Subjective experience guides betting decisions beyond accuracy: evidence from a metamemory illusion

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ABSTRACT
The goal of this research was to test whether subjective memory experiences drive accuracy regulation decisions above and beyond objective memory indices. In four experiments (n = 115) subjective recollection (i.e., reporting “Remember” in the Remember-Know task) was dissociated from memory accuracy by manipulating retrieval during a two-alternative forced-choice recognition task: in the Match condition the distracter was a novel exemplar of the target (e.g., a studied and an unstudied toaster) and in the Non-match condition the distracter was a novel exemplar of another studied but untested item (e.g., a studied toaster and an unstudied birdhouse). Participants were more accurate on Match trials, but reported subjective recollection more frequently on Non-match trials. Critically, participants also bet more often on Non-match trials to the detriment of their score (Experiment 1). This pattern persisted when participants were additionally required to retrieve details about items (Experiment 2) and when confidence assessments were collected (Experiment 3). Finally, participants bet more on Non-match trials even when subjective judgments were not elicited, suggesting that the decision process does not require reporting on subjective experience (Experiment 4). These results indicate that subjective memory experiences guide decision-making independent of objective accuracy and thus are critical to accuracy regulation.

The human experience is characterised by constant and unavoidable introspection. We routinely reflect on the quality of our memories, perhaps noticing that we can never remember where we left the keys, or that we remember certain events better than others. Likewise, we are aware of our efforts to learn new information, or to stay attentive during a lecture or conversation. This type of self-reflection is likely a uniquely human attribute, and intuitively appears to be important for decision-making and goal-directed behaviours. Indeed, many studies have found that adults and children use subjective assessments of their mental states to make decisions related to self-regulation (e.g., Koriat & Goldsmith, 1996; Metcalfe & Finn, 2008). However, in the face of increasing evidence that many controlled behaviours can be driven by unconscious processes (Carter & Van Veen, 2007; Shenhav, Botvinick, & Cohen, 2013), it remains unclear whether conscious introspection directly subserves decision-making and goal-directed behaviours, or is epiphenomenal to the corresponding cognitive and decision processes.

There is a great deal of evidence that people’s ability to monitor their mental states is related to their decision-making (Nelson & Narens, 1990; Schneider & Lockl, 2008; Son & Schwartz, 2002). It has been shown that people’s subjective assessments of their mental states are related to their decisions about what to study, what information to report or rely on, and whether or not to continue a memory search (Goldsmith & Koriat, 2008; Roebers, Schmid, & Roderer, 2009). For example, both adults and children choose to allocate additional study time to difficult items they have judged less well learned (Destan, Hembacher, Ghetti, & Roebers, 2014; Son & Metcalfe, 2000), and exclude incorrect answers from their memory reports when memory accuracy is emphasised over memory quantity by reporting only their higher confidence memories (Koriat & Goldsmith, 1996; Roebers et al., 2009). Others have demonstrated that people are more likely to continue expending effort in a memory search when they experience greater feelings of knowing (the sense that currently un-retrievable information is stored in memory; Costermans, Lories, & Ansay, 1992). Additionally, people decide which memories to rely on to pursue a reward based on the subjective qualities of those memories (Hembacher & Ghetti, 2013, 2014).

Based on this cumulative evidence, it has long been assumed that metacognitive processes are critical for decision-making. However, it remains possible that automatic monitoring and control processes underlie memory decisions that are later attributed to subjective feelings. Indeed, research has shown that many of the decisions...
we make while learning and responding are unconscious, even when we perceive them as deliberate (e.g., van Gaal, De Lange, & Cohen, 2012). For example, neural and behavioural evidence of decisions have been shown to emerge prior to participants reporting becoming conscious of them (Banks & Isham, 2009; Libet, 1985). Furthermore, recent models of decision-making emphasise unconscious mechanisms for decisions about the engagement of cognitive control (e.g., Shenav et al., 2013). This has led some to hypothesise that metacognitive introspections are epiphenomenal to their associated actions, rather than causal (e.g., Dijksterhuis & Aarts, 2010; Linser & Goschke, 2007; Wegner, 2003).

