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Perceptual fluency contributes to effects of stimulus size on judgments of learning

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ABSTRACT

Studies have demonstrated that perceptual fluency—the ease of perceiving stimuli—does not contribute to higher predictions of future memory performance (judgments of learning; JOLs) for words presented in a larger font (48 pt) than for words presented in a smaller font (18 pt). Here, we investigated whether stimulus size can affect JOLs through another mode of perceptual fluency. We presented stimuli that were initially so small as to be entirely unrecognizable but that gradually increased in size. Stimuli were pictures of common objects (Experiment 1), faces (Experiment 2), and words (Experiments 3 and 4). People indicated when they could identify the stimulus and then made a JOL. The time required for participants to identify each stimulus was our measure of perceptual fluency. In Experiments 1 to 3, we manipulated the speed of the clarification process across trials. Results showed that the less time it took to identify the clarifying stimuli, independent of clarification speed, the higher one's JOLs. Moreover, fast clarification increased JOLs indirectly by decreasing identification time. In Experiment 4, one group of participants (learner group) could base JOLs on both perceptual fluency and beliefs about how stimulus size affects memory performance, while the other group (observer group) could base JOLs only on beliefs. Inverse relations between identification time and JOLs occurred only in the learner group. These results demonstrate that perceptual fluency may produce size effects on JOLs and support the idea that fluency is an important factor in JOLs.

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Introduction

Imagine that a student is seated in the back of a large lecture hall. Most probably, lecture slides are small and hard to read from her perspective. Are viewing conditions related to how the student thinks she will perform on a test of this information? Psychological research has shown that perceptual fluency—the ease of perceiving stimuli—influences many human judgments, including judgments of truth, liking, confidence, and familiarity (e.g., Alter & Oppenheimer, 2009; Kelley & Rhodes, 2002; Reber, Winkielman, & Schwarz, 1998; Whittlesea, Jacoby, & Girard, 1990). It has been proposed that perceptual fluency also affects judgments of learning (JOLs)—the likelihood of remembering recently studied information (e.g., Besken & Mulligan, 2013, 2014; Busey, Tunnicliff, Loftus, & Loftus, 2000; Rhodes & Castel, 2008; Susser, Mulligan, & Besken, 2013; Yue, Castel, & Bjork, 2013).

Studies by Besken and Mulligan (2014) and Susser et al. (2013, Experiment 2) support the idea that perceptual fluency influences JOLs. In their studies, JOLs were higher for words heard in an intact form than for words heard in a fragmented form. In contrast, actual memory

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performance was better for fragmented words than for intact words. A similar dissociation occurred with a perceptual-interference manipulation: JOLs were higher but memory performance was worse for words presented intact than for words presented very briefly and immediately followed by a backward mask (Besken & Mulligan, 2013). However, Mueller, Dunlosky, Tauber, and Rhodes (2014) found that an effect widely cited as evidence for perceptual fluency effects on JOLs, that is, the font-size effect, does not rely on perceptual fluency (e.g., Bjork, Dunlosky, & Kornell, 2013; Diemand-Yauman, Oppenheimer, & Vaughan, 2011; Miele, Finn, & Molden, 2011; Undorf & Erdfelder, 2011).

The font-size effect was first demonstrated by Rhodes and Castel (2008), who found higher JOLs for words presented in a larger Arial font (48 pt) than for words presented in a smaller Arial font (18 pt), even though font size did not influence memory performance. This effect was robust across several experimental manipulations and has been replicated repeatedly (Hu, Liu, Li, & Luo, 2016; Kornell, Rhodes, Castel, & Tauber, 2011; McDonough & Gallo, 2012; Miele et al., 2011; Susser et al., 2013). A recent study by Mueller et al. (2014) demonstrated that the font-size effect relied on people's beliefs about how font size influences memory performance rather than on perceptual fluency. Specifically, Mueller et al. found (1) that measures of fluency (i.e., response times in a lexical decision task and self-paced study time) did not differ between 48-pt and 18-pt Arial words, (2) that most people had the belief that larger words are easier to remember than smaller words, and (3) that font-size effects were roughly equal with immediate JOLs and with pre-study JOLs that could not rely on perceptual fluency. Pre-study JOLs were prompted prior to presenting each item with the query "You are about to study a small [large] word, please rate how likely you are to remember it."

