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Abstract

Although self-regulations is an important aspect of learning, students are poor judges of their own performance. In this study, it was investigated if testing can help to improve judgment accuracy (i.e., bias). Participants either studied an expository text on probability calculations four times, or they studied the text, made a test, restudied the text, and made the same test a second time. The results show that testing leads to less overconfidence and more accurate judgments, both for learning facts and application questions.

The Effects of Testing on Meta-Cognitive Awareness

Self-regulation is becoming increasingly important in education. However, in order to self-regulate study, it is important to accurately judge one's own learning. Nevertheless, learners are often unduly overconfident about their learning and actual test performance (e.g., Lipko, Dunlosky, & Merriman, 2009; Koriat, 2011). Such overconfidence, however, is harmful for further regulation of study as students tend to discard information about which they are (over)confident (e.g., Dunlosky & Rawson, 2012) and this affects future test performance.

According to the cue utilization framework (Koriat, 1997), a number of study tools can improve meta-cognitive awareness (i.e., judgment accuracy). One very effective tool is testing. Testing leads to more accurate judgments because learners base their judgments on cues (i.e., initial test performance) that are valid indicators of (future) test performance. More specifically, students base their judgments on actual initial test performance or ability to retrieve an item instead of for example the amount of accessible information that comes to mind (i.e., the accessibility theory).

Most research investigating the effects of testing on meta-cognitive awareness or judgments of learning (JOLs) focused on judgment accuracy for words or facts. Although subjectivity -such as the accessibility and amount of perceived association- plays also a role here, such judgments are rather accurate after testing because only a single piece of information needs to be retrieved and this can either be retrieved or not. Judging one's ability to apply learned knowledge is, however, more difficult because the learner needs to successfully retrieve the relevant principles or procedures from memory and then, apply the principle or procedure. From an educational perspective it would be, however, very relevant to investigate whether testing leads to accurate judgments for application because, especially in science and mathematics

education, less emphasize is put on rote learning (i.e., retrieval of facts) and more emphasize is put on application.

Research Question

The research question investigated in the current study was: Has testing an effect on confidence and judgment accuracy (Bias) for factual knowledge and application? It is expected that testing will lead to less overconfidence as compared to re-studying for both factual knowledge and application because participants in the testing situation have the opportunity to base their judgments on appropriate cues (actual retrieval and ability to apply a principle or procedure).

Methods and Materials

Forty-four students from pre-university education (Mean age 15.61; *SD* = .65) either repeatedly studied a text, (SSSS) or studied a text, took a text, restudied the text and took the test a second time (STST). The text was about probability calculations and was 899 words long. After each study or test phase, participants made a 2-minute distracter task that was unrelated to the topic of the text (i.e., a Sudoku puzzle).

Initial Test. The initial test contained 5 facts questions and 5 application questions, one for each text section. The application items were designed using the taxonomy of Bloom (1956) and required participants to recognize a new instance of a concept or to apply a principle or procedure to a new situation. An example of an application item is: Robin throws two dice. What is the probability that he throws 12 points (i.e., sum is 12) with the two dice together? (Answer: $1/36 = 0.028$).

Final Test. The final test included the same 10 questions as in the initial test.

Confidence judgments. Participants rated on a 6 point scale (0% sure, 20% sure, 40% sure, 60% sure, 80% or 100% sure (see figure 1) how sure they were that they: 1) Can answer factual knowledge questions one week later about the text section they just read, and 2) Can answer application questions within one week about the text section they just read (see Figure 1).

Results

Making a test, after having read a text, led to lower confidence in future performance as compared to rereading the text ($p < .05$). Not only did testing lead to a decrease in confidence scores, it also led to more accurate judgments in relation to final test performance (i.e., bias as a measure of over-or underconfidence), both for fact learning and application ($p < .05$ and $p < .001$). Participants in the SSSS condition gave significantly less accurate judgments about giving the correct answer on a future test, both for factual knowledge as for application as compared to participants in the STST condition. The results of a one-sample t-test show that the bias scores of participants in the SSSS condition were significantly greater than 0, indicating significant overconfidence (Facts: $p < .001$; Application: $p < .00$). Participants in the STST condition were only significantly overconfident for factual knowledge (Facts: $p < .05$; Application: $p > .05$).

Conclusion and Implications

This study shows that retrieving information by means of testing can improve meta-cognitive awareness. Accurate meta-cognitive awareness is an important prerequisite for effective self-regulation and thus, tests seem to be promising tools to use in self-regulated learning environments. Future research might investigate the usage of testing in training programs focusing on self-regulated learning.

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