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BRIEF REPORT

If it's hard to read, it changes how long you do it: Reading time as an explanation for perceptual fluency effects on judgment

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Abstract Perceptual manipulations, such as changes in font type or figure-ground contrast, have been shown to increase judgments of difficulty or effort related to the presented material. Previous theory has suggested that this is the result of changes in online processing or perhaps the post-hoc influence of perceived difficulty recalled at the time of judgment. These two experiments seek to examine by which mechanism (or both) the fluency effect is produced. Results indicate that disfluency does in fact change in situ reading behavior, and this change significantly mediates judgments. Eye movement analyses corroborate this suggestion and observe a difference in how people read a disfluent presentation. These findings support the notion that readers are using perceptual cues in their reading experiences to change how they interact with the material, which in turn produces the observed biases.

Keywords Judgment and decision making · Perceptual fluency · Reading

Perceptual fluency, or the subjective sense of how easy/difficult information is to process (Oppenheimer, 2008), has been connected to observable biases in judgments and reasoning about that information. Disfluent textual presentations (e.g., nonstandard fonts, unfamiliar pronunciation, poor figure-ground contrast) have been shown to create perceptions of situations that are more time-consuming, difficult, less "intelligent," or even more dangerous than identical information presented in a more fluent way (see Schwarz, 2004 for a review). Similar effects on judgments have been observed with perceptually degraded presentations of faces and auditory stimuli (Kleider & Goldinger, 2004; Westerman, Lloyd & Miller, 2002). The robustness of these biases, observed across several content areas, modalities, and disciplines, provides a compelling argument that simple changes in perceived perceptual fluency can have a significant impact on judgment.

One prevailing explanation for these findings has been the feeling-as-information theory (Schwarz, 2012). Central to Schwarz's feeling-as-information theory is the assumption that people draw on their affective experiences as a critical source of information when making judgments. In the case of perceptual fluency, or more generally processing fluency, this theory would suggest that disfluent presentations produce a negative subjective response (i.e., the text is harder to read), which in turn produces a bias in judgment such that a participant views the presentation more negatively (i.e., more dangerous or more difficult; Winkelman, Schwarz, Fazendeiro & Reber, 2003). Conversely, when a text is easier to read, people have more positive (or at least neutral) perceptions of difficulty, and therefore judge the presentation more positively as well. Consistent with this line of thinking, attributing disfluent presentations to innocuous causes (e.g., printer was low on toner) has been show to attenuate negative biases in judgment (Jacoby & Dallas, 1981; Oppenheimer & Frank, 2008) and sometimes can even lead to overcompensation regarding judgments (Oppenheimer, 2006).

While the feeling-as-information theory (Schwarz, 2012) has generated much support, the effects of perceived difficulty as a result of disfluency have never been directly tested, and therefore leave room for alternative explanations. One such alternative explanation could be that disfluent presentations

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actually cause participants to process the material differently. More specifically, disfluent presentations could be changing the way people read a text, and it is this change in reading that is serving as the basis for their subsequent judgments. In other words, hard-to-read text may be processed differently than easy-to-read text, and it is this fundamental change in processing that produces a shift in judgment. There is some support for this shift in processing, as previous research has demonstrated that less fluent font presentations cause participants to adopt a more analytic perspective on reasoning problems (Alter, Oppenheimer, Epley & Eyre, 2007), focus on, and learn facts better (Diemand-Yauman, Oppenheimer, & Vaughan, 2011) and also reduce the likelihood of succumbing to semantic distortions, such as the "Moses Illusion" through more careful focus on the operators (Song & Schwarz, 2008a). Previous work on text legibility also lends some support to the notion that disfluency could be changing the way people read. Research has shown that when letters in text are made more difficult to read (e.g., when the text is made more faint), reading speed typically slows down (Arditi & Cho, 2005; Mansfield, Legge, & Bane, 1996; Tinker, 1963).

