Remind me of the context: Memory and metacognition at restudy

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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 retrieval processes to repeated learning that does not include explicit self-assessments. By manipulating environmental context in which restudy takes place, we demonstrate that repeated learning in the same environmental context augments both learning and metacognitive monitoring (as tapped into by immediate judgments of learning). These benefits arise because reinstated context facilitates spontaneous retrieval during learning in the form of recollection of previous study opportunities. 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 and metacognitive monitoring of restudy, while highlighting possible inaccuracies of metacognitive processes involved in explicit self-assessments of learning.

Keywords: Judgments of learning, Reminding, Context, Memory

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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). 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, where the basis of people's assessments of the effectiveness of the learning process is examined. In a typical experiment, participants are given pairs of words to study and after each pair is presented, they are asked to provide judgments of learning (JOLs) which are prospective confidence judgments for subsequent cued-recall performance (Hanczakowski, Zawadzka, Pasek, & Higham, 2013; Zawadzka & Higham, 2015, 2016). The major question is then what determines the magnitude of JOLs and how accurately JOLs reflect the factors that in fact shape subsequent memory performance – the question of diagnosticity of the cues shaping metacognitive monitoring of learning. To the extent to which JOLs are based on diagnostic cues, these judgments accurately predict subsequent memory performance for given materials and thus allow for exerting efficient metacognitive control over the learning process.

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 these 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, Potts, & Shanks, 2017). However, what links the vast majority of the studies concerning the basis of JOLs is that they often focus on JOLs given to materials studied only once.[1] Koriat (1997) proposed that the basis of JOLs given to materials studied once may differ substantially from JOLs given to materials studied repeatedly. For materials studied once, the basis 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,

[1] One notable exception to this pattern is the literature on so-called knowledge updating, where participants are first exposed to a certain manipulation affecting study but leaving metacognitive monitoring of study unaffected, then given a memory test revealing the effect of the study manipulation, and finally given another cycle of learning to assess whether the experience of a change in memory performance leads to more accurate monitoring for new learning (see Mueller, Dunlosky, & Tauber, 2015, for a recent review). However, knowledge updating is usually assessed with a set of novel rather than restudied materials.

& 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 basis of JOLs seems 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. Reminding refers to retrieval of previously studied items which occurs in the course of learning rather than in response to a memory testing situation. If memory for previous retrieval generally affects JOLs made at restudy, then the direct experience of retrieval occurring when the same information is restudied should also influence JOLs. Furthermore, 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: retrieval benefits memory more than re-exposure to the same items unaccompanied by retrieval from memory (e.g., Karpicke, 2009; Kornell et al., 2011). If reminding also affects JOLs, then this points to one possible source of the accuracy of metacognitive monitoring of restudy: the same factor of reminding governing both the magnitude of JOLs and the effectiveness of restudy, as evidenced by subsequent benefits to memory for reminded information. In other words, the presence versus absence of reminding is a likely candidate for a diagnostic cue for JOLs.

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. 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 of interest also 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; 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 a final memory test. As we have argued elsewhere (Hanczakowski, Zawadzka, & Coote, 2014), metacognition can serve as a probe into memory processes that are not always easily tapped into by memory tests. If reminding affects JOLs made at restudy, then this would provide an opportunity for examining the process of reminding when it develops – during repeated learning. It would thus provide means for a direct examination of the determinants of reminding.

For now, the focus of studies on reminding has been firmly placed on *recollection* of previous study episodes – instances of retrieval accompanied by access to contextual information accompanying encoding (cf. Benjamin & Tullis, 2010; Hintzman, 2011). This has been inevitable insofar as evidence for reminding was gathered from the benefits to subsequent memory. Current research suggests that retrieval benefits subsequent memory precisely because it leads to access to contextual information that accompanied study (Lehman, Smith, & Karpicke, 2014; Whiffen & Karpicke, in press). However, as suggested by dual-process theories of memory (e.g., Mandler, 1980, Yonelinas, 2002), recollection is only one of the modes of memory retrieval, the other being the more automatic process of familiarity, occurring without access to the context of encoding. Another question addressed in the present study concerns the possible effects of variations in the feeling of familiarity at restudy. For variations in familiarity of restudied materials, no effects on subsequent memory performance are expected. Whereas recollections can serve to strengthen memory

information via mechanisms responsible for the commonly observed benefits of testing (e.g., Kornell, Bjork, & Garcia, 2011; Roediger & Karpicke, 2006), slight variations in episodic familiarity for generally familiar materials such as words are unlikely to affect the effectiveness of learning (but see Reder, Liu, Keinath, & Popov, 2016, for evidence that learning can be affected by pronounced differences in familiarity). This does not mean, however, that variations in familiarity at restudy should remain without an effect on the learning process, as changes in familiarity can also affect metacognitive monitoring of learning. Familiarity is generally known to affect metacognitive processes (e.g., Hanczakowski, Pasek, Zawadzka, & Mazzoni, 2013; Koriat & Levy-Sadot, 2001; Reder & Ritter, 1992; Schwartz & Metcalfe, 1992) and thus this automatic form of retrieval at restudy can lead to increased JOLs, a hypothesis also assessed in the present study.

To summarize the logic presented so far, here we investigate how different modes of retrieval – recollection and familiarity – contribute to repeated learning. We assess how changes in recollection and familiarity affect the effectiveness of restudying the same materials. Following previous studies on reminding, we do this by examining final memory performance. We expect recollection to aid learning, resulting in facilitated retrieval in a final memory test, and familiarity to exert no influence on the effectiveness of restudy. Crucially, we gain additional leverage on the processes occurring at restudy by examining JOLs. We expect increased recollection to translate into higher JOLs. This is because we assume that recollection is a mnemonic cue for JOLs that can be described as diagnostic – the same processes that shape JOLs should also affect the effectiveness of learning as assessed in a final memory test. On the other hand, we expect also increased familiarity to affect JOLs while having no effect on the effectiveness of learning. In other words, we assume that the mnemonic cue of familiarity is a non-diagnostic basis of JOLs, creating an illusion that learning is more effective when restudied materials seem more familiar.

Reminding in context

At the core of the present study lies a manipulation of environmental context used to vary both recollection and familiarity at restudy. Variations in environmental context have long been

used to examine the dynamics of retrieval (see Smith & Vela, 2001, for a review). It has been repeatedly shown that preserving the same environmental context from encoding to retrieval – i.e., context reinstatement – affects the effectiveness of retrieval, with the contextual match condition augmenting memory performance as compared to a condition in which such a match is not preserved (Godden & Baddeley, 1975; Smith, 1979; Smith & Manzano, 2010). Indeed, the idea of context-dependent memory is now central to theorizing about memory, with a wide variety of memory phenomena, ranging from the testing effect (Lehman et al., 2014; Whiffen & Karpicke, in press) to retrieval-induced forgetting (Jonker, Seli, & MacLeod, 2013), being described as expressions of this core memory mechanism.

The effect of augmented memory when environmental context remains unchanged has been found for various types of memory tests, including free recall (Godden & Baddeley, 1975), cued recall (Smith, Handy, Angello, & Manzano, 2014), as well as recognition (Murnane, Phelps, & Malmberg, 1999). This last set of results is most important here because recollection and familiarity have been most commonly used to refer to two modes of retrieval in recognition (Yonelinas, 2002; but see McCabe, Roediger, & Karpicke, 2011, for evidence for these processes playing their roles in recall tests). Research on context reinstatement in recognition has shown that the benefits to memory brought by reinstating encoding context at retrieval stem from recollection of item-to-context associations established at study. Macken (2002) was the first to show that presenting items in reinstated contexts increases the probability of reporting *remembering* states, reflecting retrieval of contextual associations, an effect obtained for strongly encoded contextual associations also by Hockley (2008). Moreover, the specific effect of context reinstatement on recollection was revealed by using the ROC analysis by Koen et al. (2013) and further corroborated by the results from a list discrimination task by Hanczakowski, Zawadzka, and Coote (2014). The fact that context reinstatement augments recollection leads to a prediction that reinstating the original encoding context at restudy should affect the likelihood of reminding in the form of recollecting previous

study episodes. This in turn, as described earlier, may affect both the metacognitive monitoring of restudy and subsequent memory performance, hypotheses tested in the present study.

However, augmented recollection due to context reinstatement is not the only context-related phenomenon. Numerous studies on context effects in recognition have repeatedly shown that varying context familiarity affects recognition responding, with more hits and false alarms made when recognition probes are presented in a familiar environmental context (e.g., Hockley, 2008; Hockley, Bancroft, & Bryant, 2012; Murnane & Phelps, 1993). According to a prominent model of context-dependent memory, the Item, Associated Context, and Ensemble (ICE) model (Murnane et al., 1999), context familiarity becomes misattributed to items tested in these contexts which then seem more familiar themselves. Thus, variations in context at retrieval can affect recollection – as evidenced by the effects of context reinstatement – but also familiarity – as evidenced by increased hits and false alarms in the presence of familiar contexts (Murnane & Phelps, 1993; 1995). In the context of restudy, given a well-established relation between familiarity of an item and metacognitive monitoring of memory processes concerning this item (e.g., Metcalfe & Finn, 2008; Reder & Ritter, 1992; Schwartz & Metcalfe, 1992), one can predict that items restudied in a familiar context should be judged as more likely to be remembered in the future. Given that increased familiarity at restudy is unlikely to affect the learning process itself, context familiarity should become a non-diagnostic cue for JOLs made at restudy.

Importantly for the present purpose, previous studies on context effects have already documented how context may affect metacognitive monitoring of retrieval. In recent papers from our group, we showed that both recollection augmented by context reinstatement and item familiarity inflated by testing in a familiar context affect two types of metacognitive judgments made at retrieval. Hanczakowski, Zawadzka, and Coote (2014; see also Hanczakowski, Zawadzka, & Macken, 2015) investigated the role of environmental context for retrospective confidence judgments made in a recognition test. Participants studied faces paired with individual context photographs and then performed a two-alternative forced-choice recognition test for studied faces

when contexts were varied. Some faces were tested in the presence of reinstated contexts, thus preserving the encoding-retrieval match in terms of context. This reinstated context condition was compared to a re-paired context condition for which contexts were taken from a different study pair. This comparison revealed the effect of context reinstatement by which recognition performance was better and confidence was increased for reinstated contexts. Furthermore, the re-paired context condition was compared against a novel context condition which used new contexts that were not included in the study phase. This comparison speaks to the effect of context familiarity, with context familiarity increased for re-paired contexts presented in the study phase as compared to novel contexts. In the study by Hanczakowski, Zawadzka, and Coote this comparison revealed that higher context familiarity results in higher confidence but it had no effect on recognition accuracy. Hanczakowski, Zawadzka, Collie, and Macken (2017) extended these findings to feeling-of-knowing judgments – metacognitive assessments of future recognizability of currently inaccessible targets – which were also higher in the presence of re-paired contexts and still higher in the presence of reinstated contexts. In the present study, the same manipulations that were previously applied at retrieval to assess recollection, familiarity, and their effects on metacognitive monitoring of retrieval are applied at restudy to assess their effects on reminding – involuntary instances of retrieval during learning, either in the form of recollection or familiarity – as expressed in both metacognitive monitoring of restudy and subsequent memory performance.

The present study

Here we present five experiments investigating the role of variations in environmental context in shaping the retrieval processes and metacognitive monitoring when items are restudied. We manipulated the match between the environmental contexts present for the first and second study opportunity in order to influence the likelihood of recollection of the previous study episodes. To foreshadow, context reinstatement robustly affected both JOLs made at restudy and subsequent memory performance, documenting the role of environmental context in shaping recollections of previous study opportunities. We also manipulated the familiarity of environmental context present

at restudy. In contrast to the manipulation of context reinstatement, context familiarity was found generally to affect neither JOLs made at restudy nor the subsequent memory performance. This pattern held for immediate JOLs but was different when delayed JOLs (made in the absence of the to-be-recalled item) were elicited, in which case JOLs were affected by context familiarity but memory performance was not.

