

Metacognition

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Abstract

Metacognition refers to a set of processes an individual uses in monitoring ongoing cognition so as to effectively control his or her own behavior. In this article, I discuss key frameworks for characterizing metacognition and describe approaches to measuring metacognition. Modern research in metacognition assumes that monitoring of cognition plays a causal role in self-regulation of cognitive processes, making it imperative that monitoring of cognition is accurate. Accordingly, I describe research on metacognitive accuracy and several factors that reliably impact metacognitive accuracy. I conclude by discussing emerging issues and approaches to teaching metacognition.

Keywords

metacognition, metamemory, monitoring, confidence

A student of mine approached me after a recent exam, disappointed with the grade she had received. Prior to the exam, she was confident that the format of the exam (a combination of multiple-choice and short essay questions) was conducive to her strengths. She was also confident that her grasp of the material was such that she only needed to focus on several key points in the unit during her preparation for the exam. To her dismay, the resulting score on the exam was far below what she had anticipated.

Our example student is engaging in metacognition, which is “knowledge and cognition about cognitive phenomena” (Flavell, 1979, p. 906). Such “thinking about thinking” has a deep intellectual legacy in philosophy and psychology, evident in Greek writings about memory strategies (see Yates, 1966), in debates about the logic and utility of self-reflection, and in early efforts of psychologists to study the mind via introspection. Despite this rich history (see Dunlosky & Metcalfe, 2009, for an excellent review), metacognition has only been subject to extensive empirical investigation over the past four decades. The impetus for this explosion of empirical work is often tied to the developmental psychologist John Flavell (1979), who, in a seminal review, formally defined metacognition and delineated its key components, *metacognitive knowledge* and *metacognitive experiences*. Metacognitive knowledge reflects an individual’s declarative knowledge and beliefs about the factors that might influence a cognitive task. For instance, the student mentioned previously called upon metacognitive knowledge in her belief that the format of the exam would facilitate her performance and was consistent with her strengths. Metacognitive experiences, in contrast, comprise “any conscious cognitive or affective experiences that accompany and pertain to any intellectual enterprise” (Flavell, 1979, p. 906). For our example student, this might include her sense of mastery while studying

or her confidence that a response provided while taking the exam was correct.

Work in metacognition advanced further after Nelson and Narens (1990) proposed an influential framework (see Figure 1). They couched their framework within processes related to learning, but the core components can apply to any domain. In particular, Nelson and Narens distinguished between processes related to assessing and evaluating one’s learning, termed *monitoring*, and the self-regulation of learning based on information gained from monitoring, termed *control*. These processes may occur at any point during learning, during retention (i.e., a state after learning but before retrieval), or during retrieval of information. For example, a student preparing for an exam in a biological psychology class might reflect on her knowledge of the function of different components of the brain (monitoring) and choose to study those components with which she still feels unfamiliar (control). Likewise, when asked a question about the function of the frontal lobe during an exam, a student might carefully scrutinize the veracity of the information that comes to mind (monitoring) and only report the information that she feels is correct (control).

As noted, although Nelson and Narens’s (1990) framework originated as a model of metacognition applied to learning, this conception of the interplay between monitoring and control generalizes across many domains. For example, a physician might monitor whether a consultation with a patient is