The purpose of the current set of experiments is to address what is actually mediating the relationship between font manipulations and biased judgments. We seek to examine whether it is in fact increased perception of subjective difficulty that serves as the basis for bias in judgments or instead changes in cognition that produce said differences in judgment. In the current studies, participants read a text instructing how to make a sushi roll (Song & Schwarz, 2008b) and after reading were asked to make a judgment about how long they believed it would take to carry out the recipe successfully. Previous research has shown that this time judgment is susceptible to the effects of perceptual fluency (Song & Schwarz, 2008b). Participants' rating of difficulty was measured by their response to "how easy" the text was to read, and reading time was used as a global indicator of processing. If participants' perception of difficulty alone drives the previously observed bias in the time judgment, one would expect a positive relationship between these variables (i.e., more difficulty in reading equates to a more negative judgment about content, in this case longer time estimates). Furthermore, one would expect no change with how individuals interact with the material or, at the very least, any change would not be predictive of judgments. From this perspective, the relationship between changes in processing and changes in time judgment should be less important than the relationship between perceived difficulty and time judgment. However, if disfluency instead changes the way people read or process the text, one would expect the opposite pattern, and these changes in processing should be more predictive of any observed bias in the time estimate, over and above any relationship between perceived difficulty and judgment. To test these competing hypotheses, participants were timed as they read a text that was either presented in a fluent or disfluent font and also rated the perceived difficulty of reading the text. Reading time and difficulty ratings were then used to predict participants' judgments regarding the content of the text (i.e., time to construct sushi roll) to examine whether either of these metrics predict subsequent judgments.

Experiment 1

Method

Thirty-seven undergraduates (32 % female) read a text (sushi) adapted from Song and Schwarz (2008b). This text was presented in either 20-pt. Courier font ($n = 19$) or 20-pt Mistral font ($n = 18$). Based on previous research (Song & Schwarz, 2008b), presentation in the Mistral font should reduce perceived fluency and participants should rate the text as harder to read. All participants also read a control text (Flywheels; adapted from Just & Carpenter, 1980) that was always presented in the Courier font and was nearly identical in length (48 words) to the sushi text (39 words). This control text was always read before the target text. To ensure that participants were attending to the information in the text, participants were asked two true/false (T/F) questions about each text and also asked to rate how difficult each text was to read (1-8, 8 being very difficult), consistent with previous methodology used with these materials (Song & Schwarz, 2008b). For the target sushi text, participants were asked to rate how long it would take to make the sushi roll in minutes (select between 1-9 minutes). Participants read both texts on a computer at their own pace until they felt they understood the text (indicated by a keypress), and gross reading time for each text was recorded. All other questions and ratings were also computer-based.

Results and discussion

As shown in Table 1, conditions were matched on the control text such that performance on the T/F questions, rated difficulty of the text, and reading time did not differ across conditions. As for the target sushi text, results replicated previous research using these materials (Song & Schwarz, 2008b). While there was no difference on the T/F questions across font conditions for the sushi text, difficulty ratings and reading times did differ across conditions. The Mistral font version of the sushi text was rated as significantly more difficult to read, and also took longer to read, than the Courier font version of the same sushi text. As expected, reading the text in Mistral font also produced a significant increase in the time estimated to make the sushi roll. Importantly, time estimate was significantly correlated with reading time (0.51, $p < 0.01$) but not difficulty rating (0.10, *ns*). Reading-time on the target text and difficulty rating were also uncorrelated (0.02, *ns*). In sum, these results demonstrate

Table 1 Descriptive statistics for each experiment

	Courier font *M* (*SD*)	Mistral font *M* (*SD*)	*t*	Cohen's *d*
Experiment 1	(*n* = 19)	(*n* = 18)	*df* = 35	
Control text T/F (out of 2)	1.89 (0.32)	1.83 (0.38)	0.53	0.17
Target text T/F (out of 2)	1.79 (0.42)	1.94 (0.24)	1.38	0.44
Control text difficulty rating (1-8)	3.32 (2.16)	2.89 (1.49)	0.7	0.23
Target text difficulty rating (1-8)	3.0 (2.11)	5.89 (1.49)	4.79**	1.58
Sushi Roll time estimate in minutes	5.16 (1.17)	6.44 (2.06)	2.35*	0.76
Control text reading time (msec)	14561.95 (4597.34)	14946.11 (5734.75)	0.23	0.07
Target text reading time (msec)	20414.63 (6443.91)	27247.72 (10354.39)	2.42*	0.79
Experiment 2	(*n* = 17)	(*n* = 17)	*df* = 32	
Control text T/F (out of 2)	1.65 (0.61)	1.71 (0.59)	0.29	0.1
Target text T/F (out of 2)	1.76 (0.44)	1.65 (0.7)	0.59	0.19
Control text difficulty rating (1-8)	2.18 (1.7)	2.88 (1.73)	1.2	0.41
Target text difficulty rating (1-8)	2.82 (1.78)	5.76 (1.6)	5.07**	1.74
Sushi Roll time estimate in minutes	4.76 (1.35)	6.47 (1.87)	3.05**	1.05
Control text reading time (msec)	11484.12 (2546.67)	13561.94 (3876.65)	1.85	0.63
Target text reading time (msec)	12800.24 (3486.9)	17361.0 (4619.23)	3.25**	1.11
Target text overall # fixations	53.82 (18.42)	55.76 (16.28)	0.33	0.11
Target text avg. fixation length (msec)	242.65 (24.45)	319.11 (55.90)	5.17**	1.77
Target text # local regressions	14.00 (7.86)	14.88 (7.64)	0.33	0.11
Target text # global regressions	2.53 (2.9)	1.41 (2.18)	1.27	0.44

