Perceptual fluency affects judgments of learning: The font size effect
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ABSTRACT
The font size effect on judgments of learning (JOLs) refers to the fact that people give higher JOLs to large than to small font size words, despite font size having no effect on retention. The effect is important because it spotlights a process dissociation between metacognitive judgments about memory and memory performance itself. Previous research has proposed a fluency theory to account for this effect, but this theory has been contradicted by a recent study which found no difference in response times (RTs) – and hence fluency – in a lexical decision task between large and small words (Mueller, Dunlosky, Tauber, & Rhodes, 2014). In the current research, we further tested the fluency theory by employing a continuous identification (CID) task in Experiment 1 and by explicitly comparing the CID and lexical decision tasks in Experiment 2. We show that lexical decision is an inappropriate instrument for measuring differences in perceptual fluency. The CID task, in contrast, provides direct evidence that the stimulus size effect on JOLs is substantially mediated by perceptual fluency. Experiment 3 found that fluency is at least as important as beliefs about font size in contributing to the font size effect on JOLs.

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Introduction
The font size effect on judgments of learning (JOLs; i.e., estimates of the likelihood that a given item will be remembered at a future memory test) was originally reported by Rhodes and Castel (2008). They instructed participants to study words in large (48-point) or small (18-point) font sizes. After studying each word, participants made a JOL to predict the likelihood they would remember that word. Participants gave significantly higher JOLs to large than to small font size words, yet at a later test, recall performance was equivalent for large and small words. The font size effect on JOLs is robust and has been replicated dozens of times (e.g., Ball, Klein, & Brewer, 2014; Besken, 2016; Hu, Liu, Li, & Luo, 2016; Hu et al., 2015; Kornell, Rhodes, Castel, & Tauber, 2011; Li, Xie, Li, & Li, 2015; Miele, Finn, & Molden, 2011; Mueller, Dunlosky, Tauber, & Rhodes, 2014; Price & Harrison, 2017; Price, McElroy, & Martin, 2016; Susser, Mulligan, & Besken, 2013). The effect is important because JOLs determine individuals’ study strategies. Research has found that perceived importance between large and small words may produce a priori beliefs that large words are easier to remember than small words, and that they incorporate these beliefs into their JOLs. Research has found that perceived importance can moderate people’s JOLs (Castel, 2007). Mueller et al. (2014) found that some people believe that large words are more important than small words, and Rhodes and Castel (2008) proposed that participants might believe that a large font size signals the importance of a study item within the context of an experiment. Therefore, it is possible that the difference in perceived importance between large and small words may produce the font size effect on JOLs (Rhodes & Castel, 2008), Mueller et al. (2014) also found that some people believe large words are easier to remember, and therefore suggested that people apply this belief in forming their JOLs (Mueller & Dunlosky, 2017). Moreover, Hu et al. (2015) found that the font size effect on JOLs is significantly predicted by variability in people’s beliefs about the difficulty of remembering large and small words. Collectively, these findings support the belief theory (based either on beliefs about importance and practice).

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or about ease of remembering) as an account for the font size effect on JOLs.

The second explanation is a fluency theory, which postulates that large words are processed with greater perceptual fluency than small words. The experience of fluency during encoding produces a subjective feeling-of-knowing, and this subjective feeling acts as a basis for assessments about learning status (Koriat & Bjork, 2006; Koriat & Ma’ayan, 2005; Mueller, Tauber, & Dunlosky, 2013; Undorf, Zimdahl, & Bernstein, 2017). Previous studies have supplied convincing evidence that greater processing fluency produces higher JOLs – a fluency effect on JOLs (Ball et al., 2014; Besken & Mulligan, 2013; Hertzog, Dunlosky, Robinson, & Kidder, 2003; Magreehan, Serra, Schwartz, & Narciss, 2016; Undorf et al., 2017; Yang et al., 2017b).

Only two studies, though, have directly examined the role of fluency in the font size effect on JOLs. The first was conducted by Rhodes and Castel (2008). In their Experiment 6, some words were presented in a standard format (e.g., computer) and others in a format with alternating lowercase and uppercase letters (e.g., gArDeN). Rhodes and Castel’s (2008) Experiment 6 obtained a font size effect on JOLs in the standard format condition but not in the alternating format condition. They proposed that differences in perceptual fluency between large and small words were disrupted in the alternating format condition. However, Mueller et al. (2014) argued that Rhodes and Castel’s (2008) Experiment 6 cannot provide unequivocal evidence to support the fluency theory, and that prior beliefs can equally well explain the results: Participants may simply not believe that large but alternating font words are easier to remember than small alternating font words.

Mueller et al. (2014) conducted a further study to test the fluency theory by employing a lexical decision task in their Experiment 1. Words (e.g., chicken) and non-words (e.g., arage) were sequentially presented in large or small font sizes. Participants were instructed to decide, as quickly and accurately as they could, whether the presented item was a word or a non-word. Mueller et al. (2014) found no difference in response times (RTs) between large and small words, and hence suggested that “processing fluency, as measured by the lexical decision task, is not mediating the font-size effect” (p. 4).