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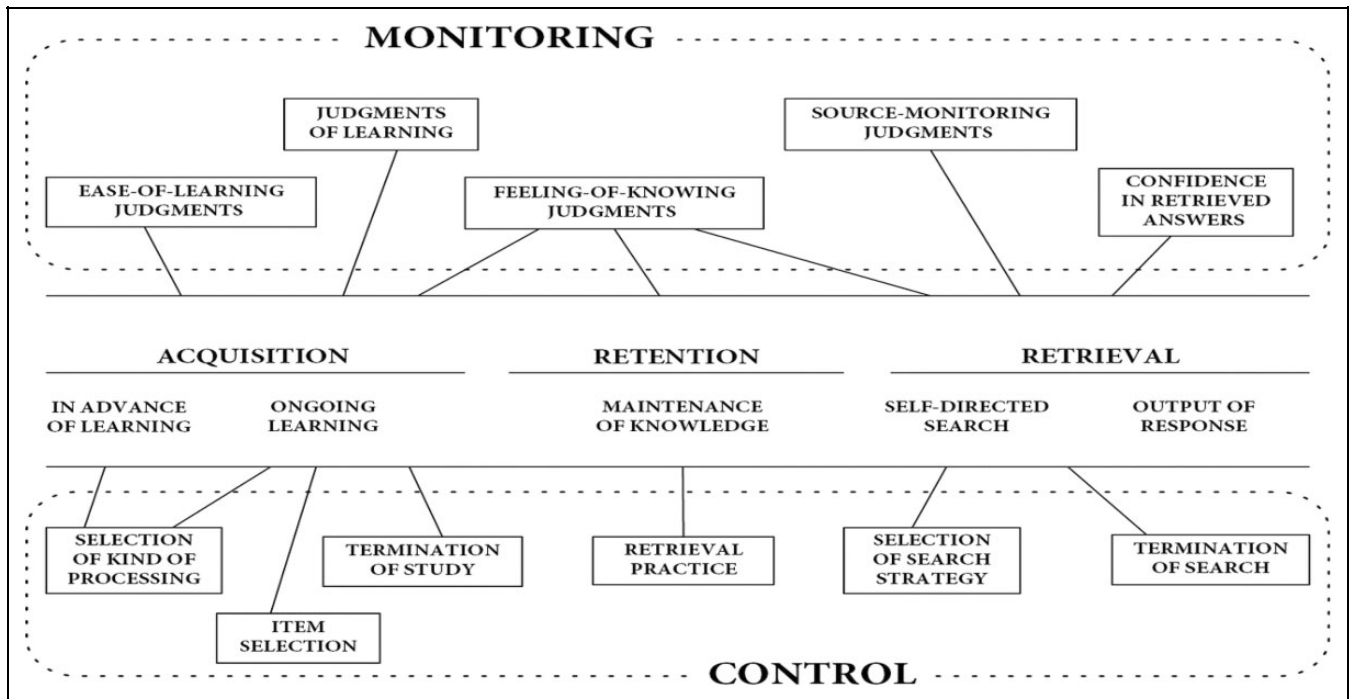


Figure 1. A framework for metacognition applied to learning proposed by Nelson and Narens (1990; from Dunlosky, Mueller, & Thiede, 2016).

producing useful information and then change her approach (a control process) if another tactic would produce better information. Similarly, a supervisor providing feedback to an employee might reflect on (monitor) whether she is clearly communicating her suggestions for improvement and then use a similar approach with another employee (control). Indeed, applications of metacognition are present in virtually all areas of research within psychology including education (e.g., Hacker, Bol, Horgan, & Rakow, 2000; Thiede et al., 2015), social processes (Bohns, 2016; Carlson, Vazire, & Furr, 2011), health (e.g., Martin, Gordon, & Lounsbury, 1998; Meyer, Payne, Meeks, Rao, & Singh, 2013), lifespan development (e.g., Castel, Middlebrooks, & McGillivray, 2016; Schneider & Löffler, 2016), clinical psychology (e.g., Izaute & Bacon, 2016; Koren, Seidman, Goldsmith, & Harvey, 2006), and psychology and law (e.g., Wixted & Wells, 2017).

Conceptual Challenges

In each of the examples described, an individual is both serving as the agent (i.e., engaging in some type of behavior) but also reflecting on that agency (i.e., reflecting on that behavior). This presents a stern challenge for research in metacognition, as it assumes that the same individual is both the observed and the observer, a quandary Nelson and Narens (1990; see also Nelson, 1996) referred to as Comte's paradox (named after the 19th-century philosopher Auguste Comte). Rather than discard the scientific study of metacognition entirely, Nelson and Narens argued that the paradox could be solved by construing of behavior and metacognition as occurring at separable levels of analysis. For example, consider the following sentence

