



## Remind me of the context: Memory and metacognition at restudy

Katarzyna Zawadzka<sup>a,\*</sup>, Nicola Simkiss<sup>b</sup>, Maciej Hanczakowski<sup>c</sup>

<sup>a</sup> Department of Psychology, University of Sheffield, UK

<sup>b</sup> School of Psychology, Cardiff University, UK

<sup>c</sup> Tenczynek, Poland



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### ABSTRACT

Mastering study materials often requires repeated learning. However, the strategy of restudying the same materials has been criticized for not giving sufficient opportunity for retrieval in the form of self-assessments that are known to benefit not only learning but also metacognitive monitoring of the learning process. Here we focus on the contribution of spontaneous retrieval in the form of reminding to repeated learning that does not require explicit self-assessments. By manipulating environmental context in which restudy takes place, we demonstrate that repeated learning in the same environmental context increases the incidence of reminding, augmenting learning and influencing metacognitive monitoring (as tapped into by immediate judgments of learning). At the same time, we demonstrate that explicit self-assessments – delayed judgments of learning – can be led astray by non-diagnostic spurious familiarity of environmental context which accompanies these assessments. The study thus reveals the positive effects of environmental context on restudy, while highlighting possible inaccuracies of metacognitive processes involved in explicit self-assessments of learning.

### Introduction

Learning often involves multiple study repetitions of the same materials. Whenever students face the task of learning a certain body of material, they are likely to keep studying these materials until they reach a certain level of mastery (Dunlosky & Thiede, 1998; Thiede & Dunlosky, 1999). Although more effective strategies of learning do exist, such as interleaving study episodes with testing (Rawson & Dunlosky, 2011; Roediger & Karpicke, 2006; Rowland, 2014), research on metacognitive control of study indicates that people prefer repeated study rather than repeated retrieval as the means of learning (Karpicke, 2009; Tullis, Finley, & Benjamin, 2013). The fact that people seem to undervalue the benefits of retrieval does not mean, however, that retrieval remains irrelevant to repeated study. Indeed, a growing body of recent work shows that even when no retrieval is explicitly required during learning, presenting the same or related materials for repeated study can remind the learners of the previous study episodes (Hintzman, 2011; Jacoby, Wahlheim, & Kelley, 2015; Putnam, Sungkhasettee, & Roediger, 2016; Tullis, Benjamin, & Ross, 2014; Wahlheim & Jacoby, 2013; Wahlheim, Maddox, & Jacoby, 2014). In other words, retrieval in the form of reminding seems to be strongly involved in repeated study. Importantly, just as explicit retrieval can augment subsequent memory performance, the benefits of reminding for future memory have also been demonstrated (e.g., Aue, Criss, &

Novak, 2017; Tullis et al., 2014; see also Hintzman, 2004, for a discussion). The present study is concerned with such retrieval at restudy and it investigates the role of environmental context in shaping reminding. It does so by examining both memory and metacognitive effects of repeated encoding in constant or varied environmental context.

#### *Reminding in metacognition and memory*

Efficient learning requires not only effective encoding strategies, but also accurate monitoring of the learning process itself. In order to decide which items should be studied (e.g., Ariel, Dunlosky, & Bailey, 2009; Hanczakowski, Zawadzka, & Cockcroft-McKay, 2014; Metcalfe & Kornell, 2005), how to schedule the study sessions (e.g., Benjamin & Bird, 2006; Son, 2004), or simply when to terminate study of a given item (e.g., Mazzoni & Cornoldi, 1993; Tullis & Benjamin, 2011), one needs to have some appreciation of how well encoded these items are. For this reason, much research conducted in recent years has focused on metacognitive aspects of learning. Two strands of research can be discerned. In one strand, the accuracy of metacognitive assessments of learning, as measured by the indices of resolution and calibration under varying conditions (see Higham, Zawadzka, & Hanczakowski, 2016, for a discussion), is directly examined. In the second strand, the bases of metacognitive judgments are pursued, with a particular focus on whether the same cues that inform metacognitive assessments of learning