Experiment 1

In this experiment, participants were presented with pairs of words for study, with each pair embedded in an individual context photograph. Participants were asked to study those word pairs and later recall second words (targets) when presented with first words of the pairs (cues). For both study phases, they were also asked to provide JOLs. All pairs were studied and tested twice, with cued-recall tests immediately following each study phase. For each pair, the same context photograph that accompanied it in the *first* study phase was later re-presented together with the cue on both cued-recall tests (see Fig. 1). The crucial context manipulation was implemented in the *second study phase* where pairs were presented with reinstated, re-paired, or novel contexts. The effects of context manipulation at restudy were examined for both the magnitude of JOLs provided in this phase, and performance on the final cued recall test that followed the second study phase. The two main aims of this procedure were to assess 1) whether context reinstatement and context familiarity affect JOLs for restudied items, and 2) whether any such effect of context on metamemory monitoring of repeated encoding is also reflected in subsequent memory performance.

Method

Participants. Thirty undergraduate students participated in exchange for course credit.

Materials and design. A list of 120 nouns was derived from the MRC database. Words were randomly divided into 60 pairs. Eighty photographs depicting landscapes, animals and buildings were collected from various Internet sources. Each study pair was yoked with its individual context photograph.

Study pairs were presented for two cycles of learning and cued recall. Yoked context photographs were presented in the first study phase and, together with their cues, in both test phases. Context photographs were manipulated in the second study phase. In that phase, 20 pairs were presented with their yoked context photographs, creating the *reinstated* context condition. Another 20 pairs were presented with context photographs that were yoked with one of the other pairs from this subset, creating the *re-paired* context condition. The final 20 pairs were presented with context photographs that were new, i.e. not included in other phases of the experiment, creating the *novel* context condition. The assignment of pairs to context conditions was counterbalanced across participants.

Procedure. Participants were asked to study pairs of words for a subsequent cued recall test. They were informed that pairs would be presented against the background of photographs but no specific instructions regarding the contextual photographs were given. In the first study-test cycle, study pairs were presented for four seconds, after which time they were replaced by a JOL prompt asking participants to rate their confidence in future recall of the target when presented with the cue on a 0-100 scale. Participants entered JOLs by typing their response on the keyboard and pressing Enter, thus moving to the next study item. The time to provide a JOL was not limited. In the cued-recall phase, which immediately followed the study phase, first words from each study pair were presented as cues, superimposed on the same context background as at study, and participants were asked to type in a target associated with a given cue within 10 seconds. The second study-test cycle, which followed immediately, differed from the first one only in one regard: in the second study phase, the contexts on which pairs were superimposed varied depending on the condition (reinstated, re-paired, novel). The second test was identical to the first one, with contexts from the first cycle being reused. The order in which participants were presented with study and test materials was randomized separately for each phase of the experiment.

Results and discussion

JOLs

The descriptive statistics for JOLs from both study phases are presented in Table 1. Given that the only manipulation was introduced in the second study phase, the results from the first study phase – JOLs and cued-recall performance – were not analysed. The analysis of mean JOLs for the second study phase with a one-way repeated-measures ANOVA with three levels (reinstated, re-paired, and novel context conditions) revealed significant differences between conditions, $F(2, 58) = 5.67$, $MSE = 34.01$, $p = .006$, $\eta_p^2 = .16$. Planned comparisons focused on the effects of context reinstatement and context familiarity. The comparison between reinstated and re-paired context conditions yielded a significant difference, $t(29) = 3.05$, $SE = 1.62$, $p = .005$, $d = 0.56$, documenting the context reinstatement effects in JOLs with higher JOLs for the reinstated than the re-paired context condition. The comparison between re-paired and novel context conditions failed to show a significant difference, $t(29) = 1.13$, $p = .27$, $d = 0.21$. The results thus reveal the effect of context reinstatement for JOLs, but no effect of context familiarity.

The JOL results are partially consistent with our initial predictions inasmuch as the context reinstatement effect was present in JOLs elicited at restudy, but the effect of context familiarity was not. The manipulation of context reinstatement is designed to promote recollection (Koen, Aly, Wang, & Yonelinas, 2013; Macken, 2002) and thus the effect of this manipulation on JOLs most likely reflects augmented recollection of previous study episodes when reinstated context is included at restudy. In other words, the effect of context reinstatement on JOLs shows how environmental context determines the likelihood of recollective reminding at restudy. However, for this claim to be fully supported, it is necessary to provide converging evidence from the memory performance measure. Additional recollection for reinstated contexts should result in augmented memory performance later, consistently with previous studies documenting benefits of recollective reminding for learning (Aue et al., 2017; Tullis et al., 2014). We present the relevant result in the next section.

Contrary to our predictions, the context familiarity effect on JOLs assigned to restudied items failed to emerge in Experiment 1. The metacognitive effects of context familiarity,

manipulated in the same way as in the present experiment, were clearly and consistently present in our previous investigations of retrieval (Hanczakowski et al., 2015; Hanczakowski, Zawadzka, & Coote, 2014; Hanczakowski et al., 2017). The contrasting findings suggest thus a difference between metacognitive processes involved in repeated learning and retrieval. One reason for which context familiarity effects were absent from JOL data in the present paradigm could be that the influence of context familiarity was overshadowed by another potent cue influencing JOLs. It is well established that in a procedure involving repeated cycles of study and testing, JOLs on encoding cycles beyond the first one depend strongly on previous test performance, a phenomenon referred to as the memory-for-past-test heuristic (Finn & Metcalfe, 2007; 2008). It remains possible that when such a strong cue is present, participants do not rely on context familiarity to shape their JOLs. In Experiment 2 we will test this hypothesis by dropping the first test from the experimental procedure and thus denying participants a mnemonic cue in the form of memory for past test performance.

Cued recall

Another question addressed in the present experiment is how variations in context at restudy affect subsequent memory performance. To remind the reader, in the present experiment contexts in which cues were embedded on the final test always matched the original encoding contexts from the first cycle of learning and testing. In other words, they matched the reinstated context condition of the second study phase and mismatched the contexts used both in the re-paired and novel context conditions (see Figure 1).

The descriptive statistics for correct cued-recall performance are presented in Table 2. A one-way repeated-measures ANOVA on correct cued recall in the final test revealed significant differences between context conditions as defined by contexts used in the second encoding phase, $F(2, 58) = 16.47$, $MSE = .01$, $p < .001$, $\eta_p^2 = .36$. Planned comparisons revealed that context reinstatement at restudy affected final cued recall performance, $t(29) = 5.05$, $SE = .03$, $p < .001$, $d = 0.91$, while the manipulation of context familiarity did not, $t < 1$. It is worth noting that these results parallel the results obtained for JOLs. The manipulation of context familiarity had no effect on JOLs,

nor did it affect the effectiveness of relearning. By contrast, context reinstatement increased JOLs, and at the same time it facilitated relearning as revealed by subsequent memory performance. This pattern demonstrates that mnemonic information elicited by reinstated contexts served as a diagnostic cue for JOLs, contributing to accurate metacognitive monitoring of restudy.

The lack of an effect of context familiarity on memory performance in the present experiment was expected, as there seems to be no reason for the familiarity of stimuli to influence the effectiveness of restudy. Of more interest here is a robust effect of context reinstatement at restudy on subsequent cued recall. Such effect is consistent with the insights gleaned from the JOL results. Reinstated contexts promote recollection of the previous study episode which translates both into higher JOLs and better memory performance later in time. Memory and metacognitive measures provide thus converging evidence regarding the role of reinstated contexts in promoting reminding in the form of recollection of previous study opportunities which in turn contribute to more efficient learning.

It has to be noted, however, that the memory effect observed here for reinstated contexts is not beyond alternative explanations. The use of original contexts in the final cued recall test meant that contexts present at the test matched the contexts used in the reinstated context condition but mismatched the contexts used in the re-paired (as well as novel) context condition. Reinstating context at restudy may strengthen the memory representations of item-to-context associations established in the first study phase, whereas using re-paired contexts cannot lead to such strengthening as the original context is not presented. Later, in the final cued-recall test, original contexts may cue the strengthened item-to-context associations in the reinstated context condition more efficiently than relatively weaker associations from the re-paired context condition. Under this scenario, the difference in the final cued-recall performance would be yet another demonstration of the context-dependent nature of cued recall (e.g., Smith et al., 2014) where the more times a given item is presented in the same context, the greater the chances that this context will be then used to retrieve this item. This context explanation of our results is incapable of addressing the JOL results as

it rests mostly on the dynamics of retrieval. Nevertheless, it does highlight the perils of inferring the relearning mechanisms from cued-recall performance occurring at a different time and under different cuing conditions. Importantly, the context and reminding mechanisms can be disentangled by removing contextual cues from the final cued-recall test. Without contextual cues, the context explanation predicts no effect of varying context at restudy whereas the reminding explanation predicts the effect to persist. A test of these predictions will be presented in Experiment 3.

Experiment 2

The present experiment assessed whether the absence of the effect of context familiarity on JOLs for restudied items would be replicated if a potent JOL cue of previous test performance was not available to participants. This aim was realized by repeating the design of Experiment 1 without the cued recall test following the first study phase. Dropping the first test allowed also for assessing the robustness of the context reinstatement effects observed in Experiment 1. The main focus in the present work is on restudy and thus it is of interest whether the patterns related to context reinstatement – increased JOLs and augmented subsequent memory performance – occur also under conditions in which study sessions occur in succession, without intervening explicit retrieval.

Method

Participants. Fifty-one undergraduate students participated in exchange for course credit. The sample size was increased as compared to Experiment 1 because we expected weaker effects of context reinstatement in the present experiment. In Experiment 1, the first cued recall test provided an additional opportunity for binding cues and retrieved targets to the original contexts, and without this opportunity in Experiment 2 item-to-context associations underlying the discussed effects should be less well encoded.

Materials, design, and procedure. All elements of the experiment remained unchanged from Experiment 1, except for the elimination of the first cued-recall test from the procedure. A 5-minute math task replaced the first cued-recall test.

Results and discussion

JOLs

The descriptive statistics for JOLs are presented in Table 1. A one-way repeated-measures ANOVA on mean JOLs given at restudy revealed significant differences between context conditions, $F(2, 100) = 3.38$, $MSE = 41.93$, $p = .038$, $\eta_p^2 = .06$. Planned comparisons focused again on the effects of context reinstatement and context familiarity. Regarding context reinstatement, the results revealed higher JOLs given in the reinstated compared to the re-paired context condition, $t(50) = 2.56$, $SE = 1.27$, $p = .014$, $d = 0.36$. Regarding context familiarity, the results again showed no significant difference between re-paired and novel context conditions, $t(50) = 1.01$, $p = .318$, $d = 0.14$.

These results are consistent with the results of Experiment 1 in documenting the effects of context reinstatement on JOLs for repeatedly studied items, while at the same time finding no evidence for the effect of context familiarity. Importantly, the present results speak to the robustness of these general patterns. First, the present experiment shows that a previous explicit retrieval attempt in a memory test is not necessary for the context reinstatement effect on metacognitive monitoring of restudy to emerge. It is worth noting that the effects of context reinstatement observed here were numerically smaller than in Experiment 1, suggesting that even though retrieval is not a pre-condition for context reinstatement to affect reminding, previous retrieval in the presence of original context might potentially serve to strengthen contextual associations and thus shape the magnitude of the described effect.