Critically, many of the previous attempts to establish a causal link between metacognitive monitoring and decision-making are arguably limited by the correspondence between the object and meta levels (i.e., the cognitive process itself and the meta representation of it): when the two coincide (e.g., stronger memories are endorsed with higher confidence than weaker memories), it is difficult to exclude the possibility that the object level actually drives behaviour despite the apparent, and perhaps epiphenomenal, relation between metacognitive assessments and decision-making. Since people’s metacognitive judgments tend to be relatively well-calibrated to their accuracy (e.g., Koriat, Sheffer, & Ma’ayan, 2002; Mazzoni & Nelson, 1995), this poses a considerable limitation to our understanding of the functional relation between metacognitive monitoring and decision-making. Although objective and subjective measures tend to be strongly associated, examples of dissociations are present in the literature and these dissociations can be exploited to examine their independent contributions to decision-making. For example, Metcalfe and Finn (2008) investigated study time allocation patterns in a word-pair learning task following an experimental manipulation that dissociated actual learning progress (as measured by a subsequent memory test) from subjective judgments of learning (JOLs), and showed that the illusory JOLs, and not actual learning, predicted study behaviour (see also Rhodes & Castel, 2009), strongly suggesting a causal relation between metacognitive judgments and people’s self-guided learning. Similarly, Persaud, McLeod, and Cowey (2007) showed that people were not more likely to bet on correct answers in three tasks that are known for producing correct answers without awareness: blindsight, an artificial grammar task, and the Iowa gambling task. Persaud et al. argued that post-decision wagering is a particularly useful measure of awareness, as participants are motivated to increase their earnings by reporting correct answers.

The results of a study by Tulving (1981) provide another example of a dissociation between accuracy and metacognitive monitoring. Tulving had participants study photographs of complex naturalistic scenes, and then tested their memory for them in a two-alternative forced-choice recognition task. Critically, there were three trial types; on a third of trials, the distracter image was similar to the target (i.e., the distracter presented a different part of the same scene; A-A’). On another third of trials, the distracter image was not similar to the target, but was similar to another studied but untested item (i.e., the distracter presented a different part of a studied scene; A-B’), and on the remaining trials, the distracter was not similar to any studied item (i.e., the distracter presented a completely new scene; A-X’). Hit rates were highest for A-A’ trials, and they were higher for A-A’ trials compared to A-B’ trials. However, participants’ subjective confidence ratings were highest for A-B’ trials compared to A-A’ and A-X’ trials. Thus, people’s judgments of their likely accuracy were systematically dissociated from their actual accuracy. Tulving speculated that perceptually similar trials (A-A’) promote higher accuracy because they elicit “deeper or more elaborate processing of retrieval information”, but does not directly address the source of the dissociation of accuracy from confidence. Dobbins, Kroll, and Liu (1998) extended Tulving’s results by eliciting Remember-Know judgments, or subjective judgments of recollection and familiarity (i.e., the sense that one recalls the past vividly and with considerable detail compared to a mere feeling of “oldness”, Gardiner & Java, 1993; Tulving, 1985). They found that participants were more likely to identify items as recollected for dissimilar trials, while they were more accurate for similar trials (see Heathcote, Freeman, Etherington, Tonkin, & Bora, 2009, for a replication with faces as stimuli). However, it remains untested whether these subjective aspects of memory states drive decision-making when they are dissociated from accuracy.

These are important questions, as much attention has been devoted to the phenomenological differences between memory states based on the assumption that the conscious experience of recollection as compared to familiarity should result in different behavioural and decision outcomes (e.g., Mandler, 1985; Tulving, 1985). For example, people might consider recollection to be particularly strong evidence of occurrence compared to a strong sense of familiarity (Yonelinas, 1994); thus when accuracy is important, people might decide to report only information that is recollected, and withhold information that is merely familiar (Hembacher & Ghetti, 2013). However, this assumption remains untested in a situation in which accuracy is dissociated from subjective experience.

For the present research we adapted Tulving’s (1981) paradigm to examine the effect of subjective assessments of memory states on decision-making when subjective assessments are dissociated from accuracy. Although the Remember-Know (RK) paradigm (Gardiner & Java, 1993; Tulving, 1985) was not designed to investigate metacognitive processes, these judgments capitalise on people’s ability to monitor and report on their ongoing cognitive states, which fall in the realm of procedural metacognition (Nelson & Narens, 1990). Indeed, RK judgments require participants to reflect on qualitative aspects of their memory: whether or not it is accompanied by contextual detail and/or a sense of re-living the experience (Tulving, 1985).
McCabe and Soderstrom (2011) made a similar assumption that RK judgments reflect a metacognitive process, and found that prospective RK judgments were more predictive of later accuracy in cued-recall compared to JOLs, suggesting that reflecting on the availability of specific details may support metacognitive calibration. In the present work, we examined whether aspects of procedural metacognition drive betting decisions in a task in which participants decided whether to bet on their likely accuracy in order to ostensibly improve their score in comparison to other participants (Hembacher & Ghetti, 2013; Persaud et al. 2007; Roebers et al., 2009).

Thus, we were able to examine participants’ likelihood of betting across two conditions, one of which was associated with higher accuracy, and the other of which was associated with higher rates of subjective recollection (Experiment 1). We then examined whether participants’ betting patterns persisted when the encoding task included two contextual details that were tested during retrieval (Experiment 2), when confidence judgments were elicited in addition to subjective recollection and familiarity judgments (Experiment 3), and when participants were not asked to report on their sense of recollection or familiarity or any other subjective experience (Experiment 4). The factors examined within each experiment allow us to test for the robustness of the metacognitive illusion and resulting decision processes, and are further justified in the introduction to the individual experiments.