\* Corresponding author at: Department of Psychology, University of Sheffield, Cathedral Court, 1 Vicar Lane, Sheffield S1 2LT, UK.  
E-mail addresses: [k.zawadzka@sheffield.ac.uk](mailto:k.zawadzka@sheffield.ac.uk) (K. Zawadzka), [maciej.hanczakowski@gmail.com](mailto:maciej.hanczakowski@gmail.com) (M. Hanczakowski).

also shape the effectiveness of the learning process itself (see Besken, 2016; Undorf & Zander, 2017; Yang, Potts, & Shanks, 2017, for recent examples). The main focus of the present study is on the latter issue of the type of cues that shape metacognitive judgments and their diagnosticity in predicting learning.

In a typical experiment concerning the bases of metacognitive assessments of learning, participants are given cue-target pairs of words to study and asked to provide for each pair a judgment of learning (JOL) which is a prospective confidence judgment concerning subsequent cued-recall performance (Hanczakowski, Zawadzka, Pasek, & Higham, 2013; Zawadzka & Higham, 2015, 2016). If JOLs are collected just after the presentation of a study item, they are sometimes referred to as immediate JOLs, in contrast to delayed JOLs elicited after the whole study phase is finished, with individual cues being presented again for metacognitive assessment of future target retrievability. While immediate JOLs tap into metacognitive appraisal of learning in the presence of to-be-mastered materials, delayed JOLs, commonly elicited when to-be-mastered materials are incomplete, are often assumed to tap into metacognitive appraisals of retrieval. Given that the focus of the present paper is on (re)study, we are chiefly concerned with immediate JOLs, although we do examine delayed JOLs in our final experiment.<sup>1</sup>

In experiments on metacognitive monitoring of encoding, a set of conditions is manipulated during study – most often in a within-participants design – and the impact of the manipulation on JOLs and subsequent memory performance is assessed. The major question is whether the manipulation has the same effect on metacognitive assessments and memory performance, or, in other words, whether JOLs are based on diagnostic cues. For example, Rhodes and Castel (2008) conducted experiments looking at whether JOLs depend on the size of a font in which to-be-remembered items are presented. They found that JOLs were indeed higher for words displayed in a larger font, although this manipulation had no effect on the final memory performance (but see Luna, Martín-Luengo, & Albuquerque, 2017). The font size as investigated by Rhodes and Castel was thus a *non-diagnostic cue* for JOLs.

A variety of factors shaping participants' JOLs have been described (see Rhodes, 2016, for a recent review), ranging from the fluency of perceptual processing of study materials (e.g., Besken & Mulligan, 2014; Undorf, Zimdahl, & Bernstein, 2017), or auditory distraction accompanying study (Hanczakowski, Beaman, & Jones, 2017), to the required mode of processing for the study materials, including testing (e.g., Karpicke, 2009; Kornell & Rhodes, 2013) or generation (e.g., Yang et al., 2017). However, what links the vast majority of the studies concerning the bases of JOLs is that they often focus on JOLs given to materials studied only once. Koriat (1997) proposed that the bases of JOLs given to materials studied once may differ substantially from JOLs given to materials studied repeatedly. For materials studied once, the bases of JOLs seem to be limited to the features of the to-be-remembered items such as ease of processing, often manipulated via changes in perceptual appearance of the studied items (e.g., Rhodes & Castel, 2008; Sungkhasettee, Friedman, & Castel, 2011; Yue, Castel, & Bjork, 2013) or the semantic relatedness of the to-be-remembered pairs of words (e.g., Dunlosky & Matvey, 2001). For materials studied repeatedly, which, arguably, is the way in which most students approach the learning task, the bases of JOLs seem to shift towards mnemonic cues which include phenomenal experiences associated with retrieval from memory, such as recollection of contextual details, ease of retrieval, or overall familiarity of the to-be-remembered materials.