This finding is surprising because prior to Mueller et al.’s (2014) study, the general consensus amongst researchers was that perceptual fluency does underlie the font size effect on JOLs, and indeed many researchers had offered the font size effect on JOLs as evidence that perceptual fluency can affect JOLs (e.g., Bjork, Dunlosky, & Kornell, 2013; Diemand-Yauman, Oppenheimer, & Vaughan, 2011; Kornell et al., 2011; Miele et al., 2011; Rhodes & Castel, 2008). It is important to note that Mueller et al. (2014) did not completely reject the fluency theory. Instead, they suggested that their results were inconsistent with the fluency theory and they encouraged future research to further explore the theory (p. 9). However, after Mueller et al.’s (2014) study was published, researchers started to acknowledge that fluency may play no role in the font size effect on JOLs (e.g., Ball et al., 2014; Finn & Tauber, 2015; Li, Jia, Li, & Li, 2016; Magreehan et al., 2016; Mueller & Dunlosky, 2017; Mueller, Dunlosky, & Tauber, 2016; Susser, Jin, & Mulligan, 2016; Susser, Panitz, Buchin, & Mulligan, 2017; Undorf et al., 2017). Taking a more neutral position, Hu et al. (2015) claimed that “Although Mueller et al. (2014) suggest that fluency does not differ… There may be other types of fluency that differ significantly between large and small words” (p. 10).

Assessing the evidence against the fluency theory

There are at least three possible reasons for the lack of a difference in RTs between large and small words in Mueller et al.’s (2014) Experiment 1. The first, as proposed by Mueller et al. (2014), is that there is truly no difference in perceptual fluency between large and small words. Secondly, their null result might be a false negative, because the number of trials (18 large and 18 small words) and sample size (31 participants) might have combined to render their experiment underpowered. It is well-known that small sample size and number of trials can lead to false negative results (Vadillo, Konstantinidis, & Shanks, 2016). The third possibility concerns the research method Mueller et al. employed, specifically, their use of RTs obtained from a lexical decision task as an index of perceptual fluency. The lexical decision task is complex (Yap, Sibley, Balota, Ratcliff, & Ruedckl, 2015): Participants need to read or identify the letter string first, judge whether it is a word or a non-word, and then select which button to press to indicate their response before the judgment RT is recorded. Participants may check the letter string letter-by-letter, and their lexical decisions may be conservative and time-consuming. Therefore, there could be considerable noise in the RTs obtained from the lexical decision task. Access to word meaning is also assumed to be involved in the lexical decision task (Chumbley & Balota, 1984). Consequently, RTs derived from Mueller et al.’s (2014) Experiment 1 might be driven by semantic processing in addition to perceptual processing of the words, and thus it is unclear to what extent their findings contradict accounts claiming that perceptual fluency underlies the font size effect on JOLs. In short, lexical decision may be a poor tool for measuring variations in perceptual fluency.

Mueller et al. (2014) tested the fluency theory more indirectly by measuring study time allocation in their Experiment 2. Participants were allowed to spend as much time as they wanted to study each word. Mueller et al. (2014) hypothesized that participants would spend less time studying large compared to small words if large words are processed more fluently than small words. However, they observed no difference between study times allocated to large and small words, and proposed that “the lack of an effect of font size on study time allocation is inconsistent with the hypothesis that encoding fluency is responsible for the font-size effect on JOLs” (p. 5).

But again, this result does not provide strong motivation to reject the fluency theory because, besides fluency, many other factors could have affected participants’ study time allocation (e.g., motivation, curiosity). Participants might believe that large words are more important than small words (Mueller et al., 2014; Rhodes & Castel, 2008), and allocate more time to them accordingly (Noh, Yan, Vendetti, Castel, & Bjork, 2014). A fluency advantage for large words (leading them to be studied for less time) may have operated in opposition to a belief that large words are important (leading them to be studied for longer), thus contributing to the overall null result. Yang, Potts, and Shanks (2017a) found that participants decreased their study times across a study phase when they were allowed to spend as much time as they wanted to study each item (e.g., Euskara-English word pairs in Yang et al.’s Experiment 1 and face-name pairs in their Experiment 2), again implying that self-regulated study time allocation can be affected by other factors besides fluency.

Moreover, recent research has found that in some situations self-regulated study time allocation is not a sensitive measure of fluency. For example, Witherby and Tauber (2017) found that participants responded faster to concrete (e.g., apple) than to abstract (e.g., idea) words in a lexical decision task, but there was no difference in study times between concrete and abstract words when participants were allowed to spend as much time as they wanted to study them. Therefore, Mueller et al.’s (2014) Experiment 2 cannot be taken as providing indirect evidence against the fluency theory because self-regulated study time allocation can be affected by many other factors besides fluency, and is an insensitive measure of fluency. Overall, Mueller et al.’s (2014) Experiments 1 and 2 fall short of providing compelling evidence against the fluency theory.
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