Second, the present results also confirm the surprising lack of the effect of variations in context familiarity on JOLs given to repeatedly studied items. Although we expected to find such effect based on our previous results confirming the impact of context familiarity on both retrospective confidence (Hanczakowski, Zawadzka, & Coote, 2014) and feeling-of-knowing judgments (Hanczakowski et al., 2017), the consistent lack of this effect for JOLs suggests an important difference between metacognitive monitoring of retrieval and repeated learning. Importantly, in Experiment 2 the effect of context familiarity on JOLs failed to emerge even when

the preceding cued-recall test was eliminated. We hypothesized that the lack of this effect in Experiment 1 could have been caused by a stronger cue of memory for past test (Finn & Metcalfe, 2008) overshadowing the cue of context familiarity. However, without previous recall participants could not have based their JOLs on previous test performance (see England & Serra, 2012, for a similar logic), yet the effect of context familiarity again failed to emerge. We return to the issue of why this effect may be absent in metacognitive monitoring of relearning in Experiments 4 and 5.

Cued recall

The descriptive statistics for cued-recall performance are presented in Table 2. A one-way repeated-measures ANOVA on correct cued recall in the final test revealed significant differences between conditions defined by the context of encoding, $F(2, 100) = 9.45$, $MSE = .02$, $p < .001$, $\eta_p^2 = .16$. Planned comparisons revealed that whereas context familiarity at encoding did not affect subsequent cued recall, $t(50) = 1.61$, $p = .11$, $d = 0.23$, context reinstatement did affect it, $t(50) = 4.26$, $SE = .03$, $p < .001$, $d = .60$. Once again, thus, reinstated contexts at relearning promoted subsequent memory performance whereas variations in context familiarity had no such effect. These results again parallel the results obtained for JOLs, demonstrating that recollection triggered by reinstated contexts serves as a diagnostic cue for metacognitive monitoring of restudy.

Earlier we have outlined two ways in which context reinstatement at restudy may affect subsequent cued-recall performance. One way is by augmented encoding of item-to-context associations in the reinstated context condition, which later supports context-dependent memory by which original contexts cue memory for to-be-retrieved targets. The second way is by the process of reminding triggered by reinstated contexts that establishes stronger memory traces as compared to encoding occurring in the re-paired context condition where reminding occurs relatively less often. Crucially, these two accounts can be distinguished by manipulating the composition of the final test. Whereas the contextual account requires the original contexts to be present at the time of the final cued recall test, the reminding account does not. Experiment 3 was conducted to test between these two accounts by eliminating contextual cues at the time of the final cued recall test.

Experiment 3

The present experiment had two aims. First, we assessed whether eliminating contextual cues at the time of the final cued-recall test would eliminate the benefits accruing from repeated study in reinstated contexts (see e.g., Smith & Handy, 2014, 2016). If these benefits observed in Experiments 1 and 2 stemmed solely from the strengthening of item-to-context associations in the reinstated context condition, then they should be abolished when the final test omits contextual cues that tap into these associations. By contrast, if these benefits reflect also augmented recollection occurring when restudy takes place in the reinstated environmental context, then we would expect to document such benefits also without contextual cues at retrieval.

Second, we also used this opportunity to further test the robustness of the effect of context reinstatement effect on JOLs. This effect, most likely reflecting reminding of the first study opportunity, emerged both with the preceding cued-recall test (Experiment 1) and without it (Experiment 2). It is important to note, however, that in both cases participants could legitimately expect contexts to be present also in the subsequent cued-recall test. For Experiment 1, those expectations could have been created by the presence of context photographs in the first cued-recall test when this test was included in the design. For Experiment 2, such expectation could have also arisen without the first cued-recall test by virtue of a general intuition that contexts were included in the procedure for some reason – presumably to play some role in a subsequent memory test. What remains unknown is whether context reinstatement would still be used as a cue for JOLs when participants can expect no contexts in the final cued-recall test. In other words, the question is whether recollection triggered by reinstated contexts would make participants expect better future memory performance if contexts are *not* present at the time of testing. We created conditions in which participants could expect the final cued-recall phase not to include context photographs by eliminating contextual cues from the first cued-recall test. In other words, in the present experiment context photographs were included only in the two study phases but were absent from both test phases. We assessed whether the lack of context cues in the first test phase would dissuade

participants from using memory experience associated with contextual cues for predicting subsequent memory performance.

Method

Participants. Forty-five undergraduate students participated in exchange for course credit.

Materials, design, and procedure. Materials and design were the same as in Experiments 1 and 2. The procedure was the same as in Experiment 1 – with cued recall tests following each study phase – except that at test cues were always presented alone, without any contextual photographs (see Figure 1).

Results and discussion

JOLs

The descriptive statistics for JOLs are presented in Table 1. A one-way repeated-measures ANOVA on mean JOLs assigned at restudy revealed significant differences between context conditions, $F(2, 88) = 4.05$, $MSE = 36.05$, $p = .021$, $\eta_p^2 = .08$. Planned comparisons focused again on the effects of context reinstatement and context familiarity. Regarding context reinstatement, the results revealed higher JOLs in the reinstated compared to the re-paired context condition, $t(44) = 2.92$, $SE = 1.22$, $p = .005$, $d = 0.44$. Regarding context familiarity, the results again showed no significant difference between re-paired and novel context conditions, $t(44) = 1.02$, $p = .31$, $d = 0.15$.

The present results concerning JOLs assigned to restudied items replicate the results of Experiments 1 and 2. By this point the absence of the context familiarity effect is perhaps less than surprising, once again indicating that participants are not inclined to use context familiarity as a cue for JOLs. We return to this issue after presenting and discussing other findings from the present experiment.

Of more interest here is again the finding of the effect of context reinstatement on JOLs. In the present experiment, the second study phase in which the impact of the context manipulation was examined was preceded by a cued-recall test in which contextual cues were absent. The type of a memory test used in a given paradigm often creates expectations regarding the nature of

subsequent tests, and these expectations in turn shape strategies that participants deploy in a memory task (Finley & Benjamin, 2012). By administering the first cued-recall test without contextual cues we thus suggested to participants that they may expect the final test also to omit contextual cues. We further reasoned that, expecting no contextual cues, participants might reduce their reliance on contextual cues while assessing their confidence in subsequent memory performance. However, the context reinstatement effect for JOLs obtained in the present experiment indicates that participants still used recollections triggered by reinstated context to inform their JOLs. These results once again confirm the robust nature of the influence recollective reminding has on metacognitive monitoring at restudy.

Cued recall

The descriptive statistics for cued-recall performance are presented in Table 2. The analysis of final test cued-recall performance as a function of the context condition in the second study phase was conducted with a one-way repeated-measures ANOVA, which revealed significant differences between context conditions, $F(2, 88) = 3.17$, $MSE = .01$, $p = .047$, $\eta_p^2 = .07$. Planned comparisons revealed that whereas context familiarity at encoding did not affect subsequent cued recall, $t(44) = 1.46$, $p = .15$, $d = 0.22$, context reinstatement did affect it, $t(44) = 2.67$, $SE = .02$, $p = .011$, $d = 0.40$. Thus, once again, variations in context familiarity at encoding were of no consequence for subsequent memory performance but reinstating contexts conferred benefits for subsequent cued recall. The pattern of memory performance mirrors the pattern of JOLs described earlier, confirming the diagnostic nature of mnemonic information elicited by reinstated contexts.

The pattern of augmented cued recall performance in the absence of contextual cues clarifies the mechanism by which context reinstatement exerts its influence on subsequent memory performance. This result supports the notion that reinstated contexts benefit encoding processes by reminding participants of the previous study opportunity. Thus, the present cued-recall results converge with conclusions derived from the JOL results in showing the role of reinstated context in promoting reminding at restudy. This process of reminding leads to the establishment of particularly

strong memory traces for stimuli embedded in reinstated contexts that can be later easily accessed whether contextual cues are again presented, as in Experiments 1 and 2, or not, as in the present experiment.[2]

The present finding of improved performance for items repeatedly studied in the same environmental context may seem surprising given previous reports on the benefits of contextual variability at encoding. It has often been argued (e.g., Lohnas, Polyn, & Kahana, 2011; Smith, Glenberg, & Bjork, 1978) that repeated encoding is more effective if it takes place in variable contexts. The argument here is that varying encoding context modifies the way to-be-remembered items are processed which contributes to the richness of memory representations for these items. Rich memory representations for items studied in varied contexts afford a variety of routes by which these items can be retrieved which generally augments memory. The concept of contextual variability seems well-grounded in theorizing about memory and indeed it is often used as an explanatory mechanism for various memory phenomena of considerable practical importance, such as the spacing effect (Melton, 1970; Siegel & Kahana, 2014). Against this background, the superiority of constant rather than variable encoding context documented in our study – even when contexts themselves cannot support retrieval at test, as in the present experiment – may come as unexpected. What the present results suggest is that reminding occurring due to repeated study in the same context can outweigh the benefits of contextual variability and thus result in benefits of restudy in the constant rather than varied contexts. We return to this important point in the General Discussion.

The results presented so far are highly consistent in revealing robust effects of context reinstatement and no effects of context familiarity on both JOLs given at restudy and subsequent memory performance. Although these results confirm our initial predictions regarding the role of

[2] This is not to say, however, that augmented contextual associations operating in the final cued-recall test did not play any role in the memory benefits of context reinstatement in Experiments 1 and 2. Experiment 3, omitting contexts at the final test, provides unique support for the role of reminding in the form of recollection at restudy but does not exclude the possibility of a dual-mechanism account of context reinstatement effects when original contexts are again presented at test. Indeed, the effect sizes for this effect were smaller in Experiment 3 ($d = 0.40$) than in Experiments 1 and 2 ($d = 0.91$, and $d = 0.60$, respectively).

environmental context in shaping recollection of previous study episodes and the role of recollection in informing metacognitive monitoring of restudy, these patterns also contrast with our hypotheses regarding the role of context familiarity. We expected the same contextual factors that shape metacognitive monitoring of retrieval in the form of retrospective confidence judgments (Hanczakowski, Zawadzka, & Coote, 2014) and feeling-of-knowing judgments (Hanczakowski et al., 2017) to affect metacognitive monitoring of repeated learning. However, the consistent lack of the effect of variations in context familiarity on JOLs at restudy directly contradicts these predictions. The remaining two experiments are devoted mainly to investigating whether there are conditions under which context familiarity affects JOLs. As a secondary goal, these experiments further pursue the boundary conditions of the context reinstatement effects documented in Experiments 1-3.

Experiment 4

The main goal of the present experiment was to investigate the role of response deadline in making JOLs in the presence of familiar and unfamiliar contexts. Experiments 1-3 showed no effect of context familiarity when there was no strict time limit to restudy pairs embedded in contextual photographs and to provide JOLs. Under such unrestricted conditions, factors other than familiarity of restudied materials contribute to JOLs, and these factors may overshadow the feeling of familiarity elicited by environmental context. In Experiment 2, we examined one potentially overshadowing cue in the form of memory for past test, but even the elimination of this cue did not cause the effect of context familiarity to emerge. However, the results presented so far clearly point to another cue that may overshadow familiarity as a cue for JOLs: recollection of previous *study* opportunities. In the present experiment we aimed to reduce the effect of recollection on JOLs in order to examine whether this would reveal an influence of familiarity.