**Experiment 1**

Experiment 1 involved a two-alternative forced-choice recognition memory task with two retrieval conditions modelled after Tulving (1981). We elected to use images of simple objects as stimuli, rather than complex scenes (Dobbins et al., 1998; Tulving, 1981) or faces (Heathcote et al., 2009), to extend the replication of previous effects to a new set of stimuli. During retrieval testing, on “Match” trials (i.e., A-A’ trials) the target was paired with a distracter that was a novel exemplar of the target item (e.g., a studied toaster and an unstudied toaster), such that the distracter was very perceptually and semantically similar to the target. On “Non-match” trials (i.e., A-B’ trials), the target was paired with a distracter that was a novel exemplar of a studied but untested item (e.g., a studied toaster and an unstudied birdhouse; Figure 1). Thus, all distracters were highly familiar to the participant, but only half were presented with their similar counterpart. The purpose of this manipulation was to induce an illusory sense of recollection for inaccurate choices on proportionately more Non-match trials (Dobbins et al., 1998; Heathcote et al., 2009). On the other hand, we predicted accuracy would be higher for Match trials due to participants’ ability to directly compare the target with its similar counterpart, which may support identifying the most diagnostic features of studied items (Dobbins et al., 1998; Heathcote et al., 2009; Tulving, 1981). On each trial, after providing a recollection or familiarity judgment, participants decided whether or not to “bet” on their answer (i.e., select the answer to count towards their overall score). We expected that participants would bet more on Non-match compared to Match trials if they relied on their subjective recollection.

**Method**

**Participants**

Participants included 24 undergraduate students at the University of California, Davis (13 females). The sample size was selected to be comparable with previous investigations of memory and metacognition among adults in which large effect sizes were observed (e.g., Metcalfe & Finn, 2008). An additional three students participated but were excluded from analyses due to chance performance, suggesting that they were not fully attending to the task. The current sample is sufficient to detect an effect size of $d = .60$ or greater with 80% power and $\alpha < .05$. Participants received class credit for participating. The protocol was approved by the Institutional Review Board of the University of California, Davis.

**Materials**

**Stimuli**

Stimuli included 160 colour images of familiar items selected from Yassa et al. (2011). The stimulus set includes pairs of images depicting very similar but distinct versions of the same object (Figure 1). The selected images consisted of 80 unique objects and their Matches. Four blocks of 20 pairs were created for counterbalancing purposes, and assigned to Set A or Set B. Assignment of items within pairs to target (A or B) or distracter (A’ or B’) status was fully counterbalanced.

**Procedure**

**Encoding task**

Participants incidentally encoded Sets A and B of the pictorial stimuli. They viewed each image for 2000 ms, and answered whether each item was more likely to be found indoors or outdoors by pressing one of two keys on a keyboard (Figure 1(a)).

**Retrieval task**

During the retrieval task (which consisted of 40 trials), participants made a forced-choice memory decision followed by a Remember or Familiar judgment (we used the word “Familiar”, as have others, e.g., Dobbins et al., 1998, as it is more intuitive than “Know”) and a betting decision. All of these responses were made on a touch-screen monitor with illustrated buttons on the screen (Figure 1(b)). On each trial, participants were first shown two images on the touch-screen monitor. On half of the trials,
studied targets (Set A1) were presented with their individual counterparts (Set A1'; Match trials). On the remaining half of trials, studied targets (Set A2) were presented with the counterparts to encoded, but untested items (Set B1'; Non-match trials). Thus, all distracters resembled studied items, but the target was sometimes presented beside a similar and familiar distracter, and was sometimes presented next to a dissimilar but familiar distracter (Figure 1(c)). Participants selected the old image by pressing the monitor. Following their selection, participants gave a Remember or Familiar judgment. Participants were told to select Remember if they could think of specific details about when they saw the image in the encoding task. They were instructed to indicate that the item was Familiar if they knew they had previously seen the item, but could not recall specific details about its presentation. Thus, Remember judgments corresponded to subjective recollection, while Familiar judgments corresponded to subjective familiarity. They made their choice by pressing either an R or an F icon on the monitor (Figure 1(b)). Finally, participants decided whether or not to bet on their answer for that trial by pressing either an icon of a treasure box if they opted to bet on that trial or a trash can if they opted not to bet (Figure 1(b)). The position of the treasure and trash icons on the left or right side of the screen was counterbalanced between participants. Participants were told that they would receive a point if they bet on a correct answer, but they would lose a point if they bet on an incorrect answer. They were told that choosing not to bet on a trial would have no effect on their score. To motivate selective betting, participants were told that their final score would be ranked compared to all other students who had participated and displayed on the screen at the end of the task in the presence of the experimenter. At the conclusion of the task, participants were explained that we did not have their ranking, and that we had included that instruction to increase motivation.

