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How beliefs can impact judgments of learning: Evaluating analytic processing theory with beliefs about fluency



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ABSTRACT

According to analytic-processing theory, when people are asked to judge their future memory performance, they search for cues that will help them reduce their uncertainty for how well they will remember each item. For instance, many people believe that more fluently performing a task is related to better task performance. Thus, when studying items for an upcoming test, items that are believed to be more easily processed are expected to be judged as more memorable. To test this prediction, we had participants judge their learning of words presented for study in two colors (blue or green), because these colors were not expected to differentially impact processing fluency or memory. During the task instructions, some participants were led to believe that one color was easier to process than another, but nothing was mentioned about whether color was related to memory. Across multiple experiments, color did not consistently influence final test performance, whereas people's judgments were significantly higher for words printed in the color that had been associated with more fluent processing. In a final experiment, a different instruction was used in which one color was associated with being more calming when read. For participant's who believed that calming was associated with better memory, JOLs were higher for the words presented in the allegedly calming color. This evidence supports analytic-processing theory and further highlights the central (and sometimes subtle) role of people's beliefs as they judge their learning.

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Introduction

Understanding people's judgments of their learning of recently studied materials has been central to research on metacognitive monitoring since [Arbuckle and Cuddy \(1969\)](#). Judgments of learning (JOLs) are in part interesting for their relevance to education and other learning applications (for a review, see [Kornell & Finn, 2016](#)). For instance, people use JOLs to allocate their study ([Metcalf & Finn, 2008](#)) and hence these monitoring judgments can contribute to the effectiveness of people's self-regulated learning (e.g., [Dunlosky & Rawson, 2012](#); [Kornell & Metcalfe,](#)

[2006](#); [Thiede, 1999](#); [Thiede, Anderson, & Theriault, 2003](#)). Given the relevance of JOLs to applications, these judgments have become one of the most widely investigated of all monitoring judgments (for reviews, see [Dunlosky & Metcalfe, 2009](#); [Rhodes, 2016](#)). In the present study, we explore answers to questions that are fundamental to basic research on JOLs. In particular, How do people make JOLs? Or more specifically, why do certain variables influence people's JOLs?

We explore one theoretical approach (called *analytic processing theory*) to answering these questions. To help illustrate this approach, first consider the font-size effect on JOLs, which has been systematically investigated since it was introduced by [Rhodes and Castel \(2008\)](#). In font-size experiments, participants are instructed to study

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words for an upcoming test, and some words are presented in a larger (48 pt) font size and others in a smaller (18 pt) font size. During study, participants are also instructed to accurately predict the likelihood of recalling each word on the final test. Although font size typically has no influence on recall, participants' JOLs are higher for words presented in a larger versus smaller font size (Rhodes & Castel, 2008). This effect has been attributed to differential processing fluency (for a review, see Mueller, Dunlosky, Tauber, & Rhodes, 2014), with JOLs being higher for larger words because they are presumably easier to process at study. Although this explanation is plausible in that processing may be easier for larger than smaller words, recent evidence suggests that most people judge that memory will be better for larger words because they also believe that the larger words are easier to process. That is, a *belief about processing fluency* appears to produce the font-size effect (Mueller et al., 2014) and not differential processing fluency per se.

According to *analytic processing* (AP) theory, people's beliefs play a central (albeit not exclusive) role in how people judge their learning. In particular, instructing people to predict memory performance triggers analytic problem solving in which people search for cues to reduce uncertainty that will help them accurately predict performance (Dunlosky, Mueller, & Tauber, 2015; Mueller, Dunlosky, & Tauber, 2016). This theory was inspired by others who have argued that human judgments are partly based on analytic processes that involve explicitly using beliefs (e.g., Kelley & Jacoby, 1996; Nisbett & Wilson, 1977). Moreover, other researchers have speculated that people's a priori theories about variables influence JOLs (e.g., Dunlosky & Matvey, 2001; Koriat, 1997); for instance, before participating in a JOL experiment, people may believe that a variable (e.g., the semantic relatedness of words within a paired associate) will influence memory, and hence it will influence JOLs. The critical new twists to AP theory are that it emphasizes (a) that people first explicitly search for cues that will allow them to reduce their uncertainty in predicting future memory performance and (b) that people will develop beliefs on-line – as they are participating in an experiment – about how different variables may help them to accurately predict performance. Either these newly formed beliefs or a priori beliefs will in part drive JOLs.

Importantly, AP theory does not rule out the contribution of processing fluency to JOLs. If people do not construct beliefs (or retrieve a priori ones) relevant to the prediction context, then the subjective experience of fluency that differs across items may influence JOLs. However, in contrast to other dual-process models of JOLs (e.g., cue-utilization framework, Koriat, 1997), AP theory emphasizes the dominant role of beliefs in constructing JOLs and provides a description of processes for how beliefs may be developed and influence JOLs. Returning to the font-size effect, we suspect that most people have never thought about the relationship between font size and memory before beginning an experiment. While studying items, most people presumably notice the changing font sizes and develop a plausible – but incorrect – theory that larger font size words are easier to process. Critically, people report believing that easier processing is

related to better memory and performance (e.g., Bjork, Dunlosky, & Kornell, 2013; Simon & Bjork, 2001), so they then incorrectly infer that font-size will affect memory and make higher JOLs for words printed in larger than smaller font sizes. That is, people endorse the belief that easier processing relates to better memory (Mueller et al., 2014), and this belief about processing fluency presumably drives the font size-JOL relationship.

It is important to emphasize that AP theory does not single out beliefs about *fluency* per se as essential, but instead any variable that a person believes influences memory or that is relevant to making more accurate judgments would be expected to impact JOLs. Nevertheless, in the present series of experiments, we tested predictions from AP theory by focusing on people's beliefs about fluency (but see Experiment 8) for two reasons: Prior research has established that people believe processing fluency is related to memory (e.g., Mueller et al., 2014) and fluency has received a great deal of attention in recent research on JOLs (e.g., Besken, 2016; Hu et al., 2015; Jia et al., 2016; Li, Jia, Li, & Li, 2016; Magreehan, Serra, Schwartz, & Narciss, 2016; Miller & Gercai, 2016; Susser & Mulligan, 2014; Undorf & Erdfelder, 2011, 2013, 2015).

One unique test of AP theory involves (a) using a variable that does not impact fluency and that people do not believe impacts processing fluency and then (b) leading them to believe that it does impact fluency. What is critical about this test is that it would provide the first experimental demonstration that people's beliefs about how a variable affects fluency will cause differences in JOLs. Of course, another possibility is that people's beliefs about processing have no causal impact, with processing cues such as fluency only impacting JOLs when fluency actually varies across levels of a variable. If so, then leading participants to believe that a variable affects fluency will not impact JOLs and will provide evidence against a central prediction from AP theory. We evaluated these predictions (and others) across multiple experiments. In general, we presented words in either blue or green font color, and during the instructions, some participants were led to believe that one color (e.g., blue) was easier to process. Notably, the instructions never referred to how fluency might be related to memory. According to AP theory, participants will make higher JOLs for words associated with the color that is presumably more (vs. less) fluently processed.

Experiment 1

To provide converging evidence, we examined both differentiated global judgments and immediate JOLs. The former involve making a global prediction for each item type (e.g., predict number of green words that will be recalled) and tap people's beliefs about how that variable (i.e., color) influences memory (Dunlosky & Hertzog, 2000). JOLs can be influenced both by beliefs and also by processing that occurs during study. Thus, concerning the central prediction from AP theory, we expected both differentiated global judgments and JOLs to be higher for the color associated with easier processing.

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