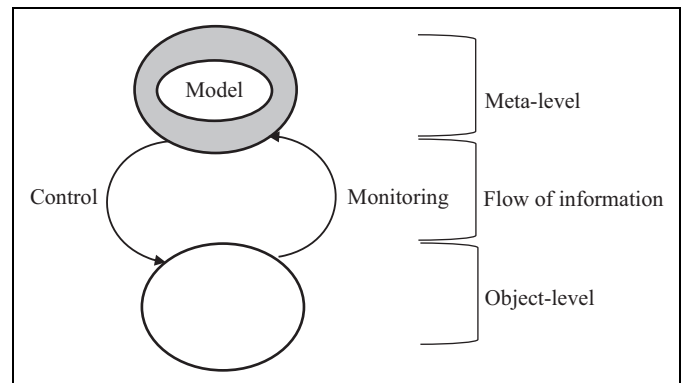


Figure 2. A conceptual framework for research on metacognition that distinguishes between behaviors and cognitions as they occur in the world (the object level) and one's understanding or model of those cognitions (the meta-level). These processes support the interplay of monitoring and control in metacognition (adapted from Nelson & Narens, 1990).

(from Nelson, 1996): "Thiss sentence contains threee errors." On the surface, it is apparent that the sentence has two errors: "This" and "three" are misspelled. But another error is present that occurs on a different level from the text: The text states that there are three errors when, in fact, there are only two. This third error regarding the correctness of the statement exists on a different level of analysis from the errors embedded in the text.

Figure 2 provides a schematic illustration of this approach within metacognition, distinguishing between the *object level* and *meta-level*. At the object level are behaviors, thoughts, and cognitions as they take place in the world. For example, if you were reading a riveting mystery novel, the object level would

include the act of reading as you translate letters, words, and sentences into a coherent representation of the text. Information from the novel would feed into a meta-level where you would monitor your reading and use that information to control reading. For instance, you might decide to pause on parts of the novel that are most important to the plot and choose to focus more attention on new events in the novel that change how you view past events. Nelson and Narens (1990) further argued that the meta-level is driven by a mental model comprising your understanding of the goal of a task and the cognitive processes necessary to complete that task. A meta-level model in this case might include your goal of reading the novel along with cognitions about the ways you can accomplish this goal. By this view, the meta-level uses its influence on the object level to meet task goals. Fundamentally, the framework of metacognition in Figure 2 proposes that awareness of cognition is separate from ongoing cognition by assuming that it is represented at another, higher level of thought at the meta-level. Indeed, Nelson and Narens even presumed that the meta-level can have its own meta-level (i.e., cognitions about meta-level cognitions), which in turn could have its own meta-level, and so forth (see, e.g., Efklides, 2008).

Measuring Metacognition

The modal study in research on metacognition asks a participant to perform a task (e.g., throwing darts, reading a text, learning foreign language vocabulary, answering general knowledge questions) and solicits judgments about that performance. Researchers may solicit these judgments *prospectively*, before the criterion task (e.g., “What is the chance that you will be able to hit the target?”), or *retrospectively*, after participants have performed the criterion task (e.g., “What is the chance that your answer to this question is correct?”). These judgments are then compared to performance on the criterion task, yielding two different classes of measurement: those focused on absolute accuracy and those focused on relative accuracy.

Absolute accuracy (sometimes termed *calibration*) refers to the overall correspondence between judgment and performance. As an illustration of this approach, consider data reported by Foster, Was, Dunlosky, and Isaacson (2017). They asked undergraduates in an educational psychology course to estimate (predict) their performance prior to taking an exam, to estimate their performance immediately after taking an exam (postdiction), and to anticipate their score on the next exam after receiving their actual exam score. Foster et al. repeated this procedure for each of the 13 exams in the course. Across all of the exams, the students’ average prediction was 84.44%, and their average score was 77.69%. Thus, the measure of absolute accuracy indicated that students were generally overconfident prior to exams, as predictions exceeded actual performance by approximately 7 percentage points. Interestingly, this pattern of overconfidence held for postdictions and for predictions of next exam performance and remained stable across all 13 exams.