Results and discussion
Planned comparisons were conducted with memory accuracy, rates of Remember judgments, and rates of betting as dependent measures across Match and Non-match trials. For these analyses and those in the following experiments, we used two-tailed paired samples t-tests. As expected, memory accuracy was higher for Match trials, $M = .75, SD = .10$, compared to Non-match trials, $M = .67, SD = .12$, $t(1,23) = 2.20, p = .04, d = .46$ (Figure 2(a)). In contrast, rates of Remember judgments were higher for Non-match trials, $M = .64, SD = .25$, compared to Match trials, $M = .48, SD = .19$, $t(1,23) = 3.27, p = .003, d = .68$ (Figure 2(b)). Furthermore, betting rates, though not identical to Remember rates, were still higher for Non-match trials, $M = .75, SD = .18$, compared to Match trials, $M = .62, SD = .20$, $t(1,23) = 2.54, p = .02, d = .53$ (Figure 2(c)).

Overall, participants were more likely to report subjective recollection on Non-match trials compared to Match trials, despite achieving higher memory accuracy for Match trials for which response selection could be based on the most diagnostic features of previously studied items. Thus, we replicated the metacognitive illusion described by Dobbins et al. (1998), Heathcote et al. (2009) and Tulving (1981) using substantially less visually complex stimuli than used previously (i.e., familiar objects rather than complex scenes or unfamiliar faces). The presence of the illusory recollection effect even when overall accuracy is higher and stimuli are less visually complex speaks to the robustness of the illusion. It eliminates
the possible interpretation that the illusion stems from participants’ confusion with the task, or that dissociations between objective and subjective memory states only emerge when memory decisions are particularly difficult, which could arguably encourage individuals to use additional cues to make memory decisions. More broadly, it contradicts the possibility that subjective experience is less important when accuracy is higher.

Although this research was not designed to address the mechanism for the dissociation between Match and Non-match trials, one possibility is that decisions on Match trials were experienced as being less fluent despite being accurate. If so, we might observe longer response latencies for Match trials, which would reflect a speed-accuracy tradeoff. To examine this possibility, we entered responses latencies in a 2 (trial type: Match versus Non-match) × 2 (trial accuracy: Accurate versus Inaccurate) repeated measures ANOVA. We found a main effect of accuracy, $F(1, 23) = 9.88, p = .005, \eta^2 = .30$, such that response latencies were greater for inaccurate trials, but no main effect of trial type, $F(1,23) = .80, p = .38, \eta = .03$, and the two did not significantly interact, $p = .89$. Response latencies were as follows; accurate Match trials: $M = 3081 \text{ ms}, SD = 918.91 \text{ ms}$; accurate Non-match trials: $M = 3251.44 \text{ ms}, SD = 1293.36 \text{ ms}$; inaccurate Match trials: $M = 3684.82 \text{ ms}, SD = 1834.59 \text{ ms}$; inaccurate Non-match trials: $M = 3809.17 \text{ ms}, SD = 1548.64 \text{ ms}$. Thus, differential response latencies for Match and Non-match trials were not likely the dimension driving people’s reports of subjective recollection.

Of importance, when given the opportunity to bet on items, participants were more likely to bet on Non-match trials, the subset of items for which they experienced an illusory sense of subjective recollection. This suggests that subjective experience can drive decision-making even when subjective experience is systematically dissociated from objective accuracy. We conducted Experiment 2 to further test the robustness of this illusion and associated betting behaviours.

**Experiment 2**

Experiment 2 was conducted to replicate the results from Experiment 1 when participants were additionally encouraged to encode specific details about the study event. During retrieval, in addition to the prompts included in Experiment 1, participants were asked to identify these specific details to determine whether the metacognitive illusion and associated betting decisions would be retained even when participants were encouraged to retrieve an additional accurate detail about the encoding context. We reasoned that the retrieval of additional contextual details about the encoding event may disrupt the metacognitive illusion because participants may consider these details, which are independent of the retrieval encoding condition, to be diagnostic of recollection.

**Method**

**Participants**

Participants included 30 undergraduate students at the University of California, Davis (12 females). This sample size is sufficient to achieve 80% power given $\alpha < .05$ to
detect the effect size, $d = .53$, observed in Experiment 1 with regard to betting. None of the participants had participated in Experiment 1. Participants received class credit for participating. The protocol was approved by the Institutional Review Board of the University of California, Davis.