$^*p < 0.05$, $^{**}p < 0.01$

that while perceptually disfluent presentations do not harm understanding, they do take longer to read, which is related to changes in judgment. However, perceived difficulty of reading the text in different fonts was not related to estimates of time judgment or the time it took to read the target text. The lack of a significant correlation between reading time and difficulty rating also suggests that these factors are unrelated and that difficulty rating must rely on some other input as its basis.

To further address the question of whether the time estimate is a result of changes in reading behavior versus ratings of subjective difficulty of the presentation, simple mediational analyses were conducted using Baron & Kenny's (1986) approach using both reading time and difficulty rating as mediators for the time estimation. If processing changes underlie the bias in time estimate, reading time should mediate judgments. Similarly, if affective cue use at the time of judgment produces this phenomenon, participants' rating of how difficult the text is to read also should mediate the time estimation (as this rating would be the basis for such feeling-based judgments). As is visible in Fig. 1a, consistent with the simple correlations, reading time fully mediates the relationship between font condition and time estimate. However, although font condition is related to difficulty rating, this does not mediate time estimate (Fig. 1b). Finally, because it is critical to consider simultaneously the mediating influence of these variables concurrently, a multiple mediational analysis was conducted using the bootstrapping procedure (5,000 samples) developed by Preacher & Hayes (2008). Predictions would be consistent with above: if reading time or difficulty drive differences in the time estimate, we would expect to see the direct relationship between font condition and time estimate to disappear or at least diminish.

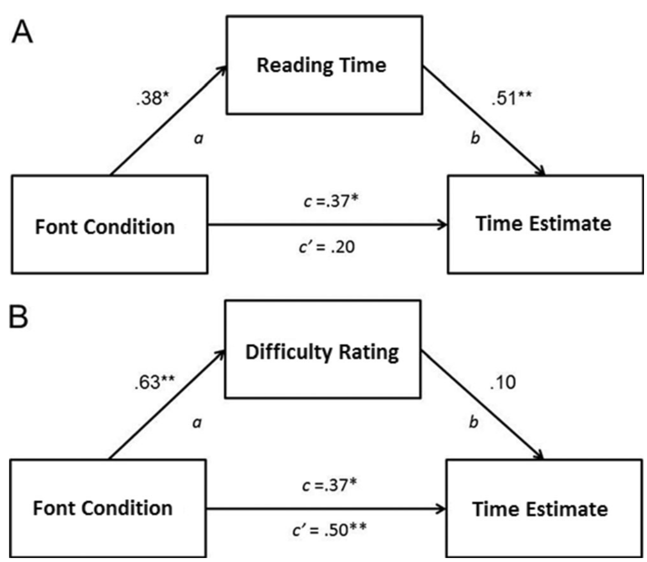

Fig. 1 Simple mediational analysis results for (**a**) reading time and (**b**) difficulty rating. $^*p < 0.05$, $^{**}p < 0.01$

Consistent with the simple mediational analyses above, results indicated that the relationship between font condition and time estimate was significantly mediated by reading time (point estimate = 0.56, *SE* = 0.37, *95 % CI*: 0.0264, 1.547), but not by difficulty estimate (point estimate = −0.13, *SE* = 0.37, *95 % CI*: −0.937, 0.587). Importantly, the direct path from font condition to time estimate ($\beta = 1.29$, $t = 2.35$, $p < 0.05$) became nonsignificant when the mediators were entered in the model ($\beta = 0.86$, $t = 1.16$, *ns*), again suggesting full mediation of the effect. This final analysis further confirms that the biases seen on the time estimates are a result of differences in online processing, and not the interference of affective information during judgment.