We suspect that perceptual fluency did not affect JOLs in previous studies on the font-size effect, because smaller words were about as easy to read as larger words (see also Besken & Mulligan, 2013, 2014). This idea is supported by research showing that people with normal vision can achieve maximum reading speed in print sizes from approximately 0.2–2.0° of visual angle (Legge & Bigelow, 2011). In this so-called *fluent range of print size*, reading speed is fairly constant. Importantly, both 48-pt and 18-pt Arial words lie in the fluent range of print size as long as viewing distances range between approximately 25 and 95 cm.

In sum, contrary to previous conclusions, Mueller et al. (2014) revealed that a font-size manipulation did not influence JOLs through perceptual fluency. Thus there is no evidence that perceptual fluency underlies stimulus size effects on JOLs. From this finding, one might conclude that perceptual fluency's influence on JOLs is the exception rather than the rule. Such an approach would accord with the idea that JOLs mainly rely on metacognitive beliefs (e.g., Mueller, Tauber, & Dunlosky, 2013; Mueller et al., 2014). Alternatively, one might conclude that perceptual fluency's effects on JOLs are pervasive, and the classic font-size effect did not rely on perceptual fluency, because 18-pt words were about as easy to read as 48-pt words. This idea is consistent with a dual-basis view that assumes JOLs to rely on both deliberate applications of metacognitive beliefs and nonanalytic, implicit inferences drawing on fluency (e.g., Koriat, 1997; Koriat, Bjork, Sheffer, & Bar, 2004; Koriat & Ma'ayan, 2005).

To test between these alternatives, one needs a size manipulation that has a large effect on perceptual fluency. Therefore, we used a visual identification procedure (see Bernstein, Loftus, & Meltzoff, 2005; Loftus & Harley, 2005). We presented people with stimuli that gradually increased in size. All stimuli were initially so small as to be entirely unrecognizable but clarified over time. Participants were asked to stop the clarification process as soon as they could identify the stimulus. We manipulated perceptual fluency by varying the speed with which stimuli clarified. In slow trials, stimulus clarification consisted of presenting all 30 images in increasing order of size. In fast trials, stimulus clarification occurred by presenting only every second image, so that maximum size was reached after 15 images. Each image was displayed on screen for an equal time in fast and slow trials.

Using this procedure, we operationally defined perceptual fluency as the time required for people to identify the stimuli: The longer the identification time, the lower the perceptual fluency. It is plausible that stimuli vary in perceptual fluency, because they are entirely unrecognizable in the beginning of the clarification procedure and are clearly visible towards the end. At the same time, the perceptual fluency manipulation is unobtrusive, because the clarification process is perceptually similar in fast and slow trials. There are several reasons for this. First, fast and slow trials began with images of equal size and ended with images of nearly equal size. Second, individual images were onscreen for an equal time in fast and slow trials. Finally, the stimuli's perceptual features introduce variability in identification times within fast and slow trials.

The advantage of this design is that it allows us to evaluate whether perceptual fluency contributes to stimulus size effects on JOLs. Specifically, two predictions follow from the hypothesis that perceptual fluency underlies stimulus size effects on JOLs. First, JOLs should be inversely related to identification time, independent of clarification speed: There should be a negative correlation between identification time and JOLs in both fast and slow trials. Notably, we predict higher JOLs for smaller stimuli than for larger stimuli. The reason for this is that stimulus size gradually increased in our paradigm, meaning that large stimulus size indicates low fluency and hard to remember. Second, identification time should mediate the effect of the experimental manipulation of clarification speed on JOLs: Fast clarification should increase JOLs indirectly through reducing identification time. In contrast, if metacognitive beliefs exclusively underlie stimulus size effects on JOLs, identification time should not mediate the effect of the clarification speed manipulation on JOLs.

Experiment 1

Participants in Experiment 1 identified common objects that clarified either quickly or slowly. Following the identification of each object, participants made a JOL

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