**Materials and procedure**

The materials and procedure for Experiment 2 were identical to Experiment 1 except for the following changes: during encoding, participants answered one of two questions about each item they studied. Sometimes they answered whether the item would be found indoors or outdoors, and sometimes they answered whether or not it would fit in a shoebox. The assignment of each item to the two questions was randomised. During retrieval, before providing a Remember or Familiar judgment, participants were asked to identify which question they had answered about the item.

**Results and discussion**

In preliminary planned comparisons, we compared rates of context accuracy (i.e., rates of correctly identifying the question paired with the item during encoding) across Remember and Familiar trials, to determine whether accurately identifying an aspect of the encoding event led to reports of subjective recollection. One participant never reported subjective familiarity, and was thus excluded from this analysis. We found that participants had significantly higher rates of contextual detail accuracy for Remember, $M = .58$, $SD = .13$, compared to Familiar trials, $M = .52$, $SD = .15$, $t(1,28) = 2.19$, $p = .04$, $d = .41$, confirming the typical result that subjective recollection states are associated with objective detail recollection (Ciaramelli & Ghetti, 2007; Dudukovic & Knowlton, 2006).

To replicate results from Experiment 1, planned comparisons were conducted with memory accuracy, rates of Remember judgments, and rates of betting as dependent measures across Match and Non-match trials. As in Experiment 1, results showed that memory accuracy was higher for Match trials, $M = .69$, $SD = .10$, compared to Non-match trials, $M = .60$, $SD = .10$, $t(1,29) = 4.52$, $p < .001$, $d = .84$. Furthermore, rates of Remember judgments were again higher for Non-match trials, $M = .73$, $SD = .22$, compared to Match trials, $M = .48$, $SD = .24$, $t(1,29) = 7.02$, $p < .001$, $d = 1.30$, and betting rates were higher for Non-match trials, $M = .82$, $SD = .13$, compared to Match trials, $M = .65$, $SD = .18$, $t(1,29) = 4.82$, $p < .001$, $d = .90$.

We conducted the same analysis as in Experiment 1 to examine the effects of trial accuracy and trial type on response latencies and, again, found a main effect of accuracy on response latency, $F(1,39) = 27.32$, $p < .001$, $\eta^2 = .41$. Although trial type did not significantly affect response latency, $F(1,39) = 1.89$, $p = .18$, $\eta = .05$, it did interact with accuracy, $F(1,39) = 6.21$, $p = .02$, $\eta = .14$, such that response latencies were longer for the Match condition among inaccurate (Match: $M = 4423.83$ ms, $SD = 2322.76$ ms; Non-match: $M = 3869.49$ ms, $SD = 1603.84$ ms) but not accurate trials (Match: $M = 3297.76$ ms, $SD = 1145.27$ ms; Non-match: $M = 3360.64$ ms, $SD = 1199.14$ ms). Thus, again, these results do not offer strong support for the idea that differential response latencies drive reports of subjective recollection.

Overall, our results show that the metacognitive illusion persisted even when participants were probed for a detail from the encoding event. Furthermore, participants were again more likely to bet on Non-match trials, replicating the results of Experiment 1. The results of Experiments 1 and 2 confirm that our retrieval manipulation induces a reliable metacognitive illusion of subjective recollection for Non-match trials, and that the experience of subjective recollection drives people to rely on their memories even when they are not veridical.

Participants in this experiment were more likely to claim recollection when they actually remembered specific details about the encoding context compared to when they did not. Yet, the fact that the retrieval of additional contextual details does not eliminate the metacognitive illusion suggests that subjective recollection in this paradigm is supported by additional factors. For example, subjective recollection may be driven by the retrieval of specific semantic details about the encoding event, which would not necessarily differentiate targets from distractors, since they differ only in perceptual details (i.e., noncriterion recollection; Parks, 2007). Similar effects have been found when testing people’s memory for distractors that are highly semantically related to studied items; people often mistakenly endorse these lures as studied, and attribute feelings of subjective recollection to their false memories (Brainerd & Reyna, 2002; Flegal & Reuter-Lorenz, 2014; Gallo & Roediger, 2002; Lampinen, Meier, Amal, & Leding, 2005). Thus, participants may have collected the experience of encoding a particular exemplar (e.g., a toaster) without recalling the specific perceptual details of the toaster that would allow for rejecting the distracter on Non-match trials (e.g., “the toaster I saw had a different lever than this one”).