Experiment 2

As the previous experiment does establish that participants are taking longer to read in disfluent conditions, which in turn predicts the subsequent bias in judgment, an open question is what ultimately leads to these longer reading times when reading disfluent text? In other words, what are readers of disfluent texts doing differently than readers of more fluent presentations? If disfluent presentations change how individuals cognitively interact with a presentation, as suggested by the results of Experiment 1, it is important to explore what observable changes in reading behavior are manifest in these conditions. One fruitful way to capture such differences is to examine participants' eye movements while reading.

Previous eyetracking research has shown that less legible fonts result in longer fixation durations and longer overall reading times but do not cause differences in comprehension (Slattery & Rayner, 2010). Similarly, in a study conducted by Reingold and Rayner (2006), participants read sentences in which only a single word was of degraded quality. Results indicated that although reading times on the perceptually degraded word were slowed, reading times on all other words (including the word directly following the degraded word) were unaffected. Reingold and Rayner (2006) argued that this result supports the idea that stimulus quality only affects very initial word processing, and not later reading processes. This suggests that disfluency might not change overall reading patterns but instead just slow reading behavior. Relevant for the current study: are the slower reading times in the perceptually disfluent font condition occurring as the result of the slowing of word processing, consistent with Reingold & Rayner (2006)? Or are increased reading times instead a result of something else, for example re-reading efforts as the participants attempt to form meaning of the disfluent passage (Murray & Kennedy, 1988)? If disfluency only slows word processing, one would expect that all other typical reading/re-reading patterns would not change between presentations. However, if disfluency requires participants to expend more effort integrating the material (similar to reading ambiguous texts; Frazier & Rayner, 1982), one might expect differences in both the number of fixations and also re-reading behavior of the text.

To address these questions, a second group of participants repeated the design from Experiment 1, save that their eye movements were recorded while reading the target text. Reading patterns between fluent and disfluent presentations were then compared across groups for evidence of changes in reading/re-reading patterns in the hopes of illuminating what might cause the inflation of reading times observed in Experiment 1. Again, if disfluency simply slows reading, all other reading patterns (i.e., # fixations and # regressions) should be consistent across font conditions, although average fixation length should increase. However, if disfluent text requires more effort to integrate, there should be not only more fixations made, but also more re-reading behavior of the text.

Methods

Thirty-four participants (56 % female) read in the same conditions used in Experiment 1. Seventeen participants read in the Courier font condition, and 17 participants read in the Mistral font condition. Eye movements were recorded for the reading of the target text using an Eyelink II eyetracker running at 60 Hz. Participants were calibrated on the eyetracker before viewing the target text. Calibration was conducted on both eyes, and the best calibrated eye was selected for data collection. Overall reading time, number of fixations, average length of fixation, local regressions (look-backs within the same line of text), and distal regressions (look-backs to previous lines in the passage) were analyzed and compared across font conditions on the target text to identify differences in reading patterns due to font condition. Reading time and the number of fixations are global measures of text processing, whereas regressions are considered evidence of re-reading (Rayner, 1998).

Results and discussion

Descriptive and inferential statistics are available in Table 1. Similar to the first experiment, there were no differences in the number of questions answered correctly, ratings of difficulty in reading, or reading time on the control flywheels text. For the target sushi text, there was again no difference on the T/F questions across font conditions, but difficulty ratings and reading time did differ. Again, when the sushi text was presented in Mistral font it was perceived as significantly more difficult to read and also took significantly longer to read than when the target text was presented in Courier font. Importantly, changes in fluency also produced a significant increase in the time estimate related to how long it would take to make the sushi roll. This time estimate was again significantly correlated with reading time (0.47, $p < 0.01$) but not with difficulty estimate (0.32, *ns*). Furthermore, as before, reading time and difficulty estimate were not related (0.26, *ns*). A multiple mediational analysis (Preacher & Hayes, 2008; 5,000 samples) was again conducted as in Experiment 1, and the pattern of results was identical. Results indicated that the relationship between font condition and time estimate was significantly mediated by reading time (point estimate = 0.57, *SE* = 0.37, *95 % CI*: 0.0155, 1.459) but not by difficulty estimate (point estimate = 0.1, *SE* = 0.64, *95 % CI*: −1.381, 1.19). Importantly, the direct path from font condition to time estimate (β = 1.71, t = 3.05, $p < 0.01$) again became non-significant when the mediators were entered in the model (β = 1.03, t = 1.24, *ns*), again suggesting full mediation of the effect (Fig. 2).