Benjamin (2005) examined the role of familiarity and recollection in making JOLs (see also Metcalfe & Finn, 2008). This study did not assess the effects of environmental context but instead focused on manipulations concerning the constituent members of study pairs. Specifically, it assessed whether JOLs made in the absence of targets (second words from studied pairs) are

affected by familiarity of cues (first words from studied pairs) and the level of encoding of the targets in the preceding study phase. These two factors were found to exert influence on JOLs, but their roles were mediated by the factor of time available to make JOLs. Cue familiarity was found to affect JOLs only when a response deadline for making JOLs was imposed, whereas target encoding – and thus by proxy the probability of recollection of a target referred to as target retrievability – affected JOLs only under unspeeded conditions. The explanation for these findings lies in how retrieval is affected by time pressure. When a strict response deadline precludes participants from retrieving targets, then the level of encoding of these targets should not affect JOLs. In the absence of target retrieval, however, the role of other cues, such as familiarity, may be revealed. Thus, given that basing JOLs on familiarity of the cues is a crude heuristic for metacognitive monitoring that often does not provide diagnostic information but can be deployed quickly (Reder & Ritter, 1992), its role is most likely to be revealed when more reliable cues to JOLs, such as target retrievability, are absent.

The question assessed in the present experiment is whether the manipulation of context familiarity translates into higher JOLs given at restudy if the role of reminding in the form of recollection is minimized. In pursuing this question, we used the same method as Benjamin (2005) and Metcalfe and Finn (2008) did in their studies on cue familiarity and target retrievability. Specifically, we contrasted the unspeeded condition similar to the one utilized in Experiments 1-3 of the present study with a speeded condition in which a deadline was imposed for restudy and providing JOLs. We expected that the response deadline would minimize the role of recollection in shaping JOLs. In other words, we expected that the likelihood of reminding in the form of recollection of previous study opportunities would be largely eliminated under the time pressure applied at restudy. With the role of recollection minimized, we predicted the effect of context reinstatement for both JOLs and subsequent memory performance to be reduced or completely eliminated in the speeded condition. We also predicted that this elimination of recollection as a cue

to JOLs would reveal the role of a quick familiarity heuristic by which higher JOLs are given when pairs seem more familiar due to misattributed familiarity of contexts in which they are embedded.

Method

Participants. Fifty-eight undergraduate students participated in exchange for course credit. The sample size was again increased for the present experiment to accommodate an additional variable in the design – the speeded/unspeeded manipulation implemented in the second study phase.

Materials, design, and procedure The materials were the same as in Experiments 1-3. The design was taken from Experiment 1 and modified to accommodate the manipulation of response deadline for the second study phase. Specifically, the second study phase was divided into two blocks. In both blocks, the study time was not limited and instead the pair with its context was presented until the JOL response was made. In the speeded block, participants were asked to provide their JOLs within a 1.5 second response deadline. The assignment of pairs to these two blocks and the order of the blocks were counterbalanced across participants.

The procedure for the present experiment was based on that used in Experiment 1 with several important changes. First, in the second study phase JOLs were no longer prompted after the presentation of the study pairs but instead participants were asked to provide their JOLs while the study pair was displayed on the screen. The procedure for the first study phase was the same as in previous experiments, with a JOL prompt following the presentation of a study pair for four seconds. Second, participants made all their JOLs on a 1-4 scale, providing responses by pressing appropriate numbers on the keyboard, to facilitate prompt responding in the speeded condition. Third, performance feedback was introduced in the speeded block of the second study phase. If a participant failed to provide a JOL response within the 1.5-second deadline, then the error message 'too slow!' displayed in red font followed the study presentation. The analysis for the speeded block, however, included all JOL responses, whether provided within or outside the allotted time window.

Results and discussion

JOLs

The descriptive statistics for JOLs are presented in Table 1. The initial analysis of mean JOLs at restudy was performed with a 2 (response condition: speeded vs. unspeeded) x 3 (context condition: reinstated, re-paired, novel) repeated-measures ANOVA, which yielded a significant main effect of response condition, $F(1, 57) = 9.93$, $MSE = .19$, $p = .003$, $\eta_p^2 = .15$. This effect reflects the fact that JOLs were generally higher when more time was available for study of the assessed pairs. The main effect of context condition was also significant, $F(2, 114) = 10.18$, $MSE = .14$, $p < .001$, $\eta_p^2 = .15$, but the interaction was not, $F < 1$. To follow-up on the significant main effect of context condition, planned comparisons were performed for data collapsed across response conditions. These revealed the effect of context reinstatement to be significant, $t(57) = 3.65$, $SE = .05$, $p = .001$, $d = 0.48$, but the effect of context familiarity was again not significant, $t < 1$. Overall, thus, in terms of the effects of context manipulation on JOLs made at restudy the present result show the same patterns of results as Experiments 1-3, with no moderating role for the response deadline imposed on JOLs.

For the present experiment, we expected to document the effect of context familiarity for speeded JOLs and the effect of context reinstatement for unspeeded JOLs. This followed both from our assumption that imposing a deadline on JOL responding would limit the role of recollection as a mnemonic cue and the logic outlined by Benjamin (2005) who argued that the role of the familiarity heuristic – cue familiarity in his study – could only be revealed under conditions under which other potent mnemonic cues such as target retrievability were not used as the basis of JOLs. However, our manipulation of response deadline did not result in the expected pattern. Instead, the present JOL results simply replicated the results of Experiment 1-3 by showing context reinstatement affecting recollection and thus JOLs independently of the response deadline and context familiarity failing to affect JOLs.

The main question that these results pose is why the effects of cue familiarity and target retrievability are moderated by the JOL response deadline, as showed by Benjamin (2005), whereas

contextual effects examined here are not. There are at least two procedural differences between our study and the study by Benjamin that are worth discussing here. First, the deadline for JOL responses imposed in our Experiment 4 was less strict than the deadline used by Benjamin. We gave our participants 1.5 seconds to provide JOL whereas Benjamin allowed only 1 second. We chose a slightly longer deadline because JOLs in our experiment were elicited for pairs of words presented intact as opposed to JOLs provided for cues only (in the absence of targets) in the study by Benjamin, and so additional time was needed to process both words. We believe, however, that this procedural difference is not vital for the patterns documented here. First, the difference in response deadlines is small, particularly if one takes into account the much more complex stimuli we used as prompts for JOLs. Second, we looked at the actual times to provide JOLs in the second study phase in the speeded condition. The average response time was 1075 ms, which is very close to the response deadline of 1000 ms imposed by Benjamin. Third, we restricted our analyses of JOLs across context conditions in the speeded block to responses that were provided within 1000 ms and even with such a restricted dataset we again obtained the context reinstatement effect, $t(52) = 2.09$, $SE = .13$, $p = .041$, $d = 0.29$, but not the context familiarity effect, $t(52) = 1.27$, $p > .21$.[3]

Another obvious difference between our procedure and the one used by Benjamin (2005) is the already mentioned issue of how JOLs were prompted. We were primarily interested in metacognitive monitoring of restudy and for this reason across all experiments we prompted JOLs for study pairs presented intact. In the metacognitive literature, these are usually referred to as immediate JOLs. By contrast, in the study by Benjamin the focus was on so-called delayed JOLs which are most often elicited only with cues (first words of the studied pairs). Experiment 5 was designed to assess whether this difference was responsible for divergent patterns of results documented here and earlier in the study by Benjamin by assessing delayed JOLs made in the absence of targets as a function of both the context condition and the response deadline for providing JOLs.

Cued recall

[3] For both analyses, five participants needed to be excluded due to missing cells.

The descriptive statistics for cued-recall performance are presented in Table 2. The initial analysis of final cued-recall performance was performed with a 2 (response condition: speeded vs. unspeeded) x 3 (context condition at encoding: reinstated, re-paired, novel) repeated-measures ANOVA. This yielded a significant main effect of response condition, $F(1, 57) = 32.43$, $MSE = .02$, $p < .001$, $\eta_p^2 = .36$, which reflected the predictable pattern of better memory performance for items which were presented for longer in the second study phase. The main effect of context was also significant, $F(2, 114) = 13.15$, $MSE = .04$, $p < .001$, $\eta_p^2 = .19$, but the interaction was not, $F < 1$. To follow-up on the significant main effect of context condition, planned comparisons were performed for data collapsed across response conditions. These revealed a significant effect of context reinstatement, $t(57) = 4.21$, $SE = .03$, $p < .001$, $d = 0.55$, but no effect of context familiarity, $t < 1$.

The cued-recall results track both the cued-recall results obtained in Experiments 1-3 and the JOL results presented earlier. This latter congruency is important inasmuch as it again speaks to the diagnosticity of recollection as a cue for JOLs: higher JOLs given for items restudied in reinstated contexts are matched by benefits for subsequent memory performance these contexts confer. These results were not modulated by response deadline, which again indicates that the response deadline manipulation was ineffective in changing the contribution of recollection elicited by context reinstatement. Also, memory performance was higher for pairs that were studied for longer in the second study phase, a result that is hardly surprising but perhaps worth stressing, as it provides another example of how cues shaping JOLs can be highly diagnostic of future memory performance. Immediate JOLs were affected both by context reinstatement and duration of study, and both of these effects were later reflected in cued-recall performance, testifying to the fact that immediate JOLs can accurately predict how conditions of learning impact upon memory.

Experiment 5

In the present experiment, we again pursued the issue of how context reinstatement and context familiarity affect both memory and metacognitive monitoring at restudy under speeded and unspeeded conditions. Here we extended the examination of the effects of changes in

environmental context to delayed JOLs elicited in the absence of targets. We thus eliminated one procedural difference that distinguished our study on the effects of environmental context from the study by Benjamin (2005) on the role of cue familiarity and target retrievability. To the extent to which context manipulations work by modulating the recollection of targets and the feeling of familiarity evoked by tested materials, we expect the same JOL patterns here as documented earlier by Benjamin. Regarding context reinstatement, we thus expected that enforcing a response deadline may reduce recollection when targets are absent at the time of making delayed JOLs. Remembering the previous study opportunity requires in this case a recollection of the missing target – a process more challenging than the recollection of the first study opportunity when both cues and targets are presented intact – which could be impeded by speeded responding. Regarding context familiarity, we again expected that under limited contribution of recollection, the effect of context familiarity on delayed JOLs will emerge in the speeded condition.

Method

Participants. Fifty-nine undergraduate students participated in exchange for course credit.

Materials, design, and procedure. The materials and design were the same as in Experiment 4. The procedure was the same as in Experiment 4 except for the fact that JOLs at restudy were elicited with the cue-and-context prompt only, without their respective targets, as presented in the bottom-right panel of Figure 1.

Results and discussion

JOLs

The descriptive statistics for JOLs are presented in Table 1. The initial analysis of mean of delayed JOLs was performed with a 2 (response condition: speeded vs. unspeeded) x 3 (context condition: reinstated, re-paired, novel) repeated-measures ANOVA, which yielded a significant main effect of response condition, $F(1, 58) = 7.83$, $MSE = .11$, $p = .007$, $\eta_p^2 = .12$. Thus, delayed JOLs were generally higher when more time was available for making these judgments. The main effect of context condition was also significant, $F(2, 116) = 8.29$, $MSE = .14$, $p < .001$, $\eta_p^2 = .13$, but the

interaction was not, $F < 1$. To follow-up on the significant main effect of context condition, planned comparisons were performed for data collapsed across response conditions. The context reinstatement effect was significant, $t(57) = 2.04$, $SE = .05$, $p = .046$, $d = 0.27$, and so was the effect of context familiarity, $t(57) = 2.36$, $SE = .04$, $p = .021$, $d = 0.31$. The present results thus replicate the context reinstatement effect on JOLs obtained in all previous experiments presented here, but this time they show this effect for delayed rather than immediate JOLs. The results also document for the first time the effect of context familiarity. Both of these context effects were not moderated by the response deadline manipulation.

The results presented here speak to the dynamics of metacognitive monitoring in the absence of to-be-remembered information. First, even though JOLs were made without targets presented at the time of metacognitive assessment, the results revealed that reminding in the form of recollection triggered by context reinstatement did occur. Thus, the full re-presentation of to-be-remembered information is not necessary for context to elicit the instances of reminding. Interestingly, augmented recollection due to context reinstatement was again impervious to the manipulation of response deadline. This null result suggests that reminding in the form of recollection may be a relatively quick process, circumventing a number of slow strategic processes engaged in explicit retrieval of targets, such as initiating a retrieval mode (Evans, Williams, Wilding, 2015) or performing cue elaboration operations (Herron, Evans, & Wilding, 2016; Unsworth, Brewer, & Spillers, 2013).