Researchers may report further refined measures of absolute accuracy, such as the signed or absolute value of the difference

between judgment and performance, or they may plot absolute accuracy by dividing judgments into bins (e.g., judgments of 0–10%, 11–20%, . . . , 91–100%) and determining the level of accuracy for each bin. The resulting graph is referred to as a calibration curve (see, e.g., Palmer, Brewer, Weber, & Nagesh, 2013). Measures of absolute accuracy invoke several significant interpretive challenges. Notably, changes in performance may affect absolute accuracy independently of a change in judgment (see Dunlosky et al., 2016, for thoughtful discussion of this issue). For example, suppose students consistently overestimate their performance on the first exam in a course; on a second exam, judgment remains the same but performance improves, leading to improved absolute accuracy. Does this change in absolute accuracy reflect the elevation in performance, better monitoring, or some combination of the two? Likewise, measures of absolute accuracy make the assumption that participants can effectively map their psychological experience of monitoring onto the scale used (often a percentage scale), permitting a direct comparison with measures of performance. Whether this assumption is justified remains an open question (Erev, Wallsten, & Budescu, 1994; Higham, Zawadzka, & Hanczakowski, 2016).

In contrast, measures of *relative accuracy* (sometimes termed *resolution*) do not assume that participants can precisely map psychological states onto the scale used. Instead, relative accuracy refers only to the degree to which judgments distinguish or discriminate between outcomes. The most common metric involves calculating some form of a correlation between judgment and outcome. Much of the experimental literature favors the nonparametric Goodman–Kruskal γ correlation because it assumes that judgments are ordinal in nature and do not have scale properties (Nelson, 1984; but see Benjamin & Diaz, 2008; Masson & Rotello, 2009, for criticisms). Regardless of the measure of association used, the interpretation of relative accuracy remains the same, with the magnitude of the correlation indicating the strength of the relation between judgment and outcome. For example, Koriath and Goldsmith (1996) had participants answer general knowledge questions (e.g., “Who was the first emperor of Rome?”) and make a judgment about whether each answer was correct. The γ correlation between assessed confidence and the accuracy was +0.87, indicating that judgment magnitude was greater for correct answers and lower for incorrect answers (i.e., participants’ judgments effectively distinguished between outcomes) and that this relation was strong.

Accuracy and Causality

Although relative accuracy was strong in Koriath and Goldsmith’s (1996) experiment, the question remains: Are our own insights about cognition accurate? Frameworks for metacognition do not take accuracy as a given. Indeed, Nelson (1996) noted that the metacognitive framework proposed in Figure 2 does not make an assumption of accuracy at the meta-level: “To the contrary, the individual participant can be treated as an imperfect measuring device of his or her own cognitions, in

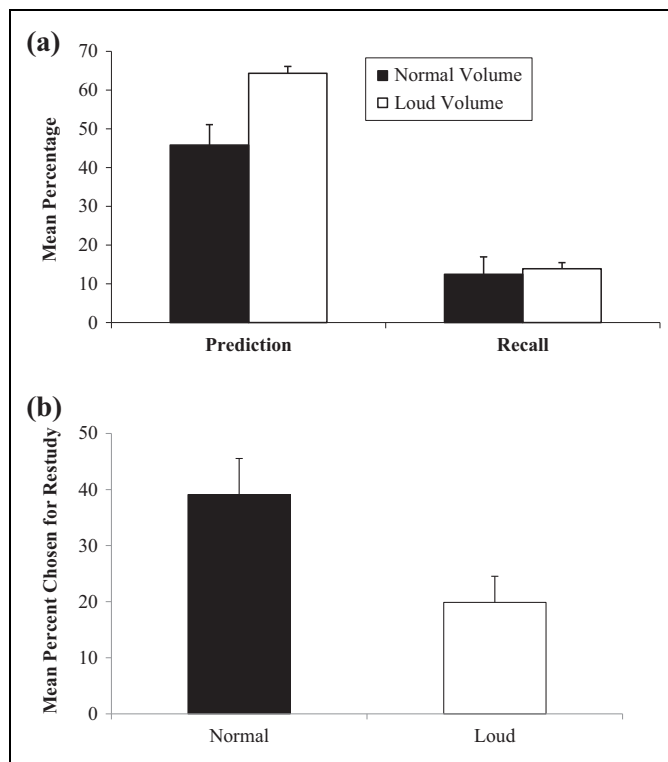


Figure 3. (a) Mean predictions and the mean percentage of words correctly recalled for words at a normal and loud volume. Error bars represent 1 standard error of the mean (adapted from Rhodes & Castel, 2009, experiment 1). (b) The mean percentage of words at a normal and loud volume chosen for restudy. Error bars represent 1 standard error of the mean (adapted from Rhodes & Castel, 2009, experiment 2).