One of the mnemonic cues affecting JOLs is the previous retrieval status of the studied information. Studies on JOLs given at restudy consistently reveal higher JOLs for information successfully retrieved in the previous tests (e.g., Finn & Metcalfe, 2008; Serra & Ariel, 2014),

indicating that memory for successful versus unsuccessful retrieval serves as a mnemonic cue for JOLs. However, retrieval can take place not only when explicitly cued by an experimenter in a memory test. Research on the dynamics of encoding has revealed that when the same, or strongly related, stimuli are presented repeatedly for study, later presentations can trigger spontaneous retrieval of previous presentations (e.g., Benjamin & Tullis, 2010; Tullis et al., 2014; Wahlheim & Jacoby, 2013). Such study-phase retrieval, referred to often as reminding, has been shown to lead to a number of mnemonic consequences, including better memory performance for repeated stimuli (Aue et al., 2017), the ability to accurately judge spacing between presentations of repeated stimuli (Hintzman, Summers, & Block, 1975), or to accurately judge the number of repetitions of the same stimulus (Hintzman, 2004). Here we focus on metacognitive consequences of reminding, hypothesizing that if memory for previous retrieval affects JOLs made at restudy, then the direct experience of retrieval occurring when the same information is restudied – reminding – should also influence JOLs.

There is indeed initial evidence for JOLs being affected by reminding. In a study by Tullis et al. (2014, Experiment 3B), reminding was examined by the presentation of semantically related vs. unrelated words in the study list, under the assumption that presentation of an item during study triggers reminding of previously studied semantically related items. Tullis et al. supplemented their procedure with immediate JOLs and revealed that the presentation of an item for study not only boosts subsequent recall performance for the previously studied related item – a result of this related item being covertly retrieved when its associate is presented – but it also increases JOLs for items which trigger reminding.

The signature of the reminding effect is that the items of which one is reminded during study are subsequently better recalled (Tullis et al., 2014; cf. Benjamin & Tullis, 2010). This remains consistent with the vast literature on the benefits of retrieval for memory (e.g., Karpicke, 2009; Kornell, Bjork, & Garcia, 2011; Whiffen & Karpicke, 2017). If reminding also affects JOLs, then this points to one possible reason why metacognitive assessments at restudy can correspond to subsequent memory performance: the same factor of reminding governs both the magnitude of JOLs and the effectiveness of restudy. In other words, the presence versus absence of reminding is a likely candidate for a diagnostic cue for JOLs, at least when one is reminded of the presentation of the same item one tries to master.<sup>2</sup>

One of the questions assessed in the present study is whether increasing the likelihood of reminding during restudy leads to increased JOLs, reflecting benefits of reminding for subsequent memory performance. We predict here that more instances of reminding will lead to increased JOLs due to greater subjective memorability of items for which retrieval of the previous study occurrence is elicited. This question is important for our understanding of metacognitive processes as built on mnemonic cues arising from feedback coming from the core processes of encoding and retrieval (Koriat, 1993, 1995; Koriat, Ma'ayan, & Nussinson, 2006). However, the effect of reminding on JOLs is also of interest for another reason. Current studies of reminding focus almost exclusively on the consequences of retrieval for subsequent memory performance. These studies demonstrate that reminding leads to benefits in a subsequent memory test because retrieval of previous episodes strengthens the memory for these episodes (e.g., Aue et al., 2017; Hintzman, 2004; Jacoby et al., 2015). Such recursive reminding, while obviously important, requires, however, inferring the dynamics of reminding from the processes occurring at a different time – during the final memory test. As we have argued elsewhere (Hanczakowski,

<sup>1</sup> For brevity and convenience, whenever the term 'JOL' is used in the present manuscript on its own, it refers to an immediate JOL.

<sup>2</sup> In the study by Tullis et al. (2014, Experiment 3B), which used semantically related items rather than repeated presentation of the same items, JOLs were higher for items that triggered reminding but subsequent performance was higher only for items that were covertly retrieved, with a recall benefit for items that triggered reminding being only marginally significant.

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