Second, the present results are the first in the present series to document a reliable effect of context familiarity on JOLs. The effect, which was absent across all experiments that assessed immediate JOLs, emerged when delayed JOLs were collected in the absence of targets, both with the speeded and un-speeded responding. The fact that the effect of context familiarity emerged here is perhaps not surprising, given the results of the previous study investigating context-dependent metacognitive monitoring of retrieval in the form of feeling-of-knowing judgments (Hanczakowski et al., 2017). As discussed earlier, this study, which served as the basis for initial predictions for the

present set of experiments, documented robust effects of context familiarity when retrieval was prompted in the absence of targets. The previous study concentrated on feeling-of-knowing judgments – predictions that the absent target would be recognized later. The present experiment looked at delayed JOLs – predictions that the absent target would be recalled later. Arguably, both judgments are very similar as they pertain to future states of memory.[4] Thus, a reliable effect of context familiarity on delayed JOLs remains consistent with previous results concerning metacognitive monitoring of retrieval. The contrast with the unexpected results of Experiments 1-4, which looked at immediate JOLs made in the presence of targets and showed no effect of context familiarity, indicates that different cues are used depending on the stimuli present at the time of metacognitive assessment. In other words, even though retrieval in the form of recollective reminding clearly contributes to metacognitive monitoring of restudy, this monitoring is partially based on a different set of cues than the metacognitive monitoring of retrieval.

Cued recall

The descriptive statistics for cued-recall performance are presented in Table 2. The analysis of final cued-recall performance was performed with a 2 (response condition: speeded vs. unspeeded) x 3 (context condition at encoding: reinstated, re-paired, novel) repeated-measures ANOVA. This analysis yielded no significant effects, $F(1, 58) = 2.36$, $p = .13$, $\eta_p^2 = .039$ for the main effect of response condition and Fs < 1 for the main effect of context condition and the interaction.

The results of the analysis of cued-recall performance are clear in showing that none of the manipulations applied at the time of making delayed JOLs had any consequences for memory

[4] The students of metacognition may note that feeling-of-knowing judgments are often collected for unrecalled items only. Indeed, that was the procedure used in the study by Hanczakowski et al. (2017), which documented the effect of context familiarity on these judgments. In the present experiment, there was no explicit requirement for participants to retrieve targets in response to the delayed JOL prompt so it is not possible to clearly assess whether the observed effect of context familiarity depends on recall status. However, the experimental procedure included a cued-recall test in the first cycle and the outcome of this test can be taken as a proxy of the state of memory in the immediately following delayed JOL phase. We thus conditionalized delayed JOLs on whether targets relevant for a given judgment were retrieved in the preceding test. To briefly summarize the results, context familiarity effect on delayed JOLs was robustly present for cues related to previously unrecalled items, $t(58) = 2.779$, $p = .007$, $d = 0.36$, but not for cues related to previously recalled items, $t < 1$. The former effect thus closely corresponds to the effect of context familiarity on feeling-of-knowing judgments given after unsuccessful retrieval attempts.

performance in the final test. This was certainly to be expected for context familiarity which failed to affect final cued-recall performance in any of the experiments. Regarding context reinstatement, one could expect reinstated contexts to augment recollection of targets and thus serve to strengthen their memory representation. Clearly, the delayed JOL results indicated that reinstated contexts triggered recollection of previous study episodes. Why, then, did reminding fail in the present experiment to affect subsequent memory performance? One possibility is that such a recollection was incomplete and did not entail access to the target itself. When cues are presented with reinstated contexts, these contexts may facilitate access to the targets but may also trigger recollection of cue-to-context associations, without the retrieval of targets. Such an additional recollection of cue-to-context associations may impact upon delayed JOLs but cannot result in additional learning for targets that is required to improve performance in the subsequent memory test. Another possibility is that reminding in the form of recollection, as expressed in delayed JOLs, did facilitate retrieval of targets but only for a small subset of the best encoded pairs for which memory, already at ceiling, was not further augmented by reminding. Independently of which of these non-exclusive explanations is correct, the important conclusion from the observed patterns is that JOLs were sensitive to the effects of context reinstatement that were not expressed in subsequent memory performance. This pattern underscores our initial argument that metacognitive judgments made at the time at which reminding occurs may serve as a powerful measure of the rate of reminding, more direct and sometimes more sensitive than measures of subsequent memory performance.

Context reinstatement is not the only manipulation that failed to affect memory performance in the present experiment while having an effect on delayed JOLs. Delayed JOLs were also higher when made without a response deadline and in the presence of familiar contexts, and both of these effects on JOLs were not reflected in final cued-recall performance. In other words, all these cues for JOLs – increased recollection, increased familiarity, increased processing time – turned out to be non-diagnostic, affecting metacognitive monitoring but not memory. This general

pattern contrasts with the results of Experiments 1-4 in which every cue affecting immediate JOLs was also found to exert its influence upon final memory performance. These included the mnemonic cue of recollection triggered by reinstated context in all of these experiments, and the duration of study time in Experiment 4.

In the literature on metacognitive monitoring it is argued that delayed JOLs are more accurate than immediate JOLs (Nelson & Dunlosky, 1991). This argument rests on the analyses of resolution of JOLs, which is a measure of the degree to which differences in JOLs assigned to various items reflect differences in retrievability of targets in the final cued-recall test. Crucially, it is argued that delayed JOLs are characterized by better resolution because they are based on more diagnostic cues that predict subsequent memory states (Dunlosky & Nelson, 1992; 1994). Consistently with this premise, it has been repeatedly shown that immediate JOLs are subjected to a number of biases resulting from non-diagnostic cues that do not affect delayed JOLs (see Rhodes & Tauber, 2011b, for a review). In effect, delaying JOLs has been suggested as the most effective way of improving the accuracy of metacognitive monitoring of the learning process. The present results, however, show that what may well be an effective strategy when to-be-remembered materials are studied once may not always work with repeated study. Here we have shown a host of non-diagnostic cues affecting delayed JOLs, which clearly contrasts with the patterns observed in Experiments 1-4, where the same cues affected immediate JOLs only when they also shaped subsequent memory performance.

General Discussion

When facing the task of learning a certain set of materials, students often need to engage in repeated study cycles. The restudy strategy has often been criticised for omitting the opportunity for retrieval. It has been argued that interleaving study with explicit retrieval attempts benefits learning in a number of ways. It strengthens memory for the tested material (Roediger & Karpicke, 2006), it potentiates new learning following retrieval (Szpunar, McDermott, & Roediger, 2008) and the feedback from retrieval attempts promotes accurate metacognitive monitoring that can be then

used to inform effective learning strategies (Nelson & Dunlosky, 1991). All these benefits of explicit retrieval certainly do occur. Nevertheless, what our study reveals is that repeated study without explicit retrieval demands can benefit from retrieval processes that occur in the form of reminding. Crucially, our study shows how these benefits are shaped by environmental context in which restudy takes place.

Our study shows that when restudy takes place in the same context as the original study opportunity, the contribution of retrieval to learning can be increased, benefitting both memory and metacognitive monitoring of learning. Reinstated contexts promote reminding in the form of recollection of previous study episodes, helping to establish stronger memory representations and providing diagnostic cues for metacognitive monitoring. However, these benefits of context effects come with a caveat. There are situations in which the learners try to assess the state of their knowledge by self-testing, monitoring the contents of their memory with cues but without the actual to-be-remembered information. In fact, such a self-testing strategy has been lauded as an important tool for augmenting metacognitive monitoring of the learning process (e.g., Kornell & Rhodes, 2013; Nelson & Dunlosky, 1991; Rhodes & Tauber, 2011b). While previous studies argued for the highly accurate nature of such self-assessments, the present results indicate that self-assessment may be led astray if made in a familiar environmental context, leading to a faulty belief that learning was more effective than it really was.

Apart from providing novel insights concerning the contribution of retrieval processes to repeated learning, the present results question two major assumptions widely held in the literature on learning processes. First, our results demonstrate that there are situations in which learning can be more effective when it takes place in constant rather than varied context. The benefits of reminding can outweigh the benefits of contextual variability, pointing to the powerful influence of retrieval at restudy on subsequent memory performance. Second, our results demonstrate that delayed JOLs can be subject to a number of biases – influences of non-diagnostic cues on metacognitive monitoring – that immediate JOLs are immune to. These findings are described in

more detail in subsequent sections that are organized around three major groups of results concerning the basis of JOLs, the context effects on memory processes, and the diagnosticity of cues informing metacognitive monitoring.

The basis of JOLs

Environmental context affects metacognitive monitoring of the learning process. Across all five experiments, we have shown that JOLs at restudy are higher if made in the presence of the same environmental context that accompanied the first study opportunity for a given item. Reinstating previous encoding contexts affected both immediate JOLs made when the entire pairs of words were re-presented intact, and delayed JOLs made when only the first words from each pair were presented as cues. These results parallel the effects of context reinstatement on retrospective confidence and feeling-of-knowing judgments documented in our previous studies (Hanczakowski, Zawadzka, & Coote, 2014; Hanczakowski et al., 2015; Hanczakowski et al., 2017). They thus serve to establish the commonality of metacognitive processes that unfold in the environmental context during both encoding and retrieval.

The impact of environmental context on JOLs made at restudy reveals the role of environmental context for governing recollection and the role of recollection in shaping metacognitive monitoring. Previous studies on context reinstatement focused mostly on the memory consequences of this manipulation, revealing how reinstated contexts facilitate retrieval in recall tests (e.g., Godden & Baddeley, 1975) or recollection of contextual associations occurring in recognition tests (e.g., Macken, 2002; Russo, Ward, Geurts, & Scheres, 1999; Tibon, Vakil, Goldstein, & Levy, 2012). That the same manipulation affects processes occurring at restudy indicates that recollection of contextual associations contributes also to memory processes occurring when the same information is presented in multiple learning cycles. This observation supports the recent theoretical arguments concerning the role of reminding in repeated learning (e.g., Benjamin & Tullis, 2010). Importantly, here we demonstrate that reminding not only affects subsequent memory, as discussed in the next section of General Discussion, but also metacognitive monitoring of memory

processes. The impact of recollection on JOLs remains consistent with a host of previous studies looking at how recollection of contextual associations affects metacognitive monitoring (e.g., Brewer, Marsh, Clark-Foos, & Meeks, 2010; Hertzog, Fulton, Sinclair, & Dunlosky, 2014; Thomas, Bulevich, & Dubois, 2011). These previous studies looked at metacognitive monitoring of retrieval, usually in the form of feeling-of-knowing judgments, and showed how retrieval of either parts of to-be-remembered information or retrieval of non-criterial contextual information (information that does not allow for answering a specific memory query) make people more confident that they know the answer to a given query and will be able to access it in the future. Again, the parallel effects of retrieval on metacognitive monitoring at encoding point to the similarity of cues that shape metacognition across various stages of the learning process.