which the individual's metacognitive monitoring is assumed to sometimes contain errors and distortions" (p. 106). Nelson's assessment, made over two decades ago, remains a fair characterization of the broader literature on metacognition, where errors and distortions are sometimes evident (e.g., Rhodes & Castel, 2008). This characterization is far from trivial, given that monitoring processes presumably have a direct, causal influence on control processes. Indeed, although individuals may be imperfect at monitoring the contents of cognition, "*A system that monitors itself (even imperfectly) may use its own introspections as input to alter the system's behavior*" (Nelson & Narens, 1990, p. 128, italics in original).

As an illustration of the causal role of metacognition in behavior, consider a metacognitive illusion reported by Rhodes and Castel (2009). They had participants listen to a list of words that varied in their volume; some of the words were played loudly, whereas others were presented at a normal (conversational) volume. Immediately after being presented with each word, participants made a monitoring judgment of the likelihood that they would remember the word on a later test. Following this learning phase, participants engaged in a free recall test, writing down as many words as they could remember. Figure 3a shows mean predictions and mean correct recall by the type of word (loud or normal volume). Participants

predicted they would remember more loud words than normal words. However, no difference in actual memory performance emerged, suggesting that participants' confidence in the memorability of loud words was an illusion. Rhodes and Castel then demonstrated the consequences of this illusion in a second experiment. Once again, participants studied words at loud and normal volumes and made predictions for each word. In addition, participants made a choice about control over learning, indicating whether they would like to restudy a word prior to the final test. As Figure 3b shows, participants were nearly twice as likely to indicate that they should restudy a normal word, even though there was no difference in objective memory performance relative to loud words. Instead, their restudy choice reflected the subjective impression from monitoring processes that normal words were less memorable and required further study (see also Metcalfe & Finn, 2008; Soderstrom & Rhodes, 2014). Thus, monitoring processes seem to have a causal impact on control over cognition.

Framed within this perspective of a causal role in cognition, the accuracy of metacognition becomes even more important. Although Nelson's (1996) assessment of metacognition as "sometimes" prone to distortion is true, any general assessment of metacognitive accuracy belies the sheer volume and variety of tasks and measures used across the many disciplines that conduct research under the rubric of metacognition. Instead, a more profitable approach may be to consider several factors that moderate and shape metacognitive accuracy (see also Dunning, Heath, & Suls, 2004).

Task Knowledge

The amount of task knowledge or expertise an individual possesses is often positively related to metacognitive accuracy. The most dramatic example of this is shown by the Dunning-Kruger effect (Kruger & Dunning, 1999; see Dunning, 2011, for a review). For example, in one experiment, participants solved logical puzzles and rated how many problems they had solved and where their performance stood with respect to their classmates (Krueger & Dunning, 1999, study 4). When grouped into quartiles, participants who performed the best demonstrated more accurate judgments than those who performed more poorly. For example, participants in the bottom quartile estimated that they had answered 5.5 of 10 problems correctly; in reality, they answered, on average, less than 1 problem correctly. Subsequent work has replicated these findings (e.g., Ehrlinger, Johnson, Banner, Dunning, & Kruger, 2008; Schlösser, Dunning, Johnson, & Kruger, 2013) and converged on an account that poor task knowledge also renders individuals less able to assess task performance, giving rise to what has been termed the "double curse of incompetence" (Dunning, Johnson, Ehrlinger, & Kruger, 2003). Researchers have found exceptions to this account of metacognitive accuracy, though. For example, domain knowledge may sometimes be negatively related to metacognition for text comprehension (e.g., Glenberg & Epstein, 1987; but see Griffin, Jee, & Wiley,

2009). Thus, although task knowledge may moderate metacognitive accuracy, the relation is by no means lawful.