Although our primary interest was in determining whether feelings of recollection drive decisions, this is not the only aspect of memory retrieval that is likely to be important for behaviour. Many studies have shown that people’s subjective confidence in their knowledge, which may derive from multiple sources including recollection and familiarity (Yonelinas, 1994), is associated with their subsequent decisions (e.g., Hall, Ariss, & Todorov, 2007; Koriat & Goldsmith, 1996; Roebers et al., 2009). Given these findings, we next asked whether subjective confidence would contribute to betting decisions independent of participants’ recollection and familiarity judgments, or whether recollection and familiarity were the primary indices driving people’ decisions in this paradigm. This investigation was pursued in Experiment 3.
Experiment 3

In this experiment, we tested whether the metacognitive illusion extended to confidence judgments with the current materials, and whether confidence judgments equally impacted decision-making. Thus, Experiment 3 is identical to Experiment 1 except that confidence judgments were elicited either before or after the subjective recollection or familiarity judgments. Although high confidence is generally associated with recollection, suggesting that it would drive decision-making similar to subjective recollection, confidence also scales with memory strength for familiar items (Yonelinas, 2001), raising the possibility that it might drive betting decisions differently from subjective recollection.

Method

Participants

Participants were 40 undergraduate students at the University of California, Davis (23 females). A larger sample size was selected for this experiment to ensure a sufficient number of participants in each counterbalance condition (see Materials and Procedure). An additional five students participated but were excluded from analyses due to chance performance indicating inattention to the task. This sample size is sufficient to achieve 90% power given \( \alpha < .05 \) to detect the effect size, \( d = .53 \), observed in Experiment 1 with regard to betting. None of the participants had participated in Experiments 1 or 2. Participants received class credit for participating. The protocol was approved by the Institutional Review Board of the University of California, Davis.

Materials and procedure

The materials and procedure for Experiment 3 were identical to those for Experiment 1 except that for every retrieval trial, participants gave a confidence judgment in addition to providing a Remember or Familiar judgment. As before, these judgments were followed by a betting decision. The order of Remember-Familiar judgments and confidence judgments was counterbalanced to exclude the possibility that judgment order affected the results, necessitating an increased sample size. Participants were asked to rate their confidence for the trial on a 3-point scale ranging from 0 (low confidence) to 2 (high confidence). Answers were given by pressing icons on the monitor.

Results and discussion

As in Experiments 1 and 2, planned comparisons were conducted to compare accuracy, subjective recollection, and betting across Match and Non-match trials. As in the previous experiments, memory accuracy was higher for Match trials, \( M = .75, SD = .11 \), compared to Non-match trials, \( M = .69, SD = .15, t(1,39) = 2.71, p = .01, d = .43 \). While subjective recollection rates were numerically higher for Non-match trials, \( M = .55, SD = .18 \), compared to Match trials, \( M = .45, SD = .18 \), this effect did not reach conventional levels of statistical significance, \( t(1,36) = 1.92, p = .06, d = .32 \). Finally, betting rates were again higher for Non-match trials, \( M = .75, SD = .17 \), compared to Match trials, \( M = .57, SD = .21, t(1,39) = 5.36, p < .001, d = .86 \). Next, we examined average confidence rates for Match compared to Non-match trials, to see if patterns were consistent with those for subjective recollection. Similar to subjective recollection, confidence was higher for Non-match, \( M = 1.55, SD = .32 \), compared to Match trials, \( M = 1.31, SD = .33, t(1,39) = 4.40, p < .001, d = .70 \), despite the reverse pattern for accuracy.

To examine the relation between confidence and subjective recollection, we first compared rates of subjective recollection across levels of confidence. As expected, rates of subjective recollection were higher for high confidence items, \( M = .92, SD = .08 \), compared to medium confidence items, \( M = .28, SD = .26 \), and higher for medium confidence compared to low confidence items, \( M = .09, SD = .23, F(2,44) = 161.70, p < .001, \eta^2_p = .88 \). To examine this relation in another way, we looked at the rates of high confidence judgments among Remember and Familiar trials. We found that rates of high confidence judgments were more frequent for Remember, \( M = .87, SD = .16 \), compared to Familiar trials, \( M = .13, SD = .21, t(1,39) = 21.42, p < .001, d = 3.43 \).

To determine whether confidence affected betting independently of subjective recollection, we compared rates of betting between trials given low-to-medium and high confidence judgments exclusively among trials endorsed with subjective recollection. Low and medium confidence were collapsed for this analysis because there were relatively fewer trials given both low or medium confidence and recollection judgments. Seventeen participants were excluded because they did not have any trials in which they had reported subjective recollection and low or medium confidence. We found that the remaining participants were significantly more likely to bet on items given high confidence judgments, \( M = 1.00, SD = .01 \), compared to medium and low confidence judgments, \( M = .70, SD = .33 \), even when only considering trials with subjective recollection judgments, \( t(1,22) = 4.48, p < .001, d = .96 \).