We started the present project taking the interrelation of encoding and retrieval processes as an assumption, and on that basis we drew a prediction that the same contextual cues that shape metacognitive monitoring of retrieval would also shape metacognitive monitoring at restudy. Although this view was confirmed for the recollective effects of context reinstatement, it was also refuted for another type of contextual manipulation. Specifically, in Experiments 1-4 we have consistently failed to find any evidence that context familiarity serves as a cue for JOLs. This is not to say that our procedure somehow failed to effectively manipulate context familiarity. A simple change introduced to the procedure – dropping targets from the restudy phase – revealed the effect of context familiarity on JOLs in Experiment 5. It seems thus that immediate JOLs are insensitive to context familiarity effects, which contrasts with the sensitivity of delayed JOLs to the same manipulation. Crucially, immediate JOLs are made while participants try to encode cue-target pairs and thus they truly reflect metacognitive monitoring of encoding. Delayed JOLs are made in the absence of targets. Under these conditions, encoding of cue-target pairs may occur only to a limited extent when targets are covertly retrieved. In any case, with the main part of the to-be-remembered information absent, delayed JOLs are very similar to feeling-of-knowing judgments in that they also reflect metacognitive monitoring of retrieval rather than encoding. It is perhaps not surprising, then,

that the pattern of results found in Experiment 5 matched more closely the pattern obtained in our investigation of the role of context in shaping feeling-of-knowing judgements (Hanczakowski et al., 2017) than the results from Experiments 1-4. In conclusion, the emerging pattern of results indicates that the context familiarity manipulation affects metacognitive monitoring of retrieval but not of restudy.

The crucial difference between immediate and delayed JOLs lies in the amount of information available to participants when making a metacognitive judgment. For immediate JOLs, participants have targets in their working memory, whereas for delayed JOLs – at least these collected in the usual procedure in which targets are not included in the judgment prompt – targets are not present in working memory unless they are successfully retrieved from long-term memory (Dunlosky & Nelson, 1992). Thus, cues conveyed when both to-be-remembered words are presented at the same time may play a role for immediate JOLs, even when made at restudy, whereas these cues are largely unavailable for delayed JOLs. The fact that the context familiarity effect emerged only at retrieval indicates that cues related to a link between to-be-remembered words, such as their semantic relatedness (see Dunlosky & Matvey, 2001), can overshadow some mnemonic information related to retrieval from memory, such as familiarity. On the other hand, the influence of such mnemonic cues can be revealed when targets are not included in the judgment prompt. The consequences of the variable contribution of mnemonic cues for the accuracy of metacognitive monitoring are discussed in the final section of the present discussion.

A final issue regarding the basis of metacognitive judgments is a difference in results documented here and obtained by Benjamin (2005; see also Metcalfe and Finn, 2008) with regard to the role of time pressure in metacognitive monitoring. Benjamin found that the cue familiarity served as the basis for delayed JOLs only when participants needed to provide their JOLs very quickly (within 1 second) whereas the role of target retrievability was revealed only when participants had ample of time to retrieve targets and then to provide their JOLs. We designed our Experiments 4 (with immediate JOLs) and 5 (with delayed JOLs) following the procedure used by Benjamin to

investigate whether the same dynamics would be observed for the effects of context familiarity and context reinstatement. However, we found that time pressure did not modulate either of the effects, with both effects present in the speeded and unspeeded conditions of Experiment 5, and the context reinstatement effect present in the speeded and unspeeded conditions of Experiment 4.

With regard to context familiarity, our finding of its role as the basis of delayed JOLs is consistent with our previous investigations of metacognitive monitoring of retrieval, where both confidence and feeling-of-knowing judgments were informed by context familiarity even though responses were not speeded (Hanczakowski, Zawadzka, & Coote, 2014; Hanczakowski et al., 2015; 2017; see also related findings for cue familiarity in Schwartz & Metcalfe, 1992). Also, other studies on the role of familiarity in metacognitive monitoring under speeded and unspeeded responding suggest that even though response deadline can modulate the magnitude of the familiarity effect, familiarity does inform metacognition of retrieval even under conditions of unspeeded responding (Koriat & Levy-Sadot, 2011). Overall thus, although our results on their own are obviously insufficient to rule out the modulating role of response timing in familiarity-based metacognition, they nevertheless strengthen the case for familiarity as the cue for metacognitive monitoring of retrieval when responding is unspeeded.

With regard to context reinstatement, our results touch upon the discussion concerning the extent to which recollection of contextual associations that occurs when study materials are re-presented intact (as, for example, in a recognition test) is similar to retrieval that occurs in recall tests. Our results seem to suggest that one difference between these processes may be their sensitivity to time pressure, which may affect recall as evidenced by Benjamin (2005), but not necessary recollection of contextual associations, as shown in the present study.[5] This observation remains in broad agreement with an argument according to which recollection may be a more automatic process than retrieval occurring in recall tests. Whereas recall tests engage a host of strategic factors, such as the initiation of a retrieval mode (Herron & Wilding, 2004; Lepage, Ghaffar,

[5] One should bear again in mind, though, that time pressure applied in the speeded condition of our study (1.5 s for a response) was somewhat milder that the one applied by Benjamin (2005), which was 1 s for a response.

Nyberg, & Tulving, 2000), or cue elaboration (Unsworth et al., 2013), recollection elicited by study materials presented intact may bypass those strategic processes. For example, Cohn and Moscovitch (2007, see also Cohn, Emrich, & Moscovitch, 2008) argued that recollection triggered by intact re-presentation of the study materials relies on automatic processes that can be preserved with aging even when other forms of more effortful retrieval requiring strategic processing are impaired. If this perspective is adopted, then the obvious next step would be to systematically investigate the effect of context reinstatement for both memory and metacognitive measures in older adults to demonstrate the automatic nature of context-dependent recollection.

Learning in context

If context reinstatement and context familiarity can both affect metacognitive monitoring, then do they also affect the learning process itself? With regard to the effects of context familiarity on the effectiveness of learning at restudy, its consequences for subsequent memory performance are clear-cut, as none of the experiments presented here found any effects of this manipulation on cued-recall performance. One could argue that familiar contexts as defined in the present study – re-paired contexts that were taken from a different study pair – could serve as cues for retrieving their original pairs and such incidental retrieval could potentially cause interference during restudy. Indeed, we found some support for a similar role of context-induced interference in one study (see Hanczakowski et al., 2017, Experiment 1), when re-paired contexts included in a cued-recall test caused impaired memory performance as compared with novel contexts. However, the consistent lack of the effect of the context familiarity manipulation on final test performance observed here suggests that those interference effects are rare, at least when participants engage in restudy rather than explicit retrieval attempts.

The issue of context at encoding becomes more interesting when one considers the effect of context reinstatement. Experiments 1-4 showed that context reinstatement at restudy benefits subsequent memory performance. The only experiment that failed to find this pattern was Experiment 5 in which targets were not presented for the second time when the context

manipulation was introduced and thus additional encoding was unlikely to occur. Experiments 1, 2, and 4 demonstrated the pattern of augmented memory for reinstated contexts when original contexts – matching the reinstated contexts – were also present in the final cued-recall test. Such effect is uncontroversial. Presenting a pair for restudy with the reinstated context should strengthen the original item-to-context association, which should clearly not occur in conditions using re-paired and novel contexts. The strengthened item-to-context associations can be later used to access targets in a cued-recall test, consistently with studies documenting context reinstatement effect for cued recall (Smith et al., 2014; see also Smith & Vela, 2001).

Experiment 3 documented the same pattern of augmented cued-recall performance when contexts were reinstated at restudy, but – critically – this time the effect was present when contexts were omitted from the final cued-recall test. As we have already noted, this effect stands in contrast to studies showing benefits of contextual variability at study (Isarida & Isarida, 2010; Smith et al., 1978). What these previous studies show is that repeated encoding is usually more effective when it takes place in varied environmental contexts rather than the same context. Our results, on the other hand, demonstrate that repeated encoding can be more effective when it takes place in the same rather than varied contexts, even when contexts are not presented at test as in Experiment 3. The superiority of constant context seems to go against a widespread assumption that the more varied the encoding, the better subsequent memory.

When various studies document results that are directly opposing, the easiest (although perhaps not the most parsimonious) way to reconcile them is to assume that there are actually two different mechanisms in operation, each creating the effect in one direction, with the ultimate result depending on the balance of strength of these mechanisms under particular experimental conditions. In our case it would mean that one mechanism is responsible for the superiority of encoding in constant contexts whereas the other mechanism is responsible for the superiority of encoding in varied contexts, with the former being stronger in our design. This reasoning finds support in a study by Bellezza and Young (1989) who examined the role of constant and varied

contexts in a procedure in which pairs of words were presented. Participants either studied A-B pairs twice or were presented with pairs A-B and C-B. Under these conditions, cue words served as contexts that were either constant or varied across repetitions. Additionally, Bellezza and Young manipulated the delay between the presentations of these stimuli with massed and spaced repetitions. The main finding was that although massed repetitions resulted in the superiority of varied encoding, spaced repetitions resulted in the reversal of this effect and the superiority of constant encoding. These results generally support the idea of two opposing mechanisms exerting their influence on encoding when contexts are manipulated.

The specific mechanism that can be responsible for the superiority of constant contexts in our study is one of reminding in the form of recollection. In the study by Bellezza and Young (1989), the role of recollection was probably negligible with massed presentations, when to-be-remembered items were still in a very accessible state. However, with spaced repetitions, constant context could facilitate retrieval from long-term memory, leading to strengthening of the retrieved representations. In the present study, the role of recollection was directly controlled via context reinstatement rather than spacing but the results are again congruent with constant context promoting recollection and thus augmenting subsequent memory performance. The involvement of reminding in producing the benefits of constant context is also consistent with our previous investigation of context effects in recognition where restudy in reinstated rather than re-paired contexts resulted in subsequent better memory for contextual information (Hanczakowski et al., 2015). All these results converge on the conclusion that reinstated contexts contribute to instances of reminding, and reminding serves as a powerful encoding mechanism that creates strong memory traces for both focal and contextual information.

Cue diagnosticity

The final issue that warrants a discussion is the relationship between JOLs and subsequent memory performance. Throughout the present paper we have described cues shaping JOLs as either diagnostic – when the same cue shapes memory in a criterial test of memory in which performance

participants try to predict – or non-diagnostic – when the cue creates a dissociation between predictions and the actual memory performance which remains unaffected by variations in this cue. From this perspective, context manipulation can give rise to mnemonic information that can be both diagnostic and non-diagnostic, depending primarily on the conditions in which JOLs are elicited.

For immediate JOLs made in the presence of targets, context information proved always to be a diagnostic cue. Variations in context familiarity did not affect these judgments but neither did they affect final memory performance. By contrast, context reinstatement robustly affected immediate JOLs and at the same time this manipulation always exerted its influence on subsequent memory performance. Thus, participants were able to correctly anticipate how different types of memory information – familiarity accruing from re-paired contexts and recollection triggered by reinstated contexts – map onto future memory. In research on metacognitive monitoring it is common to concentrate on inaccuracies of JOLs. A host of factors affecting immediate JOLs but not affecting subsequent memory performance has been described (e.g., Besken, 2016; Rhodes & Castel, 2008; 2009; Susser, Jin, & Mulligan, 2016; Susser & Mulligan, 2014) which has given rise to summary statements according to which immediate JOLs are often biased and poorly reflect factors responsible for effective learning (e.g., Finn, 2008). The present study provides a more optimistic look on JOL accuracy, demonstrating that immediate JOLs made at restudy may be informed by diagnostic cues, such as recollection, and at the same time immune to the influence of non-diagnostic cues, such as spurious familiarity.

One of the important insights of the present study is that, while immediate JOLs collected at restudy proved to be highly accurate in incorporating diagnostic mnemonic cues, the same was not the case for delayed JOLs. Experiment 5 showed that delayed JOLs were informed both by context reinstatement and variations in context familiarity. However, the manipulations of context at the delayed JOL stage had no bearing on subsequent memory performance. In consequence, both context reinstatement and context familiarity turned out to be non-diagnostic cues for delayed JOLs.

In a stark contrast to accurate immediate JOLs, delayed JOLs were found to be based on factors that create illusions of effective encoding rather than actual learning.