Prospective Versus Retrospective Judgment

As noted previously, metacognitive judgments may be prospective (anticipating the future) or retrospective (reflecting on the past) in nature. Although investigators have paid less attention to this distinction, the research that does exist suggests that reflections on the past may be more accurate than judgments about the future. For example, Dougherty, Sheck, Nelson, and Narens (2005) instructed participants to learn pairs of words (e.g., MONKEY-TABLE) in preparation for a test of memory. After the study phase, participants saw the first word of each pair (e.g., MONKEY-?) and attempted to retrieve the target (e.g., TABLE). Participants then made either a prospective judgment ("How likely are you to remember this on an upcoming test?") or a retrospective judgment ("What is the chance that you correctly remembered the target?"). Retrospective judgment predicted subsequent test performance better than prospective judgment (see also Busey, Tunnicliff, Loftus, & Loftus, 2000). One possibility is that prospective judgments necessarily rely on more noise and uncertainty than retrospective judgments, which provide access to better information, given that the judge has completed the task.

Quality of Cues

Accounts of metacognitive accuracy (e.g., Gigerenzer, Hoffrage, & Kleinbölting, 1991; Koriati, 1997) generally hold that the cues used to make judgments affect accuracy. By this account, metacognitive judgments reflect inferences about the relation between the information available and the criterion task or outcome. For example, Koriati's (1997) cue-utilization framework holds that individuals scrutinize several different types of cues when predicting learning (e.g., type of material being learned, conditions of learning). As such, predictions about learning "are accurate as long as the cues used at the time of making the judgments are consistent with the factors that affect subsequent performance on the criterion memory test" (p. 350). Under conditions in which the cues available are tightly tied to learning, metacognition can be excellent. For instance, Nelson and Dunlosky (1991) had participants study a list of 66 unrelated paired associates (e.g., TABLE-SPOON). Participants predicted their learning for each associate but did so under different conditions. For half of the items, participants made predictions immediately after learning; for the other half, participants had to wait several minutes. Delaying predictions resulted in highly accurate predictions ($\gamma = +0.90$) compared with immediate predictions ($\gamma = +0.38$). One explanation is that delaying judgment encouraged participants to attempt to retrieve the studied item; the success or failure of that retrieval is highly diagnostic of future learning outcomes (see Rhodes & Tauber, 2011b, for a review). In contrast, when judgments occurred immediately, participants relied only on what was currently accessible as a basis for prediction, impeding

accuracy when the judgment called for a prediction of future test performance. Similar findings with other metacognitive tasks suggest that the accuracy of metacognition rises and falls with the quality of the cues available (e.g., Chandler, 1994; Jemstedt, Kubik, & Jönsson, 2017; Metcalfe, Schwartz, & Joaquim, 1993).

A number of other factors drive metacognitive accuracy. For example, consistent with Flavell's (1979) original characterization, the veracity of metacognitive knowledge for a task may affect judgment (Mueller, Dunlosky, & Tauber, 2016). Likewise, metacognitive judgment may be stronger for outcomes of well-defined tasks (see Dunning et al., 2004) and can be sensitive to feedback (e.g., Rhodes & Tauber 2011a). The range of factors that influence judgment has certainly not been exhausted and continues as a focus of research.

Ongoing Questions

Just as researchers in metacognition continue to study those factors that influence judgment, a number of other issues remain at the forefront. For instance, is metacognition driven by knowledge of a task (e.g., "I'm good at taking history tests.") or experience of a task (e.g., "The questions on this history test seem easy.")? The answer certainly reflects an interaction of these two sources of information, and current research seeks to better understand this interaction (e.g., Frank & Kuhlman, 2017). Researchers also continue to examine whether training metacognition can subsequently improve task performance, with the potential for substantial applications in education and training (e.g., Hacker, Dunlosky, & Graesser, 2009; Rhodes, Clearly, & DeLosh, 2020).