Additionally, for Experiment 3, both accuracy, \( F(1,29) = 4.07, p = .05, \eta = .12 \), and match condition, \( F(1,29) = 11.09, p = .002, \eta = .28 \), predicted response latency, with inaccurate and Match trials predicting longer response latencies. Accuracy and match condition also interacted, \( F(1,29) = 5.49, p = .03, \eta = .16 \), such that the difference in response latency between Match and Non-match trials was greater for inaccurate trials (Match: \( M = 4339.97 \text{ ms}, SD = 1756.15 \text{ ms} \); Non-match: \( M = 3456.95 \text{ ms}, SD = 1731.42 \text{ ms} \)) compared to accurate trials (Match: \( M = \)
Persaud et al. (2007) found that asking participants to make quantitative estimates about win/loss contingencies in the Iowa gambling task increased participants’ betting accuracy. If participants’ betting decisions in the present task are based on spontaneous metacognitive experiences we should observe the same patterns of betting (i.e., higher rates of betting for Non-match trials) even when participants are not asked to reflect on or report their subjective memory experiences. Experiment 4 was designed to address this issue.

**Experiment 4**

In this experiment, we tested whether the present metacognitive illusion is a spontaneous phenomenon that affects decision-making when participants are not instructed to reflect on their subjective memory states. Thus, Experiment 4 is identical to Experiment 1 except that participants did not provide a Remember-Familiar judgment.

**Method**

**Participants**

Participants were 21 undergraduate students at the University of California, Davis (16 females). This sample size is sufficient to achieve 64% power given \( \alpha = .05 \) to detect the effect size, \( d = .53 \), observed in Experiment 1 with regard to betting. None of the participants had participated in Experiments 1–3. Participants received class credit for participating. The protocol was approved by the Institutional Review Board of the University of California, Davis.

**Materials and procedure**

The materials and procedure for Experiment 4 were identical to those for Experiment 1 except that participants were not asked to provide a Remember-Familiar judgment. Participants were not given any description of subjective recollection and familiarity or asked to reflect on their memory quality in any way. Instead, they made a betting decision immediately after deciding which image they had seen before.

**Results and discussion**

Planned comparisons were conducted to compare accuracy and betting across Match and Non-match trials. As in the previous experiments, memory accuracy was higher for Match trials, \( M = .80 \), \( SD = .10 \), compared to Non-match trials, \( M = .68 \), \( SD = .12 \), \( t(1,20) = 3.22, p < .01, d = 1.09 \). Thus, accuracy patterns were consistent with those observed when participants were asked to reflect on their subjective recollection and familiarity.

We next examined betting rates for Match vs. Non-match trials to determine whether participants would bet more on Non-match trials when not asked to reflect on their feelings of subjective recollection and familiarity. Indeed, betting rates were higher for Non-match trials, \( M = .82 \), \( SD = .17 \), compared to Match trials, \( M = .71 \), \( SD = .22 \), \( t(1,20) = 2.76, p = .01, d = .56 \).
These results confirm that participants’ tendency to bet on Non-match trials is not due to a direct dependence among the different measures (i.e., explicit reports and betting). Rather, the factors that promote subjective recollection and higher confidence for Non-match trials increase betting even when participants are not directed to reflect and report on these aspects of their memory. This strengthens the interpretation that subjective aspects of memory retrieval spontaneously drive people’s decisions about those memories.

Finally, for Experiment 4, accuracy predicted response latency, $F(1, 19) = 6.51, p = .02, \eta = .26$, but match condition did not, $F(1, 19) = 1.05, p = .32, \eta = .05$. The two did not interact, $p = .13$. Response latencies were as follows; accurate Match trials: $M = 2893.54$ ms, $SD = 719.30$ ms; accurate Non-match trials: $M = 3321.31$ ms, $SD = 758.24$ ms; inaccurate Match trials: $M = 3877.22$ ms, $SD = 1822.16$ ms; inaccurate Non-match trials: $M = 3859.51$ ms, $SD = 1597.60$ ms.

**General discussion**

The present research was designed to determine whether people use the subjective phenomenology associated with memory retrieval for decision-making. By dissociating the object and meta levels of memory retrieval, we found that subjective recollection and confidence were consistently related to people’s subsequent decisions about whether or not to bet on their answers. In four experiments, participants were more likely to identify the target as studied in the Match condition, but they reported subjective recollection more often in the Non-match condition.