In terms of eye movements, even though the sushi text took longer to read when presented in Mistral font, there were not significantly more fixations made in this condition. There was however a significant difference in average fixation length across font conditions with average fixations being longer when the sushi text was presented in Mistral font. What this suggests is that the perceptually disfluent font *slowed* the reading process, causing an increase in the average length of fixation. There were also no differences in the amount of local regressions (i.e., re-readings within the same line) or global regressions (i.e., re-readings of previous lines of text) across the different target texts.

When considering the eyetracking results as a whole, it suggests that readers of perceptually disfluent text fixate longer on words, but perceptually disfluent text does not seem to affect integrative processing. Such integrative processing would likely increase not only the number of fixations, but also should produce some regressions, neither of which were observed. As such, while these results do corroborate the findings of Experiment 1, they offer a critical refinement: namely that any changes in processing are due to the longer time needed to fixate on the disfluent font and not necessarily the integration of information across the text.

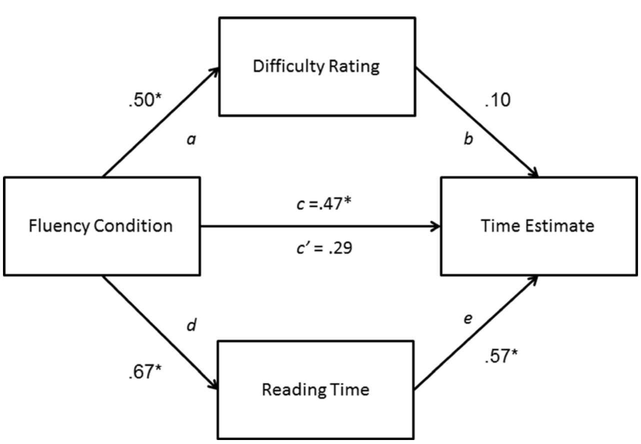

Fig. 2 Multiple mediational analysis from Experiment 2. *$p < .05$

Discussion

Results across two experiments confirm that the previous effects related to font manipulations appear to be driven by changes in online processing and not the influence of perceived difficulty at the time of judgment. This partially confirms previous explanations for disfluency that suggest disfluency can change how material is processed (Alter et al., 2007; Song & Schwarz, 2008a). Specifically, disfluency increases the time it takes to read but does not appear to increase integration processes.

Interestingly, there also appears to be a disconnect between perceived difficulty and actual reading behavior, as reading time was uncorrelated with estimates of perceived difficulty in both experiments. This finding is somewhat at odds with some research on judgments of learning (JOLs) that has found that metacognitive monitoring of study time can affect judgment (Undorf & Erdfelder, 2011). The findings here suggest that other metrics, besides simple processing time, are being used when estimating processing difficulty in disfluent situations. This is consistent with other work on JOLs, which suggest that changes in font size do affect JOLs, but these changes in JOLs do not seem to be the result of perceptual fluency (as measured by lexical decision times), but rather a belief that large items are more distinctive than small items (Mueller, Dunlosky, Tauber, & Rhodes, 2014). Similarly, more fluent presentations have been shown to increase predictions of future memory performance, but not actually change recall in such tasks when actually attempted (Rhodes & Castel, 2008; Yue, Castel, & Bjork, 2013). These results represent an interesting line of future research into what aspect of the reading/processing experience produces inflated estimates of difficulty, and also whether this information is consciously accessible or not, or whether it is even derived natively for every stimulus exposure. It would be interesting to examine the role that prior beliefs may play when producing estimates of difficulty and their subsequent effect on judgment. As these beliefs may be less malleable and stronger in magnitude, it would be interesting to explore how they might interact with different disfluency manipulations to affect judgment.

In conclusion, this work complements previous research on perceptual fluency and confirms a causal mechanism by which this effect arises. Simultaneous consideration of processing time and perceived difficulty determined that bias produced from disfluent presentations was fully mediated by processing time and was unrelated to perceived difficulty. This offers an important refinement of current explanations of perceptually fluency and offers an interesting opportunity for future research into how processing time, perceived difficulty, and beliefs about learning are connected.

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