtaposed to the well established finding that recalling learned material, compared to merely restudying it, facilitates its long-term retention (Adesope, Trevisan, & Sundararajan, 2017; Glover, 1989; Roediger III & Butler, 2011; Roediger III & Karpicke, 2006a, 2006b; Rowland, 2014) stand the results of a number of studies showing that retrieving previously studied information can even facilitate the acquisition of information that is yet to be learned (Chan, Meissner, & Davis, 2018; Yang, Potts, & Shanks, 2018). This has stimulated the use of various qualifiers such as *interim* (Wissman, Rawson, & Pyc, 2011), *interpolated* (Szpunar, Khan, & Schacter, 2013), and *forward* (Pastötter & Bäuml, 2014; Yang et al., 2018), in order to distinguish the latter testing effect from the former, now sometimes referred to as the *backward* testing effect (e.g Yang et al., 2018).

A typical demonstration of test-potentiated learning entails an initial learning phase, followed by a period during which participants either restudy the same material, engage in a memory test involving the studied material, or are not exposed to the original material at all. Finally, after a retention interval, an additional administration of a memory test reveals that the group subjected to a memory test during the intervening period has a distinct advantage over the other two groups. In one of the earliest studies showing the effect of test-potentiated new learning, Darley and Murdock (1971) observed that, when recalling studied lists of words, participants systematically produce more prior-list intrusions when probed for a given list, if their memory of a prior list had not been tested before proceeding to study the given list.

After a considerable period of silence on the topic, building on these results, Szpunar, McDermott, and Roediger (2008) told their subjects to study five lists of items in anticipation of a final cumulative test. All subjects were tested immediately after studying the final list, but they engaged in differing intermittent activities between studying the first four lists. One group was tested on each list after studying it, another group restudied each list, and a third group completed a mathematical distractor task. Participants whose memory was tested after each list produced more correct responses and fewer prior-list intrusions on the immediate test administered after studying the last list. They explained the found benefit of testing in terms of a segregation mechanism that prevents overburdening of retrieval cues, which, in the absence of testing, causes a build-up of proactive interference.

Building on these results, Szpunar et al. (2008) told their subjects to study five lists of items in anticipation of a final cumulative test. All subjects were tested immediately after studying the final list, but they engaged in differing intermittent activities between studying the first four lists. One group was tested on each list after studying it, another group restudied each list, and a third group completed a mathematical distractor task. Compared to the groups that were not tested after each list, the one that was tested recalled more items from the last list and showed fewer prior-list intrusions. The following decade has seen a rise in interest in test-potentiated new learning (Chan, Meissner, & Davis, 2018; Pastötter & Bäuml, 2014; Yang et al., 2018), with studies attempting to delineate the scope of the effect with respect to various moderating variables: the type of study materials, varieties of study designs, and populations, to name but a few.

1.1   Theoretical overview

Recently, Chan, Meissner, and Davis (2018) provided a meta-analytic analysis and comprehensive overview of the literature, identifying four *nonconflicting* theoretical frameworks which were put forth throughout the years as viable explanations. *Resource theories* generally posit that testing increases cognitive resources, but they propose different mechanisms by which this is achieved: (1) proactive interference reduction (e.g. Nunes & Weinstein, 2012; Szpunar et al., 2008; Wahlheim, 2015; Weinstein, McDermott, & Szpunar, 2011), (2) restoration of encoding/attentional resources (e.g. Pastötter, Schicker, Niedernhuber, & Bäuml, 2011), or (3) alteration of mind wandering patterns (e.g. Jing, Szpunar, & Schacter, 2016; Szpunar, Khan, & Schacter, 2013; Szpunar, Moulton, & Schacter, 2013). Whereas resource theories focus on the amount of deployable cognitive resources, *metacognitive theories* emphasise the optimisation of encoding strategies induced by retrieval attempts (e.g. Chan, Manley, Davis, & Szpunar, 2018; Cho, Neely, Crocco, & Vitrano, 2017). For example, in a recent investigation, Chan, Manley, et al. (2018) found that, compared to untested groups, the group whose memory for the first three word lists was subjected to interpolated testing displayed superior semantic organisation across lists.

The key idea underlying *context theories* is that, apart from storing the studied information per se, people store the related contextual information as well (e.g. Lehman, Smith, & Karpicke, 2014). The accessibility of this contextual information can affect the likelihood of successful retrieval of

information that is to be committed to memory. Furthermore, the claim is that, unlike restudying, attempting retrieval causes an internal context change relative to the study context (e.g. one may engage a retrieval mode), and recalled items may be updated with contextual information from the retrieval attempt, while newly encountered information is still associated only with the study context. Thus, recalling new-learning items is limited to only those items associated exclusively with the study context, providing them with the advantage observed upon testing. While this veritable circumscription of separate learning episodes is at the core of both resource and context accounts, its effect on learning is supposedly different. According to the former, isolating a learning episode through attempts at recall increases resources for subsequent learning by preventing *encoding-based* proactive interference. On the other hand, the latter place the emphasis on later *retrieval* processes, whereby isolating an earlier learning episode reduces the memory search set. Finally, *integration theories* advance the notion that the new-learning material is better integrated either with its retrieval cues or with the original-learning material.

In this study we sought to examine the influence of one proposed moderating variables, and to pitch two contending theoretical overviews against each other.

1.2 Nonepisodic recall

1.3 Feedback

1.4 Notes

According to current theories of testing, an initial test will directly benefit retention to the extent that it engages those effortful retrieval processes that will likely be called upon at the time of a later test Roediger III and Karpicke (2006a)

The expectation of a final test ensured the continued processing of materials across the study sequence.

A number of investigations employed nonepisodic recall as the format of the intermittent testing activity Divis and Benjamin (2014); Pastötter et al. (2011); **?**

Za feedback gle u Roediger i Butler (2011)

Chan et al. (2018): For example, in a multilist learning environment, having taken a recent memory test increases learners' expectation that they will again be tested in the immediate future, even when they are told that whether a test will follow each study list is determined randomly (Weinstein et al., 2014). Such test expectancies have been shown to significantly influence how participants approach

Chan et al. (2018). across a retention interval In contrast to unrelated word lists, text passages and videos are typically written/produced in a coherent manner, which should naturally invite relational processing, so any relational processing advantage induced by prior testing is likely to be modest relative to of the strategy change account that is not tied strictly to relational processing, however, may provide a reasonable explanation for the TPNL effect with text passages and videos. In a broader sense, the strategy change account specifies that performing retrieval practice allows participants to discover the type of learning needed to ensure satisfactory performance (or conversely, to realize the type of learning that is inadequate to produce satisfactory performance, if participants are performing poorly during retrieval practice), and participants can then adjust their subsequent encoding strategy accordingly. If we take this broader approach to strategy change, then this account can explain the TPNL effect with prose/video materials. However, we realize that the idea that "retrieval practice can improve later encoding strategies" is perhaps vaguely defined. In fact, such a broad definition of strategy change may render the account difficult to falsify. With this in mind, we believe that the strategy change account, as we currently conceive, should only be applied to explain the TPNL effect with word list type materials, for which advantageous encoding strategies can be more precisely defined (but see Jing et al., 2016 in which interspersed testing improved conceptual integration of materials across sections of a video lecture). In our opinion, application of this account to prose/video material should only be done when one clearly outlines what is considered an advantageous encoding strategy so that the hypothesis can be adequately tested.

Možda ZV intruzori nije pokazala razlike između skupina jer smo koristili recognition, a ne free recall.

2   Methods

These are the methods.

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