Although the present studies were not designed to address the mechanism for this dissociation, one possibility is that people may encode the semantic gist of presented items (e.g., “I saw a toaster”) and that the two retrieval conditions result in differences in the extent to which participants rely on this gist and associated sense of fluency to make decisions. The presentation of two dissimilar items in the Non-match trials might encourage reliance on this semantic gist, because the two items cannot be directly compared to discriminate which of the two is presented in its original form; this low level of scrutiny may give rise to a sense of decision fluency and increases in subjective recollection, despite its costs for accuracy. On Match trials, on the other hand, participants may have experienced lower decision fluency when faced with evidence that a gist representation is not sufficient to make the decision. This might result in lower experience of subjective recollection, while the direct comparison between the two test items may promote more careful scrutiny of diagnostic features resulting in higher accuracy. Although this explanation is intuitively appealing, we should have observed differences in response latencies, with Match trials resulting in faster responses compared to Non-Match trials. We only observed this pattern of results consistently in Experiment 3, and only for inaccurate trials in Experiment 2. Thus, although differences in global fluency may in part contribute to the current results, it is unlikely that it is the only or primary factor driving differences as a function of trial in people’s reports of subjective recollection. We can speculate that time spent comparing the perceptual evidence of the two similar test items for Match trials might tradeoff with time spent comparing each of the two stimuli to their individual memory representations in the Non-match condition. From this perspective, participants may have misinterpreted the overt scrutiny demanded by Match trials as a sign of poor memory, instead of relying on the most diagnostic features of memory accuracy (see Tulving, 1981 for similar reasoning). Future research should address these possibilities.

These experiments were designed to examine the relation between objective accuracy, subjective recollection and decision-making. In this paradigm, participants bet more often on Non-match trials, in line with their metacognitive judgments. They did so even when asked to report details about the encoding experience (Experiment 2), and when asked to report on subjective confidence (Experiment 3), highlighting the robustness of this effect. Furthermore, the effect on betting was replicated even when participants were not asked to reflect on their subjective recollection or familiarity (Experiment 4), eliminating the possibility that tasking participants with reflecting on their memory states drove the illusion and/or the associated betting patterns.

These results counter the interpretation that subjective experiences surrounding mental events are epiphenomenal to overt decision-making. Instead, these findings complement other studies that have demonstrated that people control their responses in accordance with metacognitive assessments, for example by allocating study time based on their JOLs even when those assessments do not correspond to actual learning (Metcalfe & Finn, 2008; Rhodes & Castel, 2009). These results also complement the finding that people do not choose to bet on accurate decisions they are not aware of in several other tasks (Persaud et al., 2007). This is the first study we know of to demonstrate that subjective phenomenology of recollection predicts subsequent decision processes when dissociated from accuracy.

Previous research has demonstrated a correspondence between people’s subjective confidence in their memories and their subsequent decision-making (e.g., Hembacher & Ghetti, 2014; Krikit & Goldsmith, 1996; Krebs & Roebers, 2012). For example, Hembacher and Ghetti (2014) found that 3-year-olds decided to bet on memory responses they gave higher confidence judgments, even though their confidence judgments did not discriminate between correct and incorrect answers. This finding is consistent with the present results, in that decisions were guided by subjective assessments of memory states even when those assessments were poorly calibrated and thus not confounded with accuracy. The experimental dissociation included here provides strong evidence that people use...
subjective phenomenology when making decisions about accuracy regulation.

The present research additionally highlights that metacognitive judgments do not necessarily represent direct access to mental states and processes. Indeed, the very presence of a metacognitive illusion in this paradigm indicates that some responses (e.g., selection of accurate responses in the Match condition) are made on the basis of memory and decision mechanisms that are seemingly impervious to introspection. Rather, metacognitive judgments, including judgments of subjective recollection and familiarity, are influenced by a variety of cues, including perceived difficulty, that may or may not be informative (Koriat, Nussinson, Bless, & Shaked, 2008). People’s metacognitive assessments are often quite accurate when they are not being experimentally manipulated; people feel confident when they should, and uncertain when they have less information and are likely to be wrong (Koriat et al., 2002; Mazzoni & Nelson, 1995). Relevant to the current work, McCabe and Soderstrom (2011) found that people’s prospective RK judgments for word lists were better calibrated to their later cued-recall performance compared to JOLs. They suggest that asking people to reflect on more diagnostic cues to later memory (i.e., subjective recollection) improves the resolution of metacognitive judgments. Complementary to these findings, the present results underscore that faulty metacognitive monitoring of subjective recollection can lead to negative outcomes for decision-making.

The current results have parallels in the eyewitness and autobiographical memory literatures. The finding that people’s accuracy is higher for Match trials mirrors the common finding that the presence of similar lures in lineups improves discriminability (Wells, Rydell, & Seelau, 1993), and that showups (in which only one suspect is presented for identification) are more prone to false identification than lineups (Yarmey, Yarmey, & Yarmey, 1996), although highly similar lineups may be susceptible to unacceptably high rates of false alarms (Fitzgerald, Oriet, & Price, 2015). In addition, the phenomenon of illusory recollection is not constrained to the current paradigm. Studies of autobiographical memory have shown that illusory recollection for non-occurrences can be elicited in the lab if train them to assess their mental states (e.g., Bailey, Dunlosky, & Hertzog, 2010; Dunlosky, Kubat-Silman, & Hertzog, 2003; Jacobse & Harskamp, 2009) and apply their monitoring output to online goals for learning, problem solving, and accuracy regulation.

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