It is commonly argued in the literature on learning that delayed JOLs are a superior way of monitoring learning than immediate JOLs due to their greater resolution (see Rhodes & Tauber, 2011b, for a review). The reason for this superiority of delayed JOLs is that they seem to rely to a greater extent than immediate JOLs on cues that are predictive of subsequent memory performance. When targets are again presented when delayed JOLs are prompted, their superiority vanishes (Dunlosky & Nelson, 1992). The argument is thus that when both cues and targets are presented for JOLs, participants are misled into overemphasizing various peripheral cues that are only weakly related to future memory. When targets are absent for delayed JOLs, participants are forced to rely on mnemonic cues, chiefly among them the ability to covertly retrieve information from long-term memory. Whether retrieval results in producing targets or, as sometimes happens for deceptive questions, interfering items (see Rhodes & Tauber, 2011a; Wahlheim, 2011), delayed JOLs are higher for cues for which retrieval succeeded. In rare cases in which incorrect information is accessed, JOLs do not become more accurate due to relying on retrieval from long-term memory. However, under standard, non-deceptive conditions correct targets are the most likely candidates for retrieval. Since targets that participants are able to retrieve when prompted for delayed JOLs are also highly likely to be retrieved again in the future cued-recall test, this target retrievability cue is generally highly diagnostic and thus contributes to increased accuracy of JOLs.

While we do not question the diagnostic nature of target retrievability as a cue for JOLs and the associated high resolution of delayed JOLs that often rest on this cue, we argue that our study shows how delayed JOLs are also sensitive to non-diagnostic cues, including the ones that are discounted when making immediate JOLs. There seems to be a cost associated with reducing information participants have available at the time of making metacognitive judgments. Removing targets from delayed JOLs means that mnemonic cues take over. However, not all mnemonic cues are diagnostic. While previous retrieval status of a target is clearly related to subsequent memory

performance, familiarity of a memory probe is not. As a consequence, delayed JOLs may be characterized by overreliance on certain non-diagnostic mnemonic cues, leading ultimately to inaccuracy of metacognitive monitoring of retrieval.

Conclusion

The present study looked at memory and metacognitive processes at the time of restudy. The role of environmental context was investigated. Consistently with the idea that retrieval processes contribute to repeated study of the same materials, we documented the role of recollection of previous study episodes in shaping both effective restudy and accurate metacognitive monitoring of restudy. We showed that the contribution of recollection to these processes depends on the contextual match between different study opportunities. At the same time, we also revealed a less positive role context may play in learning. We showed that context familiarity can create an illusion of learning when people try to assess how effective previous study sessions were. Together, the results demonstrate the importance of environmental context for both learning and metacognitive monitoring of learning.

References

Ariel, R., Dunlosky, J., & Bailey, H. (2009). Agenda-based regulation of study-time allocation: When agendas override item-based monitoring. *Journal of Experimental Psychology: General, 138,* 432-447.

Aue, W. R., Criss, A. H., & Novak, M. D. (2017). Evaluating mechanisms of proactive facilitation in cued recall. Journal of Memory and Language, 94, 103-118.

Bellezza, F. S., & Young, D. R. (1989). Chunking of repeated events in memory. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 15,* 990-997.

Benjamin, A. S. (2005). Response speeding mediates the contribution of cue familiarity and target retrievability to metamnemonic judgments. *Psychonomic Bulletin & Review, 12,* 874-879.

Benjamin, A. S., & Bird, R. D. (2006). Metacognitive control of the spacing of study repetitions. *Journal of Memory and Language, 55,* 126-137.

Benjamin, A. S., & Tullis, J. (2010). What makes distributed practice effective? *Cognitive Psychology, 61,* 228-247.

Besken, M. (2016). Picture-perfect is not perfect for metamemory: Testing the perceptual fluency hypothesis with degraded images. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 42,* 1417-1433.

Besken, M., & Mulligan, N. W. (2014). Perceptual fluency, auditory generation, and metamemory: Analyzing the perceptual fluency hypothesis in the auditory modality. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 40,* 429-440.

Brewer, G. A., Marsh, R. L., Clark-Foos, A., & Meeks, J. T. (2010). Non-criterial recollection influences metacognitive monitoring and control processes. *The Quarterly Journal of Experimental Psychology, 63,* 1936-1942.

Cohn, M., & Moscovitch, M. (2007). Dissociating measures of associative memory: Evidence and theoretical implications. *Journal of Memory and Language, 57,* 437-454.

Cohn, M., Emrich, S. M., & Moscovitch, M. (2008). Age-related deficits in associative memory: The influence of impaired strategic retrieval. *Psychology and Aging, 23,* 93-103.

Dunlosky, J., & Nelson, T. O. (1992). Importance of the kind of cue for judgments of learning (JOL) and the delayed-JOL effect. *Memory & Cognition, 20,* 374-380.

Dunlosky, J., & Nelson, T. O. (1994). Does the sensitivity of judgments of learning (JOLs) to the effects of various study activities depend on when JOLs occur? *Journal of Memory and Language, 33,* 545-565.

Dunlosky, J., & Thiede, K. W. (1998). What makes people study more? An evaluation of factors that affect self-paced study. *Acta Psychologica, 98,* 37-56.

England, B. D., & Serra, M. J. (2012). The contributions of anchoring and past-test performance to the underconfidence-with-practice effect. *Psychonomic Bulletin & Review, 19,* 715-722.

Evans, L. H., Williams, A. N., Wilding, E. L. (2015). Electrophysiological evidence for retrieval mode immediately after a task switch. *NeuroImage, 108,* 435-440.

Finn, B. (2008). Framing effects on metacognitive monitoring and control. *Memory & Cognition, 36,* 813-821.

Finn, B., & Metcalfe, J. (2007). The role of memory for past test in the underconfidence with practice effect. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 33,* 238-244.

Finley, J. R., & Benjamin, A. S. (2012). Adaptive and qualitative changes in encoding strategy with experience: Evidence from the test-expectancy paradigm. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 38,* 632-652.

Finn, B., & Metcalfe, J. (2008). Judgments of learning are influenced by memory for past test. *Journal of Memory and Language, 58,* 19-34.

Godden, D. R., & Baddeley, A. D. (1975). Context-dependent memory in two natural environments: Land and underwater. *British Journal of Psychology, 66,* 325-331.

Hanczakowski, M., Beaman, C. P., & Jones, D. M. (2017). When distraction benefits memory through semantic similarity. *Journal of Memory and Language, 94,* 61-74.

Hanczakowski, M., Pasek, T., Zawadzka, K., & Mazzoni, G. (2013). Cue familiarity and 'don't know' responding in episodic memory tasks. *Journal of Memory and Language, 69,* 368-383.

Hanczakowski, M., Zawadzka, K., & Cockcroft-McKay, C. (2014). Feeling of knowing and restudy choices. *Psychonomic Bulletin & Review, 21,* 1617-1622.

Hanczakowski, M., Zawadzka, K., Collie, H., & Macken, B. (2017). Metamemory in a familiar place: The effects of environmental context on feeling of knowing. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 43,* 59-71.

Hanczakowski, M., Zawadzka, K., & Coote, L. (2014). Context reinstatement in recognition: Memory and beyond. *Journal of Memory and Language, 72,* 85-97.

Hanczakowski, M., Zawadzka, K., & Macken, B. (2015). Continued effects of context reinstatement in recognition. *Memory & Cognition, 43,* 788-797.

Hanczakowski, M., Zawadzka, K., Pasek, T., & Higham, P. A. (2013). Calibration of metacognitive judgments: Insights from the underconfidence-with-practice effect. *Journal of Memory and Language, 69,* 429-444.

Herron, J. E., Evans, L. H., & Wilding, E. L. (2016). Electrophysiological evidence for flexible goal-directed cue processing during episodic retrieval. *NeuroImage, 132,* 24-31.

Herron, J. E., & Wilding, E. L. (2004). An electrophysiological dissociation of retrieval mode and retrieval orientation. *NeuroImage, 22,* 1554-1562.

Hertzog, C., Fulton, E. K., Sinclair, S. M., & Dunlosky, J. (2014). Recalled aspects of original encoding strategies influence episodic feeling of knowing. *Memory & Cognition, 42,* 126-140.

Hintzman, D. L. (2011). Research strategy in the study of memory: Fads, fallacies, and the search for the "coordinates of truth". *Perspectives on Psychological Science, 6,* 253-271.

Hockley, W. E. (2008). The effects of environmental context on recognition memory and claims of remembering. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 34,* 1412-1429.

Hockley, W. E., Bancroft, T. B., & Bryant, E. (2012). Associative and familiarity-based effects of environmental context on memory. *Canadian Journal of Experimental Psychology, 66,* 81-89.

Isarida, T., & Isarida, T. K. (2010). Effects of simple- and complex-place contexts in the multiple-context paradigm. *The Quarterly Journal of Experimental Psychology, 63,* 2399-2412.

Jacoby, L. L., Wahlheim, C. N., & Kelley, C. M. (2015). Memory consequences of looking back to notice change: Retroactive and proactive facilitation. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 41,* 1282-1297.

Jonker, T. R., Seli, P., & MacLeod, C. M. (2013). Putting retrieval-induced forgetting into context: An inhibition-free, context-based account. *Psychological Review, 120,* 852-872.

Karpicke, J. D. (2009). Metacognitive control and strategy selection: Deciding to practice retrieval during learning. *Journal of Experimental Psychology: General, 138,* 469-486.

Koen, J. D., Aly, M., Wang, W.-C., & Yonelinas, A. P. (2013). Examining the causes of memory strength variability: Recollection, attention failure, or encoding variability? *Journal of Experimental Psychology: Learning, Memory, and Cognition, 39,* 1726-1741.

Koriat, A. (1993). How do we know that we know? The accessibility model of the feeling of knowing. *Psychological Review, 100,* 609-639.

Koriat, A. (1995). Dissociating knowing and the feeling of knowing: Further evidence for the accessibility model. *Journal of Experimental Psychology: General, 124,* 311-333.

Koriat, A. (1997). Monitoring one's own knowledge during study: A cue-utilization approach to judgments of learning. *Journal of Experimental Psychology: General, 126,* 349-370.

Koriat, A., & Levy-Sadot, R. (2001). The combined contributions of the cue-familiarity and accessibility heuristics to feeling of knowing. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 27,* 34-53.

Koriat, A., Ma'ayan, H., & Nussinson, R. (2006). The intricate relationships between monitoring and control in metacognition: Lessons for the cause-and-effect relation between subjective experience and behavior. *Journal of Experimental Psychology: General, 135,* 36-69.

Kornell, N., Bjork, R. A., & Garcia, M. A. (2011). Why tests appear to prevent forgetting: A distribution-based bifurcation model. *Journal of Memory and Language, 65,* 85-97.

Kornell, N., & Rhodes, M. G. (2013). Feedback reduces the metacognitive benefit of tests. *Journal of Experimental Psychology: Applied, 19,* 1-13.

Lehman, M., Smith, M. A., & Karpicke, J. D. (2014). Toward an episodic context account of retrieval-based learning: Dissociating retrieval practice and elaboration. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 40,* 1787-1794.

Lepage, M., Ghaffar, O., Nyberg, L., & Tulving, E. (2000). Prefrontal cortex and episodic memory retrieval mode. *Proceedings of the National Academy of Sciences, 97,* 506-511.

Lohnas, L. J., Polyn, S. M., & Kahana, M. J. (2011). Contextual variability in free recall. *Journal of Memory and Language, 64,* 249-255.

Macken, W. J. (2002). Environmental context and recognition: The role of recollection and familiarity. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 28,* 153-161.

Mandler, G. (1980). Recognizing: The judgment of previous occurrence. *Psychological Review, 87,* 252-271.