Another continuing line of work merits attention because it raises important questions about consciousness. In particular, researchers in comparative cognition have reported evidence that primates and other species, such as dolphins, may engage in behaviors that appear similar to human metacognition. For example, Kornell, Son, and Terrace (2007) trained rhesus monkeys to perform a perceptual task (identifying which of several circles was the largest in a visual array). Kornell et al. also introduced a confidence-based, risk-reward element to the task. If a monkey pressed an icon representing high confidence, correct answers would yield a greater reward (food) but also the potential for greater loss, than if the monkey pressed a low-confidence icon. Overall, accuracy was superior on high-confidence trials than on low-confidence trials. Thus, the monkeys appeared to demonstrate behavior that was titrated to confidence, a hallmark of metacognition (see also Ferrigno, Kornell, & Cantlon, 2017). Importantly, a metacognitive account is only one potential explanation of this behavior, and other explanations are possible that do not invoke metacognition (see, e.g., Washburn, Beran, & Smith, 2016, for a careful review and discussion of the issues). Nevertheless, work with animals has the potential to constrain the definition of metacognition or to expand our conceptualization of cognition in nonhuman animals.

Teaching Metacognition

Lessons from the metacognition literature can broadly inform students' academic lives. For example, instructors can alert students to the fact that their ongoing assessments of learning (i.e., *monitoring* in Figure 1) will determine how they go about preparing for exams (the *control* processes highlighted in the lower portion of Figure 1). Because of this strong relation, it is imperative that students' metacognition is accurate and not subject to illusions of learning (see Figure 3). To that end, gaining task knowledge and creating learning environments where high-quality cues accurately disclose mastery (e.g., engaging in extensive self-testing) will enhance metacognition and, hopefully, student performance.

A number of class activities and demonstrations can productively illustrate these principles of metacognition for students. I have found three to be particularly useful.

American Idol and Metacognitive Awareness

One starting point to highlight the importance of metacognition, described by Lang (2012), is to show remarkably poor auditions for television programs such as *American Idol*¹. Students find the videos amusing and the activity can serve as an effective introduction for a broader question: Is it important for individuals to have accurate knowledge of their own skills and abilities?

Predicting Exam Performance

I often invite students to predict and postdict their performance on an exam. These metacognitive judgments can be compared to actual exam performance and shown to the class figure representing the aggregated data. Discussion can focus on overall patterns of data (e.g., Was the class overconfident?) but also spur individual reflection. For example, if a student found that his or her predictions exceeded anticipated performance, why did this happen? What steps can students take to make predictions that are more accurate on future exams?

Delayed Testing

Individuals frequently conflate *performance*, the immediate accessibility of a concept, with *learning*, a longer lasting change in understanding or knowledge of a concept (see Soderstrom & Bjork, 2015). A failure to appreciate this distinction can have significant consequences for metacognition. For instance, students may mistakenly believe that a long session of cramming led to durable learning when it only temporarily elevated performance (e.g., Kornell, 2009). One way to illustrate this important point is to manipulate the timing of class quizzes. For example, instructors could administer a short quiz (e.g., "Define and provide an example of assimilation.") seconds after lecturing on a topic. Students could then provide a rating of their understanding of the concept. Instructors could then administer the same quiz question a week later, with students once again rating their understanding. On this second opportunity, students should note that answering the question

at a delay required retrieval from long-term memory, which provides a sound basis for judging knowledge. Discussion can then center on how students could apply this observation in their own learning practices.

Concluding Remarks

Metacognition fascinates students. Anecdotally, many students report having the experience described in the scenario that opened this article: feeling certain of being well prepared for an exam only to receive a score that disconfirms that expectation. Experiencing this discrepancy can be an important teaching moment and one that is well informed by research and theory in metacognition. Beyond the classroom, metacognition is critical in many areas of life, from assessments of our own health ("Should I go to the doctor?"), to understanding relationships ("Does this person like me?"), to evaluating our own skills ("Am I good enough to get the lead in this play?"). Accordingly, understanding metacognition provides a framework for better understanding many of life's decisions.

Acknowledgment

I am grateful to Alan Castel for helpful comments on a prior version of this article.

Declaration of Conflicting Interests

The author declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author received no financial support for the research, authorship, and/or publication of this article.

Note

1. A personal favorite can be found at: <http://www.youtube.com/watch?v=wmWL73kl1NA>

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