Mazzoni, G., & Cornoldi, C. (1993). Strategies in study time allocation: Why is study time sometimes not effective? *Journal of Experimental Psychology: General, 122,* 47-60.

McCabe, D. P., Roediger, H. L., & Karpicke, J. D. (2011). Automatic processing influences free recall: Converging evidence from the process dissociation procedure and remember-know judgments. *Memory & Cognition, 39,* 389-402.

Melton, A. W. (1970). The situation with respect to the spacing of repetitions and memory. *Journal of Verbal Learning and Verbal Behavior, 9,* 596-606.

Metcalfe, J., & Finn, B. (2008). Familiarity and retrieval processes in delayed judgments of learning. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 34,* 1084-1097.

Metcalfe, J., & Kornell, N. (2005). A region of proximal learning model of study time allocation. *Journal of Memory and Language, 52,* 463-477.

Mueller, M. L., Dunlosky, J., & Tauber, S. K. (2015). Why is knowledge updating after task experience incomplete? Contributions of encoding experience, scaling artifact, and inferential deficit. *Memory & Cognition, 43,* 180-192.

Murnane, K., & Phelps, M. P. (1993). A global activation approach to the effect of changes in environmental context on recognition. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 19,* 882-894.

Murnane, K., & Phelps, M. P. (1995). Effects of changes in relative cue strength on context-dependent recognition. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 21,* 158-172.

Murnane, K., Phelps, M. P., & Malmberg, K. (1999). Context-dependent recognition memory: The ICE theory. *Journal of Experimental Psychology: General, 128,* 403-415.

Nelson, T. O., & Dunlosky, J. (1991). When people's judgments of learning (JOLs) are extremely accurate at predicting subsequent recall: The "delayed-JOL effect." *Psychological Science, 2,* 267-270.

Putnam, A. L., Sungkhasettee, V. W., & Roediger, H. L. (2016). When misinformation improves memory: The effects of recollecting change. *Psychological Science, 28,* 36-46.

Rawson, K. A., & Dunlosky, J. (2011). Optimizing schedules of retrieval practice for durable and efficient learning: How much is enough? *Journal of Experimental Psychology: General, 140,* 283-302.

Reder, L. M., Liu, X. L., Keinath, A., & Popov, V. (2016). Building knowledge requires bricks, not sand: The critical role of familiar constituents in learning. *Psychonomic Bulletin & Review, 23,* 271-277.

Reder, L. M., & Ritter, F. E. (1992). What determines initial feeling of knowing? Familiarity with question terms, not with the answer. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 18,* 435-451.

Rhodes, M. G., & Castel, A. D. (2008). Memory predictions are influenced by perceptual information: Evidence for metacognitive illusions. *Journal of Experimental Psychology: General, 137,* 615-625.

Rhodes, M. G., & Castel, A. D. (2009). Metacognitive illusions for auditory information: Effects on monitoring and control. *Psychonomic Bulletin & Review, 16,* 550-554.

Rhodes, M. G., & Tauber, S. K. (2011a). Monitoring memory errors: The influence of the veracity of retrieved information on the accuracy of judgements of learning. *Memory, 19,* 853-870.

Rhodes, M. G., & Tauber, S. K. (2011b). The influence of delaying judgments of learning on metacognitive accuracy: A meta-analytic review. *Psychological Bulletin, 137,* 131-148.

Roediger, H. L., & Karpicke, J. D. (2006). The power of testing memory: Basic research and implications for educational practice. *Perspectives on Psychological Science, 1,* 181-210.

Rowland, C. A. (2014). The effect of testing versus restudy on retention: A meta-analytic review of the testing effect. *Psychological Bulletin, 140,* 1432-1463.

Russo, R., Ward, G., Geurts, H., & Scheres, A. (1999). When unfamiliarity matters: Changing environmental context between study and test affects recognition memory for unfamiliar stimuli. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 25,* 488-499.

Schwartz, B. L., & Metcalfe, J. (1992). Cue familiarity but not target retrievability enhances feeling-of-knowing judgments. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 18,* 1074-1083.

Serra, M. J., & Ariel, R. (2014). People use the memory for past-test heuristic as an explicit cue for judgments of learning. *Memory & Cognition, 42,* 1260-1272.

Siegel, L. L., & Kahana, M. J. (2014). A retrieved context account of spacing and repetition effects in free recall. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 40,* 755-764.

Smith, S. M. (1979). Remembering in and out of context. *Journal of Experimental Psychology: Human Learning and Memory, 5,* 460-471.

Smith, S. M., Glenberg, A., & Bjork, R. A. (1978). Environmental context and human memory. *Memory & Cognition, 6,* 342-353.

Smith, S. M., & Handy, J. D. (2014). Effects of varied and constant environmental contexts on acquisition and retention. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 40,* 1582-1593.

Smith, S. M., & Handy, J. D. (2016). The crutch of context-dependency: Effects of contextual support and constancy on acquisition and retention. *Memory, 24,* 1134-1141.

Smith, S. M., Handy, J. D., Angello, G., & Manzano, I. (2014). Effects of similarity on environmental context cuing. *Memory, 22,* 493-508.

Smith, S. M., & Manzano, I. (2010). Video context-dependent recall. *Behavior Research Methods, 42,* 292-301.

Smith, S. M., & Vela, E. (2001). Environmental context-dependent memory: A review and meta-analysis. *Psychonomic Bulletin & Review, 8,* 203-220.

Son, L. K. (2004). Spacing one's study: Evidence for a metacognitive control strategy. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 30,* 601-604.

Sungkhasettee, V. W., Friedman, M. C., & Castel, A. D. (2011). Memory and metamemory for inverted words: Illusions of competency and desirable difficulties. *Psychonomic Bulletin & Review, 18,* 973-978.

Susser, J. A., Jin, A., & Mulligan, N. W. (2016). Identity priming consistently affects perceptual fluency but only affects metamemory when primes are obvious. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 42,* 657-662.

Susser, J. A., & Mulligan, N. W. (2014). The effect of motoric fluency on metamemory. *Psychonomic Bulletin & Review, 22,* 1014-1019.

Szpunar, K. K., McDermott, K. B., & Roediger, H. L. (2008). Testing during study insulates against the buildup of proactive interference. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 34,* 1392-1399.

Thiede, K. W., & Dunlosky, J. (1999). Toward a general model of self-regulated study: An analysis of selection of items for study and self-paced study time. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 25,* 1024-1037.

Thomas, A. K., Bulevich, J. B., & Dubois, S. (2011). Context affects feeling-of-knowing accuracy in younger and older adults. *Journal of Memory and Language, 37,* 96-108.

Tibon, R., Vakil, E., Goldstein, A., & Levy, D. A. (2012). Unitization and temporality in associative memory: Evidence for modulation of context effects. *Journal of Memory and Language, 67,* 93-105.

Tullis, J. G., & Benjamin, A. S. (2011). On the effectiveness of self-paced learning. *Journal of Memory and Language, 64,* 109-118.

Tullis, J. G., Benjamin, A. S., & Ross, B. H. (2014). The reminding effect: Presentation of associates enhances memory for related words in a list. *Journal of Experimental Psychology: General, 143,* 1526-1540.

Tullis, J. G., Finley, J. R., & Benjamin, A. S. (2013). Metacognition of the testing effect: Guiding learners to predict the benefits of retrieval. *Memory & Cognition, 41,* 429-442.

Undorf, M., Zimdahl, M. F., & Bernstein, D. M. (2017). Perceptual fluency contributes to effects of stimulus size on judgments of learning. *Journal of Memory and Language, 92,* 293-304.

Unsworth, N., Brewer, G. A., & Spillers, G. J. (2013). Focusing the search: Proactive and retroactive interference and the dynamics of free recall. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 39,* 1742-1756.

Wahlheim, C. N. (2011). Predicting memory performance under conditions of proactive interference: Immediate and delayed judgments of learning. *Memory & Cognition, 39,* 827-838.

Wahlheim, C. N., & Jacoby, L. L. (2013). Remembering change: The critical role of recursive remindings in proactive effects of memory. *Memory & Cognition, 41,* 1-15.

Wahlheim, C. N., Maddox, G. B., & Jacoby, L. L. (2014). The role of reminding in the effects of spaced repetitions on cued recall: Sufficient but not necessary. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 40,* 94-105.

Whiffen, J. W., & Karpicke, J. D. (in press). The role of episodic context in retrieval practice effects. *Journal of Experimental Psychology: Learning, Memory, and Cognition*.

Yang, C., Potts, R., & Shanks, D. R. (2017). Metacognitive unawareness of the effortful generation benefit and its effects on self-regulated learning. *Journal of Experimental Psychology: Learning, Memory, and Cognition*. Advance online publication.

Yonelinas, A. P. (2002). The nature of recollection and familiarity: A review of 30 years of research. *Journal of Memory and Language, 46,* 441-517.

Yue, C. L., Castel, A. D., & Bjork, R. A. (2013). When disfluency is – and is not – a desirable difficulty: The influence of typeface clarity on metacognitive judgments and memory. *Memory & Cognition, 41,* 229-241.

Zawadzka, K., & Higham, P. A. (2015). Judgments of learning index relative confidence, not subjective probability. *Memory & Cognition, 43,* 1168-1179.

Zawadzka, K., & Higham, P. A. (2016). Recalibration effects in judgments of learning: A signal detection analysis. *Journal of Memory and Language, 90,* 161-176.

Table 1.
Mean JOLs in Experiments 1-5 on cycles 1 and 2. JOLs on cycle 2 are presented as a function of the context condition. JOLs in Experiments 1-3 were made on a 0-100 scale whereas JOLs in Experiments 4 and 5 were made on a 1-4 scale. Standard deviations are given in parentheses.

	Cycle 1	Reinstated	Re-paired	Novel
Experiment 1	31.66 (16.42)	39.66 (21.16)	34.71 (20.58)	36.25 (19.66)
Experiment 2	38.52 (10.70)	40.07 (13.92)	36.81 (12.55)	37.83 (13.15)
Experiment 3	37.16 (12.49)	36.25 (18.29)	32.70 (18.06)	33.96 (18.44)
Experiment 4	2.18 (0.40)			
Speeded	-	2.27 (0.59)	2.09 (0.64)	2.03 (0.58)
Unspeeded	-	2.39 (0.62)	2.20 (0.60)	2.23 (0.58)
Experiment 5	2.15 (.47)			
Speeded	-	1.92 (0.63)	1.83 (0.61)	1.70 (0.54)
Unspeeded	-	2.01 (0.64)	1.91 (0.63)	1.84 (0.63)

Table 2.
Mean correct cued recall in Experiments 1-5 on cycles 1 and 2. Correct recall on cycle 2 is presented as a function of the context condition in the study phase for this cycle. Standard deviations are given in parentheses.

	Cycle 1	Reinstated	Re-paired	Novel
Experiment 1	.29 (.19)	.65 (.28)	.52 (.30)	.53 (.29)
Experiment 2	-	.54 (.26)	.43 (.25)	.47 (.27)
Experiment 3	.20 (.17)	.48 (.27)	.43 (.29)	.46 (.29)
Experiment 4	.31 (.17)			
Speeded	-	.51 (.27)	.39 (.23)	.41 (.24)
Unspeeded	-	.61 (.28)	.48 (.29)	.48 (.27)
Experiment 5	.28 (.18)			
Speeded	-	.26 (.20)	.26 (.22)	.25 (.19)
Unspeeded	-	.28 (.22)	.26 (.23)	.28 (.22)

Figure 1.

Context conditions in Experiments 1-5. The figure presents three context conditions – reinstated, re-paired, and novel – presented in columns from left to right, respectively. Experiments 4 and 5 additionally included the manipulation of the response deadline for providing JOLs either in Study phase 2 (Experiment 4) or Delayed JOLs phase (Experiment 5).